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the Appendix

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https://github.com/FirebirdSQL/firebird-documentation/issues or submit a pull
request with the necessary changes.
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Chapter 1. About the Firebird 4.0 Language Reference

This Language Reference describes the SQL language supported by Firebird 4.0.

This Firebird 4.0 Language Reference is the third comprehensive manual to cover all aspects of the query language used by developers to communicate, through their applications, with the Firebird relational database management system.

1.1. Subject

The subject of this volume is wholly Firebird’s implementation of the SQL relational database language. Firebird conforms closely with international standards for SQL, from data type support, data storage structures, referential integrity mechanisms, to data manipulation capabilities and access privileges. Firebird also implements a robust procedural language—procedural SQL (PSQL)—for stored procedures, stored functions, triggers, and dynamically-executable code blocks. These are the areas addressed in this volume.

This document does not cover configuration of Firebird, Firebird command-line tools, nor its programming APIs.

1.2. Authorship

For the Firebird 4.0 version, the Firebird 3.0 Language Reference was taken as the base, and Firebird 4.0 information was added based on the Firebird 4.0 Release Notes and feature documentation.

1.2.1. Contributors

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Pull requests with changes and fixes are also much appreciated.

1.4. Acknowledgments

Sponsors and Other Donors

See also the Acknowledgements in the Firebird 2.5 Language Reference for the sponsors of the initial Russian version and its translation.


Moscow Exchange (Russia)

Moscow Exchange is the largest exchange holding in Russia and Eastern Europe, founded on December 19, 2011, through the consolidation of the MICEX (founded in 1992) and RTS (founded in 1995) exchange groups. Moscow Exchange ranks among the world's top 20 exchanges by trading in bonds and by the total capitalization of shares traded, as well as among the 10 largest exchange platforms for trading derivatives.

IBSurgeon (ibase.ru) (Russia)

Technical support and developer of administrator tools for the Firebird DBMS.

1.5. Contributing

There are several ways you can contribute to the documentation of Firebird, or Firebird in general:

- Participate on the mailing lists (see https://www.firebirdsql.org/en/mailing-lists/)
- Report bugs or submit pull requests on GitHub (https://github.com/FirebirdSQL/)
- Become a developer (for documentation contact us on firebird-docs, for Firebird in general, use the Firebird-devel mailing list)
- Donate to the Firebird Foundation (see https://www.firebirdsql.org/en/donate/)
- Become a paying member or sponsor of the Firebird Foundation (see https://www.firebirdsql.org/en/firebird-foundation/)
Chapter 2. SQL Language Structure

This reference describes the SQL language supported by Firebird.

2.1. Background to Firebird’s SQL Language

To begin, a few points about some characteristics that are in the background to Firebird’s language implementation.

2.1.1. SQL Flavours

Distinct subsets of SQL apply to different sectors of activity. The SQL subsets in Firebird’s language implementation are:

- Dynamic SQL (DSQL)
- Procedural SQL (PSQL)
- Embedded SQL (ESQL)
- Interactive SQL (ISQL)

Dynamic SQL is the major part of the language which corresponds to the Part 2 (SQL/Foundation) part of the SQL specification. DSQL represents statements passed by client applications through the public Firebird API and processed by the database engine.

Procedural SQL augments Dynamic SQL to allow compound statements containing local variables, assignments, conditions, loops and other procedural constructs. PSQL corresponds to the Part 4 (SQL/PSM) part of the SQL specifications. Originally, PSQL extensions were available in persistent stored modules (procedures and triggers) only, but in more recent releases they were surfaced in Dynamic SQL as well (see EXECUTE BLOCK).

Embedded SQL defines the DSQL subset supported by Firebird gpre, the application which allows you to embed SQL constructs into your host programming language (C, C++, Pascal, Cobol, etc.) and preprocess those embedded constructs into the proper Firebird API calls.

Only a portion of the statements and expressions implemented in DSQL are supported in ESQL.

Interactive ISQL refers to the language that can be executed using Firebird isql, the command-line application for accessing databases interactively. As a regular client application, its native language is DSQL. It also offers a few additional commands that are not available outside its specific environment.

Both DSQL and PSQL subsets are completely presented in this reference. Neither ESQL nor ISQL flavours are described here unless mentioned explicitly.

2.1.2. SQL Dialects

SQL dialect is a term that defines the specific features of the SQL language that are available when
accessing a database. SQL dialects can be defined at the database level and specified at the connection level. Three dialects are available:

- **Dialect 1** is intended solely to allow backward compatibility with legacy databases from very old InterBase versions, v.5 and below. Dialect 1 databases retain certain language features that differ from Dialect 3, the default for Firebird databases.
  
  ◦ Date and time information are stored in a DATE data type. A TIMESTAMP data type is also available, that is identical to this DATE implementation.
  
  ◦ Double quotes may be used as an alternative to apostrophes for delimiting string data. This is contrary to the SQL standard — double quotes are reserved for a distinct syntactic purpose both in standard SQL and in Dialect 3. Double-quoting strings is therefore to be avoided strenuously.
  
  ◦ The precision for NUMERIC and DECIMAL data types is smaller than in Dialect 3 and, if the precision of a fixed decimal number is greater than 9, Firebird stores it internally as a long floating point value.
  
  ◦ The BIGINT (64-bit integer) data type is not supported.
  
  ◦ Identifiers are case-insensitive and must always comply with the rules for regular identifiers — see the section Identifiers below.
  
  ◦ Although generator values are stored as 64-bit integers, a Dialect 1 client request, `SELECT GEN_ID (MyGen, 1)` for example, will return the generator value truncated to 32 bits.

- **Dialect 2** is available only on the Firebird client connection and cannot be set in the database. It is intended to assist debugging of possible problems with legacy data when migrating a database from dialect 1 to 3.

- In **Dialect 3** databases,
  
  ◦ numbers (DECIMAL and NUMERIC data types) are stored internally as long fixed point values (scaled integers) when the precision is greater than 9.
  
  ◦ The TIME data type is available for storing time-of-day data only.
  
  ◦ The DATE data type stores only date information.
  
  ◦ The 64-bit integer data type BIGINT is available.
  
  ◦ Double quotes are reserved for delimiting non-regular identifiers, enabling object names that are case-sensitive or that do not meet the requirements for regular identifiers in other ways.
  
  ◦ All strings must be delimited with single quotes (apostrophes).
  
  ◦ Generator values are stored as 64-bit integers.

---

Use of Dialect 3 is strongly recommended for newly developed databases and applications. Both database and connection dialects should match, except under migration conditions with Dialect 2.

This reference describes the semantics of SQL Dialect 3 unless specified otherwise.
2.1.3. Error Conditions

Processing of every SQL statement either completes successfully or fails due to a specific error condition. Error handling can be done as in the client the application and on the server side using PSQL.

2.2. Basic Elements: Statements, Clauses, Keywords

The primary construct in SQL is the statement. A statement defines what the database management system should do with a particular data or metadata object. More complex statements contain simpler constructs — clauses and options.

Clauses

A clause defines a certain type of directive in a statement. For instance, the WHERE clause in a SELECT statement and in some other data manipulation statements (UPDATE, DELETE) specifies criteria for searching one or more tables for the rows that are to be selected, updated or deleted. The ORDER BY clause specifies how the output data — result set — should be sorted.

Options

Options, being the simplest constructs, are specified in association with specific keywords to provide qualification for clause elements. Where alternative options are available, it is usual for one of them to be the default, used if nothing is specified for that option. For instance, the SELECT statement will return all of the rows that match the search criteria unless the DISTINCT option restricts the output to non-duplicated rows.

Keywords

All words that are included in the SQL lexicon are keywords. Some keywords are reserved, meaning their usage as identifiers for database objects, parameter names or variables is prohibited in some or all contexts. Non-reserved keywords can be used as identifiers, although it is not recommended. From time to time, non-reserved keywords may become reserved when some new language feature is introduced.

For instance, the following statement will be executed without errors because, although ABS is a keyword, it is not a reserved word.

```sql
CREATE TABLE T (ABS INT NOT NULL);
```

On the contrary, the following statement will return an error because ADD is both a keyword and a reserved word.

```sql
CREATE TABLE T (ADD INT NOT NULL);
```

Refer to the list of reserved words and keywords in the chapter Reserved Words and Keywords.
2.3. Identifiers

All database objects have names, often called identifiers. The maximum identifier length is 63 characters character set UTF8 (252 bytes).

It is possible to restrict the actual maximum identifier length through configuration. Consult the Firebird 4.0 Release Notes for details. In this language reference we assume the default configuration of 63 characters (252 bytes).

Two types of names are valid as identifiers: regular names, similar to variable names in regular programming languages, and delimited names that are specific to SQL. To be valid, each type of identifier must conform to a set of rules, as follows:

2.3.1. Rules for Regular Object Identifiers

- Length cannot exceed 63 characters
- The name must start with an unaccented, 7-bit ASCII alphabetic character. It may be followed by other 7-bit ASCII letters, digits, underscores or dollar signs. No other characters, including spaces, are valid. The name is case-insensitive, meaning it can be declared and used in either upper or lower case. Thus, from the system's point of view, the following names are the same:

```
fullname
FULLNAME
FuLlNaMe
FullName
```

Regular name syntax

```
<name> ::= <letter> | <name><letter> | <name><digit> | <name>_ | <name>$

<letter> ::= <upper letter> | <lower letter>

<upper letter> ::= A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z

<lower letter> ::= a | b | c | d | e | f | g | h | i | j | k | l | m | n | o | p | q | r | s | t | u | v | w | x | y | z

<digit> ::= 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9
```

2.3.2. Rules for Delimited Object Identifiers

- Length cannot exceed 63 characters in character set UTF8 (252 bytes). Identifiers are stored in character set UTF8, which means characters outside the ASCII range are stored using 2 to 4 bytes.
- The entire string must be enclosed in double-quotes, e.g. "anIdentifier"
It may contain any character from the UTF8 character set, including accented characters, spaces and special characters

An identifier can be a reserved word

Delimited identifiers are case-sensitive in all contexts

Trailing spaces in delimited names are removed, as with any string constant

Delimited identifiers are available in Dialect 3 only. For more details on dialects, see SQL Dialects

**Delimited name syntax**

<delimited name> ::= "<permitted_character>[<permitted_character> ...]"

A delimited identifier such as "FULLNAME" is the same as the regular identifiers FULLNAME, fullname, FullName, and so on. The reason is that Firebird stores regular identifiers in upper case, regardless of how they were defined or declared. Delimited identifiers are always stored according to the exact case of their definition or declaration. Thus, "FullName" (quoted) is different from FullName (unquoted, i.e. regular) which is stored as FULLNAME in the metadata.

### 2.4. Literals

Literals are used to directly represent data. Examples of standard types of literals are:

- **integer** - 0, -34, 45, 0X080000000;
- **fixed-point** - 0.0, -3.14
- **floating-point** - 3.23e-23;
- **string** - 'text', 'don''t!';
- **binary string** - x'48656C6C6F20776F726C64'
- **date** - DATE '2018-01-19';
- **time** - TIME '15:12:56';
- **timestamp** - TIMESTAMP '2018-01-19 13:32:02';
- **boolean** - true, false, unknown
- **null state** - null

Details about handling the literals for each data type are discussed in the next chapter, Data Types and Subtypes.

### 2.5. Operators and Special Characters

A set of special characters is reserved for use as operators or separators.

<special char> ::= <space> | " | % | & | ' | ( | ) | * | + | , | - | . | / | : | ; | < | = | > | ? | [ | ] | ^ | { | }
Some of these characters, alone or in combinations, may be used as operators (arithmetical, string, logical), as SQL command separators, to quote identifiers and to mark the limits of string literals or comments.

**Operator Syntax**

```plaintext
<operator> ::= 
  <string concatenation operator> 
  | <arithmetic operator> 
  | <comparison operator> 
  | <logical operator> 

<string concatenation operator> ::= "||" 

<arithmetic operator> ::= * | / | + | - | 

<comparison operator> ::= = | <> | != | ~= | ^= | > | < | >= | <= 
  | !> | ~> | ^> | !< | ~< | ^< 

<logical operator> ::= NOT | AND | OR 
```

For more details on operators, see [Expressions](#).

### 2.6. Comments

Comments may be present in SQL scripts, SQL statements and PSQL modules. A comment can be any text specified by the code writer, usually used to document how particular parts of the code work. The parser ignores the text of comments.

Firebird supports two types of comments: *block* and *in-line*.

**Syntax**

```plaintext
<comment> ::= <block comment> | <single-line comment> 

<brick comment> ::= 
  /* <character>[<character> …] */ 

<single-line comment> ::= 
  -- <character>[<character> …]<end line> 
```

Block comments start with the /* character pair and end with the */ character pair. Text in block comments may be of any length and can occupy multiple lines.

In-line comments start with a pair of hyphen characters, -- and continue up to the end of the current line.
**Example**

```
CREATE PROCEDURE P(APARAM INT)
    RETURNS (B INT)
AS
BEGIN
    /* This text will be ignored during the execution of the statement
    since it is a comment */
    B = A + 1; -- In-line comment
    SUSPEND;
END
```
Chapter 3. Data Types and Subtypes

Data of various types are used to:

- define columns in a database table in the `CREATE TABLE` statement or change columns using `ALTER TABLE`
- declare or change a `domain` using the `CREATE DOMAIN` or `ALTER DOMAIN` statements
- declare local variables in stored procedures, PSQL blocks and triggers and specify parameters in stored procedures
- indirectly specify arguments and return values when declaring external functions (UDFs — user-defined functions)
- provide arguments for the `CAST()` function when explicitly converting data from one type to another

Table 1. Overview of Data Types

<table>
<thead>
<tr>
<th>Name</th>
<th>Size</th>
<th>Precision &amp; Limits</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIGINT</td>
<td>64 bits</td>
<td>From $-2^{63}$ to $(2^{63} - 1)$</td>
<td>Signed 64-bit integer. This data type is available in Dialect 3 only</td>
</tr>
<tr>
<td>BINARY($n$)</td>
<td>$n$ bytes</td>
<td>from 1 to 32,767 bytes</td>
<td>A fixed-length binary data type; synonym for <code>CHAR($n$) CHARACTER SET OCTETS</code> Values shorter than the declared length are padded with NUL up to the declared length. If the number of characters is not specified, 1 is used by default.</td>
</tr>
<tr>
<td>BLOB</td>
<td>Varying</td>
<td>The size of a BLOB segment is limited to 64K. The maximum size of a BLOB field is 4 GB</td>
<td>A data type of variable size for storing large amounts of data, such as images, text, digital sounds. The basic structural unit is a segment. The blob subtype defines its content</td>
</tr>
<tr>
<td>BOOLEAN</td>
<td>8 bits</td>
<td>false, true, unknown</td>
<td>Boolean data type</td>
</tr>
<tr>
<td><code>CHAR($n$)</code></td>
<td>$n$ characters</td>
<td>from 1 to 32,767 bytes</td>
<td>A fixed-length character data type. Values shorter than the declared length are padded with spaces (NUL for character set OCTETS) up to the declared length. If the number of characters is not specified, 1 is used by default.</td>
</tr>
<tr>
<td><code>CHARACTER($n$)</code></td>
<td>$n$ characters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Size</td>
<td>Precision &amp; Limits</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------</td>
<td>----------</td>
<td>--------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>DATE</td>
<td>32 bits</td>
<td>From 0001-01-01 AD to 9999-12-31 AD</td>
<td>Date only, no time element</td>
</tr>
<tr>
<td>DECIMAL (precision, scale)</td>
<td>Varying (16, 32, 64 or 128 bits)</td>
<td>precision = from 1 to 38, defines the least possible number of digits to store; scale = from 0 to 38, defines the number of digits after the decimal point</td>
<td>A number with a decimal point that has scale digits after the point. scale must be less than or equal to precision. Example: DECIMAL(10,3) contains a number in exactly the following format: ppppppp.sss</td>
</tr>
<tr>
<td>DOUBLE PRECISION</td>
<td>64 bits</td>
<td>2.225 * 10⁻³⁰⁸ to 1.797 * 10³⁰⁸</td>
<td>Double-precision IEEE, ~15 digits, reliable size depends on the platform</td>
</tr>
<tr>
<td>FLOAT</td>
<td>32 bits</td>
<td>1.175 * 10⁻³⁸ to 3.402 * 10³⁸</td>
<td>Single-precision IEEE, ~7 digits</td>
</tr>
<tr>
<td>FLOAT (bin_prec)</td>
<td>32 bits or 64 bits</td>
<td>bin_prec binary precision</td>
<td>Binary precision 1 - 24: synonym for FLOAT (32-bit single precision) 25 - 53: synonym for DOUBLE PRECISION (64-bit double precision)</td>
</tr>
<tr>
<td>INTEGER, INT</td>
<td>32 bits</td>
<td>-2,147,483,648 up to 2,147,483,647</td>
<td>Signed 32-bit integer</td>
</tr>
<tr>
<td>INT128</td>
<td>128 bits</td>
<td>From -2₁²⁷ to (2₁²⁷ - 1)</td>
<td>Signed 128-bit integer</td>
</tr>
<tr>
<td>NUMERIC (precision, scale)</td>
<td>Varying (16, 32, 64 or 128 bits)</td>
<td>precision = from 1 to 38, defines the exact number of digits to store; scale = from 0 to 38, defines the number of digits after the decimal point</td>
<td>A number with a decimal point that has scale digits after the point. scale must be less than or equal to precision. Example: NUMERIC(10,3) contains a number in exactly the following format: ppppppp.sss</td>
</tr>
<tr>
<td>REAL</td>
<td>32-bits</td>
<td></td>
<td>Synonym for FLOAT</td>
</tr>
<tr>
<td>SMALLINT</td>
<td>16 bits</td>
<td>-32,768 to 32,767</td>
<td>Signed short (word)</td>
</tr>
<tr>
<td>Name</td>
<td>Size</td>
<td>Precision &amp; Limits</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------</td>
<td>----------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>TIME [WITHOUT TIME ZONE]</td>
<td>4 bytes</td>
<td>0:00 to 23:59:59.9999</td>
<td>Time of day. It cannot be used to store an interval of time.</td>
</tr>
<tr>
<td>TIME WITH TIME ZONE</td>
<td>6 bytes</td>
<td>0:00 to 23:59:59.9999</td>
<td>Time of day with either a time zone offset or named zone. It cannot be used to store an interval of time.</td>
</tr>
<tr>
<td>TIMESTAMP [WITHOUT TIME ZONE]</td>
<td>8 bytes</td>
<td>From start of day 0001-01-01 AD to end of day 9999-12-31 AD</td>
<td>Date and time of day</td>
</tr>
<tr>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>10 bytes</td>
<td>From start of day 0001-01-01 AD to end of day 9999-12-31 AD</td>
<td>Date and time of day with either a time zone offset or named zone.</td>
</tr>
<tr>
<td>VARBINARY(n), BINARY VARYING(n)</td>
<td>n bytes</td>
<td>from 1 to 32,765 bytes</td>
<td>Variable length string type; synonym for VARCHAR(n) CHARACTER SET OCTETS. The total size cannot be larger than (32KB-3). The two leading bytes store the declared length. There is no default size: the n argument is mandatory. Leading and trailing NUL characters are stored, and they are not trimmed, except for those trailing characters that are past the declared length.</td>
</tr>
<tr>
<td>VARCHAR(n), CHARACTER VARYING(n)</td>
<td>n characters. Size in bytes depends on the encoding, the number of bytes in a character</td>
<td>from 1 to 32,765 bytes</td>
<td>Variable length string type. The total size of characters in bytes cannot be larger than (32KB-3), taking into account their encoding. The two leading bytes store the declared length. There is no default size: the n argument is mandatory. Leading and trailing spaces are stored, and they are not trimmed, except for those trailing characters that are past the declared length.</td>
</tr>
</tbody>
</table>

### Note About Dates

Bear in mind that a time series consisting of dates in past centuries is processed without taking into account the actual historical facts, as though the Gregorian calendar were applicable throughout the entire series.
3.1. Integer Data Types

The SMALLINT, INTEGER, BIGINT and INT128 data types are used for integers of various precision in Dialect 3. Firebird does not support an unsigned integer data type.

3.1.1. SMALLINT

The 16-bit SMALLINT data type is for compact data storage of integer data for which only a narrow range of possible values is required. Numbers of the SMALLINT type are within the range from \(-2^{16}\) to \(2^{16}-1\), that is, from -32,768 to 32,767.

SMALLINT Examples

```sql
CREATE DOMAIN DFLAG AS SMALLINT DEFAULT 0 NOT NULL
    CHECK (VALUE=-1 OR VALUE=0 OR VALUE=1);
CREATE DOMAIN RGB_VALUE AS SMALLINT;
```

3.1.2. INTEGER

The INTEGER data type is a 32-bit integer. The shorthand name of the data type is INT. Numbers of the INTEGER type are within the range from \(-2^{32}\) to \(2^{32}-1\), that is, from -2,147,483,648 to 2,147,483,647.

INTEGER Example

```sql
CREATE TABLE CUSTOMER (  
    CUST_NO INTEGER NOT NULL,  
    CUSTOMER VARCHAR(25) NOT NULL,  
    CONTACT_FIRST VARCHAR(15),  
    CONTACT_LAST VARCHAR(20),  
    ...  
    PRIMARY KEY (CUST_NO) )
```

3.1.3. BIGINT

BIGINT is an SQL:99-compliant 64-bit integer data type, available only in Dialect 3. If a client uses Dialect 1, the generator value sent by the server is reduced to a 32-bit integer (INTEGER). When Dialect 3 is used for connection, the generator value is of type BIGINT.

Numbers of the BIGINT type are within the range from \(-2^{63}\) to \(2^{63}-1\), or from -9,223,372,036,854,775,808 to 9,223,372,036,854,775,807.

3.1.4. INT128

INT128 is a 128-bit integer data type. This type is not defined in the SQL standard.

Numbers of the INT128 type are within the range from \(-2^{127}\) to \(2^{127}-1\).
3.1.5. Hexadecimal Format for Integer Numbers

Starting from Firebird 2.5, constants of integer types can be specified in a hexadecimal format by means of 9 to 16 hexadecimal digits for BIGINT or 1 to 8 digits for INTEGER. Hex representation for writing to SMALLINT is not explicitly supported, but Firebird will transparently convert a hex number to SMALLINT if necessary, provided it falls within the ranges of negative and positive SMALLINT.

The hexadecimal integer literals currently do not support INT128 values.

See https://github.com/FirebirdSQL/firebird/issues/6809

The usage and numerical value ranges of hexadecimal notation are described in more detail in the discussion of number constants in the chapter entitled Common Language Elements.

Examples Using Integer Types

```sql
CREATE TABLE WHOLELOTTARECORDS (  
    ID BIGINT NOT NULL PRIMARY KEY,  
    DESCRIPTION VARCHAR(32)  
) ;

INSERT INTO MYBIGINTS VALUES (  
    -236453287458723,  
    328832607832,  
    22,  
    -56786237632476,  
    0X6F55A09D42, -- 478177959234  
    0X7FFFFFFFFFFFFFF, -- 9223372036854775807  
    0XFFFFFFFFFFFFFFFF, -- -1  
    0X80000000, -- -2147483648, an INTEGER  
    0X8000000000, -- 2147483648, a BIGINT  
    0XFFFFFFFF, -- -1, an INTEGER  
    0X0FFFFFFFF, -- 4294967295, a BIGINT  
) ;
```

The hexadecimal INTEGERS in the above example are automatically cast to BIGINT before being inserted into the table. However, this happens after the numerical value is determined, so 0x80000000 (8 digits) and 0x8000000000 (9 digits) will be saved as different BIGINT values.

3.2. Floating-Point Data Types

Firebird supports two types of floating-point data types: approximate or binary floating-point data types (FLOAT and DOUBLE PRECISION), and decimal floating-point types (DECIMAL).  

3.2.1. Approximate Floating-Point Data Types

Approximate floating-point data types are stored in an IEEE 754 binary format that comprises sign, exponent and mantissa. Precision is dynamic, corresponding to the physical storage format of the
value, which is exactly 4 bytes for the FLOAT type and 8 bytes for DOUBLE PRECISION.

Considering the peculiarities of storing floating-point numbers in a database, these data types are not recommended for storing monetary data. For the same reasons, columns with floating-point data are not recommended for use as keys or to have uniqueness constraints applied to them.

For testing data in columns with floating-point data types, expressions should check using a range, for instance, BETWEEN, rather than searching for exact matches.

When using these data types in expressions, extreme care is advised regarding the rounding of evaluation results.

**FLOAT**

*Data Type Declaration Format*

```
FLOAT [(bin_prec)]
```

**Table 2. FLOAT Type Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>bin_prec</td>
<td>Precision in binary digits, default is 24</td>
</tr>
</tbody>
</table>

The FLOAT data type defaults to a 32-bit single precision floating-point type with an approximate precision of 7 decimal digits after the decimal point (24 binary digits). To ensure the safety of storage, rely on 6 decimal digits of precision.

The syntax `FLOAT(bin_prec)` was introduced in Firebird 4.0, and behaves as follows:

* 1 <= bin_prec <= 23: 32-bit single precision (synonym for FLOAT)
* 25 <= bin_prec <= 53: 64-bit double precision (synonym for DOUBLE PRECISION)

The behaviour of FLOAT (without explicit precision) behaves as the SQL standard type `REAL`.

**Compatibility Notes**

- Firebird 3.0 and earlier supported `FLOAT(dec_prec)` where `dec_prec` was the approximate precision in decimal digits, with 0 <= dec_prec <= 7 mapped to 32-bit single precision and P > 7 mapped to 64-bit double precision. This syntax was never documented.

- For bin_prec in `FLOAT(bin_prec)`, the values 1 <= bin_prec <= 24 are all treated as bin_prec = 24, values 25 <= bin_prec <= 53 are all handled as bin_prec = 53.

- Most Firebird tools will report FLOAT(1) - FLOAT(24) as FLOAT, and FLOAT(25) - FLOAT(53) as DOUBLE PRECISION.
The data type REAL is a synonym for FLOAT, and is provided for syntax compatibility. When used to define a column or parameter, it's indistinguishable from using FLOAT or FLOAT(1) - FLOAT(24).

**Compatibility Note**
- REAL has been available as a synonym for FLOAT since Firebird 1.0 and even earlier, but was never documented.
- Most Firebird tools will report FLOAT for REAL.

**DOUBLE PRECISION**

The DOUBLE PRECISION data type is stored with an approximate precision of 15 digits.

**Compatibility Notes**
- Firebird also has the — previously undocumented — synonyms for DOUBLE PRECISION: LONG FLOAT and LONG FLOAT(bin_prec), with 1 \( \leq \) bin_prec \( \leq \) 53.
- These non-standard type names are deprecated and may be removed in a future Firebird version.
- Firebird 3.0 and earlier supported LONG FLOAT(dec_prec) where dec_prec was the approximate precision in decimal digits, where any value for dec_prec mapped to 64-bit double precision.

### 3.2.2. Decimal Floating-Point Types

Decimal floating-point are stored in an IEEE 754 decimal format that comprises sign, exponent and coefficient. Contrary to the approximate floating-point data types, precision is either 16 or 34 decimal digits.

**DECFLOAT**

**Data Type Declaration Format**

```
DECFLOAT [(precision)]
```

**Table 3. DECFLOAT Type Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>precision</td>
<td>Precision in decimal digits, either 16 or 34. Default is 34.</td>
</tr>
</tbody>
</table>
DECFLOAT is a SQL:2016 standard-compliant numeric type that stores floating-point number precisely (decimal floating-point type), unlike FLOAT or DOUBLE PRECISION that provide a binary approximation of the purported precision.

The type is stored and transmitted as IEEE 754 standard types Decimal64 (DECFLOAT(16)) or Decimal128 (DECFLOAT(34)).

All intermediate calculations are performed with 34-digit values.

### 16-digit and 34-digit

The “16” and “34” refer to the maximum precision in Base-10 digits. See https://en.wikipedia.org/wiki/IEEE_754#Basic_and_interchange_formats for a comprehensive table.

<table>
<thead>
<tr>
<th>Type</th>
<th>Maximum precision</th>
<th>Minimum Exponent</th>
<th>Maximum Exponent</th>
<th>Smallest value</th>
<th>Largest value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DECFLOAT(16)</td>
<td>16</td>
<td>-383</td>
<td>+384</td>
<td>1E-398</td>
<td>9.9..9E+384</td>
</tr>
<tr>
<td>DECFLOAT(34)</td>
<td>34</td>
<td>-6143</td>
<td>+6144</td>
<td>1E-6176</td>
<td>9.9..9E+6144</td>
</tr>
</tbody>
</table>

Observe that although the smallest exponent for DECFLOAT(16) is -383, the smallest value has an exponent of -398, but 15 fewer digits. And similar for DECFLOAT(34), smallest exponent is -6143, but the smallest value has an exponent of -6176, but 33 fewer digits. The reason is that precision was “sacrificed” to be able to store a smaller value.

This is a result of how the value is stored: as a decimal value of 16 or 34 digits and an exponent. For example 1.234567890123456e-383 is actually stored as coefficient 1234567890123456 and exponent -398, while 1E-398 is stored as coefficient 1, exponent -398.

### Behaviour of DECFLOAT Operations

The behaviour of DECFLOAT operations in a session, specifically rounding and error behaviour, can be configured using the SET DECFLOAT management statement.

### Length of DECFLOAT Literals

It is possible to express DECFLOAT(34) values in approximate numeric literals, but only for values with a mantissa of 20 or more digits, or an absolute exponent larger than 308. Scientific notation literals with fewer digits or a smaller absolute exponent are DOUBLE PRECISION literals. Exact numeric literals with 40 or more digits — actually 39 digits, when larger than the maximum INT128 value — are also handled as DECFLOAT(34).

Alternatively, use a string literal and explicitly cast to the desired DECFLOAT type.

The length of DECFLOAT literals cannot exceed 1024 characters. Scientific notation is required for greater values. For example, 0.0<1020 zeroes>11 cannot be used as a literal, the equivalent in scientific notation, 1.1E-1022 is valid. Similarly, 10<1022 zeroes>0 can be presented as 1.0E1024.
Literals with more than 34 significant digits are rounded using the DECFLOAT rounding mode of the session.

**DECFLOAT and Functions**

**Use with Standard Functions**

A number of standard scalar functions can be used with expressions and values of the DECFLOAT type. They are:

- `ABS`
- `CEILING`
- `EXP`
- `FLOOR`
- `LN`
- `LOG`
- `LOG10`
- `POWER`
- `SIGN`
- `SQRT`

The aggregate functions `SUM`, `AVG`, `MAX` and `MIN` work with DECFLOAT data, as do all the statistics aggregates (including but not limited to `STDDEV` or `CORR`).

**Special Functions for DECFLOAT**

Firebird supports four functions, designed to support DECFLOAT data specifically:

- **COMPARE_DECFLOAT**
  - compares two DECFLOAT values to be equal, different or unordered

- **NORMALIZE_DECFLOAT**
  - takes a single DECFLOAT argument and returns it in its simplest form

- **QUANTIZE**
  - takes two DECFLOAT arguments and returns the first argument scaled using the second value as a pattern

- **TOTALORDER**
  - performs an exact comparison on two DECFLOAT values

Detailed descriptions are available in the Special Functions for DECFLOAT section of the Built-in Scalar Functions chapter.

### 3.3. Fixed-Point Data Types

Fixed-point data types ensure the predictability of multiplication and division operations, making them the choice for storing monetary values. Firebird implements two fixed-point data types: NUMERIC and DECIMAL. According to the standard, both types limit the stored number to the declared scale (the number of digits after the decimal point).

Different treatments limit precision for each type: precision for NUMERIC columns is exactly “as declared”, while DECIMAL columns accepts numbers whose precision is at least equal to what was declared.

The behaviour of NUMERIC and DECIMAL in Firebird is like the SQL-standard DECIMAL; the precision is at least equal to what was declared.
For instance, `NUMERIC(4, 2)` defines a number consisting altogether of four digits, including two digits after the decimal point; that is, it can have up to two digits before the point and no more than two digits after the point. If the number 3.1415 is written to a column with this data type definition, the value of 3.14 will be saved in the `NUMERIC(4, 2)` column.

The form of declaration for fixed-point data, for instance, `NUMERIC(p, s)`, is common to both types. It is important to realise that the `s` argument in this template is `scale`, rather than “a count of digits after the decimal point”. Understanding the mechanism for storing and retrieving fixed-point data should help to visualise why: for storage, the number is multiplied by $10^s$ (10 to the power of `s`), converting it to an integer; when read, the integer is converted back.

The method of storing fixed-point data in the database depends on several factors: declared precision, database dialect, declaration type.

### Table 5. Method of Physical Storage for Fixed-Point Numbers

<table>
<thead>
<tr>
<th>Precision</th>
<th>Data type</th>
<th>Dialect 1</th>
<th>Dialect 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 4</td>
<td>NUMERIC</td>
<td>SMALLINT</td>
<td>SMALLINT</td>
</tr>
<tr>
<td>1 - 4</td>
<td>DECIMAL</td>
<td>INTEGER</td>
<td>INTEGER</td>
</tr>
<tr>
<td>5 - 9</td>
<td>NUMERIC or DECIMAL</td>
<td>INTEGER</td>
<td>INTEGER</td>
</tr>
<tr>
<td>10 - 18</td>
<td>NUMERIC or DECIMAL</td>
<td>DOUBLE PRECISION</td>
<td>BIGINT</td>
</tr>
<tr>
<td>19 - 38</td>
<td>NUMERIC or DECIMAL</td>
<td>INT128</td>
<td>INT128</td>
</tr>
</tbody>
</table>

Numerics with precision less than 19 digits use SMALLINT, INTEGER, BIGINT or DOUBLE PRECISION as the base datatype, depending on the number of digits and SQL dialect. When precision is between 19 and 38 digits a 128-bit integer is used for internal storage, and the actual precision is always extended to the full 38 digits.

For complex calculations, those digits are cast internally to `DECFLOAT(34)`. The result of various mathematical operations, such as `LOG()`, `EXP()` and so on, and aggregate functions using a high precision numeric argument, will be `DECFLOAT(34)`.

### 3.3.1. NUMERIC

#### Data Type Declaration Format

```
NUMERIC
| NUMERIC(precision)
| NUMERIC(precision, scale)
```

### Table 6. NUMERIC Type Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>precision</td>
<td>Precision, between 1 and 38. Defaults to 9.</td>
</tr>
<tr>
<td>scale</td>
<td>Scale, between 0 and <code>precision</code>. Defaults to 0.</td>
</tr>
</tbody>
</table>
Storage Examples

Further to the explanation above, Firebird will store NUMERIC data according the declared *precision* and *scale*. Some more examples are:

<table>
<thead>
<tr>
<th>NUMERIC(4)</th>
<th>stored as</th>
<th>SMALLINT (exact data)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUMERIC(4,2)</td>
<td></td>
<td>SMALLINT (data * 10^4)</td>
</tr>
<tr>
<td>NUMERIC(10,4) (Dialect 1)</td>
<td>DOUBLE PRECISION</td>
<td>(Dialect 3) BIGINT (data * 10^4)</td>
</tr>
<tr>
<td>NUMERIC(38,6)</td>
<td></td>
<td>INT128 (data * 10^6)</td>
</tr>
</tbody>
</table>

Always keep in mind that the storage format depends on the precision. For instance, you define the column type as NUMERIC(2,2) presuming that its range of values will be -0.99...0.99. However, the actual range of values for the column will be -327.68...327.67, which is due to storing the NUMERIC(2,2) data type in the SMALLINT format. In storage, the NUMERIC(4,2), NUMERIC(3,2) and NUMERIC(2,2) data types are the same, in fact. It means that if you really want to store data in a column with the NUMERIC(2,2) data type and limit the range to -0.99...0.99, you will have to create a constraint for it.

### 3.3.2. DECIMAL

**Data Type Declaration Format**

```
DECIMAL
| DECIMAL(precision)
| DECIMAL(precision, scale)
```

**Table 7. DECIMAL Type Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>precision</td>
<td>Precision, between 1 and 38. Defaults to 9.</td>
</tr>
<tr>
<td>scale</td>
<td>Scale, between 0 and <em>precision</em>. Defaults to 0.</td>
</tr>
</tbody>
</table>

**Storage Examples**

The storage format in the database for DECIMAL is very similar to NUMERIC, with some differences that are easier to observe with the help of some more examples:

<table>
<thead>
<tr>
<th>DECIMAL(4)</th>
<th>stored as</th>
<th>INTEGER (exact data)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DECIMAL(4,2)</td>
<td></td>
<td>INTEGER (data * 10^4)</td>
</tr>
<tr>
<td>DECIMAL(10,4) (Dialect 1)</td>
<td>DOUBLE PRECISION</td>
<td>(Dialect 3) BIGINT (data * 10^4)</td>
</tr>
<tr>
<td>DECIMAL(38,6)</td>
<td></td>
<td>INT128 (data * 10^6)</td>
</tr>
</tbody>
</table>
3.4. Data Types for Dates and Times

The DATE, TIME and TIMESTAMP data types are used to work with data containing dates and times.

Firebird 4.0 introduces time zone support, using the types TIME WITH TIME ZONE and TIMESTAMP WITH TIME ZONE. In this language reference, we’ll use TIME and TIMESTAMP to refer both to the specific types without time zone — TIME [WITHOUT TIME ZONE] and TIMESTAMP [WITHOUT TIME ZONE] — and aspects of both the without time zone and with time zone types, which one we mean is usually clear from the context.

The data types TIME WITHOUT TIME ZONE, TIMESTAMP WITHOUT TIME ZONE and DATE are defined to use the session time zone when converting from or to a TIME WITH TIME ZONE or TIMESTAMP WITH TIME ZONE. TIME and TIMESTAMP are synonymous to their respective WITHOUT TIME ZONE data types.

Dialect 3 supports all the five types, while Dialect 1 has only DATE. The DATE type in Dialect 3 is “date-only”, whereas the Dialect 1 DATE type stores both date and time-of-day, equivalent to TIMESTAMP in Dialect 3. Dialect 1 has no “date-only” type.

Dialect 1 DATE data can be defined alternatively as TIMESTAMP and this is recommended for new definitions in Dialect 1 databases.

Fractions of Seconds

If fractions of seconds are stored in date and time data types, Firebird stores them to ten-thousandths of a second. If a lower granularity is preferred, the fraction can be specified explicitly as thousandths, hundredths or tenths of a second, or second, in Dialect 3 databases of ODS 11 or higher.
Some Useful Knowledge about Subseconds Precision

The time-part of a `TIME` or `TIMESTAMP` is a 4-byte WORD, with room for deci-milliseconds (or 100 microseconds) precision and time values are stored as the number of deci-milliseconds elapsed since midnight. The actual precision of values stored in or read from time(stamp) functions and variables is:

- `CURRENT_TIME` and `LOCALTIME` default to seconds precision and can be specified up to milliseconds precision with `CURRENT_TIME (0|1|2|3)` or `LOCALTIME (0|1|2|3)`
- `CURRENT_TIMESTAMP` and `LOCALTIMESTAMP` default to milliseconds precision. Precision from seconds to milliseconds can be specified with `CURRENT_TIMESTAMP (0|1|2|3)` or `LOCALTIMESTAMP (0|1|2|3)`
- Literal `'NOW'` defaults to milliseconds precision
- Function `DATEADD()` supports up to deci-milliseconds precision with `MILLISECOND`
- Function `DATEDIFF()` only supports up to milliseconds precision
- The `EXTRACT()` function returns up to deci-milliseconds precision with the `SECOND` and `MILLISECOND` arguments
- The `'+'' and `'-'` operators work with deci-milliseconds precision.

Deci-milliseconds precision is rare and is not supported by all drivers and access components. The best assumption to make from all this is that, although Firebird stores `TIME` and the `TIMESTAMP` time-part values as the number of deci-milliseconds ($10^{-4}$ seconds) elapsed since midnight, the actual precision could vary from seconds to milliseconds.

Storage of Time Zone Types

The time zone types are stored as values at UTC (offset 0), using the structure of `TIME` or `TIMESTAMP` + two extra bytes for time zone information (either an offset in minutes, or the id of a named time zone). Storing as UTC allows Firebird to index and compare two values in different time zones.

Storing at UTC has some caveats:

- When you use named zones, and the time zone rules for that zone change, the UTC time stays the same, but the local time in the named zone may change.
- For `TIME WITH TIME_ZONE`, calculating a time zone offset for a named zone to get the local time in the zone applies the rules valid at the 1st of January 2020 to ensure a stable value. This may result in unexpected or confusing results.
- When the rules of a named time zone changes, a value in the affected date range may longer match the intended value if the actual offset in that named zone changes.
### 3.4.1. DATE

**Syntax**

```sql
DATE
```  

The `DATE` data type in Dialect 3 stores only date without time. The available range for storing data is from January 01, 1 to December 31, 9999.

Dialect 1 has no “date-only” type.

In Dialect 1, date literals without a time part, as well as casts of date mnemonics 'TODAY', 'YESTERDAY' and 'TOMORROW' automatically get a zero time part.

If, for some reason, it is important to you to store a Dialect 1 timestamp literal with an explicit zero time-part, the engine will accept a literal like '2016-12-25 00:00:00.0000'. However, '2016-12-25' would have precisely the same effect, with fewer keystrokes!

### 3.4.2. TIME

**Syntax**

```sql
TIME [{ WITHOUT | WITH } TIME ZONE]
```  

For a bare `TIME`, `WITHOUT TIME ZONE` is assumed.

The `TIME` data type is available in Dialect 3 only. It stores the time of day within the range from 00:00:00.0000 to 23:59:59.9999.

If you need to get the time-part from `DATE` in Dialect 1, you can use the `EXTRACT` function.

#### Examples Using `EXTRACT()`

```sql
EXTRACT (HOUR FROM DATE_FIELD)
EXTRACT (MINUTE FROM DATE_FIELD)
EXTRACT (SECOND FROM DATE_FIELD)
```

See also the `EXTRACT()` function in the chapter entitled *Built-in Functions*.

**TIME [WITHOUT TIME ZONE]**

The `TIME` (or synonym `TIME WITHOUT TIME ZONE`) represents a time without time zone information.

**TIME WITH TIME ZONE**

The `TIME WITH TIME ZONE` represents a time with time zone information (either an offset or a named zone).
Firebird uses the ICU implementation of the IANA Time Zone Database for named zones.

Examples Using EXTRACT()

```sql
EXTRACT (TIMEZONE_HOUR FROM TIME_TZ_FIELD)
EXTRACT (TIMEZONE_MINUTE FROM TIME_TZ_FIELD)
```

### 3.4.3. TIMESTAMP

**Syntax**

```
TIMESTAMP [{ WITHOUT | WITH } TIME ZONE]
```

For a bare TIMESTAMP, WITHOUT TIME ZONE is assumed.

The TIMESTAMP data type is available in Dialect 3 and Dialect 1. It comprises two 32-bit words—a date-part and a time-part—to form a structure that stores both date and time-of-day. It is the same as the DATE type in Dialect 1.

The EXTRACT function works equally well with TIMESTAMP as with the Dialect 1 DATE type.

```
TIMESTAMP [WITHOUT TIME ZONE]
```

The TIMESTAMP (or synonym TIMESTAMP WITHOUT TIME ZONE) represents a time and date without time zone information.

```
TIMESTAMP WITH TIME ZONE
```

The TIMESTAMP WITH TIME ZONE represents a time with time zone information (either an offset or a named zone).

### 3.4.4. Session Time Zone

As the name implies, the session time zone, can be different for each database attachment. It can be set explicitly in the DPB with the item isc_dpb_session_time_zone; otherwise, by default, it uses the same time zone as the operating system of the Firebird server process. This default can be overridden in firebird.conf, setting DefaultTimeZone.

Drivers may apply different defaults, for example specifying the client time zone as the default session time zone. Check your driver documentation for details.

Subsequently, the time zone can be changed to a given time zone using a SET TIME ZONE statement or reset to its original value with SET TIME ZONE LOCAL.

### 3.4.5. Time Zone Format

A time zone is specified as a string, either a time zone region (for example, 'America/Sao_Paulo') or a displacement from GMT in hours:minutes (for example, '-03:00').
A time/timestamp with time zone is considered equal to another time/timestamp with time zone if their conversions to UTC are equivalent. For example, time '10:00 -02:00' and time '09:00 -03:00' are equivalent, since both are the same as time '12:00 GMT'.

The same equivalence applies in UNIQUE constraints and for sorting purposes.

3.4.6. Operations Using Date and Time Values

The method of storing date and time values makes it possible to involve them as operands in some arithmetic operations. In storage, a date value or date-part of a timestamp is represented as the number of days elapsed since “date zero” — November 17, 1898 — whilst a time value or the time-part of a timestamp is represented as the number of seconds (with fractions of seconds taken into account) since midnight.

An example is to subtract an earlier date, time or timestamp from a later one, resulting in an interval of time, in days and fractions of days.

Table 8. Arithmetic Operations for Date and Time Data Types

<table>
<thead>
<tr>
<th>Operand 1</th>
<th>Operation</th>
<th>Operand 2</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATE</td>
<td>+</td>
<td>TIME</td>
<td>TIMESTAMP</td>
</tr>
<tr>
<td>DATE</td>
<td>+</td>
<td>TIME WITH TIME ZONE</td>
<td>TIMESTAMP WITH TIME ZONE</td>
</tr>
<tr>
<td>DATE</td>
<td>+</td>
<td>Numeric value n</td>
<td>DATE increased by n whole days. Broken values are rounded (not floored) to the nearest integer</td>
</tr>
<tr>
<td>TIME</td>
<td>+</td>
<td>DATE</td>
<td>TIMESTAMP</td>
</tr>
<tr>
<td>TIME WITH TIME ZONE</td>
<td>+</td>
<td>DATE</td>
<td>TIMESTAMP WITH TIME ZONE</td>
</tr>
<tr>
<td>TIME</td>
<td>+</td>
<td>Numeric value n</td>
<td>TIME increased by n seconds. The fractional part is taken into account</td>
</tr>
<tr>
<td>TIME WITH TIME ZONE</td>
<td>+</td>
<td>Numeric value n</td>
<td>TIME WITH TIME ZONE increased by n seconds. The fractional part is taken into account</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td>+</td>
<td>Numeric value n</td>
<td>TIMESTAMP, where the date will advance by the number of days and part of a day represented by number n — so “+ 2.75” will push the date forward by 2 days and 18 hours</td>
</tr>
<tr>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>+</td>
<td>Numeric value n</td>
<td>TIMESTAMP WITH TIME ZONE, where the date will advance by the number of days and part of a day represented by number n — so “+ 2.75” will push the date forward by 2 days and 18 hours</td>
</tr>
<tr>
<td>DATE</td>
<td>-</td>
<td>DATE</td>
<td>Number of days elapsed, within the range DECIMAL(9, 0)</td>
</tr>
<tr>
<td>Operand 1</td>
<td>Operation</td>
<td>Operand 2</td>
<td>Result</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------</td>
<td>--------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>DATE</td>
<td>-</td>
<td>Numeric value (n)</td>
<td>DATE reduced by (n) whole days. Broken values are rounded (not floored) to the nearest integer</td>
</tr>
<tr>
<td>TIME</td>
<td>-</td>
<td>TIME</td>
<td>Number of seconds elapsed, within the range DECIMAL((9, \ 4))</td>
</tr>
<tr>
<td>TIME</td>
<td>-</td>
<td>TIME WITH TIME ZONE</td>
<td>The without time zone value is converted to WITH TIME ZONE in the current session time zone. Number of seconds elapsed between the UTC values, within the range DECIMAL((9, \ 4)). Also applies when swapping types.</td>
</tr>
<tr>
<td>TIME WITH TIME ZONE</td>
<td>-</td>
<td>TIME WITH TIME ZONE</td>
<td>Number of seconds elapsed between the UTC values, within the range DECIMAL((9, \ 4))</td>
</tr>
<tr>
<td>TIME</td>
<td>-</td>
<td>Numeric value (n)</td>
<td>TIME reduced by (n) seconds. The fractional part is taken into account</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td>-</td>
<td>TIMESTAMP</td>
<td>Number of days and part-day, within the range DECIMAL((18, \ 9))</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td>-</td>
<td>TIMEMPASS WITH TIME ZONE</td>
<td>The without time zone value is converted to WITH TIME ZONE in the current session time zone. Number of days and part-day between UTC values, within the range DECIMAL((18, \ 9)). Also applies when swapping types.</td>
</tr>
<tr>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>-</td>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>Number of days and part-day between UTC values, within the range DECIMAL((18, \ 9))</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td>-</td>
<td>Numeric value (n)</td>
<td>TIMESTAMP where the date will decrease by the number of days and part of a day represented by number (n) — so “(-2.25)” will decrease the date by 2 days and 6 hours</td>
</tr>
</tbody>
</table>

**Notes**

The DATE type is considered as TIMESTAMP in Dialect 1.

**See also**

DATEADD, DATEDIFF

### 3.4.7. Supplemental Time Zone Features

Firebird 4.0 provides a number of features to discover time zone information.
Virtual table RDB$TIME_ZONES

A virtual table listing time zones supported in the engine.

See also RDB$TIME_ZONES in System Tables.

Package RDB$TIME_ZONE_UTIL

A package of time zone utility functions and procedures:

Function DATABASE_VERSION

RDB$TIME_ZONE_UTIL.DATABASE_VERSION returns the version of the time zone database as a VARCHAR(10) CHARACTER SET ASCII.

Example

```sql
select rdb$time_zone_util.database_version() from rdb$database;
```

Returns:

```
DATABASE_VERSION
------------------
2021a
```

Procedure TRANSITIONS

RDB$TIME_ZONE_UTIL.TRANSITIONS returns the set of rules between the start and end timestamps for a named time zone.

The input parameters are:

- RDB$TIME_ZONE_NAME type CHAR(63)
- RDB$FROM_TIMESTAMP type TIMESTAMP WITH TIME ZONE
- RDB$TO_TIMESTAMP type TIMESTAMP WITH TIME ZONE

Output parameters:

- RDB$START_TIMESTAMP
  - type TIMESTAMP WITH TIME ZONE — The start timestamp of the transition
- RDB$END_TIMESTAMP
  - type TIMESTAMP WITH TIME ZONE — The end timestamp of the transition
- RDB$ZONE_OFFSET
  - type SMALLINT — The zone’s offset, in minutes
- RDB$DST_OFFSET
  - type SMALLINT — The zone’s DST offset, in minutes
RDB$EFFECTIVE_OFFSET

type SMALLINT — Effective offset (ZONE_OFFSET + DST_OFFSET)

Example

```sql
select *
from rdb$time_zone_util.transitions(
    'America/Sao_Paulo',
    timestamp '2017-01-01',
    timestamp '2019-01-01');
```

Returns (RDB$ prefix left off for brevity):

<table>
<thead>
<tr>
<th>START_TIMESTAMP</th>
<th>END_TIMESTAMP</th>
<th>ZONE_OFFSET</th>
<th>DST_OFFSET</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016-10-16 03:00:00.0000 GMT</td>
<td>2017-02-19 01:59:59.9999 GMT</td>
<td>-180</td>
<td>60</td>
</tr>
<tr>
<td>-120</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017-02-19 02:00:00.0000 GMT</td>
<td>2017-10-15 02:59:59.9999 GMT</td>
<td>-180</td>
<td>0</td>
</tr>
<tr>
<td>-180</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017-10-15 03:00:00.0000 GMT</td>
<td>2018-02-18 01:59:59.9999 GMT</td>
<td>-180</td>
<td>60</td>
</tr>
<tr>
<td>-120</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018-02-18 02:00:00.0000 GMT</td>
<td>2018-10-21 02:59:59.9999 GMT</td>
<td>-180</td>
<td>0</td>
</tr>
<tr>
<td>-180</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018-10-21 03:00:00.0000 GMT</td>
<td>2019-02-17 01:59:59.9999 GMT</td>
<td>-180</td>
<td>60</td>
</tr>
<tr>
<td>-120</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Updating the Time Zone Database**

Time zones are often changed: of course, when it happens, it is desirable to update the time zone database as soon as possible.

Firebird stores WITH TIME ZONE values translated to UTC time. Suppose a value is created with one time zone database, and a later update of that database changes the information in the range of our stored value. When that value is read, it will be returned as different to the value that was stored initially.

Firebird uses the IANA time zone database through the ICU library. The ICU library presented in the Firebird kit (Windows), or installed in a POSIX operating system, can sometimes have an outdated time zone database.

An updated database can be found on this page on the FirebirdSQL GitHub. Filename le.zip stands for little-endian and is the necessary file for most computer architectures (Intel/AMD compatible x86 or x64), while be.zip stands for big-endian architectures and is necessary mostly for RISC computer architectures. The content of the zip file must be extracted in the /tzdata sub-directory of the Firebird installation, overwriting existing *.res files belonging to the database.
/tzdata is the default directory where Firebird looks for the time zone database. It can be overridden with the ICU_TIMEZONE_FILES_DIR environment variable.

3.5. Character Data Types

For working with character data, Firebird has the fixed-length CHAR and the variable-length VARCHAR data types. The maximum size of text data stored in these data types is 32,767 bytes for CHAR and 32,765 bytes for VARCHAR. The maximum number of characters that will fit within these limits depends on the CHARACTER SET being used for the data under consideration. The collation sequence does not affect this maximum, although it may affect the maximum size of any index that involves the column.

If no character set is explicitly specified when defining a character object, the default character set specified when the database was created will be used. If the database does not have a default character set defined, the field gets the character set NONE.

3.5.1. Unicode

Most current development tools support Unicode, implemented in Firebird with the character sets UTF8 and UNICODE_FSS. UTF8 comes with collations for many languages. UNICODE_FSS is more limited and is used mainly by Firebird internally for storing metadata. Keep in mind that one UTF8 character occupies up to 4 bytes, thus limiting the size of CHAR fields to 8,191 characters (32,767/4).

The actual “bytes per character” value depends on the range the character belongs to. Non-accented Latin letters occupy 1 byte, Cyrillic letters from the WIN1251 encoding occupy 2 bytes in UTF8, characters from other encodings may occupy up to 4 bytes.

The UTF8 character set implemented in Firebird supports the latest version of the Unicode standard, thus recommending its use for international databases.

3.5.2. Client Character Set

While working with strings, it is essential to keep the character set of the client connection in mind. If there is a mismatch between the character sets of the stored data and that of the client connection, the output results for string columns are automatically re-encoded, both when data are sent from the client to the server and when they are sent back from the server to the client. For example, if the database was created in the WIN1251 encoding but KOI8R or UTF8 is specified in the client’s connection parameters, the mismatch will be transparent.

3.5.3. Special Character Sets

Character set NONE

The character set NONE is a special character set in Firebird. It can be characterized such that each byte is a part of a string, but the string is stored in the system without any clues about what constitutes any character: character encoding, collation, case, etc. are simply unknown. It is the responsibility of the client application to deal with the data and provide the means to interpret the
string of bytes in some way that is meaningful to the application and the human user.

*Character set OCTETS*

Data in OCTETS encoding are treated as bytes that may not actually be interpreted as characters. OCTETS provides a way to store binary data, which could be the results of some Firebird functions. The database engine has no concept of what it is meant to do with a string of bits in OCTETS, other than just store it and retrieve it. Again, the client side is responsible for validating the data, presenting them in formats that are meaningful to the application and its users and handling any exceptions arising from decoding and encoding them. Since Firebird 4.0 CHAR and VARCHAR with character set OCTETS have synonyms BINARY and VARBINARY.

### 3.5.4. Collation Sequence

Each character set has a default collation sequence (COLLATE) that specifies the collation order. Usually, it provides nothing more than ordering based on the numeric code of the characters and a basic mapping of upper- and lower-case characters. If some behaviour is needed for strings that is not provided by the default collation sequence and a suitable alternative collation is supported for that character set, a COLLATE collation clause can be specified in the column definition.

A COLLATE clause can be applied in other contexts besides the column definition. For greater-than/less-than comparison operations, it can be added in the WHERE clause of a SELECT statement. If output needs to be sorted in a special alphabetic sequence, or case-insensitively, and the appropriate collation exists, then a COLLATE clause can be included with the ORDER BY clause when rows are being sorted on a character field and with the GROUP BY clause in case of grouping operations.

#### Case-Insensitive Searching

For a case-insensitive search, the UPPER function could be used to convert both the search argument and the searched strings to upper-case before attempting a match:

```sql
...  
  where upper(name) = upper(:flt_name)
```

For strings in a character set that has a case-insensitive collation available, you can simply apply the collation, to compare the search argument and the searched strings directly. For example, using the WIN1251 character set, the collation PXW_CYRL is case-insensitive for this purpose:

```sql
...  
  WHERE FIRST_NAME COLLATE PXW_CYRL >= :FLT_NAME
  ...  
  ORDER BY NAME COLLATE PXW_CYRL
```

*See also*

CONTAINING
**UTF8 Collation Sequences**

The following table shows the possible collation sequences for the UTF8 character set.

**Table 9. Collation Sequences for Character Set UTF8**

<table>
<thead>
<tr>
<th>Collation</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCS_BASIC</td>
<td>Collation works according to the position of the character in the table (binary). Added in Firebird 2.0</td>
</tr>
<tr>
<td>UNICODE</td>
<td>Collation works according to the UCA algorithm (Unicode Collation Algorithm) (alphabetical). Added in Firebird 2.0</td>
</tr>
<tr>
<td>UTF8</td>
<td>The default, binary collation, identical to UCS_BASIC, which was added for SQL compatibility</td>
</tr>
<tr>
<td>UNICODE_CI</td>
<td>Case-insensitive collation, works without taking character case into account. Added in Firebird 2.1</td>
</tr>
<tr>
<td>UNICODE_CI_AI</td>
<td>Case-insensitive, accent-insensitive collation, works alphabetically without taking character case or accents into account. Added in Firebird 2.5</td>
</tr>
</tbody>
</table>

**Example**

An example of collation for the UTF8 character set without taking into account the case or accentuation of characters (similar to `COLLATE PXW_CYRL`).

```sql
... ORDER BY NAME COLLATE UNICODE_CI_AI
```

### 3.5.5. Character Indexes

In Firebird earlier than version 2.0, a problem can occur with building an index for character columns that use a non-standard collation sequence: the length of an indexed field is limited to 252 bytes with no `COLLATE` specified or 84 bytes if `COLLATE` is specified. Multi-byte character sets and compound indexes limit the size even further.

Starting from Firebird 2.0, the maximum length for an index equals one quarter of the page size, i.e. from 1,024 — for page size 4,096 — to 8,192 bytes — for page size 32,768. The maximum length of an indexed string is 9 bytes less than that quarter-page limit.

**Calculating Maximum Length of an Indexed String Field**

The following formula calculates the maximum length of an indexed string (in characters):

```
max_char_length = FLOOR((page_size / 4 - 9) / N)
```

where $N$ is the number of bytes per character in the character set.
The table below shows the maximum length of an indexed string (in characters), according to page size and character set, calculated using this formula.

Table 10. Maximum Index Lengths by Page Size and Character Size

<table>
<thead>
<tr>
<th>Page Size</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,096</td>
<td>1,015</td>
<td>507</td>
<td>338</td>
<td>253</td>
<td>169</td>
</tr>
<tr>
<td>8,192</td>
<td>2,039</td>
<td>1,019</td>
<td>679</td>
<td>509</td>
<td>339</td>
</tr>
<tr>
<td>16,384</td>
<td>4,087</td>
<td>2,043</td>
<td>1,362</td>
<td>1,021</td>
<td>681</td>
</tr>
<tr>
<td>32,768</td>
<td>8,183</td>
<td>4,091</td>
<td>2,727</td>
<td>2,045</td>
<td>1,363</td>
</tr>
</tbody>
</table>

With case-insensitive collations (“_CI”), one character in the index will occupy not 4, but 6 (six) bytes, so the maximum key length for a page of — for example — 4,096 bytes, will be 169 characters.

See also
CREATE DATABASE, Collation sequence, SELECT, WHERE, GROUP BY, ORDER BY

3.5.6. Character Types in Detail

BINARY

Data Type Declaration Format

BINARY [(length)]

Table 11. BINARY Type Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>length</td>
<td>Length in bytes between 1 and 32,767; defaults to 1.</td>
</tr>
</tbody>
</table>

BINARY is a fixed-length data type, and is an SQL standard-compliant alias for CHAR(length) CHARACTER SET OCTETS. Values shorter than the declared length are padded with NUL up to the declared length.

Some tools may report the type as CHAR CHARACTER SET OCTETS instead of BINARY.

See also
CHAR, VARBINARY

CHAR
**Data Type Declaration Format**

```
{CHAR | CHARACTER} [(length)]
[CHARACTER SET <set>] [COLLATE <name>]
```

**Table 12. CHAR Type Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>length</td>
<td>Length in characters, defaults to 1. A valid length is from 1 to the maximum number of characters that can be accommodated within 32,767 bytes.</td>
</tr>
<tr>
<td>set</td>
<td>Character set name</td>
</tr>
<tr>
<td>name</td>
<td>Collation name</td>
</tr>
</tbody>
</table>

CHAR is a fixed-length data type. Values shorter than the declared length are padded with spaces up to the declared length. Generally, the pad character does not have to be a space: it depends on the character set. For example, the pad character for the OCTETS character set is NUL.

The full name of this data type is CHARACTER, but there is no requirement to use full names and people rarely do so.

Fixed-length character data can be used to store codes whose length is standard and has a definite “width” in directories. An example of such a code is an EAN13 barcode — 13 characters, all filled.

- Since Firebird 4.0, CHAR CHARACTER SET OCTETS has the alias BINARY
- Formally, the COLLATE clause is not part of the data type declaration, and its position depends on the syntax of the statement.

**See also**

BINARY, VARCHAR

**VARBINARY**

**Data Type Declaration Format**

```
{VARBINARY | BINARY VARYING} (length)
```

**Table 13. VARBINARY Type Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>length</td>
<td>Length in bytes between 1 and 32,765</td>
</tr>
</tbody>
</table>

VARBINARY is variable length binary type, and is an SQL standard-compliant alias for VARCHAR(length) CHARACTER SET OCTETS.

Some tools may report the type as VARCHAR CHARACTER SET OCTETS instead of VARBINARY.
VARCHAR

Data Type Declaration Format

```
{VARCHAR | {CHAR | CHARACTER} VARYING} (length)
[CHARACTER SET <set>] [COLLATE <name>]
```

Table 14. VARCHAR Type Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>length</td>
<td>Length in characters. A valid length is from 1 to the maximum number of characters that can be accommodated within 32,765 bytes.</td>
</tr>
<tr>
<td>set</td>
<td>Character set name</td>
</tr>
<tr>
<td>name</td>
<td>Collation name</td>
</tr>
</tbody>
</table>

VARCHAR is the basic string type for storing texts of variable length, up to a maximum of 32,765 bytes. The stored structure is equal to the actual size of the data plus 2 bytes where the length of the data is recorded.

All characters that are sent from the client application to the database are considered meaningful, including the leading and trailing spaces.

The full name of this type is CHARACTER VARYING. Another variant of the name is written as CHAR VARYING.

- Since Firebird 4.0, VARCHAR CHARACTER SET OCTETS has the alias VARBINARY
- Formally, the COLLATE clause is not part of the data type declaration, and its position depends on the syntax of the statement.

See also

VARBINARY, CHAR

NCHAR

Data Type Declaration Format

```
{NCHAR | NATIONAL {CHAR | CHARACTER}} [(length)]
```

NCHAR is a fixed-length character data type with the ISO8859_1 character set predefined. In all other respects it is the same as CHAR.

If no length is specified, it is taken to be 1.

A similar data type is available for the variable-length string type: NATIONAL {CHAR | CHARACTER}
3.6. Boolean Data Type

3.6.1. BOOLEAN

Data Type Declaration Format

```sql
BOOLEAN
```

The SQL:2008 compliant BOOLEAN data type (8 bits) comprises the distinct truth values TRUE and FALSE. Unless prohibited by a NOT NULL constraint, the BOOLEAN data type also supports the truth value UNKNOWN as the null value. The specification does not make a distinction between the NULL value of this data type, and the truth value UNKNOWN that is the result of an SQL predicate, search condition, or Boolean value expression: they may be used interchangeably to mean exactly the same thing.

As with many programming languages, the SQL BOOLEAN values can be tested with implicit truth values. For example, `field1 OR field2` and `NOT field1` are valid expressions.

The IS Operator

Predicates can use the operator `Boolean IS [NOT]` for matching. For example, `field1 IS FALSE`, or `field1 IS NOT TRUE`.

- Equivalence operators (“=”, “!~”, “<>” and so on) are valid in all comparisons.

BOOLEAN Examples

1. Inserting and selecting

```sql
CREATE TABLE TBOOL (ID INT, BVAL BOOLEAN);
COMMIT;

INSERT INTO TBOOL VALUES (1, TRUE);
INSERT INTO TBOOL VALUES (2, 2 = 4);
INSERT INTO TBOOL VALUES (3, NULL = 1);
COMMIT;

SELECT * FROM TBOOL;
  ID   BVAL
  ======== ========
  1 <true>
  2 <false>
  3 <null>
```
2. Test for TRUE value

```sql
SELECT * FROM TBOOL WHERE BVAL;
ID    BVAL
======    =====
 1  <true>
```

3. Test for FALSE value

```sql
SELECT * FROM TBOOL WHERE BVAL IS FALSE;
ID    BVAL
======    =====
 2  <false>
```

4. Test for UNKNOWN value

```sql
SELECT * FROM TBOOL WHERE BVAL IS UNKNOWN;
ID    BVAL
======    =====
 3    <null>
```

5. Boolean values in SELECT list

```sql
SELECT ID, BVAL, BVAL AND ID < 2
FROM TBOOL;
ID    BVAL
======    =====
 1  <true>  <true>
 2  <false> <false>
 3    <null> <false>
```

6. PSQL declaration with start value

```sql
DECLARE VARIABLE VAR1 BOOLEAN = TRUE;
```

7. Valid syntax, but as with a comparison with NULL, will never return any record

```sql
SELECT * FROM TBOOL WHERE BVAL = UNKNOWN;
SELECT * FROM TBOOL WHERE BVAL <> UNKNOWN;
```

**Use of Boolean against other data types**

Although BOOLEAN is not inherently convertible to any other data type, from version 3.0.1 the strings 'true' and 'false' (case-insensitive) will be implicitly cast to BOOLEAN in value expressions, e.g.
if (true > 'false') then ...

'false' is converted to BOOLEAN. Any attempt to use the Boolean operators AND, NOT, OR and IS will fail. NOT 'False', for example, is invalid.

A BOOLEAN can be explicitly converted to and from string with CAST. UNKNOWN is not available for any form of casting.

3.7. Binary Data Types

The types BINARY and VARBINARY are covered earlier in section Character Data Types.

BLOBs (Binary Large Objects) are complex structures used to store text and binary data of an undefined length, often very large.

Syntax

BLOB [SUB_TYPE <subtype>]
  [SEGMENT SIZE <segment size>]
  [CHARACTER SET <character set>]
  [COLLATE <collation name>]

Shortened syntax

BLOB (<segment size>)
BLOB (<segment size>, <subtype>)
BLOB (, <subtype>)

Formally, the COLLATE clause is not part of the data type declaration, and its position depends on the syntax of the statement.

Segment Size

Specifying the BLOB segment size is throwback to times past, when applications for working with BLOB data were written in C (Embedded SQL) with the help of the gpre pre-compiler. Nowadays, it is effectively irrelevant. The segment size for BLOB data is determined by the client side and is usually larger than the data page size, in any case.
3.7.1. **BLOB Subtypes**

The optional `SUB_TYPE` parameter specifies the nature of data written to the column. Firebird provides two pre-defined subtypes for storing user data:

**Subtype 0: BINARY**

If a subtype is not specified, the specification is assumed to be for untyped data and the default `SUB_TYPE 0` is applied. The alias for subtype zero is `BINARY`. This is the subtype to specify when the data are any form of binary file or stream: images, audio, word-processor files, PDFs and so on.

**Subtype 1: TEXT**

Subtype 1 has an alias, `TEXT`, which can be used in declarations and definitions. For instance, `BLOB SUB_TYPE TEXT`. It is a specialized subtype used to store plain text data that is too large to fit into a string type. A `CHARACTER SET` may be specified, if the field is to store text with a different encoding to that specified for the database. From Firebird 2.0, a `COLLATE` clause is also supported.

Specifying a `CHARACTER SET` without `SUB_TYPE` implies `SUB_TYPE TEXT`.

**Custom Subtypes**

It is also possible to add custom data subtypes, for which the range of enumeration from -1 to -32,768 is reserved. Custom subtypes enumerated with positive numbers are not allowed, as the Firebird engine uses the numbers from 2-upward for some internal subtypes in metadata.

3.7.2. **BLOB Specifics**

**Size**

The maximum size of a BLOB field is limited to 4GB, regardless of whether the server is 32-bit or 64-bit. (The internal structures related to BLOBs maintain their own 4-byte counters.) For a page size of 4 KB (4096 bytes) the maximum size is lower — slightly less than 2GB.

**Operations and Expressions**

Text BLOBs of any length and any character set—including multi-byte—can be operands for practically any statement or internal functions. The following operators are supported completely:

- `=` (assignment)
- `=, <>, <, <=, >, >=` (comparison)
- `||` (concatenation)
- `BETWEEN`, `IS [NOT] DISTINCT FROM`
- `IN`, `ANY | SOME`
- `ALL`

Partial support:

- An error occurs with these if the search argument is larger than or equal to 32 KB:
  - `STARTING [WITH], LIKE`,
  - `LIKE [NOT] FULL`
CONTAINING

• Aggregation clauses work not on the contents of the field itself, but on the BLOB ID. Aside from that, there are some quirks:

    SELECT DISTINCT
    ORDER BY
    GROUP BY

returns several NULL values by mistake if they are present

concatenates the same strings if they are adjacent to each other, but does not do it if they are remote from each other

BLOB Storage

• By default, a regular record is created for each BLOB and it is stored on a data page that is allocated for it. If the entire BLOB fits onto this page, it is called a level 0 BLOB. The number of this special record is stored in the table record and occupies 8 bytes.

• If a BLOB does not fit onto one data page, its contents are put onto separate pages allocated exclusively to it (blob pages), while the numbers of these pages are stored into the BLOB record. This is a level 1 BLOB.

• If the array of page numbers containing the BLOB data does not fit onto a data page, the array is put on separate blob pages, while the numbers of these pages are put into the BLOB record. This is a level 2 BLOB.

• Levels higher than 2 are not supported.

See also

FILTER, DECLARE FILTER

3.8. Array Types

Firebird does not offer much in the way of language or tools for working with the contents of arrays, and there are no plans to improve this. This limits the usefulness and accessibility of array types. Therefore, the general advice is: do not use arrays.

The support of arrays in the Firebird DBMS is a departure from the traditional relational model. Supporting arrays in the DBMS could make it easier to solve some data-processing tasks involving large sets of similar data.

Arrays in Firebird are stored in BLOB of a specialized type. Arrays can be one-dimensional and multi-dimensional and of any data type except BLOB and ARRAY.
Example

```
CREATE TABLE SAMPLE_ARR (
   ID INTEGER NOT NULL PRIMARY KEY,
   ARR_INT INTEGER [4]
);
```

This example will create a table with a field of the array type consisting of four integers. The subscripts of this array are from 1 to 4.

### 3.8.1. Specifying Explicit Boundaries for Dimensions

By default, dimensions are 1-based—subscripts are numbered from 1. To specify explicit upper and lower bounds of the subscript values, use the following syntax:

```
['<lower>:<upper> ']
```

### 3.8.2. Adding More Dimensions

A new dimension is added using a comma in the syntax. In this example we create a table with a two-dimensional array, with the lower bound of subscripts in both dimensions starting from zero:

```
CREATE TABLE SAMPLE_ARR2 (
   ID INTEGER NOT NULL PRIMARY KEY,
   ARR_INT INTEGER [0:3, 0:3]
);
```

The database employee.fdb, found in the ..examples/empbuild directory of any Firebird distribution package, contains a sample stored procedure showing some simple work with arrays:

### 3.8.3. PSQL Source for `SHOW_Langs`, a procedure involving an array
CREATE OR ALTER PROCEDURE SHOW_LANGS (  
    CODE VARCHAR(5),  
    GRADE SMALLINT,  
    CTY VARCHAR(15))  
RETURNS (LANGUAGES VARCHAR(15))  
AS  
    DECLARE VARIABLE I INTEGER;  
BEGIN  
    I = 1;  
    WHILE (I <= 5) DO  
        BEGIN  
            SELECT LANGUAGE_REQ[:I]  
            FROM JOB  
                WHERE (JOB_CODE = :CODE)  
                    AND (JOB_GRADE = :GRADE)  
                    AND (JOB_COUNTRY = :CTY)  
                    AND (LANGUAGE_REQ IS NOT NULL))  
            INTO :LANGUAGES;  
            IF (LANGUAGES = '') THEN  
                /* PRINTS 'NULL' INSTEAD OF BLANKS */  
                LANGUAGES = 'NULL';  
                I = I +1;  
                SUSPEND;  
            END  
        END  
    END

If the features described are enough for your tasks, you might consider using arrays in your projects. Currently, no improvements are planned to enhance support for arrays in Firebird.

3.9. Special Data Types

“Special” data types ...

3.9.1. SQL_NULL Data Type

The SQL_NULL type holds no data, but only a state: NULL or NOT NULL. It is not available as a data type for declaring table fields, PSQL variables or parameter descriptions. It was added to support the use of untyped parameters in expressions involving the IS NULL predicate.

An evaluation problem occurs when optional filters are used to write queries of the following type:

```sql
WHERE col1 = :param1 OR :param1 IS NULL
```

After processing, at the API level, the query will look like this:
WHERE col1 = ? OR ? IS NULL

This is a case where the developer writes an SQL query and considers :param1 as though it were a variable that he can refer to twice. However, at the API level, the query contains two separate and independent parameters. The server cannot determine the type of the second parameter since it comes in association with IS NULL.

The SQL_NULL data type solves this problem. Whenever the engine encounters an “? IS NULL” predicate in a query, it assigns the SQL_NULL type to the parameter, which will indicate that parameter is only about “nullness” and the data type or the value need not be addressed.

The following example demonstrates its use in practice. It assumes two named parameters—say, :size and :colour—which might, for example, get values from on-screen text fields or drop-down lists. Each named parameter corresponds with two positional parameters in the query.

```
SELECT
    SH.SIZE, SH.COLOUR, SH.PRICE
FROM SHIRTS SH
WHERE (SH.SIZE = ? OR ? IS NULL)
    AND (SH.COLOUR = ? OR ? IS NULL)
```

Explaining what happens here assumes the reader is familiar with the Firebird API and the passing of parameters in XSQLVAR structures—what happens under the surface will not be of interest to those who are not writing drivers or applications that communicate using the “naked” API.

The application passes the parameterized query to the server in the usual positional ?-form. Pairs of “identical” parameters cannot be merged into one so, for two optional filters, for example, four positional parameters are needed: one for each ? in our example.

After the call to isc_dsql_describe_bind(), the SQLTYPE of the second and fourth parameters will be set to SQL_NULL. Firebird has no knowledge of their special relation with the first and third parameters: that responsibility lies entirely on the application side.

Once the values for size and colour have been set (or left unset) by the user and the query is about to be executed, each pair of XSQLVARs must be filled as follows:

**User has supplied a value**
- First parameter (value compare): set *sqldata to the supplied value and *sqlind to 0 (for NOT NULL)
- Second parameter (NULL test): set sqldata to null (null pointer, not SQL NULL) and *sqlind to 0 (for NOT NULL)

**User has left the field blank**
- Both parameters: set sqldata to null (null pointer, not SQL NULL) and *sqlind to -1 (indicating NULL)

In other words: The value compare parameter is always set as usual. The SQL_NULL parameter is set
the same, except that sqldata remains null at all times.

### 3.10. Conversion of Data Types

When composing an expression or specifying an operation, the aim should be to use compatible data types for the operands. When a need arises to use a mixture of data types, it should prompt you to look for a way to convert incompatible operands before subjecting them to the operation. The ability to convert data may well be an issue if you are working with Dialect 1 data.

#### 3.10.1. Explicit Data Type Conversion

The CAST function enables explicit conversion between many pairs of data types.

**Syntax**

```plaintext
CAST (<expression> AS <target_type>)
```

- `<target_type>` ::= `<domain_or_non_array_type> | <array_datatype>`

- `<domain_or_non_array_type>` ::= !! See **Scalar Data Types Syntax** !!

- `<array_datatype>` ::= !! See **Array Data Types Syntax** !!

See also **CAST()** in Chapter *Built-in Scalar Functions*.

**Casting to a Domain**

When you cast to a domain, any constraints declared for it are taken into account, i.e., NOT NULL or CHECK constraints. If the value does not pass the check, the cast will fail.

If **TYPE OF** is additionally specified — casting to its base type — any domain constraints are ignored during the cast. If **TYPE OF** is used with a character type (CHAR/VARCHAR), the character set and collation are retained.

**Casting to TYPE OF COLUMN**

When operands are cast to the type of a column, the specified column may be from a table or a view.

Only the type of the column itself is used. For character types, the cast includes the character set, but not the collation. The constraints and default values of the source column are not applied.
Example

```sql
CREATE TABLE TTT (
    S VARCHAR (40)
    CHARACTER SET UTF8 COLLATE UNICODE_CI_AI
);
COMMIT;

SELECT
    CAST ('I have many friends' AS TYPE OF COLUMN TTT.S)
FROM RDB$DATABASE;
```

### Conversions Possible for the `CAST` Function

#### Table 15. Conversions with `CAST`

<table>
<thead>
<tr>
<th>From Data Type</th>
<th>To Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numeric types</td>
<td>Numeric types, [VAR]CHAR, BLOB</td>
</tr>
<tr>
<td>[VAR]CHAR</td>
<td>[VAR]CHAR, BLOB, Numeric types, DATE, TIME, TIMESTAMP, BOOLEAN</td>
</tr>
<tr>
<td>BLOB</td>
<td>[VAR]CHAR, BLOB, Numeric types, DATE, TIME, TIMESTAMP, BOOLEAN</td>
</tr>
<tr>
<td>DATE, TIME</td>
<td>[VAR]CHAR, BLOB, TIMESTAMP</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td>[VAR]CHAR, BLOB, DATE, TIME</td>
</tr>
<tr>
<td>BOOLEAN</td>
<td>BOOLEAN, [VAR]CHAR, BLOB</td>
</tr>
</tbody>
</table>

To convert string data types to the BOOLEAN type, the value must be (case-insensitive) 'true' or 'false', or NULL.

⚠️ Keep in mind that partial information loss is possible. For instance, when you cast the TIMESTAMP data type to the DATE data type, the time-part is lost.

### Datetime Formats

To cast string data types to the DATE, TIME or TIMESTAMP data types, you need the string argument to be one of the predefined datetime mnemonics (see Table 16) or a representation of the date in one of the allowed datetime formats (see Datetime Format Syntax),

#### Table 16. Predefined Datetime Mnemonics

<table>
<thead>
<tr>
<th>Literal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>'NOW'</td>
<td>Current date and time</td>
</tr>
<tr>
<td>'TODAY'</td>
<td>Current date</td>
</tr>
<tr>
<td>'TOMORROW'</td>
<td>Current date + 1 (day)</td>
</tr>
<tr>
<td>'YESTERDAY'</td>
<td>Current date - 1 (day)</td>
</tr>
</tbody>
</table>
Casting the date mnemonics 'TODAY', 'TOMORROW' or 'YESTERDAY' to a TIMESTAMP WITH TIME ZONE will produce a value at 00:00:00 UTC rebased to the session time zone.

For example cast('TODAY' as timestamp with time zone) on 2021-05-02 20:00 - 2021-05-03 19:59 New York (or 2021-05-03 00:00 - 2021-05-03 23:59 UTC) with session time zone America/New_York will produce a value TIMESTAMP '2021-05-02 20:00:00.0000 America/New_York', while cast('TODAY' as date) or CURRENT_DATE will produce either DATE '2021-05-02' or DATE '2021-05-03' depending on the actual date.

Sample Date Literal Interpretations

```
select
cast('04.12.2014' as date) as d1, -- DD.MM.YYYY
    cast('04 12 2014' as date) as d2, -- MM DD YYYY
    cast('4-12-2014' as date) as d3, -- MM-DD-YYYY
    cast('04/12/2014' as date) as d4, -- MM/DD/YYYY
    cast('04.12.14' as date) as d5, -- DD.MM.YY
-- DD.MM with current year
    cast('04.12' as date) as d6,
    -- MM/DD with current year
    cast('04/12' as date) as d7,
    cast('2014/12/04' as date) as d8, -- YYYY/MM/DD
    cast('2014 12 04' as date) as d9, -- YYYY MM DD
    cast('2014-12-04' as date) as d10, -- YYYY-MM-DD
    cast('4 Jan 2014' as date) as d11, -- YYYY-MM-DD
    cast('2014 Jan 4' as date) as d12, -- YYYY MM DD
    cast('Jan 4 2014' as date) as d13, -- YYYY MM DD
    cast('Jan 4 2014' as date) as d14, -- MM DD YYYY
    cast('11:37' as time) as t1, -- HH:mm
    cast('11:37:12' as time) as t2, -- HH:mm:ss
    cast('11:31:12.1234' as time) as t3, -- HH:mm:ss.nnnn
-- DD.MM.YYYY HH:mm
    cast('04.12.2014 11:37' as timestamp) as dt1,
    -- MM/DD/YYYY HH:mm:ss
    cast('04/12/2014 11:37:12' as timestamp) as dt2,
    -- DD.MM.YYYY HH:mm:ss
    cast('04.12.2014 11:31:12.1234' as timestamp) as dt3,
    cast('now' as timestamp) as m1,
    cast('today' as date) as m2,
    cast('yesterday' as date) as m3,
    cast('tomorrow' as date) as m4
from rdb$database
```

Shorthand Casts for Datetime Data Types

Firebird allows the use of a shorthand “C-style” type syntax for casts from string to the types DATE, TIME and TIMESTAMP. The SQL standard calls these datetime literals.
These literal expressions are evaluated directly during parsing, as though the statement were already prepared for execution. As this produced unexpected or confusing results when using the datetime mnemonics like 'NOW', especially in PSQL code, the datetime mnemonics are no longer allowed in datetime literals since Firebird 4.0.

To use datetime mnemonics, use the full `CAST` syntax. An example of using such an expression in a trigger:

```sql
NEW.CHANGE_DATE = CAST('now' AS TIMESTAMP);
```

### 3.10.2. Implicit Data Type Conversion

Implicit data conversion is not possible in Dialect 3 — the `CAST` function is almost always required to avoid data type clashes.

In Dialect 1, in many expressions, one type is implicitly cast to another without the need to use the `CAST` function. For instance, the following statement in Dialect 1 is valid:

```sql
UPDATE ATABLE
  SET ADATE = '25.12.2016' + 1
```

The date literal will be cast to the date type implicitly.

In Dialect 3, this statement will throw error 35544569, “Dynamic SQL Error: expression evaluation not supported, Strings cannot be added or subtracted in dialect 3” — a cast will be needed:

```sql
UPDATE ATABLE
  SET ADATE = CAST ('25.12.2016' AS DATE) + 1
```

Or, with a datetime literal:

```sql
UPDATE ATABLE
  SET ADATE = DATE '25.12.2016' + 1
```

In Dialect 1, mixing integer data and numeric strings is usually possible because the parser will try to cast the string implicitly. For example,
2 + '1'

will be executed correctly.

In Dialect 3, an expression like this will raise an error, so you will need to write it as a `CAST` expression:

```sql
2 + CAST('1' AS SMALLINT)
```

The exception to the rule is during string concatenation.

**Implicit Conversion During String Concatenation**

When multiple data elements are being concatenated, all non-string data will undergo implicit conversion to string, if possible.

*Example*

```sql
SELECT 30||' days hath September, April, June and November' CONCAT$
     FROM RDB$DATABASE;
```

```
CONCAT$
------------------------------------------------
30 days hath September, April, June and November
```

### 3.11. Custom Data Types — Domains

In Firebird, the concept of a “user-defined data type” is implemented in the form of the *domain*. Creating a domain does not truly create a new data type, of course. A domain provides the means to encapsulate an existing data type with a set of attributes and make this “capsule” available for multiple usage across the whole database. If several tables need columns defined with identical or nearly identical attributes, a domain makes sense.

Domain usage is not limited to column definitions for tables and views. Domains can be used to declare input and output parameters and variables in PSQL code.

#### 3.11.1. Domain Attributes

A domain definition contains required and optional attributes. The *data type* is a required attribute. Optional attributes include:

- a default value
- to allow or forbid NULL
- CHECK constraints
- character set (for character data types and text BLOB fields)
• collation (for character data types)

Sample domain definition

```
CREATE DOMAIN BOOL3 AS SMALLINT
    CHECK (VALUE IS NULL OR VALUE IN (0, 1));
```

See also

Explicit Data Type Conversion for the description of differences in the data conversion mechanism when domains are specified for the `TYPE OF` and `TYPE OF COLUMN` modifiers.

### 3.11.2. Domain Override

While defining a column using a domain, it is possible to override some of the attributes inherited from the domain. Table 3.9 summarises the rules for domain override.

#### Table 17. Rules for Overriding Domain Attributes in Column Definition

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Override?</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data type</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Default value</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Text character set</td>
<td>Yes</td>
<td>It can be also used to restore the default database values for the column</td>
</tr>
<tr>
<td>Text collation sequence</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>CHECK constraints</td>
<td>Yes</td>
<td>To add new conditions to the check, you can use the corresponding CHECK clauses in the CREATE and ALTER statements at the table level.</td>
</tr>
<tr>
<td>NOT NULL</td>
<td>No</td>
<td>Often it is better to leave domain nullable in its definition and decide whether to make it NOT NULL when using the domain to define columns.</td>
</tr>
</tbody>
</table>

### 3.11.3. Creating and Administering Domains

A domain is created with the DDL statement `CREATE DOMAIN`.

#### Short Syntax

```
CREATE DOMAIN name [AS <type>
    [DEFAULT {<const> | <literal> | NULL | <context_var>}]]
    [NOT NULL] [CHECK (<condition>)]
    [COLLATE <collation>]
```

See also

`CREATE DOMAIN` in the Data Definition Language (DDL) section.
**Altering a Domain**

To change the attributes of a domain, use the DDL statement `ALTER DOMAIN`. With this statement you can:

- rename the domain
- change the data type
- drop the current default value
- set a new default value
- drop the `NOT NULL` constraint
- set the `NOT NULL` constraint
- drop an existing `CHECK` constraint
- add a new `CHECK` constraint

**Short Syntax**

```
ALTER DOMAIN name
    [TO new_name]
    [{SET DEFAULT { <literal> | NULL | <context_var> } | DROP DEFAULT}]
    [{SET | DROP} NOT NULL ]
    [{ADD [CONSTRAINT] CHECK (<dom_condition>) | DROP CONSTRAINT}]
    [{TYPE <datatype>}]
```

**Example**

```
ALTER DOMAIN STORE_GRP SET DEFAULT -1;
```

When changing a domain, its dependencies must be taken into account: whether there are table columns, any variables, input and/or output parameters with the type of this domain declared in the PSQL code. If you change domains in haste, without carefully checking them, your code may stop working!

⚠️ When you convert data types in a domain, you must not perform any conversions that may result in data loss. Also, for example, if you convert `VARCHAR` to `INTEGER`, check carefully that all data using this domain can be successfully converted.

**See also**

`ALTER DOMAIN` in the Data Definition Language (DDL) section.

**Deleting (Dropping) a Domain**

The DDL statement `DROP DOMAIN` deletes a domain from the database, provided it is not in use by any other database objects.
3.12. Data Type Declaration Syntax

This section documents the syntax of declaring data types. Data type declaration commonly occurs in DDL statements, but also in CAST and EXECUTE BLOCK.

The syntax documented below is referenced from other parts of this language reference.

3.12.1. Scalar Data Types Syntax

The scalar data types are simple data types that hold a single value. For reasons of organisation, the syntax of BLOB types are defined separately in BLOB Data Types Syntax.

Scalar Data Types Syntax

```
<domain_or_non_array_type> ::= 
   <scalar_datatype> 
   | <blob_datatype> 
   | [TYPE OF] domain 
   | TYPE OF COLUMN rel.col

<scalar_datatype> ::= 
   SMALLINT | INT[GER] | BIGINT | INT128 
   | REAL | FLOAT [(bin_prec)] | DOUBLE PRECISION 
   | DECIMAL [(precision [, scale])] 
   | DECIMAL [precision] 
   | BOOLEAN 
   | DATE | TIME | TIMESTAMP 
   | {CHAR | CHARACTER} VARYING (length) 
   | {CHAR | CHARACTER} {CHARACTER SET charset} 
   | {CHAR | CHARACTER} [(length)] [CHARACTER SET charset] 
   | {VARCHAR | CHAR | CHARACTER} VARYING (length) 
   | {VARCHAR | CHAR | CHARACTER} [(length)] 
   | {NCHAR | NATIONAL} [CHARACTER | CHAR] VARYING (length) 
   | {NCHAR | NATIONAL} [CHARACTER | CHAR] [(length)] 
   | BINARY [(length)]
   | {VARBINARY | BINARY VARYING} (length)
```

Table 18. Arguments for the Scalar Data Types Syntax
<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>domain</td>
<td>Domain (only non-array domains)</td>
</tr>
<tr>
<td>rel</td>
<td>Name of a table or view</td>
</tr>
<tr>
<td>col</td>
<td>Name of a column in a table or view (only columns of a non-array type)</td>
</tr>
<tr>
<td>bin_prec</td>
<td>Binary precision, default is 24.</td>
</tr>
<tr>
<td></td>
<td>1 - 24: 32-bit single precision</td>
</tr>
<tr>
<td></td>
<td>25 - 53: 64-bit double precision (synonym of DOUBLE PRECISION)</td>
</tr>
<tr>
<td>dec_prec</td>
<td>Decimal precision of DECFLOAT, either 16 or 34; Default is 34</td>
</tr>
<tr>
<td>precision</td>
<td>Numeric precision in decimal digits. From 1 to 38</td>
</tr>
<tr>
<td>scale</td>
<td>Scale, or number of decimals. From 0 to 38. It must be less than or equal to precision</td>
</tr>
<tr>
<td>length</td>
<td>The maximum length of a string, in characters, or — for BINARY and VARBINARY — bytes; optional for fixed-width character types, defaults to 1</td>
</tr>
<tr>
<td>charset</td>
<td>Character set</td>
</tr>
<tr>
<td>domain_or_non_array_type</td>
<td>Non-array types that can be used in PSQL code and casts</td>
</tr>
</tbody>
</table>

**Use of Domains in Declarations**

A domain name can be specified as the type of a PSQL parameter or local variable. The parameter or variable will inherit all domain attributes. If a default value is specified for the parameter or variable, it overrides the default value specified in the domain definition.

If the `TYPE OF` clause is added before the domain name, only the data type of the domain is used: any of the other attributes of the domain — NOT NULL constraint, CHECK constraints, default value — are neither checked nor used. However, if the domain is of a text type, its character set and collation sequence are always used.

**Use of Column Type in Declarations**

Input and output parameters or local variables can also be declared using the data type of columns in existing tables and views. The `TYPE OF COLUMN` clause is used for that, specifying `relationname .columnname` as its argument.

When `TYPE OF COLUMN` is used, the parameter or variable inherits only the data type and — for string types — the character set and collation sequence. The constraints and default value of the column are ignored.

**3.12.2. BLOB Data Types Syntax**

The BLOB data types hold binary, character or custom format data of unspecified size. For more information, see Binary Data Types.
### BLOB Data Types Syntax

```plaintext
<Blob_datatype> ::= 
  BLOB [SUB_TYPE {subtype_num | subtype_name}] 
  [SEGMENT SIZE seglen] [CHARACTER SET charset] 
  | BLOB [(seglen [, subtype_num])] 
```

### Table 19. Arguments for the Blob Data Types Syntax

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>charset</td>
<td>Character set (ignored for sub-types other than TEXT/1)</td>
</tr>
<tr>
<td>subtype_num</td>
<td>BLOB subtype number</td>
</tr>
<tr>
<td>subtype_name</td>
<td>BLOB subtype mnemonic name; this can be TEXT, BINARY, or one of the (other) standard or custom names defined in RDB$TYPES for RDB$FIELD_NAME = 'RDB$FIELD_SUB_TYPE'.</td>
</tr>
<tr>
<td>seglen</td>
<td>Segment size, cannot be greater than 65,535, defaults to 80 when not specified. See also Segment Size</td>
</tr>
</tbody>
</table>

### 3.12.3. Array Data Types Syntax

The array data types hold multiple scalar values in a single or multi-dimensional array. For more information, see Array Types

### Array Data Types Syntax

```plaintext
<array_datatype> ::= 
  {SMALLINT | INTEGER | BIGINT | INT128} <array_dim> 
  | {REAL | FLOAT [(bin_prec)] | DOUBLE PRECISION} <array_dim> 
  | DECIMAL [(dec_prec)] 
  | BOOLEAN <array_dim> 
  | {DATE | TIME | TIMESTAMP} <array_dim> 
  | {DECIMAL | NUMERIC} [(precision [, scale])] <array_dim> 
  | {VARCHAR | CHAR | CHARACTER} VARYING (length) <array_dim> [CHARACTER SET charset] 
  | {CHAR | CHARACTER} [(length)] <array_dim> [CHARACTER SET charset] 
  | {NCHAR | NATIONAL {CHARACTER | CHAR}} VARYING (length) <array_dim> 
  | {NCHAR | NATIONAL {CHARACTER | CHAR}} [(length)] <array_dim> 
  | BINARY [(length)] <array_dim> 
  | VARBINARY | BINARY VARYING} (length) <array_dim> 

<array_dim> ::= '[ ' [m:n [,m:n ...] ']' 
```

### Table 20. Arguments for the Array Data Types Syntax
<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>array_dim</td>
<td>Array dimensions</td>
</tr>
<tr>
<td>bin_prec</td>
<td>Binary precision, default is 24.</td>
</tr>
<tr>
<td></td>
<td>1 - 24: 32-bit single precision</td>
</tr>
<tr>
<td></td>
<td>25 - 53: 64-bit double precision (synonym of DOUBLE PRECISION)</td>
</tr>
<tr>
<td>dec_prec</td>
<td>Decimal precision of DECFLOAT, either 16 or 34; default is 34</td>
</tr>
<tr>
<td>precision</td>
<td>Numeric precision in decimal digits. From 1 to 38</td>
</tr>
<tr>
<td>scale</td>
<td>Scale, or number of decimals. From 0 to 38. It must be less than or equal to precision</td>
</tr>
<tr>
<td>length</td>
<td>The maximum length of a string, in characters, or — for BINARY and VARBINARY — bytes; optional for fixed-width character types, defaults to 1</td>
</tr>
<tr>
<td>charset</td>
<td>Character set</td>
</tr>
<tr>
<td>m, n</td>
<td>Integer numbers defining the index range of an array dimension</td>
</tr>
</tbody>
</table>
Chapter 4. Common Language Elements

This chapter covers the elements that are common throughout the implementation of the SQL language — the *expressions* that are used to extract and operate on conditions about data and the *predicates* that test the truth of those assertions.

### 4.1. Expressions

SQL expressions provide formal methods for evaluating, transforming and comparing values. SQL expressions may include table columns, variables, constants, literals, various statements and predicates and also other expressions. The complete list of possible tokens in expressions follows.

**Description of Expression Elements**

**Column name**
- Identifier of a column from a specified table used in evaluations or as a search condition. A column of the array type cannot be an element in an expression except when used with the IS [NOT] NULL predicate.

**Array element**
- An expression may contain a reference to an array member i.e., `<array_name>[s]`, where `s` is the subscript of the member in the array `<array_name>`

**Arithmetic operators**
- The `+`, `-`, `*`, `/` characters used to calculate values

**Concatenation operator**
- The `||` ("double-pipe") operator used to concatenate strings

**Logical operators**
- The reserved words NOT, AND and OR, used to combine simple search conditions in order to create complex conditions

**Comparison operators**
- The symbols `=`, `<>`, `!=`, `<=`, `<`, `>=`, `>`, `!`, `^`, `^` and `^`

**Comparison predicates**
- LIKE, STARTING WITH, CONTAINING, SIMILAR TO, BETWEEN, IS [NOT] NULL, IS [NOT] {TRUE | FALSE | UNKNOWN} and IS [NOT] DISTINCT FROM

**Existential predicates**
- Predicates used to check the existence of values in a set. The IN predicate can be used both with sets of comma-separated constants and with subqueries that return a single column. The EXISTS, SINGULAR, ALL, ANY and SOME predicates can be used only with subqueries.

**Constant or Literal**
- Numbers, or string literals enclosed in apostrophes, Boolean values TRUE, FALSE and UNKNOWN, NULL
Datetime literal

An expression, similar to a string literal enclosed in apostrophes, that can be interpreted as a date, time or timestamp value. Datetime literals can be strings of characters and numerals, such as `TIMESTAMP '25.12.2016 15:30:35'`, that can be resolved as datetime value, also used for string literals that can be cast to a datetime type.

Datetime mnemonics

A string literal with a description of a desired datetime value that can be cast to a datetime type. For example 'TODAY', 'NOW'.

Context variable

An internally-defined context variable

Local variable

Declared local variable, input or output parameter of a PSQL module (stored procedure, trigger, unnamed PSQL block in DSQL)

Positional parameter

A member of in an ordered group of one or more unnamed parameters passed to a stored procedure or prepared query

Subquery

A `SELECT` statement enclosed in parentheses that returns a single (scalar) value or, when used in existential predicates, a set of values

Function identifier

The identifier of an internal or external function in a function expression

Type cast

An expression explicitly converting data of one data type to another using the `CAST` function (`CAST <value> AS <datatype>`) . For date/time literals only, the shorthand syntax `<datatype> <value>` is also supported (`DATE '2016-12-25'`).

Conditional expression

Expressions using `CASE` and related internal functions

Parentheses

Bracket pairs (…) used to group expressions. Operations inside the parentheses are performed before operations outside them. When nested parentheses are used, the most deeply nested expressions are evaluated first and then the evaluations move outward through the levels of nesting.

COLLATE clause

Clause applied to `CHAR` and `VARCHAR` types to specify the character-set-specific collation sequence to use in string comparisons

NEXT VALUE FOR sequence

Expression for obtaining the next value of a specified generator (sequence). The internal
GEN_ID() function does the same.

**AT expression**

Expression to change the time zone of a datetime.

### 4.1.1. Literals (Constants)

A literal — or constant — is a value that is supplied directly in an SQL statement, not derived from an expression, a parameter, a column reference nor a variable. It can be a string or a number.

#### String Literals

A string literal is a series of characters enclosed between a pair of apostrophes (“single quotes”). The maximum length of a string literal is 32,765 for CHAR/VARCHAR, or 65,533 bytes for BLOB; the maximum character count will be determined by the number of bytes used to encode each character.

- Double quotes are *NOT VALID* for quoting strings. The SQL standard reserves double quotes for a different purpose: quoting identifiers.
- If a literal apostrophe is required within a string constant, it is “escaped” by prefixing it with another apostrophe. For example, 'Mother O’Reilly’s homemade hooch'. Or use the alternative quote literal: q'{Mother O'Reilly's homemade hooch}'
- Care should be taken with the string length if the value is to be written to a CHAR or VARCHAR column. The maximum length for a CHAR or VARCHAR` literal is 32,765 bytes.

The character set of a string constant is assumed to be the same as the character set of its destined storage.

#### String Literals in Hexadecimal Notation

From Firebird 2.5 forward, string literals can be entered in hexadecimal notation, so-called “binary strings”. Each pair of hex digits defines one byte in the string. Strings entered this way will be type BINARY (or character set OCTETS) by default, unless the *introducer syntax* is used to force a string to be interpreted as another character set.

**Syntax**

```
{x|X}'<hexstring>'
```

```mermaid
sequenceDiagram
    participant H ('hexstring')
    participant C ('<hexdigit>')

    C --> H: an even number of <hexdigit>
    C --> H: one of 0..9, A..F, a..f
```

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**Examples**

```sql
select x'4E657276656E' from rdb$database
-- returns 4E657276656E, a 6-byte 'binary' string

select _ascii x'4E657276656E' from rdb$database
-- returns 'Nerven' (same string, now interpreted as ASCII text)

select _iso8859_1 x'53E46765' from rdb$database
-- returns 'Säge' (4 chars, 4 bytes)

select _utf8 x'53C3A46765' from rdb$database
-- returns 'Säge' (4 chars, 5 bytes)
```

**Notes**

The client interface determines how binary strings are displayed to the user. The _isql_ utility, for example, uses upper case letters A-F, while FlameRobin uses lower case letters. Other client programs may use other conventions, such as displaying spaces between the byte pairs: '4E 65 72 76 65 6E'.

The hexadecimal notation allows any byte value (including 00) to be inserted at any position in the string. However, if you want to coerce it to anything other than OCTETS, it is your responsibility to supply the bytes in a sequence that is valid for the target character set.

**Alternative String Literals**

Since Firebird 3.0, it is possible to use a character, or character pair, other than the doubled (escaped) apostrophe, to embed a quoted string inside another string without the need to escape the quote. The keyword q or Q preceding a quoted string informs the parser that certain left-right pairs or pairs of identical characters within the string are the delimiters of the embedded string literal.

**Syntax**

```sql
<alternative string literal> ::= 
  { q | Q } <quote> <start char> [<char> ...] <end char> <quote>
```

**Rules**

When `<start char>` is ‘,’ ‘{’, ‘[’ or ‘<’, `<end char>` is paired up with its respective “partner”, viz. ‘)’, ‘}’, ‘]’ and ‘>’. In other cases, `<end char>` is the same as `<start char>`.

Inside the string, i.e. `<char>` items, single (not escaped) quotes can be used. Each quote will be part of the result string.
Examples

```sql
select q'\{abc\{def\}ghi\}' from rdb$database;    -- result: abc{def}ghi
select q'\!That's a string!' from rdb$database;   -- result: That's a string
```

**Introducer Syntax for String Literals**

If necessary, a string literal may be preceded by a character set name, itself prefixed with an underscore “_”. This is known as *introducer syntax*. Its purpose is to inform the engine about how to interpret and store the incoming string.

Example

```sql
INSERT INTO People
VALUES (_ISO8859_1 'Hans-Jörg Schäfer')
```

**Number Literals**

A number literal is any valid number in a supported notation:

- In SQL, for numbers in the standard decimal notation, the decimal point is always represented by period character (',.'), full-stop, dot); thousands are not separated. Inclusion of commas, blanks, etc. will cause errors.
- Exponential notation is supported. For example, 0.0000234 can be expressed as `2.34e-5`.
- Hexadecimal notation is supported by Firebird 2.5 and higher versions — see below.

The format of the literal decides the type (`<d>` for a decimal digit, `<h>` for a hexadecimal digit):

<table>
<thead>
<tr>
<th>Format</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;d&gt;[&lt;d&gt; ...]</code></td>
<td>INTEGER, BIGINT, INT128 or DECFLOAT(34) (depends on if value fits in the type). DECFLOAT(34) is used for values that do not fit in INT128.</td>
</tr>
<tr>
<td>`0{x</td>
<td>X} &lt;h&gt;&lt;h&gt;[&lt;h&gt;&lt;h&gt; ...]`</td>
</tr>
<tr>
<td><code>&lt;d&gt;[&lt;d&gt; ...] &quot;.&quot; [&lt;d&gt; ...]</code></td>
<td>NUMERIC(18, n), NUMERIC(38, n) or DECFLOAT(34) where n depends on the number of digits after the decimal point, and precision on the total number of digits. For backwards compatibility, some values of 19 digits are mapped to NUMERIC(18, 2). DECFLOAT(34) is used when the unscaled value does not fit in INT128.</td>
</tr>
</tbody>
</table>
Hexadecimal Notation for Numbers

From Firebird 2.5 forward, integer values can be entered in hexadecimal notation. Numbers with 1-8 hex digits will be interpreted as type INTEGER; numbers with 9-16 hex digits as type BIGINT.

Syntax

0{x|X}<hexdigits>

<hexdigits> ::= 1-16 of <hexdigit>
<hexdigit> ::= one of 0..9, A..F, a..f

Examples

select 0x6F4A0D3 from rdb$database -- returns 117088467
select 0x4F9 from rdb$database -- returns 1273
select 0x6E44F9A8 from rdb$database -- returns 1850014120
select 0x9E44F9A8 from rdb$database -- returns -1639646808 (an INTEGER)
select 0x09E44F9A8 from rdb$database -- returns 2655320488 (a BIGINT)
select 0x28ED678A4C987 from rdb$database -- returns 720001751632263
select 0xFFFFFFFFFFFFFFFF from rdb$database -- returns -1

Hexadecimal Value Ranges

- Hex numbers in the range 0 .. 7FFF FFFF are positive INTEGERS with values between 0 .. 2147483647 decimal. To coerce a number to BIGINT, prepend enough zeroes to bring the total number of hex digits to nine or above. That changes the type but not the value.
- Hex numbers between 8000 0000 .. FFFF FFFF require some attention:
  - When written with eight hex digits, as in 0x9E44F9A8, a value is interpreted as 32-bit INTEGER. Since the leftmost bit (sign bit) is set, it maps to the negative range -2147483648 .. -1 decimal.
  - With one or more zeroes prepended, as in 0x09E44F9A8, a value is interpreted as 64-bit BIGINT in the range 0000 0000 8000 0000 .. 0000 0000 FFFF FFFF. The sign bit is not set now, so they map to the positive range 2147483648 .. 4294967295 decimal.

Thus, in this range — and only in this range — prepending a mathematically insignificant 0 results in a totally different value. This is something to be aware of.

- Hex numbers between 1 0000 0000 .. 7FFF FFFF FFFF FFFF are all positive BIGINT.
- Hex numbers between 8000 0000 0000 0000 .. FFFF FFFF FFFF FFFF are all negative BIGINT.
- A SMALLINT cannot be written in hex, strictly speaking, since even 0x1 is evaluated as INTEGER.
However, if you write a positive integer within the 16-bit range `0x0000` (decimal zero) to `0x7FFF` (decimal 32767) it will be converted to SMALLINT transparently.

It is possible to write to a negative SMALLINT in hex, using a 4-byte hex number within the range `0xFFFF8000` (decimal -32768) to `0xFFFFFFFF` (decimal -1).

**Boolean Literals**

A Boolean literal is one of TRUE, FALSE or UNKNOWN.

**Datetime Literals**

Formally, the SQL standard defines datetime literals as a prefix DATE, TIME and TIMESTAMP followed by a string literal with a datetime format. Historically, Firebird documentation has referred to these datetime literals as "shorthand casts".

In Firebird 4.0, the use of datetime mnemonics in datetime literals (e.g. DATE 'TODAY') is no longer allowed.

The format of datetime literals and strings in Firebird 4.0 is more strict compared to earlier Firebird versions.

**Datetime Literal Syntax**

```
<datetime_literal> ::= 
    DATE '<<date_format>>'
  | TIME { '<<time_format>>' | '<<time_tz_format>>' }
  | TIMESTAMP { '<<timestamp_format>>' | '<<timestamp_tz_format>>' }
```
Datetime Format Syntax

```xml
<date_format> ::= 
    [YYYY<p>]MM<p>DD
    | MM<p>DD[<p>{ YYYY | YY }]
    | DD<p>MM[<p>{ YYYY | YY }]

<time_format> ::= HH[:mm:ss<f][NNNN]]

<timestamp_format> ::= <date_format> [<space> <time_format>]

<time_zone> ::= 
    { + | - }HH:MM
    | time zone name (e.g. Europe/Berlin)

<time_tz_format> ::= <time_format> [<space>] <time_zone>

<timestamp_tz_format> ::= <timestamp_format> [<space>] <time_zone>

<p> ::= whitespace | . | - | /
<f> ::= : | .
```

Table 21. Date and Time Literal Format Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>datetime_literal</td>
<td>Datetime literal</td>
</tr>
<tr>
<td>date_format</td>
<td>Format of date</td>
</tr>
<tr>
<td>time_format</td>
<td>Format of time</td>
</tr>
<tr>
<td>timestamp_format</td>
<td>Format of timestamp</td>
</tr>
<tr>
<td>time_zone</td>
<td>Format of time zone</td>
</tr>
<tr>
<td>time_tz_format</td>
<td>Format of time with time zone</td>
</tr>
<tr>
<td>timestamp_tz_format</td>
<td>Format of timestamp with time zone</td>
</tr>
<tr>
<td>YYYY</td>
<td>Four-digit year</td>
</tr>
<tr>
<td>YY</td>
<td>Two-digit year</td>
</tr>
<tr>
<td>MM</td>
<td>Month It may contain 1 or 2 digits (1-12 or 01-12). You can also specify</td>
</tr>
<tr>
<td></td>
<td>the three-letter shorthand name or the full name of a month in English.</td>
</tr>
<tr>
<td></td>
<td>Case-insensitive</td>
</tr>
<tr>
<td>DD</td>
<td>Day. It may contain 1 or 2 digits (1-31 or 01-31)</td>
</tr>
<tr>
<td>HH</td>
<td>Hour. It may contain 1 or 2 digits (0-23 or 00-23)</td>
</tr>
<tr>
<td>mm</td>
<td>Minutes. It may contain 1 or 2 digits (0-59 or 00-59)</td>
</tr>
<tr>
<td>SS</td>
<td>Seconds. It may contain 1 or 2 digits (0-59 or 00-59)</td>
</tr>
<tr>
<td>NNNN</td>
<td>Ten-thousandths of a second. It may contain from 1 to 4 digits (0-9999)</td>
</tr>
</tbody>
</table>
A date separator, any of permitted characters. Leading and trailing spaces are ignored. The choice of separator in a date decides whether the parser reads \( \text{MM}<p>DD \) or \( DD<p>MM \).

Fractional seconds separator

Use of the complete specification of the year in the four-digit form — YYYY — is strongly recommended, to avoid confusion in date calculations and aggregations.

Example

```sql
-- 1
UPDATE PEOPLE
SET AGECAT = 'SENIOR'
WHERE BIRTHDATE < DATE '1-Jan-1943';
-- 2
INSERT INTO APPOINTMENTS
(EMPLOYEE_ID, CLIENT_ID, APP_DATE, APP_TIME)
VALUES (973, 8804, DATE '1-Jan-2021' + 2, TIME '16:00');
-- 3
NEW.LASTMOD = TIMESTAMP '1-Jan-2021 16:00';
```

Although the Firebird datetime syntax is very flexible, to avoid ambiguity we recommend using the ISO-8601 order (year-month-day), ‘-’ as the date separator, 4 digits for year, 2 digits for month, day, minute and second, and ‘.’ as second.fractions separator. This format is also the only one defined in the SQL standard.

In short, use `TIMESTAMP '2021-05-03 04:05:00.1 +02:00'`, not `TIMESTAMP '3.5.21 4:5:0:1 +2:0'`.

4.1.2. SQL Operators

SQL operators comprise operators for comparing, calculating, evaluating and concatenating values.

Operator Precedence

SQL Operators are divided into four types. Each operator type has a precedence, a ranking that determines the order in which operators and the values obtained with their help are evaluated in an expression. The higher the precedence of the operator type is, the earlier it will be evaluated. Each operator has its own precedence within its type, that determines the order in which they are evaluated in an expression.

Operators with the same precedence are evaluated from left to right. To force a different evaluation order, operations can be grouped by means of parentheses.

Table 22. Operator Type Precedence
<table>
<thead>
<tr>
<th>Operator Type</th>
<th>Precedence</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concatenation</td>
<td>1</td>
<td>Strings are concatenated before any other operations take place</td>
</tr>
<tr>
<td>Arithmetic</td>
<td>2</td>
<td>Arithmetic operations are performed after strings are concatenated, but before comparison and logical operations</td>
</tr>
<tr>
<td>Comparison</td>
<td>3</td>
<td>Comparison operations take place after string concatenation and arithmetic operations, but before logical operations</td>
</tr>
<tr>
<td>Logical</td>
<td>4</td>
<td>Logical operators are executed after all other types of operators</td>
</tr>
</tbody>
</table>

**Concatenation Operator**

The concatenation operator, two pipe characters known as “double pipe”—‘||’—concatenates (connects together) two character strings to form a single string. Character strings can be constants or values obtained from columns or other expressions.

**Example**

```sql
SELECT LAST_NAME || ', ' || FIRST_NAME AS FULL_NAME
FROM EMPLOYEE
```

**Arithmetic Operators**

**Table 23. Arithmetic Operator Precedence**

<table>
<thead>
<tr>
<th>Operator</th>
<th>Purpose</th>
<th>Precedence</th>
</tr>
</thead>
<tbody>
<tr>
<td>+signed_number</td>
<td>Unary plus</td>
<td>1</td>
</tr>
<tr>
<td>-signed_number</td>
<td>Unary minus</td>
<td>1</td>
</tr>
<tr>
<td>*</td>
<td>Multiplication</td>
<td>2</td>
</tr>
<tr>
<td>/</td>
<td>Division</td>
<td>2</td>
</tr>
<tr>
<td>+</td>
<td>Addition</td>
<td>3</td>
</tr>
<tr>
<td>-</td>
<td>Subtraction</td>
<td>3</td>
</tr>
</tbody>
</table>

**Example**

```sql
UPDATE T
SET A = 4 + 1/(B-C)*D
```

Where operators have the same precedence, they are evaluated in left-to-right sequence.
Comparison Operators

Table 24. Comparison Operator Precedence

<table>
<thead>
<tr>
<th>Operator</th>
<th>Purpose</th>
<th>Precedence</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS</td>
<td>Checks that the expression on the left is (not) NULL or the Boolean value on the right</td>
<td>1</td>
</tr>
<tr>
<td>=</td>
<td>Is equal to, is identical to</td>
<td>2</td>
</tr>
<tr>
<td>&lt;&gt;</td>
<td>Is not equal to</td>
<td>2</td>
</tr>
<tr>
<td>&gt;</td>
<td>Is greater than</td>
<td>2</td>
</tr>
<tr>
<td>&lt;</td>
<td>Is less than</td>
<td>2</td>
</tr>
<tr>
<td>&gt;=</td>
<td>Is greater than or equal to</td>
<td>2</td>
</tr>
<tr>
<td>&lt;=</td>
<td>Is less than or equal to</td>
<td>2</td>
</tr>
<tr>
<td>!&gt;</td>
<td>Is not greater than</td>
<td>2</td>
</tr>
<tr>
<td>!&lt;</td>
<td>Is not less than</td>
<td>2</td>
</tr>
</tbody>
</table>

This group also includes comparison predicates BETWEEN, LIKE, CONTAINING, SIMILAR TO and others.

Example

```
IF (SALARY > 1400) THEN
...
```

See also

Other Comparison Predicates.

Logical Operators

Table 25. Logical Operator Precedence

<table>
<thead>
<tr>
<th>Operator</th>
<th>Purpose</th>
<th>Precedence</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOT</td>
<td>Negation of a search condition</td>
<td>1</td>
</tr>
<tr>
<td>AND</td>
<td>Combines two or more predicates, each of which must be true for the entire predicate to be true</td>
<td>2</td>
</tr>
<tr>
<td>OR</td>
<td>Combines two or more predicates, of which at least one predicate must be true for the entire predicate to be true</td>
<td>3</td>
</tr>
</tbody>
</table>

Example

```
IF (A < B OR (A > C AND A > D) AND NOT (C = D)) THEN ...
```

NEXT VALUE FOR

Available in
NEXT VALUE FOR sequence-name

NEXT VALUE FOR returns the next value of a sequence. SEQUENCE is the SQL-standard term for what is historically called a generator in Firebird and its ancestor, InterBase. The NEXT VALUE FOR operator is equivalent to the legacy GEN_ID (..., increment) function with increment the increment stored in the metadata of the sequence. It is the recommended syntax for retrieving the next sequence value.

Unlike the GEN_ID function, the NEXT VALUE FOR expression does not take any parameters and thus, provides no way to retrieve the current value of a sequence, nor to step the next value by a different value than the increment configured for the sequence. GEN_ID (..., <step value>) is still needed for these tasks. A step value of 0 returns the current sequence value.

The increment of a sequence can be configured with the INCREMENT clause of CREATE SEQUENCE or ALTER SEQUENCE.

Example

NEW.CUST_ID = NEXT VALUE FOR CUSTSEQ;

See also
SEQUENCE (GENERATOR), GEN_ID()

AT Time Zone Expression

Available in
DSQL, PSQL

Syntax

<at expr> ::= <expr> AT { TIME ZONE <time zone string> | LOCAL }

The AT expression expresses a datetime value in a different time zone, while keeping the same UTC instant.

AT translates a time/timestamp value to its corresponding value in another time zone. If LOCAL is used, the value is converted to the session time zone.

When expr is a WITHOUT TIME ZONE type, expr is first converted to a WITH TIME ZONE in the session time zone and then transformed to the specified time zone.
Examples

```sql
select time '12:00 GMT' at time zone '-03:00' from rdb$database;
select current_timestamp at time zone 'America/Sao_Paulo' from rdb$database;
select timestamp '2018-01-01 12:00 GMT' at local from rdb$database;
```

### 4.1.3. Conditional Expressions

A conditional expression is one that returns different values according to how a certain condition is met. It is composed by applying a conditional function construct, of which Firebird supports several. This section describes only one conditional expression construct: **CASE**. All other conditional expressions apply internal functions derived from **CASE** and are described in [Conditional Functions](#).

**CASE**

**Available in**

DSQL, PSQL

The **CASE** construct returns a single value from a number of possible values. Two syntactic variants are supported:

- The **simple CASE**, comparable to a *case construct* in Pascal or a *switch* in C
- The **searched CASE**, which works like a series of "if … else if … else if" clauses.

**Simple CASE**

**Syntax**

```sql
...
CASE <test-expr>
  WHEN <expr> THEN <result>
  [WHEN <expr> THEN <result> ...]
  [ELSE <defaultresult>]
END
...
```

When this variant is used, *test-expr* is compared to the first *expr*, second *expr* and so on, until a match is found, and the corresponding result is returned. If no match is found, *defaultresult* from the optional ELSE clause is returned. If there are no matches and no ELSE clause, NULL is returned.

The matching works identically to the "=" operator. That is, if *test-expr* is NULL, it does not match any *expr*, not even an expression that resolves to NULL.

The returned result does not have to be a literal value: it might be a field or variable name, compound expression or NULL literal.
Example

```
SELECT
    NAME,
    AGE,
    CASE UPPER(SEX)
        WHEN 'M' THEN 'Male'
        WHEN 'F' THEN 'Female'
        ELSE 'Unknown'
    END GENDER,
    RELIGION
    FROM PEOPLE
```

A short form of the simple CASE construct is the DECODE function.

**Searched CASE**

**Syntax**

```
CASE
    WHEN <bool_expr> THEN <result>
    […]
    [ELSE <defaultresult>]
END
```

The *bool_expr* expression is one that gives a ternary logical result: TRUE, FALSE or NULL. The first expression to return TRUE determines the result. If no expressions return TRUE, *defaultresult* from the optional ELSE clause is returned as the result. If no expressions return TRUE and there is no ELSE clause, the result will be NULL.

As with the simple CASE construct, the result need not be a literal value: it might be a field or variable name, a compound expression, or be NULL.

**Example**

```
CANVOTE = CASE
    WHEN AGE >= 18 THEN 'Yes'
    WHEN AGE < 18 THEN 'No'
    ELSE 'Unsure'
END
```

### 4.1.4. NULL in Expressions

NULL is not a value in SQL, but a state indicating that the value of the element either is unknown or it does not exist. It is not a zero, nor a void, nor an “empty string”, and it does not act like any value.

When you use NULL in numeric, string or date/time expressions, the result will always be NULL. When you use NULL in logical (Boolean) expressions, the result will depend on the type of the operation and on other participating values. When you compare a value to NULL, the result will be unknown.
NULL means NULL but, in Firebird, the logical result unknown is also represented by NULL.

**Expressions Returning NULL**

Expressions in this list will always return NULL:

1 + 2 + 3 + NULL
'Home ' || 'sweet ' || NULL
MyField = NULL
MyField <> NULL
NULL = NULL
not (NULL)

If it seems difficult to understand why, remember that NULL is a state that stands for “unknown”.

**NULL in Logical Expressions**

It has already been shown that NOT (NULL) results in NULL. The interaction is a bit more complicated for the logical AND and logical OR operators:

NULL or false → NULL
NULL or true → true
NULL or NULL → NULL
NULL and false → false
NULL and true → NULL
NULL and NULL → NULL

As a basic rule-of-thumb, if applying TRUE instead of NULL produces a different result than applying FALSE, then the outcome of the original expression is unknown, or NULL.

**Examples**

(1 = NULL) or (1 <> 1) → returns NULL
(1 = NULL) or FALSE → returns NULL
(1 = NULL) or (1 = 1) → returns TRUE
(1 = NULL) or TRUE → returns TRUE
(1 = NULL) or (1 = NULL) → returns NULL
(1 = NULL) or UNKNOWN → returns NULL
(1 = NULL) and (1 <> 1) → returns FALSE
(1 = NULL) and FALSE → returns FALSE
(1 = NULL) and (1 = 1) → returns NULL
(1 = NULL) and TRUE → returns NULL
(1 = NULL) and (1 = NULL) → returns NULL
(1 = NULL) and UNKNOWN → returns NULL
4.1.5. Subqueries

A subquery is a special form of expression that is actually a query embedded within another query. Subqueries are written in the same way as regular SELECT queries, but they must be enclosed in parentheses. Subquery expressions can be used in the following ways:

- To specify an output column in the SELECT list
- To obtain values or conditions for search predicates (the WHERE, HAVING clauses).
- To produce a set that the enclosing query can select from, as though were a regular table or view. Subqueries like this appear in the FROM clause (derived tables) or in a Common Table Expression (CTE).

**Correlated Subqueries**

A subquery can be correlated. A query is correlated when the subquery and the main query are interdependent. To process each record in the subquery, it is necessary to fetch a record in the main query; i.e. the subquery fully depends on the main query.

**Sample Correlated Subquery**

```
SELECT *
FROM Customers C
WHERE EXISTS
  (SELECT *
    FROM Orders O
    WHERE C.cnum = O.cnum
    AND O.adate = DATE '10.03.1990');
```

When subqueries are used to get the values of the output column in the SELECT list, a subquery must return a scalar result (see below).

**Scalar Results**

Subqueries used in search predicates, other than existential and quantified predicates, must return a scalar result; that is, not more than one column from not more than one matching row or aggregation. If the result would return more, a run-time error will occur (“Multiple rows in a singleton select...”).

Although it is reporting a genuine error, the message can be slightly misleading. A “singleton SELECT” is a query that must not be capable of returning more than one row. However, “singleton” and “scalar” are not synonymous: not all singleton SELECTS are required to be scalar; and single-column selects can return multiple rows for existential and quantified predicates.

**Subquery Examples**

1. A subquery as the output column in a SELECT list:
SELECT
e.first_name,
e.last_name,
(SELECT
    sh.new_salary
FROM
    salary_history sh
WHERE
    sh.emp_no = e.emp_no
ORDER BY sh.change_date DESC ROWS 1) AS last_salary
FROM
employee e

2. A subquery in the WHERE clause for obtaining the employee’s maximum salary and filtering by it:

SELECT
e.first_name,
e.last_name,
e.salary
FROM employee e
WHERE
    e.salary = (SELECT MAX(ie.salary)
                FROM employee ie )

4.2. Predicates

A predicate is a simple expression asserting some fact, let’s call it P. If P resolves as TRUE, it succeeds. If it resolves to FALSE or NULL (UNKNOWN), it fails. A trap lies here, though: suppose the predicate, P, returns FALSE. In this case NOT(P) will return TRUE. On the other hand, if P returns NULL (unknown), then NOT(P) returns NULL as well.

In SQL, predicates can appear in CHECK constraints, WHERE and HAVING clauses, CASE expressions, the IIF() function and in the ON condition of JOIN clauses, and anywhere a normal expression can occur.

4.2.1. Conditions

A condition — or Boolean expression — is a statement about the data that, like a predicate, can resolve to TRUE, FALSE or NULL. Conditions consist of one or more predicates, possibly negated using NOT and connected by AND and OR operators. Parentheses may be used for grouping predicates and controlling evaluation order.

A predicate may embed other predicates. Evaluation sequence is in the outward direction, i.e., the innermost predicates are evaluated first. Each “level” is evaluated in precedence order until the truth value of the ultimate condition is resolved.
4.2.2. Comparison Predicates

A comparison predicate consists of two expressions connected with a comparison operator. There are six traditional comparison operators:

\[=, >, <, \geq, \leq, \neq\]

For the complete list of comparison operators with their variant forms, see Comparison Operators.

If one of the sides (left or right) of a comparison predicate has NULL in it, the value of the predicate will be UNKNOWN.

**Examples**

1. Retrieve information about computers with the CPU frequency not less than 500 MHz and the price lower than $800:

   ```sql
   SELECT *
   FROM Pc
   WHERE speed >= 500 AND price < 800;
   ```

2. Retrieve information about all dot matrix printers that cost less than $300:

   ```sql
   SELECT *
   FROM Printer
   WHERE ptrtype = 'matrix' AND price < 300;
   ```

3. The following query will return no data, even if there are printers with no type specified for them, because a predicate that compares NULL with NULL returns NULL:

   ```sql
   SELECT *
   FROM Printer
   WHERE ptrtype = NULL AND price < 300;
   ```

   On the other hand, ptrtype can be tested for NULL and return a result: it is just that it is not a comparison test:

   ```sql
   SELECT *
   FROM Printer
   WHERE ptrtype IS NULL AND price < 300;
   ```

   —see IS [NOT] NULL.
Note about String Comparison
When CHAR and VARCHAR fields are compared for equality, trailing spaces are ignored in all cases.

Other Comparison Predicates
Other comparison predicates are marked by keyword symbols.

**BETWEEN**

*Available in*
DSQL, PSQL, ESQL

*Syntax*

```sql
<value> [NOT] BETWEEN <value_1> AND <value_2>
```

The BETWEEN predicate tests whether a value falls within a specified range of two values. (NOT BETWEEN tests whether the value does not fall within that range.)

The operands for BETWEEN predicate are two arguments of compatible data types. Unlike in some other DBMS, the BETWEEN predicate in Firebird is not symmetrical — if the lower value is not the first argument, the BETWEEN predicate will always return FALSE. The search is inclusive (the values represented by both arguments are included in the search). In other words, the BETWEEN predicate could be rewritten:

```sql
<value> >= <value_1> AND <value> <= <value_2>
```

When BETWEEN is used in the search conditions of DML queries, the Firebird optimizer can use an index on the searched column, if it is available.

*Example*

```sql
SELECT *
FROM EMPLOYEE
WHERE HIRE_DATE BETWEEN date '1992-01-01' AND CURRENT_DATE
```

**LIKE**

*Available in*
DSQL, PSQL, ESQL
Syntax

```plaintext
<match_value>  [NOT] LIKE <pattern>
               [ESCAPE <escape character>]
```

```plaintext
<match_value> ::= character-type expression
<pattern> ::= search pattern
<escape character> ::= escape character
```

The LIKE predicate compares the character-type expression with the pattern defined in the second expression. Case- or accent-sensitivity for the comparison is determined by the collation that is in use. A collation can be specified for either operand, if required.

**Wildcards**

Two wildcard symbols are available for use in the search pattern:

- the percentage symbol (%) will match any sequence of zero or more characters in the tested value
- the underscore character (_) will match any single character in the tested value

If the tested value matches the pattern, taking into account wildcard symbols, the predicate is TRUE.

**Using the ESCAPE Character Option**

If the search string contains either of the wildcard symbols, the ESCAPE clause can be used to specify an escape character. The escape character must precede the `%` or `_` symbol in the search string, to indicate that the symbol is to be interpreted as a literal character.

**Examples using LIKE**

1. Find the numbers of departments whose names start with the word “Software”:

   ```sql
   SELECT DEPT_NO
   FROM DEPT
   WHERE DEPT_NAME LIKE 'Software%';
   ```

   It is possible to use an index on the DEPT_NAME field if it exists.

   **About LIKE and the Optimizer**

   Actually, the LIKE predicate does not use an index. However, if the predicate takes the form of LIKE 'string%', it will be converted to the STARTING WITH predicate, which will use an index. This optimization only works for literal patterns, not for parameters.

   So, if you need to search for the beginning of a string, it is recommended to use the STARTING WITH predicate instead of the LIKE predicate.
2. Search for employees whose names consist of 5 letters, start with the letters “Sm” and end with “th”. The predicate will be true for such names as “Smith” and “Smyth”.

```
SELECT first_name
FROM employee
WHERE first_name LIKE 'Sm_th'
```

3. Search for all clients whose address contains the string “Rostov”:

```
SELECT *
FROM CUSTOMER
WHERE ADDRESS LIKE '%Rostov%'
```

If you need to do a case-insensitive search for something enclosed inside a string (LIKE '%Abc%'), use of the `CONTAINING` predicate is recommended, in preference to the LIKE predicate.

4. Search for tables containing the underscore character in their names. The ‘#’ character is used as the escape character:

```
SELECT RDB$RELATION_NAME
FROM RDB$RELATIONS
WHERE RDB$RELATION_NAME LIKE '%#_%' ESCAPE '#'
```

See also

`STARTING WITH, CONTAINING, SIMILAR TO`

`STARTING WITH`

Available in

DSQL, PSQL, ESQL

Syntax

```
<value> [NOT] STARTING WITH <value>
```

The `STARTING WITH` predicate searches for a string or a string-like type that starts with the characters in its `value` argument. The case- and accent-sensitivity of `STARTING WITH` depends on the collation of the first `value`.

When `STARTING WITH` is used in the search conditions of DML queries, the Firebird optimizer can use an index on the searched column, if it exists.
Example

Search for employees whose last names start with “Jo”:

```sql
SELECT LAST_NAME, FIRST_NAME
FROM EMPLOYEE
WHERE LAST_NAME STARTING WITH 'Jo'
```

See also

LIKE

CONTAINING

Available in

DSQL, PSQL, ESQL

Syntax

```
<value> [NOT] CONTAINING <value>
```

The CONTAINING predicate searches for a string or a string-like type looking for the sequence of characters that matches its argument. It can be used for an alphanumeric (string-like) search on numbers and dates. A CONTAINING search is not case-sensitive. However, if an accent-sensitive collation is in use then the search will be accent-sensitive.

Examples

1. Search for projects whose names contain the substring “Map”:

   ```sql
   SELECT *
   FROM PROJECT
   WHERE PROJ_NAME CONTAINING 'Map';
   ```

   Two rows with the names “AutoMap” and “MapBrowser port” are returned.

2. Search for changes in salaries with the date containing number 84 (in this case, it means changes that took place in 1984):

   ```sql
   SELECT *
   FROM SALARY_HISTORY
   WHERE CHANGE_DATE CONTAINING 84;
   ```

See also

LIKE

SIMILAR TO

Available in
DSQL, PSQL

Syntax

\[
\text{string-expression} \ [\text{NOT}] \ \text{SIMILAR TO} \ \langle \text{pattern} \rangle \ [\text{ESCAPE} \ \langle \text{escape-char} \rangle ]
\]

\[
\langle \text{pattern} \rangle \ ::= \text{an SQL regular expression}
\]

\[
\langle \text{escape-char} \rangle \ ::= \text{a single character}
\]

SIMILAR TO matches a string against an SQL regular expression pattern. Unlike in some other languages, the pattern must match the entire string in order to succeed — matching a substring is not enough. If any operand is NULL, the result is NULL. Otherwise, the result is TRUE or FALSE.

**Syntax: SQL Regular Expressions**

The following syntax defines the SQL regular expression format. It is a complete and correct top-down definition. It is also highly formal, rather long and probably perfectly fit to discourage everybody who hasn’t already some experience with regular expressions (or with highly formal, rather long top-down definitions). Feel free to skip it and read the next section, **Building Regular Expressions**, which uses a bottom-up approach, aimed at the rest of us.
Building Regular Expressions

In this section are the elements and rules for building SQL regular expressions.

Characters

Within regular expressions, most characters represent themselves. The only exceptions are the special characters below:

```
[ ] ( ) | ^ - + * % _ ? { }
```
... and the escape character, if it is defined.

A regular expression that contains no special character or escape characters matches only strings that are identical to itself (subject to the collation in use). That is, it functions just like the ‘=’ operator:

```
'Apple' similar to 'Apple'   -- true
'Apples' similar to 'Apple'  -- false
'Apple' similar to 'Apples'  -- false
'APPLE' similar to 'Apple'   -- depends on collation
```

### Wildcards

The known SQL wildcards ‘_’ and ‘%’ match any single character and a string of any length, respectively:

```
'Birne' similar to 'B_rne'   -- true
'Birne' similar to 'B_ne'    -- false
'Birne' similar to 'B%ne'    -- true
'Birne' similar to 'Bir%ne%' -- true
'Birne' similar to 'Birr%ne' -- false
```

Notice how ‘%’ also matches the empty string.

### Character Classes

A bunch of characters enclosed in brackets define a character class. A character in the string matches a class in the pattern if the character is a member of the class:

```
'Citroen' similar to 'Cit[arju]oen'  -- true
'Citroen' similar to 'Ci[tr]oen'     -- false
'Citroen' similar to 'Ci[tr][tr]oen' -- true
```

As can be seen from the second line, the class only matches a single character, not a sequence.

Within a class definition, two characters connected by a hyphen define a range. A range comprises the two endpoints and all the characters that lie between them in the active collation. Ranges can be placed anywhere in the class definition without special delimiters to keep them apart from the other elements.

```
'Datte' similar to 'Dat[q-u]e'   -- true
'Datte' similar to 'Dat[abq-uy]e' -- true
'Datte' similar to 'Dat[bcg-km-pwz]e' -- false
```

### Predefined Character Classes
The following predefined character classes can also be used in a class definition:

[:ALPHA:]
Latin letters a..z and A..Z. With an accent-insensitive collation, this class also matches accented forms of these characters.

[:DIGIT:]
Decimal digits 0..9.

[:ALNUM:]
Union of [:ALPHA:] and [:DIGIT:].

[:UPPER:]
Uppercase Latin letters A..Z. Also matches lowercase with case-insensitive collation and accented forms with accent-insensitive collation.

[:LOWER:]
Lowercase Latin letters a..z. Also matches uppercase with case-insensitive collation and accented forms with accent-insensitive collation.

[:SPACE:]
Matches the space character (ASCII 32).

[:WHITESPACE:]
Matches horizontal tab (ASCII 9), linefeed (ASCII 10), vertical tab (ASCII 11), formfeed (ASCII 12), carriage return (ASCII 13) and space (ASCII 32).

Including a predefined class has the same effect as including all its members. Predefined classes are only allowed within class definitions. If you need to match against a predefined class and nothing more, place an extra pair of brackets around it.

'Erdbeere' similar to 'Erd[:ALNUM:]eere'     -- true
'Erdbeere' similar to 'Erd[:DIGIT:]eere'     -- false
'Erdbeere' similar to 'Erda[:SPACE:]b)eere'   -- true
'Erdbeere' similar to [:ALPHA:]                -- false
'E'        similar to [:ALPHA:]                -- true

If a class definition starts with a caret, everything that follows is excluded from the class. All other characters match:

'Framboise' similar to 'Fra[^ck-p]boise'       -- false
'Framboise' similar to 'Fr[^a][^a]boise'       -- false
'Framboise' similar to 'Fra[^[:DIGIT:]]boise'  -- true

If the caret is not placed at the start of the sequence, the class contains everything before the caret, except for the elements that also occur after the caret:
Lastly, the already mentioned wildcard ‘_’ is a character class of its own, matching any single character.

**Quantifiers**

A question mark (‘?’) immediately following a character or class indicates that the preceding item may occur 0 or 1 times in order to match:

- ‘Hallon’ similar to ‘Hal?on’ -- false
- ‘Hallon’ similar to ‘Hal?lon’ -- true
- ‘Hallon’ similar to ‘Halll?on’ -- true
- ‘Hallon’ similar to ‘Hallll?on’ -- false
- ‘Hallon’ similar to ‘Halx?lon’ -- true
- ‘Hallon’ similar to ‘H[a-c]?llon[x-z]?’ -- true

An asterisk (‘*’) immediately following a character or class indicates that the preceding item may occur 0 or more times in order to match:

- ‘Icaque’ similar to ‘Ica*que’ -- true
- ‘Icaque’ similar to ‘Icar*que’ -- true
- ‘Icaque’ similar to ‘I[a-c]*que’ -- true
- ‘Icaque’ similar to ‘*_’ -- true
- ‘Icaque’ similar to ‘[[:ALPHA:]]*’ -- true
- ‘Icaque’ similar to ‘Ica[xyz]*e’ -- false

A plus sign (‘+’) immediately following a character or class indicates that the preceding item must occur 1 or more times in order to match:

- ‘Jujube’ similar to ‘Ju_+’ -- true
- ‘Jujube’ similar to ‘Ju+jube’ -- true
- ‘Jujube’ similar to ‘Jujuber+’ -- false
- ‘Jujube’ similar to ‘J[jux]+be’ -- true
- ‘Jujube’ similar to ‘J[[:DIGIT:]]+ujube’ -- false

If a character or class is followed by a number enclosed in braces (‘{’ and ‘}’), it must be repeated exactly that number of times in order to match:
If the number is followed by a comma (','), the item must be repeated at least that number of times in order to match:

- 'Limone' similar to 'Li{2,}mone' -- false
- 'Limone' similar to 'Li{1,}mone' -- true
- 'Limone' similar to 'Li[nezom]{2,}' -- true

If the braces contain two numbers separated by a comma, the second number not smaller than the first, then the item must be repeated at least the first number and at most the second number of times in order to match:

- 'Mandarijn' similar to 'M[a-p]{2,5}rijn' -- true
- 'Mandarijn' similar to 'M[a-p]{2,3}rijn' -- false
- 'Mandarijn' similar to 'M[a-p]{2,3}arijn' -- true

The quantifiers '?', '*' and '+' are shorthand for \{0,1\}, \{0,\} and \{1,\}, respectively.

**OR-ing Terms**

Regular expression terms can be OR'ed with the '|' operator. A match is made when the argument string matches at least one of the terms:

- 'Nektarin' similar to 'Nek|tarin' -- false
- 'Nektarin' similar to 'Nektarin|Persika' -- true
- 'Nektarin' similar to 'M_+|N_+|P_+' -- true

**Subexpressions**

One or more parts of the regular expression can be grouped into subexpressions (also called subpatterns) by placing them between parentheses ('(' and ')'). A subexpression is a regular expression in its own right. It can contain all the elements allowed in a regular expression, and can also have quantifiers added to it.

- 'Orange' similar to 'O(ra|ri|ro)nge' -- true
- 'Orange' similar to 'O(r[a-e])+nge' -- true
- 'Orange' similar to 'O(ra){2,4}nge' -- false
- 'Orange' similar to 'O(r(an|in)g|rong)?e' -- true

**Escaping Special Characters**
In order to match against a character that is special in regular expressions, that character has to be escaped. There is no default escape character; rather, the user specifies one when needed:

\'
Peer (Poire)\' similar to 'P[^ ]+ \(P[^ ]+\)' escape '\'
-- true
\'
Pera [Pear]\' similar to 'P[^ ]+ \#[P[^ ]+\#]' escape '#'
-- true
\'
Päron-äppledryck\' similar to 'P%$-ä%' escape '$'
-- true
\'
Pärondryck\' similar to 'P%--ä%' escape '-'
-- false

The last line demonstrates that the escape character can also escape itself, if needed.

**IS [NOT] DISTINCT FROM**

*Available in*

DSQL, PSQL

**Syntax**

<operand1> IS [NOT] DISTINCT FROM <operand2>

Two operands are considered *DISTINCT* (different) if they have a different value or if one of them is NULL and the other non-null. They are considered *NOT DISTINCT* (equal) if they have the same value or if both of them are NULL.

**IS [NOT] DISTINCT FROM** always returns TRUE or FALSE and never UNKNOWN (NULL) (unknown value). Operators ‘=’ and ‘<>’, conversely, will return UNKNOWN (NULL) if one or both operands are NULL.

**Table 26. Results of Various Comparison Predicates**

<table>
<thead>
<tr>
<th>Operand values</th>
<th>=</th>
<th>IS NOT DISTINCT FROM</th>
<th>&lt;&gt;</th>
<th>IS DISTINCT FROM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same value</td>
<td>TRUE</td>
<td>TRUE</td>
<td>FALSE</td>
<td>FALSE</td>
</tr>
<tr>
<td>Different values</td>
<td>FALSE</td>
<td>FALSE</td>
<td>TRUE</td>
<td>TRUE</td>
</tr>
<tr>
<td>Both NULL</td>
<td>UNKNOWN</td>
<td>TRUE</td>
<td>UNKNOWN</td>
<td>FALSE</td>
</tr>
<tr>
<td>One NULL, one non-NULL</td>
<td>UNKNOWN</td>
<td>FALSE</td>
<td>UNKNOWN</td>
<td>TRUE</td>
</tr>
</tbody>
</table>

**Examples**

```sql
SELECT ID, NAME, TEACHER
FROM COURSES
WHERE START_DAY IS NOT DISTINCT FROM END_DAY;
```

-- PSQL fragment

```sql
IF (NEW.JOB IS DISTINCT FROM OLD.JOB)
THEN POST_EVENT 'JOB_CHANGED';
```

---

Chapter 4. Common Language Elements

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See also
IS [NOT] NULL, Boolean IS [NOT]

Boolean IS [NOT]

Available in
DSQL, PSQL

Syntax

<value> IS [NOT] { TRUE | FALSE | UNKNOWN }

The IS predicate with Boolean literal values checks if the expression on the left side matches the Boolean value on the right side. The expression on the left side must be of type BOOLEAN, otherwise an exception is raised.

The IS [NOT] UNKNOWN is equivalent to IS [NOT] NULL.

The right side of the predicate only accepts the literals TRUE, FALSE and UNKNOWN (and NULL). It does not accept expressions.

Using the IS predicate with a Boolean data type

-- Checking FALSE value
SELECT * FROM TBOOL WHERE BVAL IS FALSE;

<table>
<thead>
<tr>
<th>ID</th>
<th>BVAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>&lt;false&gt;</td>
</tr>
</tbody>
</table>

-- Checking UNKNOWN value
SELECT * FROM TBOOL WHERE BVAL IS UNKNOWN;

<table>
<thead>
<tr>
<th>ID</th>
<th>BVAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>&lt;null&gt;</td>
</tr>
</tbody>
</table>

See also
IS [NOT] NULL

IS [NOT] NULL

Available in
DSQL, PSQL, ESQL

Syntax

<value> IS [NOT] NULL
Since NULL is not a value, these operators are not comparison operators. The IS [NOT] NULL predicate tests that the expression on the left side has a value (IS NOT NULL) or has no value (IS NULL).

Example

Search for sales entries that have no shipment date set for them:

```sql
SELECT * FROM SALES
WHERE SHIP_DATE IS NULL;
```

Note regarding the IS predicates

Up to and including Firebird 2.5, the IS predicates, like the other comparison predicates, do not have precedence over the others. In Firebird 3.0 and higher, these predicates take precedence above the others.

4.2.3. Existential Predicates

This group of predicates includes those that use subqueries to submit values for all kinds of assertions in search conditions. Existential predicates are so called because they use various methods to test for the existence or non-existence of some condition, returning TRUE if the existence or non-existence is confirmed or FALSE otherwise.

**EXISTS**

*Available in*

DSQL, PSQL, ESQL

*Syntax*

```sql
[NOT] EXISTS (<select_stmt>)
```

The EXISTS predicate uses a subquery expression as its argument. It returns TRUE if the subquery result would contain at least one row; otherwise it returns FALSE.

NOT EXISTS returns FALSE if the subquery result would contain at least one row; it returns TRUE otherwise.

The subquery can specify multiple columns, or SELECT *, because the evaluation is made on the number of rows that match its criteria, not on the data.

*Examples*

1. Find those employees who have projects.
2. Find those employees who have no projects.

```
SELECT *
FROM employee
WHERE NOT EXISTS(SELECT *
                 FROM employee_project ep
                 WHERE ep.emp_no = employee.emp_no)
```

**IN**

*Available in*

DSQL, PSQL, ESQL

**Syntax**

```
<value> [NOT] IN (<select_stmt> | <value_list>)

<value_list> ::= <value_1> [, <value_2> …]
```

The IN predicate tests whether the value of the expression on the left side is present in the set of values specified on the right side. The set of values cannot have more than 1500 items. The IN predicate can be replaced with the following equivalent forms:

```
(value > <value_1> [OR <value> = <value_2> …])

<value> = { ANY | SOME } (<select_stmt>)
```

When the IN predicate is used in the search conditions of DML queries, the Firebird optimizer can use an index on the searched column, if a suitable one exists.

In its second form, the IN predicate tests whether the value of the expression on the left side is present — or not present, if NOT IN is used — in the result of the executed subquery on the right side.

The subquery must be specified to result in only one column, otherwise the error “`count of column list and variable list do not match`” will occur.

Queries specified using the IN predicate with a subquery can be replaced with a similar query using the EXISTS predicate. For instance, the following query:
can be replaced with a similar one using the EXISTS predicate:

```sql
SELECT model, speed, hd
FROM PC
WHERE
model IN (SELECT *
FROM product
WHERE maker = 'A');
```

However, a query using NOT IN with a subquery does not always give the same result as its NOT EXISTS counterpart. The reason is that EXISTS always returns TRUE or FALSE, whereas IN returns NULL in one of these two cases:

a. when the test value is NULL and the IN () list is not empty

b. when the test value has no match in the IN () list and at least one list element is NULL

It is in only these two cases that IN () will return NULL while the corresponding EXISTS predicate will return FALSE ('no matching row found'). In a search or, for example, an IF (…) statement, both results mean “failure” and it makes no difference to the outcome.

But, for the same data, NOT IN () will return NULL, while NOT EXISTS will return TRUE, leading to opposite results.

As an example, suppose you have the following query:

```sql
-- Looking for people who were not born
-- on the same day as any famous New York citizen
SELECT P1.name AS NAME
FROM Personnel P1
WHERE P1.birthday NOT IN (SELECT C1.birthday
FROM Celebrities C1
WHERE C1.birthcity = 'New York');
```

Now, assume that the NY celebrities list is not empty and contains at least one NULL birthday. Then for every citizen who does not share his birthday with a NY celebrity, NOT IN will return NULL, because that is what IN does. The search condition is thereby not satisfied and the citizen will be left out of the SELECT result, which is wrong.
For citizens whose birthday does match with a celebrity's birthday, NOT IN will correctly return FALSE, so they will be left out too, and no rows will be returned.

If the NOT EXISTS form is used:

```sql
-- Looking for people who were not born
-- on the same day as any famous New York citizen
SELECT P1.name AS NAME
FROM Personnel P1
WHERE NOT EXISTS (SELECT *
FROM Celebrities C1
WHERE C1.birthcity = 'New York'
AND C1.birthday = P1.birthday);
```

non-matches will have a NOT EXISTS result of TRUE and their records will be in the result set.

If there is any chance of NULLs being encountered when searching for a non-match, you will want to use NOT EXISTS.

**Examples of use**

1. Find employees with the names “Pete”, “Ann” and “Roger”:

   ```sql
   SELECT *
   FROM EMPLOYEE
   WHERE FIRST_NAME IN ('Pete', 'Ann', 'Roger');
   ```

2. Find all computers that have models whose manufacturer starts with the letter “A”:

   ```sql
   SELECT model, speed, hd
   FROM PC
   WHERE model IN (SELECT model
                    FROM product
                    WHERE maker STARTING WITH 'A');
   ```

**See also**

EXISTS

SINGULAR

Available in

DSQL, PSQL, ESQL
The SINGULAR predicate takes a subquery as its argument and evaluates it as TRUE if the subquery returns exactly one result row; otherwise the predicate is evaluated as FALSE. The subquery may list several output columns since the rows are not returned anyway. They are only tested for (singular) existence. For brevity, people usually specify `SELECT *`. The SINGULAR predicate can return only two values: TRUE or FALSE.

**Example**
Find those employees who have only one project.

```sql
SELECT *
FROM employee
WHERE SINGULAR(SELECT *
               FROM employee_project ep
               WHERE ep.emp_no = employee.emp_no)
```

### 4.2.4. Quantified Subquery Predicates

A quantifier is a logical operator that sets the number of objects for which this condition is true. It is not a numeric quantity, but a logical one that connects the condition with the full set of possible objects. Such predicates are based on logical universal and existential quantifiers that are recognised in formal logic.

In subquery expressions, quantified predicates make it possible to compare separate values with the results of subqueries; they have the following common form:

```
<value expression> <comparison operator> <quantifier> <subquery>
```

**ALL**

*Available in*
DSQL, PSQL, ESQL

**Syntax**

```
<value> <op> ALL (<select_stmt>)
```

When the ALL quantifier is used, the predicate is TRUE if every value returned by the subquery satisfies the condition in the predicate of the main query.

**Example**
Show only those clients whose ratings are higher than the rating of every client in Paris.
If the subquery returns an empty set, the predicate is TRUE for every left-side value, regardless of the operator. This may appear to be contradictory, because every left-side value will thus be considered both smaller and greater than, both equal to and unequal to, every element of the right-side stream.

Nevertheless, it aligns perfectly with formal logic: if the set is empty, the predicate is true 0 times, i.e. for every row in the set.

**ANY and SOME**

*Available in*

DSQL, PSQL, ESQL

*Syntax*

```
<value> <op> {ANY | SOME} (<select_stmt>)
```

The quantifiers ANY and SOME are identical in their behaviour. Apparently, both are present in the SQL standard so that they could be used interchangeably in order to improve the readability of operators. When the ANY or the SOME quantifier is used, the predicate is TRUE if any of the values returned by the subquery satisfies the condition in the predicate of the main query. If the subquery would return no rows at all, the predicate is automatically considered as FALSE.

*Example*

Show only those clients whose ratings are higher than those of one or more clients in Rome.

```
SELECT *
FROM Customers
WHERE rating > ANY
  (SELECT rating
   FROM Customers
   WHERE city = 'Rome')
```
Chapter 5. Data Definition (DDL) Statements

DDL is the data definition language subset of Firebird's SQL language. DDL statements are used to create, modify and delete database objects that have been created by users. When a DDL statement is committed, the metadata for the object are created, changed or deleted.

5.1. DATABASE

This section describes how to create a database, connect to an existing database, alter the file structure of a database and how to delete one. It also explains how to back up a database in two quite different ways and how to switch the database to the “copy-safe” mode for performing an external backup safely.

5.1.1. CREATE DATABASE

Used for
Creating a new database

Available in
DSQL, ESQL
Syntax

\[
\text{CREATE } \{\text{DATABASE | SCHEMA} \} <\text{filespec}>
\]

[<db_initial_option> [<db_initial_option> ...]]

[<db_config_option> [<db_config_option> ...]]

<db_initial_option> ::= 
  USER username 
  | PASSWORD 'password'
  | ROLE rolename 
  | PAGE_SIZE [=] size 
  | LENGTH [=] num [PAGE[S]] 
  | SET NAMES 'charset'

<db_config_option> ::= 
  DEFAULT CHARACTER SET default_charset 
  | <sec_file>
  | DIFFERENCE FILE 'diff_file' -- not supported in ESQL

<filespec> ::= "" [server_spec]{filepath | db_alias} ""

<server_spec> ::= 
  host[/{port | service}]: 
  | \host\ 
  | <protocol>://[host[:{port | service}]/]

<protocol> ::= inet | inet4 | inet6 | wnet | xnet

<sec_file> ::= 
  FILE 'filepath' 
  | [LENGTH [=] num [PAGE[S]]] 
  | [STARTING AT [PAGE]] pagenum

Each \textit{db_initial_option} and \textit{db_config_option} can occur at most once, except \textit{sec_file}, which can occur zero or more times.

\begin{tabular}{|l|p{5in}|}
\hline
\textbf{Parameter} & \textbf{Description} \\
\hline
filespec & File specification for primary database file \\
\hline
server_spec & Remote server specification. Some protocols require specifying a hostname. Optionally includes a port number or service name. Required if the database is created on a remote server. \\
\hline
filepath & Full path and file name including its extension. The file name must be specified according to the rules of the platform file system being used. \\
\hline
db_alias & Database alias previously created in the databases.conf file \\
\hline
\end{tabular}
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>host</td>
<td>Host name or IP address of the server where the database is to be created</td>
</tr>
<tr>
<td>port</td>
<td>The port number where the remote server is listening (parameter <code>RemoteServicePort</code> in <code>firebird.conf</code> file)</td>
</tr>
<tr>
<td>service</td>
<td>Service name. Must match the parameter value of <code>RemoteServiceName</code> in <code>firebird.conf</code> file</td>
</tr>
<tr>
<td>username</td>
<td>Username of the owner of the new database. The maximum length is 63 characters. The username can optionally be enclosed in single or double quotes. When a username is enclosed in double quotes, it is case-sensitive following the rules for quoted identifiers. When enclosed in single quotes, it behaves as if the value was specified without quotes. The user must be an administrator or have the <code>CREATE DATABASE</code> privilege.</td>
</tr>
<tr>
<td>password</td>
<td>Password of the user as the database owner. When using the Legacy_Auth authentication plugin, only the first 8 characters are used. Case-sensitive</td>
</tr>
<tr>
<td>rolename</td>
<td>The name of the role whose rights should be taken into account when creating a database. The role name can be enclosed in single or double quotes. When the role name is enclosed in double quotes, it is case-sensitive following the rules for quoted identifiers. When enclosed in single quotes, it behaves as if the value was specified without quotes.</td>
</tr>
<tr>
<td>size</td>
<td>Page size for the database, in bytes. Possible values are 4096, 8192, 16384 and 32768. The default page size is 8192.</td>
</tr>
<tr>
<td>num</td>
<td>Maximum size of the primary database file, or a secondary file, in pages</td>
</tr>
<tr>
<td>charset</td>
<td>Specifies the character set of the connection available to a client connecting after the database is successfully created. Single quotes are required.</td>
</tr>
<tr>
<td>default_charset</td>
<td>Specifies the default character set for string data types</td>
</tr>
<tr>
<td>collation</td>
<td>Default collation for the default character set</td>
</tr>
<tr>
<td>sec_file</td>
<td>File specification for a secondary file</td>
</tr>
<tr>
<td>pagenum</td>
<td>Starting page number for a secondary database file</td>
</tr>
<tr>
<td>diff_file</td>
<td>File path and name for DIFFERENCE files (.delta files) for backup mode</td>
</tr>
</tbody>
</table>

The CREATE DATABASE statement creates a new database. You can use CREATE DATABASE or CREATE SCHEMA. They are synonymous, but we recommend to always use CREATE DATABASE as this may change in a future version of Firebird.

A database may consist of one or several files. The first (main) file is called the primary file, subsequent files are called secondary file(s).

**Multi-file Databases**

Nowadays, multi-file databases are considered an anachronism. It made sense to use multi-file databases on old file systems where the size of any file is limited. For instance, you could not create a file larger than 4 GB on FAT32.
The primary file specification is the name of the database file and its extension with the full path to it according to the rules of the OS platform file system being used. The database file must not exist at the moment the database is being created. If it does exist, you will get an error message, and the database will not be created.

If the full path to the database is not specified, the database will be created in one of the system directories. The particular directory depends on the operating system. For this reason, unless you have a strong reason to prefer that situation, always specify either the absolute path or an alias when creating a database.

**Using a Database Alias**

You can use aliases instead of the full path to the primary database file. Aliases are defined in the `databases.conf` file in the following format:

```
alias = filepath
```

Executing a `CREATE DATABASE` statement requires special consideration in the client application or database driver. As a result, it is not always possible to execute a `CREATE DATABASE` statement. Some drivers provide other ways to create databases. For example, Jaybird provides the class `org.firebirdsql.management.FBManager` to programmatically create a database.

If necessary, you can always fallback to `isql` to create a database.

**Creating a Database on a Remote Server**

If you create a database on a remote server, you need to specify the remote server specification. The remote server specification depends on the protocol being used. If you use the TCP/IP protocol to create a database, the primary file specification should look like this:

```
host/[{port|service}]:{filepath | db_alias}
```

If you use the Named Pipes protocol to create a database on a Windows server, the primary file specification should look like this:

```
\host\{filepath | db_alias}
```

Firebird also has a unified URL-like syntax for the remote server specification. In this syntax, the first part specifies the name of the protocol, then a host name or IP address, port number, and path of the primary database file, or an alias.

The following values can be specified as the protocol:

**INET**

TCP/IP (first tries to connect using the IPv6 protocol, if it fails, then IPv4)
INET4
  TCP/IP v4

INET6
  TCP/IP v6

WNET
  NetBEUI or Named Pipes Protocol

XNET
  local protocol (does not include a host, port and service name)

<protocol>://[host[:{port | service}]][{filepath | db_alias}]

Optional Parameters for CREATE DATABASE

USER and PASSWORD

Clauses for specifying the username and the password, respectively, of an existing user in the security database (security4.fdb or whatever is configured in the SecurityDatabase configuration). You do not have to specify the username and password if the ISC_USER and ISC_PASSWORD environment variables are set. The user specified in the process of creating the database will be its owner. This will be important when considering database and object privileges.

ROLE

The ROLE clause specifies the name of the role (usually RDB$ADMIN), which will be taken into account when creating the database. The role must be assigned to the user in the applicable security database.

PAGE_SIZE

Clause for specifying the database page size. This size will be set for the primary file and all secondary files of the database. If you specify the database page size less than 4,096, it will be automatically rounded up to 4,096. Other values not equal to either 4,096, 8,192, 16,384 or 32,768 will be changed to the closest smaller supported value. If the database page size is not specified, it is set to the default value of 8,192.

Bigger Isn’t Always Better.

Larger page sizes can fit more records on a single page, have wider indexes, and more indexes, but they will also waste more space for blobs (compare the wasted space of a 3KB blob on page size 4096 with one on 32768: +/- 1KB vs +/- 29KB), and increase memory consumption of the page cache.

LENGTH

Clause specifying the maximum size of the primary or secondary database file, in pages. When a database is created, its primary and secondary files will occupy the minimum number of pages necessary to store the system data, regardless of the value specified in the LENGTH clause. The
LENGTH value does not affect the size of the only (or last, in a multi-file database) file. The file will keep increasing its size automatically when necessary.

**SET NAMES**

Clause specifying the character set of the connection available after the database is successfully created. The character set NONE is used by default. Notice that the character set should be enclosed in a pair of apostrophes (single quotes).

**DEFAULT CHARACTER SET**

Clause specifying the default character set for creating data structures of string data types. Character sets are used for CHAR, VARCHAR and BLOB SUB_TYPE TEXT data types. The character set NONE is used by default. It is also possible to specify the default COLLATION for the default character set, making that collation sequence the default for the default character set. The default will be used for the entire database except where an alternative character set, with or without a specified collation, is used explicitly for a field, domain, variable, cast expression, etc.

**STARTING AT**

Clause that specifies the database page number at which the next secondary database file should start. When the previous file is completely filled with data according to the specified page number, the system will start adding new data to the next database file.

**DIFFERENCE FILE**

Clause specifying the path and name for the file delta that stores any mutations to the database file after it has been switched to the “copy-safe” mode by the ALTER DATABASE BEGIN BACKUP statement. For the detailed description of this clause, see ALTER DATABASE.

**Specifying the Database Dialect**

Databases are created in Dialect 3 by default. For the database to be created in SQL dialect 1, you will need to execute the statement SET SQL DIALECT 1 from script or the client application, e.g. in isql, before the CREATE DATABASE statement.

**Who Can Create a Database**

The CREATE DATABASE statement can be executed by:

- Administrators
- Users with the CREATE DATABASE privilege

**Examples Using CREATE DATABASE**

1. Creating a database in Windows, located on disk D with a page size of 4,096. The owner of the database will be the user *wizard*. The database will be in Dialect , and will use WIN1251 as its default character set.
2. Creating a database in the Linux operating system with a page size of 8,192 (default). The owner of the database will be the user wizard. The database will be in Dialect 3 and will use UTF8 as its default character set, with UNICODE_CI_AI as the default collation.

```sql
CREATE DATABASE '/home/firebird/test.fdb'
USER 'wizard' PASSWORD 'player'
DEFAULT CHARACTER SET UTF8 COLLATION UNICODE_CI_AI;
```

3. Creating a database on the remote server “baseserver” with the path specified in the alias “test” that has been defined previously in the file databases.conf. The TCP/IP protocol is used. The owner of the database will be the user wizard. The database will be in Dialect 3 and will use UTF8 as its default character set.

```sql
CREATE DATABASE 'baseserver:test'
USER 'wizard' PASSWORD 'player'
DEFAULT CHARACTER SET UTF8;
```

4. Creating a database in Dialect 3 with UTF8 as its default character set. The primary file will contain up to 10,000 pages with a page size of 8,192. As soon as the primary file has reached the maximum number of pages, Firebird will start allocating pages to the secondary file test.fdb2. If that file is filled up to its maximum as well, test.fdb3 becomes the recipient of all new page allocations. As the last file, it has no page limit imposed on it by Firebird. New allocations will continue for as long as the file system allows it or until the storage device runs out of free space. If a LENGTH parameter were supplied for this last file, it would be ignored.

```sql
SET SQL DIALECT 3;
CREATE DATABASE 'baseserver:D:\test.fdb'
USER 'wizard' PASSWORD 'player'
PAGE_SIZE = 8192
DEFAULT CHARACTER SET UTF8
FILE 'D:\test.fdb2'
STARTING AT PAGE 10001
FILE 'D:\test.fdb3'
STARTING AT PAGE 20001;
```

5. Creating a database in Dialect 3 with UTF8 as its default character set. The primary file will contain up to 10,000 pages with a page size of 8,192. As far as file size and the use of secondary files are concerned, this database will behave exactly like the one in the previous example.
SET SQL DIALECT 3;
CREATE DATABASE 'baseserver:D:\test.fdb'
USER 'wizard' PASSWORD 'player'
PAGE_SIZE = 8192
LENGTH 10000 PAGES
DEFAULT CHARACTER SET UTF8
FILE 'D:\test.fdb2'
FILE 'D:\test.fdb3'
STARTING AT PAGE 20001;

See also
ALTER DATABASE, DROP DATABASE

5.1.2. ALTER DATABASE

Used for
 Altering the file organisation of a database, toggling its “copy-safe” state, managing encryption, and other database-wide configuration

Available in
DSQL, ESQL — limited feature set
### Syntax

```
ALTER {DATABASE | SCHEMA} <alter_db_option> [<alter_db_option> ...]
```

```
<alter_db_option> ::=  
                  | <add_sec_clause>
                  | {ADD DIFFERENCE FILE 'diff_file' | DROP DIFFERENCE FILE}
                  | {BEGIN | END} BACKUP
                  | SET DEFAULT CHARACTER SET charset
                  | {ENCRYPT WITH plugin_name [KEY key_name] | DECRYPT}
                  | SET LINGER TO linger_duration
                  | DROP LINGER
                  | SET DEFAULT SQL SECURITY {INVOKER | DEFINER}
                  | {ENABLE | DISABLE} PUBLICATION
                  | INCLUDE <pub_table_filter> TO PUBLICATION
                  | EXCLUDE <pub_table_filter> FROM PUBLICATION

<add_sec_clause> ::= ADD <sec_file> [<sec_file> ...]
```

```
<sec_file> ::=  
              | FILE 'filepath'
              | [STARTING [AT [PAGE]]] pagenum
              | [LENGTH [=] num] [PAGE[S]]

<pub_table_filter> ::=  
                        | ALL
                        | TABLE table_name [, table_name ...]
```

Multiple files can be added in one ADD clause:

```sql
ALTER DATABASE  
ADD FILE x LENGTH 8000  
FILE y LENGTH 8000  
FILE z
```

Multiple occurrences of `add_sec_clause` (ADD FILE clauses) are allowed; an ADD FILE clause that adds multiple files (as in the example above) can be mixed with others that add only one file. The statement was documented incorrectly in the old `InterBase 6 Language Reference`.

### Table 28. ALTER DATABASE Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>add_sec_clause</td>
<td>Adding a secondary database file</td>
</tr>
<tr>
<td>sec_file</td>
<td>File specification for secondary file</td>
</tr>
<tr>
<td>filepath</td>
<td>Full path and file name of the delta file or secondary database file</td>
</tr>
<tr>
<td>pagenum</td>
<td>Page number from which the secondary database file is to start</td>
</tr>
</tbody>
</table>
### Parameter Table

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>num</td>
<td>Maximum size of the secondary file in pages</td>
</tr>
<tr>
<td>diff_file</td>
<td>File path and name of the .delta file (difference file)</td>
</tr>
<tr>
<td>charset</td>
<td>New default character set of the database</td>
</tr>
<tr>
<td>linger_duration</td>
<td>Duration of linger delay in seconds; must be greater than or equal to 0 (zero)</td>
</tr>
<tr>
<td>plugin_name</td>
<td>The name of the encryption plugin</td>
</tr>
<tr>
<td>key_name</td>
<td>The name of the encryption key</td>
</tr>
<tr>
<td>pub_table_filter</td>
<td>Filter of tables to include to or exclude from publication</td>
</tr>
<tr>
<td>table_name</td>
<td>Name (identifier) of a table</td>
</tr>
</tbody>
</table>

The `ALTER DATABASE` statement can:

- add secondary files to a database
- switch a single-file database into and out of the “copy-safe” mode (DSQL only)
- set or unset the path and name of the delta file for physical backups (DSQL only)

---

**Who Can Alter the Database**

The `ALTER DATABASE` statement can be executed by:

- Administrators
- Users with the `ALTER DATABASE` privilege

---

**Parameters for `ALTER DATABASE`**

**ADD (FILE)**

Adds secondary files to the database. It is necessary to specify the full path to the file and the name of the secondary file. The description for the secondary file is similar to the one given for the `CREATE DATABASE` statement.

**ADD DIFFERENCE FILE**

Specifies the path and name of the delta file that stores any mutations to the database whenever it is switched to the “copy-safe” mode. This clause does not actually add any file. It just overrides the default name and path of the .delta file. To change the existing settings, you should delete the previously specified description of the .delta file using the `DROP DIFFERENCE FILE` clause before specifying the new description of the delta file. If the path and name of the .delta file are not overridden, the file will have the same path and name as the database, but with the .delta file extension.
If only a file name is specified, the .delta file will be created in the current directory of the server. On Windows, this will be the system directory—a very unwise location to store volatile user files and contrary to Windows file system rules.

**DROP DIFFERENCE FILE**

Deletes the description (path and name) of the .delta file specified previously in the `ADD DIFFERENCE FILE` clause. The file is not actually deleted. `DROP DIFFERENCE FILE` deletes the path and name of the .delta file from the database header. Next time the database is switched to the “copy-safe” mode, the default values will be used (i.e. the same path and name as those of the database, but with the .delta extension).

**BEGIN BACKUP**

Switches the database to the “copy-safe” mode. `ALTER DATABASE` with this clause freezes the main database file, making it possible to back it up safely using file system tools, even if users are connected and performing operations with data. Until the backup state of the database is reverted to `NORMAL`, all changes made to the database will be written to the .delta (difference) file.

Despite its syntax, a statement with the `BEGIN BACKUP` clause does not start a backup process but just creates the conditions for doing a task that requires the database file to be read-only temporarily.

**END BACKUP**

Switches the database from the “copy-safe” mode to the normal mode. A statement with this clause merges the .delta file with the main database file and restores the normal operation of the database. Once the `END BACKUP` process starts, the conditions no longer exist for creating safe backups by means of file system tools.

Use of `BEGIN BACKUP` and `END BACKUP` and copying the database files with filesystem tools, is not safe with multi-file databases! Use this method only on single-file databases.

Making a safe backup with the `gbak` utility remains possible at all times, although it is not recommended running `gbak` while the database is in `LOCKED` or `MERGE` state.

**SET DEFAULT CHARACTER SET**

Changes the default character set of the database. This change does not affect existing data or columns. The new default character set will only be used in subsequent DDL commands.

**ENCRYPT WITH**

See Encrypting a Database in the Security chapter.

**DECRYPT**

See Decrypting a Database in the Security chapter.
SET LINGER TO

Sets the linger-delay. The linger-delay applies only to Firebird SuperServer, and is the number of seconds the server keeps a database file (and its caches) open after the last connection to that database was closed. This can help to improve performance at low cost, when the database is opened and closed frequently, by keeping resources “warm” for the next connection.

This mode can be useful for web applications - without a connection pool - where the connection to the database usually “lives” for a very short time.

The SET LINGER TO and DROP LINGER clauses can be combined in a single statement, but the last clause “wins”. For example, ALTER DATABASE SET LINGER TO 5 DROP LINGER will set the linger-delay to 0 (no linger), while ALTER DATABASE DROP LINGER SET LINGER to 5 will set the linger-delay to 5 seconds.

DROP LINGER

Drops the linger-delay (sets it to zero). Using DROP LINGER is equivalent to using SET LINGER TO 0.

Dropping LINGER is not an ideal solution for the occasional need to turn it off for some once-only condition where the server needs a forced shutdown. The gfix utility now has the -NoLinger switch, which will close the specified database immediately after the last attachment is gone, regardless of the LINGER setting in the database. The LINGER setting is retained and works normally the next time.

The same one-off override is also available through the Services API, using the tag isc_spb_prp_nolinger, e.g. (in one line):

```
fbsvcmgr host:service_mgr user sysdba password xxx
action_properties dbname employee prp_nolinger
```

The DROP LINGER and SET LINGER TO clauses can be combined in a single statement, but the last clause “wins”.

SET DEFAULT SQL SECURITY

Specifies the default SQL SECURITY option to apply at runtime for objects without the SQL Security property set. See also SQL Security in chapter Security.

ENABLE PUBLICATION

Enables publication of this database for replication. Replication begins (or continues) with the next transaction started after this transaction commits.

DISABLE PUBLICATION

Enables publication of this database for replication. Replication is disabled immediately after commit.

EXCLUDE … FROM PUBLICATION

Excludes tables from publication. If INCLUDE ALL TO PUBLICATION clause is used, then all tables
created afterwards will also be replicated, unless overridden explicitly in the `CREATE TABLE` statement.

**INCLUDE ... TO PUBLICATION**

Includes tables to publication. If `INCLUDE ALL TO PUBLICATION` clause is used, then all tables created afterwards will also be replicated, unless overridden explicitly in the `CREATE TABLE` statement.

**Replication**

- Other than the syntax, configuring Firebird for replication is not covered in this language reference.
- All replication management commands are DDL statements and thus effectively executed at the transaction commit time.

**Examples of ALTER DATABASE Usage**

1. Adding a secondary file to the database. As soon as 30000 pages are filled in the previous primary or secondary file, the Firebird engine will start adding data to the secondary file `test4.fdb`.

   ```sql
   ALTER DATABASE
   ADD FILE 'D:\test4.fdb'
   STARTING AT PAGE 30001;
   ```

2. Specifying the path and name of the delta file:

   ```sql
   ALTER DATABASE
   ADD DIFFERENCE FILE 'D:\test.diff';
   ```

3. Deleting the description of the delta file:

   ```sql
   ALTER DATABASE
   DROP DIFFERENCE FILE;
   ```

4. Switching the database to the “copy-safe” mode:

   ```sql
   ALTER DATABASE
   BEGIN BACKUP;
   ```

5. Switching the database back from the “copy-safe” mode to the normal operation mode:

   ```sql
   ALTER DATABASE
   END BACKUP;
   ```
6. Changing the default character set for a database to WIN1251

ALTER DATABASE
SET DEFAULT CHARACTER SET WIN1252;

7. Setting a *linger*-delay of 30 seconds

ALTER DATABASE
SET LINGER TO 30;

8. Encrypting the database with a plugin called *DbCrypt*

ALTER DATABASE
ENCRIPT WITH *DbCrypt*;

9. Decrypting the database

ALTER DATABASE
DECRIPT;

See also

CREATE DATABASE, DROP DATABASE

5.1.3. DROP DATABASE

*Used for*
Deleting the database to which you are currently connected

*Available in*
DSQL, ESQL

*Syntax*

DROP DATABASE

The DROP DATABASE statement deletes the current database. Before deleting a database, you have to connect to it. The statement deletes the primary file, all secondary files and all shadow files.

Contrary to CREATE DATABASE and ALTER DATABASE, DROP SCHEMA is not a valid alias for DROP DATABASE. This is intentional.

**Who Can Drop a Database**

The DROP DATABASE statement can be executed by:
• Administrators
• Users with the DROP DATABASE privilege

**Example of DROP DATABASE**

Deleting the current database

```sql
DROP DATABASE;
```

*See also*

CREATE DATABASE, ALTER DATABASE

## 5.2. SHADOW

A *shadow* is an exact, page-by-page copy of a database. Once a shadow is created, all changes made in the database are immediately reflected in the shadow. If the primary database file becomes unavailable for some reason, the DBMS will switch to the shadow.

This section describes how to create and delete shadow files.

### 5.2.1. CREATE SHADOW

*Used for*

Creating a shadow for the current database

*Available in*

DSQL, ESQL

*Syntax*

```
CREATE SHADOW <sh_num> [{AUTO | MANUAL}] [CONDITIONAL]
  'filepath' [LENGTH [=] num [PAGE[S]]]
  [<secondary_file> ...]
```

```plaintext
<secondary_file> ::= 
FILE 'filepath'
  [STARTING [AT [PAGE]] pagenum]
  [LENGTH [=] num [PAGE[S]]]
```

**Table 29. CREATE SHADOW Statement Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sh_num</td>
<td>Shadow number — a positive number identifying the shadow set</td>
</tr>
<tr>
<td>filepath</td>
<td>The name of the shadow file and the path to it, in accord with the rules of the operating system</td>
</tr>
<tr>
<td>num</td>
<td>Maximum shadow size, in pages</td>
</tr>
</tbody>
</table>
The CREATE SHADOW statement creates a new shadow. The shadow starts duplicating the database right at the moment it is created. It is not possible for a user to connect to a shadow.

Like a database, a shadow may be multi-file. The number and size of a shadow's files are not related to the number and size of the files of database it is shadowing.

The page size for shadow files is set to be equal to the database page size and cannot be changed.

If a calamity occurs involving the original database, the system converts the shadow to a copy of the database and switches to it. The shadow is then unavailable. What happens next depends on the MODE option.

**AUTO | MANUAL Modes**

When a shadow is converted to a database, it becomes unavailable. A shadow might alternatively become unavailable because someone accidentally deletes its file, or the disk space where the shadow files are stored is exhausted or is itself damaged.

- If the AUTO mode is selected (the default value), shadowing ceases automatically, all references to it are deleted from the database header, and the database continues functioning normally.

  If the CONDITIONAL option was set, the system will attempt to create a new shadow to replace the lost one. It does not always succeed, however, and a new one may need to be created manually.

- If the MANUAL mode attribute is set when the shadow becomes unavailable, all attempts to connect to the database and to query it will produce error messages. The database will remain inaccessible until either the shadow again becomes available, or the database administrator deletes it using the DROP SHADOW statement. MANUAL should be selected if continuous shadowing is more important than uninterrupted operation of the database.

**Options for CREATE SHADOW**

**LENGTH**

Specifies the maximum size of the primary or secondary shadow file in pages. The LENGTH value does not affect the size of the only shadow file, nor the last if it is a set. The last (or only) file will keep automatically growing as long as it is necessary.

**STARTING AT**

Specifies the shadow page number at which the next shadow file should start. The system will start adding new data to the next shadow file when the previous file is filled with data up to the specified page number.

You can verify the sizes, names and location of the shadow files by connecting to the database using *isql* and running the command SHOW DATABASE;
Who Can Create a Shadow

The CREATE SHADOW statement can be executed by:

- Administrators
- Users with the ALTER DATABASE privilege

Examples Using CREATE SHADOW

1. Creating a shadow for the current database as “shadow number 1”:

   ```
   CREATE SHADOW 1 'g:\data\test.shd';
   ```

2. Creating a multi-file shadow for the current database as “shadow number 2”:

   ```
   CREATE SHADOW 2 'g:\data\test.sh1'
   LENGTH 8000 PAGES
   FILE 'g:\data\test.sh2';
   ```

See also

CREATE DATABASE, DROP SHADOW

5.2.2. DROP SHADOW

Used for

Deleting a shadow from the current database

Available in

DSQL, ESQL

Syntax

```
DROP SHADOW sh_num
   [{DELETE | PRESERVE} FILE]
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sh_num</td>
<td>Shadow number — a positive number identifying the shadow set</td>
</tr>
</tbody>
</table>

The DROP SHADOW statement deletes the specified shadow for the current database. When a shadow is dropped, all files related to it are deleted and shadowing to the specified `sh_num` ceases. The optional DELETE FILE clause makes this behaviour explicit. On the contrary, the PRESERVE FILE clause will remove the shadow from the database, but the file itself will not be deleted.
Who Can Drop a Shadow

The DROP_SHADOW statement can be executed by:

- Administrators
- Users with the ALTER_DATABASE privilege

Example of DROP_SHADOW

Deleting “shadow number 1”:

```sql
DROP_SHADOW 1;
```

See also

CREATE_SHADOW

5.3. DOMAIN

DOMAIN is one of the object types in a relational database. A domain is created as a specific data type with some attributes attached to it. Once it has been defined in the database, it can be reused repeatedly to define table columns, PSQL arguments and PSQL local variables. Those objects inherit all of the attributes of the domain. Some attributes can be overridden when the new object is defined, if required.

This section describes the syntax of statements used to create, modify and delete domains. A detailed description of domains and their usage can be found in **Custom Data Types — Domains**.

5.3.1. CREATE_DOMAIN

Used for
Creating a new domain

Available in
DSQL, ESQL

Syntax

```
CREATE DOMAIN name [AS] <datatype> 
[DEFAULT {<literal> | NULL | <context_var>}] 
[NOT NULL] [CHECK (<dom_condition>)] 
[COLLATE collation_name]
```

```
<datatype> ::= 
<scalar_datatype> | <blob_datatype> | <array_datatype>

<scalar_datatype> ::= 
!! See Scalar Data Types Syntax !!

<blob_datatype> ::= 
```
<array_datatype> ::= 
!! See Array Data Types Syntax !!

<dom_condition> ::= 
<val> <operator> <val>
| <val> [NOT] BETWEEN <val> AND <val>
| <val> [NOT] IN ({<val> [, <val> ...] | <select_list>})
| <val> IS [NOT] NULL
| <val> IS [NOT] DISTINCT FROM <val>
| <val> [NOT] CONTAINING <val>
| <val> [NOT] STARTING [WITH] <val>
| <val> [NOT] LIKE <val> [ESCAPE <val>]
| <val> [NOT] SIMILAR TO <val> [ESCAPE <val>]
| <val> <operator> {ALL | SOME | ANY} (<select_list>)
| [NOT] EXISTS (<select_expr>)
| [NOT] SINGULAR (<select_expr>)
| (<dom_condition>)
| NOT <dom_condition>
| <dom_condition> OR <dom_condition>
| <dom_condition> AND <dom_condition>

<operator> ::= 
<> | != | ^= | ~= | = | < | > | <= | >=
| !< | ^< | ~< | !> | ^> | ~> 

<val> ::= 
VALUE
| <literal>
| <context_var>
| <expression>
| NULL
| NEXT VALUE FOR genname
| GEN_ID(genname, <val>)
| CAST(<val> AS <cast_type>)
| (<select_one>)
| func([<val> [, <val> ...)])

<cast_type> ::= <domain_or_non_array_type> | <array_datatype>

<domain_or_non_array_type> ::= 
!! See Scalar Data Types Syntax !!

Table 31. CREATE DOMAIN Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>Domain name. The maximum length is 63 characters</td>
</tr>
<tr>
<td>datatype</td>
<td>SQL data type</td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>literal</td>
<td>A literal value that is compatible with <code>datatype</code></td>
</tr>
<tr>
<td>context_var</td>
<td>Any context variable whose type is compatible with <code>datatype</code></td>
</tr>
<tr>
<td>dom_condition</td>
<td>Domain condition</td>
</tr>
<tr>
<td>collation_name</td>
<td>Name of a collation sequence that is valid for <code>charset_name</code>, if it is supplied with <code>datatype</code> or, otherwise, is valid for the default character set of the database</td>
</tr>
<tr>
<td>select_one</td>
<td>A scalar <code>SELECT</code> statement — selecting one column and returning only one row</td>
</tr>
<tr>
<td>select_list</td>
<td>A <code>SELECT</code> statement selecting one column and returning zero or more rows</td>
</tr>
<tr>
<td>select_expr</td>
<td>A <code>SELECT</code> statement selecting one or more columns and returning zero or more rows</td>
</tr>
<tr>
<td>expression</td>
<td>An expression resolving to a value that is compatible with <code>datatype</code></td>
</tr>
<tr>
<td>genname</td>
<td>Sequence (generator) name</td>
</tr>
<tr>
<td>func</td>
<td>Internal function or UDF</td>
</tr>
</tbody>
</table>

The `CREATE DOMAIN` statement creates a new domain.

Any SQL data type can be specified as the domain type.

**Type-specific Details**

**Array Types**

- If the domain is to be an array, the base type can be any SQL data type except `BLOB` and array.
- The dimensions of the array are specified between square brackets. (In the Syntax block, these brackets appear in quotes to distinguish them from the square brackets that identify optional syntax elements.)
- For each array dimension, one or two integer numbers define the lower and upper boundaries of its index range:
  - By default, arrays are 1-based. The lower boundary is implicit and only the upper boundary need be specified. A single number smaller than 1 defines the range `num..1` and a number greater than 1 defines the range `1..num`.
  - Two numbers separated by a colon (‘:`’) and optional whitespace, the second greater than the first, can be used to define the range explicitly. One or both boundaries can be less than zero, as long as the upper boundary is greater than the lower.
- When the array has multiple dimensions, the range definitions for each dimension must be separated by commas and optional whitespace.
- Subscripts are validated only if an array actually exists. It means that no error messages regarding invalid subscripts will be returned if selecting a specific element returns nothing or if an array field is `NULL`.  

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String Types

You can use the CHARACTER SET clause to specify the character set for the CHAR, VARCHAR and BLOB (SUB_TYPE TEXT) types. If the character set is not specified, the character set specified as DEFAULT CHARACTER SET of the database will be used. If no character set was specified then, the character set NONE is applied by default when you create a character domain.

With character set NONE, character data are stored and retrieved the way they were submitted. Data in any encoding can be added to a column based on such a domain, but it is impossible to add this data to a column with a different encoding. Because no transliteration is performed between the source and destination encodings, errors may result.

DEFAULT Clause

The optional DEFAULT clause allows you to specify a default value for the domain. This value will be added to the table column that inherits this domain when the INSERT statement is executed, if no value is specified for it in the DML statement. Local variables and arguments in PSQL modules that reference this domain will be initialized with the default value. For the default value, use a literal of a compatible type or a context variable of a compatible type.

NOT NULL Constraint

Columns and variables based on a domain with the NOT NULL constraint will be prevented from being written as NULL, i.e., a value is required.

When creating a domain, take care to avoid specifying limitations that would contradict one another. For instance, NOT NULL and DEFAULT NULL are contradictory.

CHECK Constraint(s)

The optional CHECK clause specifies constraints for the domain. A domain constraint specifies conditions that must be satisfied by the values of table columns or variables that inherit from the domain. A condition must be enclosed in parentheses. A condition is a logical expression (also called a predicate) that can return the Boolean results TRUE, FALSE and UNKNOWN. A condition is considered satisfied if the predicate returns the value TRUE or “unknown value” (equivalent to NULL). If the predicate returns FALSE, the condition for acceptance is not met.

VALUE Keyword

The keyword VALUE in a domain constraint substitutes for the table column that is based on this domain or for a variable in a PSQL module. It contains the value assigned to the variable or the table column. VALUE can be used anywhere in the CHECK constraint, though it is usually used in the left part of the condition.

COLLATE

The optional COLLATE clause allows you to specify the collation sequence if the domain is based on one of the string data types, including BLOBs with text subtypes. If no collation sequence is specified, the collation sequence will be the one that is default for the specified character set at the time the domain is created.
Who Can Create a Domain

The CREATE DOMAIN statement can be executed by:

- Administrators
- Users with the CREATE DOMAIN privilege

CREATE DOMAIN Examples

1. Creating a domain that can take values greater than 1,000, with a default value of 10,000.

   CREATE DOMAIN CUSTNO AS
   INTEGER DEFAULT 10000
   CHECK (VALUE > 1000);

2. Creating a domain that can take the values 'Yes' and 'No' in the default character set specified during the creation of the database.

   CREATE DOMAIN D_BOOLEAN AS
   CHAR(3) CHECK (VALUE IN ('Yes', 'No'));

3. Creating a domain with the UTF8 character set and the UNICODE_CI_AI collation sequence.

   CREATE DOMAIN FIRSTNAME AS
   VARCHAR(30) CHARACTER SET UTF8
   COLLATE UNICODE_CI_AI;

4. Creating a domain of the DATE type that will not accept NULL and uses the current date as the default value.

   CREATE DOMAIN D_DATE AS
   DATE DEFAULT CURRENT_DATE
   NOT NULL;

5. Creating a domain defined as an array of 2 elements of the NUMERIC(18, 3) type. The starting array index is 1.

   CREATE DOMAIN D_POINT AS
   NUMERIC(18, 3) [2];

   Domains defined over an array type may be used only to define table columns. You cannot use array domains to define local variables in PSQL modules.

6. Creating a domain whose elements can be only country codes defined in the COUNTRY table.
CREATE DOMAIN D_COUNTRYCODE AS CHAR(3)
    CHECK (EXISTS(SELECT * FROM COUNTRY
        WHERE COUNTRYCODE = VALUE));

The example is given only to show the possibility of using predicates with
queries in the domain test condition. It is not recommended to create this style
of domain in practice unless the lookup table contains data that are never
deleted.

See also
ALTER DOMAIN, DROP DOMAIN

5.3.2. ALTER DOMAIN

Used for
Altering the current attributes of a domain or renaming it

Available in
DSQL, ESQL

Syntax

```
ALTER DOMAIN domain_name
    [TO new_name]
    [TYPE <datatype>]
    [{SET DEFAULT {<literal> | NULL | <context_var>} | DROP DEFAULT}]
    [{SET | DROP} NOT NULL]
    [{ADD [CONSTRAINT] CHECK (<dom_condition>) | DROP CONSTRAINT}]
```

- `<datatype>` ::= <scalar_datatype> | <blob_datatype>
- `<scalar_datatype>` ::= !! See Scalar Data Types Syntax !!
- `<blob_datatype>` ::= !! See BLOB Data Types Syntax !!
- `!! See also CREATE DOMAIN Syntax !!`

Table 32. ALTER DOMAIN Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>new_name</td>
<td>New name for domain. The maximum length is 63 characters</td>
</tr>
<tr>
<td>literal</td>
<td>A literal value that is compatible with datatype</td>
</tr>
<tr>
<td>context_var</td>
<td>Any context variable whose type is compatible with datatype</td>
</tr>
</tbody>
</table>
The ALTER DOMAIN statement enables changes to the current attributes of a domain, including its name. You can make any number of domain alterations in one ALTER DOMAIN statement.

**ALTER DOMAIN clauses**

**TO name**
Use the TO clause to rename the domain, as long as there are no dependencies on the domain, i.e. table columns, local variables or procedure arguments referencing it.

**SET DEFAULT**
With the SET DEFAULT clause you can set a new default value. If the domain already has a default value, there is no need to delete it first — it will be replaced by the new one.

**DROP DEFAULT**
Use this clause to delete a previously specified default value and replace it with NULL.

**SET NOT NULL**
Use this class to add a NOT NULL constraint to the domain; columns or parameters of this domain will be prevented from being written as NULL, i.e., a value is required.

Adding a NOT NULL constraint to an existing domain will subject all columns using this domain to a full data validation, so ensure that the columns have no nulls before attempting the change.

**DROP NOT NULL**
Drop the NOT NULL constraint from the domain.

An explicit NOT NULL constraint on a column that depends on a domain prevails over the domain. In this situation, the modification of the domain to make it nullable does not propagate to the column.

**ADD CONSTRAINT CHECK**
Use the ADD CONSTRAINT CHECK clause to add a CHECK constraint to the domain. If the domain already has a CHECK constraint, it will have to be deleted first, using an ALTER DOMAIN statement that includes a DROP CONSTRAINT clause.

**TYPE**
The TYPE clause is used to change the data type of the domain to a different, compatible one. The system will forbid any change to the type that could result in data loss. An example would be if the number of characters in the new type were smaller than in the existing type.

When you alter the attributes of a domain, existing PSQL code may become invalid. For information on how to detect it, read the piece entitled *The RDB$VALID_BLR Field* in Appendix A.
What ALTER DOMAIN Cannot Alter

- If the domain was declared as an array, it is not possible to change its type or its dimensions; nor can any other type be changed to an array type.
- There is no way to change the default collation without dropping the domain and recreating it with the desired attributes.

Who Can Alter a Domain

The ALTER DOMAIN statement can be executed by:

- Administrators
- The owner of the domain
- Users with the ALTER ANY DOMAIN privilege

Domain alterations can be prevented by dependencies from objects to which the user does not have sufficient privileges.

ALTER DOMAIN Examples

1. Changing the data type to INTEGER and setting or changing the default value to 2,000:

   ALTER DOMAIN CUSTNO
   TYPE INTEGER
   SET DEFAULT 2000;

2. Renaming a domain.

   ALTER DOMAIN D_BOOLEAN TO D_BOOL;

3. Deleting the default value and adding a constraint for the domain:

   ALTER DOMAIN D_DATE
   DROP DEFAULT
   ADD CONSTRAINT CHECK (VALUE >= date '01.01.2000');

4. Changing the CHECK constraint:

   ALTER DOMAIN D_DATE
   DROP CONSTRAINT;

   ALTER DOMAIN D_DATE
   ADD CONSTRAINT CHECK
   (VALUE BETWEEN date '01.01.1900' AND date '31.12.2100');
5. Changing the data type to increase the permitted number of characters:

```
ALTER DOMAIN FIRSTNAME
    TYPE VARCHAR(50) CHARACTER SET UTF8;
```

6. Adding a NOT NULL constraint:

```
ALTER DOMAIN FIRSTNAME
    SET NOT NULL;
```

7. Removing a NOT NULL constraint:

```
ALTER DOMAIN FIRSTNAME
    DROP NOT NULL;
```

See also

CREATE DOMAIN, DROP DOMAIN

### 5.3.3. DROP DOMAIN

**Used for**
Deleting an existing domain

**Available in**
DSQL, ESQL

**Syntax**

```
DROP DOMAIN domain_name
```

The `DROP DOMAIN` statement deletes a domain that exists in the database. It is not possible to delete a domain if it is referenced by any database table columns or used in any PSQL module. In order to delete a domain that is in use, all columns in all tables that refer to the domain will have to be dropped and all references to the domain will have to be removed from PSQL modules.

**Who Can Drop a Domain**

The `DROP DOMAIN` statement can be executed by:

- Administrators
- The owner of the domain
- Users with the DROP ANY DOMAIN privilege
Example of DROP DOMAIN

Deleting the COUNTRYNAME domain

DROP DOMAIN COUNTRYNAME;

See also
CREATE DOMAIN, ALTER DOMAIN

5.4. TABLE

As a relational DBMS, Firebird stores data in tables. A table is a flat, two-dimensional structure containing any number of rows. Table rows are often called records.

All rows in a table have the same structure and consist of columns. Table columns are often called fields. A table must have at least one column. Each column contains a single type of SQL data.

This section describes how to create, alter and delete tables in a database.

5.4.1. CREATE TABLE

Used for
creating a new table (relation)

Available in
DSQL, ESQL

Syntax

CREATE [GLOBAL TEMPORARY] TABLE tablename
    [EXTERNAL [FILE] 'filespec']
    (col_def [, {col_def | <tconstraint>} ...])
    [{<table_attrs> | gtt_table_attrs}]

<col_def> ::= 
    <regular_col_def>
    | <computed_col_def>
    | <identity_col_def>

<regular_col_def> ::= 
    colname {<datatype> | domainname} 
    [DEFAULT {<literal> | NULL | <context_var>}]
    [<col_constraint> ...]
    [COLLATE collation_name]

<computed_col_def> ::= 
    colname [{<datatype> | domainname}] 
    {COMPUTED [BY] | GENERATED ALWAYS AS} (<expression>)
<identity_col_def> ::=  
colname {<datatype> | domainname}  
generated {always | by default} as identity  
[(<identity_col_option>...)]  
[<col_constraint> ...]

<identity_col_option> ::=  
start with start_value  
| increment [by] inc_value

<datatype> ::=  
<scalar_datatype> | <blob_datatype> | <array_datatype>

<scalar_datatype> ::=  
!! see Scalar Data Types Syntax !!

<blob_datatype> ::=  
!! see BLOB Data Types Syntax !!

<array_datatype> ::=  
!! see Array Data Types Syntax !!

<col_constraint> ::=  
[constraint constr_name]  
{ primary key [<using_index>]  
| unique [<using_index>]  
| references other_table [(colname)] [<using_index>]  
| on delete {no action | cascade | set default | set null}]  
| on update {no action | cascade | set default | set null}]  
| check (<check_condition>)  
| not null }

<tconstraint> ::=  
[constraint constr_name]  
{ primary key (<col_list>) [<using_index>]  
| unique (<col_list>) [<using_index>]  
| foreign key (<col_list>)  
| references other_table [(<col_list>)] [<using_index>]  
| on delete {no action | cascade | set default | set null}]  
| on update {no action | cascade | set default | set null}]  
| check (<check_condition>) }  

<col_list> ::= colname [, colname ...]

<using_index> ::= using  
[asc[ending] | desc[ending]] index indexname

<check_condition> ::=  
<val> <operator> <val>  
| <val> [not] between <val> and <val>  
| <val> [not] in (<val> [, <val> ...] | <select_list>)
| (val) IS [NOT] NULL
| (val) IS [NOT] DISTINCT FROM (val)
| (val) [NOT] CONTAINING (val)
| (val) [NOT] STARTING [WITH] (val)
| (val) [NOT] LIKE (val) [ESCAPE (val)]
| (val) [NOT] SIMILAR TO (val) [ESCAPE (val)]
| (val) <operator> {ALL | SOME | ANY} (<select_list>)
| [NOT] EXISTS (<select_expr>)
| [NOT] SINGULAR (<select_expr>)
| (<check_condition>)
| NOT <check_condition>
| <check_condition> OR <check_condition>
| <check_condition> AND <check_condition>

<operator> ::=<operator> ::= 
  <> | != | ^= | ~= | = | < | > | <= | >=  
  | !< | ^< | ~< | !> | ^> | ~>^>

(val) ::=<val> ::=  
  colname ['[','array_idx [, array_idx ...']']
  | <literal>
  | <context_var>
  | <expression>
  | NULL
  | NEXT VALUE FOR genname
  | GEN_ID(genname, (val))
  | CAST((val) AS <cast_type>)
  | (<select_one>)
  | func([(val) [, (val) ...]])

<cast_type> ::=<cast_type> ::= <domain_or_non_array_type> | <array_datatype>

<domain_or_non_array_type> ::=<domain_or_non_array_type> ::= 
  !! See Scalar Data Types Syntax !!

<table_attrs> ::=<table_attrs> ::= <table_attr> [<table_attr> ...]

<table_attr> ::=<table_attr> ::= 
  <sql_security>
  | {ENABLE | DISABLE} PUBLICATION

<sql_security> ::=<sql_security> ::= SQL SECURITY {INVOKER | DEFINER}

<gtt_table_attrs> ::=<gtt_table_attrs> ::= <gtt_table_attr> [<gtt_table_attr> ...]

<gtt_table_attr> ::=<gtt_table_attr> ::=  
  <sql_security>
  | ON COMMIT {DELETE | PRESERVE} ROWS

Table 33. CREATE TABLE Statement Parameters
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tablename</td>
<td>Name (identifier) for the table. The maximum length is 63 characters and must be unique in the database.</td>
</tr>
<tr>
<td>filespec</td>
<td>File specification (only for external tables). Full file name and path, enclosed in single quotes, correct for the local file system and located on a storage device that is physically connected to Firebird's host computer.</td>
</tr>
<tr>
<td>colname</td>
<td>Name (identifier) for a column in the table. The maximum length is 63 characters and must be unique in the table.</td>
</tr>
<tr>
<td>tconstraint</td>
<td>Table constraint</td>
</tr>
<tr>
<td>table_attrs</td>
<td>Attributes of a normal table</td>
</tr>
<tr>
<td>gtt_table_attrs</td>
<td>Attributes of a global temporary table</td>
</tr>
<tr>
<td>datatype</td>
<td>SQL data type</td>
</tr>
<tr>
<td>domain_name</td>
<td>Domain name</td>
</tr>
<tr>
<td>start_value</td>
<td>The initial value of the identity column</td>
</tr>
<tr>
<td>inc_value</td>
<td>The increment (or step) value of the identity column, default is 1; zero (0) is not allowed.</td>
</tr>
<tr>
<td>col_constraint</td>
<td>Column constraint</td>
</tr>
<tr>
<td>constr_name</td>
<td>The name (identifier) of a constraint. The maximum length is 63 characters.</td>
</tr>
<tr>
<td>other_table</td>
<td>The name of the table referenced by the foreign key constraint</td>
</tr>
<tr>
<td>other_col</td>
<td>The name of the column in other_table that is referenced by the foreign key</td>
</tr>
<tr>
<td>literal</td>
<td>A literal value that is allowed in the given context</td>
</tr>
<tr>
<td>context_var</td>
<td>Any context variable whose data type is allowed in the given context</td>
</tr>
<tr>
<td>check_condition</td>
<td>The condition applied to a CHECK constraint, that will resolve as either true, false or NULL</td>
</tr>
<tr>
<td>collation</td>
<td>Collation</td>
</tr>
<tr>
<td>select_one</td>
<td>A scalar SELECT statement — selecting one column and returning only one row</td>
</tr>
<tr>
<td>select_list</td>
<td>A SELECT statement selecting one column and returning zero or more rows</td>
</tr>
<tr>
<td>select_expr</td>
<td>A SELECT statement selecting one or more columns and returning zero or more rows</td>
</tr>
<tr>
<td>expression</td>
<td>An expression resolving to a value that is allowed in the given context</td>
</tr>
<tr>
<td>genname</td>
<td>Sequence (generator) name</td>
</tr>
<tr>
<td>func</td>
<td>Internal function or UDF</td>
</tr>
</tbody>
</table>

The `CREATE TABLE` statement creates a new table. Any user can create it and its name must be unique.
among the names of all tables, views and stored procedures in the database.

A table must contain at least one column that is not computed, and the names of columns must be unique in the table.

A column must have either an explicit SQL data type, the name of a domain whose attributes will be copied for the column, or be defined as COMPUTED BY an expression (a calculated field).

A table may have any number of table constraints, including none.

**Character Columns**

You can use the CHARACTER SET clause to specify the character set for the CHAR, VARCHAR and BLOB (text subtype) types. If the character set is not specified, the default character set of the database - at time of the creation of the column - will be used. If the database has no default character set, the NONE character set is applied. In this case, data is stored and retrieved the way it was submitted. Data in any encoding can be added to such a column, but it is not possible to add this data to a column with a different encoding. No transliteration is performed between the source and destination encodings, which may result in errors.

The optional COLLATE clause allows you to specify the collation sequence for character data types, including BLOB SUB_TYPE TEXT. If no collation sequence is specified, the default collation sequence for the specified character set - at time of the creation of the column - is applied.

**Setting a DEFAULT Value**

The optional DEFAULT clause allows you to specify the default value for the table column. This value will be added to the column when an INSERT statement is executed if no value was specified for it and that column was omitted from the INSERT command.

The default value can be a literal of a compatible type, a context variable that is type-compatible with the data type of the column, or NULL, if the column allows it. If no default value is explicitly specified, NULL is implied.

An expression cannot be used as a default value.

**Domain-based Columns**

To define a column, you can use a previously defined domain. If the definition of a column is based on a domain, it may contain a new default value, additional CHECK constraints, and a COLLATE clause that will override the values specified in the domain definition. The definition of such a column may contain additional column constraints (for instance, NOT NULL), if the domain does not have it.

It is not possible to define a domain-based column that is nullable if the domain was defined with the NOT NULL attribute. If you want to have a domain that might be used for defining both nullable and non-nullable columns and variables, it is better practice defining the domain nullable and apply NOT NULL in the downstream column definitions and variable declarations.
Identity Columns (Autoincrement)

Identity columns are defined using the `GENERATED {ALWAYS | BY DEFAULT} AS IDENTITY` clause. The identity column is a column associated with an internal sequence generator. Its value is set automatically every time it is not specified in the `INSERT` statement, or when the column value is specified as `DEFAULT`.

Rules

- The data type of an identity column must be an exact number type with zero scale. Allowed types are `SMALLINT`, `INTEGER`, `BIGINT`, `NUMERIC(p[,0])` and `DECIMAL(p[,0])` with `p <= 18`.
  - The `INT128` type and numeric types with a precision higher than 18 are not supported.
- An identity column cannot have a `DEFAULT` or `COMPUTED` value.
- An identity column can be altered to become a regular column.
- A regular column cannot be altered to become an identity column.
- Identity columns are implicitly `NOT NULL` (non-nullable), and cannot be made nullable.
- Uniqueness is not enforced automatically. A `UNIQUE` or `PRIMARY KEY` constraint is required to guarantee uniqueness.
- The use of other methods of generating key values for identity columns, e.g. by trigger-generator code or by allowing users to change or add them, is discouraged to avoid unexpected key violations.
- The `INCREMENT` value cannot be zero (0).

GENERATED ALWAYS

An identity column of type `GENERATED ALWAYS` will always generate a column value on insert. Explicitly inserting a value into a column of this type is not allowed, unless either:

1. the specified value is `DEFAULT`; this generates the identity value as normal.
2. the `OVERRIDING SYSTEM VALUE` clause is specified in the `INSERT` statement; this allows a user value to be inserted.

GENERATED BY DEFAULT

An identity column of type `GENERATED BY DEFAULT` will generate a value on insert if no value — other than `DEFAULT` — is specified on insert. When the `OVERRIDING USER VALUE` clause is specified in the `INSERT` statement, the user-provided value is ignored, and an identity value is generated (as if the column was not included in the insert, or the value `DEFAULT` was specified).

START WITH Option

The optional `START WITH` clause allows you to specify an initial value other than 1.
Previous versions of Firebird instead used the specified value as the initial value of the internal generator backing the identity column, so the first value was 1 higher than the `START WITH` value.

This has been fixed in Firebird 4.0 and now the first value generated is the `START WITH` value, see also firebird#6615.

**INCREMENT Option**

The optional `INCREMENT` clause allows you to specify another non-zero step value than 1.

The SQL standard specifies that if `INCREMENT` is specified with a negative value, and `START WITH` is not specified, that the first value generated should be the maximum of the column type (e.g. $2^{31}-1$ for `INTEGER`). Instead, Firebird will start at 1.

**Calculated Fields**

Calculated fields can be defined with the `COMPUTED [BY]` or `GENERATED ALWAYS AS` clause (according to the SQL:2003 standard). They mean the same. Describing the data type is not required (but possible) for calculated fields, as the DBMS calculates and stores the appropriate type as a result of the expression analysis. Appropriate operations for the data types included in an expression must be specified precisely.

If the data type is explicitly specified for a calculated field, the calculation result is converted to the specified type. This means, for instance, that the result of a numeric expression could be rendered as a string.

In a query that selects a `COMPUTED BY` column, the expression is evaluated for each row of the selected data.

Instead of a computed column, in some cases it makes sense to use a regular column whose value is evaluated in triggers for adding and updating data. It may reduce the performance of inserting/updating records, but it will increase the performance of data selection.

**Defining an Array Column**

- If the column is to be an array, the base type can be any SQL data type except `BLOB` and `array`.
- The dimensions of the array are specified between square brackets. (In the Syntax block these brackets appear in quotes to distinguish them from the square brackets that identify optional syntax elements.)
- For each array dimension, one or two integer numbers define the lower and upper boundaries of its index range:
  - By default, arrays are 1-based. The lower boundary is implicit and only the upper boundary need be specified. A single number smaller than 1 defines the range `num..1` and a number greater than 1 defines the range `1..num`.
  - Two numbers separated by a colon (‘:’) and optional whitespace, the second greater than the
first, can be used to define the range explicitly. One or both boundaries can be less than zero, as long as the upper boundary is greater than the lower.

- When the array has multiple dimensions, the range definitions for each dimension must be separated by commas and optional whitespace.
- Subscripts are validated *only* if an array actually exists. It means that no error messages regarding invalid subscripts will be returned if selecting a specific element returns nothing or if an array field is NULL.

**Constraints**

Five types of constraints can be specified. They are:

- Primary key (PRIMARY KEY)
- Unique key (UNIQUE)
- Foreign key (REFERENCES)
- CHECK constraint (CHECK)
- NOT NULL constraint (NOT NULL)

Constraints can be specified at column level (“column constraints”) or at table level (“table constraints”). Table-level constraints are required when keys (unique constraint, Primary Key, Foreign Key) consist of multiple columns and when a CHECK constraint involves other columns in the row besides the column being defined. The NOT NULL constraint can only be specified as a column constraint. Syntax for some types of constraint may differ slightly according to whether the constraint is defined at the column or table level.

- A column-level constraint is specified during a column definition, after all column attributes except COLLATION are specified, and can involve only the column specified in that definition.
- A table-level constraint can only be specified after the definitions of the columns used in the constraint.
- Table-level constraints are a more flexible way to set constraints, since they can cater for constraints involving multiple columns.
- You can mix column-level and table-level constraints in the same CREATE TABLE statement.

The system automatically creates the corresponding index for a primary key (PRIMARY KEY), a unique key (UNIQUE) and a foreign key (REFERENCES for a column-level constraint, FOREIGN KEY REFERENCES for one at the table level).

**Names for Constraints and Their Indexes**

Column-level constraints and their indexes are named automatically:

- The constraint name has the form RDB$INTEGR_n, where n represents one or more digits.
- The index name has the form RDB$PRIMEN (for a primary key index), RDB$FOREIGNN (for a foreign key index) or RDB$N (for a unique key index). Again, n represents one or more digits.

Automatic naming of table-level constraints and their indexes follows the same pattern, unless the
names are supplied explicitly.

**Named Constraints**

A constraint can be named explicitly if the `CONSTRAINT` clause is used for its definition. While the `CONSTRAINT` clause is optional for defining column-level constraints, it is mandatory for table-level constraints. By default, the constraint index will have the same name as the constraint. If a different name is wanted for the constraint index, a `USING` clause can be included.

**The USING Clause**

The `USING` clause allows you to specify a user-defined name for the index that is created automatically and, optionally, to define the direction of the index—either ascending (the default) or descending.

**PRIMARY KEY**

The `PRIMARY KEY` constraint is built on one or more *key columns*, where each column has the `NOT NULL` constraint specified. The values across the key columns in any row must be unique. A table can have only one primary key.

- A single-column Primary Key can be defined as a column level or a table-level constraint
- A multi-column Primary Key must be specified as a table-level constraint

**The UNIQUE Constraint**

The `UNIQUE` constraint defines the requirement of content uniqueness for the values in a key throughout the table. A table can contain any number of unique key constraints.

As with the Primary Key, the Unique constraint can be multi-column. If so, it must be specified as a table-level constraint.

**NULL in Unique Keys**

Firebird’s SQL-99-compliant rules for `UNIQUE` constraints allow one or more `NULLs` in a column with a `UNIQUE` constraint. That makes it possible to define a `UNIQUE` constraint on a column that does not have the `NOT NULL` constraint.

For `UNIQUE` keys that span multiple columns, the logic is a little complicated:

- Multiple rows having null in all the columns of the key are allowed
- Multiple rows having keys with different combinations of nulls and non-null values are allowed
- Multiple rows having the same key columns null and the rest filled with non-null values are allowed, provided the values differ in at least one column
- Multiple rows having the same key columns null and the rest filled with non-null values that are the same in every column will violate the constraint

The rules for uniqueness can be summarised thus:
In principle, all nulls are considered distinct. However, if two rows have exactly the same key columns filled with non-null values, the NULL columns are ignored and the uniqueness is determined on the non-null columns as though they constituted the entire key.

Illustration

RECREATE TABLE t( x int, y int, z int, unique(x,y,z));  
INSERT INTO t values( NULL, 1, 1 );  
INSERT INTO t values( NULL, NULL, 1 );  
INSERT INTO t values( NULL, NULL, NULL );  
INSERT INTO t values( NULL, NULL, NULL ); -- Permitted  
INSERT INTO t values( NULL, NULL, 1 );    -- Not permitted

FOREIGN KEY

A Foreign Key ensures that the participating column(s) can contain only values that also exist in the referenced column(s) in the master table. These referenced columns are often called target columns. They must be the primary key or a unique key in the target table. They need not have a NOT NULL constraint defined on them although, if they are the primary key, they will, of course, have that constraint.

The foreign key columns in the referencing table itself do not require a NOT NULL constraint.

A single-column Foreign Key can be defined in the column declaration, using the keyword REFERENCES:

... ,  
ARTIFACT_ID INTEGER REFERENCES COLLECTION (ARTIFACT_ID),  

The column ARTIFACT_ID in the example references a column of the same name in the table COLLECTIONS.

Both single-column and multi-column foreign keys can be defined at the table level. For a multi-column Foreign Key, the table-level declaration is the only option. This method also enables the provision of an optional name for the constraint:

...  
CONSTRAINT FK_ARTSOURCE FOREIGN KEY(DEALER_ID, COUNTRY)  
REFERENCES DEALER (DEALER_ID, COUNTRY),  

Notice that the column names in the referenced ("master") table may differ from those in the Foreign Key.

If no target columns are specified, the Foreign Key automatically references the target table's Primary Key.
Foreign Key Actions

With the sub-clauses ON UPDATE and ON DELETE it is possible to specify an action to be taken on the affected foreign key column(s) when referenced values in the master table are changed:

**NO ACTION**

(the default) - Nothing is done

**CASCADE**

The change in the master table is propagated to the corresponding row(s) in the child table. If a key value changes, the corresponding key in the child records changes to the new value; if the master row is deleted, the child records are deleted.

**SET DEFAULT**

The Foreign Key columns in the affected rows will be set to their default values *as they were when the foreign key constraint was defined.*

**SET NULL**

The Foreign Key columns in the affected rows will be set to NULL.

The specified action, or the default NO ACTION, could cause a Foreign Key column to become invalid. For example, it could get a value that is not present in the master table, or it could become NULL while the column has a NOT NULL constraint. Such conditions will cause the operation on the master table to fail with an error message.

Example

```plaintext
...
CONSTRAINT FK_ORDERS_CUST
FOREIGN KEY (CUSTOMER) REFERENCES CUSTOMERS (ID)
ON UPDATE CASCADE ON DELETE SET NULL
```

**CHECK** Constraint

The CHECK constraint defines the condition the values inserted in this column must satisfy. A condition is a logical expression (also called a predicate) that can return the TRUE, FALSE and UNKNOWN values. A condition is considered satisfied if the predicate returns TRUE or value UNKNOWN (equivalent to NULL). If the predicate returns FALSE, the value will not be accepted. This condition is used for inserting a new row into the table (the INSERT statement) and for updating the existing value of the table column (the UPDATE statement) and also for statements where one of these actions may take place (UPDATE OR INSERT, MERGE).

A CHECK constraint on a domain-based column does not replace an existing CHECK condition on the domain, but becomes an addition to it. The Firebird engine has no way, during definition, to verify that the extra CHECK does not conflict with the existing one.

CHECK constraints — whether defined at table level or column level — refer to table columns *by their names*. The use of the keyword VALUE as a placeholder — as in domain CHECK constraints — is not
valid in the context of defining column constraints.

Example

with two column-level constraints and one at table-level:

```
CREATE TABLE PLACES (  
  ...  
  LAT DECIMAL(9, 6) CHECK (ABS(LAT) <= 90),  
  LON DECIMAL(9, 6) CHECK (ABS(LON) <= 180),  
  ...  
  CONSTRAINT CHK_POLES CHECK (ABS(LAT) < 90 OR LON = 0)  
);  
```

**NOT NULL Constraint**

In Firebird, columns are nullable by default. The **NOT NULL** constraint specifies that the column cannot take **NULL** in place of a value.

A **NOT NULL** constraint can only be defined as a column constraint, not as a table constraint.

**SQL SECURITY Clause**

The **SQL SECURITY** clause specifies the security context for executing functions referenced in calculated columns, and check constraints, and the default context used for triggers fired for this table. When SQL Security is not specified, the default value of the database is applied at runtime.

See also **SQL Security** in chapter **Security**.

**Replication Management**

When the database has been configured using **ALTER DATABASE INCLUDE ALL TO PUBLICATION**, new tables will automatically be added for publication, unless overridden using the **DISABLE PUBLICATION** clause.

If the database has not been configured for **INCLUDE ALL** (or has later been reconfigured using **ALTER DATABASE EXCLUDE ALL FROM PUBLICATION**), new tables will not automatically be added for publication. To include tables for publication, the **ENABLE PUBLICATION** clause must be used.

**Who Can Create a Table**

The **CREATE TABLE** statement can be executed by:

- **Administrators**
- Users with the **CREATE TABLE** privilege

The user executing the **CREATE TABLE** statement becomes the owner of the table.
1. Creating the `COUNTRY` table with the primary key specified as a column constraint.

```
CREATE TABLE COUNTRY (
    COUNTRY COUNTRYNAME NOT NULL PRIMARY KEY,
    CURRENCY VARCHAR(10) NOT NULL
);
```

2. Creating the `STOCK` table with the named primary key specified at the column level and the named unique key specified at the table level.

```
CREATE TABLE STOCK (
    MODEL SMALLINT NOT NULL CONSTRAINT PK_STOCK PRIMARY KEY,
    MODELNAME CHAR(10) NOT NULL,
    ITEMID INTEGER NOT NULL,
    CONSTRAINT MOD_UNIQUE UNIQUE (MODELNAME, ITEMID)
);
```

3. Creating the `JOB` table with a primary key constraint spanning two columns, a foreign key constraint for the `COUNTRY` table and a table-level `CHECK` constraint. The table also contains an array of 5 elements.

```
CREATE TABLE JOB (
    JOB_CODE JOBCODE NOT NULL,
    JOB_GRADE JOBGRADE NOT NULL,
    JOB_COUNTRY COUNTRYNAME,
    JOB_TITLE VARCHAR(25) NOT NULL,
    MIN_SALARY NUMERIC(18, 2) DEFAULT 0 NOT NULL,
    MAX_SALARY NUMERIC(18, 2) NOT NULL,
    JOB_REQUIREMENT BLOB SUB_TYPE 1,
    LANGUAGE_REQ VARCHAR(15) [1:5],
    PRIMARY KEY (JOB_CODE, JOB_GRADE),
    FOREIGN KEY (JOB_COUNTRY) REFERENCES COUNTRY (COUNTRY)
    ON UPDATE CASCADE
    ON DELETE SET NULL,
    CONSTRAINT CHK_SALARY CHECK (MIN_SALARY < MAX_SALARY)
);
```

4. Creating the `PROJECT` table with primary, foreign and unique key constraints with custom index names specified with the `USING` clause.
CREATE TABLE PROJECT (
    PROJ_ID   PROJNO NOT NULL,
    PROJ_NAME VARCHAR(20) NOT NULL UNIQUE USING DESC INDEX IDX_PROJNAME,
    PROJ_DESC BLOB SUB_TYPE 1,
    TEAM_LEADER EMPNO,
    PRODUCT   PRODTYPE,
    CONSTRAINT PK_PROJECT PRIMARY KEY (PROJ_ID) USING INDEX IDX_PROJ_ID,
    FOREIGN KEY (TEAM_LEADER) REFERENCES EMPLOYEE (EMP_NO) USING INDEX IDX_LEADER
);
INVOKER, the user would also need the EXECUTE privilege on function f.

```sql
set term ^;
create function f() returns int
as
begin
    return 3;
end^
set term ;^;
create table t (i integer, c computed by (i + f())) SQL SECURITY DEFINER;
insert into t values (2);
grant select on table t to user us;
commit;
connect 'localhost:/tmp/7.fdb' user us password 'pas';
select * from t;
```

8. With DEFINER set for table tr, user US needs only the INSERT privilege on tr. If it were set for INVOKER, either the user or the trigger would also need the INSERT privilege on table t. The result would be the same if SQL SECURITY DEFINER were specified for trigger tr_ins:

```sql
create table tr (i integer) SQL SECURITY DEFINER;
create table t (i integer);
set term ^;
create trigger tr_ins for tr after insert
as
    begin
        insert into t values (NEW.i);
    end^
set term ;^;
grant insert on table tr to user us;
commit;
connect 'localhost:/tmp/29.fdb' user us password 'pas';
insert into tr values(2);
```

**Global Temporary Tables (GTT)**

Global temporary tables have persistent metadata, but their contents are transaction-bound (the default) or connection-bound. Every transaction or connection has its own private instance of a GTT, isolated from all the others. Instances are only created if and when the GTT is referenced. They are destroyed when the transaction ends or on disconnection. The metadata of a GTT can be modified or removed using ALTER TABLE and DROP TABLE, respectively.
Syntax

```
CREATE GLOBAL TEMPORARY TABLE tablename
  (<column_def> [, {<column_def> | <table_constraint>} ...])
  [<gtt_table_attrs>]

<gtt_table_attrs> ::= <gtt_table_attr> [gtt_table_attr> ...]
<gtt_table_attr> ::= <sql_security>
  | ON COMMIT {DELETE | PRESERVE} ROWS
```

Syntax notes

- ON COMMIT DELETE ROWS creates a transaction-level GTT (the default), ON COMMIT PRESERVE ROWS a connection-level GTT.
- An EXTERNAL [FILE] clause is not allowed in the definition of a global temporary table.

GTTs are writable in read-only transactions. The effect is as follows:

**Read-only transaction in read-write database**

Writable in both ON COMMIT PRESERVE ROWS and ON COMMIT DELETE ROWS

**Read-only transaction in read-only database**

Writable in ON COMMIT DELETE ROWS only

**Restrictions on GTTs**

GTTs can be “dressed up” with all the features and paraphernalia of ordinary tables (keys, references, indexes, triggers and so on) but there are a few restrictions:

- GTTs and regular tables cannot reference one another
- A connection-bound (“PRESERVE ROWS”) GTT cannot reference a transaction-bound (“DELETE ROWS”) GTT
- Domain constraints cannot reference any GTT
- The destruction of a GTT instance at the end of its life cycle does not cause any BEFORE/AFTER delete triggers to fire
In an existing database, it is not always easy to distinguish a regular table from a GTT, or a transaction-level GTT from a connection-level GTT. Use this query to find out what type of table you are looking at:

```sql
select t.rdb$type_name
from rdb$relations r
join rdb$types t on r.rdb$relation_type = t.rdb$type
where t.rdb$field_name = 'RDB$RELATION_TYPE'
and r.rdb$relation_name = 'TABLENAME'
```

For an overview of the types of all the relations in the database:

```sql
select r.rdb$relation_name, t.rdb$type_name
from rdb$relations r
join rdb$types t on r.rdb$relation_type = t.rdb$type
where t.rdb$field_name = 'RDB$RELATION_TYPE'
and coalesce (r.rdb$system_flag, 0) = 0
```

The `RDB$TYPE_NAME` field will show `PERSISTENT` for a regular table, `VIEW` for a view, `GLOBAL_TEMPORARY_PRESERVE` for a connection-bound GTT and `GLOBAL_TEMPORARY_DELETE` for a transaction_bound GTT.

**Examples of Global Temporary Tables**


```sql
CREATE GLOBAL TEMPORARY TABLE MYCONNGTT (
    ID INTEGER NOT NULL PRIMARY KEY,
    TXT VARCHAR(32),
    TS TIMESTAMP DEFAULT CURRENT_TIMESTAMP)
ON COMMIT PRESERVE ROWS;
```

2. Creating a transaction-scoped global temporary table that uses a foreign key to reference a connection-scoped global temporary table. The `ON COMMIT` sub-clause is optional because `DELETE ROWS` is the default.

```sql
CREATE GLOBAL TEMPORARY TABLE MYTXGTT (
    ID INTEGER NOT NULL PRIMARY KEY,
    PARENT_ID INTEGER NOT NULL REFERENCES MYCONNGTT(ID),
    TXT VARCHAR(32),
    TS TIMESTAMP DEFAULT CURRENT_TIMESTAMP
) ON COMMIT DELETE ROWS;
```
External Tables

The optional EXTERNAL [FILE] clause specifies that the table is stored outside the database in an external text file of fixed-length records. The columns of a table stored in an external file can be of any type except BLOB or ARRAY, although for most purposes, only columns of CHAR types would be useful.

All you can do with a table stored in an external file is insert new rows (INSERT) and query the data (SELECT). Updating existing data (UPDATE) and deleting rows (DELETE) are not possible.

A file that is defined as an external table must be located on a storage device that is physically present on the machine where the Firebird server runs and, if the parameter ExternalFileAccess in the firebird.conf configuration file is Restrict, it must be in one of the directories listed there as the argument for Restrict. If the file does not exist yet, Firebird will create it on first access.

The ability to use external files for a table depends on the value set for the ExternalFileAccess parameter in firebird.conf:

- If it is set to None (the default), any attempt to access an external file will be denied.
- The Restrict setting is recommended, for restricting external file access to directories created explicitly for the purpose by the server administrator. For example:
  - ExternalFileAccess = Restrict externalfiles will restrict access to a directory named externalfiles directly beneath the Firebird root directory
  - ExternalFileAccess = d:\databases\outfiles; e:\infiles will restrict access to just those two directories on the Windows host server. Note that any path that is a network mapping will not work. Paths enclosed in single or double quotes will not work, either.
- If this parameter is set to Full, external files may be accessed anywhere on the host file system. This creates a security vulnerability and is not recommended.

External File Format

The “row” format of the external table is fixed length and binary. There are no field delimiters: both field and row boundaries are determined by maximum sizes, in bytes, of the field definitions. It is important to keep this in mind, both when defining the structure of the external table and when designing an input file for an external table that is to import data from another application. The ubiquitous “.csv” format, for example, is of no use as an input file and cannot be generated directly into an external file.

The most useful data type for the columns of external tables is the fixed-length CHAR type, of suitable lengths for the data they are to carry. Date and number types are easily cast to and from strings whereas, unless the files are to be read by another Firebird database, the native data types — binary data — will appear to external applications as unparseable “alphabetti”.

Of course, there are ways to manipulate typed data so as to generate output files from Firebird that can be read directly as input files to other applications, using stored procedures, with or without
employing external tables. Such techniques are beyond the scope of a language reference. Here, we provide some guidelines and tips for producing and working with simple text files, since the external table feature is often used as an easy way to produce or read transaction-independent logs that can be studied off-line in a text editor or auditing application.

**Row Delimiters**

Generally, external files are more useful if rows are separated by a delimiter, in the form of a “newline” sequence that is recognised by reader applications on the intended platform. For most contexts on Windows, it is the two-byte 'CRLF' sequence, carriage return (ASCII code decimal 13) and line feed (ASCII code decimal 10). On POSIX, LF on its own is usual; for some MacOSX applications, it may be LFCR. There are various ways to populate this delimiter column. In our example below, it is done by using a BEFORE INSERT trigger and the internal function ASCII_CHAR.

**External Table Example**

For our example, we will define an external log table that might be used by an exception handler in a stored procedure or trigger. The external table is chosen because the messages from any handled exceptions will be retained in the log, even if the transaction that launched the process is eventually rolled back because of another, unhandled exception. For demonstration purposes, it has just two data columns, a time stamp and a message. The third column stores the row delimiter:

```sql
CREATE TABLE ext_log
EXTERNAL FILE 'd:/externals/log_me.txt' (
    stamp CHAR (24),
    message CHAR(100),
    crlf CHAR(2) -- for a Windows context
);
COMMIT;
```

Now, a trigger, to write the timestamp and the row delimiter each time a message is written to the file:

```sql
SET TERM ^
CREATE TRIGGER bi_ext_log FOR ext_log
ACTIVE BEFORE INSERT
AS
BEGIN
    IF (new.stamp is NULL) then
        new.stamp = CAST (CURRENT_TIMESTAMP as CHAR(24));
    new.crlf = ASCII_CHAR(13) || ASCII_CHAR(10);
END ^
COMMIT ^
SET TERM ;^`

Inserting some records (which could have been done by an exception handler or a fan of Shakespeare):
5.4.2. ALTER TABLE

*Used for*

Altering the structure of a table.

*Available in*

DSQL, ESQL
Syntax

```
ALTER TABLE tablename <operation> [, <operation> ...]
```

```
<operation> ::= 
  ADD <col_def>  
  | ADD <tconstraint> 
  | DROP colname 
  | DROP CONSTRAINT constr_name 
  | ALTER [COLUMN] colname <col_mod> 
  | ALTER SQL SECURITY {INVOKER | DEFINER} 
  | DROP SQL SECURITY 
  | {ENABLE | DISABLE} PUBLICATION
```

```
<col_mod> ::= 
  TO newname 
  | POSITION newpos 
  | <regular_col_mod> 
  | <computed_col_mod> 
  | <identity_col_mod>
```

```
<regular_col_mod> ::= 
  TYPE {<datatype> | domainname} 
  | SET DEFAULT {<literal> | NULL | <context_var>} 
  | DROP DEFAULT 
  | {SET | DROP} NOT NULL
```

```
<computed_col_mod> ::= 
  [TYPE <datatype>] {COMPUTED [BY] | GENERATED ALWAYS AS} (<expression>)
```

```
<identity_col_mod> ::= 
  SET GENERATED {ALWAYS | BY DEFAULT} [identity_mod_option]... 
  | <identity_mod_options>... 
  | DROP IDENTITY
```

```
<identity_mod_options> ::= 
  RESTART [WITH restart_value] 
  | SET INCREMENT [BY] inc_value
```

!! See CREATE TABLE syntax for further rules !!

Table 34. ALTER TABLE Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tablename</td>
<td>Name (identifier) of the table</td>
</tr>
<tr>
<td>operation</td>
<td>One of the available operations altering the structure of the table</td>
</tr>
<tr>
<td>colname</td>
<td>Name (identifier) for a column in the table. The maximum length is 63 characters. Must be unique in the table.</td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>domain_name</td>
<td>Domain name</td>
</tr>
<tr>
<td>newname</td>
<td>New name (identifier) for the column. The maximum length is 63 characters. Must be unique in the table.</td>
</tr>
<tr>
<td>newpos</td>
<td>The new column position (an integer between 1 and the number of columns in the table)</td>
</tr>
<tr>
<td>other_table</td>
<td>The name of the table referenced by the foreign key constraint</td>
</tr>
<tr>
<td>literal</td>
<td>A literal value that is allowed in the given context</td>
</tr>
<tr>
<td>context_var</td>
<td>A context variable whose type is allowed in the given context</td>
</tr>
<tr>
<td>check_condition</td>
<td>The condition of a CHECK constraint that will be satisfied if it evaluates to TRUE or UNKNOWN/NULL</td>
</tr>
<tr>
<td>restart_value</td>
<td>The first value of the identity column after restart</td>
</tr>
<tr>
<td>inc_value</td>
<td>The increment (or step) value of the identity column; zero (0) is not allowed.</td>
</tr>
</tbody>
</table>

The `ALTER TABLE` statement changes the structure of an existing table. With one `ALTER TABLE` statement it is possible to perform multiple operations, adding/dropping columns and constraints and also altering column specifications.

Multiple operations in an `ALTER TABLE` statement are separated with commas.

**Version Count Increments**

Some changes in the structure of a table increment the metadata change counter (“version count”) assigned to every table. The number of metadata changes is limited to 255 for each table, or 32,000 for each view. Once the counter reaches this limit, you will not be able to make any further changes to the structure of the table or view without resetting the counter.

**To reset the metadata change counter**

You need to back up and restore the database using the `gbak` utility.

**The ADD Clause**

With the `ADD` clause you can add a new column or a new table constraint. The syntax for defining the column and the syntax of defining the table constraint correspond with those described for `CREATE TABLE` statement.

**Effect on Version Count**

- Each time a new column is added, the metadata change counter is increased by one
- Adding a new table constraint does not increase the metadata change counter
Points to Be Aware of

1. Adding a column with a NOT NULL constraint without a DEFAULT value will fail if the table has existing rows. When adding a non-nullable column, it is recommended either to set a default value for it, or to create it as nullable, update the column in existing rows with a non-null value, and then add a NOT NULL constraint.

2. When a new CHECK constraint is added, existing data is not tested for compliance. Prior testing of existing data against the new CHECK expression is recommended.

3. Although adding an identity column is supported, this will only succeed if the table is empty. Adding an identity column will fail if the table has one or more rows.

The DROP Clause

The DROP colname clause deletes the specified column from the table. An attempt to drop a column will fail if anything references it. Consider the following items as sources of potential dependencies:

- column or table constraints
- indexes
- stored procedures and triggers
- views

Effect on Version Count

- Each time a column is dropped, the table's metadata change counter is increased by one.

The DROP CONSTRAINT Clause

The DROP CONSTRAINT clause deletes the specified column-level or table-level constraint.

A PRIMARY KEY or UNIQUE key constraint cannot be deleted if it is referenced by a FOREIGN KEY constraint in another table. It will be necessary to drop that FOREIGN KEY constraint before attempting to drop the PRIMARY KEY or UNIQUE key constraint it references.

Effect on Version Count

- Deleting a column constraint or a table constraint does not increase the metadata change counter.

The ALTER [COLUMN] Clause

With the ALTER [COLUMN] clause, attributes of existing columns can be modified without the need to drop and re-add the column. Permitted modifications are:

- change the name (does not affect the metadata change counter)
- change the data type (increases the metadata change counter by one)
- change the column position in the column list of the table (does not affect the metadata change counter)
counter)

- delete the default column value (does not affect the metadata change counter)
- set a default column value or change the existing default (does not affect the metadata change counter)
- change the type and expression for a computed column (does not affect the metadata change counter)
- set the NOT NULL constraint (does not affect the metadata change counter)
- drop the NOT NULL constraint (does not affect the metadata change counter)
- change the type of an identity column, or change an identity column to a regular column
- restart an identity column
- change the increment of an identity column

Renaming a Column: the TO Clause

The TO keyword with a new identifier renames an existing column. The table must not have an existing column that has the same identifier.

It will not be possible to change the name of a column that is included in any constraint: PRIMARY KEY, UNIQUE key, FOREIGN KEY, column constraint or the CHECK constraint of the table.

Renaming a column will also be disallowed if the column is used in any trigger, stored procedure or view.

Changing the Data Type of a Column: the TYPE Clause

The keyword TYPE changes the data type of an existing column to another, allowable type. A type change that might result in data loss will be disallowed. As an example, the number of characters in the new type for a CHAR or VARCHAR column cannot be smaller than the existing specification for it.

If the column was declared as an array, no change to its type or its number of dimensions is permitted.

The data type of a column that is involved in a foreign key, primary key or unique constraint cannot be changed at all.

Changing the Position of a Column: the POSITION Clause

The POSITION keyword changes the position of an existing column in the notional “left-to-right” layout of the record.

Numbering of column positions starts at 1.

- If a position less than 1 is specified, an error message will be returned
- If a position number is greater than the number of columns in the table, its new position will be adjusted silently to match the number of columns.
The DROP DEFAULT and SET DEFAULT Clauses

The optional DROP DEFAULT clause deletes the default value for the column if it was put there previously by a CREATE TABLE or ALTER TABLE statement.

- If the column is based on a domain with a default value, the default value will revert to the domain default
- An execution error will be raised if an attempt is made to delete the default value of a column which has no default value or whose default value is domain-based

The optional SET DEFAULT clause sets a default value for the column. If the column already has a default value, it will be replaced with the new one. The default value applied to a column always overrides one inherited from a domain.

The SET NOT NULL and DROP NOT NULL Clauses

The SET NOT NULL clause adds a NOT NULL constraint on an existing table column. Contrary to definition in CREATE TABLE, it is not possible to specify a constraint name.

The successful addition of the NOT NULL constraint is subject to a full data validation on the table, so ensure that the column has no nulls before attempting the change.

An explicit NOT NULL constraint on domain-based column overrides domain settings. In this scenario, changing the domain to be nullable does not extend to a table column.

Dropping the NOT NULL constraint from the column if its type is a domain that also has a NOT NULL constraint, has no observable effect until the NOT NULL constraint is dropped from the domain as well.

The COMPUTED [BY] or GENERATED ALWAYS AS Clauses

The data type and expression underlying a computed column can be modified using a COMPUTED [BY] or GENERATED ALWAYS AS clause in the ALTER TABLE ALTER [COLUMN] statement. Converting a regular column to a computed one and vice versa are not permitted.

Changing Identity Columns

or identity columns (SET GENERATED {ALWAYS | BY DEFAULT}) it is possible to modify several properties using the following clauses.

Identity Type

The SET GENERATED {ALWAYS | BY DEFAULT} changes an identity column from ALWAYS to BY DEFAULT and vice versa. It is not possible to use this to change a regular column to an identity column.

RESTART

The RESTART clause restarts the sequence used for generating identity values. If only the RESTART clause is specified, then the sequence resets to the initial value specified when the identity column
was defined. If the optional **WITH restart_value** clause is specified, the sequence will restart with the specified value.

In Firebird 3.0, **RESTART WITH restart_value** would also change the configured initial value to **restart_value**. This was not compliant with the SQL standard, so in Firebird 4.0, **RESTART WITH restart_value** will only restart the sequence with the specified value. Subsequent **RESTARTs** (without **WITH**) will use the **START WITH** value specified when the identity column was defined.

It is currently not possible to change the configured start value.

**SET INCREMENT**

The **SET INCREMENT** clause changes the increment of the identity column.

**DROP IDENTITY**

The **DROP IDENTITY** clause will change an identity column to a regular column.

It is not possible to change a regular column to an identity column.

**Changing SQL Security**

Using the **ALTER SQL SECURITY** or **DROP SQL SECURITY** clauses, it is possible to change or drop the SQL Security property of a table. After dropping SQL Security, the default value of the database is applied at runtime.

If the SQL Security property is changed for a table, triggers that do not have an explicit SQL Security property will not see the effect of the change until the next time the trigger is loaded into the metadata cache.

**Replication Management**

To stop replicating a table, use the **DISABLE PUBLICATION** clause. To start replicating a table, use the **ENABLE PUBLICATION** clause.

The change in publication status takes effect at commit.

**Attributes that Cannot Be Altered**

The following alterations are not supported:

- Changing the collation of a character type column

**Who Can Alter a Table?**

The **ALTER TABLE** statement can be executed by:

- Administrators
- The owner of the table
• Users with the ALTER ANY TABLE privilege

**Examples Using ALTER TABLE**

1. Adding the CAPITAL column to the COUNTRY table.

   ```sql
   ALTER TABLE COUNTRY
   ADD CAPITAL VARCHAR(25);
   ```

2. Adding the CAPITAL column with the NOT NULL and UNIQUE constraint and deleting the CURRENCY column.

   ```sql
   ALTER TABLE COUNTRY
   ADD CAPITAL VARCHAR(25) NOT NULL UNIQUE,
   DROP CURRENCY;
   ```

3. Adding the CHK_SALARY check constraint and a foreign key to the JOB table.

   ```sql
   ALTER TABLE JOB
   ADD CONSTRAINT CHK_SALARY CHECK (MIN_SALARY < MAX_SALARY),
   ADD FOREIGN KEY (JOB_COUNTRY) REFERENCES COUNTRY (COUNTRY);
   ```

4. Setting default value for the MODEL field, changing the type of the ITEMID column and renaming the MODELNAME column.

   ```sql
   ALTER TABLE STOCK
   ALTER COLUMN MODEL SET DEFAULT 1,
   ALTER COLUMN ITEMID TYPE BIGINT,
   ALTER COLUMN MODELNAME TO NAME;
   ```

5. Restarting the sequence of an identity column.

   ```sql
   ALTER TABLE objects
   ALTER ID RESTART WITH 100;
   ```

6. Changing the computed columns NEW_SALARY and SALARYCHANGE.

   ```sql
   ALTER TABLE SALARY_HISTORY
   ALTER NEW_SALARY GENERATED ALWAYS AS
   (OLD_SALARY + OLD_SALARY * PERCENT_CHANGE / 100),
   ALTER SALARY_CHANGE COMPUTED BY
   (OLD_SALARY * PERCENT_CHANGE / 100);
   ```
See also
CREATE TABLE, DROP TABLE, CREATE DOMAIN

5.4.3. DROP TABLE

Used for
Dropping (deleting) a table

Available in
DSQL, ESQL

Syntax

```sql
DROP TABLE tablename
```

Table 35. DROP TABLE Statement Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tablename</td>
<td>Name (identifier) of the table</td>
</tr>
</tbody>
</table>

The `DROP TABLE` statement drops (deletes) an existing table. If the table has dependencies, the `DROP TABLE` statement will fail with an execution error.

When a table is dropped, all its triggers and indexes will be deleted as well.

Who Can Drop a Table?

The `DROP TABLE` statement can be executed by:

- Administrators
- The owner of the table
- Users with the `DROP ANY TABLE` privilege

Example of DROP TABLE

Dropping the `COUNTRY` table.

```sql
DROP TABLE COUNTRY;
```

See also
CREATE TABLE, ALTER TABLE, RECREATE TABLE

5.4.4. RECREATE TABLE

Used for
Creating a new table (relation) or recreating an existing one

Available in
DSQL

Syntax

```sql
RECREATE [GLOBAL TEMPORARY] TABLE tablename
  [EXTERNAL [FILE] 'filespec']
  (<col_def> [, {<col_def> | <tconstraint>} ...])
  [{<table_attrs> | <gtt_table_attrs>}]```

See the CREATE TABLE section for the full syntax of CREATE TABLE and descriptions of defining tables, columns and constraints.

RECREATE TABLE creates or recreates a table. If a table with this name already exists, the RECREATE TABLE statement will try to drop it and create a new one. Existing dependencies will prevent the statement from executing.

**Example of RECREATE TABLE**

Creating or recreating the COUNTRY table.

```sql
RECREATE TABLE COUNTRY (  
  COUNTRY COUNTRYNAME NOT NULL PRIMARY KEY,
  CURRENCY VARCHAR(10) NOT NULL
)
```

See also

CREATE TABLE, DROP TABLE

5.5. INDEX

An index is a database object used for faster data retrieval from a table or for speeding up the sorting in a query. Indexes are used also to enforce the referential integrity constraints PRIMARY KEY, FOREIGN KEY and UNIQUE.

This section describes how to create indexes, activate and deactivate them, delete them and collect statistics (recalculate selectivity) for them.

5.5.1. CREATE INDEX

*Used for*

Creating an index for a table

*Available in*

DSQL, ESQL
Syntax

CREATE [UNIQUE] [ASC|DESC] INDEX indexname ON tablename
{ (col [, col ...]) | COMPUTED BY (<expression>) }

Table 36. CREATE INDEX Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>indexname</td>
<td>Index name. The maximum length is 63 characters</td>
</tr>
<tr>
<td>tablename</td>
<td>The name of the table for which the index is to be built</td>
</tr>
<tr>
<td>col</td>
<td>Name of a column in the table. Columns of the types BLOB and ARRAY and computed fields cannot be used in an index</td>
</tr>
<tr>
<td>expression</td>
<td>The expression that will compute the values for a computed index, also known as an “expression index”</td>
</tr>
</tbody>
</table>

The CREATE INDEX statement creates an index for a table that can be used to speed up searching, sorting and grouping. Indexes are created automatically in the process of defining constraints, such as primary key, foreign key or unique constraints.

An index can be built on the content of columns of any data type except for BLOB and arrays. The name (identifier) of an index must be unique among all index names.

Key Indexes

When a primary key, foreign key or unique constraint is added to a table or column, an index with the same name is created automatically, without an explicit directive from the designer. For example, the PK_COUNTRY index will be created automatically when you execute and commit the following statement:

```
ALTER TABLE COUNTRY ADD CONSTRAINT PK_COUNTRY
PRIMARY KEY (ID);
```

Who Can Create an Index?

The CREATE INDEX statement can be executed by:

- Administrators
- The owner of the table
- Users with the ALTER ANY TABLE privilege

Unique Indexes

Specifying the keyword UNIQUE in the index creation statement creates an index in which uniqueness will be enforced throughout the table. The index is referred to as a “unique index”. A unique index is not a constraint.
Unique indexes cannot contain duplicate key values (or duplicate key value combinations, in the case of compound, or multi-column, or multi-segment) indexes. Duplicated NULLs are permitted, in accordance with the SQL:99 standard, in both single-segment and multi-segment indexes.

Index Direction

All indexes in Firebird are uni-directional. An index may be constructed from the lowest value to the highest (ascending order) or from the highest value to the lowest (descending order). The keywords ASC[ENDING] and DESC[ENDING] are used to specify the direction of the index. The default index order is ASC[ENDING]. It is quite valid to define both an ascending and a descending index on the same column or key set.

A descending index can be useful on a column that will be subjected to searches on the high values (“newest”, maximum, etc.)

Firebird uses B-tree indexes, which are bidirectional. However, due to technical limitations, Firebird uses an index in one direction only.

See also Firebird for the Database Expert: Episode 3 - On disk consistency

Computed (Expression) Indexes

In creating an index, you can use the COMPUTED BY clause to specify an expression instead of one or more columns. Computed indexes are used in queries where the condition in a WHERE, ORDER BY or GROUP BY clause exactly matches the expression in the index definition. The expression in a computed index may involve several columns in the table.

You can actually create a computed index on a computed field, but such an index will never be used.

Limits on Indexes

Certain limits apply to indexes.

The maximum length of a key in an index is limited to ¼ of the page size.

Maximum Indexes per Table

The number of indexes that can be accommodated for each table is limited. The actual maximum for a specific table depends on the page size and the number of columns in the indexes.

<table>
<thead>
<tr>
<th>Page Size</th>
<th>Number of Indexes Depending on Column Count</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single</td>
</tr>
<tr>
<td>4096</td>
<td>203</td>
</tr>
<tr>
<td>8192</td>
<td>408</td>
</tr>
</tbody>
</table>

Table 37. Maximum Indexes per Table
Character Index Limits

The maximum indexed string length is 9 bytes less than the maximum key length. The maximum indexable string length depends on the page size and the character set.

Table 38. Maximum indexable (VAR)CHAR length

<table>
<thead>
<tr>
<th>Page Size</th>
<th>Maximum Indexable String Length by Charset Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 byte/char</td>
</tr>
<tr>
<td>4096</td>
<td>1015</td>
</tr>
<tr>
<td>8192</td>
<td>2039</td>
</tr>
<tr>
<td>16384</td>
<td>4087</td>
</tr>
<tr>
<td>32768</td>
<td>8183</td>
</tr>
</tbody>
</table>

Depending on the collation, the maximum size can be further reduced as case-insensitive and accent-insensitive collations require more bytes per character in an index. See also Character Indexes in Chapter Data Types and Subtypes.

Examples Using CREATE INDEX

1. Creating an index for the UPDATER_ID column in the SALARY_HISTORY table

   ```sql
   CREATE INDEX IDX_UPDATER
   ON SALARY_HISTORY (UPDATER_ID);
   ```

2. Creating an index with keys sorted in the descending order for the CHANGE_DATE column in the SALARY_HISTORY table

   ```sql
   CREATE DESCENDING INDEX IDX_CHANGE
   ON SALARY_HISTORY (CHANGE_DATE);
   ```

3. Creating a multi-segment index for the ORDER_STATUS, PAID columns in the SALES table

   ```sql
   CREATE INDEX IDX_SALESTAT
   ON SALES (ORDER_STATUS, PAID);
   ```

4. Creating an index that does not permit duplicate values for the NAME column in the COUNTRY table

   ```sql
   ```
CREATE UNIQUE INDEX UNQ_COUNTRY_NAME
ON COUNTRY (NAME);

5. Creating a computed index for the PERSONS table

CREATE INDEX IDX_NAME_UPPER ON PERSONS
    COMPUTED BY (UPPER (NAME));

An index like this can be used for a case-insensitive search:

SELECT *
FROM PERSONS
WHERE UPPER(NAME) STARTING WITH UPPER('Iv');

See also
ALTER INDEX, DROP INDEX

5.5.2. ALTER INDEX

Used for
Activating or deactivating an index; rebuilding an index

Available in
DSQL, ESQL

Syntax

ALTER INDEX indexname {ACTIVE | INACTIVE}

Table 39. ALTER INDEX Statement Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>indexname</td>
<td>Index name</td>
</tr>
</tbody>
</table>

The ALTER INDEX statement activates or deactivates an index. There is no facility on this statement for altering any attributes of the index.

INACTIVE

With the INACTIVE option, the index is switched from the active to inactive state. The effect is similar to the DROP INDEX statement except that the index definition remains in the database. Altering a constraint index to the inactive state is not permitted.

An active index can be deactivated if there are no queries prepared using that index; otherwise, an “object in use” error is returned.
Activating an inactive index is also safe. However, if there are active transactions modifying the table, the transaction containing the `ALTER INDEX` statement will fail if it has the `NOWAIT` attribute. If the transaction is in `WAIT` mode, it will wait for completion of concurrent transactions.

On the other side of the coin, if our `ALTER INDEX` succeeds and starts to rebuild the index at `COMMIT`, other transactions modifying that table will fail or wait, according to their `WAIT`/`NOWAIT` attributes. The situation is exactly the same for `CREATE INDEX`.

**How is it Useful?**

It might be useful to switch an index to the inactive state whilst inserting, updating or deleting a large batch of records in the table that owns the index.

**ACTIVE**

With the `ACTIVE` option, if the index is in the inactive state, it will be switched to active state and the system rebuilds the index.

**How is it Useful?**

Even if the index is active when `ALTER INDEX ... ACTIVE` is executed, the index will be rebuilt. Rebuilding indexes can be a useful piece of housekeeping to do, occasionally, on the indexes of a large table in a database that has frequent inserts, updates or deletes but is infrequently restored.

**Who Can Alter an Index?**

The `ALTER INDEX` statement can be executed by:

- Administrators
- The owner of the table
- Users with the `ALTER ANY TABLE` privilege

**Use of `ALTER INDEX` on a Constraint Index**

Altering the index of a `PRIMARY KEY`, `FOREIGN KEY` or `UNIQUE` constraint to `INACTIVE` is not permitted. However, `ALTER INDEX ... ACTIVE` works just as well with constraint indexes as it does with others, as an index rebuilding tool.

**ALTER INDEX Examples**

1. Deactivating the `IDX_UPDATER` index

   ```sql
   ALTER INDEX IDX_UPDATER INACTIVE;
   ```

2. Switching the `IDX_UPDATER` index back to the active state and rebuilding it

   ```sql
   ALTER INDEX IDX_UPDATER ACTIVE;
   ```
See also
CREATE INDEX, DROP INDEX, SET STATISTICS

5.5.3. DROP INDEX

Used for
Dropping (deleting) an index

Available in
DSQL, ESQL

Syntax

```
DROP INDEX indexname
```

Table 40. DROP INDEX Statement Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>indexname</td>
<td>Index name</td>
</tr>
</tbody>
</table>

The `DROP INDEX` statement drops (deletes) the named index from the database.

A constraint index cannot dropped using `DROP INDEX`. Constraint indexes are dropped during the process of executing the command `ALTER TABLE ... DROP CONSTRAINT ...`.

Who Can Drop an Index?

The `DROP INDEX` statement can be executed by:

- **Administrators**
- The owner of the table
- Users with the `ALTER ANY TABLE` privilege

DROP INDEX Example

Dropping the IDX_UPDATER index

```
DROP INDEX IDX_UPDATER;
```

See also
CREATE INDEX, ALTER INDEX

5.5.4. SET STATISTICS

Used for
Recalculating the selectivity of an index
Available in
DSQL, ESQL

Syntax

```
SET STATISTICS INDEX indexname
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>indexname</td>
<td>Index name</td>
</tr>
</tbody>
</table>

Table 41. SET STATISTICS Statement Parameter

The `SET STATISTICS` statement recalculates the selectivity of the specified index.

**Who Can Update Index Statistics?**

The `SET STATISTICS` statement can be executed by:

- Administrators
- The owner of the table
- Users with the ALTER ANY TABLE privilege

**Index Selectivity**

The selectivity of an index is the result of evaluating the number of rows that can be selected in a search on every index value. A unique index has the maximum selectivity because it is impossible to select more than one row for each value of an index key if it is used. Keeping the selectivity of an index up to date is important for the optimizer’s choices in seeking the most optimal query plan.

Index statistics in Firebird are not automatically recalculated in response to large batches of inserts, updates or deletions. It may be beneficial to recalculate the selectivity of an index after such operations because the selectivity tends to become outdated.

- The statements `CREATE INDEX` and `ALTER INDEX ACTIVE` both store index statistics that completely correspond to the contents of the newly-[re]built index.

It can be performed under concurrent load without risk of corruption. However, be aware that, under concurrent load, the newly calculated statistics could become outdated as soon as `SET STATISTICS` finishes.

**Example Using SET STATISTICS**

Recalculating the selectivity of the index IDX_UPDATER

```
SET STATISTICS INDEX IDX_UPDATER;
```

See also

`CREATE INDEX`, `ALTER INDEX`
A view is a virtual table that is actually a stored and named SELECT query for retrieving data of any complexity. Data can be retrieved from one or more tables, from other views and also from selectable stored procedures.

Unlike regular tables in relational databases, a view is not an independent data set stored in the database. The result is dynamically created as a data set when the view is selected.

The metadata of a view are available to the process that generates the binary code for stored procedures and triggers, just as though they were concrete tables storing persistent data.

**5.6.1. CREATE VIEW**

*Used for*
Creating a view

*Available in*
DSQL

*Syntax*

```
CREATE VIEW viewname [full_column_list]
   AS select_statement
   [WITH CHECK OPTION]
```

<full_column_list> ::= (colname [, colname ...])

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>viewname</td>
<td>View name. The maximum length is 63 characters</td>
</tr>
<tr>
<td>select_statement</td>
<td>SELECT statement</td>
</tr>
<tr>
<td>full_column_list</td>
<td>The list of columns in the view</td>
</tr>
<tr>
<td>colname</td>
<td>View column name. Duplicate column names are not allowed.</td>
</tr>
</tbody>
</table>

The CREATE VIEW statement creates a new view. The identifier (name) of a view must be unique among the names of all views, tables and stored procedures in the database.

The name of the new view can be followed by the list of column names that should be returned to the caller when the view is invoked. Names in the list do not have to be related to the names of the columns in the base tables from which they derive.

If the view column list is omitted, the system will use the column names and/or aliases from the SELECT statement. If duplicate names or non-aliased expression-derived columns make it impossible to obtain a valid list, creation of the view fails with an error.

The number of columns in the view’s list must exactly match the number of columns in the
selection list of the underlying SELECT statement in the view definition.

**Additional Points**

- If the full list of columns is specified, it makes no sense to specify aliases in the SELECT statement because the names in the column list will override them.
- The column list is optional if all the columns in the SELECT are explicitly named and are unique in the selection list.

**Updatable Views**

A view can be updatable or read-only. If a view is updatable, the data retrieved when this view is called can be changed by the DML statements `INSERT`, `UPDATE`, `DELETE`, `UPDATE OR INSERT` or `MERGE`. Changes made in an updatable view are applied to the underlying table(s).

A read-only view can be made updateable with the use of triggers. Once triggers have been defined on a view, changes posted to it will never be written automatically to the underlying table, even if the view was updatable to begin with. It is the responsibility of the programmer to ensure that the triggers update (or delete from, or insert into) the base tables as needed.

A view will be automatically updatable if all the following conditions are met:

- the SELECT statement queries only one table or one updatable view
- the SELECT statement does not call any stored procedures
- each base table (or base view) column not present in the view definition meets one of the following conditions:
  - it is nullable
  - it has a non-NULL default value
  - it has a trigger that supplies a permitted value
- the SELECT statement contains no fields derived from subqueries or other expressions
- the SELECT statement does not contain fields defined through aggregate functions (`MIN`, `MAX`, `AVG`, `SUM`, `COUNT`, `LIST`, etc.), statistical functions (`CORR`, `COVAR_POP`, `COVAR_SAMP`, etc.), linear regression functions (`REGR_AVGX`, `REGR_AVGY`, etc.) or any type of window function
- the SELECT statement contains no `ORDER BY`, `GROUP BY` or `HAVING` clause
- the SELECT statement does not include the keyword `DISTINCT` or row-restrictive keywords such as `ROWS`, `FIRST`, `SKIP`, `OFFSET` or `FETCH`

**WITH CHECK OPTION**

The optional `WITH CHECK OPTION` clause requires an updatable view to check whether new or updated data meet the condition specified in the `WHERE` clause of the SELECT statement. Every attempt to insert a new record or to update an existing one is checked whether the new or updated record would meet the `WHERE` criteria. If they fail the check, the operation is not performed and an appropriate error message is returned.

`WITH CHECK OPTION` can be specified only in a `CREATE VIEW` statement in which a `WHERE` clause is
Please note:

If WITH CHECK OPTION is used, the engine checks the input against the WHERE clause before passing anything to the base relation. Therefore, if the check on the input fails, any default clauses or triggers on the base relation that might have been designed to correct the input will never come into action.

Furthermore, view fields omitted from the INSERT statement are passed as NULLs to the base relation, regardless of their presence or absence in the WHERE clause. As a result, base table defaults defined on such fields will not be applied. Triggers, on the other hand, will fire and work as expected.

For views that do not have WITH CHECK OPTION, fields omitted from the INSERT statement are not passed to the base relation at all, so any defaults will be applied.

Who Can Create a View?

The CREATE VIEW statement can be executed by:

- Administrators
- Users with the CREATE VIEW privilege

The creator of a view becomes its owner.

To create a view, a non-admin user also needs at least SELECT access to the underlying table(s) and/or view(s), and the EXECUTE privilege on any selectable stored procedures involved.

To enable insertions, updates and deletions through the view, the creator/owner must also possess the corresponding INSERT, UPDATE and DELETE rights on the underlying object(s).

Granting other users privileges on the view is only possible if the view owner has these privileges on the underlying objects WITH GRANT OPTION. It will always be the case if the view owner is also the owner of the underlying objects.

Examples of Creating Views

1. Creating view returning the JOB_CODE and JOB_TITLE columns only for those jobs where MAX_SALARY is less than $15,000.

```sql
CREATE VIEW ENTRY_LEVEL_JOBS AS
SELECT JOB_CODE, JOB_TITLE
FROM JOB
WHERE MAX_SALARY < 15000;
```

2. Creating a view returning the JOB_CODE and JOB_TITLE columns only for those jobs where MAX_SALARY is less than $15,000. Whenever a new record is inserted or an existing record is updated, the MAX_SALARY < 15000 condition will be checked. If the condition is not true, the
insert/update operation will be rejected.

```
CREATE VIEW ENTRY_LEVEL_JOBS AS
SELECT JOB_CODE, JOB_TITLE
FROM JOB
WHERE MAX_SALARY < 15000
WITH CHECK OPTION;
```

3. Creating a view with an explicit column list.

```
CREATE VIEW PRICE_WITH_MARKUP (    
    CODE_PRICE,
    COST,
    COST_WITH_MARKUP
) AS
SELECT
    CODE_PRICE,
    COST,
    COST * 1.1
FROM PRICE;
```

4. Creating a view with the help of aliases for fields in the SELECT statement (the same result as in Example 3).

```
CREATE VIEW PRICE_WITH_MARKUP AS
SELECT
    CODE_PRICE,
    COST,
    COST * 1.1 AS COST_WITH_MARKUP
FROM PRICE;
```

5. Creating a read-only view based on two tables and a stored procedure.

```
CREATE VIEW GOODS_PRICE AS
SELECT
    goods.name AS goodsname,
    price.cost AS cost,
    b.quantity AS quantity
FROM
    goods
JOIN price ON goods.code_goods = price.code_goods
LEFT JOIN sp_get_balance(goods.code_goods) b ON 1 = 1;
```

See also

ALTER VIEW, CREATE OR ALTER VIEW, RECREATE VIEW, DROP VIEW
5.6.2. ALTER VIEW

*Used for*
Modifying an existing view

*Available in*
DSQL

*Syntax*

```sql
ALTER VIEW viewname [<full_column_list>]
    AS <select_statement>
    [WITH CHECK OPTION]

<full_column_list> ::= (colname [, colname ...])
```

**Table 43. ALTER VIEW Statement Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>viewname</td>
<td>Name of an existing view</td>
</tr>
<tr>
<td>select_statement</td>
<td>SELECT statement</td>
</tr>
<tr>
<td>full_column_list</td>
<td>The list of columns in the view</td>
</tr>
<tr>
<td>colname</td>
<td>View column name. Duplicate column names are not allowed.</td>
</tr>
</tbody>
</table>

Use the `ALTER VIEW` statement for changing the definition of an existing view. Privileges for views remain intact and dependencies are not affected.

The syntax of the `ALTER VIEW` statement corresponds completely with that of `CREATE VIEW`.

Be careful when you change the number of columns in a view. Existing application code and PSQL modules that access the view may become invalid. For information on how to detect this kind of problem in stored procedures and trigger, see *The RDB$VALID_BLR Field* in the Appendix.

**Who Can Alter a View?**

The `ALTER VIEW` statement can be executed by:

- *Administrators*
- The owner of the view
- Users with the `ALTER ANY VIEW` privilege

**Example using** `ALTER VIEW`
ALTER VIEW PRICE_WITH_MARKUP

ALTER VIEW PRICE_WITH_MARKUP (  
   CODE_PRICE,  
   COST,  
   COST_WITH_MARKUP  
) AS  
SELECT  
   CODE_PRICE,  
   COST,  
   COST * 1.15  
FROM PRICE;

See also
CREATE VIEW, CREATE OR ALTER VIEW, RECREATE VIEW

5.6.3. CREATE OR ALTER VIEW

Used for
Creating a new view or altering an existing view.

Available in
DSQL

Syntax

CREATE OR ALTER VIEW {viewname} [<full_column_list>]
   AS <select_statement>
   [WITH CHECK OPTION]

<full_column_list> ::= (colname [, colname ...])

Table 44. CREATE OR ALTER VIEW Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>viewname</td>
<td>Name of a view which may or may not exist</td>
</tr>
<tr>
<td>select_statement</td>
<td>SELECT statement</td>
</tr>
<tr>
<td>full_column_list</td>
<td>The list of columns in the view</td>
</tr>
<tr>
<td>colname</td>
<td>View column name. Duplicate column names are not allowed.</td>
</tr>
</tbody>
</table>

Use the CREATE OR ALTER VIEW statement for changing the definition of an existing view or creating it if it does not exist. Privileges for an existing view remain intact and dependencies are not affected.

The syntax of the CREATE OR ALTER VIEW statement corresponds completely with that of CREATE VIEW.
Example of CREATE OR ALTER VIEW

Creating the new view PRICE_WITH_MARKUP view or altering it if it already exists

```
CREATE OR ALTER VIEW PRICE_WITH_MARKUP (
   CODE_PRICE,
   COST,
   COST * 1.15
) AS
SELECT
   CODE_PRICE,
   COST,
   COST * 1.15
FROM PRICE;
```

See also

CREATE VIEW, ALTER VIEW, RECREATE VIEW

5.6.4. DROP VIEW

Used for
Deleting (dropping) a view

Available in
DSQL

Syntax

```
DROP VIEW viewname
```

Table 45. DROP VIEW Statement Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>viewname</td>
<td>View name</td>
</tr>
</tbody>
</table>

The DROP VIEW statement drops (deletes) an existing view. The statement will fail if the view has dependencies.

Who Can Drop a View?

The DROP VIEW statement can be executed by:

- Administrators
- The owner of the view
- Users with the DROP ANY VIEW privilege
Example

Deleting the PRICE_WITH_MARKUP view

DROP VIEW PRICE_WITH_MARKUP;

See also

CREATE VIEW, RECREATE VIEW, CREATE OR ALTER VIEW

5.6.5. RECREATE VIEW

Used for

Creating a new view or recreating an existing view

Available in

DSQL

Syntax

RECREATE VIEW viewname [full_column_list] AS <select_statement> [WITH CHECK OPTION]

<full_column_list> ::= (colname [, colname ...])

Table 46. RECREATE VIEW Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>viewname</td>
<td>View name. The maximum length is 63 characters</td>
</tr>
<tr>
<td>select_statement</td>
<td>SELECT statement</td>
</tr>
<tr>
<td>full_column_list</td>
<td>The list of columns in the view</td>
</tr>
<tr>
<td>colname</td>
<td>View column name. Duplicate column names are not allowed.</td>
</tr>
</tbody>
</table>

Creates or recreates a view. If there is a view with this name already, the engine will try to drop it before creating the new instance. If the existing view cannot be dropped, because of dependencies or insufficient rights, for example, RECREATE VIEW fails with an error.

Example of RECREATE VIEW
Creating the new view `PRICE_WITH_MARKUP` view or recreating it, if it already exists

```sql
RECREATE VIEW PRICE_WITH_MARKUP (  
    CODE_PRICE,  
    COST,  
    COST_WITH_MARKUP  
) AS  
SELECT  
    CODE_PRICE,  
    COST,  
    COST * 1.15  
FROM PRICE;
```

See also

`CREATE VIEW`, `DROP VIEW`, `CREATE OR ALTER VIEW`

5.7. TRIGGER

A trigger is a special type of stored procedure that is not called directly, instead being executed when a specified event occurs in the associated table or view. A DML trigger is specific to one and only one relation (table or view) and one phase in the timing of the event (BEFORE or AFTER). It can be specified to execute for one specific event (insert, update, delete) or for some combination of two or three of those events.

Two other forms of trigger exist:

1. a “database trigger” can be specified to fire at the start or end of a user session (connection) or a user transaction.
2. a “DDL trigger” can be specified to fire at the before or after execution of one or more types of DDL statements.

5.7.1. CREATE TRIGGER

*Used for*

Creating a new trigger

*Available in*

DSQL, ESQL

*Syntax*

```sql
CREATE TRIGGER triname  
{ <relation_trigger_legacy>  
| <relation_trigger_sql2003>  
| <database_trigger>  
| <ddl_trigger> }  
{<psql_trigger> | <external-module-body>}
```
<relation_trigger_legacy> ::=  
  FOR {tablename | viewname} 
  [ACTIVE | INACTIVE]  
  {BEFORE | AFTER} <mutation_list> 
  [POSITION number]

<relation_trigger_sql2003> ::=  
  [ACTIVE | INACTIVE]  
  {BEFORE | AFTER} <mutation_list> 
  ON {tablename | viewname} 
  [POSITION number]

<database_trigger> ::=  
  [ACTIVE | INACTIVE] ON <db_event> 
  [POSITION number]

<ddl_trigger> ::=  
  [ACTIVE | INACTIVE]  
  {BEFORE | AFTER} <ddl_event> 
  [POSITION number]

<mutation_list> ::=  
  <mutation> [OR <mutation> [OR <mutation>]]

<mutation> ::= INSERT | UPDATE | DELETE

<db_event> ::=  
  CONNECT | DISCONNECT  
  | TRANSACTION {START | COMMIT | ROLLBACK}

<ddl_event> ::=  
  ANY DDL STATEMENT  
  | <ddl_event_item> [{OR <ddl_event_item>} ...]

<ddl_event_item> ::=  
  {CREATE | ALTER | DROP} TABLE  
  | {CREATE | ALTER | DROP} PROCEDURE  
  | {CREATE | ALTER | DROP} FUNCTION  
  | {CREATE | ALTER | DROP} TRIGGER  
  | {CREATE | ALTER | DROP} EXCEPTION  
  | {CREATE | ALTER | DROP} VIEW  
  | {CREATE | ALTER | DROP} DOMAIN  
  | {CREATE | ALTER | DROP} ROLE  
  | {CREATE | ALTER | DROP} SEQUENCE  
  | {CREATE | ALTER | DROP} USER  
  | {CREATE | ALTER | DROP} INDEX  
  | {CREATE | DROP} COLLATION  
  | ALTER CHARACTER SET  
  | {CREATE | ALTER | DROP} PACKAGE  
  | {CREATE | DROP} PACKAGE BODY  
  | {CREATE | ALTER | DROP} MAPPING
### Syntax of Module Body

The `CREATE TRIGGER` statement is used for creating a new trigger. A trigger can be created either for a relation (table | view) event (or a combination of events), for a database event, or for a DDL event.

`CREATE TRIGGER`, along with its associates `ALTER TRIGGER`, `CREATE OR ALTER TRIGGER` and `RECREATE TRIGGER`, is a **compound statement**, consisting of a header and a body. The header specifies the name of the trigger, the name of the relation (for a DML trigger), the phase of the trigger, the event(s) it applies to, and the position to determine an order between triggers.

The trigger body consists of optional declarations of local variables and named cursors followed by one or more statements, or blocks of statements, all enclosed in an outer block that begins with the keyword `BEGIN` and ends with the keyword `END`. Declarations and embedded statements are terminated with semi-colons (`;`).

The name of the trigger must be unique among all trigger names.

---

### Table 47. `CREATE TRIGGER` Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>trigname</td>
<td>Trigger name. The maximum length is 63 characters. It must be unique among all trigger names in the database.</td>
</tr>
<tr>
<td>relation_trigger_legacy</td>
<td>Legacy style of trigger declaration for a relation trigger</td>
</tr>
<tr>
<td>relation_trigger_sql2003</td>
<td>Relation trigger declaration compliant with the SQL:2003 standard</td>
</tr>
<tr>
<td>database_trigger</td>
<td>Database trigger declaration</td>
</tr>
<tr>
<td>tablename</td>
<td>Name of the table with which the relation trigger is associated</td>
</tr>
<tr>
<td>viewname</td>
<td>Name of the view with which the relation trigger is associated</td>
</tr>
<tr>
<td>mutation_list</td>
<td>List of relation (table</td>
</tr>
<tr>
<td>number</td>
<td>Position of the trigger in the firing order. From 0 to 32,767</td>
</tr>
<tr>
<td>db_event</td>
<td>Connection or transaction event</td>
</tr>
<tr>
<td>ddl_event</td>
<td>List of metadata change events</td>
</tr>
<tr>
<td>ddl_event_item</td>
<td>One of the metadata change events</td>
</tr>
</tbody>
</table>

---

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Statement Terminators

Some SQL statement editors—specifically the *isql* utility that comes with Firebird and possibly some third-party editors—employ an internal convention that requires all statements to be terminated with a semi-colon. This creates a conflict with PSQL syntax when coding in these environments. If you are unacquainted with this problem and its solution, please study the details in the PSQL chapter in the section entitled Switching the Terminator in *isql*.

SQL Security

The `SQL SECURITY` clause specifies the security context for executing other routines or inserting into other tables.

By default, a trigger applies the SQL Security property defined on its table (or—if the table doesn’t have the SQL Security property set—the database default), but it can be overridden by specifying it explicitly.

If the SQL Security property is changed for the table, triggers that do not have an explicit SQL Security property will not see the effect of the change until the next time the trigger is loaded into the metadata cache.

See also *SQL Security* in chapter Security.

The Trigger Body

The trigger body is either a PSQL body, or an external UDR module body.

See The Module Body in the PSQL chapter for details.

DML Triggers (on Tables or Views)

DML—or “relation”—triggers are executed at the row (record) level, every time the row image changes. A trigger can be either *ACTIVE* or *INACTIVE*. Only active triggers are executed. Triggers are created *ACTIVE* by default.

Who Can Create a DML Trigger?

DML triggers can be created by:

- Administrators
- The owner of the table (or view)
- Users with the `ALTER ANY TABLE` or—for a view—`ALTER ANY VIEW` privilege

Forms of Declaration

Firebird supports two forms of declaration for relation triggers:

- The original, legacy syntax
- The SQL:2003 standard-compliant form (recommended)
The SQL:2003 standard-compliant form is the recommended one.

A relation trigger specifies — among other things — a *phase* and one or more *events*.

**Phase**

Phase concerns the timing of the trigger with regard to the change-of-state event in the row of data:

- A BEFORE trigger is fired before the specified database operation (insert, update or delete) is carried out
- An AFTER trigger is fired after the database operation has been completed

**Row Events**

A relation trigger definition specifies at least one of the DML operations INSERT, UPDATE and DELETE, to indicate one or more events on which the trigger should fire. If multiple operations are specified, they must be separated by the keyword OR. No operation may occur more than once.

Within the statement block, the Boolean context variables INSERTING, UPDATING and DELETING can be used to test which operation is currently executing.

**Firing Order of Triggers**

The keyword POSITION allows an optional execution order (“firing order”) to be specified for a series of triggers that have the same phase and event as their target. The default position is 0. If no positions are specified, or if several triggers have a single position number, the triggers will be executed in the alphabetical order of their names.

**Examples of CREATE TRIGGER for Tables and Views**

1. Creating a trigger in the “legacy” form, firing before the event of inserting a new record into the CUSTOMER table occurs.

   ```sql
   CREATE TRIGGER SET_CUST_NO FOR CUSTOMER
   ACTIVE BEFORE INSERT POSITION 0
   AS
   BEGIN
   IF (NEW.CUST_NO IS NULL) THEN
     NEW.CUST_NO = GEN_ID(CUST_NO_GEN, 1);
   END
   ```

2. Creating a trigger firing before the event of inserting a new record into the CUSTOMER table in the SQL:2003 standard-compliant form.
CREATE TRIGGER set_cust_no
ACTIVE BEFORE INSERT ON customer POSITION 0
AS
BEGIN
  IF (NEW.cust_no IS NULL) THEN
    NEW.cust_no = GEN_ID(cust_no_gen, 1);
  END

3. Creating a trigger that will file after either inserting, updating or deleting a record in the CUSTOMER table.

CREATE TRIGGER TR_CUST_LOG
ACTIVE AFTER INSERT OR UPDATE OR DELETE
ON CUSTOMER POSITION 10
AS
BEGIN
  INSERT INTO CHANGE_LOG (LOG_ID, ID_TABLE, TABLE_NAME, MUTATION)
  VALUES (NEXT VALUE FOR SEQ_CHANGE_LOG, OLD.CUST_NO, 'CUSTOMER',
  CASE
    WHEN INSERTING THEN 'INSERT'
    WHEN UPDATING THEN 'UPDATE'
    WHEN DELETING THEN 'DELETE'
  END);
END

4. With DEFINER set for trigger tr_ins, user US needs only the INSERT privilege on tr. If it were set for INVOKER, either the user or the trigger would also need the INSERT privilege on table t.
create table tr (i integer);
create table t (i integer);
set term ^;
create trigger tr_ins for tr after insert SQL SECURITY DEFINER
as
begin
    insert into t values (NEW.i);
end^
set term ;^
grant insert on table tr to user us;

commit;

connect 'localhost:/tmp/29.fdb' user us password 'pas';
insert into tr values(2);

The result would be the same if SQL SECURITY DEFINER were specified for table TR:

create table tr (i integer) SQL SECURITY DEFINER;
create table t (i integer);
set term ^;
create trigger tr_ins for tr after insert
as
begin
    insert into t values (NEW.i);
end^
set term ;^
grant insert on table tr to user us;

commit;

connect 'localhost:/tmp/29.fdb' user us password 'pas';
insert into tr values(2);

**Database Triggers**

Triggers can be defined to fire upon “database events”, which really refers to a mixture of events that act across the scope of a session (connection) and events that act across the scope of an individual transaction:

- CONNECT
- DISCONNECT
- TRANSACTION START
- TRANSACTION COMMIT
- TRANSACTION ROLLBACK
DDL Triggers are a sub-type of database triggers, covered in a separate section.

Who Can Create a Database Trigger?

Database triggers can be created by:

- **Administrators**
- Users with the `ALTER DATABASE` privilege

Execution of Database Triggers and Exception Handling

CONNECT and DISCONNECT triggers are executed in a transaction created specifically for this purpose. If all goes well, the transaction is committed. Uncaught exceptions cause the transaction to roll back, and

- for a CONNECT trigger, the connection is then broken and the exception is returned to the client
- for a DISCONNECT trigger, exceptions are not reported. The connection is broken as intended

TRANSACTION triggers are executed within the transaction whose start, commit or rollback evokes them. The action taken after an uncaught exception depends on the event:

- In a TRANSACTION START trigger, the exception is reported to the client and the transaction is rolled back
- In a TRANSACTION COMMIT trigger, the exception is reported, the trigger's actions so far are undone and the commit is cancelled
- In a TRANSACTION ROLLBACK trigger, the exception is not reported and the transaction is rolled back as intended.

Traps

Obviously there is no direct way of knowing if a DISCONNECT or TRANSACTION ROLLBACK trigger caused an exception. It also follows that the connection to the database cannot happen if a CONNECT trigger causes an exception and a transaction cannot start if a TRANSACTION START trigger causes one, either. Both phenomena effectively lock you out of your database until you get in there with database triggers suppressed and fix the bad code.

Suppressing Database Triggers

Some Firebird command-line tools have been supplied with switches that an administrator can use to suppress the automatic firing of database triggers. So far, they are:

```
gbak -nodbtriggers
isql -nodbtriggers
nbackup -T
```

Two-phase Commit

In a two-phase commit scenario, TRANSACTION COMMIT triggers fire in the prepare phase, not at the
Some Caveats

1. The use of the \texttt{IN AUTONOMOUS TRANSACTION DO} statement in the database event triggers related to transactions (\texttt{TRANSACTION START}, \texttt{TRANSACTION ROLLBACK}, \texttt{TRANSACTION COMMIT}) may cause the autonomous transaction to enter an infinite loop.

2. The \texttt{DISCONNECT} and \texttt{TRANSACTION ROLLBACK} event triggers will not be executed when clients are disconnected via monitoring tables (\texttt{DELETE FROM MON$ATTACHMENTS})

Only the database owner and \textbf{administrators} have the authority to create database triggers.

Examples of \texttt{CREATE TRIGGER for “Database Triggers”}

1. Creating a trigger for the event of connecting to the database that logs users logging into the system. The trigger is created as inactive.

   ```sql
   CREATE TRIGGER tr_log_connect
   INACTIVE ON CONNECT POSITION 0
   AS
   BEGIN
     INSERT INTO LOG_CONNECT (ID,
                               USERNAME,
                               ATIME)
     VALUES (NEXT VALUE FOR SEQ_LOG_CONNECT,
             CURRENT_USER,
             CURRENT_TIMESTAMP);
   END
   ```

2. Creating a trigger for the event of connecting to the database that does not permit any users, except for SYSDBA, to log in during off hours.

   ```sql
   CREATE EXCEPTION E_INCORRECT_WORKTIME 'The working day has not started yet.';

   CREATE TRIGGER TR_LIMIT_WORKTIME ACTIVE
   ON CONNECT POSITION 1
   AS
   BEGIN
     IF ((CURRENT_USER <> 'SYSDBA') AND
         NOT (CURRENT_TIME BETWEEN time '9:00' AND time '17:00')) THEN
       EXCEPTION E_INCORRECT_WORKTIME;
   END
   ```

DDL Triggers

DDL triggers allow restrictions to be placed on users who attempt to create, alter or drop a DDL object. Their other purposes is to keep a metadata change log.
DDL triggers fire on specified metadata changes events in a specified phase. BEFORE triggers run before changes to system tables. AFTER triggers run after changes in system tables.  

⚠️ The event type [BEFORE | AFTER] of a DDL trigger cannot be changed.

In some sense, DDL triggers are a sub-type of database triggers.

**Who Can Create a DDL Trigger?**

DDL triggers can be created by:

- Administrators
- Users with the ALTER DATABASE privilege

**Suppressing DDL Triggers**

A DDL trigger is a type of database trigger. See [Suppressing Database Triggers](#) how to suppress database — and DDL — triggers.

**Examples of DDL Triggers**

1. Here is how you might use a DDL trigger to enforce a consistent naming scheme, in this case, stored procedure names should begin with the prefix “SP_”:

   ```sql
   set auto on;
   create exception e_invalid_sp_name 'Invalid SP name (should start with SP_)';
   set term !;
   create trigger trig_ddl_sp before CREATE PROCEDURE
   as
   begin
   if (rdb$get_context('DDL_TRIGGER', 'OBJECT_NAME') not starting 'SP_') then
   exception e_invalid_sp_name;
   end!
   ```

   Test
create procedure sp_test
as
begin
end!

create procedure test
as
begin
end!

-- The last command raises this exception and procedure TEST is not created
-- Statement failed, SQLSTATE = 42000
-- exception 1
-- -E_INVALID_SP_NAME
-- -Invalid SP name (should start with SP_)
-- -At trigger 'TRIG_DDL_SP' line: 4, col: 5

set term ;!

2. Implement custom DDL security, in this case restricting the running of DDL commands to certain users:

create exception e_access_denied 'Access denied';

set term !;

create trigger trig_ddl before any ddl statement
as
begin
    if (current_user <> 'SUPER_USER') then
        exception e_access_denied;
    end!

Test
create procedure sp_test
as
begin
end!

-- The last command raises this exception and procedure SP_TEST is not created
-- Statement failed, SQLSTATE = 42000
-- exception 1
-- -E_ACCESS_DENIED
-- -Access denied
-- -At trigger 'TRIG_DDL' line: 4, col: 5

set term ;!

Firebird has privileges for executing DDL statements, so writing a DDL trigger for this should be a last resort, if the same effect cannot be achieved using privileges.

3. Use a trigger to log DDL actions and attempts:
create sequence ddl_seq;

create table ddl_log (  
id bigint not null primary key,  
moment timestamp not null,  
user_name varchar(63) not null,  
event_type varchar(25) not null,  
object_type varchar(25) not null,  
ddl_event varchar(25) not null,  
object_name varchar(63) not null,  
sql_text blob sub_type text not null,  
ok char(1) not null  
);

set term !;

create trigger trig_ddl_log_before before before any ddl statement  
as  
   declare id type of column ddl_log.id;  
begin  
   -- We do the changes in an AUTONOMOUS TRANSACTION, so if an exception happens  
   -- and the command didn't run, the log will survive.  
   in autonomous transaction do  
      begin  
         insert into ddl_log (id, moment, user_name, event_type, object_type,  
                             ddl_event, object_name, sql_text, ok)  
            values (next value for ddl_seq, current_timestamp, current_user,  
                     rdb$get_context('DDL_TRIGGER', 'EVENT_TYPE'),  
                     rdb$get_context('DDL_TRIGGER', 'OBJECT_TYPE'),  
                     rdb$get_context('DDL_TRIGGER', 'DDL_EVENT'),  
                     rdb$get_context('DDL_TRIGGER', 'OBJECT_NAME'),  
                     rdb$get_context('DDL_TRIGGER', 'SQL_TEXT'),  
                     'N')  
            returning id into id;  
         rdb$set_context('USER_SESSION', 'trig_ddl_log_id', id);  
      end  
   end  
end!

The above trigger will fire for this DDL command. It's a good idea to use -nodbtriggers when working with them!
create trigger trig_ddl_log_after after any ddl statement
as
begin
    -- Here we need an AUTONOMOUS TRANSACTION because the original transaction
    -- will not see the record inserted on the BEFORE trigger autonomous
    -- transaction if user transaction is not READ COMMITTED.
in autonomous transaction do
    update ddl_log set ok = 'Y'
    where id = rdb$get_context('USER_SESSION', 'trig_ddl_log_id');
end!
commit!
set term ;!

-- Delete the record about trig_ddl_log_after creation.
delete from ddl_log;
commit;

Test

-- This will be logged one time
-- (as T1 did not exist, RECREATE acts as CREATE) with OK = Y.
recreate table t1 (    n1 integer,
    n2 integer    );

-- This will fail as T1 already exists, so OK will be N.
create table t1 (    n1 integer,
    n2 integer    );

-- T2 does not exist. There will be no log.
drop table t2;

-- This will be logged twice
-- (as T1 exists, RECREATE acts as DROP and CREATE) with OK = Y.
recreate table t1 (    n integer    );
commit;
### SQL Text:

```sql
recreate table t1 (
    n1 integer,
    n2 integer
)
```

### SQL Text:

```sql
create table t1 (
    n1 integer,
    n2 integer
)
```

### SQL Text:

```sql
recreate table t1 (
    n integer
)
```

### SQL Text:

```sql
create table t1 (
    n integer
)
```

### See also

- ALTER TRIGGER
- CREATE OR ALTER TRIGGER
- RECREATE TRIGGER
- DROP TRIGGER
- DDL Triggers

**5.7.2. ALTER TRIGGER**

*Used for*

Modifying and deactivating an existing trigger

*Available in*

DSQL, ESQL
### Syntax

```sql
ALTER TRIGGER triname
  [ACTIVE | INACTIVE]
  [{BEFORE | AFTER} <mutation_list>]
  [POSITION number]
  {<psql_trigger> | <external-module-body>}

<psql_trigger> ::= 
  [SQL_SECURITY]
  [sql_module-body]

<sql_security> ::= 
  SQL SECURITY {INVOKER | DEFINER}
  | DROP SQL SECURITY

!! See syntax of CREATE TRIGGER for further rules !!
```

The `ALTER TRIGGER` statement only allows certain changes to the header and body of a trigger.

### Permitted Changes to Triggers

- Status (`ACTIVE | INACTIVE`)
- Phase (`BEFORE | AFTER`) (of DML triggers)
- Events (of DML triggers)
- Position in the firing order
- Modifications to code in the trigger body

If an element is not specified, it remains unchanged.

- A DML trigger cannot be changed to a database (or DDL) trigger.
- It is not possible to change the event(s) or phase of a database (or DDL) trigger.

### Reminders

The `BEFORE` keyword directs that the trigger be executed before the associated event occurs; the `AFTER` keyword directs that it be executed after the event.

More than one DML event—`INSERT`, `UPDATE`, `DELETE`—can be covered in a single trigger. The events should be separated with the keyword `OR`. No event should be mentioned more than once.

The keyword `POSITION` allows an optional execution order ("firing order") to be specified for a series of triggers that have the same phase and event as their target. The default position is 0. If no positions are specified, or if several triggers have a single position number, the triggers will be executed in the alphabetical order of their names.
Who Can Alter a Trigger?

DML triggers can be altered by:

- **Administrators**
- The owner of the table (or view)
- Users with the **ALTER ANY TABLE** or — for a view — **ALTER ANY VIEW** privilege

Database and DDL triggers can be altered by:

- **Administrators**
- Users with the **ALTER DATABASE** privilege

Examples using **ALTER TRIGGER**

1. Deactivating the `set_cust_no` trigger (switching it to the inactive status).
   
   ```sql
   ALTER TRIGGER set_cust_no INACTIVE;
   ```

2. Changing the firing order position of the `set_cust_no` trigger.
   
   ```sql
   ALTER TRIGGER set_cust_no POSITION 14;
   ```

3. Switching the `TR_CUST_LOG` trigger to the inactive status and modifying the list of events.
   
   ```sql
   ALTER TRIGGER TR_CUST_LOG
   INACTIVE AFTER INSERT OR UPDATE;
   ```

4. Switching the `tr_log_connect` trigger to the active status, changing its position and body.
   
   ```sql
   ALTER TRIGGER tr_log_connect
   ACTIVE POSITION 1
   AS
   BEGIN
   INSERT INTO LOG_CONNECT (ID,
   USERNAME,
   ROLENAME,
   ATIME)
   VALUES (NEXT VALUE FOR SEQ_LOG_CONNECT,
   CURRENT_USER,
   CURRENT_ROLE,
   CURRENT_TIMESTAMP);
   END
   ```

See also
CREATE TRIGGER, CREATE OR ALTER TRIGGER, RECREATE TRIGGER, DROP TRIGGER

5.7.3. CREATE OR ALTER TRIGGER

Used for
Creating a new trigger or altering an existing trigger

Available in
DSQL

Syntax

```
CREATE OR ALTER TRIGGER triname
{ <relation_trigger_legacy>
| <relation_trigger_sql2003>
| <database_trigger>
| <ddl_trigger> }
{<psql_trigger> | <external-module-body>}
```

!! See syntax of CREATE TRIGGER for further rules !!

The CREATE OR ALTER TRIGGER statement creates a new trigger if it does not exist; otherwise it alters and recompiles it with the privileges intact and dependencies unaffected.

Example of CREATE OR ALTER TRIGGER

Creating a new trigger if it does not exist or altering it if it does exist

```
CREATE OR ALTER TRIGGER set_cust_no
ACTIVE BEFORE INSERT ON customer POSITION 0
AS
BEGIN
    IF (NEW.cust_no IS NULL) THEN
        NEW.cust_no = GEN_ID(cust_no_gen, 1);
    END
```

See also

CREATE TRIGGER, ALTER TRIGGER, RECREATE TRIGGER

5.7.4. DROP TRIGGER

Used for
Dropping (deleting) an existing trigger

Available in
DSQL, ESQL
Syntax

```
DROP TRIGGER trigname
```

Table 48. DROP TRIGGER Statement Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>trigname</td>
<td>Trigger name</td>
</tr>
</tbody>
</table>

The DROP TRIGGER statement drops (deletes) an existing trigger.

**Who Can Drop a Trigger?**

DML triggers can be dropped by:

- Administrators
- The owner of the table (or view)
- Users with the ALTER ANY TABLE or — for a view — ALTER ANY VIEW privilege

Database and DDL triggers can be dropped by:

- Administrators
- Users with the ALTER DATABASE privilege

**Example of DROP TRIGGER**

*Deleting the set_cust_no trigger*

```
DROP TRIGGER set_cust_no;
```

*See also*

CREATE TRIGGER, RECREATE TRIGGER

**5.7.5. RECREATE TRIGGER**

*Used for*

Creating a new trigger or recreating an existing trigger

*Available in*

DSQL
The RECREATE TRIGGER statement creates a new trigger if no trigger with the specified name exists; otherwise the RECREATE TRIGGER statement tries to drop the existing trigger and create a new one. The operation will fail on COMMIT if the trigger is in use.

Be aware that dependency errors are not detected until the COMMIT phase of this operation.

Example of RECREATE TRIGGER

Creating or recreating the set_cust_no trigger.

RECREATE TRIGGER set_cust_no
ACTIVE BEFORE INSERT ON customer POSITION 0
AS
BEGIN
  IF (NEW.cust_no IS NULL) THEN
    NEW.cust_no = GEN_ID(cust_no_gen, 1);
  END

See also
CREATE TRIGGER, DROP TRIGGER, CREATE OR ALTER TRIGGER

5.8. PROCEDURE

A stored procedure is a software module that can be called from a client, another procedure, function, executable block or trigger. Stored procedures, stored functions, executable blocks and triggers are written in procedural SQL (PSQL). Most SQL statements are available in PSQL as well, sometimes with some limitations or extensions, notable limitations are DDL and transaction control statements.

Stored procedures can have many input and output parameters.

5.8.1. CREATE PROCEDURE

Used for
Creating a new stored procedure
Available in
DSQL, ESQL

Syntax

```plaintext
CREATE PROCEDURE procname [ ( [ <in_params> ] ) ]
    [RETURNS (<out_params>)]
    {<sql_procedure> | <external-module-body>}

<in_params> ::= <inparam> [, <inparam> ...]
<inparam> ::= <param_decl> [={ | DEFAULT} <value>]
<out_params> ::= <outparam> [, <outparam> ...]
<outparam> ::= <param_decl>

<value> ::= {<literal> | NULL | <context_var>}
<param_decl> ::= paramname <domain_or_non_array_type> [NOT NULL]
    [COLLATE collation]
<type> ::=<datatype>
    | [TYPE OF] domain
    | TYPE OF COLUMN rel.col
<domain_or_non_array_type> ::= !! See Scalar Data Types Syntax !!
<sql_procedure> ::= [SQL SECURITY {INVOKER | DEFINER}]
    <psql-module-body>
<psql-module-body> ::= !! See Syntax of Module Body !!
<external-module-body> ::= !! See Syntax of Module Body !!
```

Table 49. CREATE PROCEDURE Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>procname</td>
<td>Stored procedure name. The maximum length is 63 characters. Must be unique among all table, view and procedure names in the database</td>
</tr>
<tr>
<td>inparam</td>
<td>Input parameter description</td>
</tr>
<tr>
<td>outparam</td>
<td>Output parameter description</td>
</tr>
</tbody>
</table>
The CREATE PROCEDURE statement creates a new stored procedure. The name of the procedure must be unique among the names of all stored procedures, tables and views in the database.

CREATE PROCEDURE is a compound statement, consisting of a header and a body. The header specifies the name of the procedure and declares input parameters and the output parameters, if any, that are to be returned by the procedure.

The procedure body consists of declarations for any local variables and named cursors that will be used by the procedure, followed by one or more statements, or blocks of statements, all enclosed in an outer block that begins with the keyword BEGIN and ends with the keyword END. Declarations and embedded statements are terminated with semi-colons (‘;’).

Statement Terminators

Some SQL statement editors—specifically the isql utility that comes with Firebird and possibly some third-party editors—employ an internal convention that requires all statements to be terminated with a semi-colon. This creates a conflict with PSQL syntax when coding in these environments. If you are unacquainted with this problem and its solution, please study the details in the PSQL chapter in the section entitled Switching the Terminator in isql.

Parameters

Each parameter has a data type. The NOT NULL constraint can also be specified for any parameter, to prevent NULL being passed or assigned to it.

A collation sequence can be specified for string-type parameters, using the COLLATE clause.

Input Parameters

Input parameters are presented as a parenthesized list following the name of the function. They are passed by value into the procedure, so any changes inside the procedure has no effect on the parameters in the caller. Input parameters may have default values. Parameters with default values specified must be added at the end of the list of parameters.

Output Parameters

The optional RETURNS clause is for specifying a parenthesised list of output parameters for the stored procedure.
SQL Security

The SQL SECURITY clause specifies the security context for executing other routines or inserting into other tables. When SQL Security is not specified, the default value of the database is applied at runtime.

The SQL SECURITY clause can only be specified for PSQL procedures, and is not valid for procedures defined in a package.

See also SQL Security in chapter Security.

Variable, Cursor and Subroutine Declarations

The optional declarations section, located at the start of the body of the procedure definition, defines variables (including cursors) and subroutines local to the procedure. Local variable declarations follow the same rules as parameters regarding specification of the data type. See details in the PSQL chapter for DECLARE VARIABLE, DECLARE CURSOR, DECLARE FUNCTION, and DECLARE PROCEDURE.

External UDR Procedures

A stored procedure can also be located in an external module. In this case, instead of a procedure body, the CREATE PROCEDURE specifies the location of the procedure in the external module using the EXTERNAL clause. The optional NAME clause specifies the name of the external module, the name of the procedure inside the module, and — optionally — user-defined information. The required ENGINE clause specifies the name of the UDR engine that handles communication between Firebird and the external module. The optional AS clause accepts a string literal “body”, which can be used by the engine or module for various purposes.

Who Can Create a Procedure

The CREATE PROCEDURE statement can be executed by:

- Administrators
- Users with the CREATE PROCEDURE privilege

The user executing the CREATE PROCEDURE statement becomes the owner of the table.

Examples

1. Creating a stored procedure that inserts a record into the BREED table and returns the code of the inserted record:
CREATE PROCEDURE ADD_BREED (
    NAME D_BREEDNAME, /* Domain attributes are inherited */
    NAME_EN TYPE OF D_BREEDNAME, /* Only the domain type is inherited */
    SHORTNAME TYPE OF COLUMN BREED.SHORTNAME,
    /* The table column type is inherited */
    REMARK VARCHAR(120) CHARACTER SET WIN1251 COLLATE PXW_CYRL,
    CODE_ANIMAL INT NOT NULL DEFAULT 1
) RETURNS (
    CODE_BREED INT
) AS
BEGIN
    INSERT INTO BREED (
        CODE_ANIMAL, NAME, NAME_EN, SHORTNAME, REMARK)
    VALUES (
        :CODE_ANIMAL, :NAME, :NAME_EN, :SHORTNAME, :REMARK)
    RETURNING CODE_BREED INTO CODE_BREED;
END

2. Creating a selectable stored procedure that generates data for mailing labels (from employee.fdb):

CREATE PROCEDURE mail_label (cust_no INTEGER)
RETURNS (line1 CHAR(40), line2 CHAR(40), line3 CHAR(40),
    line4 CHAR(40), line5 CHAR(40), line6 CHAR(40))
AS
    DECLARE VARIABLE customer VARCHAR(25);
    DECLARE VARIABLE first_name VARCHAR(15);
    DECLARE VARIABLE last_name VARCHAR(20);
    DECLARE VARIABLE addr1 VARCHAR(30);
    DECLARE VARIABLE addr2 VARCHAR(30);
    DECLARE VARIABLE city VARCHAR(25);
    DECLARE VARIABLE state VARCHAR(15);
    DECLARE VARIABLE country VARCHAR(15);
    DECLARE VARIABLE postcode VARCHAR(12);
    DECLARE VARIABLE cnt INTEGER;
BEGIN
    line1 = '';
    line2 = '';
    line3 = '';
    line4 = '';
    line5 = '';
    line6 = '';

    SELECT customer, contact_first, contact_last, address_line1,
        address_line2, city, state_province, country, postal_code
    FROM CUSTOMER
    WHERE cust_no = :cust_no

IF (customer IS NOT NULL) THEN
    line1 = customer;
IF (first_name IS NOT NULL) THEN
    line2 = first_name || ' ' || last_name;
ELSE
    line2 = last_name;
IF (addr1 IS NOT NULL) THEN
    line3 = addr1;
IF (addr2 IS NOT NULL) THEN
    line4 = addr2;

IF (country = 'USA') THEN
    BEGIN
        IF (city IS NOT NULL) THEN
            line5 = city || ', ' || state || '  ' || postcode;
        ELSE
            line5 = state || '  ' || postcode;
    END
ELSE
    BEGIN
        IF (city IS NOT NULL) THEN
            line5 = city || ', ' || state;
        ELSE
            line5 = state;
        END
        line6 = country || '  ' || postcode;
    END

SUSPEND; -- the statement that sends an output row to the buffer
-- and makes the procedure "selectable"

3. With DEFINER set for procedure p, user US needs only the EXECUTE privilege on p. If it were set for INVOKER, either the user or the procedure would also need the INSERT privilege on table t.
set term ^;
create procedure p (i integer) SQL SECURITY DEFINER
as
begin
insert into t values (:i);
end^
set term ;^

grant execute on procedure p to user us;
commit;

connect 'localhost:/tmp/17.fdb' user us password 'pas';
execute procedure p(1);

See also
CREATE OR ALTER PROCEDURE, ALTER PROCEDURE, RECREATE PROCEDURE, DROP PROCEDURE

5.8.2. ALTER PROCEDURE

Used for
Modifying an existing stored procedure

Available in
DSQL, ESQL

Syntax

ALTER PROCEDURE procname [ ( [ <in_params> ] ) ]
[RETURNS (<out_params>)]
{<psql_procedure> | <external-module-body>}

!! See syntax of CREATE PROCEDURE for further rules !!

The ALTER PROCEDURE statement allows the following changes to a stored procedure definition:

- the set and characteristics of input and output parameters
- local variables
- code in the body of the stored procedure

After ALTER PROCEDURE executes, existing privileges remain intact and dependencies are not affected.

Altering a procedure without specifying the SQL SECURITY clause will remove the SQL Security property if currently set for this procedure. This means the behaviour will revert to the database default.
Take care about changing the number and type of input and output parameters in stored procedures. Existing application code and procedures and triggers that call it could become invalid because the new description of the parameters is incompatible with the old calling format. For information on how to troubleshoot such a situation, see the article The RDB$VALID_BLR Field in the Appendix.

Who Can Alter a Procedure

The ALTER PROCEDURE statement can be executed by:

- Administrators
- The owner of the stored procedure
- Users with the ALTER ANY PROCEDURE privilege

ALTER PROCEDURE Example

Altering the GET_EMP_PROJ stored procedure.

```
ALTER PROCEDURE GET_EMP_PROJ (  
   EMP_NO SMALLINT)  
RETURNS (  
   PROJ_ID VARCHAR(20))  
AS  
BEGIN  
FOR SELECT  
   PROJ_ID  
FROM  
   EMPLOYEE_PROJECT  
WHERE  
   EMP_NO = :emp_no  
INTO :proj_id  
DO  
   SUSPEND;  
END
```

See also

CREATE PROCEDURE, CREATE OR ALTER PROCEDURE, RECREATE PROCEDURE, DROP PROCEDURE

5.8.3. CREATE OR ALTER PROCEDURE

Used for
Creating a new stored procedure or altering an existing one

Available in
DSQL
Syntax

CREATE OR ALTER PROCEDURE proname [ ( [ <in_params> ] ) ]
[RETURNS (<out_params>)]
{<psql_procedure> | <external-module-body>}

!! See syntax of CREATE PROCEDURE for further rules !!

The CREATE OR ALTER PROCEDURE statement creates a new stored procedure or alters an existing one. If the stored procedure does not exist, it will be created by invoking a CREATE PROCEDURE statement transparently. If the procedure already exists, it will be altered and compiled without affecting its existing privileges and dependencies.

CREATE OR ALTER PROCEDURE Example

Creating or altering the GET_EMP_PROJ procedure.

```
CREATE OR ALTER PROCEDURE GET_EMP_PROJ (
    EMP_NO SMALLINT)
RETURNS (
    PROJ_ID VARCHAR(20))
AS
BEGIN
    FOR SELECT
    PROJ_ID
    FROM
    EMPLOYEE_PROJECT
    WHERE
    EMP_NO = :emp_no
    INTO :proj_id
    DO
    SUSPEND;
END
```

See also

CREATE PROCEDURE, ALTER PROCEDURE, RECREATE PROCEDURE

5.8.4. DROP PROCEDURE

Used for

Deleting a stored procedure

Available in

DSQL, ESQL

Syntax

DROP PROCEDURE proname
The **DROP PROCEDURE** statement deletes an existing stored procedure. If the stored procedure has any dependencies, the attempt to delete it will fail and the appropriate error will be raised.

### Who Can Drop a Procedure

The **ALTER PROCEDURE** statement can be executed by:

- **Administrators**
- The owner of the stored procedure
- Users with the **DROP ANY PROCEDURE** privilege

#### DROP PROCEDURE Example

Deleting the **GET_EMP_PROJ** stored procedure.

```sql
DROP PROCEDURE GET_EMP_PROJ;
```

See also **CREATE PROCEDURE**, **RECREATE PROCEDURE**

### 5.8.5. RECREATE PROCEDURE

**Used for**

Creating a new stored procedure or recreating an existing one

**Available in**

DSQL

**Syntax**

```sql
RECREATE PROCEDURE procname [ ( [ <in_params> ] ) ]
[RETURNS (<out_params>)]
{<psql_procedure> | <external-module-body>}
```

!! See syntax of **CREATE PROCEDURE** for further rules !!

The **RECREATE PROCEDURE** statement creates a new stored procedure or recreates an existing one. If there is a procedure with this name already, the engine will try to delete it and create a new one. Recreating an existing procedure will fail at the **COMMIT** request if the procedure has dependencies.

Be aware that dependency errors are not detected until the **COMMIT** phase of this operation.
After a procedure is successfully recreated, privileges to execute the stored procedure, and the privileges of the stored procedure itself are dropped.

**RECREATE PROCEDURE Example**

Creating the new GET_EMP_PROJ stored procedure or recreating the existing GET_EMP_PROJ stored procedure.

```sql
RECREATE PROCEDURE GET_EMP_PROJ (
    EMP_NO SMALLINT
) RETURNS (  
    PROJ_ID VARCHAR(20)
) AS  
BEGIN  
FOR SELECT  
    PROJ_ID  
FROM  
    EMPLOYEE_PROJECT  
WHERE  
    EMP_NO = :emp_no  
INTO :proj_id  
DO  
    SUSPEND;  
END
```

See also

CREATE PROCEDURE, DROP PROCEDURE, CREATE OR ALTER PROCEDURE

5.9. FUNCTION

A stored function is a user-defined function stored in the metadata of a database, and running on the server. Stored functions can be called by stored procedures, stored functions (including the function itself), triggers and client programs. When a stored function calls itself, such a stored function is called a recursive function.

Unlike stored procedures, stored functions always return a single scalar value. To return a value from a stored functions, use the RETURN statement, which immediately ends the function.

See also

EXTERNAL FUNCTION

5.9.1. CREATE FUNCTION

Used for

Creating a new stored function

Available in

DSQL
Syntax

CREATE FUNCTION funcname [ ( [ <in_params> ] ) ]
  RETURNS <domain_or_non_array_type> [COLLATE collation]
  [DETERMINISTIC]
  {<psql_function> | <external-module-body>}

<in_params> ::= <inparam> [, <inparam> ... ]

<inparam> ::= <param-decl> [ { = | DEFAULT } <value> ]

<value> ::= { <literal> | NULL | <context-var> }

<param-decl> ::= paramname <domain_or_non_array_type> [NOT NULL]
  [COLLATE collation]

<domain_or_non_array_type> ::=  
  !! See Scalar Data Types Syntax !!

<psql_function> ::=  
  [SQL SECURITY { INVOKER | DEFINER }]
  <psql-module-body>

<psql-module-body> ::=  
  !! See Syntax of Module Body !!

<external-module-body> ::=  
  !! See Syntax of Module Body !!

Table 51. CREATE FUNCTION Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>funcname</td>
<td>Stored function name. The maximum length is 63 characters. Must be unique among all function names in the database.</td>
</tr>
<tr>
<td>inparam</td>
<td>Input parameter description</td>
</tr>
<tr>
<td>collation</td>
<td>Collation sequence</td>
</tr>
<tr>
<td>literal</td>
<td>A literal value that is assignment-compatible with the data type of the parameter</td>
</tr>
<tr>
<td>context-var</td>
<td>Any context variable whose type is compatible with the data type of the parameter</td>
</tr>
<tr>
<td>paramname</td>
<td>The name of an input parameter of the function. The maximum length is 63 characters. The name of the parameter must be unique among input parameters of the function and its local variables.</td>
</tr>
</tbody>
</table>

The CREATE FUNCTION statement creates a new stored function. The stored function name must be unique among the names of all stored and external (legacy) functions, excluding sub-functions or functions in packages. For sub-functions or functions in packages, the name must be unique within
It is advisable to not reuse function names between global stored functions and stored functions in packages, although this is legal. At the moment, it is not possible to call a function or procedure from the global namespace from inside a package, if that package defines a function or procedure with the same name. In that situation, the function or procedure of the package will be called.

CREATE FUNCTION is a compound statement with a header and a body. The header defines the name of the stored function, and declares input parameters and return type.

The function body consists of optional declarations of local variables, named cursors, and subroutines (sub-functions and sub-procedures), and one or more statements or statement blocks, enclosed in an outer block that starts with the keyword BEGIN and ends with the keyword END. Declarations and statements inside the function body must be terminated with a semicolon (’;’).

Statement Terminators

Some SQL statement editors—specifically the isql utility that comes with Firebird and possibly some third-party editors—employ an internal convention that requires all statements to be terminated with a semi-colon. This creates a conflict with PSQL syntax when coding in these environments. If you are unacquainted with this problem and its solution, please study the details in the PSQL chapter in the section entitled Switching the Terminator in isql.

Parameters

Each parameter has a data type.

A collation sequence can be specified for string-type parameters, using the COLLATE clause.

Input Parameters

Input parameters are presented as a parenthesized list following the name of the function. They are passed by value into the function, so any changes inside the function has no effect on the parameters in the caller. The NOT NULL constraint can also be specified for any input parameter, to prevent NULL being passed or assigned to it. Input parameters may have default values. Parameters with default values specified must be added at the end of the list of parameters.

Output Parameter

The RETURNS clause specifies the return type of the stored function. If a function returns a string value, then it is possible to specify the collation using the COLLATE clause. As a return type, you can specify a data type, a domain name, the type of a domain (using TYPE OF), or the type of a column of a table or view (using TYPE OF COLUMN).

Deterministic functions

The optional DETERMINISTIC clause indicates that the function is deterministic. Deterministic functions always return the same result for the same set of inputs. Non-deterministic functions can return different results for each invocation, even for the same set of inputs. If a function is specified as deterministic, then such a function might not be called again if it has already been called once
Current versions of Firebird do not actually cache results of deterministic functions.

Specifying the `DETERMINISTIC` clause is actually something like a “promise” that the function will return the same thing for equal inputs. At the moment, a deterministic function is considered an invariant, and works like other invariants. That is, they are computed and cached at the current execution level of a given statement.

This is easily demonstrated with an example:

```sql
CREATE FUNCTION FN_T
RETURNS DOUBLE PRECISION DETERMINISTIC
AS
BEGIN
    RETURN rand ();
END;

- the function will be evaluated twice and will return 2 different values
SELECT fn_t () FROM rdb $ database
UNION ALL
SELECT fn_t () FROM rdb $ database;

- the function will be evaluated once and will return 2 identical values
WITH t (n) AS (
    SELECT 1 FROM rdb $ database
    UNION ALL
    SELECT 2 FROM rdb $ database
)
SELECT n, fn_t () FROM
```

**SQL Security**

The SQL `SECURITY` clause specifies the security context for executing other routines or inserting into other tables. When SQL Security is not specified, the default value of the database is applied at runtime.

The SQL `SECURITY` clause can only be specified for PSQL functions, and is not valid for functions defined in a package.

See also *SQL Security* in chapter Security.

**Variable, Cursor and Subroutine Declarations**

The optional declarations section, located at the start of the body of the function definition, defines
variables (including cursors) and subroutines local to the function. Local variable declarations follow the same rules as parameters regarding specification of the data type. See details in the PSQL chapter for DECLARE VARIABLE, DECLARE CURSOR, DECLARE FUNCTION, and DECLARE PROCEDURE.

**Function Body**

The header section is followed by the function body, consisting of one or more PSQL statements enclosed between the outer keywords BEGIN and END. Multiple BEGIN … END blocks of terminated statements may be embedded inside the procedure body.

**External UDR Functions**

A stored function can also be located in an external module. In this case, instead of a function body, the CREATE FUNCTION specifies the location of the function in the external module using the EXTERNAL clause. The optional NAME clause specifies the name of the external module, the name of the function inside the module, and—optionally—user-defined information. The required ENGINE clause specifies the name of the UDR engine that handles communication between Firebird and the external module. The optional AS clause accepts a string literal “body”, which can be used by the engine or module for various purposes.

External UDR (User Defined Routine) functions created using CREATE FUNCTION … EXTERNAL … should not be confused with legacy UDFs (User Defined Functions) declared using DECLARE EXTERNAL FUNCTION.

UDFs are deprecated, and a legacy from previous Firebird functions. Their capabilities are significantly inferior to the capabilities to the new type of external UDR functions.

**Who Can Create a Function**

The CREATE FUNCTION statement can be executed by:

- Administrators
- Users with the CREATE FUNCTION privilege

The user who created the stored function becomes its owner.

**CREATE FUNCTION Examples**

1. Creating a stored function

```
CREATE FUNCTION ADD_INT (A INT, B INT DEFAULT 0)
RETURNS INT
AS
BEGIN
  RETURN A + B;
END
```

Calling in a select:
SELECT ADD_INT(2, 3) AS R FROM RDB$DATABASE

Call inside PSQL code, the second optional parameter is not specified:

MY_VAR = ADD_INT(A);

2. Creating a deterministic stored function

CREATE FUNCTION FN_E()
RETURNS DOUBLE PRECISION DETERMINISTIC
AS
BEGIN
RETURN EXP(1);
END

3. Creating a stored function with table column type parameters

Returns the name of a type by field name and value

CREATE FUNCTION GET_MNEMONIC (
   AFIELD_NAME TYPE OF COLUMN RDB$TYPES.RDB$FIELD_NAME,
   ATYPE TYPE OF COLUMN RDB$TYPES.RDB$TYPE)
RETURNS TYPE OF COLUMN RDB$TYPES.RDB$TYPE_NAME
AS
BEGIN
RETURN (SELECT RDB$TYPE_NAME
   FROM RDB$TYPES
   WHERE RDB$FIELD_NAME = :AFIELD_NAME
   AND RDB$TYPE = :ATYPE);
END

4. Creating an external stored function

Create a function located in an external module (UDR). Function implementation is located in the external module udrcpp_example. The name of the function inside the module is wait_event.

CREATE FUNCTION wait_event (
   event_name varchar (31) CHARACTER SET ascii
) RETURNS INTEGER
EXTERNAL NAME 'udrcpp_example!Wait_event'
ENGINE udr

5. Creating a stored function containing a sub-function

Creating a function to convert a number to hexadecimal format.
CREATE FUNCTION INT_TO_HEX ( 
    ANumber BIGINT ,
    AByte_Per_Number SMALLINT = 8) 
RETURNS CHAR (66) 
AS 
DECLARE VARIABLE xMod SMALLINT ; 
DECLARE VARIABLE xResult VARCHAR (64); 
DECLARE FUNCTION TO_HEX (ANum SMALLINT ) RETURNS CHAR 
AS 
BEGIN 
    RETURN CASE ANum 
    WHEN 0 THEN '0' 
    WHEN 1 THEN '1' 
    WHEN 2 THEN '2' 
    WHEN 3 THEN '3' 
    WHEN 4 THEN '4' 
    WHEN 5 THEN '5' 
    WHEN 6 THEN '6' 
    WHEN 7 THEN '7' 
    WHEN 8 THEN '8' 
    WHEN 9 THEN '9' 
    WHEN 10 THEN 'A' 
    WHEN 11 THEN 'B' 
    WHEN 12 THEN 'C' 
    WHEN 13 THEN 'D' 
    WHEN 14 THEN 'E' 
    WHEN 15 THEN 'F' 
    ELSE NULL 
    END; 
END 
BEGIN 
    xMod = MOD (ANumber, 16); 
    ANumber = ANumber / 16; 
    xResult = TO_HEX (xMod); 
    WHILE (ANUMBER> 0) DO 
    BEGIN 
        xMod = MOD (ANumber, 16); 
        ANumber = ANumber / 16; 
        xResult = TO_HEX (xMod) || xResult; 
    END 
    RETURN '0x' || LPAD (xResult, AByte_Per_Number * 2, '0' ); 
END 

6. With DEFINER set for function f, user US needs only the EXECUTE privilege on f. If it were set for INVOKER, the user would also need the INSERT privilege on table t.
set term ^;
create function f (i integer) returns int SQL SECURITY DEFINER
as
begin
    insert into t values (:i);
    return i + 1;
end^
set term ;^
grant execute on function f to user us;
commit;
connect 'localhost:/tmp/59.fdb' user us password 'pas';
select f(3) from rdb$database;

See also
CREATE OR ALTER FUNCTION, ALTER FUNCTION, RECREATE FUNCTION, DROP FUNCTION, DECLARE EXTERNAL FUNCTION

5.9.2. ALTER FUNCTION

Used for
Modifying an existing stored function

Available in
DSQL

Syntax

```
ALTER FUNCTION funcname
    [ ( [ <in_params> ] ) ]
    RETURNS <domain_or_non_array_type> [COLLATE collation]
    [DETERMINISTIC]
    {<psql_function> | <external-module-body>}
```

!! See syntax of CREATE FUNCTION for further rules !!

The ALTER FUNCTION statement allows the following changes to a stored function definition:

- the set and characteristics of input and output type
- local variables, named cursors, and subroutines
- code in the body of the stored procedure

For external functions (UDR), you can change the entry point and engine name. For legacy external functions declared using DECLARE EXTERNAL FUNCTION—also known as UDFs—it is not possible to convert to PSQL and vice versa.
After ALTER FUNCTION executes, existing privileges remain intact and dependencies are not affected.

Altering a function without specifying the SQL SECURITY clause will remove the SQL Security property if currently set for this function. This means the behaviour will revert to the database default.

Take care about changing the number and type of input parameters and the output type of a stored function. Existing application code and procedures, functions and triggers that call it could become invalid because the new description of the parameters is incompatible with the old calling format. For information on how to troubleshoot such a situation, see the article The RDB$VALID_BLR Field in the Appendix.

Who Can Alter a Function

The ALTER FUNCTION statement can be executed by:

- Administrators
- Owner of the stored function
- Users with the ALTER ANY FUNCTION privilege

Examples of ALTER FUNCTION

Altering a stored function

```
ALTER FUNCTION ADD_INT(A INT, B INT, C INT)
RETURNS INT
AS
BEGIN
    RETURN A + B + C;
END
```

See also

CREATE FUNCTION, CREATE OR ALTER FUNCTION, RECREATE FUNCTION, DROP FUNCTION

5.9.3. CREATE OR ALTER FUNCTION

Used for
Creating a new or modifying an existing stored function

Available in
DSQL
The `CREATE OR ALTER FUNCTION` statement creates a new stored function or alters an existing one. If the stored function does not exist, it will be created by invoking a `CREATE FUNCTION` statement transparently. If the function already exists, it will be altered and compiled (through `ALTER FUNCTION`) without affecting its existing privileges and dependencies.

### Examples of `CREATE OR ALTER FUNCTION`

**Create a new or alter an existing stored function**

```sql
CREATE OR ALTER FUNCTION ADD_INT(A INT, B INT DEFAULT 0)
RETURNS INT
AS
BEGIN
  RETURN A + B;
END
```

See also

`CREATE FUNCTION, ALTER FUNCTION, DROP FUNCTION`

### 5.9.4. DROP FUNCTION

**Used for**

Dropping a stored function

**Available in**

DSQL

**Syntax**

```sql
DROP FUNCTION funcname
```

**Table 52. DROP FUNCTION Statement Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>funcname</td>
<td>Stored function name. The maximum length is 63 characters. Must be unique among all function names in the database.</td>
</tr>
</tbody>
</table>

The `DROP FUNCTION` statement deletes an existing stored function. If the stored function has any
dependencies, the attempt to delete it will fail, and the appropriate error will be raised.

**Who Can Drop a Function**

The DROP FUNCTION statement can be executed by:

- Administrators
- Owner of the stored function
- Users with the DROP ANY FUNCTION privilege

**Examples of DROP FUNCTION**

```sql
DROP FUNCTION ADD_INT;
```

See also

CREATE FUNCTION, CREATE OR ALTER FUNCTION, RECREATE FUNCTION

### 5.9.5. RECREATE FUNCTION

**Used for**

Creating a new stored function or recreating an existing one

**Available in**

DSQL

**Syntax**

```sql
RECREATE FUNCTION funcname
  [ ( [ <in_params> ] ) ]
  RETURNS <domain_or_non_array_type> [COLLATE collation]
  [DETERMINISTIC]
  {<psql_function> | <external-module-body>}
```

!! See syntax of CREATE FUNCTION for further rules !!

The RECREATE FUNCTION statement creates a new stored function or recreates an existing one. If there is a function with this name already, the engine will try to drop it and then create a new one. Recreating an existing function will fail at COMMIT if the function has dependencies.

Be aware that dependency errors are not detected until the COMMIT phase of this operation.

After a procedure is successfully recreated, existing privileges to execute the stored function and the privileges of the stored function itself are dropped.
Examples of \texttt{RECREATE FUNCTION}

Creating or recreating a stored function

\begin{verbatim}
RECREATE FUNCTION ADD_INT(A INT, B INT DEFAULT 0)
    RETURNS INT
AS
BEGIN
    RETURN A + B;
END
\end{verbatim}

See also

CREATE FUNCTION, DROP FUNCTION

\section*{5.10. \texttt{EXTERNAL FUNCTION}}

External functions (UDFs) have been aggressively deprecated in Firebird 4.0:

- The default setting for the configuration parameter \texttt{UdfAccess} is \texttt{None}. In order to run UDFs at all will now require an explicit configuration of \texttt{Restrict path-list}
- The UDF libraries (\texttt{ib_udf}, \texttt{fbudf}) are no longer distributed in the installation kits
- Most of the functions in the libraries previously distributed in the shared (dynamic) libraries \texttt{ib_udf} and \texttt{fbudf} had already been replaced with built-in functional analogs. A few remaining UDFs have been replaced with either analog routines in a new library of UDRs named \texttt{udf_compat} or converted to stored functions.

Refer to \textit{Deprecation of External Functions (UDFs)} in the \textit{Compatibility} chapter of the Firebird 4.0 Release notes for details and instructions about upgrading to use the safe functions.

- Replacement of UDFs with UDRs or stored functions is strongly recommended

External functions, also known as “User-Defined Functions” (UDFs) are programs written in an external programming language and stored in dynamically loaded libraries. Once declared in a database, they become available in dynamic and procedural statements as though they were implemented in the SQL language.

External functions extend the possibilities for processing data with SQL considerably. To make a function available to a database, it is declared using the statement \texttt{DECLARE EXTERNAL FUNCTION}.

The library containing a function is loaded when any function included in it is called.
External functions declared as DECLARE EXTERNAL FUNCTION are a legacy from previous versions of Firebird. Their capabilities are inferior to the capabilities of the new type of external functions, UDR (User-Defined Routine). Such functions are declared as CREATE FUNCTION ... EXTERNAL ... . See CREATE FUNCTION for details.

External functions may be contained in more than one library — or “module”, as it is referred to in the syntax.

UDFs are fundamentally insecure. We recommend avoiding their use whenever possible, and disabling UDFs in your database configuration (UdfAccess = None in firebird.conf; this is the default since Firebird 4). If you do need to call native code from your database, use a UDR external engine instead.

See also
FUNCTION

5.10.1. DECLARE EXTERNAL FUNCTION

Used for
Declaring a user-defined function (UDF) to the database

Available in
DSQL, ESQL

Syntax

DECLARE EXTERNAL FUNCTION funcname
   [{ <arg_desc_list> | ( <arg_desc_list> ) }]
RETURNS { <return_value> | ( <return_value> ) }
   ENTRY_POINT 'entry_point' MODULE_NAME 'library_name'

<arg_desc_list> ::=<arg_type_decl> [, <arg_type_decl> ...]
<arg_type_decl> ::=<udf_data_type> [BY {DESCRIPTOR | SCALAR_ARRAY} | NULL]
<udf_data_type> ::=<scalar_datatype>
   | BLOB
   | CSTRING(length) [ CHARACTER SET charset ]
<scalar_datatype> ::=<return_value> ::={ <udf_data_type> | PARAMETER param_num }[{ BY VALUE | BY DESCRIPTOR [FREE_IT] | FREE_IT ]}

!! See Scalar Data Types Syntax !!
### Table 53. DECLARE EXTERNAL FUNCTION Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>funcname</td>
<td>Function name in the database. The maximum length is 63 characters. It should be unique among all internal and external function names in the database and need not be the same name as the name exported from the UDF library via ENTRY_POINT.</td>
</tr>
<tr>
<td>entry_point</td>
<td>The exported name of the function</td>
</tr>
<tr>
<td>library_name</td>
<td>The name of the module (MODULE_NAME) from which the function is exported. This will be the name of the file, without the “.dll” or “.so” file extension.</td>
</tr>
<tr>
<td>length</td>
<td>The maximum length of a null-terminated string, specified in bytes</td>
</tr>
<tr>
<td>charset</td>
<td>Character set of the CSTRING</td>
</tr>
<tr>
<td>param_num</td>
<td>The number of the input parameter, numbered from 1 in the list of input parameters in the declaration, describing the data type that will be returned by the function</td>
</tr>
</tbody>
</table>

The DECLARE EXTERNAL FUNCTION statement makes a user-defined function available in the database. UDF declarations must be made in each database that is going to use them. There is no need to declare UDFs that will never be used.

The name of the external function must be unique among all function names. It may be different from the exported name of the function, as specified in the ENTRY_POINT argument.

### DECLARE EXTERNAL FUNCTION Input Parameters

The input parameters of the function follow the name of the function and are separated with commas. Each parameter has an SQL data type specified for it. Arrays cannot be used as function parameters. In addition to the SQL types, the CSTRING type is available for specifying a null-terminated string with a maximum length of LENGTH bytes. There are several mechanisms for passing a parameter from the Firebird engine to an external function, each of these mechanisms will be discussed below.

By default, input parameters are passed by reference. There is no separate clause to explicitly indicate that parameters are passed by reference.

When passing a NULL value by reference, it is converted to the equivalent of zero, for example, a number ‘0’ or an empty string (“’’”). If the keyword NULL is specified after a parameter, then with passing a NULL values, the null pointer will be passed to the external function.

Declaring a function with the NULL keyword does not guarantee that the function will correctly handle a NULL input parameter. Any function must be written or rewritten to correctly handle NULL values. Always use the function declaration as provided by its developer.

If BY DESCRIPTOR is specified, then the input parameter is passed by descriptor. In this case, the UDF parameter will receive a pointer to an internal structure known as a descriptor. The descriptor
contains information about the data type, sub-type, precision, character set and collation, scale, a pointer to the data itself and some flags, including the NULL indicator. This declaration only works if the external function is written using a handle.

When passing a function parameter by descriptor, the passed value is not cast to the declared data type.

The BY SCALAR_ARRAY clause is used when passing arrays as input parameters. Unlike other types, you cannot return an array from a UDF.

**Clauses and Keywords**

**RETURNS clause**

(Required) specifies the output parameter returned by the function. A function is scalar, it returns one value (output parameter). The output parameter can be of any SQL type (except an array or an array element) or a null-terminated string (CSTRING). The output parameter can be passed by reference (the default), by descriptor or by value. If the BY_DESCRIPTOR clause is specified, the output parameter is passed by descriptor. If the BY VALUE clause is specified, the output parameter is passed by value.

**PARAMETER keyword**

specifies that the function returns the value from the parameter under number `param_num`. It is necessary if you need to return a value of data type BLOB.

**FREE_IT keyword**

means that the memory allocated for storing the return value will be freed after the function is executed. It is used only if the memory was allocated dynamically in the UDF. In such a UDF, the memory must be allocated with the help of the `ib_util_malloc` function from the `ib_util` module, a requirement for compatibility with the functions used in Firebird code and in the code of the shipped UDF modules, for allocating and freeing memory.

**ENTRY_POINT clause**

specifies the name of the entry point (the name of the imported function), as exported from the module.

**MODULE_NAME clause**

defines the name of the module where the exported function is located. The link to the module should not be the full path and extension of the file, if that can be avoided. If the module is located in the default location (in the ..\UDF subdirectory of the Firebird server root) or in a location explicitly configured in `firebird.conf`, it makes it easier to move the database between different platforms. The `UDFAccess` parameter in the `firebird.conf` file allows access restrictions to external functions modules to be configured.

Any user connected to the database can declare an external function (UDF).

**Who Can Create an External Function**

The `DECLARE EXTERNAL FUNCTION` statement can be executed by:
• Administrators
• Users with the CREATE FUNCTION privilege

The user who created the function becomes its owner.

**Examples using DECLARE EXTERNAL FUNCTION**

1. Declaring the `addDay` external function located in the `fbudf` module. The input and output parameters are passed by reference.

```
DECLARE EXTERNAL FUNCTION addDay
    TIMESTAMP, INT
    RETURNS TIMESTAMP
    ENTRY_POINT 'addDay' MODULE_NAME 'fbudf';
```

2. Declaring the `invl` external function located in the `fbudf` module. The input and output parameters are passed by descriptor.

```
DECLARE EXTERNAL FUNCTION invl
    INT BY DESCRIPTOR, INT BY DESCRIPTOR
    RETURNS INT BY DESCRIPTOR
    ENTRY_POINT 'idNvl' MODULE_NAME 'fbudf';
```

3. Declaring the `isLeapYear` external function located in the `fbudf` module. The input parameter is passed by reference, while the output parameter is passed by value.

```
DECLARE EXTERNAL FUNCTION isLeapYear
    TIMESTAMP
    RETURNS INT BY VALUE
    ENTRY_POINT 'isLeapYear' MODULE_NAME 'fbudf';
```

4. Declaring the `i64Truncate` external function located in the `fbudf` module. The input and output parameters are passed by descriptor. The second parameter of the function is used as the return value.

```
DECLARE EXTERNAL FUNCTION i64Truncate
    NUMERIC(18) BY DESCRIPTOR, NUMERIC(18) BY DESCRIPTOR
    RETURNS PARAMETER 2
    ENTRY_POINT 'fbtruncate' MODULE_NAME 'fbudf';
```

See also

ALTER EXTERNAL FUNCTION, DROP EXTERNAL FUNCTION, CREATE FUNCTION
5.10.2. **ALTER EXTERNAL FUNCTION**

*Used for*

Changing the entry point and/or the module name for a user-defined function (UDF)

*Available in*

DSQL

*Syntax*

```
ALTER EXTERNAL FUNCTION funcname
    [ENTRY_POINT 'new_entry_point']
    [MODULE_NAME 'new_library_name']
```

*Table 54. ALTER EXTERNAL FUNCTION Statement Parameters*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>funcname</td>
<td>Function name in the database</td>
</tr>
<tr>
<td>new_entry_point</td>
<td>The new exported name of the function</td>
</tr>
<tr>
<td>new_library_name</td>
<td>The new name of the module (MODULE_NAME from which the function is exported). This will be the name of the file, without the “.dll” or “.so” file extension.</td>
</tr>
</tbody>
</table>

The ALTER EXTERNAL FUNCTION statement changes the entry point and/or the module name for a user-defined function (UDF). Existing dependencies remain intact after the statement containing the change(s) is executed.

**The ENTRY_POINT clause**

is for specifying the new entry point (the name of the function as exported from the module).

**The MODULE_NAME clause**

is for specifying the new name of the module where the exported function is located.

Any user connected to the database can change the entry point and the module name.

**Who Can Alter an External Function**

The ALTER EXTERNAL FUNCTION statement can be executed by:

- **Administrators**
- Owner of the external function
- Users with the ALTER ANY FUNCTION privilege

**Examples using ALTER EXTERNAL FUNCTION**
Changing the entry point for an external function

ALTER EXTERNAL FUNCTION invl ENTRY_POINT 'intNvl';

Changing the module name for an external function

ALTER EXTERNAL FUNCTION invl MODULE_NAME 'fbudf2';

See also
DECLARE EXTERNAL FUNCTION, DROP EXTERNAL FUNCTION

5.10.3. DROP EXTERNAL FUNCTION

Used for
Removing a user-defined function (UDF) from a database

Available in
DSQL, ESQL

Syntax

DROP EXTERNAL FUNCTION funcname

Table 55. DROP EXTERNAL FUNCTION Statement Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>funcname</td>
<td>Function name in the database</td>
</tr>
</tbody>
</table>

The DROP EXTERNAL FUNCTION statement deletes the declaration of a user-defined function from the database. If there are any dependencies on the external function, the statement will fail and the appropriate error will be raised.

Any user connected to the database can delete the declaration of an internal function.

Who Can Drop an External Function

The DROP EXTERNAL FUNCTION statement can be executed by:

- Administrators
- Owner of the external function
- Users with the DROP ANY FUNCTION privilege

Example using DROP EXTERNAL FUNCTION

Deleting the declaration of the addDay function.

DROP EXTERNAL FUNCTION addDay;
5.11. PACKAGE

A package is a group of procedures and functions managed as one entity.

5.11.1. CREATE PACKAGE

*Used for*
Declaring the package header

*Available in*
DSQL
**Syntax**

```sql
CREATE PACKAGE package_name
[SQL SECURITY {INVOKER | DEFINER}]
AS
BEGIN
 [ <package_item> ... ]
END

<package_item> ::= 
  <function_decl>; 
  | <procedure_decl>;

<function_decl> ::= 
  FUNCTION funcname [ ( [ <in_params> ] ) ] 
  RETURNS <domain_or_non_array_type> [COLLATE collation] 
  [DETERMINISTIC]

<procedure_decl> ::= 
  PROCEDURE proname [ ( [ <in_params> ] ) ] 
  [RETURNS (<out_params>)]

<in_params> ::= <inparam> [, <inparam> ... ]

<inparam> ::= <param_decl> [ = | DEFAULT ] <value>

<out_params> ::= <outparam> [, <outparam> ... ]

<outparam> ::= <param_decl>

<value> ::= { literal | NULL | context_var }

<param_decl> ::= paramname <domain_or_non_array_type> [NOT NULL] 
  [COLLATE collation]

<domain_or_non_array_type> ::= 
  !! See Scalar Data Types Syntax !!
```

Table 56. CREATE PACKAGE Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>package_name</td>
<td>Package name. The maximum length is 63 characters. The package name must be unique among all package names.</td>
</tr>
<tr>
<td>function_decl</td>
<td>Function declaration</td>
</tr>
<tr>
<td>procedure_decl</td>
<td>Procedure declaration</td>
</tr>
<tr>
<td>func_name</td>
<td>Function name. The maximum length is 63 characters. The function name must be unique within the package.</td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>proc_name</td>
<td>Procedure name. The maximum length is 63 characters. The function name must be unique within the package.</td>
</tr>
<tr>
<td>collation</td>
<td>Collation sequence</td>
</tr>
<tr>
<td>inparam</td>
<td>Input parameter declaration</td>
</tr>
<tr>
<td>outparam</td>
<td>Output parameter declaration</td>
</tr>
<tr>
<td>literal</td>
<td>A literal value that is assignment-compatible with the data type of the parameter</td>
</tr>
<tr>
<td>context_var</td>
<td>Any context variable that is assignment-compatible with the data type of the parameter</td>
</tr>
<tr>
<td>paramname</td>
<td>The name of an input parameter of a procedure or function, or an output parameter of a procedure. The maximum length is 63 characters. The name of the parameter must be unique among input and output parameters of the procedure or function.</td>
</tr>
</tbody>
</table>

The `CREATE PACKAGE` statement creates a new package header. Routines (procedures and functions) declared in the package header are available outside the package using the full identifier (`package_name.proc_name` or `package_name.func_name`). Routines defined only in the package body — but not in the package header — are not visible outside the package.

**Package procedure and function names may shadow global routines**

If a package header or package body declares a procedure or function with the same name as a stored procedure or function in the global namespace, it is not possible to call that global procedure or function from the package body. In this case, the procedure or function of the package will always be called.

For this reason, it is recommended that the names of stored procedures and functions in packages do not overlap with names of stored procedures and functions in the global namespace.

**Statement Terminators**

Some SQL statement editors — specifically the `isql` utility that comes with Firebird and possibly some third-party editors — employ an internal convention that requires all statements to be terminated with a semi-colon. This creates a conflict with PSQL syntax when coding in these environments. If you are unacquainted with this problem and its solution, please study the details in the PSQL chapter in the section entitled *Switching the Terminator in isql*.

**SQL Security**

The `SQL SECURITY` clause specifies the security context for executing other routines or inserting into other tables from functions or procedures defined in this package. When SQL Security is not specified, the default value of the database is applied at runtime.

The `SQL SECURITY` clause can only be specified for the package, not for individual procedures and
functions of the package.

See also *SQL Security* in chapter *Security*.

**Procedure and Function Parameters**

For details on stored procedure parameters, see *Parameters* in `CREATE PROCEDURE`.

For details on function parameters, see *Parameters* in `CREATE FUNCTION`.

**Who Can Create a Package**

The `CREATE PACKAGE` statement can be executed by:

- **Administrators**
- **Users with the `CREATE PACKAGE` privilege**

The user who created the package header becomes its owner.

**Examples of `CREATE PACKAGE`**

1. Create a package header

```
CREATE PACKAGE APP_VAR
AS
BEGIN
  FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC;
  FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC;
  PROCEDURE SET_DATERANGE(ADATEBEGIN DATE,
                           ADATEEND DATE DEFAULT CURRENT_DATE);
END
```

1. With `DEFINER` set for package `pk`, user `US` needs only the `EXECUTE` privilege on `pk`. If it were set for `INVOKER`, either the user or the package would also need the `INSERT` privilege on table `t`. 
create table t (i integer);
set term ^;
create package pk SQL SECURITY DEFINER
as
begin
  function f(i integer) returns int;
end^

create package body pk
as
begin
  function f(i integer) returns int
  as
  begin
    insert into t values (:i);
    return i + 1;
  end
end^
set term ;^
grant execute on package pk to user us;
commit;

connect 'localhost:/tmp/69.fdb' user us password 'pas';
select pk.f(3) from rdb$database;

See also
CREATE PACKAGE BODY, RECREATE PACKAGE BODY, ALTER PACKAGE, DROP PACKAGE, RECREATE PACKAGE

5.11.2. ALTER PACKAGE

Used for
Altering the package header

Available in
DSQL

Syntax

ALTER PACKAGE package_name
  [ SQL SECURITY { INVOKER | DEFINER } ]
  AS
  [ <package_item> ... ]
END

!! See syntax of CREATE PACKAGE for further rules!!
The ALTER PACKAGE statement modifies the package header. It can be used to change the number and definition of procedures and functions, including their input and output parameters. However, the source and compiled form of the package body is retained, though the body might be incompatible after the change to the package header. The validity of a package body for the defined header is stored in the column RDB$PACKAGES.RDB$VALID_BODY_FLAG.

Altering a package without specifying the SQL SECURITY clause will remove the SQL Security property if currently set for this package. This means the behaviour will revert to the database default.

**Who Can Alter a Package**

The ALTER PACKAGE statement can be executed by:

- **Administrators**
- The owner of the package
- Users with the ALTER ANY PACKAGE privilege

**Examples of ALTER PACKAGE**

**Modifying a package header**

```sql
ALTER PACKAGE APP_VAR
AS
BEGIN
  FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC;
  FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC;
  PROCEDURE SET_DATERANGE(ADATEBEGIN DATE,
    ADATEEND DATE DEFAULT CURRENT_DATE);
END
```

See also

CREATE PACKAGE, DROP PACKAGE, ALTER PACKAGE BODY, RECREATE PACKAGE BODY

### 5.11.3. CREATE OR ALTER PACKAGE

**Used for**

Creating a new or altering an existing package header

**Available in**

DSQL
Syntax

CREATE OR ALTER PACKAGE package_name
[SQL SECURITY {INVOKER | DEFINER}]
AS
BEGIN
  [ <package_item> ... ]
END

!! See syntax of CREATE PACKAGE for further rules!!

The `CREATE OR ALTER PACKAGE` statement creates a new package or modifies an existing package header. If the package header does not exist, it will be created using `CREATE PACKAGE`. If it already exists, then it will be modified using `ALTER PACKAGE` while retaining existing privileges and dependencies.

**Examples of CREATE OR ALTER PACKAGE**

Creating a new or modifying an existing package header

```sql
CREATE OR ALTER PACKAGE APP_VAR
AS
BEGIN
  FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC;
  FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC;
  PROCEDURE SET_DATERANGE(ADATEBEGIN DATE, ADATEEND DATE DEFAULT CURRENT_DATE);
END
```

See also

CREATE PACKAGE, ALTER PACKAGE, RECREATE PACKAGE, ALTER PACKAGE BODY, RECREATE PACKAGE BODY

**5.11.4. DROP PACKAGE**

*Used for*
Dropping a package header

*Available in*
DSQL

**Syntax**

```
DROP PACKAGE package_name
```

**Table 57. DROP PACKAGE Statement Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>package_name</td>
<td>Package name</td>
</tr>
</tbody>
</table>
The DROP PACKAGE statement deletes an existing package header. If a package body exists, it will be dropped together with the package header. If there are still dependencies on the package, an error will be raised.

**Who Can Drop a Package**

The DROP PACKAGE statement can be executed by:

- Administrators
- The owner of the package
- Users with the DROP ANY PACKAGE privilege

**Examples of DROP PACKAGE**

*Dropping a package header*

```sql
DROP PACKAGE APP_VAR
```

**See also**

CREATE PACKAGE, DROP PACKAGE BODY

### 5.11.5. RECREATE PACKAGE

**Used for**

Creating a new or recreating an existing package header

**Available in**

DSQL

**Syntax**

```sql
RECREATE PACKAGE package_name
[SQL SECURITY {INVOKER | DEFINER}]
AS
BEGIN
  [ <package_item> ... ]
END
```

!! See syntax of CREATE PACKAGE for further rules!!

The RECREATE PACKAGE statement creates a new package or recreates an existing package header. If a package header with the same name already exists, then this statement will first drop it and then create a new package header. It is not possible to recreate the package header if there are still dependencies on the existing package, or if the body of the package exists. Existing privileges of the package itself are not preserved, nor are privileges to execute the procedures or functions of the package.
Examples of **RECREATE PACKAGE**

Creating a new or recreating an existing package header

```sql
RECREATE PACKAGE APP_VAR
AS
BEGIN
FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC;
FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC;
PROCEDURE SET_DATERANGE(ADATEBEGIN DATE,
ADATEEND DATE DEFAULT CURRENT_DATE);
END
```

See also
CREATE PACKAGE, DROP PACKAGE, CREATE PACKAGE BODY, RECREATE PACKAGE BODY

### 5.12. PACKAGE BODY

#### 5.12.1. CREATE PACKAGE BODY

*Used for*
Creating the package body

*Available in*
DSQL
Syntax

CREATE PACKAGE BODY name
AS
BEGIN
  [ <package_item> ... ]
  [ <package_body_item> ... ]
END

<p>package_item ::=</p>
  !! See CREATE PACKAGE syntax !!

<p>package_body_item ::=</p>
  <function_impl> |<procedure_impl>

<p>function_impl ::=</p>
  FUNCTION funcname [ ( [ <in_params> ] ) ]
  RETURNS <domain_or_non_array_type> [COLLATE collation]
  [DETERMINISTIC]
  <module-body>

<p>procedure_impl ::=</p>
  PROCEDURE procname [ ( [ <in_params> ] ) ]
  [RETURNS (<out_params>)]
  <module-body>

<p>module-body ::=</p>
  !! See Syntax of Module Body !!

<p>in_params ::=</p>
  !! See CREATE PACKAGE syntax !!
  !! See also Rules below !!

<p>out_params ::=</p>
  !! See CREATE PACKAGE syntax !!

<p>domain_or_non_array_type ::=</p>
  !! See Scalar Data Types Syntax !!

Table 58. CREATE PACKAGE BODY Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>package_name</td>
<td>Package name. The maximum length is 63 characters. The package name must be unique among all package names.</td>
</tr>
<tr>
<td>function_impl</td>
<td>Function implementation. Essentially a CREATE FUNCTION statement without CREATE.</td>
</tr>
<tr>
<td>procedure_impl</td>
<td>Procedure implementation. Essentially a CREATE PROCEDURE statement without CREATE.</td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>func_name</td>
<td>Function name. The maximum length is 63 characters. The function name must be unique within the package.</td>
</tr>
<tr>
<td>collation</td>
<td>Collation sequence</td>
</tr>
<tr>
<td>proc_name</td>
<td>Procedure name. The maximum length is 63 characters. The function name must be unique within the package.</td>
</tr>
</tbody>
</table>

The `CREATE PACKAGE BODY` statement creates a new package body. The package body can only be created after the package header has been created. If there is no package header with name `package_name`, an appropriate error will be raised.

All procedures and functions declared in the package header must be implemented in the package body. Additional procedures and functions may be defined and implemented in the package body only. Procedure and functions defined in the package body, but not defined in the package header are not visible outside the package body.

The names of procedures and functions defined in the package body must be unique among the names of procedures and functions defined in the package header and implemented in the package body.

**Package procedure and function names may shadow global routines**

If a package header or package body declares a procedure or function with the same name as a stored procedure or function in the global namespace, it is not possible to call that global procedure or function from the package body. In this case, the procedure or function of the package will always be called.

For this reason, it is recommended that the names of stored procedures and functions in packages do not overlap with names of stored procedures and functions in the global namespace.

**Rules**

- In the package body, all procedures and functions must be implemented with the same signature as declared in the header and at the beginning of the package body.
- The default values for procedure or function parameters cannot be overridden (as specified in the package header or in `<package_item>`). This means default values can only be defined in `<package_body_item>` for procedures or functions that have not been defined in the package header or earlier in the package body.

**UDF declarations (DECLARE EXTERNAL FUNCTION) is not supported for packages. Use UDR instead.**

**Who Can Create a Package Body**

The `CREATE PACKAGE BODY` statement can be executed by:

- **Administrators**
The owner of the package

Users with the ALTER ANY PACKAGE privilege

**Examples of CREATE PACKAGE BODY**

*Creating the package body*

```sql
CREATE PACKAGE BODY APP_VAR
AS
BEGIN
  - Returns the start date of the period
  FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC
  AS
  BEGIN
    RETURN RDB$GET_CONTEXT('USER_SESSION', 'DATEBEGIN');
  END
  - Returns the end date of the period
  FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC
  AS
  BEGIN
    RETURN RDB$GET_CONTEXT('USER_SESSION', 'DATEEND');
  END
  - Sets the date range of the working period
  PROCEDURE SET_DATERANGE(ADATEBEGIN DATE, ADATEEND DATE)
  AS
  BEGIN
    RDB$SET_CONTEXT('USER_SESSION', 'DATEBEGIN', ADATEBEGIN);
    RDB$SET_CONTEXT('USER_SESSION', 'DATEEND', ADATEEND);
  END
END
```

*See also*

ALTER PACKAGE BODY, DROP PACKAGE BODY, RECREATE PACKAGE BODY, CREATE PACKAGE

**5.12.2. ALTER PACKAGE BODY**

*Used for*

Altering the package body

*Available in*

DSQL
Syntax

```
ALTER PACKAGE BODY name
AS
BEGIN
  [ <package_item> ... ]
  [ <package_body_item> ... ]
END

!! See syntax of CREATE PACKAGE BODY for further rules !!
```

The `ALTER PACKAGE BODY` statement modifies the package body. It can be used to change the definition and implementation of procedures and functions of the package body.

See `CREATE PACKAGE BODY` for more details.

**Who Can Alter a Package Body**

The `ALTER PACKAGE BODY` statement can be executed by:

- **Administrators**
- The owner of the package
- Users with the `ALTER ANY PACKAGE` privilege

**Examples of ALTER PACKAGE BODY**
Modifying the package body

```
ALTER PACKAGE BODY APP_VAR
AS
BEGIN
  - Returns the start date of the period
  FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC
  AS
  BEGIN
    RETURN RDB$GET_CONTEXT('USER_SESSION', 'DATEBEGIN');
  END
  - Returns the end date of the period
  FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC
  AS
  BEGIN
    RETURN RDB$GET_CONTEXT('USER_SESSION', 'DATEEND');
  END
  - Sets the date range of the working period
  PROCEDURE SET_DATERANGE(ADATEBEGIN DATE, ADATEEND DATE)
  AS
  BEGIN
    RDB$SET_CONTEXT('USER_SESSION', 'DATEBEGIN', ADATEBEGIN);
    RDB$SET_CONTEXT('USER_SESSION', 'DATEEND', ADATEEND);
  END
END
```

See also

CREATE PACKAGE BODY, DROP PACKAGE BODY, RECREATE PACKAGE BODY, ALTER PACKAGE

5.12.3. DROP PACKAGE BODY

Used for

Dropping a package body

Available in

DSQL

Syntax

```
DROP PACKAGE package_name
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>package_name</td>
<td>Package name</td>
</tr>
</tbody>
</table>

The DROP PACKAGE BODY statement deletes the package body.
Who Can Drop a Package Body

The DROP PACKAGE BODY statement can be executed by:

- Administrators
- The owner of the package
- Users with the ALTER ANY PACKAGE privilege

Examples of DROP PACKAGE BODY

Dropping the package body

DROP PACKAGE BODY APP_VAR;

See also

CREATE PACKAGE BODY, ALTER PACKAGE BODY, DROP PACKAGE

5.12.4. RECREATE PACKAGE BODY

Used for
Creating a new or recreating an existing package body

Available in
DSQL

Syntax

RECREATE PACKAGE BODY name
AS
BEGIN
    [ <package_item> ... ]
    [ <package_body_item> ... ]
END

!! See syntax of CREATE PACKAGE BODY for further rules !!

The RECREATE PACKAGE BODY statement creates a new or recreates an existing package body. If a package body with the same name already exists, the statement will try to drop it and then create a new package body. After recreating the package body, privileges of the package and its routines are preserved.

See CREATE PACKAGE BODY for more details.

Examples of RECREATE PACKAGE BODY
Recruiting the package body

RECREATE PACKAGE BODY APP_VAR AS
BEGIN
- Returns the start date of the period
  FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC AS
  BEGIN
    RETURN RDB$GET_CONTEXT('USER_SESSION', 'DATEBEGIN');
  END
- Returns the end date of the period
  FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC AS
  BEGIN
    RETURN RDB$GET_CONTEXT('USER_SESSION', 'DATEEND');
  END
- Sets the date range of the working period
  PROCEDURE SET_DATERANGE(ADATEBEGIN DATE, ADATEEND DATE) AS
  BEGIN
    RDB$SET_CONTEXT('USER_SESSION', 'DATEBEGIN', ADATEBEGIN);
    RDB$SET_CONTEXT('USER_SESSION', 'DATEEND', ADATEEND);
  END
END

See also
CREATE PACKAGE BODY, ALTER PACKAGE BODY, DROP PACKAGE BODY, ALTER PACKAGE

5.13. FILTER

A BLOB FILTER is a database object that is a special type of external function, with the sole purpose of taking a BLOB object in one format and converting it to a BLOB object in another format. The formats of the BLOB objects are specified with user-defined BLOB subtypes.

External functions for converting BLOB types are stored in dynamic libraries and loaded when necessary.

For more details on BLOB subtypes, see Binary Data Types.

5.13.1. DECLARE FILTER

Used for
Declaring a BLOB filter to the database

Available in
DSQL, ESQL
**Syntax**

```
DECLARE FILTER filtername
    INPUT_TYPE <sub_type> OUTPUT_TYPE <sub_type>
    ENTRY_POINT 'function_name' MODULE_NAME 'library_name'
```

```
<sub_type> ::= number | <mnemonic>

<mnemonic> ::=  
    BINARY | TEXT | BLR | ACL | RANGES 
    | SUMMARY | FORMAT | TRANSACTION_DESCRIPTION 
    | EXTERNAL_FILE_DESCRIPTION | user_defined
```

**Table 60. DECLARE FILTER Statement Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>filtername</td>
<td>Filter name in the database. The maximum length is 63 characters. It need not be the same name as the name exported from the filter library via ENTRY_POINT.</td>
</tr>
<tr>
<td>sub_type</td>
<td>BLOB subtype</td>
</tr>
<tr>
<td>number</td>
<td>BLOB subtype number (must be negative)</td>
</tr>
<tr>
<td>mnemonic</td>
<td>BLOB subtype mnemonic name</td>
</tr>
<tr>
<td>function_name</td>
<td>The exported name (entry point) of the function</td>
</tr>
<tr>
<td>library_name</td>
<td>The name of the module where the filter is located</td>
</tr>
<tr>
<td>user_defined</td>
<td>User-defined BLOB subtype mnemonic name</td>
</tr>
</tbody>
</table>

The DECLARE FILTER statement makes a BLOB filter available to the database. The name of the BLOB filter must be unique among the names of BLOB filters.

**Specifying the Subtypes**

The subtypes can be specified as the subtype number or as the subtype mnemonic name. Custom subtypes must be represented by negative numbers (from -1 to -32,768). An attempt to declare more than one BLOB filter with the same combination of the input and output types will fail with an error.

**INPUT_TYPE**

- clause defining the BLOB subtype of the object to be converted

**OUTPUT_TYPE**

- clause defining the BLOB subtype of the object to be created.
Mnemonic names can be defined for custom BLOB subtypes and inserted manually into the system table RDB$TYPES system table:

```sql
INSERT INTO RDB$TYPES (RDB$FIELD_NAME, RDB$TYPE, RDB$TYPE_NAME)
VALUES ('RDB$FIELD_SUB_TYPE', -33, 'MIDI');
```

After the transaction is committed, the mnemonic names can be used in declarations when you create new filters.

The value of the column RDB$FIELD_NAME must always be 'RDB$FIELD_SUB_TYPE'. If a mnemonic names was defined in upper case, they can be used case-insensitively and without quotation marks when a filter is declared, following the rules for other object names.

**Warning**

In general, the system tables are not writable by users. However, inserting custom types into RDB$TYPES is still possible if the user is an administrator, or has the system privilege CREATE_USER_TYPES.

**Parameters**

**ENTRY_POINT**

clause defining the name of the entry point (the name of the imported function) in the module.

**MODULE_NAME**

The clause defining the name of the module where the exported function is located. By default, modules must be located in the UDF folder of the root directory on the server. The UDFAccess parameter in firebird.conf allows editing of access restrictions to filter libraries.

Any user connected to the database can declare a BLOB filter.

**Who Can Create a BLOB Filter?**

The DECLARE FILTER statement can be executed by:

- **Administrators**
- **Users with the CREATE FILTER privilege**

The user executing the DECLARE FILTER statement becomes the owner of the filter.

**Examples of DECLARE FILTER**

1. Creating a BLOB filter using subtype numbers.
2. Creating a BLOB filter using subtype mnemonic names.

```sql
DECLARE FILTER DESC_FILTER
  INPUT_TYPE 1
  OUTPUT_TYPE -4
  ENTRY_POINT 'desc_filter'
  MODULE_NAME 'FILTERLIB';
```

```sql
DECLARE FILTER FUNNEL
  INPUT_TYPE blr OUTPUT_TYPE text
  ENTRY_POINT 'blr2asc' MODULE_NAME 'myfilterlib';
```

See also

DROP FILTER

5.13.2. DROP FILTER

*Used for*

Removing a BLOB filter declaration from the database

*Available in*

DSQL, ESQL

*Syntax*

```
DROP FILTER filtername
```

*Table 61. DROP FILTER Statement Parameter*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>filtername</td>
<td>Filter name in the database</td>
</tr>
</tbody>
</table>

The DROP FILTER statement removes the declaration of a BLOB filter from the database. Removing a BLOB filter from a database makes it unavailable for use from that database. The dynamic library where the conversion function is located remains intact and the removal from one database does not affect other databases in which the same BLOB filter is still declared.

**Who Can Drop a BLOB Filter?**

The DROP FILTER statement can be executed by:

- **Administrators**
- The owner of the filter
- Users with the DROP ANY FILTER privilege
DROP FILTER Example

Dropping a BLOB filter.

DROP FILTER DESC_FILTER;

See also
DECLARE FILTER

5.14. SEQUENCE (GENERATOR)

A sequence — or generator — is a database object used to get unique number values to fill a series. “Sequence” is the SQL-compliant term for the same thing which — in Firebird — has traditionally been known as “generator”. Firebird has syntax for both terms.

Sequences are always stored as 64-bit integers, regardless of the SQL dialect of the database.

If a client is connected using Dialect 1, the server handles sequence values as 32-bit integers. Passing a sequence value to a 32-bit field or variable will not cause errors as long as the current value of the sequence does not exceed the limits of a 32-bit number. However, as soon as the sequence value exceeds this limit, a database in Dialect 3 will produce an error. A database in Dialect 1 will truncate (overflow) the value, which could compromise the uniqueness of the series.

This section describes how to create, alter, set and drop sequences.

5.14.1. CREATE SEQUENCE

Used for
Creating a new SEQUENCE (GENERATOR)

Available in
DSQL, ESQL

Syntax

```
CREATE {SEQUENCE | GENERATOR} seq_name
  [START WITH start_value]
  [INCREMENT [BY] increment]
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>seq_name</td>
<td>Sequence (generator) name. The maximum length is 63 characters</td>
</tr>
<tr>
<td>start_value</td>
<td>Initial value of the sequence. Default is 1.</td>
</tr>
<tr>
<td>increment</td>
<td>Increment of the sequence (when using NEXT VALUE FOR seq_name); cannot be 0. Default is 1.</td>
</tr>
</tbody>
</table>
The statements `CREATE SEQUENCE` and `CREATE GENERATOR` are synonymous—both create a new sequence. Either can be used, but `CREATE SEQUENCE` is recommended as that is the syntax defined in the SQL standard.

When a sequence is created, its current value is set so that the next value obtained from `NEXT VALUE FOR seq_name` is equal to `start_value`. In other words, the current value of the sequence is set to `(start_value - increment)`. By default, the `start_value` is 1 (one).

The optional `INCREMENT [BY]` clause allows you to specify an increment for the `NEXT VALUE FOR seq_name` expression. By default, the increment is 1 (one). The increment cannot be set to 0 (zero). The `GEN_ID(seq_name, <step>)` function can be called instead, to “step” the series by a different integer number. The increment specified through `INCREMENT [BY]` is not used for `GEN_ID`.

---

### Non-standard behaviour for negative increments

The SQL standard specifies that sequences with a negative increment should start at the maximum value of the sequence ($2^{63} - 1$) and count down. Firebird does not do that, and instead starts at 1.

This may change in a future Firebird version.

---

### Who Can Create a Sequence?

The `CREATE SEQUENCE (CREATE GENERATOR)` statement can be executed by:

- Administrators
- Users with the `CREATE SEQUENCE (CREATE GENERATOR)` privilege

The user executing the `CREATE SEQUENCE (CREATE GENERATOR)` statement becomes its owner.

### Examples of `CREATE SEQUENCE`

1. Creating the `EMP_NO_GEN` sequence using `CREATE SEQUENCE`.

   ```sql
   CREATE SEQUENCE EMP_NO_GEN;
   ```

2. Creating the `EMP_NO_GEN` sequence using `CREATE GENERATOR`.

   ```sql
   CREATE GENERATOR EMP_NO_GEN;
   ```

3. Creating the `EMP_NO_GEN` sequence with an initial value of 5 and an increment of 1.

   ```sql
   CREATE SEQUENCE EMP_NO_GEN START WITH 5;
   ```

4. Creating the `EMP_NO_GEN` sequence with an initial value of 1 and an increment of 10.
CREATE SEQUENCE EMP_NO_GEN INCREMENT BY 10;

5. Creating the EMP_NO_GEN sequence with an initial value of 5 and an increment of 10.

CREATE SEQUENCE EMP_NO_GEN START WITH 5 INCREMENT BY 10;

See also
ALTER SEQUENCE, CREATE OR ALTER SEQUENCE, DROP SEQUENCE, RECREATE SEQUENCE, SET GENERATOR, NEXT VALUE FOR, GEN_ID() function

5.14.2. ALTER SEQUENCE

Used for
Setting the next value of a sequence or changing its increment

Available in
DSQL

Syntax

ALTER {SEQUENCE | GENERATOR} seq_name
   [RESTART [WITH newvalue]]
   [INCREMENT [BY] increment]

Table 63. ALTER SEQUENCE Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>seq_name</td>
<td>Sequence (generator) name</td>
</tr>
<tr>
<td>newvalue</td>
<td>New sequence (generator) value. A 64-bit integer from $-2^{63}$ to $2^{63}-1$.</td>
</tr>
<tr>
<td>increment</td>
<td>Increment of the sequence (when using NEXT VALUE FOR seq_name); cannot be 0.</td>
</tr>
</tbody>
</table>

The ALTER SEQUENCE statement sets the current value of a sequence to the specified value and/or changes the increment of the sequence.

The RESTART WITH newvalue clause allows you to set the next value generated by NEXT VALUE FOR seq_name. To achieve this, the current value of the sequence is set to (newvalue - increment) with increment either as specified in the statement, or stored in the metadata of the sequence. The RESTART clause (without WITH) restarts the sequence with the initial value stored in the metadata of the sequence.
Contrary to Firebird 3.0, in Firebird 4.0 `RESTART WITH` only restarts the sequence with the specified value, and does not store `newvalue` as the new initial value of the sequence. A subsequent `ALTER SEQUENCE RESTART` will use the initial value specified when the sequence was created, and not the `newvalue` of this statement. This behaviour is specified in the SQL standard.

It is currently not possible to change the initial value stored in the metadata.

Incorrect use of the `ALTER SEQUENCE` statement (changing the current value of the sequence or generator) is likely to break the logical integrity of data, or result in primary key or unique constraint violations.

`INCREMENT [BY]` allows you to change the sequence increment for the `NEXT VALUE FOR` expression.

Changing the increment value takes effect for all queries that run after the transaction commits. Procedures that are called for the first time after changing the commit, will use the new value if they use `NEXT VALUE FOR`. Procedures that were already used (and cached in the metadata cache) will continue to use the old increment. You may need to close all connections to the database for the metadata cache to clear, and the new increment to be used. Procedures using `NEXT VALUE FOR` do not need to be recompiled to see the new increment. Procedures using `GEN_ID(gen, expression)` are not affected when the increment is changed.

**Who Can Alter a Sequence?**

The `ALTER SEQUENCE (ALTER GENERATOR)` statement can be executed by:

- **Administrators**
- The owner of the sequence
- Users with the `ALTER ANY SEQUENCE (ALTER ANY GENERATOR)` privilege

**Examples of ALTER SEQUENCE**

1. Setting the value of the `EMP_NO_GEN` sequence so the next value is 145.

   ```sql
   ALTER SEQUENCE EMP_NO_GEN RESTART WITH 145;
   ```

2. Resetting the base value of the sequence `EMP_NO_GEN` to the initial value stored in the metadata

   ```sql
   ALTER SEQUENCE EMP_NO_GEN RESTART;
   ```

3. Changing the increment of sequence `EMP_NO_GEN` to 10

   ```sql
   ALTER SEQUENCE EMP_NO_GEN INCREMENT BY 10;
   ```
5.14.3. CREATE OR ALTER SEQUENCE

Used for
Creating a new or modifying an existing sequence

Available in
DSQL, ESQL

Syntax

```sql
CREATE OR ALTER {SEQUENCE | GENERATOR} seq_name
  {RESTART | START WITH start_value}
  [INCREMENT [BY] increment]
```

Table 64. CREATE OR ALTER SEQUENCE Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>seq_name</td>
<td>Sequence (generator) name. The maximum length is 63 characters</td>
</tr>
<tr>
<td>start_value</td>
<td>Initial value of the sequence. Default is 1.</td>
</tr>
<tr>
<td>increment</td>
<td>Increment of the sequence (when using NEXT VALUE FOR seq_name); cannot be 0. Default is 1.</td>
</tr>
</tbody>
</table>

If the sequence does not exist, it will be created. An existing sequence will be changed:

- If RESTART is specified, the sequence will restarted with the initial value stored in the metadata.
- If the START WITH clause is specified, the sequence is restarted with start_value, but the start_value is not stored. In other words, it behaves as RESTART WITH in ALTER SEQUENCE.
- If the INCREMENT [BY] clause is specified, increment is stored as the increment in the metadata, and used for subsequent calls to NEXT VALUE FOR

Example of CREATE OR ALTER SEQUENCE

Create a new or modify an existing sequence EMP_NO_GEN

```sql
CREATE OR ALTER SEQUENCE EMP_NO_GEN
  START WITH 10
  INCREMENT BY 1
```

See also

CREATE SEQUENCE, ALTER SEQUENCE, DROP SEQUENCE, RECREATE SEQUENCE, SET GENERATOR, NEXT VALUE FOR, GEN_ID() function
5.14.4. DROP SEQUENCE

Used for
Dropping (deleting) a SEQUENCE (GENERATOR)

Available in
DSQL, ESQL

Syntax

```
DROP {SEQUENCE | GENERATOR} seq_name
```

*Table 65. DROP SEQUENCE Statement Parameter*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>seq_name</td>
<td>Sequence (generator) name. The maximum length is 63 characters</td>
</tr>
</tbody>
</table>

The statements DROP SEQUENCE and DROP GENERATOR statements are equivalent: both drop (delete) an existing sequence (generator). Either is valid but DROP SEQUENCE, being defined in the SQL standard, is recommended.

The statements will fail if the sequence (generator) has dependencies.

Who Can Drop a Sequence?

The DROP SEQUENCE (DROP GENERATOR) statement can be executed by:

- Administrators
- The owner of the sequence
- Users with the DROP ANY SEQUENCE (DROP ANY GENERATOR) privilege

**Example of DROP SEQUENCE**

*Dropping the EMP_NO_GEN series:*

```
DROP SEQUENCE EMP_NO_GEN;
```

See also

CREATE SEQUENCE, CREATE OR ALTER SEQUENCE, RECREATE SEQUENCE

5.14.5. RECREATE SEQUENCE

Used for
Creating or recreating a sequence (generator)

Available in
DSQL, ESQL
RECREATE {SEQUENCE | GENERATOR} seq_name

[START WITH start_value]
[INCREMENT [BY] increment]

Table 66. RECREATE SEQUENCE Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>seq_name</td>
<td>Sequence (generator) name. The maximum length is 63 characters</td>
</tr>
<tr>
<td>start_value</td>
<td>Initial value of the sequence</td>
</tr>
<tr>
<td>increment</td>
<td>Increment of the sequence (when using NEXT VALUE FOR seq_name); cannot be 0</td>
</tr>
</tbody>
</table>

See CREATE SEQUENCE for the full syntax of CREATE SEQUENCE and descriptions of defining a sequences and its options.

RECREATE SEQUENCE creates or recreates a sequence. If a sequence with this name already exists, the RECREATE SEQUENCE statement will try to drop it and create a new one. Existing dependencies will prevent the statement from executing.

Example of RECREATE SEQUENCE

Recreating sequence EMP_NO_GEN

```
RECREATE SEQUENCE EMP_NO_GEN
START WITH 10
INCREMENT BY 2;
```

See also

CREATE SEQUENCE, ALTER SEQUENCE, CREATE OR ALTER SEQUENCE, DROP SEQUENCE, SET GENERATOR, NEXT VALUE FOR, GEN_ID() function

5.14.6. SET GENERATOR

Used for

Setting the current value of a sequence or generator to a specified value

Available in

DSQL, ESQL

Syntax

```
SET GENERATOR seq_name TO new_val
```

Table 67. SET GENERATOR Statement Parameters
The SET GENERATOR statement sets the current value of a sequence or generator to the specified value.

Although SET GENERATOR is considered outdated, it is retained for backward compatibility. Use of the standards-compliant ALTER SEQUENCE is recommended.

**Who Can Use a SET GENERATOR?**

The SET GENERATOR statement can be executed by:

- Administrators
- The owner of the sequence (generator)
- Users with the ALTER ANY SEQUENCE (ALTER ANY GENERATOR) privilege

**Example of SET GENERATOR**

*Setting the value of the EMP_NO_GEN sequence to 145:*

```sql
SET GENERATOR EMP_NO_GEN TO 145;
```

Similar effects can be achieved with ALTER SEQUENCE:

```sql
ALTER SEQUENCE EMP_NO_GEN
RESTART WITH 145 + increment;
```

Here, the value of `increment` is the current increment of the sequence. We need add it as ALTER SEQUENCE calculates the current value to set based on the next value it should produce.

See also

`ALTER SEQUENCE`, `CREATE SEQUENCE`, `CREATE OR ALTER SEQUENCE`, `DROP SEQUENCE`, `NEXT VALUE FOR`, `GEN_ID()` function

### 5.15. EXCEPTION

This section describes how to create, modify and delete custom exceptions for use in error handlers in PSQL modules.

#### 5.15.1. CREATE EXCEPTION

*Used for*
Creating a new exception for use in PSQL modules

*Available in*
DSQL, ESQl

**Syntax**

```sql
CREATE EXCEPTION exception_name '<message>'
<message> ::= <message-part> [<message-part> ...]
<message-part> ::= <text>
| @<slot>
<slot> ::= one of 1..9
```

**Table 68. CREATE EXCEPTION Statement Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>exception_name</td>
<td>Exception name. The maximum length is 63 characters</td>
</tr>
<tr>
<td>message</td>
<td>Default error message. The maximum length is 1,021 characters</td>
</tr>
<tr>
<td>text</td>
<td>Text of any character</td>
</tr>
<tr>
<td>slot</td>
<td>Slot number of a parameter. Numbering starts at 1. Maximum slot number is 9.</td>
</tr>
</tbody>
</table>

The statement `CREATE EXCEPTION` creates a new exception for use in PSQL modules. If an exception with the same name exists, the statement will fail with an appropriate error message.

The exception name is a standard identifier. In a Dialect 3 database, it can be enclosed in double quotes to make it case-sensitive and, if required, to use characters that are not valid in regular identifiers. See [Identifiers](#) for more information.

The default message is stored in character set `NONE`, i.e. in characters of any single-byte character set. The text can be overridden in the PSQL code when the exception is thrown.

The error message may contain “parameter slots” that can be filled when raising the exception.

- If the `message` contains a parameter slot number that is greater than 9, the second and subsequent digits will be treated as literal text. For example `@10` will be interpreted as slot 1 followed by a literal ‘0’.

- Custom exceptions are stored in the system table `RDB$EXCEPTIONS`.

**Who Can Create an Exception**

The `CREATE EXCEPTION` statement can be executed by:
• Administrators

• Users with the CREATE EXCEPTION privilege

The user executing the CREATE EXCEPTION statement becomes the owner of the exception.

**CREATE EXCEPTION Examples**

*Creating an exception named E_LARGE_VALUE*

```
CREATE EXCEPTION E_LARGE_VALUE
' The value is out of range';
```

*Creating a parameterized exception E_INVALID_VALUE*

```
CREATE EXCEPTION E_INVALID_VALUE
'Invalid value @1 for field @2';
```

**Tips**

Grouping CREATE EXCEPTION statements together in system update scripts will simplify working with them and documenting them. A system of prefixes for naming and categorising groups of exceptions is recommended.

*See also*

ALTER EXCEPTION, CREATE OR ALTER EXCEPTION, DROP EXCEPTION, RECREATE EXCEPTION

### 5.15.2. ALTER EXCEPTION

**Used for**

Modifying the message returned from a custom exception

**Available in**

DSQL, ESQL

**Syntax**

```
ALTER EXCEPTION exception_name '<message>'
```

!! See syntax of CREATE EXCEPTION for further rules !!
• Users with the ALTER ANY EXCEPTION privilege

**ALTER EXCEPTION Examples**

*Changing the default message for the exception E_LARGE_VALUE*

```sql
ALTER EXCEPTION E_LARGE_VALUE
  'The value exceeds the prescribed limit of 32,765 bytes';
```

*See also*

CREATE EXCEPTION, CREATE OR ALTER EXCEPTION, DROP EXCEPTION, RECREATE EXCEPTION

### 5.15.3. CREATE OR ALTER EXCEPTION

*Used for*

Modifying the message returned from a custom exception, if the exception exists; otherwise, creating a new exception

*Available in*

DSQL

**Syntax**

```sql
CREATE OR ALTER EXCEPTION exception_name '<message>'
```

!! See syntax of CREATE EXCEPTION for further rules !!

The statement CREATE OR ALTER EXCEPTION is used to create the specified exception if it does not exist, or to modify the text of the error message returned from it if it exists already. If an existing exception is altered by this statement, any existing dependencies will remain intact.

**CREATE OR ALTER EXCEPTION Example**

*Changing the message for the exception E_LARGE_VALUE*

```sql
CREATE OR ALTER EXCEPTION E_LARGE_VALUE
  'The value is higher than the permitted range 0 to 32,765';
```

*See also*

CREATE EXCEPTION, ALTER EXCEPTION, RECREATE EXCEPTION

### 5.15.4. DROP EXCEPTION

*Used for*

Deleting a custom exception

*Available in*
Drop Exception

**Syntax**

```sql
DROP EXCEPTION exception_name
```

**Table 69. DROP EXCEPTION Statement Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>exception_name</td>
<td>Exception name</td>
</tr>
</tbody>
</table>

The statement `DROP EXCEPTION` is used to delete an exception. Any dependencies on the exception will cause the statement to fail, and the exception will not be deleted.

### Who Can Drop an Exception

The `DROP EXCEPTION` statement can be executed by:

- **Administrators**
- The owner of the exception
- Users with the `DROP ANY EXCEPTION` privilege

**DROP EXCEPTION Examples**

Dropping exception `E_LARGE_VALUE`

```
DROP EXCEPTION E_LARGE_VALUE;
```

**See also**

`CREATE EXCEPTION`, `RECREATE EXCEPTION`

### 5.15.5. RECREATE EXCEPTION

**Used for**

Creating a new custom exception or recreating an existing one

**Available in**

DSQL

**Syntax**

```sql
RECREATE EXCEPTION exception_name '<message>'
```

!! See syntax of `CREATE EXCEPTION` for further rules !!

The statement `RECREATE EXCEPTION` creates a new exception for use in PSQL modules. If an exception with the same name exists already, the `RECREATE EXCEPTION` statement will try to drop it and create a new one. If there are any dependencies on the existing exception, the attempted deletion fails and
RECREATE EXCEPTION is not executed.

**RECREATE EXCEPTION Example**

Recreating the `E_LARGE_VALUE` exception

```sql
RECREATE EXCEPTION E_LARGE_VALUE
  'The value exceeds its limit';
```

See also

`CREATE EXCEPTION`, `DROP EXCEPTION`, `CREATE OR ALTER EXCEPTION`

### 5.16. COLLATION

In SQL, text strings are sortable objects. This means that they obey ordering rules, such as alphabetical order. Comparison operations can be applied to such text strings (for example, “less than” or “greater than”), where the comparison must apply a certain sort order or collation. For example, the expression “'a' < 'b'” means that ‘a’ precedes ‘b’ in the collation. The expression “'c' > 'b'” means that ‘c’ follows ‘b’ in the collation. Text strings of more than one character are sorted using sequential character comparisons: first the first characters of the two strings are compared, then the second characters, and so on, until a difference is found between the two strings. This difference defines the sort order.

A **COLLATION** is the schema object that defines a collation (or sort order).

### 5.16.1. CREATE COLLATION

*Used for*

Creating a new collation for a supported character set available to the database

*Available in*

DSQL

**Syntax**

```sql
CREATE COLLATION collname
  FOR charset
  [FROM {basecoll | EXTERNAL ('extname')}]
  [NO PAD | PAD SPACE]
  [CASE [IN]SENSITIVE]
  [ACCENT [IN]SENSITIVE]
  ['<specific-attributes>']

<specific-attributes> ::= <attribute> [; <attribute> ...]

<attribute> ::= attrname=attrvalue
```

*Table 70. CREATE COLLATION Statement Parameters*
The CREATE COLLATION statement does not “create” anything, its purpose is to make a collation known to a database. The collation must already be present on the system, typically in a library file, and must be properly registered in a .conf file in the intl subdirectory of the Firebird installation.

The collation may alternatively be based on one that is already present in the database.

**How the Engine Detects the Collation**

The optional FROM clause specifies the base collation that is used to derive a new collation. This collation must already be present in the database. If the keyword EXTERNAL is specified, then Firebird will scan the .conf files in $fbroot/intl/, where extname must exactly match the name in the configuration file (case-sensitive).

If no FROM clause is present, Firebird will scan the .conf file(s) in the intl subdirectory for a collation with the collation name specified in CREATE COLLATION. In other words, omitting the FROM basecoll clause is equivalent to specifying FROM EXTERNAL ('collname').

The — single-quoted — extname is case-sensitive and must correspond exactly with the collation name in the .conf file. The collname, charset and basecoll parameters are case-insensitive unless enclosed in double-quotes.

When creating a collation, you can specify whether trailing spaces are included in the comparison. If the NO PAD clause is specified, trailing spaces are taken into account in the comparison. If the PAD SPACE clause is specified, trailing spaces are ignored in the comparison.

The optional CASE clause allows you to specify whether the comparison is case-sensitive or case-insensitive.

The optional ACCENT clause allows you to specify whether the comparison is accent-sensitive or accent-insensitive (e.g. if 'e' and 'é' are considered equal or unequal).

**Specific Attributes**

The CREATE COLLATION statement can also include specific attributes to configure the collation. The available specific attributes are listed in the table below. Not all specific attributes apply to every collation. If the attribute is not applicable to the collation, but is specified when creating it, it will not cause an error.

- Specific attribute names are case sensitive.

In the table, “1 bpc” indicates that an attribute is valid for collations of character sets using 1 byte
per character (so-called narrow character sets), and “UNI” for “Unicode collations”.

Table 71. Specific Collation Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Values</th>
<th>Valid for</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISABLE-COMPRESSIONS</td>
<td>0, 1</td>
<td>1 bpc</td>
<td>Disables compressions (a.k.a. contractions). Compressions cause certain character sequences to be sorted as atomic units, e.g. Spanish c+h as a single character ch</td>
</tr>
<tr>
<td>DISABLE-EXPANSIONS</td>
<td>0, 1</td>
<td>1 bpc</td>
<td>Disables expansions. Expansions cause certain characters (e.g. ligatures or umlauted vowels) to be treated as character sequences and sorted accordingly</td>
</tr>
<tr>
<td>ICU-VERSION</td>
<td>default or M.m</td>
<td>UNI</td>
<td>Specifies the ICU library version to use. Valid values are the ones defined in the applicable <code>&lt;intl_module&gt;</code> element in <code>intl/fbintl.conf</code>. Format: either the string literal “default” or a major+minor version number like “3.0” (both unquoted).</td>
</tr>
<tr>
<td>LOCALE</td>
<td>xx_YY</td>
<td>UNI</td>
<td>Specifies the collation locale. Requires complete version of ICU libraries. Format: a locale string like “du_NL” (unquoted)</td>
</tr>
<tr>
<td>MULTI-LEVEL</td>
<td>0, 1</td>
<td>1 bpc</td>
<td>Uses more than one ordering level</td>
</tr>
<tr>
<td>NUMERIC-SORT</td>
<td>0, 1</td>
<td>UNI</td>
<td>Treats contiguous groups of decimal digits in the string as atomic units and sorts them numerically. (This is also known as natural sorting)</td>
</tr>
<tr>
<td>SPECIALS-FIRST</td>
<td>0, 1</td>
<td>1 bpc</td>
<td>Orders special characters (spaces, symbols etc.) before alphanumeric characters</td>
</tr>
</tbody>
</table>

If you want to add a new character set with its default collation into your database, declare and run the stored procedure `sp_register_character_set(name, max_bytes_per_character)`, found in `misc/intl.sql` under the Firebird installation directory.

In order for this to work, the character set must be present on the system and registered in a `.conf` file in the `intl` subdirectory.

Who Can Create a Collation

The `CREATE COLLATION` statement can be executed by:
• Administrators

• Users with the CREATE COLLATION privilege

The user executing the CREATE COLLATION statement becomes the owner of the collation.

Examples using CREATE COLLATION

1. Creating a collation using the name found in the fbintl.conf file (case-sensitive)

   ```sql
   CREATE COLLATION ISO8859_1_UNICODE FOR ISO8859_1;
   ```

2. Creating a collation using a special (user-defined) name (the “external” name must completely match the name in the fbintl.conf file)

   ```sql
   CREATE COLLATION LAT_UNI
       FOR ISO8859_1
       FROM EXTERNAL ('ISO8859_1_UNICODE');
   ```

3. Creating a case-insensitive collation based on one already existing in the database

   ```sql
   CREATE COLLATION ES_ES_NOPAD_CI
       FOR ISO8859_1
       FROM ES_ES
       NO PAD
       CASE INSENSITIVE;
   ```

4. Creating a case-insensitive collation based on one already existing in the database with specific attributes

   ```sql
   CREATE COLLATION ES_ES_CI_COMPR
       FOR ISO8859_1
       FROM ES_ES
       CASE INSENSITIVE
       'DISABLE-COMPRESSIONS=0';
   ```

5. Creating a case-insensitive collation by the value of numbers (the so-called natural collation)
CREATE COLLATION nums_coll FOR UTF8
    FROM UNICODE
    CASE INSENSITIVE 'NUMERIC-SORT=1';

CREATE DOMAIN dm_nums AS varchar(20)
    CHARACTER SET UTF8 COLLATE nums_coll; -- original (manufacturer) numbers

CREATE TABLE wares(id int primary key, articul dm_nums ...);

See also
DROP COLLATION

5.16.2. DROP COLLATION

Used for
Removing a collation from the database

Available in
DSQL

Syntax

DROP COLLATION collname

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>collname</td>
<td>The name of the collation</td>
</tr>
</tbody>
</table>

The DROP COLLATION statement removes the specified collation from the database, if it exists. An error will be raised if the specified collation is not present.

If you want to remove an entire character set with all its collations from the database, declare and execute the stored procedure sp_unregister_character_set(name) from the misc/intl.sql subdirectory of the Firebird installation.

Who Can Drop a Collation

The Drop COLLATION statement can be executed by:

- Administrators
- The owner of the collation
- Users with the DROP ANY COLLATION privilege
Example using DROP COLLATION

Deleting the ES_ES_NOPAD_CI collation.

DROP COLLATION ES_ES_NOPAD_CI;

See also

CREATE COLLATION

5.17. CHARACTER SET

5.17.1. ALTER CHARACTER SET

Used for

Setting the default collation for a character set

Available in

DSQL

Syntax

```
ALTER CHARACTER SET charset
    SET DEFAULT COLLATION collation
```

Table 73. ALTER CHARACTER SET Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>charset</td>
<td>Character set identifier</td>
</tr>
<tr>
<td>collation</td>
<td>The name of the collation</td>
</tr>
</tbody>
</table>

The ALTER CHARACTER SET statement changes the default collation for the specified character set. It will affect the future usage of the character set, except for cases where the COLLATE clause is explicitly overridden. In that case, the collation sequence of existing domains, columns and PSQL variables will remain intact after the change to the default collation of the underlying character set.

If you change the default collation for the database character set (the one defined when the database was created), it will change the default collation for the database.

If you change the default collation for the character set that was specified during the connection, string constants will be interpreted according to the new collation value, except in those cases where the character set and/or the collation have been overridden.

Who Can Alter a Character Set

The ALTER CHARACTER SET statement can be executed by:
• Administrators
• Users with the ALTER ANY CHARACTER SET privilege

**ALTER CHARACTER SET Example**

Setting the default UNICODE_CI_AI collation for the UTF8 encoding

```sql
ALTER CHARACTER SET UTF8
SET DEFAULT COLLATION UNICODE_CI_AI;
```

### 5.18. Comments

Database objects and a database itself may be annotated with comments. It is a convenient mechanism for documenting the development and maintenance of a database. Comments created with `COMMENT ON` will survive a `gbak` backup and restore.

#### 5.18.1. COMMENT ON

*Used for*
Documenting metadata

*Available in*
DSQL

**Syntax**

```sql
COMMENT ON <object> IS {'sometext' | NULL}

<object> ::= 
  {DATABASE | SCHEMA}
  | <basic-type> objectname
  | USER username [USING PLUGIN pluginname]
  | COLUMN relationname.fieldname
  | [{'PROCEDURE | FUNCTION}] PARAMETER
  | [{PROCEDURE | [EXTERNAL] FUNCTION}
    [packagename.]routinename.paramname
  | {PROCEDURE | [EXTERNAL] FUNCTION}
    [package_name.]routinename

<basic-type> ::= 
  CHARACTER SET | COLLATION | DOMAIN
  | EXCEPTION | FILTER | GENERATOR
  | INDEX | PACKAGE | ROLE
  | SEQUENCE | TABLE | TRIGGER
  | VIEW
```

*Table 74. COMMENT ON Statement Parameters*
### Parameter | Description
---|---
sometext | Comment text
basic-type | Metadata object type
objectname | Metadata object name
username | Username
pluginname | User manager plugin name
relationname | Name of table or view
fieldname | Name of the column
package_name | Name of the package
routinename | Name of stored procedure or function
paramname | Name of a stored procedure or function parameter

The `COMMENT ON` statement adds comments for database objects (metadata). Comments are saved to the `RDB$DESCRIPTION` column of the corresponding system tables. Client applications can view comments from these fields.

1. If you add an empty comment ("'"), it will be saved as `NULL` in the database.
2. By default, the `COMMENT ON USER` statement will create comments on users managed by the default user manager (the first plugin listed in the `UserManager` config option). The `USING PLUGIN` can be used to comment on a user managed by a different user manager.
3. Comments on users are not stored for the `Legacy_UserManager`.
4. Comments on users are stored in the security database.
5. `SCHEMA` is currently a synonym for `DATABASE`; this may change in a future version, so we recommend to always use `DATABASE`.

Comments on users are visible to that user through the `SEC$USERS` virtual table.

### Who Can Add a Comment

The `COMMENT ON` statement can be executed by:

- **Administrators**
- The owner of the object that is commented on
- Users with the `ALTER ANY object_type` privilege, where `object_type` is the type of object commented on (e.g. `PROCEDURE`)

### Examples using `COMMENT ON`

1. Adding a comment for the current database
2. Adding a comment for the METALS table

```
COMMENT ON TABLE METALS IS 'Metal directory';
```

3. Adding a comment for the ISALLOY field in the METALS table

```
COMMENT ON COLUMN METALS.ISALLOY IS '0 = fine metal, 1 = alloy';
```

4. Adding a comment for a parameter

```
COMMENT ON PARAMETER ADD_EMP_PROJ.EMP_NO IS 'Employee ID';
```

5. Adding a comment for a package, its procedures and functions, and their parameters

```
COMMENT ON PACKAGE APP_VAR IS 'Application Variables';

COMMENT ON FUNCTION APP_VAR.GET_DATEBEGIN
IS 'Returns the start date of the period';

COMMENT ON PROCEDURE APP_VAR.SET_DATERANGE
IS 'Set date range';

COMMENT ON
PROCEDURE PARAMETER APP_VAR.SET_DATERANGE.ADATEBEGIN
IS 'Start Date';
```
Chapter 6. Data Manipulation (DML) Statements

DML—data manipulation language—is the subset of SQL that is used by applications and procedural modules to extract and change data. Extraction, for the purpose of reading data, both raw and manipulated, is achieved with the `SELECT` statement. `INSERT` is for adding new data and `DELETE` is for erasing data that are no longer required. `UPDATE`, `MERGE` and `UPDATE OR INSERT` all modify data in various ways.

6.1. SELECT

*Used for*
Retrieving data

*Available in*
DSQL, ESQL, PSQL

*Global syntax*

```
WITH [RECURSIVE] <cte> [, <cte> ...]
SELECT
  [FIRST m] [SKIP n]
  [{DISTINCT | ALL}] <columns>
FROM
  <source> [[AS] alias]
  [<joins>]
[WHERE <condition>]
[GROUP BY <grouping-list>]
[HAVING <aggregate-condition>]]
[WINDOW <window_definition> [, <window_definition> ...]]
[PLAN <plan-expr>]
[UNION [{DISTINCT | ALL}] <other-select>]
[ORDER BY <ordering-list>]
[{{ ROWS <m> [TO <n>]}
  | [OFFSET n {ROW | ROWS}]
  | [FETCH {FIRST | NEXT} [m] {ROW | ROWS} ONLY}]
]
[FOR UPDATE [OF <columns>]]
[WITH LOCK]
INTO <variables>

<variables> ::= [:]varname [, [:]varname ...]
```

The `SELECT` statement retrieves data from the database and hands them to the application or the enclosing SQL statement. Data are returned in zero or more *rows*, each containing one or more *columns* or *fields*. The total of rows returned is the *result set* of the statement.
The only mandatory parts of the SELECT statement are:

- The SELECT keyword, followed by a columns list. This part specifies what you want to retrieve.
- The FROM keyword, followed by a selectable object. This tells the engine where you want to get it from.

In its most basic form, SELECT retrieves a number of columns from a single table or view, like this:

```
select id, name, address
from contacts
```

Or, to retrieve all the columns:

```
select * from sales
```

In practice, a SELECT statement is usually executed with a WHERE clause, which limits the rows returned. The result set may be sorted by an ORDER BY clause, and FIRST … SKIP, OFFSET … FETCH or ROWS may further limit the number of returned rows, and can - for example - be used for pagination.

The column list may contain all kinds of expressions instead of just column names, and the source need not be a table or view: it may also be a derived table, a common table expression (CTE) or a selectable stored procedure (SP). Multiple sources may be combined in a JOIN, and multiple result sets may be combined in a UNION.

The following sections discuss the available SELECT subclauses and their usage in detail.

### 6.1.1. FIRST, SKIP

**Used for**

Retrieving a slice of rows from an ordered set

**Available in**

DSQL, PSQL

**Syntax**

```
SELECT
  [FIRST <m>] [SKIP <n>]
  FROM ...
 ...
```

\(<m>, <n> ::= <integer-literal> | <query-parameter> | (<integer-expression>)
```

Table 75. Arguments for the FIRST and SKIP Clauses
FIRST and SKIP are non-standard syntax

FIRST and SKIP are Firebird-specific clauses. Use the SQL-standard OFFSET, FETCH syntax wherever possible.

FIRST limits the output of a query to the first \( m \) rows. SKIP will suppress the given \( n \) rows before starting to return output.

FIRST and SKIP are both optional. When used together as in “FIRST \( m \) SKIP \( n \)”, the \( n \) topmost rows of the output set are discarded, and the first \( m \) rows of the rest of the set are returned.

Characteristics of FIRST and SKIP

- Any argument to FIRST and SKIP that is not an integer literal or an SQL parameter must be enclosed in parentheses. This implies that a subquery expression must be enclosed in two pairs of parentheses.
- SKIP 0 is allowed but totally pointless.
- FIRST 0 is also allowed and returns an empty set.
- Negative SKIP and/or FIRST values result in an error.
- If a SKIP lands past the end of the dataset, an empty set is returned.
- If the number of rows in the dataset (or the remainder left after a SKIP) is less than the value of the \( m \) argument supplied for FIRST, that smaller number of rows is returned. These are valid results, not error conditions.

Examples of FIRST/SKIP

1. The following query will return the first 10 names from the People table:

```
select first 10 id, name from People
order by name asc
```

2. The following query will return everything but the first 10 names:

```
select skip 10 id, name from People
order by name asc
```

3. And this one returns the last 10 rows. Notice the double parentheses:

```
select first 10, skip 10 id, name from People
order by name asc
```
4. This query returns rows 81 to 100 of the People table:

```sql
select first 20 skip 80 id, name from People
order by name asc
```

See also
OFFSET, FETCH, ROWS

### 6.1.2. The SELECT Columns List

The columns list contains one or more comma-separated value expressions. Each expression provides a value for one output column. Alternatively, * ("select star" or "select all") can be used to stand for all the columns in a relation (i.e. a table, view or selectable stored procedure).
Syntax

```
SELECT
    [...] 
    [{DISTINCT | ALL}] <select_list>
    [...] 
    FROM ...

<select_list> ::= * | <output_column> [, <output_column> ...]

<output_column> ::= 
    <qualifier>.* 
    | <value_expression> [COLLATE collation] [[AS] alias]

<value_expression> ::= 
    [<qualifier>.]col_name 
    | [selectable_SP_outparm] 
    | <literal> 
    | <context-variable> 
    | <function-call> 
    | <single-value-subselect> 
    | <CASE-construct> 
    | any other expression returning a single value of a Firebird data type or NULL

<qualifier> ::= a relation name or alias

<function-call> ::= 
    <normal_function> 
    | <aggregate_function> 
    | <window_function>

<normal_function> ::= 
    !! See Built-in Scalar Functions !!

<aggregate_function> ::= 
    !! See Aggregate Functions !!

>window_function> ::= 
    !! See Window Functions !!
```

Table 76. Arguments for the SELECT Columns List

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>qualifier</td>
<td>Name of relation (view, stored procedure, derived table); or an alias for it</td>
</tr>
<tr>
<td>collation</td>
<td>Only for character-type columns: a collation name that exists and is valid for the character set of the data</td>
</tr>
<tr>
<td>alias</td>
<td>Column or field alias</td>
</tr>
<tr>
<td>col_name</td>
<td>Name of a table or view column</td>
</tr>
<tr>
<td>Argument</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>selectable_SP_outparm</td>
<td>Declared name of an output parameter of a selectable stored procedure</td>
</tr>
<tr>
<td>literal</td>
<td>A literal</td>
</tr>
<tr>
<td>context-variable</td>
<td>Context variable</td>
</tr>
<tr>
<td>function-call</td>
<td>Scalar, aggregate, or window function expression</td>
</tr>
<tr>
<td>single-value-subselect</td>
<td>A subquery returning one scalar value (singleton)</td>
</tr>
<tr>
<td>CASE-construct</td>
<td>CASE construct setting conditions for a return value</td>
</tr>
</tbody>
</table>

It is always valid to qualify a column name (or “*”) with the name or alias of the table, view or selectable SP to which it belongs, followed by a dot (‘.’). For example, `relationname.columnname`, `relationname.*`, `alias.columnname`, `alias.*`. Qualifying is required if the column name occurs in more than one relation taking part in a join. Qualifying “*” is always mandatory if it is not the only item in the column list.

Aliases hide the original relation name: once a table, view or procedure has been aliased, only the alias can be used as its qualifier throughout the query. The relation name itself becomes unavailable.

The column list may optionally be preceded by one of the keywords DISTINCT or ALL:

- **DISTINCT** filters out any duplicate rows. That is, if two or more rows have the same values in every corresponding column, only one of them is included in the result set
- **ALL** is the default: it returns all of the rows, including duplicates. ALL is rarely used; it is supported for compliance with the SQL standard.

A **COLLATE** clause will not change the appearance of the column as such. However, if the specified collation changes the case or accent sensitivity of the column, it may influence:

- The ordering, if an **ORDER BY** clause is also present and it involves that column
- Grouping, if the column is part of a **GROUP BY** clause
- The rows retrieved (and hence the total number of rows in the result set), if **DISTINCT** is used

**Examples of SELECT queries with different types of column lists**

A simple SELECT using only column names:

```sql
select cust_id, cust_name, phone
from customers
where city = 'London'
```

A query featuring a concatenation expression and a function call in the columns list:
select 'Mr./Mrs. ' || lastname, street, zip, upper(city)
from contacts
where date_last_purchase(id) = current_date

A query with two subselects:

select p.fullname,
   (select name from classes c where c.id = p.class) as class,
   (select name from mentors m where m.id = p.mentor) as mentor
from pupils p

The following query accomplishes the same as the previous one using joins instead of subselects:

select p.fullname,
   c.name as class,
   m.name as mentor
join classes c on c.id = p.class
from pupils p
join mentors m on m.id = p.mentor

This query uses a CASE construct to determine the correct title, e.g. when sending mail to a person:

select case upper(sex)
   when 'F' then 'Mrs.'
   when 'M' then 'Mr.'
   else ''
end as title,
lastname,
address
from employees

Query using a window function. Ranks employees by salary.

SELECT
   id,
salary,
   name,
   DENSE_RANK() OVER (ORDER BY salary) AS EMP_RANK
FROM employees
ORDER BY salary;

Querying a selectable stored procedure:
Chapter 6. Data Manipulation (DML) Statements

```
select * from interesting_transactions(2010, 3, 'S')
   order by amount
```

Selecting from columns of a derived table. A derived table is a parenthesized SELECT statement whose result set is used in an enclosing query as if it were a regular table or view. The derived table is shown in bold here:

```
select fieldcount,
       count(relation) as num_tables
from <strong>(select rdb$relation_name as relation,
               count(*) as fieldcount
       from rdb$relations r
       join rdb$relation_fields rf
       on rf.rdb$relation_name = r.rdb$relation_name
       group by relation)</strong>
group by fieldcount
```

Asking the time through a context variable (CURRENT_TIME):

```
select current_time from rdb$database
```

For those not familiar with RDB$DATABASE: this is a system table that is present in all Firebird databases and is guaranteed to contain exactly one row. Although it wasn't created for this purpose, it has become standard practice among Firebird programmers to select from this table if you want to select “from nothing”, i.e. if you need data that are not bound to a table or view, but can be derived from the expressions in the output columns alone. Another example is:

```
select power(12, 2) as twelve_squared, power(12, 3) as twelve_cubed
       from rdb$database
```

Finally, an example where you select some meaningful information from RDB$DATABASE itself:

```
select rdb$character_set_name from rdb$database
```

As you may have guessed, this will give you the default character set of the database.

See also

Functions, Aggregate Functions, Window Functions, Context Variables, CASE, Subqueries

6.1.3. The FROM clause

The FROM clause specifies the source(s) from which the data are to be retrieved. In its simplest form, this is just a single table or view. However, the source can also be a selectable stored procedure, a derived table, or a common table expression. Multiple sources can be combined using various types
of joins.

This section focuses on single-source selects. Joins are discussed in a following section.

Syntax

```
SELECT ...
FROM <source>
[<joins>]
[...]
```

```
<source> ::= 
{ table 
| view 
| selectable-stored-procedure [(<args>)] 
| <derived-table> 
| LATERAL <derived-table> 
| <common-table-expression> 
} [[AS] alias]
```

```
<derived-table> ::= 
(<select-statement>) [[AS] alias] [(<column-aliases>)]
```

```
<common-table-expression> ::= 
  WITH [RECURSIVE] <cte-def> [, <cte-def> ...]
<select-statement>
```

```
<cte-def> ::= name [(<column-aliases>)] AS (<select-statement>)
```

```
<column-aliases> ::= column-alias [, column-alias ...]
```

Table 77. Arguments for the FROM Clause

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>table</td>
<td>Name of a table</td>
</tr>
<tr>
<td>view</td>
<td>Name of a view</td>
</tr>
<tr>
<td>selectable-stored-procedure</td>
<td>Name of a selectable stored procedure</td>
</tr>
<tr>
<td>args</td>
<td>Selectable stored procedure arguments</td>
</tr>
<tr>
<td>derived-table</td>
<td>Derived table query expression</td>
</tr>
<tr>
<td>cte-def</td>
<td>Common table expression (CTE) definition, including an “ad hoc” name</td>
</tr>
<tr>
<td>select-statement</td>
<td>Any SELECT statement</td>
</tr>
<tr>
<td>column-aliases</td>
<td>Alias for a column in a relation, CTE or derived table</td>
</tr>
<tr>
<td>name</td>
<td>The “ad hoc” name for a CTE</td>
</tr>
<tr>
<td>alias</td>
<td>The alias of a data source (table, view, procedure, CTE, derived table)</td>
</tr>
</tbody>
</table>
Selecting **FROM** a table or view

When selecting from a single table or view, the **FROM** clause requires nothing more than the name. An alias may be useful or even necessary if there are subqueries that refer to the main select statement (as they often do — subqueries like this are called *correlated subqueries*).

**Examples**

```sql
select id, name, sex, age from actors
where state = 'Ohio'
```

```sql
select * from birds
where type = 'flightless'
order by family, genus, species
```

```sql
select firstname,
    middlename,
    lastname,
    date_of_birth,
    (select name from schools s where p.school = s.id) schoolname
from pupils p
where year_started = '2012'
order by schoolname, date_of_birth
```
Never mix column names with column aliases!
If you specify an alias for a table or a view, you must always use this alias in place of the table name whenever you query the columns of the relation (and wherever else you make a reference to columns, such as ORDER BY, GROUP BY and WHERE clauses).

Correct use:

```
SELECT PEARS
FROM FRUIT;

SELECT FRUIT.PEARS
FROM FRUIT;

SELECT PEARS
FROM FRUIT F;

SELECT F.PEARS
FROM FRUIT F;
```

Incorrect use:

```
SELECT FRUIT.PEARS
FROM FRUIT F;
```

Selecting FROM a stored procedure

A selectable stored procedure is a procedure that:

- contains at least one output parameter, and
- utilizes the SUSPEND keyword so the caller can fetch the output rows one by one, just as when selecting from a table or view.

The output parameters of a selectable stored procedure correspond to the columns of a regular table.

Selecting from a stored procedure without input parameters is just like selecting from a table or view:

```
select * from suspicious_transactions
where assignee = 'John'
```

Any required input parameters must be specified after the procedure name, enclosed in parentheses:
Values for optional parameters (that is, parameters for which default values have been defined) may be omitted or provided. However, if you provide them only partly, the parameters you omit must all be at the tail end.

Supposing that the procedure `visible_stars` from the previous example has two optional parameters: `min_magn` (numeric(3,1)) and `spectral_class` (varchar(12)), the following queries are all valid:

```sql
select name, az, alt 
from visible_stars('Brugge', current_date, '22:30');

select name, az, alt 
from visible_stars('Brugge', current_date, '22:30', 4.0);

select name, az, alt 
from visible_stars('Brugge', current_date, '22:30', 4.0, 'G');
```

But this one isn't, because there's a “hole” in the parameter list:

```sql
select name, az, alt 
from visible_stars('Brugge', current_date, '22:30', 'G');
```

An alias for a selectable stored procedure is specified after the parameter list:

```sql
select number, 
    (select name from contestants c where c.number = gw.number) 
from get_winners('#34517', 'AMS') gw
```

If you refer to an output parameter (“column”) by qualifying it with the full procedure name, the procedure alias should be omitted:

```sql
select number, 
    (select name from contestants c where c.number = get_winners.number) 
from get_winners('#34517', 'AMS')
```

See also

* Stored Procedures, CREATE PROCEDURE
Selecting FROM a derived table

A derived table is a valid SELECT statement enclosed in parentheses, optionally followed by a table alias and/or column aliases. The result set of the statement acts as a virtual table which the enclosing statement can query.

Syntax

```
(<select-query>)
[[AS] derived-table-alias]
[[<(derived-column-aliases)>]]
```

<derived-column-aliases> := column-alias [, column-alias ...]

The set returned data set by this “SELECT FROM (SELECT FROM..)” style of statement is a virtual table that can be queried within the enclosing statement, as if it were a regular table or view.

LATERAL Derived Tables

The keyword LATERAL marks a table as a lateral derived table. Lateral derived tables can reference tables (including derived tables) that occur earlier in the FROM clause. See Joins with LATERAL Derived Tables for more information.

Example using a derived table

The derived table in the query below returns the list of table names in the database, and the number of columns in each table. A “drill-down” query on the derived table returns the counts of fields and the counts of tables having each field count:

```
SELECT
   FIELDCOUNT,
   COUNT(RELATION) AS NUM_TABLES
FROM (SELECT
   R.RDB$RELATION_NAME RELATION,
   COUNT(*) AS FIELDCOUNT
FROM RDB$RELATIONS R
JOIN RDB$RELATION_FIELDS RF
ON RF.RDB$RELATION_NAME = R.RDB$RELATION_NAME
GROUP BY RELATION)
GROUP BY FIELDCOUNT
```

A trivial example demonstrating how the alias of a derived table and the list of column aliases (both optional) can be used:
More about Derived Tables

Derived tables can

- be nested
- be unions, and can be used in unions
- contain aggregate functions, subqueries and joins
- be used in aggregate functions, subqueries and joins
- be calls to selectable stored procedures or queries to them
- have WHERE, ORDER BY and GROUP BY clauses, FIRST/SKIP or ROWS directives, et al.

Furthermore,

- Each column in a derived table must have a name. If it does not have a name, such as when it is a constant or a run-time expression, it should be given an alias, either in the regular way or by including it in the list of column aliases in the derived table’s specification.
  - The list of column aliases is optional but, if it exists, it must contain an alias for every column in the derived table
- The optimizer can process derived tables very effectively. However, if a derived table is included in an inner join and contains a subquery, the optimizer will be unable to use any join order.

A more useful example

Suppose we have a table COEFFS which contains the coefficients of a number of quadratic equations we have to solve. It has been defined like this:

```sql
create table coeffs (  
a double precision not null,  
b double precision not null,  
c double precision not null,  
constraint chk_a_not_zero check (a <> 0)
)
```

Depending on the values of a, b and c, each equation may have zero, one or two solutions. It is possible to find these solutions with a single-level query on table COEFFS, but the code will look rather messy and several values (like the discriminant) will have to be calculated multiple times per row. A derived table can help keep things clean here:
If we want to show the coefficients next to the solutions (which may not be a bad idea), we can alter the query like this:

```sql
select
  a, b, c,
  iif (D >= 0, (-b - sqrt(D)) / denom, null) sol_1,
  iif (D > 0, (-b + sqrt(D)) / denom, null) sol_2
from
  (select a, b, c, b*b - 4*a*c as D, 2*a as denom
   from coeffs)
```

Notice that whereas the first query used a column aliases list for the derived table, the second adds aliases internally where needed. Both methods work, as long as every column is guaranteed to have a name.

All columns in the derived table will be evaluated as many times as they are specified in the main query. This is important, as it can lead to unexpected results when using non-deterministic functions. The following shows an example of this.

```sql
SELECT
  UUID_TO_CHAR(X) AS C1,
  UUID_TO_CHAR(X) AS C2,
  UUID_TO_CHAR(X) AS C3
FROM (SELECT GEN_UUID() AS X
      FROM RDB$DATABASE) T;
```

The result if this query produces three different values:

```
<table>
<thead>
<tr>
<th>C1</th>
<th>C2</th>
<th>C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>80AAECED-65CD-4C2F-90AB-5D548C3C7279</td>
<td>C1214CD3-423C-406D-B5B0-95BF432ED3E3</td>
<td>EB176C10-F754-4689-8B84-64B666381154</td>
</tr>
</tbody>
</table>
```

To ensure a single result of the GEN_UUID function, you can use the following method:
SELECT
    UUID_TO_CHAR(X) AS C1,
    UUID_TO_CHAR(X) AS C2,
    UUID_TO_CHAR(X) AS C3
FROM (SELECT GEN_UUID() AS X
    FROM RDB$DATABASE
    UNION ALL
    SELECT NULL FROM RDB$DATABASE WHERE 1 = 0) T;

This query produces a single result for all three columns:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>80AAECED-65CD-4C2F-90AB-5D548C3C7279</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>80AAECED-65CD-4C2F-90AB-5D548C3C7279</td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>80AAECED-65CD-4C2F-90AB-5D548C3C7279</td>
<td></td>
</tr>
</tbody>
</table>

An alternative solution is to wrap the GEN_UUID query in a subquery:

SELECT
    UUID_TO_CHAR(X) AS C1,
    UUID_TO_CHAR(X) AS C2,
    UUID_TO_CHAR(X) AS C3
FROM (SELECT
    (SELECT GEN_UUID() FROM RDB$DATABASE) AS X
    FROM RDB$DATABASE) T;

This is an artifact of the current implementation. This behaviour may change in a future Firebird version.

Selecting FROM a Common Table Expression (CTE)

A common table expression — or CTE — is a more complex variant of the derived table, but it is also more powerful. A preamble, starting with the keyword WITH, defines one or more named CTE's, each with an optional column aliases list. The main query, which follows the preamble, can then access these CTE's as if they were regular tables or views. The CTE's go out of scope once the main query has run to completion.

For a full discussion of CTE's, please refer to the section Common Table Expressions ("WITH ... AS ... SELECT").

The following is a rewrite of our derived table example as a CTE:
with vars (b, D, denom) as (
    select b, b*b - 4*a*c, 2*a from coeffs
)
select
    iif (D >= 0, (-b - sqrt(D)) / denom, null) sol_1,
    iif (D > 0, (-b + sqrt(D)) / denom, null) sol_2
from vars

Except for the fact that the calculations that have to be made first are now at the beginning, this isn't a great improvement over the derived table version. However, we can now also eliminate the double calculation of sqrt(D) for every row:

with vars (b, D, denom) as (
    select b, b*b - 4*a*c, 2*a from coeffs
),
vars2 (b, D, denom, sqrtD) as (
    select b, D, denom, iif (D >= 0, sqrt(D), null) from vars
)
select
    iif (D >= 0, (-b - sqrtD) / denom, null) sol_1,
    iif (D > 0, (-b + sqrtD) / denom, null) sol_2
from vars2

The code is a little more complicated now, but it might execute more efficiently (depending on what takes more time: executing the SQRT function or passing the values of b, D and denom through an extra CTE). Incidentally, we could have done the same with derived tables, but that would involve nesting.

All columns in the CTE will be evaluated as many times as they are specified in the main query. This is important, as it can lead to unexpected results when using non-deterministic functions. The following shows an example of this.

WITH T (X) AS (
    SELECT GEN_UUID()
    FROM RDB$DATABASE
) SELECT
    UUID_TO_CHAR(X) as c1,
    UUID_TO_CHAR(X) as c2,
    UUID_TO_CHAR(X) as c3
FROM T

The result if this query produces three different values:
To ensure a single result of the `GEN_UUID` function, you can use the following method:

```sql
WITH T (X) AS (
    SELECT GEN_UUID()
    FROM RDB$DATABASE
    UNION ALL
    SELECT NULL FROM RDB$DATABASE WHERE 1 = 0
)
SELECT
    UUID_TO_CHAR(X) as c1,
    UUID_TO_CHAR(X) as c2,
    UUID_TO_CHAR(X) as c3
FROM T;
```

This query produces a single result for all three columns:

C1  80AAECED-65CD-4C2F-90AB-5D548C3C7279
C2  80AAECED-65CD-4C2F-90AB-5D548C3C7279
C3  80AAECED-65CD-4C2F-90AB-5D548C3C7279

An alternative solution is to wrap the `GEN_UUID` query in a subquery:

```sql
WITH T (X) AS (
    SELECT (SELECT GEN_UUID() FROM RDB$DATABASE)
    FROM RDB$DATABASE
)
SELECT
    UUID_TO_CHAR(X) as c1,
    UUID_TO_CHAR(X) as c2,
    UUID_TO_CHAR(X) as c3
FROM T;
```

This is an artifact of the current implementation. This behaviour may change in a future Firebird version.

*See also*

Common Table Expressions ("WITH ... AS ... SELECT").

### 6.1.4. Joins

Joins combine data from two sources into a single set. This is done on a row-by-row basis and usually involves checking a *join condition* in order to determine which rows should be merged and
appear in the resulting dataset. There are several types (INNER, OUTER) and classes (qualified, natural, etc.) of joins, each with its own syntax and rules.

Since joins can be chained, the datasets involved in a join may themselves be joined sets.

Syntax

```sql
SELECT ...
    FROM <source>
    [ <joins> ]
    [ ... ]

<source> ::= 
    { table
      | view
      | selectable-stored-procedure [(<args>)]
      | <derived-table>
      | LATERAL <derived-table>
      | <common-table-expression>
    } [[AS] alias]

<joins> ::= <join> [<join> ...]

<join> ::= 
    [ <join-type> ] JOIN <source> <join-condition>
    | NATURAL [ <join-type> ] JOIN <source>
    | {CROSS JOIN | ,} <source>

<join-type> ::= INNER | {LEFT | RIGHT | FULL} [OUTER]

<join-condition> ::= ON <condition> | USING (<column-list>)
```

Table 78. Arguments for JOIN Clauses

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>table</td>
<td>Name of a table</td>
</tr>
<tr>
<td>view</td>
<td>name of a view</td>
</tr>
<tr>
<td>selectable-stored-procedure</td>
<td>Name of a selectable stored procedure</td>
</tr>
<tr>
<td>args</td>
<td>Selectable stored procedure input parameter(s)</td>
</tr>
<tr>
<td>derived-table</td>
<td>Reference, by name, to a derived table</td>
</tr>
<tr>
<td>common-table-expression</td>
<td>Reference, by name, to a common table expression (CTE)</td>
</tr>
<tr>
<td>alias</td>
<td>An alias for a data source (table, view, procedure, CTE, derived table)</td>
</tr>
<tr>
<td>condition</td>
<td>Join condition (criterion)</td>
</tr>
<tr>
<td>Argument</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>column-list</td>
<td>The list of columns used for an equi-join</td>
</tr>
</tbody>
</table>

**Inner vs. Outer Joins**

A join always combines data rows from two sets (usually referred to as the left set and the right set). By default, only rows that meet the join condition (i.e. that match at least one row in the other set when the join condition is applied) make it into the result set. This default type of join is called an *inner join*. Suppose we have the following two tables:

*Table A*

<table>
<thead>
<tr>
<th>ID</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>Just some text</td>
</tr>
<tr>
<td>235</td>
<td>Silence</td>
</tr>
</tbody>
</table>

*Table B*

<table>
<thead>
<tr>
<th>CODE</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>-23</td>
<td>56.7735</td>
</tr>
<tr>
<td>87</td>
<td>416.0</td>
</tr>
</tbody>
</table>

If we join these tables like this:

```sql
select *
from A
join B on A.id = B.code;
```

then the result set will be:

<table>
<thead>
<tr>
<th>ID</th>
<th>S</th>
<th>CODE</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>Just some text</td>
<td>87</td>
<td>416.0</td>
</tr>
</tbody>
</table>

The first row of *A* has been joined with the second row of *B* because together they met the condition “*A*.id = *B*.code”. The other rows from the source tables have no match in the opposite set and are therefore not included in the join. Remember, this is an *INNER* join. We can make that fact explicit by writing:

```sql
select *
from A
inner join B on A.id = B.code;
```

However, since *INNER* is the default, it is usually omitted.
It is perfectly possible that a row in the left set matches several rows from the right set or vice versa. In that case, all those combinations are included, and we can get results like:

<table>
<thead>
<tr>
<th>ID</th>
<th>S</th>
<th>CODE</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>Just some text</td>
<td>87</td>
<td>416.0</td>
</tr>
<tr>
<td>87</td>
<td>Just some text</td>
<td>87</td>
<td>-1.0</td>
</tr>
<tr>
<td>-23</td>
<td>Don’t know</td>
<td>-23</td>
<td>56.7735</td>
</tr>
<tr>
<td>-23</td>
<td>Still don’t know</td>
<td>-23</td>
<td>56.7735</td>
</tr>
<tr>
<td>-23</td>
<td>I give up</td>
<td>-23</td>
<td>56.7735</td>
</tr>
</tbody>
</table>

Sometimes we want (or need) all the rows of one or both of the sources to appear in the joined set, regardless of whether they match a record in the other source. This is where outer joins come in. A **LEFT** outer join includes all the records from the left set, but only matching records from the right set. In a **RIGHT** outer join it’s the other way around. **FULL** outer joins include all the records from both sets. In all outer joins, the “holes” (the places where an included source record doesn’t have a match in the other set) are filled up with **NULL**s.

In order to make an outer join, you must specify **LEFT**, **RIGHT** or **FULL**, optionally followed by the keyword **OUTER**.

Below are the results of the various outer joins when applied to our original tables A and B:

```sql
select *
from A
left [outer] join B on A.id = B.code;
```

<table>
<thead>
<tr>
<th>ID</th>
<th>S</th>
<th>CODE</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>Just some text</td>
<td>87</td>
<td>416.0</td>
</tr>
<tr>
<td>235</td>
<td>Silence</td>
<td>&lt;null&gt;</td>
<td>&lt;null&gt;</td>
</tr>
</tbody>
</table>

```sql
select *
from A
right [outer] join B on A.id = B.code
```

<table>
<thead>
<tr>
<th>ID</th>
<th>S</th>
<th>CODE</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;null&gt;</td>
<td>&lt;null&gt;</td>
<td>-23</td>
<td>56.7735</td>
</tr>
<tr>
<td>87</td>
<td>Just some text</td>
<td>87</td>
<td>416.0</td>
</tr>
</tbody>
</table>
Qualified joins

Qualified joins specify conditions for the combining of rows. This happens either explicitly in an ON clause or implicitly in a USING clause.

Syntax

<qualified-join> ::= [<join-type>] JOIN <source> <join-condition>

<join-type> ::= INNER | {LEFT | RIGHT | FULL} [OUTER]

<join-condition> ::= ON <condition> | USING (<column-list>)

Explicit-condition joins

Most qualified joins have an ON clause, with an explicit condition that can be any valid Boolean expression, but usually involves some comparison between the two sources involved.

Quite often, the condition is an equality test (or a number of ANDed equality tests) using the “=” operator. Joins like these are called equi-joins. (The examples in the section on inner and outer joins were all equi-joins.)

Examples of joins with an explicit condition:

/* Select all Detroit customers who made a purchase
   in 2013, along with the purchase details: */
select * from customers c
   join sales s on s.cust_id = c.id
   where c.city = 'Detroit' and s.year = 2013;

/* Same as above, but include non-buying customers: */
select * from customers c
   left join sales s on s.cust_id = c.id
   where c.city = 'Detroit' and s.year = 2013;
/* For each man, select the women who are taller than he. Men for whom no such woman exists are not included. */
select m.fullname as man, f.fullname as woman
from males m
join females f on f.height > m.height;

/* Select all pupils with their class and mentor. Pupils without a mentor are also included. Pupils without a class are not included. */
select p.firstname, p.middlename, p.lastname, c.name, m.name
from pupils p
join classes c on c.id = p.class
left join mentors m on m.id = p.mentor;

Named columns joins

Equi-joins often compare columns that have the same name in both tables. If this is the case, we can also use the second type of qualified join: the named columns join.

Named columns joins are not supported in Dialect 1 databases.

Named columns joins have a USING clause which states just the column names. So instead of this:

```
select * from flotsam f
join jetsam j
on f.sea = j.sea
and f.ship = j.ship;
```

we can also write:

```
select * from flotsam
join jetsam using (sea, ship)
```

which is considerably shorter. The result set is a little different though—at least when using “SELECT *”:

- The explicit-condition join—with the ON clause—will contain each of the columns SEA and SHIP twice: once from table FLOTSAM, and once from table JETSAM. Obviously, they will have the same values.
- The named columns join—with the USING clause—will contain these columns only once.

If you want all the columns in the result set of the named columns join, set up your query like this:
select f.*, j.*
from flotsam f
join jetsam j using (sea, ship);

This will give you the exact same result set as the explicit-condition join.

For an OUTER named columns join, there’s an additional twist when using “SELECT *” or an unqualified column name from the USING list:

If a row from one source set doesn’t have a match in the other but must still be included because of the LEFT, RIGHT or FULL directive, the merged column in the joined set gets the non-NULL value. That is fair enough, but now you can’t tell whether this value came from the left set, the right set, or both. This can be especially deceiving when the value came from the right hand set, because “*” always shows combined columns in the left hand part — even in the case of a RIGHT join.

Whether this is a problem or not depends on the situation. If it is, use the “a.*, b.*” approach shown above, with a and b the names or aliases of the two sources. Or better yet, avoid “*” altogether in your serious queries and qualify all column names in joined sets. This has the additional benefit that it forces you to think about which data you want to retrieve and where from.

It is your responsibility to make sure the column names in the USING list are of compatible types between the two sources. If the types are compatible but not equal, the engine converts them to the type with the broadest range of values before comparing the values. This will also be the data type of the merged column that shows up in the result set if “SELECT *” or the unqualified column name is used. Qualified columns on the other hand will always retain their original data type.

If, when joining by named columns, you are using a join column in the WHERE clause, always use the qualified column name, otherwise an index on this column will not be used.

```
SELECT 1 FROM t1 a JOIN t2 b USING (x) WHERE x = 0;
-- PLAN JOIN (A NATURAL, B INDEX (RDB$2))
```

However:

```
SELECT 1 FROM t1 a JOIN t2 b USING (x) WHERE a.x = 0;
-- PLAN JOIN (A INDEX (RDB$1), B INDEX (RDB$2))

SELECT 1 FROM t1 a JOIN t2 b USING (x) WHERE b.x = 0;
-- PLAN JOIN (A INDEX (RDB$1), B INDEX (RDB$2))
```

The fact is, the unspecified column in this case is implicitly replaced by `COALESCE(a.x, b.x)`. This clever trick is used to disambiguate column names, but it also interferes with the use of the index.
Natural joins

Taking the idea of the named columns join a step further, a natural join performs an automatic equi-join on all the columns that have the same name in the left and right table. The data types of these columns must be compatible.

Natural joins are not supported in Dialect 1 databases.

Syntax

```plaintext
<natural-join> ::= NATURAL [<join-type>] JOIN <source>

<join-type> ::= INNER | {LEFT | RIGHT | FULL} [OUTER]
```

Given these two tables:

```sql
create table TA (
    a bigint,
    s varchar(12),
    ins_date date
);
```

```sql
create table TB (
    a bigint,
    descr varchar(12),
    x float,
    ins_date date
);
```

A natural join on TA and TB would involve the columns `a` and `ins_date`, and the following two statements would have the same effect:

```sql
select * from TA
    natural join TB;
```

```sql
select * from TA
    join TB using (a, ins_date);
```

Like all joins, natural joins are inner joins by default, but you can turn them into outer joins by specifying LEFT, RIGHT or FULL before the JOIN keyword.

If there are no columns with the same name in the two source relations, a CROSS JOIN is performed. We'll get to this type of join in a minute.
Cross joins

A cross join produces the full set product of the two data sources. This means that it successfully
matches every row in the left source to every row in the right source.

Syntax

```
<cross-join> ::= {CROSS JOIN | ,} <source>
```

Please notice that the comma syntax is deprecated! It is only supported to keep legacy code working
and may disappear in some future version.

Cross-joining two sets is equivalent to joining them on a tautology (a condition that is always true).
The following two statements have the same effect:

```
select * from TA
cross join TB;
```

```
select * from TA
join TB on 1 = 1;
```

Cross joins are inner joins, because they only include matching records – it just so happens that
every record matches! An outer cross join, if it existed, wouldn’t add anything to the result, because
what outer joins add are non-matching records, and these don’t exist in cross joins.

Cross joins are seldom useful, except if you want to list all the possible combinations of two or more
variables. Suppose you are selling a product that comes in different sizes, different colors and
different materials. If these variables are each listed in a table of their own, this query would
return all the combinations:

```
select m.name, s.size, c.name
from materials m
cross join sizes s
cross join colors c;
```

Implicit Joins

In the SQL:89 standard, the tables involved in a join were specified as a comma-delimited list in the
FROM clause (in other words, a cross join). The join conditions were then specified in the WHERE clause
among other search terms. This type of join is called an implicit join.

An example of an implicit join:
/*
 * A sample of all Detroit customers who
 * made a purchase.
 */
SELECT *
FROM customers c, sales s
WHERE s.cust_id = c.id AND c.city = 'Detroit'

The implicit join syntax is deprecated and may be removed in a future version. We recommend using the explicit join syntax shown earlier.

Mixing Explicit and Implicit Joins

Mixing explicit and implicit joins is not recommend, but is allowed. However, some types of mixing are not supported by Firebird.

For example, the following query will raise the error “Column does not belong to referenced table”

```
SELECT *
FROM TA, TB
JOIN TC ON TA.COL1 = TC.COL1
WHERE TA.COL2 = TB.COL2
```

That is because the explicit join cannot see the TA table. However, the next query will complete without error, since the restriction is not violated.

```
SELECT *
FROM TA, TB
JOIN TC ON TB.COL1 = TC.COL1
WHERE TA.COL2 = TB.COL2
```

A Note on Equality

This note about equality and inequality operators applies everywhere in Firebird’s SQL language, not just in JOIN conditions.

The “=” operator, which is explicitly used in many conditional joins and implicitly in named column joins and natural joins, only matches values to values. According to the SQL standard, NULL is not a value and hence two NULLs are neither equal nor unequal to one another. If you need NULLs to match each other in a join, use the IS NOT DISTINCT FROM operator. This operator returns true if the operands have the same value or if they are both NULL.

```
select *
from A join B
on A.id is not distinct from B.code;
```
Likewise, in the — extremely rare — cases where you want to join on inequality, use IS DISTINCT FROM, not “<>”, if you want NULL to be considered different from any value and two NULLs considered equal:

```sql
select *
  from A join B
  on A.id is distinct from B.code;
```

**Ambiguous field names in joins**

Firebird rejects unqualified field names in a query if these field names exist in more than one dataset involved in a join. This is even true for inner equi-joins where the field name figures in the ON clause like this:

```sql
select a, b, c
  from TA
  join TB on TA.a = TB.a;
```

There is one exception to this rule: with named columns joins and natural joins, the unqualified field name of a column taking part in the matching process may be used legally and refers to the merged column of the same name. For named columns joins, these are the columns listed in the USING clause. For natural joins, they are the columns that have the same name in both relations. But please notice again that, especially in outer joins, plain colname isn't always the same as left.colname or right.colname. Types may differ, and one of the qualified columns may be NULL while the other isn't. In that case, the value in the merged, unqualified column may mask the fact that one of the source values is absent.

**Joins with stored procedures**

If a join is performed with a stored procedure that is not correlated with other data streams via input parameters, there are no oddities. If correlation is involved, an unpleasant quirk reveals itself. The problem is that the optimizer denies itself any way to determine the interrelationships of the input parameters of the procedure from the fields in the other streams:

```sql
SELECT *
FROM MY_TAB
JOIN MY_PROC(MY_TAB.F) ON 1 = 1;
```

Here, the procedure will be executed before a single record has been retrieved from the table, MY_TAB. The **isc_no_cur_rec** error (**no current record for fetch operation**) is raised, interrupting the execution.

The solution is to use syntax that specifies the join order *explicitly*:
```
SELECT *
FROM MY_TAB
LEFT JOIN MY_PROC(MY_TAB.F) ON 1 = 1;
```

This forces the table to be read before the procedure and everything works correctly.

This quirk has been recognised as a bug in the optimizer and will be fixed in the next version of Firebird.

**Joins with LATERAL Derived Tables**

A derived table defined with the LATERAL keyword is called a lateral derived table. If a derived table is defined as lateral, then it is allowed to refer to other tables in the same FROM clause, but only those declared before it in the FROM clause.

**Lateral Derived Table Examples**

```sql
select dt.population, dt.city_name, c.country_name
from (select distinct country_name from cities) AS c,
     LATERAL (select first 1 city_name, population
             from cities
             where cities.country_name = c.country_name
             order by population desc) AS dt;
```

```sql
--
select salespeople.name,
       max_sale.amount,
       customer_of_max_sale.customer_name
from salespeople,
     LATERAL ( select max(amount) as amount from all_sales
              where all_sales.salesperson_id = salespeople.id
     ) as max_sale,
     LATERAL ( select customer_name from all_sales
              where all_sales.salesperson_id = salespeople.id
                      and all_sales.amount = max_sale.amount
     ) as customer_of_max_sale;
```

### 6.1.5. The WHERE clause

The WHERE clause serves to limit the rows returned to the ones that the caller is interested in. The condition following the keyword WHERE can be as simple as a check like “AMOUNT = 3” or it can be a multilayered, convoluted expression containing subselects, predicates, function calls, mathematical and logical operators, context variables and more.

The condition in the WHERE clause is often called the *search condition*, the *search expression* or simply the *search*.

In DSQL and ESQL, the search expression may contain parameters. This is useful if a query has to be repeated a number of times with different input values. In the SQL string as it is passed to the
server, question marks are used as placeholders for the parameters. They are called *positional	parameters* because they can only be told apart by their position in the string. Connectivity libraries
often support *named parameters* of the form :id, :amount, :a etc. These are more user-friendly; the
library takes care of translating the named parameters to positional parameters before passing the
statement to the server.

The search condition may also contain local (PSQL) or host (ESQL) variable names, preceded by a
colon.

**Syntax**

```
SELECT ...
FROM ...
[...]
WHERE <search-condition>
[...]
```

**Table 79. Argument of WHERE**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>search-condition</td>
<td>A Boolean expression returning TRUE, FALSE or possibly UNKNOWN (NULL)</td>
</tr>
</tbody>
</table>

Only those rows for which the search condition evaluates to TRUE are included in the result set. Be
careful with possible NULL outcomes: if you negate a NULL expression with NOT, the result will still be
NULL and the row will not pass. This is demonstrated in one of the examples below.

**Examples**

```
select genus, species from mammals
   where family = 'Felidae'
   order by genus;
```

```
select * from persons
   where birthyear in (1880, 1881)
       or birthyear between 1891 and 1898;
```

```
select name, street, borough, phone
   from schools s
   where exists (select * from pupils p where p.school = s.id)
   order by borough, street;
```

```
select * from employees
   where salary >= 10000 and position <> 'Manager';
```
The following example shows what can happen if the search condition evaluates to \texttt{NULL}.

Suppose you have a table listing some children's names and the number of marbles they possess. At a certain moment, the table contains these data:

<table>
<thead>
<tr>
<th>CHILD</th>
<th>MARBLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anita</td>
<td>23</td>
</tr>
<tr>
<td>Bob E.</td>
<td>12</td>
</tr>
<tr>
<td>Chris</td>
<td>&lt;null&gt;</td>
</tr>
<tr>
<td>Deirdre</td>
<td>1</td>
</tr>
<tr>
<td>Eve</td>
<td>17</td>
</tr>
<tr>
<td>Fritz</td>
<td>0</td>
</tr>
<tr>
<td>Gerry</td>
<td>21</td>
</tr>
<tr>
<td>Hadassah</td>
<td>&lt;null&gt;</td>
</tr>
<tr>
<td>Isaac</td>
<td>6</td>
</tr>
</tbody>
</table>

First, please notice the difference between \texttt{NULL} and 0: Fritz is \textit{known} to have no marbles at all, Chris's and Hadassah's marble counts are unknown.

Now, if you issue this SQL statement:

\begin{verbatim}
select list(child) from marbletable where marbles > 10;
\end{verbatim}

you will get the names Anita, Bob E., Eve and Gerry. These children all have more than 10 marbles.
If you negate the expression:

```
select list(child) from marbletable where not marbles > 10
```

it's the turn of Deirdre, Fritz and Isaac to fill the list. Chris and Hadassah are not included, because they aren't known to have ten marbles or less. Should you change that last query to:

```
select list(child) from marbletable where marbles <= 10;
```

the result will still be the same, because the expression `NULL <= 10` yields `UNKNOWN`. This is not the same as `TRUE`, so Chris and Hadassah are not listed. If you want them listed with the “poor” children, change the query to:

```
select list(child) from marbletable
where marbles <= 10 or marbles is null;
```

Now the search condition becomes true for Chris and Hadassah, because “marbles is null” obviously returns `TRUE` in their case. In fact, the search condition cannot be `NULL` for anybody now.

Lastly, two examples of `SELECT` queries with parameters in the search. It depends on the application how you should define query parameters and even if it is possible at all. Notice that queries like these cannot be executed immediately: they have to be `prepared` first. Once a parameterized query has been prepared, the user (or calling code) can supply values for the parameters and have it executed many times, entering new values before every call. How the values are entered and the execution started is up to the application. In a GUI environment, the user typically types the parameter values in one or more text boxes and then clicks an “Execute”, “Run” or “Refresh” button.

```
select name, address, phone from stores
where city = ? and class = ?;
```

```
select * from pants
where model = :model and size = :size and color = :col;
```

The last query cannot be passed directly to the engine; the application must convert it to the other format first, mapping named parameters to positional parameters.

### 6.1.6. The `GROUP BY` clause

`GROUP BY` merges output rows that have the same combination of values in its item list into a single row. Aggregate functions in the select list are applied to each group individually instead of to the dataset as a whole.

If the select list only contains aggregate columns or, more generally, columns whose values don’t
depend on individual rows in the underlying set, GROUP BY is optional. When omitted, the final result set of will consist of a single row (provided that at least one aggregated column is present).

If the select list contains both aggregate columns and columns whose values may vary per row, the GROUP BY clause becomes mandatory.

**Syntax**

```sql
SELECT ... FROM ...
    GROUP BY <grouping-item> [, <grouping-item> ...]
    [HAVING <grouped-row-condition>]
...```

Table 80. Arguments for the GROUP BY Clause

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>non-aggr-expression</td>
<td>Any non-aggregating expression that is not included in the SELECT list, i.e. unselected columns from the source set or expressions that do not depend on the data in the set at all</td>
</tr>
<tr>
<td>column-copy</td>
<td>A literal copy, from the SELECT list, of an expression that contains no aggregate function</td>
</tr>
<tr>
<td>column-alias</td>
<td>The alias, from the SELECT list, of an expression (column) that contains no aggregate function</td>
</tr>
<tr>
<td>column-position</td>
<td>The position number, in the SELECT list, of an expression (column) that contains no aggregate function</td>
</tr>
</tbody>
</table>

A general rule of thumb is that every non-aggregate item in the SELECT list must also be in the GROUP BY list. You can do this in three ways:

1. By copying the item verbatim from the select list, e.g. “class” or “'D:' || upper(doccode)”.
2. By specifying the column alias, if it exists.
3. By specifying the column position as an integer literal between 1 and the number of columns. Integer values resulting from expressions or parameter substitutions are simply invariables and will be used as such in the grouping. They will have no effect though, as their value is the same for each row.
If you group by a column position, the expression at that position is copied internally from the select list. If it concerns a subquery, that subquery will be executed again in the grouping phase. That is to say, grouping by the column position, rather than duplicating the subquery expression in the grouping clause, saves keystrokes and bytes, but it is not a way of saving processing cycles!

In addition to the required items, the grouping list may also contain:

- Columns from the source table that are not in the select list, or non-aggregate expressions based on such columns. Adding such columns may further subdivide the groups. However, since these columns are not in the select list, you can't tell which aggregated row corresponds to which value in the column. So, in general, if you are interested in this information, you also include the column or expression in the select list— which brings you back to the rule: “every non-aggregate column in the select list must also be in the grouping list”.

- Expressions that aren't dependent on the data in the underlying set, e.g. constants, context variables, single-value non-correlated subselects etc. This is only mentioned for completeness, as adding such items is utterly pointless: they don't affect the grouping at all. “Harmless but useless” items like these may also figure in the select list without being copied to the grouping list.

**Examples**

When the select list contains only aggregate columns, GROUP BY is not mandatory:

```sql
select count(*), avg(age) from students
  where sex = 'M';
```

This will return a single row listing the number of male students and their average age. Adding expressions that don’t depend on values in individual rows of table STUDENTS doesn’t change that:

```sql
select count(*), avg(age), current_date from students
  where sex = 'M';
```

The row will now have an extra column showing the current date, but other than that, nothing fundamental has changed. A GROUP BY clause is still not required.

However, in both the above examples it is allowed. This is perfectly valid:

```sql
select count(*), avg(age) from students
  where sex = 'M'
  group by class;
```

This will return a row for each class that has boys in it, listing the number of boys and their average age in that particular class. (If you also leave the current_date field in, this value will be repeated on every row, which is not very exciting.)
The above query has a major drawback though: it gives you information about the different classes, but it doesn’t tell you which row applies to which class. In order to get that extra bit of information, the non-aggregate column `CLASS` must be added to the select list:

```sql
select class, count(*), avg(age) from students
  where sex = 'M'
  group by class;
```

Now we have a useful query. Notice that the addition of column `CLASS` also makes the `GROUP BY` clause mandatory. We can’t drop that clause anymore, unless we also remove `CLASS` from the column list.

The output of our last query may look something like this:

<table>
<thead>
<tr>
<th>CLASS</th>
<th>COUNT</th>
<th>AVG</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>12</td>
<td>13.5</td>
</tr>
<tr>
<td>2B</td>
<td>9</td>
<td>13.9</td>
</tr>
<tr>
<td>3A</td>
<td>11</td>
<td>14.6</td>
</tr>
<tr>
<td>3B</td>
<td>12</td>
<td>14.4</td>
</tr>
<tr>
<td>…</td>
<td>…</td>
<td>…</td>
</tr>
</tbody>
</table>

The headings “COUNT” and “AVG” are not very informative. In a simple case like this, you might get away with that, but in general you should give aggregate columns a meaningful name by aliasing them:

```sql
select class, count(*) as num_boys, avg(age) as boys_avg_age
  from students
  where sex = 'M'
  group by class;
```

As you may recall from the formal syntax of the columns list, the `AS` keyword is optional.

Adding more non-aggregate (or rather: row-dependent) columns requires adding them to the `GROUP BY` clause too. For instance, you might want to see the above information for girls as well; and you may also want to differentiate between boarding and day students:
select class, sex, boarding_type, count(*) as number, avg(age) as avg_age
from students
group by class, sex, boarding_type;

This may give you the following result:

<table>
<thead>
<tr>
<th>CLASS</th>
<th>SEX</th>
<th>BOARDING_TYPE</th>
<th>NUMBER</th>
<th>AVG_AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>F</td>
<td>BOARDING</td>
<td>9</td>
<td>13.3</td>
</tr>
<tr>
<td>2A</td>
<td>F</td>
<td>DAY</td>
<td>6</td>
<td>13.5</td>
</tr>
<tr>
<td>2A</td>
<td>M</td>
<td>BOARDING</td>
<td>7</td>
<td>13.6</td>
</tr>
<tr>
<td>2A</td>
<td>M</td>
<td>DAY</td>
<td>5</td>
<td>13.4</td>
</tr>
<tr>
<td>2B</td>
<td>F</td>
<td>BOARDING</td>
<td>11</td>
<td>13.7</td>
</tr>
<tr>
<td>2B</td>
<td>F</td>
<td>DAY</td>
<td>5</td>
<td>13.7</td>
</tr>
<tr>
<td>2B</td>
<td>M</td>
<td>BOARDING</td>
<td>6</td>
<td>13.8</td>
</tr>
</tbody>
</table>

Each row in the result set corresponds to one particular combination of the columns CLASS, SEX and BOARDING_TYPE. The aggregate results—number and average age—are given for each of these rather specific groups individually. In a query like this, you don't see a total for boys as a whole, or day students as a whole. That's the tradeoff: the more non-aggregate columns you add, the more you can pinpoint very specific groups, but the more you also lose sight of the general picture. Of course, you can still obtain the “coarser” aggregates through separate queries.

HAVING

Just as a WHERE clause limits the rows in a dataset to those that meet the search condition, so the HAVING sub-clause imposes restrictions on the aggregated rows in a grouped set. HAVING is optional, and can only be used in conjunction with GROUP BY.

The condition(s) in the HAVING clause can refer to:

- Any aggregated column in the select list. This is the most widely used case.
- Any aggregated expression that is not in the select list, but allowed in the context of the query. This is sometimes useful too.
- Any column in the GROUP BY list. While legal, it is more efficient to filter on these non-aggregated data at an earlier stage: in the WHERE clause.
- Any expression whose value doesn't depend on the contents of the dataset (like a constant or a context variable). This is valid but utterly pointless, because it will either suppress the entire set or leave it untouched, based on conditions that have nothing to do with the set itself.
A HAVING clause can not contain:

- Non-aggregated column expressions that are not in the GROUP BY list.
- Column positions. An integer in the HAVING clause is just an integer.
- Column aliases — not even if they appear in the GROUP BY clause!

**Examples**

Building on our earlier examples, this could be used to skip small groups of students:

```sql
select class,
       count(*) as num_boys,
       avg(age) as boys_avg_age
from students
where sex = 'M'
group by class
having count(*) >= 5;
```

To select only groups that have a minimum age spread:

```sql
select class,
       count(*) as num_boys,
       avg(age) as boys_avg_age
from students
where sex = 'M'
group by class
having max(age) - min(age) > 1.2;
```

Notice that if you’re really interested in this information, you’d normally include \( \text{min}(age) \) and \( \text{max}(age) \) — or the expression “\( \text{max}(age) - \text{min}(age) \)” — in the select list as well!

To include only 3rd classes:

```sql
select class,
       count(*) as num_boys,
       avg(age) as boys_avg_age
from students
where sex = 'M'
group by class
having class starting with '3';
```

Better would be to move this condition to the **WHERE** clause:
select class,  
count(*) as num_boys,  
avg(age) as boys_avg_age  
from students  
where sex = 'M' and class starting with '3'  
group by class;

6.1.7. The WINDOW Clause

The WINDOW clause defines one or more named Windows that can be referenced by window functions in the current query specification.

Syntax

```
<query_spec> ::=  
    SELECT  
        [<limit_clause>]  
        [<distinct_clause>]  
        <select_list>  
        <from_clause>  
        [<where_clause>]  
        [<group_clause>]  
        [<having_clause>]  
        [<named_windows_clause>]  
        [<plan_clause>]

<named_windows_clause> ::=  
    WINDOW <window_definition> [, <window_definition> ...]

>window definition> ::=  
    new_window_name AS <window_specification>

>window_specification> ::=  
    !! See Window (Analytical) Functions !!
```

In a query with multiple SELECT and WINDOW clauses (for example, with subqueries), the scope of the `new_window_name` is confined to its query context. That means a window name from an inner context cannot be used in an outer context, nor vice versa. However, the same window name can be used independently in different contexts, though to avoid confusion it might be better to avoid this.

For more information, see Window (Analytical) Functions.

Example Using Named Windows
select id, department, salary, count(*) over w1, first_value(salary) over w2, last_value(salary) over w2 from employee window w1 as (partition by department), w2 as (w1 order by salary) order by department, salary;

6.1.8. The **PLAN Clause**

The **PLAN** clause enables the user to submit a data retrieval plan, thus overriding the plan that the optimizer would have generated automatically.

**Syntax**

```plaintext
PLAN <plan-expr>

<plan-expr> ::= ( <plan-item> [, <plan-item> ...] )
    | <sorted-item>
    | <joined-item>
    | <merged-item>
    | <hash-item>

<sorted-item> ::= SORT ( <plan-item> )

<joined-item> ::= JOIN ( <plan-item>, <plan-item> [, <plan-item> ...] )

<merged-item> ::= [SORT] MERGE ( <sorted-item>, <sorted-item> [, <sorted-item> ...] )

<hash-item> ::= HASH ( <plan-item>, <plan-item> [, <plan-item> ...] )

<plan-item> ::= <basic-item> | <plan-expr>

<basic-item> ::= <relation> { NATURAL
    | INDEX ( <indexlist> )
    | ORDER index [INDEX ( <indexlist> )] }

<relation> ::= table | view [table]

<indexlist> ::= index [, index ...]
```
Every time a user submits a query to the Firebird engine, the optimizer computes a data retrieval strategy. Most Firebird clients can make this retrieval plan visible to the user. In Firebird’s own isql utility, this is done with the command `SET PLAN ON`. If you are studying query plans rather than running queries, `SET PLANONLY ON` will show the plan without executing the query. Use `SET PLANONLY OFF` to execute the query and show the plan.

A more detailed plan can be obtained when you enable an advanced plan. In `isql` this can be done with `SET EXPLAIN ON`. The advanced plan displays more detailed information about the access methods used by the optimizer, however it cannot be included in the PLAN clause of a statement. The description of the advanced plan is beyond the scope of this Language Reference.

In most situations, you can trust that Firebird will select the optimal query plan for you. However, if you have complicated queries that seem to be underperforming, it may very well be worth your while to examine the plan and see if you can improve on it.

**Simple plans**

The simplest plans consist of just a relation name followed by a retrieval method. For example, for an unsorted single-table select without a WHERE clause:

```sql
select * from students
plan (students natural);
```

Advanced plan:

```
Select Expression
  -> Table "STUDENTS" Full Scan
```

If there’s a WHERE or a HAVING clause, you can specify the index to be used for finding matches:

```sql
select * from students
  where class = '3C'
plan (students index (ix_stud_class));
```

Advanced plan:
The `INDEX` directive is also used for join conditions (to be discussed a little later). It can contain a list of indexes, separated by commas.

ORDER specifies the index for sorting the set if an ORDER BY or GROUP BY clause is present:

```sql
select * from students
    plan (students order pk_students)
    order by id;
```

Advanced plan:

```sql
Select Expression
    -> Table "STUDENTS" Access By ID
    -> Index "PK_STUDENTS" Full Scan
ORDER and INDEX can be combined:

```sql
select * from students
    where class >= '3'
    plan (students order pk_students index (ix_stud_class))
    order by id;
```

Advanced plan:

```sql
Select Expression
    -> Filter
    -> Table "STUDENTS" Access By ID
    -> Index "PK_STUDENTS" Full Scan
    -> Bitmap
    -> Index "IX_STUD_CLASS" Range Scan (full match)

It is perfectly OK if ORDER and INDEX specify the same index:

```sql
select * from students
    where class >= '3'
    plan (students order ix_stud_class index (ix_stud_class))
    order by class;
```
Advanced plan:

Select Expression
  -> Filter
  -> Table "STUDENTS" Access By ID
  -> Index "IX_STUD_CLASS" Range Scan (lower bound: 1/1)
  -> Bitmap
  -> Index "IX_STUD_CLASS" Range Scan (lower bound: 1/1)

For sorting sets when there's no usable index available (or if you want to suppress its use), leave out ORDER and prepend the plan expression with SORT:

```sql
select * from students
  plan sort (students natural)
  order by name;
```

Advanced plan:

Select Expression
  -> Sort (record length: 128, key length: 56)
  -> Table "STUDENTS" Full Scan

Or when an index is used for the search:

```sql
select * from students
  where class >= '3'
  plan sort (students index (ix_stud_class))
  order by name;
```

Advanced plan:

```sql
elect Expression
  -> Sort (record length: 136, key length: 56)
  -> Filter
  -> Table "STUDENTS" Access By ID
  -> Bitmap
  -> Index "IX_STUD_CLASS" Range Scan (lower bound: 1/1)
```

Notice that SORT, unlike ORDER, is outside the parentheses. This reflects the fact that the data rows are retrieved unordered and sorted afterwards by the engine.

When selecting from a view, specify the view and the table involved. For instance, if you have a view FRESHMEN that selects just the first-year students:
select * from freshmen
plan (freshmen students natural);

Advanced plan:

Select Expression
-> Table "STUDENTS" as "FRESHMEN" Full Scan

Or, for instance:

select * from freshmen
where id > 10
plan sort (freshmen students index (pk_students))
order by name desc;

Advanced plan:

Select Expression
-> Sort (record length: 144, key length: 24)
  -> Filter
    -> Table "STUDENTS" as "FRESHMEN" Access By ID
      -> Bitmap
        -> Index "PK_STUDENTS" Range Scan (lower bound: 1/1)

⚠️ If a table or view has been aliased, it is the alias, not the original name, that must be used in the PLAN clause.

**Composite plans**

When a join is made, you can specify the index which is to be used for matching. You must also use the JOIN directive on the two streams in the plan:

```sql
select s.id, s.name, s.class, c.mentor
from students s
join classes c on c.name = s.class
plan join (s natural, c index (pk_classes));
```

Advanced plan:
Select Expression
-> Nested Loop Join (inner)
  -> Table "STUDENTS" as "S" Full Scan
  -> Filter
    -> Table "CLASSES" as "C" Access By ID
    -> Bitmap
      -> Index "PK_CLASSES" Unique Scan

The same join, sorted on an indexed column:

```sql
select s.id, s.name, s.class, c.mentor
from students s
  join classes c on c.name = s.class
plan join (s order pk_students, c index (pk_classes))
order by s.id;
```

Advanced plan:

Select Expression
-> Nested Loop Join (inner)
  -> Table "STUDENTS" as "S" Access By ID
  -> Index "PK_STUDENTS" Full Scan
  -> Filter
    -> Table "CLASSES" as "C" Access By ID
    -> Bitmap
      -> Index "PK_CLASSES" Unique Scan

And on a non-indexed column:

```sql
select s.id, s.name, s.class, c.mentor
from students s
  join classes c on c.name = s.class
plan sort (join (s natural, c index (pk_classes)))
order by s.name;
```

Advanced plan:

Select Expression
-> Sort (record length: 152, key length: 12)
-> Nested Loop Join (inner)
  -> Table "STUDENTS" as "S" Full Scan
  -> Filter
    -> Table "CLASSES" as "C" Access By ID
    -> Bitmap
      -> Index "PK_CLASSES" Unique Scan
With a search condition added:

```sql
select s.id, s.name, s.class, c.mentor
from students s
join classes c on c.name = s.class
where s.class <= '2'
plan sort (join (s index (fk_student_class), c index (pk_classes)))
order by s.name;
```

Advanced plan:

```
Select Expression
  -> Sort (record length: 152, key length: 12)
  -> Nested Loop Join (inner)
  -> Filter
  -> Table "STUDENTS" as "S" Access By ID
    -> Bitmap
      -> Index "FK_STUDENT_CLASS" Range Scan (lower bound: 1/1)
  -> Filter
  -> Table "CLASSES" as "C" Access By ID
    -> Bitmap
      -> Index "PK_CLASSES" Unique Scan
```

As a left outer join:

```sql
select s.id, s.name, s.class, c.mentor
from classes c
left join students s on c.name = s.class
where s.class <= '2'
plan sort (join (c natural, s index (fk_student_class)))
order by s.name;
```

Advanced plan:

```
Select Expression
  -> Sort (record length: 192, key length: 56)
  -> Filter
  -> Nested Loop Join (outer)
  -> Table "CLASSES" as "C" Full Scan
  -> Filter
  -> Table "STUDENTS" as "S" Access By ID
    -> Bitmap
      -> Index "FK_STUDENT_CLASS" Range Scan (full match)
```

If there are no indices available to match the join condition (or if you don’t want to use it), then it is possible connect the streams using HASH or MERGE method.
To connect using the HASH method in the plan, the HASH directive is used instead of the JOIN directive. In this case, the smaller (secondary) stream is materialized completely into an internal buffer. While reading this secondary stream, a hash function is applied and a pair \{hash, pointer to buffer\} is written to a hash table. Then the primary stream is read and its hash key is tested against the hash table.

```sql
select *
from students s
join classes c on c.cookie = s.cookie
plan hash (c natural, s natural)
```

**Advanced plan:**

```
Select Expression
  -> Filter
  -> Hash Join (inner)
    -> Table "STUDENTS" as "S" Full Scan
    -> Record Buffer (record length: 145)
    -> Table "CLASSES" as "C" Full Scan
```

For a **MERGE** join, the plan must first sort both streams on their join column(s) and then merge. This is achieved with the SORT directive (which we've already seen) and **MERGE** instead of **JOIN**:

```sql
select * from students s
join classes c on c.cookie = s.cookie
plan merge (sort (c natural), sort (s natural));
```

Adding an **ORDER BY** clause means the result of the merge must also be sorted:

```sql
select * from students s
join classes c on c.cookie = s.cookie
plan sort (merge (sort (c natural), sort (s natural)))
order by c.name, s.id;
```

Finally, we add a search condition on two indexable columns of table **STUDENTS**:

```sql
select * from students s
join classes c on c.cookie = s.cookie
where s.id < 10 and s.class <= '2'
plan sort (merge (sort (c natural),
    sort (s index (pk_students, fk_student_class))))
order by c.name, s.id;
```

As follows from the formal syntax definition, **JOINs** and **MERGEs** in the plan may combine more than two streams. Also, every plan expression may be used as a plan item in an encompassing plan. This
means that plans of certain complicated queries may have various nesting levels.

Finally, instead of `MERGE` you may also write `SORT MERGE`. As this makes absolutely no difference and may create confusion with “real” `SORT` directives (the ones that do make a difference), it’s probably best to stick to plain `MERGE`.

In addition to the plan for the main query, you can specify a plan for each subquery. For example, the following query with multiple plans will work:

```sql
select *
from color
where exists (
    select *
    from hors
    where horse.code_color = color.code_color
    plan (horse index (fk_horse_color)))
plan (color natural)
```

Occasionally, the optimizer will accept a plan and then not follow it, even though it does not reject it as invalid. One such example was

```sql
MERGE (unsorted stream, unsorted stream)
```

It is advisable to treat such as plan as “deprecated”.

### 6.1.9. UNION

The `UNION` clause concatenates two or more datasets, thus increasing the number of rows but not the number of columns. Datasets taking part in a `UNION` must have the same number of columns, and columns at corresponding positions must be of the same type. Other than that, they may be totally unrelated.

By default, a union suppresses duplicate rows. `UNION ALL` shows all rows, including any duplicates. The optional `DISTINCT` keyword makes the default behaviour explicit.
Unions take their column names from the first select query. If you want to alias union columns, do so in the column list of the topmost SELECT. Aliases in other participating selects are allowed and may even be useful, but will not propagate to the union level.

If a union has an ORDER BY clause, the only allowed sort items are integer literals indicating 1-based column positions, optionally followed by an ASC/DESC and/or a NULLS {FIRST | LAST} directive. This also implies that you cannot order a union by anything that isn’t a column in the union. (You can, however, wrap it in a derived table, which gives you back all the usual sort options.)

Unions are allowed in subqueries of any kind and can themselves contain subqueries. They can also contain joins, and can take part in a join when wrapped in a derived table.

Examples
This query presents information from different music collections in one dataset using unions:

```sql
select id, title, artist, length, 'CD' as medium
  from cds
union
select id, title, artist, length, 'LP'
  from records
union
select id, title, artist, length, 'MC'
  from cassettes
order by 3, 2 -- artist, title;
```

If id, title, artist and length are the only fields in the tables involved, the query can also be written as:

```sql
select c.*, 'CD' as medium
  from cds c
union
select r.*, 'LP'
  from records r
union
select c.*, 'MC'
  from cassettes c
order by 3, 2 -- artist, title;
```

Qualifying the “stars” is necessary here because they are not the only item in the column list. Notice how the “c” aliases in the first and third select do not conflict with each other: their scopes are not union-wide but apply only to their respective select queries.

The next query retrieves names and phone numbers from translators and proofreaders. Translators who also work as proofreaders will show up only once in the result set, provided their phone number is the same in both tables. The same result can be obtained without DISTINCT. With ALL, these people would appear twice.

```sql
select name, phone from translators
  union distinct
select name, telephone from proofreaders;
```

A UNION within a subquery:

```sql
select name, phone, hourly_rate from clowns
  where hourly_rate < all
    (select hourly_rate from jugglers
      union
    select hourly_rate from acrobats)
  order by hourly_rate;
```
6.1.10. ORDER BY

When a SELECT statement is executed, the result set is not sorted in any way. It often happens that rows appear to be sorted chronologically, simply because they are returned in the same order they were added to the table by INSERT statements. This is not something you should rely on: the order may change depending on the plan or updates to rows, etc. To specify an explicit sorting order for the set specification, an ORDER BY clause is used.

Syntax

```
SELECT ... FROM ...
...
ORDER BY <ordering-item> [, <ordering-item> ...]
```

```
<ordering-item> ::= 
{col-name | col-alias | col-position | <expression>}
[COLLABE collation-name]
[ASC[ENDING] | DESC[ENDING]]
[NULLS {FIRST|LAST}]
```

Table 82. Arguments for the ORDER BY Clause

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>col-name</td>
<td>Full column name</td>
</tr>
<tr>
<td>col-alias</td>
<td>Column alias</td>
</tr>
<tr>
<td>col-position</td>
<td>Column position in the SELECT list</td>
</tr>
<tr>
<td>expression</td>
<td>Any expression</td>
</tr>
<tr>
<td>collation-name</td>
<td>Collation name (sorting order for string types)</td>
</tr>
</tbody>
</table>

The ORDER BY consists of a comma-separated list of the columns on which the result data set should be sorted. The sort order can be specified by the name of the column — but only if the column was not previously aliased in the SELECT columns list. The alias must be used if it was used in the select list. The ordinal position number of the column in the SELECT column list, the alias given to the column in the SELECT list with the help of the AS keyword, or the number of the column in the SELECT list can be used without restriction.

The three forms of expressing the columns for the sort order can be mixed in the same ORDER BY clause. For instance, one column in the list can be specified by its name and another column can be specified by its number.

If you sort by column position or alias, then the expression corresponding to this position (alias) will be copied from the SELECT list. This also applies to subqueries, thus, the subquery will be executed at least twice.
If you use the column position to specify the sort order for a query of the SELECT * style, the server expands the asterisk to the full column list in order to determine the columns for the sort. It is, however, considered “sloppy practice” to design ordered sets this way.

**Sorting Direction**

The keyword **ASCENDING**—usually abbreviated to **ASC**—specifies a sort direction from lowest to highest. **ASCENDING** is the default sort direction.

The keyword **DESCENDING**—usually abbreviated to **DESC**—specifies a sort direction from highest to lowest.

Specifying ascending order for one column and descending order for another is allowed.

**Collation Order**

The keyword **COLLATE** specifies the collation order for a string column if you need a collation that is different from the normal one for this column. The normal collation order will be either the default one for the database character set, or the one set explicitly in the column’s definition.

**NULLs Position**

The keyword **NULLS** defines where NULL in the associated column will fall in the sort order: **NULLS FIRST** places the rows with the NULL column **above** rows ordered by that column’s value; **NULLS LAST** places those rows **after** the ordered rows.

**NULLS FIRST** is the default.

**Ordering UNION-ed Sets**

The discrete queries contributing to a **UNION** cannot take an **ORDER BY** clause. The only option is to order the entire output, using one **ORDER BY** clause at the end of the overall query.

The simplest — and, in some cases, the only — method for specifying the sort order is by the ordinal column position. However, it is also valid to use the column names or aliases, from the first contributing query *only*.

The **ASC/DESC** and/or **NULLS** directives are available for this global set.

If discrete ordering within the contributing set is required, use of derived tables or common table expressions for those sets may be a solution.

**Examples of ORDER BY**

Sorting the result set in ascending order, ordering by the **RDB$CHARACTER_SET_ID** and **RDB$COLLATION_ID** columns of the **RDB$COLLATIONS** table:
SELECT
  RDB$CHARACTER_SET_ID AS CHARSET_ID,
  RDB$COLLATION_ID AS COLL_ID,
  RDB$COLLATION_NAME AS NAME
FROM RDB$COLLATIONS
ORDER BY RDB$CHARACTER_SET_ID, RDB$COLLATION_ID;

The same, but sorting by the column aliases:

SELECT
  RDB$CHARACTER_SET_ID AS CHARSET_ID,
  RDB$COLLATION_ID AS COLL_ID,
  RDB$COLLATION_NAME AS NAME
FROM RDB$COLLATIONS
ORDER BY CHARSET_ID, COLL_ID;

Sorting the output data by the column position numbers:

SELECT
  RDB$CHARACTER_SET_ID AS CHARSET_ID,
  RDB$COLLATION_ID AS COLL_ID,
  RDB$COLLATION_NAME AS NAME
FROM RDB$COLLATIONS
ORDER BY 1, 2;

Sorting a SELECT * query by position numbers—possible, but nasty and not recommended:

SELECT *
FROM RDB$COLLATIONS
ORDER BY 3, 2;

Sorting by the second column in the BOOKS table, or—if BOOKS has only one column—the FILMS.DIRECTOR column:

SELECT
  BOOKS.*,
  FILMS.DIRECTOR
FROM BOOKS, FILMS
ORDER BY 2;

Sorting in descending order by the values of column PROCESS_TIME, with NULLs placed at the beginning of the set:
SELECT *
FROM MSG
ORDER BY PROCESS_TIME DESC NULLS FIRST;

Sorting the set obtained by a UNION of two queries. Results are sorted in descending order for the values in the second column, with NULLs at the end of the set; and in ascending order for the values of the first column with NULLs at the beginning.

SELECT
  DOC_NUMBER, DOC_DATE
FROM PAYORDER
UNION ALL
SELECT
  DOC_NUMBER, DOC_DATE
FROM BUDGORDER
ORDER BY 2 DESC NULLS LAST, 1 ASC NULLS FIRST;

6.1.11. ROWS

Used for
Retrieving a slice of rows from an ordered set

Available in
DSQL, PSQL

Syntax

SELECT <columns> FROM ...
[WHERE ...]
[ORDER BY ...]
ROWS m [TO n]

Table 83. Arguments for the ROWS Clause

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>m, n</td>
<td>Any integer expressions</td>
</tr>
</tbody>
</table>

ROWS is non-standard syntax

ROWS is a Firebird-specific clause. Use the SQL-standard OFFSET, FETCH syntax wherever possible.

Limits the amount of rows returned by the SELECT statement to a specified number or range.

The ROWS clause also does the same job as the FIRST and SKIP clauses, but neither are SQL-compliant. Unlike FIRST and SKIP, and OFFSET and FETCH, the ROWS and TO clauses accept any type of integer expression as their arguments, without parentheses. Of course, parentheses may still be needed for
nested evaluations inside the expression, and a subquery must always be enclosed in parentheses.

- Numbering of rows in the intermediate set—the overall set cached on disk before the “slice” is extracted—starts at 1.

- OFFSET/FETCH, FIRST/SKIP, and ROWS can all be used without the ORDER BY clause, although it rarely makes sense to do so—except perhaps when you want to take a quick look at the table data and don’t care that rows will be in a non-deterministic order. For this purpose, a query like “SELECT * FROM TABLE1 ROWS 20” would return the first 20 rows instead of a whole table that might be rather big.

Calling \texttt{ROWS} \texttt{m} retrieves the first \texttt{m} records from the set specified.

**Characteristics of using \texttt{ROWS} \texttt{m} without a \texttt{TO} clause:**

- If \texttt{m} is greater than the total number of records in the intermediate data set, the entire set is returned
- If \texttt{m} = 0, an empty set is returned
- If \texttt{m} < 0, the \texttt{SELECT} statement call fails with an error

Calling \texttt{ROWS} \texttt{m TO n} retrieves the rows from the set, starting at row \texttt{m} and ending after row \texttt{n}—the set is inclusive.

**Characteristics of using \texttt{ROWS} \texttt{m} with a \texttt{TO} clause:**

- If \texttt{m} is greater than the total number of rows in the intermediate set and \texttt{n} \texttt{\geq} \texttt{m}, an empty set is returned
- If \texttt{m} is not greater than \texttt{n} and \texttt{n} is greater than the total number of rows in the intermediate set, the result set will be limited to rows starting from \texttt{m}, up to the end of the set
- If \texttt{m} < 1 and \texttt{n} < 1, the \texttt{SELECT} statement call fails with an error
- If \texttt{n} = \texttt{m} - 1, an empty set is returned
- If \texttt{n} < \texttt{m} - 1, the \texttt{SELECT} statement call fails with an error

**Using a \texttt{TO} clause without a \texttt{ROWS} clause:**

While \texttt{ROWS} replaces the \texttt{FIRST} and \texttt{SKIP} syntax, there is one situation where the \texttt{ROWS} syntax does not provide the same behaviour: specifying \texttt{SKIP \texttt{n}} on its own returns the entire intermediate set, without the first \texttt{n} rows. The \texttt{ROWS \ldots \texttt{TO}} syntax needs a little help to achieve this.

With the \texttt{ROWS} syntax, you need a \texttt{ROWS} clause \textit{in association with} the \texttt{TO} clause and deliberately make the second (\texttt{n}) argument greater than the size of the intermediate data set. This is achieved by creating an expression for \texttt{n} that uses a subquery to retrieve the count of rows in the intermediate set and adds 1 to it.
Replacing of **FIRST/Skip and OFFSET/FETCH**

The **ROWS** clause can be used instead of the SQL-standard **OFFSET/FETCH** or non-standard **FIRST/Skip** clauses, except the case where only **OFFSET** or **SKIP** is used, that is when the whole result set is returned except for skipping the specified number of rows from the beginning.

In order to implement this behaviour using **ROWS**, you must specify the **TO** clause with a value larger than the size of the returned result set.

**Mixing **ROWS** and **FIRST/Skip or OFFSET/FETCH**

**ROWS** syntax cannot be mixed with **FIRST/Skip** or **OFFSET/FETCH** in the same **SELECT** expression. Using the different syntaxes in different subqueries in the same statement is allowed.

**ROWS Syntax in UNION Queries**

When **ROWS** is used in a **UNION** query, the **ROWS** directive is applied to the unioned set and must be placed after the last **SELECT** statement.

If a need arises to limit the subsets returned by one or more **SELECT** statements inside **UNION**, there are a couple of options:

1. Use **FIRST/Skip** syntax in these **SELECT** statements — bearing in mind that an ordering clause (**ORDER BY**) cannot be applied locally to the discrete queries, but only to the combined output.
2. Convert the queries to derived tables with their own **ROWS** clauses.

**Examples of **ROWS**

The following examples rewrite the **examples** used in the section about **FIRST** and **SKIP**, **earlier in this chapter**.

Retrieve the first ten names from the output of a sorted query on the **PEOPLE** table:

```sql
SELECT id, name
FROM People
ORDER BY name ASC
ROWS 1 TO 10;
```

or its equivalent

```sql
SELECT id, name
FROM People
ORDER BY name ASC
ROWS 10;
```

Return all records from the **PEOPLE** table except for the first 10 names:
SELECT id, name
FROM People
ORDER BY name ASC
ROWS 11 TO (SELECT COUNT(*) FROM People);

And this query will return the last 10 records (pay attention to the parentheses):

SELECT id, name
FROM People
ORDER BY name ASC
ROWS (SELECT COUNT(*) - 9 FROM People)
TO (SELECT COUNT(*) FROM People);

This one will return rows 81-100 from the PEOPLE table:

SELECT id, name
FROM People
ORDER BY name ASC
ROWS 81 TO 100;

ROWS can also be used with the UPDATE and DELETE statements.

See also
FIRST, SKIP, OFFSET, FETCH

6.1.12. OFFSET, FETCH

Used for
Retrieving a slice of rows from an ordered set

Available in
DSQL, PSQL

Syntax

SELECT <columns> FROM ...
[WHERE ...]
[ORDER BY ...]
[OFFSET <m> {ROW | ROWS}]
[FETCH {FIRST | NEXT} [ <n> ] { ROW | ROWS } ONLY]

<m>, <n> ::=  
<integer.literal>  
| <query-parameter>
Table 84. Arguments for the OFFSET and FETCH Clause

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>integer-literal</td>
<td>Integer literal</td>
</tr>
<tr>
<td>query-parameter</td>
<td>Query parameter place-holder. ? in DSQL and :paramname in PSQL</td>
</tr>
</tbody>
</table>

The OFFSET and FETCH clauses are an SQL:2008 compliant equivalent for FIRST/Skip, and an alternative for ROWS. The OFFSET clause specifies the number of rows to skip. The FETCH clause specifies the number of rows to fetch.

When <n> is left out of the FETCH clause (eg FETCH FIRST ROW ONLY), one row will be fetched.

The choice between ROW or ROWS, or FIRST or NEXT in the clauses is just for aesthetic purposes (eg making the query more readable or grammatically correct). Technically there is no difference between OFFSET 10 ROW or OFFSET 10 ROWS, or FETCH NEXT 10 ROWS ONLY or FETCH FIRST 10 ROWS ONLY.

As with SKIP and FIRST, OFFSET and FETCH clauses can be applied independently, in both top-level and nested query expressions.

1. Firebird doesn't support the percentage FETCH defined in the SQL standard.
2. Firebird doesn't support the FETCH … WITH TIES defined in the SQL standard.
3. The FIRST/Skip and ROWS clause are non-standard alternatives.
4. The OFFSET and/or FETCH clauses cannot be combined with ROWS or FIRST/Skip on the same query expression.
5. Expressions, column references, etc are not allowed within either clause.
6. Contrary to the ROWS clause, OFFSET and FETCH are only available on SELECT statements.

Examples of OFFSET and FETCH

Return all rows except the first 10, ordered by column COL1

```
SELECT *
FROM T1
ORDER BY COL1
OFFSET 10 ROWS
```

Return the first 10 rows, ordered by column COL1

```
SELECT *
FROM T1
ORDER BY COL1
FETCH FIRST 10 ROWS ONLY
```
Using OFFSET and FETCH clauses in a derived table and in the outer query

```sql
SELECT * 
FROM ( 
SELECT * 
FROM T1 
ORDER BY COL1 DESC 
OFFSET 1 ROW 
FETCH NEXT 10 ROWS ONLY 
) a 
ORDER BY a.COL1 
FETCH FIRST ROW ONLY
```

The following examples rewrite the FIRST/SKIP examples and ROWS examples earlier in this chapter.

Retrieve the first ten names from the output of a sorted query on the PEOPLE table:

```sql
SELECT id, name 
FROM People 
ORDER BY name ASC 
FETCH NEXT 10 ROWS ONLY;
```

Return all records from the PEOPLE table except for the first 10 names:

```sql
SELECT id, name 
FROM People 
ORDER BY name ASC 
OFFSET 10 ROWS;
```

And this query will return the last 10 records. Contrary to FIRST/SKIP and ROWS we cannot use expressions (including sub-queries). To retrieve the last 10 rows, reverse the sort to the first (last) 10 rows, and then sort in the right order.

```sql
SELECT id, name 
FROM ( 
SELECT id, name 
FROM People 
ORDER BY name DESC 
FETCH FIRST 10 ROWS ONLY 
) a 
ORDER BY name ASC;
```

This one will return rows 81-100 from the PEOPLE table:
See also
FIRST, SKIP, ROWS

6.1.13. FOR UPDATE [OF]

Syntax

```
SELECT ... FROM single_table
[WHERE ...]
[FOR UPDATE [OF <column_list>]]
```

FOR UPDATE does not do what its name suggests. It’s only effect currently is to disable the pre-fetch buffer.

It is likely to change in future: the plan is to validate cursors marked with FOR UPDATE if they are truly updateable and reject positioned updates and deletes for cursors evaluated as non-updateable.

The OF sub-clause does not do anything at all.

6.1.14. WITH LOCK

Used for
Limited pessimistic locking

Available in
DSQL, PSQL

Syntax

```
SELECT ... FROM single_table
[WHERE ...]
[FOR UPDATE [OF <column_list>]]
WITH LOCK
```

WITH LOCK provides a limited explicit pessimistic locking capability for cautious use in conditions where the affected row set is:

a. extremely small (ideally singleton), and
b. precisely controlled by the application code.
This is for experts only!

The need for a pessimistic lock in Firebird is very rare indeed and should be well understood before use of this extension is considered.

It is essential to understand the effects of transaction isolation and other transaction attributes before attempting to implement explicit locking in your application.

If the `WITH LOCK` clause succeeds, it will secure a lock on the selected rows and prevent any other transaction from obtaining write access to any of those rows, or their dependants, until your transaction ends.

`WITH LOCK` can only be used with a top-level, single-table `SELECT` statement. It is *not* available:

- in a subquery specification
- for joined sets
- with the `DISTINCT` operator, a `GROUP BY` clause or any other aggregating operation
- with a view
- with the output of a selectable stored procedure
- with an external table
- with a `UNION` query

As the engine considers, in turn, each record falling under an explicit lock statement, it returns either the record version that is the most currently committed, regardless of database state when the statement was submitted, or an exception.

Wait behaviour and conflict reporting depend on the transaction parameters specified in the TPB block:

Table 85. How TPB settings affect explicit locking

<table>
<thead>
<tr>
<th>TPB mode</th>
<th>Behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>isc_tpb_consistency</code></td>
<td>Explicit locks are overridden by implicit or explicit table-level locks and are ignored.</td>
</tr>
<tr>
<td><code>isc_tpb_concurrency</code> + <code>isc_tpb_nowait</code></td>
<td>If a record is modified by any transaction that was committed since the transaction attempting to get explicit lock started, or an active transaction has performed a modification of this record, an update conflict exception is raised immediately.</td>
</tr>
<tr>
<td>TPB mode</td>
<td>Behaviour</td>
</tr>
<tr>
<td>------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>isc_tpb_concurrency +</td>
<td>If the record is modified by any transaction that has committed since the transaction attempting to get explicit lock started, an update conflict exception is raised immediately.</td>
</tr>
<tr>
<td>isc_tpb_wait</td>
<td>If an active transaction is holding ownership on this record (via explicit locking or by a normal optimistic write-lock) the transaction attempting the explicit lock waits for the outcome of the blocking transaction and, when it finishes, attempts to get the lock on the record again. This means that, if the blocking transaction committed a modified version of this record, an update conflict exception will be raised.</td>
</tr>
<tr>
<td>isc_tpb_read_committed +</td>
<td>If there is an active transaction holding ownership on this record (via explicit locking or normal update), an update conflict exception is raised immediately.</td>
</tr>
<tr>
<td>isc_tpb_nowait</td>
<td></td>
</tr>
<tr>
<td>isc_tpb_read_committed +</td>
<td>If there is an active transaction holding ownership on this record (via explicit locking or by a normal optimistic write-lock), the transaction attempting the explicit lock waits for the outcome of blocking transaction and, when it finishes, attempts to get the lock on the record again.</td>
</tr>
<tr>
<td>isc_tpb_wait</td>
<td>Update conflict exceptions can never be raised by an explicit lock statement in this TPB mode.</td>
</tr>
</tbody>
</table>

**Usage with a **FOR UPDATE** Clause**

If the **FOR UPDATE** sub-clause precedes the **WITH LOCK** sub-clause, buffered fetches are suppressed. Thus, the lock will be applied to each row, one by one, at the moment it is fetched. It becomes possible, then, that a lock which appeared to succeed when requested will nevertheless fail subsequently, when an attempt is made to fetch a row which has become locked by another transaction in the meantime.

As an alternative, it may be possible in your access components to set the size of the fetch buffer to 1. This would enable you to process the currently-locked row before the next is fetched and locked, or to handle errors without rolling back your transaction.

OF <column_list>

This optional sub-clause does nothing at all.

*See also*

**FOR UPDATE [OF]**

**How the engine deals with **WITH LOCK**

When an **UPDATE** statement tries to access a record that is locked by another transaction, it either raises an update conflict exception or waits for the locking transaction to finish, depending on TPB mode. Engine behaviour here is the same as if this record had already been modified by the locking
No special gdscodes are returned from conflicts involving pessimistic locks.

The engine guarantees that all records returned by an explicit lock statement are actually locked and do meet the search conditions specified in WHERE clause, as long as the search conditions do not depend on any other tables, via joins, subqueries, etc. It also guarantees that rows not meeting the search conditions will not be locked by the statement. It can not guarantee that there are no rows which, though meeting the search conditions, are not locked.

This situation can arise if other, parallel transactions commit their changes during the course of the locking statement’s execution.

The engine locks rows at fetch time. This has important consequences if you lock several rows at once. Many access methods for Firebird databases default to fetching output in packets of a few hundred rows (“buffered fetches”). Most data access components cannot bring you the rows contained in the last-fetched packet, when an error occurred.

**Caveats using WITH LOCK**

- Rolling back of an implicit or explicit savepoint releases record locks that were taken under that savepoint, but it doesn’t notify waiting transactions. Applications should not depend on this behaviour as it may get changed in the future.

- While explicit locks can be used to prevent and/or handle unusual update conflict errors, the volume of deadlock errors will grow unless you design your locking strategy carefully and control it rigorously.

- Most applications do not need explicit locks at all. The main purposes of explicit locks are:
  1. to prevent expensive handling of update conflict errors in heavily loaded applications, and
  2. to maintain integrity of objects mapped to a relational database in a clustered environment.

If your use of explicit locking doesn’t fall in one of these two categories, then it’s the wrong way to do the task in Firebird.

- Explicit locking is an advanced feature; do not misuse it! While solutions for these kinds of problems may be very important for web sites handling thousands of concurrent writers, or for ERP/CRM systems operating in large corporations, most application programs do not need to work in such conditions.

**Examples using explicit locking**

i. Simple:

```
SELECT * FROM DOCUMENT WHERE ID=? WITH LOCK;
```

ii. Multiple rows, one-by-one processing with DSQL cursor:
6.1.15. INTO

Used for
Passing SELECT output into variables

Available in
PSQL

Syntax
In PSQL the INTO clause is placed at the very end of the SELECT statement.

```
SELECT [...] <column-list>
FROM ...
[...] [INTO <variable-list>]

<variable-list> ::= [:]psqlvar [, [:]psqlvar ...]
```

The colon prefix before local variable names in PSQL is optional in the INTO clause.

In PSQL code (triggers, stored procedures and executable blocks), the results of a SELECT statement can be loaded row-by-row into local variables. It is often the only way to do anything with the returned values at all, unless an explicit or implicit cursor name is specified. The number, order and types of the variables must match the columns in the output row.

A “plain” SELECT statement can only be used in PSQL if it returns at most one row, i.e., if it is a singleton select. For multi-row selects, PSQL provides the FOR SELECT loop construct, discussed later in the PSQL chapter. PSQL also supports the DECLARE CURSOR statement, which binds a named cursor to a SELECT statement. The cursor can then be used to walk the result set.

Examples

1. Selecting some aggregated values and passing them into previously declared variables min_amt, avg_amt and max_amt:

```
select min(amount), avg(cast(amount as float)), max(amount)
from orders
where artno = 372218
into min_amt, avg_amt, max_amt;
```
The \textit{CAST} serves to make the average a real number; otherwise, since amount is presumably an integer field, SQL rules would truncate it to the nearest lower integer.

2. A PSQL trigger that retrieves two values as a \texttt{BLOB} field (using the \texttt{LIST()} function) and assigns it \texttt{INTO} a third field:

\begin{verbatim}
select list(name, ', ') from persons p 
where p.id in (new.father, new.mother) 
into new.parentnames;
\end{verbatim}

\textbf{6.1.16. Common Table Expressions ("WITH \ldots AS \ldots SELECT")}

\textit{Available in} 
DSQL, PSQL

\textit{Syntax}

\begin{verbatim}
<cte-construct> ::= 
<cte-defs> 
<main-query>

<cte-defs> ::= WITH [RECURSIVE] <cte> [ , <cte> ... ]

<cte> ::= name [ ( column-list ) ] AS ( cte-stmt )

<column-list> ::= column-alias [ , column-alias ... ]
\end{verbatim}

\textit{Table 86. Arguments for Common Table Expressions}

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cte-stmt</td>
<td>Any SELECT statement, including UNION</td>
</tr>
<tr>
<td>main-query</td>
<td>The main SELECT statement, which can refer to the CTEs defined in the preamble</td>
</tr>
<tr>
<td>name</td>
<td>Alias for a table expression</td>
</tr>
<tr>
<td>column-alias</td>
<td>Alias for a column in a table expression</td>
</tr>
</tbody>
</table>

A common table expression or \textit{CTE} can be described as a virtual table or view, defined in a preamble to a main query, and going out of scope after the main query's execution. The main query can reference any \textit{CTEs} defined in the preamble as if they were regular tables or views. \textit{CTEs} can be recursive, i.e. self-referencing, but they cannot be nested.

\textbf{CTE Notes}

- A \textit{CTE} definition can contain any legal SELECT statement, as long as it doesn't have a "WITH⋯"
• CTEs defined for the same main query can reference each other, but care should be taken to avoid loops.
• CTEs can be referenced from anywhere in the main query.
• Each CTE can be referenced multiple times in the main query, using different aliases if necessary.
• When enclosed in parentheses, CTE constructs can be used as subqueries in SELECT statements, but also in UPDATES, MERGES etc.
• In PSQL, CTEs are also supported in FOR loop headers:

```sql
for
  with my_rivers as (select * from rivers where owner = 'me')
  select name, length from my_rivers into :rname, :rlen
do
begin
  ..
end
```

Example

```sql
with dept_year_budget as (  
  select fiscal_year,  
    dept_no,  
    sum(projected_budget) as budget  
  from proj_dept_budget  
  group by fiscal_year, dept_no  
)
select d.dept_no,  
  d.department,  
  dyb_2008.budget as budget_08,  
  dyb_2009.budget as budget_09  
from department d  
left join dept_year_budget dyb_2008  
on d.dept_no = dyb_2008.dept_no  
and dyb_2008.fiscal_year = 2008  
left join dept_year_budget dyb_2009  
on d.dept_no = dyb_2009.dept_no  
and dyb_2009.fiscal_year = 2009  
where exists (    
  select * from proj_dept_budget b    
  where d.dept_no = b.dept_no    
);
```
Recursive CTEs

A recursive (self-referencing) CTE is a UNION which must have at least one non-recursive member, called the anchor. The non-recursive member(s) must be placed before the recursive member(s). Recursive members are linked to each other and to their non-recursive neighbour by UNION ALL operators. The unions between non-recursive members may be of any type.

Recursive CTEs require the RECURSIVE keyword to be present right after WITH. Each recursive union member may reference itself only once, and it must do so in a FROM clause.

A great benefit of recursive CTEs is that they use far less memory and CPU cycles than an equivalent recursive stored procedure.

Execution Pattern

The execution pattern of a recursive CTE is as follows:

- The engine begins execution from a non-recursive member.
- For each row evaluated, it starts executing each recursive member one by one, using the current values from the outer row as parameters.
- If the currently executing instance of a recursive member produces no rows, execution loops back one level and gets the next row from the outer result set.

Example of recursive CTEs
WITH RECURSIVE DEPT_YEARS AS (  
    SELECT  
      FISCAL_YEAR,  
      DEPT_NO,  
      SUM(PROJECTED_BUDGET) BUDGET  
    FROM PROJ_DEPT_BUDGET  
    GROUP BY FISCAL_YEAR, DEPT_NO  
  ),  
DEPT_TREE AS (  
    SELECT  
      DEPT_NO,  
      HEAD_DEPT,  
      DEPARTMENT,  
      CAST('' AS VARCHAR(255)) AS INDENT  
    FROM DEPARTMENT  
    WHERE HEAD_DEPT IS NULL  
    UNION ALL  
    SELECT  
      D.DEPT_NO,  
      D.HEAD_DEPT,  
      D.DEPARTMENT,  
      H.INDENT || ' '  
    FROM DEPARTMENT D  
    JOIN DEPT_TREE H ON H.HEAD_DEPT = D.DEPT_NO  
  )  
SELECT  
  D.DEPT_NO,  
  D.INDENT || D.DEPARTMENT DEPARTMENT,  
  DYB_2008.BUDGET AS BUDGET_08,  
  DYB_2009.BUDGET AS BUDGET_09  
FROM DEPT_TREE D  
LEFT JOIN DEPT_YEARS DYB_2008 ON  
  (D.DEPT_NO = DYB_2008.DEPT_NO) AND  
  (DYB_2008.FISCAL_YEAR = 2008)  
LEFT JOIN DEPT_YEARS DYB_2009 ON  
  (D.DEPT_NO = DYB_2009.DEPT_NO) AND  
  (DYB_2009.FISCAL_YEAR = 2009);  

The next example returns the pedigree of a horse. The main difference is that recursion occurs simultaneously in two branches of the pedigree.

WITH RECURSIVE PEDIGREE (  
  CODE_HORSE,  
  CODE_FATHER,  
  CODE_MOTHER,  
  NAME,  
  MARK,  
  DEPTH)  
AS (SELECT
HORSE.CODE_HORSE,
HORSE.CODE_FATHER,
HORSE.CODE_MOTHER,
HORSE.NAME,
CAST('' AS VARCHAR(80)),
0
FROM
HORSE
WHERE
  HORSE.CODE_HORSE = :CODE_HORSE
UNION ALL
SELECT
  HORSE.CODE_HORSE,
  HORSE.CODE_FATHER,
  HORSE.CODE_MOTHER,
  HORSE.NAME,
  'F' || PEDIGREE.MARK,
  PEDIGREE.DEPTH + 1
FROM
HORSE
JOIN PEDIGREE
  ON HORSE.CODE_HORSE = PEDIGREE.CODE_FATHER
WHERE
  PEDIGREE.DEPTH < :MAX_DEPTH
UNION ALL
SELECT
  HORSE.CODE_HORSE,
  HORSE.CODE_FATHER,
  HORSE.CODE_MOTHER,
  HORSE.NAME,
  'M' || PEDIGREE.MARK,
  PEDIGREE.DEPTH + 1
FROM
HORSE
JOIN PEDIGREE
  ON HORSE.CODE_HORSE = PEDIGREE.CODE_MOTHER
WHERE
  PEDIGREE.DEPTH < :MAX_DEPTH
)
SELECT
  CODE_HORSE,
  NAME,
  MARK,
  DEPTH
FROM
PEDIGREE

Notes on recursive CTEs

- Aggregates (DISTINCT, GROUP BY, HAVING) and aggregate functions (SUM, COUNT, MAX etc) are not allowed in recursive union members.
• A recursive reference cannot participate in an outer join.
• The maximum recursion depth is 1024.

6.2. INSERT

Used for
Inserting rows of data into a table

Available in
DSQL, ESQL, PSQL

Syntax

```
INSERT INTO target
    { DEFAULT VALUES
    | [([<column_list>])] [<override_opt>] <value_source> }
    [RETURNING <returning_list> [INTO <variables>]]

<column_list> ::= col_name [, col_name ...]
<override_opt> ::= OVERRIDING {USER | SYSTEM} VALUE
[value_source] ::= VALUES (<value_list>) | <select_stmt>
[value_list] ::= <ins_value> [, <ins_value> ...]
<ins_value> ::= <value_expression> | DEFAULT
$returning_list ::= * | <output_column> [, <output_column>]
<output_column> ::= target.*
    | <return_expression> [COLLATE collation] [[AS] alias]
$return_expression ::= <value_expression>
    | [target.]col_name
[value_expression] ::= <literal>
    | <context-variable>
    | any other expression returning a single value of a Firebird data type or NULL
<variables> ::= [:]varname [, [:]varname ...]
```

Table 87. Arguments for the INSERT Statement Parameters
The INSERT statement is used to add rows to a table or to one or more tables underlying a view:

- If the column values are supplied in a VALUES clause, exactly one row is inserted.
- The values may be provided instead by a SELECT expression, in which case zero to many rows may be inserted.
- With the DEFAULT VALUES clause, no values are provided at all and exactly one row is inserted.

Restrictions

- Columns returned to the NEW.column_name context variables in triggers should not have a colon (":")) prefixed to their names
- No column may appear more than once in the column list.

**ALERT: BEFORE INSERT Triggers**

Regardless of the method used for inserting rows, be mindful of any columns in the target table or view that are populated by BEFORE INSERT triggers, such as primary keys and case-insensitive search columns. Those columns should be excluded from both the column_list and the VALUES list if, as they should, the triggers test the NEW.column_name for NULL.

### 6.2.1. INSERT … VALUES

The VALUES list must provide a value for every column in the column list, in the same order and of the correct type. The column list need not specify every column in the target but, if the column list is absent, the engine requires a value for every column in the table or view (computed columns excluded).

The value DEFAULT allows a column to be specified in the column list, but instructs Firebird to use the default value (either NULL or the value specified in the DEFAULT clause of the column definition). For identity columns, specifying DEFAULT will generate the identity value. It is possible to include calculated columns in the column list and specifying DEFAULT as the column value.
**Introducer syntax** provides a way to identify the character set of a value that is a string constant (literal). Introducer syntax works only with literal strings: it cannot be applied to string variables, parameters, column references or values that are expressions.

**Examples**

```sql
INSERT INTO cars (make, model, year)
VALUES ('Ford', 'T', 1908);

INSERT INTO cars
VALUES ('Ford', 'T', 1908, 'USA', 850);

-- notice the '_' prefix (introducer syntax)
INSERT INTO People
VALUES (_ISO8859_1 'Hans-Jörg Schäfer');
```

### 6.2.2. INSERT … SELECT

For this method of inserting, the output columns of the `SELECT` statement must provide a value for every target column in the column list, in the same order and of the correct type.

Literal values, context variables or expressions of compatible type can be substituted for any column in the source row. In this case, a source column list and a corresponding `VALUES` list are required.

If the column list is absent—as it is when `SELECT *` is used for the source expression—the `column_list` must contain the names of every column in the target table or view (computed columns excluded).
Examples

```sql
INSERT INTO cars (make, model, year)
    SELECT make, model, year
    FROM new_cars;

INSERT INTO cars
    SELECT * FROM new_cars;

INSERT INTO Members (number, name)
    SELECT number, name FROM NewMembers
    WHERE Accepted = 1
    UNION ALL
    SELECT number, name FROM SuspendedMembers
    WHERE Vindicated = 1

INSERT INTO numbers(num)
    WITH RECURSIVE r(n) as (
        SELECT 1 FROM rdb$database
        UNION ALL
        SELECT n+1 FROM r WHERE n < 100
    )
    SELECT n FROM r
```

Of course, the column names in the source table need not be the same as those in the target table. Any type of SELECT statement is permitted, as long as its output columns exactly match the insert columns in number, order and type. Types need not be exactly the same, but they must be assignment-compatible.

When using and `INSERT … SELECT` with a `RETURNING` clause, the `SELECT` has to produce at most one row, as `RETURNING` currently only works for statements affecting at most one row.

This behaviour may change in future Firebird versions.

### 6.2.3. INSERT … DEFAULT VALUES

The `DEFAULT VALUES` clause allows insertion of a record without providing any values at all, either directly or from a `SELECT` statement. This is only possible if every `NOT NULL` or `CHECKed` column in the table either has a valid default declared or gets such a value from a `BEFORE INSERT` trigger. Furthermore, triggers providing required field values must not depend on the presence of input values.

Specifying `DEFAULT VALUES` is equivalent to specifying a values list with value `DEFAULT` for all columns.
6.2.4. **OVERRIDING**

The **OVERRIDING** clause controls the behaviour of an identity column for this statement only.

**OVERRIDING SYSTEM VALUE**

The user-provided value for the identity column is used, and no value is generated using the identity. In other words, for this insert, the identity will behave as if it is **GENERATED BY DEFAULT**. This option can only be specified for tables with a **GENERATED ALWAYS AS IDENTITY** column.

This can be useful when merging or importing data from another source. After such an insert, it may be necessary to change the next value of the identity sequence using **ALTER TABLE** to prevent subsequent inserts from generating colliding identity values.

**OVERRIDING USER VALUE**

The user-provided value for the identity column is ignored, and the column value is generated using the identity. In other words, for this insert, the identity will behave as if it is **GENERATED ALWAYS**, while allowing the identity column in the column-list. This option can only be specified for tables with a **GENERATED BY DEFAULT AS IDENTITY** column.

It is usually simpler to leave out the identity column to achieve the same effect.

**Examples of OVERRIDING**

```sql
-- for GENERATED ALWAYS AS IDENTITY
-- value 11 is used anyway
insert into objects_always (id, name)
  OVERRIDING SYSTEM VALUE values (11, 'Laptop');

-- for GENERATED BY DEFAULT AS IDENTITY
-- value 12 is not used
insert into objects_default (id, name)
  OVERRIDING USER VALUE values (12, 'Laptop');
```

6.2.5. **The RETURNING Clause**

An **INSERT** statement adding *at most one row* may optionally include a **RETURNING** clause in order to return values from the inserted row. The clause, if present, need not contain all of the insert columns and may also contain other columns or expressions. The returned values reflect any changes that may have been made in **BEFORE INSERT** triggers.

The user executing the statement needs to have **SELECT** privileges on the columns specified in the **RETURNING** clause.
The syntax of the `returning_list` is similar to the column list of a `SELECT` clause. It is possible to reference all columns using `*` or `table_name.*`.

The optional INTO sub-clause is only valid in PSQL.

### Multiple INSERTS

In DSQL, a statement with `RETURNING` always returns only one row. If the `RETURNING` clause is specified and more than one row is inserted by the `INSERT` statement, the statement fails and an error message is returned. This behaviour may change in future Firebird versions.

### Examples

```sql
INSERT INTO Scholars (firstname, lastname, address, phone, email)
VALUES ('Henry', 'Higgins', '27A Wimpole Street', '3231212', NULL)
RETURNING lastname, fullname, id;

INSERT INTO Scholars (firstname, lastname, address, phone, email)
VALUES ('Henry', 'Higgins', '27A Wimpole Street', '3231212', NULL)
RETURNING *;

INSERT INTO Dumbbells (firstname, lastname, iq)
SELECT fname, lname, iq
FROM Friends
ORDER BY iq ROWS 1
RETURNING id, firstname, iq
INTO :id, :fname, :iq;
```

- `RETURNING` is supported for `VALUES` and `DEFAULT VALUES` inserts, and singleton `SELECT` inserts.
- In DSQL, a statement with a `RETURNING` clause always returns exactly one row. If no record was actually inserted, the fields in this row are all `NULL`. This behaviour may change in a later version of Firebird. In PSQL, if no row was inserted, nothing is returned, and the target variables keep their existing values.

### 6.2.6. Inserting into BLOB columns

Inserting into BLOB columns is only possible under the following circumstances:

1. The client application has made special provisions for such inserts, using the Firebird API. In this case, the *modus operandi* is application-specific and outside the scope of this manual.
2. The value inserted is a string literal of no more than 65,533 bytes (64KB - 3).
A limit, in characters, is calculated at run-time for strings that are in multi-byte character sets, to avoid overrunning the bytes limit. For example, for a UTF8 string (max. 4 bytes/character), the run-time limit is likely to be about \( \text{floor}(65533/4) = 16383 \) characters.

3. You are using the “INSERT … SELECT” form and one or more columns in the result set are BLOBs.

### 6.3. UPDATE

**Used for**

Modifying rows in tables and views

**Available in**

DSQL, ESQL, PSQL

**Syntax**

```
UPDATE target [[AS] alias]
SET col_name = <upd_value> [, col_name = <upd_value> ...]
[WHERE {<search-conditions> | CURRENT OF cursorname}]
[PLAN <plan_items>]
[ORDER BY <sort_items>]
[ROWS m [TO n]]
[RETURNING <returning_list> [INTO <variables>]]
```

- `<upd_value>` ::= `<value_expression>` | DEFAULT
- `<returning_list>` ::= `*` | `<output_column>` [, `<output_column>`]
- `<output_column>` ::= target.* | NEW.* | OLD.* | `<return_expression>` [COLLATE `collation`] [[AS] alias]
- `<return_expression>` ::= `<value_expression>`
- `<variables>` ::= `[:varname [, [:varname ...]]`

*Table 88. Arguments for the UPDATE Statement Parameters*
The UPDATE statement changes values in a table or in one or more of the tables that underlie a view. The columns affected are specified in the SET clause. The rows affected may be limited by the WHERE and ROWS clauses. If neither WHERE nor ROWS is present, all the records in the table will be updated.

### 6.3.1. Using an alias

If you assign an alias to a table or a view, the alias must be used when specifying columns and also in any column references included in other clauses.

**Example**

Correct usage:

```plaintext
update Fruit set soort = 'pisang' where ...  
update Fruit set Fruit.soort = 'pisang' where ...  
update Fruit F set soort = 'pisang' where ...  
update Fruit F set F.soort = 'pisang' where ...  
```

Not possible:

```plaintext
update Fruit F set Fruit.soort = 'pisang' where ...  
```
6.3.2. The SET Clause

In the SET clause, the assignment phrases, containing the columns with the values to be set, are separated by commas. In an assignment phrase, column names are on the left and the values or expressions containing the assignment values are on the right. A column may be included only once in the SET clause.

A column name can be used in expressions on the right. The old value of the column will always be used in these right-side values, even if the column was already assigned a new value earlier in the SET clause.

Using the value DEFAULT will set the column to its default value (either NULL or the value specified on the DEFAULT clause of the column definition). For an identity column, specifying DEFAULT will generate a new identity value. It is possible to “update” calculated columns in the SET clause if and only if the assigned value is DEFAULT.

> It is not possible to assign DEFAULT as a parameter value.

Here is an example

Data in the TSET table:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

The statement:

```
UPDATE tset SET a = 5, b = a;
```

will change the values to:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

Notice that the old values (1 and 2) are used to update the b column even after the column was assigned a new value (5).
It was not always like that. Before version 2.5, columns got their new values immediately upon assignment. It was non-standard behaviour that was fixed in version 2.5.

To maintain compatibility with legacy code, the configuration file firebird.conf includes the parameter OldSetClauseSemantics, that can be set True (1) to restore the old, bad behaviour. It is a temporary measure—the parameter will be removed in the future.

### 6.3.3. The WHERE Clause

The WHERE clause sets the conditions that limit the set of records for a searched update.

In PSQL, if a named cursor is being used for updating a set, using the WHERE CURRENT OF clause, the action is limited to the row where the cursor is currently positioned. This is a positioned update.

To be able to use the WHERE CURRENT OF clause in DSQL, the cursor name needs to be set on the statement handle before executing the statement.

**Examples**

```sql
UPDATE People
    SET firstname = 'Boris'
    WHERE lastname = 'Johnson';

UPDATE employee e
    SET salary = salary * 1.05
    WHERE EXISTS(
        SELECT *
        FROM employee_project ep
        WHERE e.emp_no = ep.emp_no);

UPDATE addresses
    SET city = 'Saint Petersburg', citycode = 'PET'
    WHERE city = 'Leningrad'

UPDATE employees
    SET salary = 2.5 * salary
    WHERE title = 'CEO'
```

For string literals with which the parser needs help to interpret the character set of the data, the introducer syntax may be used. The string literal is preceded by the character set name, prefixed with an underscore character:
6.3.4. The ORDER BY and ROWS Clauses

The ORDER BY and ROWS clauses make sense only when used together. However, they can be used separately.

If ROWS has one argument, \( m \), the rows to be updated will be limited to the first \( m \) rows.

**Points to note**
- If \( m > \) the number of rows being processed, the entire set of rows is updated
- If \( m = 0 \), no rows are updated
- If \( m < 0 \), an error occurs and the update fails

If two arguments are used, \( m \) and \( n \), ROWS limits the rows being updated to rows from \( m \) to \( n \) inclusively. Both arguments are integers and start from 1.

**Points to note**
- If \( m > \) the number of rows being processed, no rows are updated
- If \( n > \) the number of rows, rows from \( m \) to the end of the set are updated
- If \( m < 1 \) or \( n < 1 \), an error occurs and the update fails
- If \( n = m - 1 \), no rows are updated
- If \( n < m - 1 \), an error occurs and the update fails

**ROWS Example**

```sql
UPDATE employees
SET salary = salary + 50
ORDER BY salary ASC
ROWS 20;
```

6.3.5. The RETURNING Clause

An UPDATE statement involving *at most one row* may include RETURNING in order to return some values from the row being updated. RETURNING may include data from any column of the row, not necessarily the columns that are currently being updated. It can include literals or expressions not associated with columns, if there is a need for that.

The user executing the statement needs to have SELECT privileges on the columns specified in the RETURNING clause.
When the \texttt{RETURNING} set contains data from the current row, the returned values report changes made in the \texttt{BEFORE UPDATE} triggers, but not those made in \texttt{AFTER UPDATE} triggers.

The context variables \texttt{OLD.fieldname} and \texttt{NEW.fieldname} can be used as column names. If \texttt{OLD.} or \texttt{NEW.} is not specified, or if the table name (\texttt{target}) is specified instead the column values returned are the \texttt{NEW.} ones.

The syntax of the \texttt{returning\_list} is similar to the column list of a \texttt{SELECT} clause. It is possible to reference all columns using \texttt{*}, or \texttt{table\_name.*}, \texttt{NEW.*} and/or \texttt{OLD.*}.

In DSQL, a statement with \texttt{RETURNING} always returns a single row. Attempts to execute an \texttt{UPDATE} \ldots \texttt{RETURNING} \ldots that affects multiple rows will result in the error “multiple rows in singleton select”. If the statement updates no records, the returned values contain \texttt{NULL}. This behaviour may change in future Firebird versions.

\textbf{The \texttt{INTO} Sub-clause}

In PSQL, the \texttt{INTO} clause can be used to pass the returning values to local variables. It is not available in DSQL. If no records are updated, nothing is returned and variables specified in \texttt{RETURNING} will keep their previous values.

\textbf{RETURNING Example (DSQL)}

```
UPDATE Scholars
SET firstname = 'Hugh', lastname = 'Pickering'
WHERE firstname = 'Henry' and lastname = 'Higgins'
RETURNING id, old.lastname, new.lastname;
```

\section*{6.3.6. Updating BLOB columns}

Updating a BLOB column always replaces the entire contents. Even the BLOB ID, the “handle” that is stored directly in the column, is changed. BLOBs can be updated if:

1. The client application has made special provisions for this operation, using the Firebird API. In this case, the \textit{modus operandi} is application-specific and outside the scope of this manual.

2. The new value is a string literal of no more than 65,533 bytes (64KB - 3).

   A limit, in characters, is calculated at run-time for strings that are in multi-byte character sets, to avoid overflowing the bytes limit. For example, for a UTF8 string (max. 4 bytes/character), the run-time limit is likely to be about \( \text{floor}(65533/4) = 16383 \) characters.

3. The source is itself a BLOB column or, more generally, an expression that returns a BLOB.

4. You use the \texttt{INSERT CURSOR} statement (ESQL only).
6.4. UPDATE OR INSERT

Used for
Updating an existing record in a table or, if it does not exist, inserting it

Available in
DSQL, PSQl

Syntax

UPDATE OR INSERT INTO
  target [([column_list])]
  [<override_opt>]
  VALUES (<value_list>)
  [MATCHING ([column_list])]
  [RETURNING <returning_list> [INTO <variables>]]

<column_list> ::= col_name [, col_name ...]

<override_opt> ::= OVERRIDING {USER | SYSTEM} VALUE

)value_list> ::= <ins_value> [, <ins_value> ...]

<ins_value> ::= <value> | DEFAULT

<returning_list> ::= * | <output_column> [, <output_column>]

<output_column> ::=
  target.* | NEW.* | OLD.*
  | <return_expression> [COLLATE collation] [[AS] alias]

<return_expression> ::= <value_expression>
  | [target.]col_name
  | NEW.col_name
  | OLD.col_name

<value_expression> ::= <literal>
  | <context-variable>
  | any other expression returning a single
    value of a Firebird data type or NULL

:variables> ::= [:]varname [, [:]varname ...]

Table 89. Arguments for the UPDATE OR INSERT Statement Parameters
**Argument** | **Description**
--- | ---
**target** | The name of the table or view where the record(s) is to be updated or a new record inserted
**col_name** | Name of a column in the table or view
**value_expression** | An expression whose value is to be used for inserting or updating the table, or returning a value
**return_expression** | An expression returned in the RETURNING clause
**varname** | Variable name — PSQL only

**Restrictions**
- If the table has no primary key, the MATCHING clause is mandatory.
- In the MATCHING list as well as in the update/insert column list, each column name may occur only once.
- The “INTO <variables>” subclause is only available in PSQL.
- When values are returned into the context variable NEW, this name must not be preceded by a colon (“:”).

### 6.4.1. The **RETURNING** clause

The optional **RETURNING** clause, if present, need not contain all the columns mentioned in the statement and may also contain other columns or expressions. The returned values reflect any changes that may have been made in BEFORE triggers, but not those in AFTER triggers. OLD.fieldname and NEW.fieldname may both be used in the list of columns to return; for field names not preceded by either of these, the new value is returned.

The user executing the statement needs to have SELECT privileges on the columns specified in the **RETURNING** clause.

The syntax of the **returning_list** is similar to the column list of a SELECT clause. It is possible to reference all columns using *, or table_name.*, NEW.*, and/or OLD.*.

In DSQL, a statement with a **RETURNING** clause always returns exactly one row. If a RETURNING clause is present and more than one matching record is found, an error “multiple rows in singleton select” is raised. This behaviour may change in a later version of Firebird.

The optional INTO sub-clause is only valid in PSQL.

---

**UPDATE OR INSERT** inserts a new record or updates one or more existing records. The action taken depends on the values provided for the columns in the MATCHING clause (or, if the latter is absent, in the primary key). If there are records found matching those values, they are updated. If not, a new record is inserted. A match only counts if all the values in the MATCHING or primary key columns are equal. Matching is done with the **IS NOT DISTINCT** operator, so one NULL matches another.
6.4.2. Example of UPDATE OR INSERT

Modifying data in a table, using UPDATE OR INSERT in a PSQL module. The return value is passed to a local variable, whose colon prefix is optional.

```
UPDATE OR INSERT INTO Cows (Name, Number, Location)
  VALUES ('Suzy Creamcheese', 3278823, 'Green Pastures')
  MATCHING (Number)
  RETURNING rec_id into :id;
```

```
UPDATE OR INSERT INTO Cows (Name, Number, Location)
  VALUES ('Suzy Creamcheese', 3278823, 'Green Pastures')
  MATCHING (Number)
  RETURNING old.*, new.*;
```

6.5. DELETE

*Used for*

Deleting rows from a table or view

*Available in*

DSQL, ESQL, PSQL
DELETE
    FROM target [[AS] alias]
    [WHERE {<search-conditions> | CURRENT OF cursorname}]
    [PLAN <plan_items>]
    [ORDER BY <sort_items>]
    [ROWS m [TO n]]
    [RETURNING <returning_list> [INTO <variables>]]

<returning_list> ::= * | <output_column> [, <output_column>]

<output_column> ::= 
    target.*
    | <return_expression> [COLLATE collation] [[AS] alias]

<return_expression> ::= 
    <value_expression>
    | [target].col_name

[value_expression] ::= 
    <literal>
    | <context-variable>
    | any other expression returning a single value of a Firebird data type or NULL

:variables> ::= 
    [:]varname [, [:]varname ...]

Table 90. Arguments for the DELETE Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>target</td>
<td>The name of the table or view from which the records are to be deleted</td>
</tr>
<tr>
<td>alias</td>
<td>Alias for the target table or view</td>
</tr>
<tr>
<td>search-conditions</td>
<td>Search condition limiting the set of rows being targeted for deletion</td>
</tr>
<tr>
<td>cursorname</td>
<td>The name of the cursor in which current record is positioned for deletion</td>
</tr>
<tr>
<td>plan_items</td>
<td>Query plan clause</td>
</tr>
<tr>
<td>sort_items</td>
<td>ORDER BY clause</td>
</tr>
<tr>
<td>m, n</td>
<td>Integer expressions for limiting the number of rows being deleted</td>
</tr>
<tr>
<td>return_expression</td>
<td>An expression to be returned in the RETURNING clause</td>
</tr>
<tr>
<td>value_expression</td>
<td>An expression whose value is used for returning</td>
</tr>
<tr>
<td>varname</td>
<td>Name of a PSQL variable</td>
</tr>
</tbody>
</table>

DELETE removes rows from a database table or from one or more of the tables that underlie a view. WHERE and ROWS clauses can limit the number of rows deleted. If neither WHERE nor ROWS is present, DELETE removes all the rows in the relation.
6.5.1. Aliases

If an alias is specified for the target table or view, it must be used to qualify all field name references in the DELETE statement.

**Examples**

Supported usage:

```sql
delete from Cities where name starting 'Alex';
delete from Cities where Cities.name starting 'Alex';
delete from Cities C where name starting 'Alex';
delete from Cities C where C.name starting 'Alex';
```

Not possible:

```sql
delete from Cities C where Cities.name starting 'Alex';
```

6.5.2. WHERE

The WHERE clause sets the conditions that limit the set of records for a searched delete.

In PSQL, if a named cursor is being used for deleting a set, using the WHERE CURRENT OF clause, the action is limited to the row where the cursor is currently positioned. This is a positioned delete.

To be able to use the WHERE CURRENT OF clause in DSQL, the cursor name needs to be set on the statement handle before executing the statement.

**Examples**

```sql
DELETE FROM People
   WHERE firstname <> 'Boris' AND lastname <> 'Johnson';

DELETE FROM employee e
   WHERE NOT EXISTS(  
      SELECT *  
      FROM employee_project ep  
      WHERE e.emp_no = ep.emp_no);

DELETE FROM Cities
   WHERE CURRENT OF Cur_Cities;  -- ESQL and PSQL only
```
6.5.3. PLAN

A PLAN clause allows the user to optimize the operation manually.

Example

```sql
DELETE FROM Submissions
WHERE date_entered < '1-Jan-2002'
PLAN (Submissions INDEX ix_subm_date);
```

6.5.4. ORDER BY and ROWS

The ORDER BY clause orders the set before the actual deletion takes place. It only makes sense in combination with ROWS, but is also valid without it.

The ROWS clause limits the number of rows being deleted. Integer literals or any integer expressions can be used for the arguments \( m \) and \( n \).

If ROWS has one argument, \( m \), the rows to be deleted will be limited to the first \( m \) rows.

**Points to note**
- If \( m > \) the number of rows being processed, the entire set of rows is deleted
- If \( m = 0 \), no rows are deleted
- If \( m < 0 \), an error occurs and the deletion fails

If two arguments are used, \( m \) and \( n \), ROWS limits the rows being deleted to rows from \( m \) to \( n \) inclusively. Both arguments are integers and start from 1.

**Points to note**
- If \( m > \) the number of rows being processed, no rows are deleted
- If \( m > 0 \) and \( \leq \) the number of rows in the set and \( n \) is outside these values, rows from \( m \) to the end of the set are deleted
- If \( m < 1 \) or \( n < 1 \), an error occurs and the deletion fails
- If \( n = m - 1 \), no rows are deleted
- If \( n < m - 1 \), an error occurs and the deletion fails

**Examples**

Deleting the oldest purchase:

```sql
DELETE FROM Purchases
ORDER BY date ROWS 1;
```

Deleting the highest custno(s):
Deleting all sales, ORDER BY clause pointless:

```
DELETE FROM Sales
  ORDER BY custno DESC ROWS 1 to 10;
```

Deleting one record starting from the end, i.e. from Z...:

```
DELETE FROM popgroups
  ORDER BY name DESC ROWS 1;
```

Deleting the five oldest groups:

```
DELETE FROM popgroups
  ORDER BY formed ROWS 5;
```

No sorting (ORDER BY) is specified so 8 found records, starting from the fifth one, will be deleted:

```
DELETE FROM popgroups
ROWS 5 TO 12;
```

### 6.5.5. RETURNING

A `DELETE` statement removing *at most one row* may optionally include a `RETURNING` clause in order to return values from the deleted row. The clause, if present, need not contain all the relation’s columns and may also contain other columns or expressions.

The user executing the statement needs to have `SELECT` privileges on the columns specified in the `RETURNING` clause.

The syntax of the `returning_list` is similar to the column list of a `SELECT` clause. It is possible to reference all columns using `*`, or `table_name.*`.

- In DSQL, a statement with `RETURNING` always returns a singleton, never a multi-row set. If a `RETURNING` clause is present and more than one matching record is found, an error “multiple rows in singleton select” is raised. If no records are deleted, the returned columns contain `NULL`. This behaviour may change in future Firebird versions
- The `INTO` clause is available only in PSQL
  - If the row is not deleted, nothing is returned and the target variables keep their values
Examples

DELETE FROM Scholars
    WHERE firstname = 'Henry' and lastname = 'Higgins'
    RETURNING lastname, fullname, id;

DELETE FROM Scholars
    WHERE firstname = 'Henry' and lastname = 'Higgins'
    RETURNING *;

DELETE FROM Dumbbells
    ORDER BY iq DESC
    ROWS 1
    RETURNING lastname, iq into :lname, :iq;

6.6. MERGE

Used for
Merging data from a source set into a target relation

Available in
DSQL, PSQL

Syntax

MERGE INTO target [[AS target_alias]]
    USING <source> [[AS source_alias]]
    ON <join_condition>
    <merge_when> [ <merge_when> ... ]
    [RETURNING <returning_list> [INTO <variables>]]

<merge_when> ::= 
    <merge_when_matched>
| <merge_when_not_matched>

<merge_when_matched> ::= 
    WHEN MATCHED [ AND <condition> ] THEN
    { UPDATE SET <assignment-list>
    | DELETE }

<merge_when_not_matched> ::= 
    WHEN NOT MATCHED [ AND <condition> ] THEN
    INSERT ([ <column_list> ]) [ <override_opt>]
    VALUES ( <value_list> )

<source> ::= tablename | ( <select_stmt> )

<assignment_list ::= 
    col_name = <m_value> [, col_name = <m_value> ...] ]}
<override_opt> ::= 
    OVERRIDING {USER | SYSTEM} VALUE

<column_list> ::= colname [, colname ...]

:value_list> ::= <m_value> [, <m_value> ...]

<m_value> ::= <value_expression> | DEFAULT

:returning_list> ::= * | <output_column> [, <output_column>]

<output_column> ::= 
    target.* | NEW.* | OLD.*
    | <return_expression> [COLLATE collation] [[AS] alias]

<return_expression> ::= 
    <value_expression>
    | [target.]col_name
    | NEW.col_name
    | OLD.col_name

<value_expression> ::= 
    <literal>
    | <context-variable>
    | any other expression returning a single
      value of a Firebird data type or NULL

:variables> ::= 
    [:]varname [, [:]varname ...]

Table 91. Arguments for the MERGE Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>target</td>
<td>Name of target relation (table or updatable view)</td>
</tr>
<tr>
<td>source</td>
<td>Data source. It can be a table, a view, a stored procedure or a derived table</td>
</tr>
<tr>
<td>target_alias</td>
<td>Alias for the target relation (table or updatable view)</td>
</tr>
<tr>
<td>source_alias</td>
<td>Alias for the source relation or set</td>
</tr>
<tr>
<td>join_conditions</td>
<td>The (ON) condition(s) for matching the source records with those in the target</td>
</tr>
<tr>
<td>condition</td>
<td>Additional test condition in WHEN MATCHED or WHEN NOT MATCHED clause</td>
</tr>
<tr>
<td>tablename</td>
<td>Table or view name</td>
</tr>
<tr>
<td>select_stmt</td>
<td>Select statement of the derived table</td>
</tr>
<tr>
<td>col_name</td>
<td>Name of a column in the target relation</td>
</tr>
<tr>
<td>Argument</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>value_expression</td>
<td>The value assigned to a column in the target table. This expression may be a literal value, a PSQL variable, a column from the source, or a compatible context variable</td>
</tr>
<tr>
<td>return_expression</td>
<td>The expression to be returned in the RETURNING clause. Can be a column reference to source or target, or a column reference of the NEW or OLD context of the target, or a value.</td>
</tr>
<tr>
<td>ret_alias</td>
<td>Alias for the value expression in the RETURNING clause</td>
</tr>
<tr>
<td>varname</td>
<td>Name of a PSQL local variable</td>
</tr>
</tbody>
</table>

The `MERGE` statement merges records from the source into a target table or updatable view. The source may be a table, view or “anything you can SELECT from” in general. Each source record will be used to update one or more target records, insert a new record in the target table, delete a record from the target table or do nothing.

The action taken depends on the supplied join condition, the `WHEN` clause(s), and the (optional) condition in the `WHEN` clause. The join condition and condition in the `WHEN` will typically contain a comparison of fields in the source and target relations.

Multiple `WHEN MATCHED` and `WHEN NOT MATCHED` clauses are allowed. For each row in the source, the `WHEN` clauses are checked in the order they are specified in the statement. If the condition in the `WHEN` clause does not evaluate to true, the clause is skipped, and the next clause will be checked. This will be done until the condition for a `WHEN` clause evaluates to true, or a `WHEN` clauses without condition matches, or there are no more `WHEN` clauses. If a matching clause is found, the action associated with the clause is executed. For each row in the source, at most one action is executed. If the `WHEN MATCHED` clause is present, and several records match a single record in the target table, an error is raised.

At least one `WHEN` clause must be present.

`WHEN NOT MATCHED` is evaluated from the source viewpoint, that is, the table or set specified in `USING`. It has to work this way because if the source record does not match a target record, `INSERT` is executed. Of course, if there is a target record which does not match a source record, nothing is done.

Currently, the `ROW_COUNT` variable returns the value 1, even if more than one record is modified or inserted. For details and progress, refer to firebird#4722.

### 6.6.1. The **RETURNING** Clause

A `MERGE` statement that affects at most one row can contain a `RETURNING` clause to return values added, modified or removed. If a `RETURNING` clause is present and more than one matching record is found, an error “multiple rows in singleton select” is raised. The `RETURNING` clause can contain any columns from the target table (or updateable view), as well as other columns (eg from the source) and expressions.

The user executing the statement needs to have `SELECT` privileges on the columns specified in the
The optional INTO sub-clause is only valid in PSQL.

The restriction that RETURNING can only be used with a statement that affects at most one row might be removed in a future version.

Column names can be qualified by the OLD or NEW prefix to define exactly what value to return: before or after modification. The returned values include the changes made by BEFORE triggers.

The syntax of the returning_list is similar to the column list of a SELECT clause. It is possible to reference all columns using *, or table_name.*, NEW.* and/or OLD.*.

For the UPDATE or INSERT action, unqualified column names, or those qualified by the target table name or alias will behave as if qualified by NEW, while for the DELETE action as if qualified by OLD.

The following example modifies the previous example to affect one line, and adds a RETURNING clause to return the old and new quantity of goods, and the difference between those values.

**Using MERGE with a RETURNING clause**

```sql
MERGE INTO PRODUCT_INVENTORY AS TARGET
USING ( 
    SELECT
      SL.ID_PRODUCT,
      SUM(SL.QUANTITY)
    FROM SALES_ORDER_LINE SL
    JOIN SALES_ORDER S ON S.ID = SL.ID_SALES_ORDER
    WHERE S.BYDATE = CURRENT_DATE
    AND SL.ID_PRODUCT =: ID_PRODUCT
    GROUP BY 1
) AS SRC (ID_PRODUCT, QUANTITY)
ON TARGET.ID_PRODUCT = SRC.ID_PRODUCT
WHEN MATCHED AND TARGET.QUANTITY - SRC.QUANTITY <= 0 THEN
    DELETE
WHEN MATCHED THEN
    UPDATE SET
      TARGET.QUANTITY = TARGET.QUANTITY - SRC.QUANTITY,
      TARGET.BYDATE = CURRENT_DATE
RETURNING OLD.QUANTITY, NEW.QUANTITY, SRC.QUANTITY
INTO : OLD_QUANTITY, :NEW_QUANTITY, :DIFF_QUANTITY
```

**6.6.2. Examples of MERGE**

1. Update books when present, or add new record if absent
2. Using a derived table

Merged INTO customers c
USING (SELECT * from customers_delta WHERE id > 10) cd
ON (c.id = cd.id)
WHEN MATCHED THEN
  UPDATE SET name = cd.name
WHEN NOT MATCHED THEN
  INSERT (id, name) values (cd.id, cd.name);

3. Together with a recursive CTE

Merged INTO numbers
USING (WITH RECURSIVE r(n) AS (  
  SELECT 1 FROM rdb$database 
  UNION ALL 
  SELECT n+1 FROM r WHERE n < 200 
)  
SELECT n FROM r ) t
ON numbers.num = t.n
WHEN NOT MATCHED THEN
  INSERT(num) VALUES(t.n);

4. Using DELETE clause

Merged INTO SALARY_HISTORY
USING (  
  SELECT EMP_NO  
  FROM EMPLOYEE  
  WHERE DEPT_NO = 120) EMP  
ON SALARY_HISTORY.EMP_NO = EMP.EMP_NO  
WHEN MATCHED THEN DELETE

5. The following example updates the PRODUCT_INVENTORY table daily based on orders processed in the SALES_ORDER_LINE table. If the stock level of the product would drop to zero or lower, then the row for that product is removed from the PRODUCT_INVENTORY table.
MERGE INTO PRODUCT_INVENTORY AS TARGET
USING (SELECT
   SL.ID_PRODUCT, SUM(SL.QUANTITY)
FROM SALES_ORDER_LINE SL
JOIN SALES_ORDER S ON S.ID = SL.ID_SALES_ORDER
WHERE S.BYDATE = CURRENT_DATE
GROUP BY 1
) AS SRC (ID_PRODUCT, QUANTITY)
ON TARGET.ID_PRODUCT = SRC.ID_PRODUCT
WHEN MATCHED AND TARGET.QUANTITY - SRC.QUANTITY <= 0 THEN
   DELETE
WHEN MATCHED THEN
   UPDATE SET
      TARGET.QUANTITY = TARGET.QUANTITY - SRC.QUANTITY,
      TARGET.BYDATE = CURRENT_DATE

See also
SELECT, INSERT, UPDATE, UPDATE OR INSERT, DELETE

6.7. EXECUTE PROCEDURE

Used for
Executing a stored procedure

Available in
DSQL, ESQL, PSQL

Syntax

EXECUTE PROCEDURE procname
   {{ <inparam-list | ( <inparam-list> ) }}
   [RETURNING_VALUES { <outvar-list> | ( <outvar-list> ) ]

<inparam-list> ::=<inparam> [, <inparam> ...]

<outvar-list> ::=<outvar> [, <outvar> ...]

<outvar> ::= [:]varname

Table 92. Arguments for the EXECUTE PROCEDURE Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>proctype</td>
<td>Name of the stored procedure</td>
</tr>
<tr>
<td>Argument</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>inparam</td>
<td>An expression evaluating to the declared data type of an input parameter</td>
</tr>
<tr>
<td>varname</td>
<td>A PSQL variable to receive the return value</td>
</tr>
</tbody>
</table>

Executes an *executable stored procedure*, taking a list of one or more input parameters, if they are defined for the procedure, and returning a one-row set of output values, if they are defined for the procedure.

### 6.7.1. “Executable” Stored Procedure

The `EXECUTE PROCEDURE` statement is most commonly used to invoke the style of stored procedure that is written to perform some data-modifying task at the server side — those that do not contain any `SUSPEND` statements in their code. They can be designed to return a result set, consisting of only one row, which is usually passed, via a set of `RETURNING_VALUES()` variables, to another stored procedure that calls it. Client interfaces usually have an API wrapper that can retrieve the output values into a single-row buffer when calling `EXECUTE PROCEDURE` in DSQL.

Invoking the other style of stored procedure — a “selectable” one — is possible with `EXECUTE PROCEDURE`, but it returns only the first row of an output set which is almost surely designed to be multi-row. Selectable stored procedures are designed to be invoked by a `SELECT` statement, producing output that behaves like a virtual table.

- In PSQL and DSQL, input parameters may be any expression that resolves to the expected type.
- Although parentheses are not required after the name of the stored procedure to enclose the input parameters, their use is recommended for the sake of good housekeeping.
- Where output parameters have been defined in a procedure, the `RETURNING_VALUES` clause can be used in PSQL to retrieve them into a list of previously declared variables that conforms in sequence, data type and number with the defined output parameters.
- The list of `RETURNING_VALUES` may be optionally enclosed in parentheses and their use is recommended.
- When DSQL applications call `EXECUTE PROCEDURE` using the Firebird API or some form of wrapper for it, a buffer is prepared to receive the output row and the `RETURNING_VALUES` clause is not used.

### 6.7.2. Examples of `EXECUTE PROCEDURE`

1. In PSQL, with optional colons and without optional parentheses:

```sql
EXECUTE PROCEDURE MakeFullName
 :FirstName, :MiddleName, :LastName
RETURNING_VALUES :FullName;
```
2. In Firebird’s command-line utility *isql*, with literal parameters and optional parentheses:

```sql
EXECUTE PROCEDURE MakeFullName ('J', 'Edgar', 'Hoover');
```

In DSQL (eg in *isql*), RETURNING_VALUES is not used. Any output values are captured by the application and displayed automatically.

3. A PSQL example with expression parameters and optional parentheses:

```sql
EXECUTE PROCEDURE MakeFullName
('Mr./Mrs. ' || FirstName, MiddleName, upper(LastName))
RETURNING_VALUES (FullName);
```

### 6.8. EXECUTE BLOCK

*Used for*

Creating an “anonymous” block of PSQL code in DSQL for immediate execution

*Available in*

DSQL

*Syntax*

```sql
EXECUTE BLOCK [(<inparams>)]
[RETURNS (<outparams>)]
<psql-module-body>
```

- `<inparams>` ::= `<param_decl> = ? [, <inparams>]`
- `<outparams>` ::= `<param_decl> [, <outparams>]`
- `<param_decl>` ::= `paramname <domain_or_non_array_type> [NOT NULL] [COLLATE collation]`

- `<domain_or_non_array_type>` ::= `!! See Scalar Data Types Syntax !!`
- `<psql-module-body>` ::= `!! See Syntax of a Module Body !!`

*Table 93. Arguments for the EXECUTE BLOCK Statement Parameters*

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>param_decl</td>
<td>Name and description of an input or output parameter</td>
</tr>
<tr>
<td>Argument</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>paramname</td>
<td>The name of an input or output parameter of the procedural block, up to 63 characters long. The name must be unique among input and output parameters and local variables in the block</td>
</tr>
<tr>
<td>collation</td>
<td>Collation sequence</td>
</tr>
</tbody>
</table>

Executes a block of PSQL code as if it were a stored procedure, optionally with input and output parameters and variable declarations. This allows the user to perform “on-the-fly” PSQl within a DSQL context.

### 6.8.1. Examples

1. This example injects the numbers 0 through 127 and their corresponding ASCII characters into the table `ASCIITABLE`:

   ```sql
   EXECUTE BLOCK AS 
   declare i INT = 0; 
   BEGIN 
   WHILE (i < 128) DO 
   BEGIN 
   INSERT INTO AsciiTable VALUES (:i, ascii_char(:i)); 
   i = i + 1; 
   END 
   END
   ```

2. The next example calculates the geometric mean of two numbers and returns it to the user:

   ```sql
   EXECUTE BLOCK (x DOUBLE PRECISION = ?, y DOUBLE PRECISION = ?) RETURNS (gmean DOUBLE PRECISION) AS 
   BEGIN 
   gmean = SQRT(x*y); 
   SUSPEND;
   END
   ```

   Because this block has input parameters, it has to be prepared first. Then the parameters can be set and the block executed. It depends on the client software how this must be done and even if it is possible at all — see the notes below.

3. Our last example takes two integer values, `smallest` and `largest`. For all the numbers in the range `smallest`...`largest`, the block outputs the number itself, its square, its cube and its fourth power.
EXECUTE BLOCK (smallest INT = ?, largest INT = ?) 
RETURNS (number INT, square BIGINT, cube BIGINT, fourth BIGINT) 
AS 
BEGIN 
    number = smallest; 
    WHILE (number <= largest) DO 
    BEGIN 
        square = number * number; 
        cube   = number * square; 
        fourth = number * cube; 
        SUSPEND; 
        number = number + 1; 
    END 
END 

Again, it depends on the client software if and how you can set the parameter values.

6.8.2. Input and output parameters

Executing a block without input parameters should be possible with every Firebird client that allows the user to enter his or her own DSQL statements. If there are input parameters, things get trickier: these parameters must get their values after the statement is prepared, but before it is executed. This requires special provisions, which not every client application offers. (Firebird’s own isql, for one, doesn’t.)

The server only accepts question marks (“?”) as placeholders for the input values, not “:a”, “:MyParam” etc., or literal values. Client software may support the “:xxx” form though, and will preprocess it before sending it to the server.

If the block has output parameters, you must use SUSPEND or nothing will be returned.

Output is always returned in the form of a result set, just as with a SELECT statement. You can’t use RETURNING_VALUES or execute the block INTO some variables, even if there is only one result row.

PSQL Links

For more information about writing PSQL, consult Chapter Procedural SQL (PSQL) Statements.

6.8.3. Statement Terminators

Some SQL statement editors — specifically the isql utility that comes with Firebird and possibly some third-party editors — employ an internal convention that requires all statements to be terminated with a semi-colon. This creates a conflict with PSQL syntax when coding in these environments. If you are unacquainted with this problem and its solution, please study the details in the PSQL chapter in the section entitled Switching the Terminator in isql.
Chapter 7. Procedural SQL (PSQL) Statements

Procedural SQL (PSQL) is a procedural extension of SQL. This language subset is used for writing stored procedures, triggers, and PSQL blocks.

PSQL provides all the basic constructs of traditional structured programming languages, and also includes DML statements (SELECT, INSERT, UPDATE, DELETE, etc.), with a slight modified syntax in some cases.

7.1. Elements of PSQL

A procedural extension may contain declarations of local variables, routines and cursors, assignments, conditional statements, loops, statements for raising custom exceptions, error handling and sending messages (events) to client applications. Triggers have access to special context variables, two arrays that store, respectively, the NEW values for all columns during insert and update activity, and the OLD values during update and delete work.

Statements that modify metadata (DDL) are not available in PSQL.

7.1.1. DML Statements with Parameters

If DML statements (SELECT, INSERT, UPDATE, DELETE, etc.) in the body of the module (procedure, function, trigger or block) use parameters, only named parameters can be used. If DML statements contain named parameters, then they must be previously declared as local variables using DECLARE [VARIABLE] in the declaration section of the module, or as input or output variables in the module header.

When a DML statement with parameters is included in PSQL code, the parameter name must be prefixed by a colon (‘:’) in most situations. The colon is optional in statement syntax that is specific to PSQL, such as assignments and conditionals and the INTO clause. The colon prefix on parameters is not required when calling stored procedures from within another PSQL module or in DSQL.

7.1.2. Transactions

Stored procedures and functions (including those defined in packages) are executed in the context of the transaction in which they are called. Triggers are executed as an intrinsic part of the operation of the DML statement: thus, their execution is within the same transaction context as the statement itself. Individual transactions are launched for database event triggers.

Statements that start and end transactions are not available in PSQL, but it is possible to run a statement or a block of statements in an autonomous transaction.

7.1.3. Module Structure

PSQL code modules consist of a header and a body. The DDL statements for defining them are complex statements; that is, they consist of a single statement that encloses blocks of multiple statements. These statements begin with a verb (CREATE, ALTER, DROP, RECREATE, CREATE OR ALTER) and end with the last END statement of the body.
The Module Header

The header provides the module name and defines any input and output parameters or—for functions—the return type. Stored procedures and PSQL blocks may have input and output parameters. Functions may have input parameters and must have a scalar return type. Triggers do not have either input or output parameters.

The header of a trigger indicates the database event (insert, update or delete, or a combination) and the phase of operation (BEFORE or AFTER that event) that will cause it to “fire”.

The Module Body

The module body is either a PSQL module body, or an external module body.

Syntax of a Module Body

```
<module-body> ::= <psql-module-body> | <external-module-body>

<psql-module-body> ::= AS [<declarations>] BEGIN [<PSQL_statements>] END

<external-module-body> ::= EXTERNAL [NAME <extname>] ENGINE engine [AS '<extbody>']

<declarations> ::= <declare-item> [<declare-item ...]

<declare-item> ::= <declare-var> | <declare-cursor> | <declare-subfunc> | <declare-subproc>

<extname> ::= '<module-name>!<routine-name>[!<misc-info>]

<declare-var> ::= !! See DECLARE VARIABLE !!

<declare-cursor> ::= !! See DECLARE CURSOR !!

<declare-subfunc> ::= !! See DECLARE FUNCTION !!

<declare-subproc>> ::= !! See DECLARE PROCEDURE !!
```
### Parameter | Description
--- | ---
declarations | Section for declaring local variables, named cursors, and subroutines
PSQL_statements | Procedural SQL statements. Some PSQL statements may not be valid in all types of PSQL. For example, `RETURN <value>;` is only valid in functions.
declare_var | Local variable declaration
declare_cursor | Named cursor declaration
declare-subfunc | Sub-function declaration or forward declaration
declare-subproc | Sub-procedure declaration or forward declaration
extname | String identifying the external procedure
textbody | External procedure body. A string literal that can be used by UDRs for various purposes.
engine | String identifying the UDR engine
module-name | The name of the module that contains the procedure
routine-name | The internal name of the procedure inside the external module
misc-info | Optional string that is passed to the procedure in the external module

**The PSQL Module Body**

The PSQL body starts with an optional section that declares variables and subroutines, followed by a block of statements that run in a logical sequence, like a program. A block of statements — or compound statement — is enclosed by the `BEGIN` and `END` keywords, and is executed as a single unit of code. The main `BEGIN…END` block may contain any number of other `BEGIN…END` blocks, both embedded and sequential. Blocks can be nested to a maximum depth of 512 blocks. All statements except `BEGIN` and `END` are terminated by semicolons (`;`). No other character is valid for use as a terminator for PSQL statements.
Switching the Terminator in *isql*

Here we digress a little, to explain how to switch the terminator character in the *isql* utility to make it possible to define PSQL modules in that environment without conflicting with *isql* itself, which uses the same character, semicolon (‘;’), as its own statement terminator.

**isql Command** SET TERM

*Used for*
Changing the terminator character(s) to avoid conflict with the terminator character in PSQL statements

*Available in*
ISQL only

*Syntax*

```
SET TERM new_terminator old_terminator
```

*Table 95. SET TERM Parameters*

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>new_terminator</td>
<td>New terminator</td>
</tr>
<tr>
<td>old_terminator</td>
<td>Old terminator</td>
</tr>
</tbody>
</table>

When you write your triggers and stored procedures in *isql*—either in the interactive interface or in scripts—running a SET TERM statement is needed to switch the normal *isql* statement terminator from the semicolon to some other character or short string, to avoid conflict with the non-changeable semicolon terminator in PSQL. The switch to an alternative terminator needs to be done before you begin defining PSQL objects or running your scripts.

The alternative terminator can be any string of characters except for a space, an apostrophe or the current terminator character(s). Any letter character(s) used will be case-sensitive.

*Example*

Changing the default semicolon to ‘^’ (caret) and using it to submit a stored procedure definition: character as an alternative terminator character:
The External Module Body

The external module body specifies the UDR engine used to execute the external module, and optionally specifies the name of the UDR routine to call (<extname>) and/or a string (<extbody>) with UDR-specific semantics.

Configuration of external modules and UDR engines is not covered further in this Language Reference. Consult the documentation of a specific UDR engine for details.

7.2. Stored Procedures

A stored procedure is executable code stored in the database metadata for execution on the server. A stored procedure can be called by other stored procedures (including itself), functions, triggers and client applications. A procedure that calls itself is known as recursive.

7.2.1. Benefits of Stored Procedures

Stored procedures have the following advantages:

**Modularity**
applications working with the database can use the same stored procedure, thereby reducing the size of the application code and avoiding code duplication.

**Simpler Application Support**
when a stored procedure is modified, changes appear immediately to all host applications, without the need to recompile them if the parameters were unchanged.

**Enhanced Performance**
since stored procedures are executed on a server instead of at the client, network traffic is reduced, which improves performance.
7.2.2. Types of Stored Procedures

Firebird supports two types of stored procedures: executable and selectable.

Executable Procedures

Executable procedures usually modify data in a database. They can receive input parameters and return a single set of output (RETURNS) parameters. They are called using the EXECUTE PROCEDURE statement. See an example of an executable stored procedure at the end of the CREATE PROCEDURE section of Chapter 5.

Selectable Procedures

Selectable stored procedures usually retrieve data from a database, returning an arbitrary number of rows to the caller. The caller receives the output one row at a time from a row buffer that the database engine prepares for it.

Selectable procedures can be useful for obtaining complex sets of data that are often impossible or too difficult or too slow to retrieve using regular DSQI SELECT queries. Typically, this style of procedure iterates through a looping process of extracting data, perhaps transforming it before filling the output variables (parameters) with fresh data at each iteration of the loop. A SUSPEND statement at the end of the iteration fills the buffer and waits for the caller to fetch the row. Execution of the next iteration of the loop begins when the buffer has been cleared.

Selectable procedures may have input parameters, and the output set is specified by the RETURNS clause in the header.

A selectable stored procedure is called with a SELECT statement. See an example of a selectable stored procedure at the end of the CREATE PROCEDURE section of Chapter 5.

7.2.3. Creating a Stored Procedure

The syntax for creating executable stored procedures and selectable stored procedures is exactly the same. The difference comes in the logic of the program code.

For information about creating stored procedures, see CREATE PROCEDURE in Chapter Data Definition (DDL) Statements.

7.2.4. Modifying a Stored Procedure

For information about modifying existing stored procedures, see ALTER PROCEDURE, CREATE OR ALTER PROCEDURE, RECREATE PROCEDURE, in Chapter Data Definition (DDL) Statements.

7.2.5. Deleting a Stored Procedure

For information about deleting stored procedures, see DROP PROCEDURE in Chapter Data Definition (DDL) Statements.
7.3. Stored Functions

A stored function is executable code stored in the database metadata for execution on the server. A stored function can be called by other stored functions (including itself), procedures, triggers and client applications. A function that calls itself is known as recursive.

Unlike stored procedures, stored functions always return one scalar value. To return a value from a stored function, use the `RETURN` statement, which immediately terminates the function.

7.3.1. Creating a Stored Function

For information about creating stored functions, see `CREATE FUNCTION` in Chapter Data Definition (DDL) Statements.

7.3.2. Modifying a Stored Function

For information about modifying stored functions, see `ALTER FUNCTION`, `CREATE OR ALTER FUNCTION`, `RECREATE FUNCTION`, in Chapter Data Definition (DDL) Statements.

7.3.3. Deleting a Stored Function

For information about deleting stored procedures, see `DROP FUNCTION` in Chapter Data Definition (DDL) Statements.

7.4. PSQL Blocks

A self-contained, unnamed (“anonymous”) block of PSQL code can be executed dynamically in DSQL, using the `EXECUTE BLOCK` syntax. The header of an anonymous PSQL block may optionally contain input and output parameters. The body may contain local variables, cursor declarations and local routines, followed by a block of PSQL statements.

An anonymous PSQL block is not defined and stored as an object, unlike stored procedures and triggers. It executes in run-time and cannot reference itself.

Just like stored procedures, anonymous PSQL blocks can be used to process data and to retrieve data from the database.

Syntax (incomplete)

```sql
EXECUTE BLOCK
   [([<inparam> = ? [, <inparam> = ? ...]])
   [RETURNS (<outparam> [, <outparam> ...])]
   <psql-module-body>

<psql-module-body> ::= 
   !! See Syntax of Module Body !!
```

Table 96. PSQL Block Parameters
### 7.5. Packages

A package is a group of stored procedures and function defined as a single database object.

Firebird packages are made up of two parts: a header (`PACKAGE` keyword) and a body (`PACKAGE BODY` keywords). This separation is very similar to Delphi modules, the header corresponds to the interface part, and the body corresponds to the implementation part.

#### 7.5.1. Benefits of Packages

The notion of “packaging” the code components of a database operation addresses has several advantages:

**Modularisation**

Blocks of interdependent code are grouped into logical modules, as done in other programming languages.

In programming, it is well recognised that grouping code in various ways, in namespaces, units or classes, for example, is a good thing. This is not possible with standard stored procedures and functions in the database. Although they can be grouped in different script files, two problems remain:

a. The grouping is not represented in the database metadata.

b. Scripted routines all participate in a flat namespace and are callable by everyone (we are not referring to security permissions here).

**Easier tracking of dependencies**

Packages make it easy to track dependencies between a collection of related routines, as well as between this collection and other routines, both packaged and unpackaged.

Whenever a packaged routine determines that it uses a certain database object, a dependency on that object is registered in Firebird’s system tables. Thereafter, to drop, or maybe alter that object, you first need to remove what depends on it. Since the dependency on other objects only exists for the package body, and not the package body, this package body can easily be removed, even if some other object depends on this package. When the body is dropped, the header remains, allowing you to recreate its body once the changes related to the removed object are done.
Simplify permission management

As Firebird runs routines with the caller privileges, it is necessary also to grant resource usage to each routine when these resources would not be directly accessible to the caller. Usage of each routine needs to be granted to users and/or roles.

Packaged routines do not have individual privileges. The privileges apply to the package as a whole. Privileges granted to packages are valid for all package body routines, including private ones, but are stored for the package header. An EXECUTE privilege on a package granted to a user (or other object), grants that user the privilege to execute all routines defined in the package header.

For example

```
GRANT SELECT ON TABLE secret TO PACKAGE pk_secret;
GRANT EXECUTE ON PACKAGE pk_secret TO ROLE role_secret;
```

Private scopes

Stored procedures and functions can be privates; that is, make them available only for internal usage within the defining package.

All programming languages have the notion of routine scope, which is not possible without some form of grouping. Firebird packages also work like Delphi units in this regard. If a routine is not declared in the package header (interface) and is implemented in the body (implementation), it becomes a private routine. A private routine can only be called from inside its package.

7.5.2. Creating a Package

For information on creating packages, see CREATE PACKAGE, CREATE PACKAGE BODY

7.5.3. Modifying a Package

For information on modifying existing package header or bodies, see ALTER PACKAGE, CREATE OR ALTER PACKAGE, RECREATE PACKAGE, ALTER PACKAGE BODY, RECREATE PACKAGE BODY

7.5.4. Deleting a Package

For information on deleting a package, see DROP PACKAGE, DROP PACKAGE BODY

7.6. Triggers

A trigger is another form of executable code that is stored in the metadata of the database for execution by the server. A trigger cannot be called directly. It is called automatically (“fired”) when data-changing events involving one particular table or view occur, or on a specific database event.

A trigger applies to exactly one table or view or database event, and only one phase in an event (BEFORE or AFTER the event). A single DML trigger might be written to fire only when one specific data-changing event occurs (INSERT, UPDATE or DELETE), or it might be written to apply to more than one of those.
A DML trigger is executed in the context of the transaction in which the data-changing DML statement is running. For triggers that respond to database events, the rule is different: for DDL triggers and transaction triggers, the trigger runs in the same transaction that executed the DDL, for other types, a new default transaction is started.

### 7.6.1. Firing Order (Order of Execution)

More than one trigger can be defined for each phase-event combination. The order in which they are executed (known as “firing order” can be specified explicitly with the optional `POSITION` argument in the trigger definition. You have 32,767 numbers to choose from. Triggers with the lowest position numbers fire first.

If a `POSITION` clause is omitted, or if several matching event-phase triggers have the same position number, then the triggers will fire in alphabetical order.

### 7.6.2. DML Triggers

DML triggers are those that fire when a DML operation changes the state of data: updating rows in tables, inserting new rows or deleting rows. They can be defined for both tables and views.

#### Trigger Options

Six base options are available for the event-phase combination for tables and views:

- Before a new row is inserted: `BEFORE INSERT`
- After a new row is inserted: `AFTER INSERT`
- Before a row is updated: `BEFORE UPDATE`
- After a row is updated: `AFTER UPDATE`
- Before a row is deleted: `BEFORE DELETE`
- After a row is deleted: `AFTER DELETE`

These base forms are for creating single phase/single-event triggers. Firebird also supports forms for creating triggers for one phase and multiple-events, `BEFORE INSERT OR UPDATE OR DELETE`, for example, or `AFTER UPDATE OR DELETE`: the combinations are your choice.

> “Multi-phase” triggers, such as `BEFORE OR AFTER …`, are not possible.

The Boolean context variables `INSERTING`, `UPDATING` and `DELETING` can be used in the body of a trigger to determine the type of event that fired the trigger.

#### OLD and NEW Context Variables

For DML triggers, the Firebird engine provides access to sets of `OLD` and `NEW` context variables. Each is an array of the values of the entire row: one for the values as they are before the data-changing event (the `BEFORE` phase) and one for the values as they will be after the event (the `AFTER` phase). They are referenced in statements using the form `NEW.column_name` and `OLD.column_name`, respectively. The `column_name` can be any column in the table’s definition, not just those that are
being updated.

The NEW and OLD variables are subject to some rules:

- In all triggers, the OLD value is read-only
- In BEFORE UPDATE and BEFORE INSERT code, the NEW value is read/write, unless it is a COMPUTED BY column
- In INSERT triggers, references to the OLD variables are invalid and will throw an exception
- In DELETE triggers, references to the NEW variables are invalid and will throw an exception
- In all AFTER trigger code, the NEW variables are read-only

### 7.6.3. Database Triggers

A trigger associated with a database or transaction event can be defined for the following events:

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Event Type</th>
<th>Trigger Execution Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connecting to a database</td>
<td>ON CONNECT</td>
<td>Before the trigger is executed, a default transaction is automatically started</td>
</tr>
<tr>
<td>Disconnecting from a database</td>
<td>ON DISCONNECT</td>
<td>Before the trigger is executed, a default transaction is automatically started</td>
</tr>
<tr>
<td>When a transaction is started</td>
<td>ON TRANSACTION START</td>
<td>The trigger is executed in the current transaction context</td>
</tr>
<tr>
<td>When a transaction is committed</td>
<td>ON TRANSACTION COMMIT</td>
<td>The trigger is executed in the current transaction context</td>
</tr>
<tr>
<td>When a transaction is cancelled</td>
<td>ON TRANSACTION ROLLBACK</td>
<td>The trigger is executed in the current transaction context</td>
</tr>
</tbody>
</table>

### 7.6.4. DDL Triggers

DDL triggers fire on specified metadata changes events in a specified phase. BEFORE triggers run before changes to system tables. AFTER triggers run after changes in system tables.

DDL triggers are a specific type of database trigger, so most rules for and semantics of database triggers also apply for DDL triggers.

**Semantics**

1. **BEFORE** triggers are fired before changes to the system tables. **AFTER** triggers are fired after system table changes.

   **Important Rule**
   
   The event type [BEFORE | AFTER] of a DDL trigger cannot be changed.

2. When a DDL statement fires a trigger that raises an exception (BEFORE or AFTER, intentionally or unintentionally) the statement will not be committed. That is, exceptions can be used to ensure that a DDL operation will fail if the conditions are not precisely as intended.
3. DDL trigger actions are executed only when committing the transaction in which the affected DDL command runs. Never overlook the fact that what is possible to do in an AFTER trigger is exactly what is possible to do after a DDL command without autocommit. You cannot, for example, create a table and then use it in the trigger.

4. With “CREATE OR ALTER” statements, a trigger is fired one time at the CREATE event or the ALTER event, according to the previous existence of the object. With RECREATE statements, a trigger is fired for the DROP event if the object exists, and for the CREATE event.

5. ALTER and DROP events are generally not fired when the object name does not exist. For the exception, see point 6.

6. The exception to rule 5 is that BEFORE ALTER/DROP USER triggers fire even when the username does not exist. This is because, underneath, these commands perform DML on the security database, and the verification is not done before the command on it is run. This is likely to be different with embedded users, so do not write code that depends on this.

7. If some exception is raised after the DDL command starts its execution and before AFTER triggers are fired, AFTER triggers will not be fired.

8. Packaged procedures and triggers do not fire individual {CREATE | ALTER | DROP} {PROCEDURE | FUNCTION} triggers.

The DDL_TRIGGER Context Namespace

When a DDL trigger is running, the DDL_TRIGGER namespace is available for use with RDB$GET_CONTEXT. This namespace contains information on the currently firing trigger.

See also The DDL_TRIGGER Namespace in RDB$GET_CONTEXT in Chapter Built-in Scalar Functions.

7.6.5. Creating Triggers

For information on creating triggers, see CREATE TRIGGER, CREATE OR ALTER TRIGGER, RECREATE TRIGGER in Chapter Data Definition (DDL) Statements.

7.6.6. Modifying Triggers

For information on modifying triggers, see ALTER TRIGGER, CREATE OR ALTER TRIGGER, RECREATE TRIGGER in Chapter Data Definition (DDL) Statements.

7.6.7. Deleting a Trigger

For information on deleting triggers, see DROP TRIGGER in Chapter Data Definition (DDL) Statements.

7.7. Writing the Body Code

This section takes a closer look at the procedural SQL language constructs and statements that are available for coding the body of a stored procedure, trigger or anonymous PSQL block.
Colon Marker (‘:’)

The colon marker prefix (‘:’) is used in PSQL to mark a reference to a variable in a DML statement. The colon marker is not required before variable names in other PSQL code.

Since Firebird 3.0, the colon prefix can also be used for the NEW and OLD contexts, and for cursor variables.

7.7.1. Assignment Statements

Used for
Assigning a value to a variable

Available in
PSQL

Syntax

\[ \text{varname} = \text{value_expr}; \]

Table 97. Assignment Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>varname</td>
<td>Name of a parameter or local variable</td>
</tr>
<tr>
<td>value_expr</td>
<td>An expression, constant or variable whose value resolves to the same data type as varname</td>
</tr>
</tbody>
</table>

PSQL uses the equal symbol (‘=’) as its assignment operator. The assignment statement assigns an SQL expression value on the right to the variable on the left of the operator. The expression can be any valid SQL expression: it may contain literals, internal variable names, arithmetic, logical and string operations, calls to internal functions, stored functions or external functions (UDFs).

Example using assignment statements
CREATE PROCEDURE MYPROC (  
a INTEGER,
b INTEGER,
name VARCHAR (30)
)
RETURNS (  
c INTEGER,
str VARCHAR(100)
)  
AS
BEGIN
   -- assigning a constant
   c = 0;
   str = '';
   SUSPEND;
   -- assigning expression values
   c = a + b;
   str = name || CAST(b AS VARCHAR(10));
   SUSPEND;
   -- assigning expression value
   -- built by a query
   c = (SELECT 1 FROM rdb$database);
   -- assigning a value from a context variable
   str = CURRENT_USER;
   SUSPEND;
END

See also
DECLARE VARIABLE

7.7.2. Management Statements in PSQL

Management statement are allowed in PSQL blocks (triggers, procedures, functions and EXECUTE BLOCK), which is especially helpful for applications that need some management statements to be executed at the start of a session, specifically in ON CONNECT triggers.

The management statements permitted in PSQL are:

   ALTER SESSION RESET
   SET BIND
   SET DECFLOAT
   SET ROLE
   SET SESSION IDLE TIMEOUT
   SET STATEMENT TIMEOUT
   SET TIME ZONE
   SET TRUSTED ROLE
Example of Management Statements in PSQL

```sql
create or alter trigger on_connect on connect
as
begin
    set bind of decfloat to double precision;
    set time zone 'America/Sao_Paulo';
end
```

Although useful as a workaround, using `ON CONNECT` triggers to configure bind and time zone is usually not the right approach.

See also
Management Statements

7.7.3. DECLARE VARIABLE

*Used for*
Declaring a local variable

*Available in*
PSQL

*Syntax*

```
DECLARE [VARIABLE] varname
    <domain_or_non_array_type> [NOT NULL] [COLLATE collation]
    [{DEFAULT | = } <initvalue>];

<domain_or_non_array_type> ::= !! See Scalar Data Types Syntax !!

<initvalue> ::= <literal> | <context_var>
```

Table 98. DECLARE VARIABLE Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>varname</td>
<td>Name of the local variable</td>
</tr>
<tr>
<td>collation</td>
<td>Collation sequence</td>
</tr>
<tr>
<td>initvalue</td>
<td>Initial value for this variable</td>
</tr>
<tr>
<td>literal</td>
<td>Literal of a type compatible with the type of the local variable</td>
</tr>
<tr>
<td>context_var</td>
<td>Any context variable whose type is compatible with the type of the local variable</td>
</tr>
</tbody>
</table>

The statement `DECLARE [VARIABLE]` is used for declaring a local variable. The keyword `VARIABLE` can be omitted. One `DECLARE [VARIABLE]` statement is required for each local variable. Any number of
DECLARE [VARIABLE] statements can be included and in any order. The name of a local variable must be unique among the names of local variables and input and output parameters declared for the module.

A special case of DECLARE [VARIABLE] — declaring cursors — is covered separately in DECLARE .. CURSOR

Data Type for Variables

A local variable can be of any SQL type other than an array.

- A domain name can be specified as the type; the variable will inherit all of its attributes.
- If the TYPE OF domain clause is used instead, the variable will inherit only the domain's data type, and, if applicable, its character set and collation attributes. Any default value or constraints such as NOT NULL or CHECK constraints are not inherited.
- If the TYPE OF COLUMN relation.column option is used to “borrow” from a column in a table or view, the variable will inherit only the column's data type, and, if applicable, its character set and collation attributes. Any other attributes are ignored.

NOT NULL Constraint

For local variables, you can specify the NOT NULL constraint, disallowing NULL values for the variable. If a domain has been specified as the data type and the domain already has the NOT NULL constraint, the declaration is unnecessary. For other forms, including use of a domain that is nullable, the NOT NULL constraint can be included if needed.

CHARACTER SET and COLLATE clauses

Unless specified, the character set and collation sequence of a string variable will be the database defaults. A CHARACTER SET clause can be included, if required, to handle string data that is going to be in a different character set. A valid collation sequence (COLLATE clause) can also be included, with or without the character set clause.

Initializing a Variable

Local variables are NULL when execution of the module begins. They can be initialized so that a starting or default value is available when they are first referenced. The DEFAULT <initvalue> form can be used, or just the assignment operator, '=': <initvalue> = <initvalue>. The value can be any type-compatible literal or context variable, including NULL.

Be sure to use this clause for any variables that have a NOT NULL constraint and do not otherwise have a default value available.

Examples of various ways to declare local variables
CREATE OR ALTER PROCEDURE SOME_PROC
AS
-- Declaring a variable of the INT type
DECLARE I INT;
-- Declaring a variable of the INT type that does not allow NULL
DECLARE VARIABLE J INT NOT NULL;
-- Declaring a variable of the INT type with the default value of 0
DECLARE VARIABLE K INT DEFAULT 0;
-- Declaring a variable of the INT type with the default value of 1
DECLARE VARIABLE L INT = 1;
-- Declaring a variable based on the COUNTRYNAME domain
DECLARE FARM_COUNTRY COUNTRYNAME;
-- Declaring a variable of the type equal to the COUNTRYNAME domain
DECLARE FROM_COUNTRY TYPE OF COUNTRYNAME;
-- Declaring a variable with the type of the CAPITAL column in the COUNTRY table
DECLARE CAPITAL TYPE OF COLUMN COUNTRY.CAPITAL;
BEGIN
  /* PSQL statements */
END

See also
Data Types and Subtypes, Custom Data Types — Domains, CREATE DOMAIN

7.7.4. DECLARE .. CURSOR

Used for
Declaring a named cursor

Available in
PSQL

Syntax

DECLARE [VARIABLE] cursor_name
  [[NO] SCROLL] CURSOR
FOR (<select>);

Table 99. DECLARE ⋯ CURSOR Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cursor_name</td>
<td>Cursor name</td>
</tr>
<tr>
<td>select</td>
<td>SELECT statement</td>
</tr>
</tbody>
</table>

The DECLARE ⋯ CURSOR ⋯ FOR statement binds a named cursor to the result set obtained in the SELECT statement specified in the FOR clause. In the body code, the cursor can be opened, used to iterate row-by-row through the result set, and closed. While the cursor is open, the code can perform positioned updates and deletes using the WHERE CURRENT OF in the UPDATE or DELETE
Forward-Only and Scrollable Cursors

The cursor can be forward-only (unidirectional) or scrollable. The optional clause SCROLL makes the cursor scrollable, the NO SCROLL clause, forward-only. By default, cursors are forward-only.

Forward-only cursors can—as the name implies—only move forward in the dataset. Forward-only cursors only support the FETCH [NEXT FROM] statement, other commands raise an error. Scrollable cursors allow you to move not only forward in the dataset, but also back, as well as N positions relative to the current position.

Scrollable cursors are materialized as a temporary dataset, as such, they consume additional memory or disk space, so use them only when you really need them.

Cursor Idiosyncrasies

- The optional FOR UPDATE clause can be included in the SELECT statement, but its absence does not prevent successful execution of a positioned update or delete.

- Care should be taken to ensure that the names of declared cursors do not conflict with any names used subsequently in statements for AS CURSOR clauses.

- If the cursor is needed only to walk the result set, it is nearly always easier and less error-prone to use a FOR SELECT statement with the AS CURSOR clause. Declared cursors must be explicitly opened, used to fetch data, and closed. The context variable ROW_COUNT has to be checked after each fetch and, if its value is zero, the loop has to be terminated. A FOR SELECT statement does this automatically.

Nevertheless, declared cursors provide a high level of control over sequential events and allow several cursors to be managed in parallel.

- The SELECT statement may contain parameters. For instance:

```sql
SELECT NAME || :SFX FROM NAMES WHERE NUMBER = :NUM
```

Each parameter has to have been declared beforehand as a PSQL variable, even if they originate as input and output parameters. When the cursor is opened, the parameter is assigned the current value of the variable.
Unstable Variables and Cursors

If the value of the PSQL variable used in the SELECT statement of the cursor changes during the execution of the loop, then its new value may—but not always—be used when selecting the next rows. It is better to avoid such situations. If you really need this behaviour, then you should thoroughly test your code and make sure you understand how changes to the variable affect the query results.

Note particularly that the behaviour may depend on the query plan, specifically on the indexes being used. Currently, there are no strict rules for this behaviour, and this may change in future versions of Firebird.

Examples Using Named Cursors

1. Declaring a named cursor in the trigger.

```sql
CREATE OR ALTER TRIGGER TBU_STOCK
    BEFORE UPDATE ON STOCK
AS
    DECLARE C_COUNTRY CURSOR FOR (
        SELECT
            COUNTRY,
            CAPITAL
        FROM COUNTRY
    );
BEGIN
    /* PSQL statements */
END
```

2. Declaring a scrollable cursor

```sql
EXECUTE BLOCK
    RETURNS (
        N INT,
        RNAME CHAR(63)
    )
AS
    - Declaring a scrollable cursor
    DECLARE C SCROLL CURSOR FOR (
        SELECT
            ROW_NUMBER() OVER (ORDER BY RDB$RELATION_NAME) AS N,
            RDB$RELATION_NAME
        FROM RDB$RELATIONS
        ORDER BY RDB$RELATION_NAME);
BEGIN
    /* PSQL statements */
END
```
EXECUTE BLOCK
RETURNS (SCRIPT BLOB SUB_TYPE TEXT)
AS
DECLARE VARIABLE FIELDS VARCHAR(8191);
DECLARE VARIABLE FIELD_NAME TYPE OF RDB$FIELD_NAME;
DECLARE VARIABLE RELATION RDB$RELATION_NAME;
DECLARE VARIABLE SOURCE TYPE OF COLUMN RDB$RELATIONS.RDB$VIEW_SOURCE;
DECLARE VARIABLE CUR_R CURSOR FOR (
  SELECT
    RDB$RELATION_NAME,
    RDB$VIEW_SOURCE
  FROM
    RDB$RELATIONS
  WHERE
    RDB$VIEW_SOURCE IS NOT NULL);
-- Declaring a named cursor where
-- a local variable is used
DECLARE CUR_F CURSOR FOR (
  SELECT
    RDB$FIELD_NAME
  FROM
    RDB$RELATION_FIELDS
  WHERE
    -- It is important that the variable must be declared earlier
    RDB$RELATION_NAME = :RELATION);
BEGIN
  OPEN CUR_R;
  WHILE (1 = 1) DO
    BEGIN
      FETCH CUR_R
      INTO :RELATION, :SOURCE;
      IF (ROW_COUNT = 0) THEN
        LEAVE;
      END
      FIELDS = NULL;
      -- The CUR_F cursor will use the value
      -- of the RELATION variable initiated above
      OPEN CUR_F;
      WHILE (1 = 1) DO
        BEGIN
          FETCH CUR_F
          INTO :FIELD_NAME;
          IF (ROW_COUNT = 0) THEN
            LEAVE;
          END
          IF (FIELDS IS NULL) THEN
            FIELDS = TRIM(FIELD_NAME);
          ELSE
            FIELDS = FIELDS || TRIM(FIELD_NAME);
          END
        END
      END
    END
  END
END;
FIELDS = FIELDS || ', ' || TRIM(FIELD_NAME);
END
CLOSE CUR_F;

SCRIPT = 'CREATE VIEW ' || RELATION;
IF (FIELDS IS NOT NULL) THEN
    SCRIPT = SCRIPT || ' (' || FIELDS || ');
SCRIPT = SCRIPT || ' AS ' || ASCII_CHAR(13);
SCRIPT = SCRIPT || SOURCE;
SUSPEND;
END
CLOSE CUR_R;
END

See also
OPEN, FETCH, CLOSE

7.7.5. DECLARE FUNCTION

Used for
Declaring a sub-function

Available in
PSQL

Syntax

<declare-subfunc> ::= <subfunc-forward> | <subfunc-def>

<subfunc-forward> ::= <subfunc-header>;

<subfunc-def> ::= <subfunc-header> <psql-module-body>

<subfunc-header> ::= DECLARE FUNCTION subfuncname [ ( [ <in_params> ] ) ]
    RETURNS <domain_or_non_array_type> [COLLATE collation]
    [DETERMINISTIC]

<in_params> ::= !! See CREATE FUNCTION Syntax !!

<domain_or_non_array_type> ::= !! See Scalar Data Types Syntax !!

<psql-module-body> ::= !! See Syntax of Module Body !!
Table 100. DECLARE FUNCTION Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>subfuncname</td>
<td>Sub-function name</td>
</tr>
<tr>
<td>collation</td>
<td>Collation name</td>
</tr>
</tbody>
</table>

The DECLARE FUNCTION statement declares a sub-function. A sub-function is only visible to the PSQL module that defined the sub-function.

Sub-functions have a number of restrictions:

- A sub-function cannot be nested in another subroutine. Subroutines are only supported in top-level PSQL modules (stored procedures, stored functions, triggers and anonymous PSQL blocks). This restriction is not enforced by the syntax, but attempts to create nested sub-functions will raise an error “feature is not supported” with detail message “nested sub function”.

- Currently, the sub-function has no direct access to use variables and cursors from its parent module. However, it can access other routines from its parent modules, including recursive calls to itself. In some cases a forward declaration of the routine may be necessary.

A sub-function can be forward declared to resolve mutual dependencies between subroutine, and must be followed by its actual definition. When a sub-function is forward declared and has parameters with default values, the default values should only be specified in the forward declaration, and should not be repeated in subfunc_def.

- Declaring a sub-function with the same name as a stored function will hide that stored function from your module. It will not be possible to call that stored function.

- Contrary to DECLARE [VARIABLE], a DECLARE FUNCTION is not terminated by a semicolon. The END of its main BEGIN … END block is considered its terminator.

Examples of Sub-Functions

1. Subfunction within a stored function
CREATE OR ALTER FUNCTION FUNC1 (n1 INTEGER, n2 INTEGER)
RETURNS INTEGER
AS
- Subfunction
  DECLARE FUNCTION SUBFUNC (n1 INTEGER, n2 INTEGER)
  RETURNS INTEGER
  AS
  BEGIN
    RETURN n1 + n2;
  END
  BEGIN
    RETURN SUBFUNC (n1, n2);
  END

2. Recursive function call

execute block returns (i integer, o integer)
as
  -- Recursive function without forward declaration.
  declare function fibonacci(n integer) returns integer
  as
  begin
    if (n = 0 or n = 1) then
      return n;
    else
      return fibonacci(n - 1) + fibonacci(n - 2);
    end
  begin
    i = 0;
    while (i < 10)
      do
        o = fibonacci(i);
        suspend;
        i = i + 1;
      end
  end

See also
DECLARE PROCEDURE, CREATE FUNCTION

7.7.6. DECLARE PROCEDURE

Used for
Declaring a sub-procedure
### Available in

PSQL

### Syntax

```latex
<declare-subproc> ::= <subproc-forward> | <subproc-def>

<subproc-forward> ::= <subproc-header>;

<subproc-def> ::= <subproc-header> <psql-module-body>

<subproc-header> ::= DECLARE subprocname [ ( [ <in_params> ] ) ] [RETURNS (<out_params>)]

<in_params> ::= !! See CREATE PROCEDURE Syntax !!

<domain_or_non_array_type> ::= !! See Scalar Data Types Syntax !!

<psql-module-body> ::= !! See Syntax of Module Body !!
```

### Table 101. DECLARE PROCEDURE Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>subprocname</td>
<td>Sub-procedure name</td>
</tr>
<tr>
<td>collation</td>
<td>Collation name</td>
</tr>
</tbody>
</table>

The DECLARE PROCEDURE statement declares a sub-procedure. A sub-procedure is only visible to the PSQL module that defined the sub-procedure.

Sub-procedures have a number of restrictions:

- A sub-procedure cannot be nested in another subroutine. Subroutines are only supported in top-level PSQL modules (stored procedures, stored functions, triggers and anonymous PSQL blocks). This restriction is not enforced by the syntax, but attempts to create nested sub-procedures will raise an error “feature is not supported” with detail message “nested sub procedure”.

- Currently, the sub-procedure has no direct access to use variables and cursors from its parent module. It can access other routines from its parent modules. In some cases a forward declaration may be necessary.

A sub-procedure can be forward declared to resolve mutual dependencies between subroutines, and must be followed by its actual definition. When a sub-procedure is forward declared and has parameters with default values, the default values should only be specified in the forward declaration, and should not be repeated in `subproc_def`.
Declaring a sub-procedure with the same name as a stored procedure, table or view will hide that stored procedure, table or view from your module. It will not be possible to call that stored procedure, table or view.

Contrary to DECLARE [VARIABLE], a DECLARE PROCEDURE is not terminated by a semicolon. The END of its main BEGIN … END block is considered its terminator.

Examples of Sub-Procedures

1. Subroutines in EXECUTE BLOCK

```sql
EXECUTE BLOCK
  RETURNS (name VARCHAR(63))
AS
  -- Sub-procedure returning a list of tables
  DECLARE PROCEDURE get_tables
    RETURNS (table_name VARCHAR(63))
  AS
    BEGIN
      FOR SELECT RDB$RELATION_NAME
        FROM RDB$RELATIONS
        WHERE RDB$VIEW_BLR IS NULL
        INTO table_name
      DO SUSPEND;
    END
  -- Sub-procedure returning a list of views
  DECLARE PROCEDURE get_views
    RETURNS (view_name VARCHAR(63))
  AS
    BEGIN
      FOR SELECT RDB$RELATION_NAME
        FROM RDB$RELATIONS
        WHERE RDB$VIEW_BLR IS NOT NULL
        INTO view_name
      DO SUSPEND;
    END
  BEGIN
    FOR SELECT table_name
      FROM get_tables
    UNION ALL
    SELECT view_name
      FROM get_views
    INTO name
    DO SUSPEND;
  END
```

2. With forward declaration and parameter with default value
execute block returns (o integer)
    as
    -- Forward declaration of P1.
    declare procedure p1(i integer = 1) returns (o integer);

    -- Forward declaration of P2.
    declare procedure p2(i integer) returns (o integer);

    -- Implementation of P1 should not re-declare parameter default value.
    declare procedure p1(i integer) returns (o integer)
    as
    begin
        execute procedure p2(i) returning_values o;
    end

    declare procedure p2(i integer) returns (o integer)
    as
    begin
        o = i;
    end
    begin
        execute procedure p1 returning_values o;
        suspend;
    end

See also

DECLARE FUNCTION, CREATE PROCEDURE

7.7.7. BEGIN … END

Used for
Delimiting a block of statements

Available in
PSQL

Syntax

<block> ::= 
    BEGIN
    [ <compound_statement> ... ]
    END

<compound_statement> ::= { <block> | <statement> }

The BEGIN … END construct is a two-part statement that wraps a block of statements that are executed as one unit of code. Each block starts with the half-statement BEGIN and ends with the other half-statement END. Blocks can be nested a maximum depth of 512 nested blocks. A block can
be empty, allowing them to act as stubs, without the need to write dummy statements.

The BEGIN and END statements have no line terminators (semicolon). However, when defining or altering a PSQL module in the \textit{isql} utility, that application requires that the last END statement be followed by its own terminator character, that was previously switched — using \texttt{SET TERM} — to some string other than a semicolon. That terminator is not part of the PSQL syntax.

The final, or outermost, \texttt{END} statement in a trigger terminates the trigger. What the final \texttt{END} statement does in a stored procedure depends on the type of procedure:

- In a selectable procedure, the final \texttt{END} statement returns control to the caller, returning SQLCODE 100, indicating that there are no more rows to retrieve
- In an executable procedure, the final \texttt{END} statement returns control to the caller, along with the current values of any output parameters defined.

\texttt{BEGIN \ldots END Examples}
A sample procedure from the employee.fdb database, showing simple usage of BEGIN…END blocks:

```sql
SET TERM ^;
CREATE OR ALTER PROCEDURE DEPT_BUDGET (
    DNO CHAR(3))
RETURNS (
    TOT DECIMAL(12,2))
AS
    DECLARE VARIABLE SUMB DECIMAL(12,2);
    DECLARE VARIABLE RDNO CHAR(3);
    DECLARE VARIABLE CNT  INTEGER;
BEGIN
    TOT = 0;

    SELECT BUDGET
    FROM DEPARTMENT
    WHERE DEPT_NO = :DNO
    INTO :TOT;

    SELECT COUNT(BUDGET)
    FROM DEPARTMENT
    WHERE HEAD_DEPT = :DNO
    INTO :CNT;

    IF (CNT = 0) THEN
        SUSPEND;

    FOR SELECT DEPT_NO
        FROM DEPARTMENT
        WHERE HEAD_DEPT = :DNO
        INTO :RDNO
    DO
        BEGIN
            EXECUTE PROCEDURE DEPT_BUDGET(:RDNO)
                RETURNING_VALUES :SUMB;
            TOT = TOT + SUMB;
        END

        SUSPEND;
    END

    END^;
SET TERM ;^ 
```

See also
EXIT, SET TERM

**7.7.8. IF ⋅⋅ THEN ⋅⋅ ELSE**

*Used for*
Conditional branching
Available in
PSQL

Syntax

```
IF (<condition>)
    THEN <compound_statement>
    [ELSE <compound_statement>]
```

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>condition</td>
<td>A logical condition returning TRUE, FALSE or UNKNOWN</td>
</tr>
<tr>
<td>compound_statement</td>
<td>A single statement, or two or more statements wrapped in BEGIN · · END</td>
</tr>
</tbody>
</table>

Table 102. IF · · THEN · · ELSE Parameters

The conditional branch statement `IF · · THEN` is used to branch the execution process in a PSQL module. The condition is always enclosed in parentheses. If the condition returns the value TRUE, execution branches to the statement or the block of statements after the keyword `THEN`. If an `ELSE` is present, and the condition returns FALSE or UNKNOWN, execution branches to the statement or the block of statements after it.
Multi-Branch Decisions

PSQL does not provide more advanced multi-branch jumps, such as CASE or SWITCH. However, it is possible to chain IF … THEN … ELSE statements, see the example section below. Alternatively, the CASE statement from DSQL is available in PSQL and is able to satisfy at least some use cases in the manner of a switch:

```sql
CASE <test_expr>
  WHEN <expr> THEN <result>
  [WHEN <expr> THEN <result> ...]
  [ELSE <defaultresult>]
END

CASE
  WHEN <bool_expr> THEN <result>
  [WHEN <bool_expr> THEN <result> ...]
  [ELSE <defaultresult>]
END
```

**Example in PSQL**

```sql
...  
C = CASE
    WHEN A=2 THEN 1
    WHEN A=1 THEN 3
    ELSE 0
    END;
...
```

**IF Examples**

1. An example using the If statement. Assume that the FIRST, LINE2 and LAST variables were declared earlier.

   ```sql
   ...
   IF (FIRST IS NOT NULL) THEN
     LINE2 = FIRST || ' ' || LAST;
   ELSE
     LINE2 = LAST;
   ...
   ```

2. Given IF … THEN … ELSE is a statement, it is possible to chain them together. Assume that the INT_VALUE and STRING_VALUE variables were declared earlier.
IF (INT_VALUE = 1) THEN
    STRING_VALUE = 'one';
ELSE IF (INT_VALUE = 2) THEN
    STRING_VALUE = 'two';
ELSE IF (INT_VALUE = 3) THEN
    STRING_VALUE = 'three';
ELSE
    STRING_VALUE = 'too much';

This specific example can be replaced with a simple CASE or the DECODE function.

See also

WHILE ... DO, CASE

7.7.9. WHILE ... DO

Used for
Looping constructs

Available in
PSQL

Syntax

[label:]
WHILE <condition> DO
<compound_statement>

Table 103. WHILE ... DO Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>label</td>
<td>Optional label for LEAVE and CONTINUE. Follows the rules for identifiers.</td>
</tr>
<tr>
<td>condition</td>
<td>A logical condition returning TRUE, FALSE or UNKNOWN</td>
</tr>
<tr>
<td>compound_statement</td>
<td>A single statement, or two or more statements wrapped in BEGIN ... END</td>
</tr>
</tbody>
</table>

A WHILE statement implements the looping construct in PSQL. The statement or the block of statements will be executed until the condition returns TRUE. Loops can be nested to any depth.

WHILE ... DO Examples

A procedure calculating the sum of numbers from 1 to I shows how the looping construct is used.
CREATE PROCEDURE SUM_INT (I INTEGER)
RETURNS (S INTEGER)
AS
BEGIN
    S = 0;
    WHILE (i > 0) DO
        BEGIN
            S = S + i;
            i = i - 1;
        END
    END
END

Executing the procedure in *isql*:

```sql
EXECUTE PROCEDURE SUM_INT(4);
```

the result is:

```
S
======
10
```

See also

**IF ... THEN ... ELSE, BREAK, LEAVE, CONTINUE, EXIT, FOR SELECT, FOR EXECUTE STATEMENT**

**7.7.10. BREAK**

*Used for*

Exiting a loop

*Available in*

PSQL
Syntax

Syntax

Table 104. BREAK Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>label</td>
<td>Label</td>
</tr>
<tr>
<td>select_stmt</td>
<td>SELECT statement</td>
</tr>
<tr>
<td>condition</td>
<td>A logical condition returning TRUE, FALSE or UNKNOWN</td>
</tr>
</tbody>
</table>

The BREAK statement immediately terminates the inner loop of a WHILE or FOR looping statement. Code continues to be executed from the first statement after the terminated loop block.

BREAK is similar to LEAVE, except it doesn’t support a label.

See also

LEAVE

7.7.11. LEAVE

Used for

Exiting a loop

Available in

PSQL
Syntax

[loop_stmt]:
BEGIN
...
LEAVE [label];
...
END

<loop_stmt> ::= 
  FOR <select_stmt> INTO <var_list> DO
  | FOR EXECUTE STATEMENT ... INTO <var_list> DO
  | WHILE (<condition>)} DO

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>label</td>
<td>Label</td>
</tr>
<tr>
<td>select_stmt</td>
<td>SELECT statement</td>
</tr>
<tr>
<td>condition</td>
<td>A logical condition returning TRUE, FALSE or UNKNOWN</td>
</tr>
</tbody>
</table>

The LEAVE statement immediately terminates the inner loop of a WHILE or FOR looping statement. Using the optional label parameter, LEAVE can also exit an outer loop, that is, the loop labelled with label. Code continues to be executed from the first statement after the terminated loop block.

**LEAVE Examples**

1. Leaving a loop if an error occurs on an insert into the NUMBERS table. The code continues to be executed from the line \( C = 0 \).

```sql
... 
WHILE (B < 10) DO 
BEGIN 
  INSERT INTO NUMBERS(B) 
  VALUES (:B); 
  B = B + 1; 
  WHEN ANY DO 
  BEGIN 
    EXECUTE PROCEDURE LOG_ERROR ( 
      CURRENT_TIMESTAMP, 
      'ERROR IN B LOOP'); 
    LEAVE; 
  END 
END 
C = 0; 
... 
```
2. An example using labels in the LEAVE statement. LEAVE LOOPA terminates the outer loop and LEAVE LOOPB terminates the inner loop. Note that the plain LEAVE statement would be enough to terminate the inner loop.

```sql
... STMT1 = 'SELECT NAME FROM FARMS'; LOOPA:
  FOR EXECUTE STATEMENT :STMT1 INTO :FARM DO
    BEGIN
      STMT2 = 'SELECT NAME ' || 'FROM ANIMALS WHERE FARM = ''; LOOPB:
        FOR EXECUTE STATEMENT :STMT2 || :FARM || '''
          INTO :ANIMAL DO
            BEGIN
              IF (ANIMAL = 'FLUFFY') THEN
                LEAVE LOOPB;
              ELSE IF (ANIMAL = FARM) THEN
                LEAVE LOOPA;
              ELSE
                SUSPEND;
            END
        END
    END
...```

See also 
BREAK, CONTINUE, EXIT

7.7.12. CONTINUE

Used for
Continuing with the next iteration of a loop

Available in
PSQL
**Syntax**

```
[label:]
<loop_stmt>
BEGIN
...
  CONTINUE [label];
...
END

<loop_stmt> ::= 
  FOR <select_stmt> INTO <var_list> DO  
  | FOR EXECUTE STATEMENT ... INTO <var_list> DO  
  | WHILE (<condition>)} DO
```

**Table 106. CONTINUE Statement Parameters**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>label</td>
<td>Label</td>
</tr>
<tr>
<td>select_stmt</td>
<td>SELECT statement</td>
</tr>
<tr>
<td>condition</td>
<td>A logical condition returning TRUE, FALSE or UNKNOWN</td>
</tr>
</tbody>
</table>

The CONTINUE statement skips the remainder of the current block of a loop and starts the next iteration of the current WHILE or FOR loop. Using the optional label parameter, CONTINUE can also start the next iteration of an outer loop, that is, the loop labelled with label.

**CONTINUE Examples**

**Using the CONTINUE statement**

```
FOR SELECT A, D
  FROM ATABLE INTO achar, ddate
DO
BEGIN
  IF (ddate < current_date - 30) THEN
    CONTINUE;
  ELSE
    BEGIN
      /* do stuff */
    END
  END
END
```

**See also**

BREAK, LEAVE, EXIT

**7.7.13. EXIT**

**Used for**
Terminating module execution

Available in
PSQL

Syntax

EXIT;

The EXIT statement causes execution of the current PSQL module to jump to the final END statement from any point in the code, thus terminating the program.

Calling EXIT in a function will result in the function returning NULL.

EXIT Examples

Using the EXIT statement in a selectable procedure

CREATE PROCEDURE GEN_100
  RETURNS (I INTEGER)
AS
BEGIN
  I = 1;
  WHILE (1=1) DO
    BEGIN
      SUSPEND;
      IF (I=100) THEN
        EXIT;
      I = I + 1;
    END
  END
END

See also
BREAK, LEAVE, CONTINUE, SUSPEND

7.7.14. SUSPEND

Used for
Passing output to the buffer and suspending execution while waiting for caller to fetch it

Available in
PSQL

Syntax

SUSPEND;

The SUSPEND statement is used in a selectable stored procedure to pass the values of output
parameters to a buffer and suspend execution. Execution remains suspended until the calling application fetches the contents of the buffer. Execution resumes from the statement directly after the SUSPEND statement. In practice, this is likely to be a new iteration of a looping process.

**Important Notes**

1. The SUSPEND statement can only occur in stored procedures or sub-procedures.
2. The presence of the SUSPEND keyword defines a stored procedure as a selectable procedure.
3. Applications using interfaces that wrap the API perform the fetches from selectable procedures transparently.
4. If a selectable procedure is executed using EXECUTE PROCEDURE, it behaves as an executable procedure. When a SUSPEND statement is executed in such a stored procedure, it is the same as executing the EXIT statement, resulting in immediate termination of the procedure.
5. SUSPEND “breaks” the atomicity of the block in which it is located. If an error occurs in a selectable procedure, statements executed after the final SUSPEND statement will be rolled back. Statements that executed before the final SUSPEND statement will not be rolled back unless the transaction is rolled back.

**SUSPEND Examples**

*Using the SUSPEND statement in a selectable procedure*

```sql
CREATE PROCEDURE GEN_100
  RETURNS (I INTEGER)
AS
BEGIN
  I = 1;
  WHILE (1=1) DO
    BEGIN
      SUSPEND;
      IF (I=100) THEN
        EXIT;
      I = I + 1;
    END
  END
END
```

*See also*

EXIT

**7.7.15. EXECUTE STATEMENT**

*Used for*

Executing dynamically created SQL statements

*Available in*
PSQL

Syntax

<execute_statement> ::= EXECUTE STATEMENT <argument>
                      [<option> ...]
                      [INTO <variables>];

<argument> ::= <paramless_stmt>
               | (<paramless_stmt>)
               | (<stmt_with_params>) (<param_values>)

<param_values> ::= <named_values> | <positional_values>

<named_values> ::= <named_value> [, <named_value> ...]

<named_value> ::= [EXCESS] paramname := <value_expr>

<positional_values> ::= <value_expr> [, <value_expr> ...]

<option> ::= WITH {AUTONOMOUS | COMMON} TRANSACTION
           | WITH CALLER PRIVILEGES
           | AS USER user
           | PASSWORD password
           | ROLE role
           | ON EXTERNAL [DATA SOURCE] <connection_string>

<connection_string> ::= !! See <filespec> in the CREATE DATABASE syntax !!

<variables> ::= [:]varname [, [:]varname ...]

Table 107. EXECUTE STATEMENT Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>paramless_stmt</td>
<td>Literal string or variable containing a non-parameterized SQL query</td>
</tr>
<tr>
<td>stmt_with_params</td>
<td>Literal string or variable containing a parameterized SQL query</td>
</tr>
<tr>
<td>paramname</td>
<td>SQL query parameter name</td>
</tr>
<tr>
<td>value_expr</td>
<td>SQL expression resolving to a value</td>
</tr>
<tr>
<td>user</td>
<td>Username. It can be a string, CURRENT_USER or a string variable</td>
</tr>
<tr>
<td>password</td>
<td>Password. It can be a string or a string variable</td>
</tr>
<tr>
<td>role</td>
<td>Role. It can be a string, CURRENT_ROLE or a string variable</td>
</tr>
<tr>
<td>connection_string</td>
<td>Connection string. It can be a string literal or a string variable</td>
</tr>
<tr>
<td>varname</td>
<td>Variable</td>
</tr>
</tbody>
</table>

The statement EXECUTE STATEMENT takes a string parameter and executes it as if it were a DSQL
statement. If the statement returns data, it can be passed to local variables by way of an INTO clause.

**Parameterized Statements**

You can use parameters—either named or positional—in the DSQL statement string. Each parameter must be assigned a value.

**Special Rules for Parameterized Statements**

1. Named and positional parameters cannot be mixed in one query
2. Each parameter must be used in the statement text.

   To relax this rule, named parameters can be prefixed with the keyword EXCESS to indicate that the parameter may be absent from the statement text. This option is useful for dynamically generated statements that conditionally include or exclude certain parameters.

3. If the statement has parameters, they must be enclosed in parentheses when EXECUTE STATEMENT is called, regardless of whether they come directly as strings, as variable names or as expressions
4. Each named parameter must be prefixed by a colon ("\"") in the statement string itself, but not when the parameter is assigned a value
5. Positional parameters must be assigned their values in the same order as they appear in the query text
6. The assignment operator for parameters is the special operator “\:=”, similar to the assignment operator in Pascal
7. Each named parameter can be used in the statement more than once, but its value must be assigned only once
8. With positional parameters, the number of assigned values must match the number of parameter placeholders (question marks) in the statement exactly

**Examples of EXECUTE STATEMENT with parameters**

1. With named parameters:
DECLARE license_num VARCHAR(15);
DECLARE connect_string VARCHAR (100);
DECLARE stmt VARCHAR (100) =
  'SELECT license
   FROM cars
   WHERE driver = :driver AND location = :loc';
BEGIN
  ...
  SELECT connstr
  FROM databases
  WHERE cust_id = :id
  INTO connect_string;
  ...
  FOR
    SELECT id
    FROM drivers
    INTO current_driver
  DO
    BEGIN
      FOR
        SELECT location
        FROM driver_locations
        WHERE driver_id = :current_driver
        INTO current_location
      DO
        BEGIN
          EXECUTE STATEMENT (stmt)
            (driver := current_driver,
             loc := current_location)
          ON EXTERNAL connect_string
          INTO license_num;
        ...
DECLARE license_num VARCHAR (15);
DECLARE connect_string VARCHAR (100);
DECLARE stmt VARCHAR (100) =
    'SELECT license
     FROM cars
     WHERE driver = ? AND location = ?';
BEGIN
    ... select connstr
    FROM databases
    WHERE cust_id = :id
    into connect_string;
    ...
    FOR
    SELECT id
    FROM drivers
    INTO current_driver
    DO
    BEGIN
        FOR
        SELECT location
        FROM driver_locations
        WHERE driver_id = :current_driver
        INTO current_location
        DO
        BEGIN
            ...
            EXECUTE STATEMENT (stmt)
            (current_driver, current_location)
            ON EXTERNAL connect_string
            INTO license_num;
            ...

3. Use of EXCESS to allow named parameters to be unused (note: this is a FOR EXECUTE STATEMENT):
CREATE PROCEDURE P_EXCESS (A_ID INT, A_TRAN INT = NULL, A_CONN INT = NULL)
    RETURNS (ID INT, TRAN INT, CONN INT)
AS
DECLARE S VARCHAR(255);
DECLARE W VARCHAR(255) = '';
BEGIN
    S = 'SELECT * FROM TTT WHERE ID = :ID';
    IF (A_TRAN IS NOT NULL)
        THEN W = W || ' AND TRAN = :a';
    IF (A_CONN IS NOT NULL)
        THEN W = W || ' AND CONN = :b';
    IF (W <> '')
        THEN S = S || W;

    -- could raise error if TRAN or CONN is null
    -- FOR EXECUTE STATEMENT (:S) (a := :A_TRAN, b := A_CONN, id := A_ID)

    -- OK in all cases
    FOR EXECUTE STATEMENT (:S) (EXCESS a := :A_TRAN, EXCESS b := A_CONN, id := A_ID)
        INTO :ID, :TRAN, :CONN
    DO SUSPEND;
END

WITH {AUTONOMOUS | COMMON} TRANSACTION

By default, the executed SQL statement runs within the current transaction. Using WITH AUTONOMOUS TRANSACTION causes a separate transaction to be started, with the same parameters as the current transaction. This separate transaction will be committed when the statement was executed without errors and rolled back otherwise.

The clause WITH COMMON TRANSACTION uses the current transaction whenever possible; this is the default behaviour. If the statement must run in a separate connection, an already started transaction within that connection is used, if available. Otherwise, a new transaction is started with the same parameters as the current transaction. Any new transactions started under the “COMMON” regime are committed or rolled back with the current transaction.

WITH CALLER PRIVILEGES

By default, the SQL statement is executed with the privileges of the current user. Specifying WITH CALLER PRIVILEGES combines the privileges of the calling procedure or trigger with those of the user, just as if the statement were executed directly by the routine. WITH CALLER PRIVILEGES has no effect if the ON EXTERNAL clause is also present.

ON EXTERNAL [DATA SOURCE]

With ON EXTERNAL [DATA SOURCE], the SQL statement is executed in a separate connection to the same or another database, possibly even on another server. If connection_string is NULL or “'” (empty...
string), the entire ON EXTERNAL [DATA SOURCE] clause is considered absent, and the statement is executed against the current database.

**Connection Pooling**

- External connections made by statements WITH COMMON TRANSACTION (the default) will remain open until the current transaction ends. They can be reused by subsequent calls to EXECUTE STATEMENT, but only if connection_string is exactly the same, including case
- External connections made by statements WITH AUTONOMOUS TRANSACTION are closed as soon as the statement has been executed
- Statements using WITH AUTONOMOUS TRANSACTION can and will re-use connections that were opened earlier by statements WITH COMMON TRANSACTION. If this happens, the reused connection will be left open after the statement has been executed. (It must be, because it has at least one active transaction!)

**Transaction Pooling**

- If WITH COMMON TRANSACTION is in effect, transactions will be reused as much as possible. They will be committed or rolled back together with the current transaction
- If WITH AUTONOMOUS TRANSACTION is specified, a fresh transaction will always be started for the statement. This transaction will be committed or rolled back immediately after the statement’s execution

**Exception Handling**

When ON EXTERNAL is used, the extra connection is always made via a so-called external provider, even if the connection is to the current database. One of the consequences is that exceptions cannot be caught in the usual way. Every exception caused by the statement is wrapped in either an eds_connection or an eds_statement error. In order to catch them in your PSQL code, you have to use WHEN GDSCODE eds_connection, WHEN GDSCODE eds_statement or WHEN ANY.

Without ON EXTERNAL, exceptions are caught in the usual way, even if an extra connection is made to the current database.

**Miscellaneous Notes**

- The character set used for the external connection is the same as that for the current connection
- Two-phase commits are not supported

**AS USER, PASSWORD and ROLE**

The optional AS USER, PASSWORD and ROLE clauses allow specification of which user will execute the SQL statement and with which role. The method of user login, and whether a separate connection is opened, depends on the presence and values of the ON EXTERNAL [DATA SOURCE], AS USER, PASSWORD and ROLE clauses:

- If ON EXTERNAL is present, a new connection is always opened, and:
  - If at least one of AS USER, PASSWORD and ROLE is present, native authentication is attempted
with the given parameter values (locally or remotely, depending on connection_string). No
defaults are used for missing parameters

- If all three are absent, and connection_string contains no hostname, then the new
  connection is established on the local server with the same user and role as the current
  connection. The term 'local' means “on the same machine as the server” here. This is not
  necessarily the location of the client

- If all three are absent, and connection_string contains a hostname, then trusted
  authentication is attempted on the remote host (again, ‘remote’ from the perspective of the
  server). If this succeeds, the remote operating system will provide the username (usually the
  operating system account under which the Firebird process runs)

• If ON EXTERNAL is absent:

  - If at least one of AS USER, PASSWORD and ROLE is present, a new connection to the current
    database is opened with the supplied parameter values. No defaults are used for missing
    parameters

  - If all three are absent, the statement is executed within the current connection

  If a parameter value is NULL or “” (empty string), the entire parameter is
  considered absent. Additionally, AS USER is considered absent if its value is equal to
  CURRENT_USER, and ROLE if it is the same as CURRENT_ROLE.

Caveats with EXECUTE STATEMENT

1. There is no way to validate the syntax of the enclosed statement
2. There are no dependency checks to discover whether tables or columns have been dropped
3. Even though the performance in loops has been significantly improved in Firebird 2.5,
   execution is still considerably slower than when the same statements are executed directly
4. Return values are strictly checked for data type in order to avoid unpredictable type-casting
   exceptions. For example, the string ‘1234’ would convert to an integer, 1234, but ’abc’ would
   give a conversion error

All in all, this feature is meant to be used very cautiously, and you should always take the caveats
into account. If you can achieve the same result with PSQL and/or DSQL, it will almost always be
preferable.

See also
FOR EXECUTE STATEMENT

7.7.16. FOR SELECT

Used for
Looping row-by-row through a selected result set

Available in
PSQL
Syntax

```sql
[label:]
FOR <select_stmt> [AS CURSOR cursor_name] DO <compound_statement>
```

Table 108. FOR SELECT Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>label</td>
<td>Optional label for LEAVE and CONTINUE. Follows the rules for identifiers.</td>
</tr>
<tr>
<td>select_stmt</td>
<td>SELECT statement</td>
</tr>
<tr>
<td>cursor_name</td>
<td>Cursor name. It must be unique among cursor names in the PSQL module (stored procedure, stored function, trigger or PSQL block)</td>
</tr>
<tr>
<td>compound_statement</td>
<td>A single statement, or a block of statements wrapped in BEGIN…END, that performs all the processing for this FOR loop</td>
</tr>
</tbody>
</table>

The FOR SELECT statement

- retrieves each row sequentially from the result set, and executes the statement or block of statements for each row. In each iteration of the loop, the field values of the current row are copied into pre-declared variables.

  Including the AS CURSOR clause enables positioned deletes and updates to be performed—see notes below

- can embed other FOR SELECT statements

- can contain named parameters that must be previously declared in the DECLARE VARIABLE statement or exist as input or output parameters of the procedure

- requires an INTO clause at the end of the SELECT … FROM … specification. In each iteration of the loop, the field values of the current row are copied to the list of variables specified in the INTO clause. The loop repeats until all rows are retrieved, after which it terminates

- can be terminated before all rows are retrieved by using a BREAK, LEAVE or EXIT statement

The Undeclared Cursor

The optional AS CURSOR clause surfaces the set in the FOR SELECT structure as an undeclared, named cursor that can be operated on using the WHERE CURRENT OF clause inside the statement or block following the DO command, in order to delete or update the current row before execution moves to the next row. In addition, it is possible to use the cursor name as a record variable (similar to OLD and NEW in triggers), allowing access to the columns of the result set (i.e. `cursor_name.columnname`).

Rules for Cursor Variables

- When accessing a cursor variable in a DML statement, the colon prefix can be added before the cursor name (i.e. `:cursor_name.columnname`) for disambiguation, similar to variables.

  The cursor variable can be referenced without colon prefix, but in that case, depending on the scope of the contexts in the statement, the name may resolve in the statement context instead of
to the cursor (e.g. you select from a table with the same name as the cursor).

- Cursor variables are read-only
- In a FOR SELECT statement without an AS CURSOR clause, you must use the INTO clause. If an AS CURSOR clause is specified, the INTO clause is allowed, but optional; you can access the fields through the cursor instead.
- Reading from a cursor variable returns the current field values. This means that an UPDATE statement (with a WHERE CURRENT OF clause) will update not only the table, but also the fields in the cursor variable for subsequent reads. Executing a DELETE statement (with a WHERE CURRENT OF clause) will set all fields in the cursor variable to NULL for subsequent reads.

Other points to take into account regarding undeclared cursors:

1. The OPEN, FETCH and CLOSE statements cannot be applied to a cursor surfaced by the AS CURSOR clause.
2. The cursor_name argument associated with an AS CURSOR clause must not clash with any names created by DECLARE VARIABLE or DECLARE CURSOR statements at the top of the module body, nor with any other cursors surfaced by an AS CURSOR clause.
3. The optional FOR UPDATE clause in the SELECT statement is not required for a positioned update.

Examples using FOR SELECT

1. A simple loop through query results:

```sql
CREATE PROCEDURE SHOWNUMS
RETURNS (AA INTEGER, BB INTEGER, SM INTEGER, DF INTEGER)
AS
BEGIN
FOR SELECT DISTINCT A, B
FROM NUMBERS
ORDER BY A, B
INTO AA, BB
DO
BEGIN
SM = AA + BB;
DF = AA - BB;
suspend;
END
END
```

2. Nested FOR SELECT loop:
CREATE PROCEDURE RELFIELDS
RETURNS ( 
    RELATION CHAR(32),
    POS INTEGER,
    FIELD CHAR(32))
AS
BEGIN
    FOR SELECT RDB$RELATION_NAME
        FROM RDB$RELATIONS
        ORDER BY 1
        INTO :RELATION
    DO
    BEGIN
        FOR SELECT
            RDB$FIELD_POSITION + 1,
            RDB$FIELD_NAME
        FROM RDB$RELATION_FIELDS
        WHERE
            RDB$RELATION_NAME = :RELATION
        ORDER BY RDB$FIELD_POSITION
        INTO :POS, :FIELD
        DO
        BEGIN
            IF (POS = 2) THEN
                RELATION = ' "';

                SUSPEND;
            END
        END
    END
END

3. Using the AS CURSOR clause to surface a cursor for the positioned delete of a record:
CREATE PROCEDURE DELTOWN (
    TOWNTODELETE VARCHAR(24))
RETURNS (
    TOWN VARCHAR(24),
    POP INTEGER)
AS
BEGIN
    FOR SELECT TOWN, POP
    FROM TOWNS
    INTO :TOWN, :POP AS CURSOR TCUR
    DO
    BEGIN
        IF (:TOWN = :TOWNTODELETE) THEN
        -- Positional delete
        DELETE FROM TOWNS
        WHERE CURRENT OF TCUR;
        ELSE
        SUSPEND;
    END
    END
END

4. Using an implicitly declared cursor as a cursor variable

EXECUTE BLOCK
    RETURNS (o CHAR(63))
AS
BEGIN
    FOR SELECT rdb$relation_name AS name
    FROM rdb$relations AS CURSOR c
    DO
    BEGIN
        o = c.name;
        SUSPEND;
    END
END

5. Disambiguating cursor variables within queries
EXECUTE BLOCK
  RETURNS (o1 CHAR(63), o2 CHAR(63))
AS
BEGIN
  FOR SELECT rdb$relation_name
    FROM rdb$relations
    WHERE
      rdb$relation_name = 'RDB$RELATIONS' AS CURSOR c
  DO
    BEGIN
      FOR SELECT
        -- with a prefix resolves as a cursor
        :c.rdb$relation_name x1,
        -- no prefix as an alias for the rdb$relations table
        c.rdb$relation_name x2
      FROM rdb$relations c
      WHERE
        rdb$relation_name = 'RDB$DATABASE' AS CURSOR d
    DO
      BEGIN
        o1 = d.x1;
        o2 = d.x2;
        SUSPEND;
      END
    END
  END
END

See also
DECLARE .. CURSOR, BREAK, LEAVE, CONTINUE, EXIT, SELECT, UPDATE, DELETE

7.7.17. FOR EXECUTE STATEMENT

Used for
Executing dynamically created SQL statements that return a row set

Available in
PSQL

Syntax

[label:]
FOR <execute_statement> DO <compound_statement>

Table 109. FOR EXECUTE STATEMENT Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>label</td>
<td>Optional label for LEAVE and CONTINUE. Follows the rules for identifiers.</td>
</tr>
</tbody>
</table>
**Argument** | **Description**
--- | ---
execute_stmt | An EXECUTE STATEMENT statement
compound_statement | A single statement, or a block of statements wrapped in BEGIN…END, that performs all the processing for this FOR loop

The statement FOR EXECUTE STATEMENT is used, in a manner analogous to FOR SELECT, to loop through the result set of a dynamically executed query that returns multiple rows.

**FOR EXECUTE STATEMENT Examples**

*Executing a dynamically constructed SELECT query that returns a data set*

```sql
CREATE PROCEDURE DynamicSampleThree (  
    Q_FIELD_NAME VARCHAR(100),  
    Q_TABLE_NAME VARCHAR(100)  
) RETURNS(  
    LINE VARCHAR(32000)  
)  
AS  
    DECLARE VARIABLE P_ONE_LINE VARCHAR(100);  
BEGIN  
    LINE = '';  
    FOR  
        EXECUTE STATEMENT  
            'SELECT T1.' || :Q_FIELD_NAME ||  
                ' FROM ' || :Q_TABLE_NAME || ' T1'  
        INTO :P_ONE_LINE  
    DO  
        IF (:P_ONE_LINE IS NOT NULL) THEN  
            LINE = :LINE || :P_ONE_LINE || ' ';  
            SUSPEND;  
        END  
    END
```

See also

EXECUTE STATEMENT, BREAK, LEAVE, CONTINUE

### 7.7.18. OPEN

*Used for*

Opening a declared cursor

*Available in*

PSQL

**Syntax**

```sql
OPEN cursor_name;
```
Table 110. OPEN Statement Parameter

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cursor_name</td>
<td>Cursor name. A cursor with this name must be previously declared with a DECLARE CURSOR statement</td>
</tr>
</tbody>
</table>

An OPEN statement opens a previously declared cursor, executes its declared SELECT statement, and makes the first record of the result data set ready to fetch. OPEN can be applied only to cursors previously declared in a DECLARE .. CURSOR statement.

If the SELECT statement of the cursor has parameters, they must be declared as local variables or exist as input or output parameters before the cursor is declared. When the cursor is opened, the parameter is assigned the current value of the variable.

**OPEN Examples**

1. Using the OPEN statement:

   ```sql
   SET TERM ^;
   
   CREATE OR ALTER PROCEDURE GET_RELATIONS_NAMES
   RETURNS ( 
       RNAME CHAR(63) 
   ) AS
     DECLARE C CURSOR FOR ( 
         SELECT RDB$RELATION_NAME 
         FROM RDB$RELATIONS);
     BEGIN
       OPEN C;
       WHILE (1 = 1) DO 
       BEGIN 
         FETCH C INTO :RNAME;
         IF (ROW_COUNT = 0) THEN 
           LEAVE;
           SUSPEND;
         END 
       END 
       CLOSE C;
     END^ 
   SET TERM ;^
   ``

2. A collection of scripts for creating views using a PSQL block with named cursors:

   ```sql
   EXECUTE BLOCK 
   RETURNS ( 
       SCRIPT BLOB SUB_TYPE TEXT) 
   ```
DECLARE VARIABLE FIELDS VARCHAR(8191);
DECLARE VARIABLE FIELD_NAME TYPE OF RDB$FIELD_NAME;
DECLARE VARIABLE RELATION RDB$RELATION_NAME;
DECLARE VARIABLE SOURCE TYPE OF COLUMN RDB$RELATIONS.RDB$VIEW_SOURCE;
-- named cursor
DECLARE VARIABLE CUR_R CURSOR FOR ( 
    SELECT 
        RDB$RELATION_NAME, 
        RDB$VIEW_SOURCE 
    FROM 
        RDB$RELATIONS 
    WHERE 
        RDB$VIEW_SOURCE IS NOT NULL);
-- named cursor with local variable
DECLARE CUR_F CURSOR FOR ( 
    SELECT 
        RDB$FIELD_NAME 
    FROM 
        RDB$RELATION_FIELDS 
    WHERE 
        -- Important! The variable has to be declared earlier 
        RDB$RELATION_NAME = :RELATION);
BEGIN
    OPEN CUR_R;
    WHILE (1 = 1) DO
        BEGIN
            FETCH CUR_R
                INTO :RELATION, :SOURCE;
            IF (ROW_COUNT = 0) THEN
                LEAVE;
            FIELDS = NULL;
            -- The CUR_F cursor will use 
            -- variable value of RELATION initialized above
            OPEN CUR_F;
            WHILE (1 = 1) DO
                BEGIN
                    FETCH CUR_F
                        INTO :FIELD_NAME;
                    IF (ROW_COUNT = 0) THEN
                        LEAVE;
                    IF (FIELDS IS NULL) THEN
                        FIELDS = TRIM(FIELD_NAME);
                    ELSE
                        FIELDS = FIELDS || ', ' || TRIM(FIELD_NAME);
                    END
                END
            CLOSE CUR_F;
        SCRIPT = 'CREATE VIEW ' || RELATION;
IF (FIELDS IS NOT NULL) THEN
    SCRIPT = SCRIPT || ' (' || FIELDS || ')';

    SCRIPT = SCRIPT || ' AS ' || ASCII_CHAR(13);
    SCRIPT = SCRIPT || SOURCE;
    SUSPEND;
END
CLOSE CUR_R;
END

See also
DECLARE .. CURSOR, FETCH, CLOSE

7.7.19. FETCH

Used for
Fetching successive records from a data set retrieved by a cursor

Available in
PSQL

Syntax

FETCH [<fetch_scroll> FROM] cursor_name
    [INTO [:]varname [, [:]varname ...]];

<fetch_scroll> ::= NEXT | PRIOR | FIRST | LAST
    | RELATIVE n
    | ABSOLUTE n

Table 111. FETCH Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cursor_name</td>
<td>Cursor name. A cursor with this name must be previously declared with a DECLARE ... CURSOR statement and opened by an OPEN statement.</td>
</tr>
<tr>
<td>varname</td>
<td>Variable name</td>
</tr>
<tr>
<td>n</td>
<td>Integer expression for the number of rows</td>
</tr>
</tbody>
</table>

The FETCH statement fetches the first and successive rows from the result set of the cursor and assigns the column values to PSQL variables. The FETCH statement can be used only with a cursor declared with the DECLARE .. CURSOR statement.

Using the optional fetch_scroll part of the FETCH statement, you can specify in which direction and how many rows to advance the cursor position. The NEXT clause can be used for scrollable and forward-only cursors. Other clauses are only supported for scrollable cursors.
The Scroll Options

NEXT
  moves the cursor one row forward; this is the default

PRIOR
  moves the cursor one record back

FIRST
  moves the cursor to the first record.

LAST
  moves the cursor to the last record

RELATIVE  \textit{n}
  moves the cursor \textit{n} rows from the current position; positive numbers move forward, negative numbers move backwards; using zero (0) will not move the cursor, and ROW\_COUNT will be set to zero as no new row was fetched.

ABSOLUTE  \textit{n}
  moves the cursor to the specified row; \textit{n} is an integer expression, where 1 indicates the first row. For negative values, the absolute position is taken from the end of the result set, so -1 indicates the last row, -2 the second to last row, etc. A value of zero (0) will position before the first row.

The optional INTO clause gets data from the current row of the cursor and loads them into PSQL variables. If fetch moved beyond the bounds of the result set, the variables will be set to NULL.

It is also possible to use the cursor name as a variable of a row type (similar to OLD and NEW in triggers), allowing access to the columns of the result set (i.e. \textit{cursor\_name.columnname}).

Rules for Cursor Variables

• When accessing a cursor variable in a DML statement, the colon prefix can be added before the cursor name (i.e. \textbf{\textit{cursor\_name.columnname}}) for disambiguation, similar to variables.

  The cursor variable can be referenced without colon prefix, but in that case, depending on the scope of the contexts in the statement, the name may resolve in the statement context instead of to the cursor (e.g. you select from a table with the same name as the cursor).

• Cursor variables are read-only

• In a \textbf{FOR SELECT} statement without an \textbf{AS CURSOR} clause, you must use the INTO clause. If an \textbf{AS CURSOR} clause is specified, the INTO clause is allowed, but optional; you can access the fields through the cursor instead.

• Reading from a cursor variable returns the current field values. This means that an \textbf{UPDATE} statement (with a \textbf{WHERE CURRENT OF} clause) will update not only the table, but also the fields in the cursor variable for subsequent reads. Executing a \textbf{DELETE} statement (with a \textbf{WHERE CURRENT OF} clause) will set all fields in the cursor variable to NULL for subsequent reads.

• When the cursor is not positioned on a row — it is positioned before the first row, or after the last row — attempts to read from the cursor variable will result in error “\textbf{Cursor cursor\_name}
For checking whether all the rows of the result set have been fetched, the context variable \texttt{ROW\_COUNT} returns the number of rows fetched by the statement. If a record was fetched, then \texttt{ROW\_COUNT} is one (1), otherwise zero (0).

**FETCH Examples**

1. Using the \texttt{FETCH} statement:

```sql
CREATE OR ALTER PROCEDURE GET_RELATIONS_NAMES
    RETURNS (RNAME CHAR(63))
AS
    DECLARE C CURSOR FOR (
        SELECT RDB$RELATION_NAME
        FROM RDB$RELATIONS);
BEGIN
    OPEN C;
    WHILE (1 = 1) DO
        FETCH C INTO RNAME;
        IF (ROW_COUNT = 0) THEN
            LEAVE;
            SUSPEND;
        END
    END
    CLOSE C;
END
```

2. Using the \texttt{FETCH} statement with nested cursors:

```sql
EXECUTE BLOCK
    RETURNS (SCRIPT BLOB SUB_TYPE TEXT)
AS
    DECLARE VARIABLE FIELDS VARCHAR (8191);
    DECLARE VARIABLE FIELD_NAME TYPE OF RDB$FIELD_NAME;
    DECLARE VARIABLE RELATION RDB$RELATION_NAME;
    DECLARE VARIABLE SRC TYPE OF COLUMN RDB$RELATIONS.RDB$VIEW_SOURCE;
    -- Named cursor declaration
    DECLARE VARIABLE CUR_R CURSOR FOR (
        SELECT
            RDB$RELATION_NAME,
            RDB$VIEW_SOURCE
        FROM RDB$RELATIONS
        WHERE RDB$VIEW_SOURCE IS NOT NULL);
    -- Declaring a named cursor in which
    -- a local variable is used
    DECLARE CUR_F CURSOR FOR (
        SELECT RDB$FIELD_NAME
        FROM RDB$RELATION_FIELDS
```
WHERE
-- It is important that the variable must be declared earlier
RDB$RELATION_NAME =: RELATION);
BEGIN
OPEN CUR_R;
WHILE (1 = 1) DO
BEGIN
FETCH CUR_R INTO RELATION, SRC;
IF (ROW_COUNT = 0) THEN
    LEAVE;
FIELDS = NULL;
-- Cursor CUR_F will use the value
-- the RELATION variable initialized above
OPEN CUR_F;
WHILE (1 = 1) DO
BEGIN
    FETCH CUR_F INTO FIELD_NAME;
    IF (ROW_COUNT = 0) THEN
        LEAVE;
    IF (FIELDS IS NULL) THEN
        FIELDS = TRIM (FIELD_NAME);
    ELSE
        FIELDS = FIELDS || ',' || TRIM(FIELD_NAME);
    END
    CLOSE CUR_F;
    SCRIPT = 'CREATE VIEW' || RELATION;
    IF (FIELDS IS NOT NULL) THEN
        SCRIPT = SCRIPT || '(' || FIELDS || ')' ;
    SCRIPT = SCRIPT || 'AS' || ASCII_CHAR (13);
    SCRIPT = SCRIPT || SRC;
    SUSPEND;
    END
    CLOSE CUR_R;
END

3. An example of using the FETCH statement with a scrollable cursor

EXECUTE BLOCK
RETURNS (N INT, RNAME CHAR (63))
AS
DECLARE C SCROLL CURSOR FOR (
    SELECT
        ROW_NUMBER() OVER (ORDER BY RDB$RELATION_NAME) AS N,
        RDB$RELATION_NAME
    FROM RDB$RELATIONS
    ORDER BY RDB$RELATION_NAME);
BEGIN
OPEN C;
-- move to the first record (N = 1)
FETCH FIRST FROM C;
DECLARE .. CURSOR, OPEN, CLOSE

7.7.20. CLOSE

Used for
Closing a declared cursor

Available in
CLOSE cursor_name;

Table 112. CLOSE Statement Parameter

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cursor_name</td>
<td>Cursor name. A cursor with this name must be previously declared with a DECLARE ... CURSOR statement and opened by an OPEN statement</td>
</tr>
</tbody>
</table>

A CLOSE statement closes an open cursor. Any cursors that are still open will be automatically closed after the module code completes execution. Only a cursor that was declared with DECLARE .. CURSOR can be closed with a CLOSE statement.

CLOSE Examples

See FETCH Examples

See also
DECLARE .. CURSOR, OPEN, FETCH

7.7.21. IN AUTONOMOUS TRANSACTION

Used for
Executing a statement or a block of statements in an autonomous transaction

Available in
PSQL

Syntax

IN AUTONOMOUS TRANSACTION DO <compound_statement>

Table 113. IN AUTONOMOUS TRANSACTION Statement Parameter

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>compound_statement</td>
<td>A single statement, or a block of statements</td>
</tr>
</tbody>
</table>

The IN AUTONOMOUS TRANSACTION statement enables execution of a statement or a block of statements in an autonomous transaction. Code running in an autonomous transaction will be committed right after its successful execution, regardless of the status of its parent transaction. This can be used when certain operations must not be rolled back, even if an error occurs in the parent transaction.

An autonomous transaction has the same isolation level as its parent transaction. Any exception that is thrown in the block of the autonomous transaction code will result in the autonomous transaction being rolled back and all changes made will be undone. If the code executes successfully, the autonomous transaction will be committed.
**IN AUTONOMOUS TRANSACTION Examples**

Using an autonomous transaction in a trigger for the database ON CONNECT event, in order to log all connection attempts, including those that failed:

```sql
CREATE TRIGGER TR_CONNECT ON CONNECT AS BEGIN -- Logging all attempts to connect to the database IN AUTONOMOUS TRANSACTION DO INSERT INTO LOG(MSG) VALUES ('USER ' || CURRENT_USER || ' CONNECTS.'); IF (EXISTS(SELECT * FROM BLOCKED_USERS WHERE USERNAME = CURRENT_USER)) THEN BEGIN -- Logging that the attempt to connect to the database failed and sending -- a message about the event IN AUTONOMOUS TRANSACTION DO BEGIN INSERT INTO LOG(MSG) VALUES ('USER ' || CURRENT_USER || ' REFUSED.'); POST_EVENT 'CONNECTION ATTEMPT BY BLOCKED USER!'; END -- now calling an exception EXCEPTION EX_BADUSER; END END
```

**See also**

Transaction Control

**7.7.22. POST_EVENT**

**Used for**
Notifying listening clients about database events in a module

**Available in**
PSQL

**Syntax**

```
POST_EVENT event_name;
```

**Table 114. POST_EVENT Statement Parameter**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>event_name</td>
<td>Event name (message) limited to 127 bytes</td>
</tr>
</tbody>
</table>
The `POST_EVENT` statement notifies the event manager about the event, which saves it to an event table. When the transaction is committed, the event manager notifies applications that are signalling their interest in the event.

The event name can be some sort of code, or a short message: the choice is open as it is just a string up to 127 bytes.

The content of the string can be a string literal, a variable or any valid SQL expression that resolves to a string.

**POST_EVENT Examples**

Notifying the listening applications about inserting a record into the `SALES` table:

```sql
CREATE TRIGGER POST_NEW_ORDER FOR SALES
ACTIVE AFTER INSERT POSITION 0
AS
BEGIN
    POST_EVENT 'new_order';
END
```

### 7.7.23. RETURN

**Used for**

Return a value from a stored function

**Available in**

PSQL

**Syntax**

```sql
RETURN value;
```

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>Expression with the value to return; Can be any expression type-compatible with the return type of the function</td>
</tr>
</tbody>
</table>

The `RETURN` statement ends the execution of a function and returns the value of the expression `value`.

`RETURN` can only be used in PSQL functions (stored and local functions).

**RETURN Examples**

See CREATE FUNCTION Examples
7.8. Trapping and Handling Errors

Firebird has a useful lexicon of PSQL statements and resources for trapping errors in modules and for handling them. Firebird uses built-in exceptions that are raised for errors occurring when working DML and DDL statements.

In PSQL code, exceptions are handled by means of the `WHEN` statement. Handling an exception in the code involves either fixing the problem in situ, or stepping past it; either solution allows execution to continue without returning an exception message to the client.

An exception results in execution being terminated in the current block. Instead of passing the execution to the `END` statement, the procedure moves outward through levels of nested blocks, starting from the block where the exception is caught, searching for the code of the handler that “knows” about this exception. It stops searching when it finds the first `WHEN` statement that can handle this exception.

7.8.1. System Exceptions

An exception is a message that is generated when an error occurs.

All exceptions handled by Firebird have predefined numeric values for context variables (symbols) and text messages associated with them. Error messages are output in English by default. Localized Firebird builds are available, where error messages are translated into other languages.

Complete listings of the system exceptions can be found in Appendix B: Exception Codes and Messages:

- SQLSTATE Error Codes and Descriptions
- "GDSCODE Error Codes, SQLCODEs and Descriptions"

7.8.2. Custom Exceptions

Custom exceptions can be declared in the database as persistent objects and called in the PSQL code to signal specific errors; for example, to enforce certain business rules. A custom exception consists of an identifier, and a default message of 1021 bytes. For details, see `CREATE EXCEPTION`.

7.8.3. EXCEPTION

Used for
Throwing a user-defined exception or re-throwing an exception

Available in
PSQL
Syntax

```sql
EXCEPTION [
    exception_name
    [ custom_message
        | USING (<value_list>)
    ]
]
<value_list> ::= <val> [, <val> ...]
```

Table 116. EXCEPTION Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>exception_name</td>
<td>Exception name</td>
</tr>
<tr>
<td>custom_message</td>
<td>Alternative message text to be returned to the caller interface when an exception is thrown. Maximum length of the text message is 1,021 bytes</td>
</tr>
<tr>
<td>val</td>
<td>Value expression that replaces parameter slots in the exception message text</td>
</tr>
</tbody>
</table>

The EXCEPTION statement with `exception_name` throws the user-defined exception with the specified name. An alternative message text of up to 1,021 bytes can optionally override the exception’s default message text.

The default exception message can contain slots for parameters that can be filled when throwing an exception. To pass parameter values to an exception, use the `USING` clause. Considering, in left-to-right order, each parameter passed in the exception-raising statement as “the Nth”, with N starting at 1:

- If the Nth parameter is not passed, its slot is not replaced
- If a `NULL` parameter is passed, the slot will be replaced with the string “*** null ***”
- If more parameters are passed than are defined in the exception message, the surplus ones are ignored
- The maximum number of parameters is 9
- The maximum message length, including parameter values, is 1053 bytes

The status vector is generated this code combination `isc_except`, `<exception number>`, `isc_formated_exception`, `<formatted exception message>`, `<exception parameters>`.

The error code used (`isc_formated_exception`) was introduced in Firebird 3.0, so the client must be at least version 3.0, or at least use the `firebird.msg` from version 3.0 or higher, in order to translate the status vector to a string.
If the message contains a parameter slot number that is greater than 9, the second and subsequent digits will be treated as literal text. For example @10 will be interpreted as slot 1 followed by a literal ‘0’.

As an example:

```
CREATE EXCEPTION ex1
   'something wrong in @ 1 @ 2 @ 3 @ 4 @ 5 @ 6 @ 7 @ 8 @ 9 @ 10 @ 11';
SET TERM ^;
EXECUTE BLOCK AS
   BEGIN
      EXCEPTION ex1 USING ( 'a' , 'b' , 'c' , 'd' , 'e' , 'f' , 'g' , 'h' , 'i' );
   END^
```

This will produce the following output

```
Statement failed, SQLSTATE = HY000
exception 1
-EX1
-something wrong in abcdefghi a0 a1
```

Exceptions can be handled in a WHEN … DO statement. If an exception is not handled in a module, then the effects of the actions executed inside this module are cancelled, and the caller program receives the exception (either the default text, or the custom text).

Within the exception-handling block — and only within it — the caught exception can be re-thrown by executing the EXCEPTION statement without parameters. If located outside the block, the re-thrown EXCEPTION call has no effect.

Custom exceptions are stored in the system table `RDB$EXCEPTIONS`.

**EXCEPTION Examples**

1. Throwing an exception upon a condition in the `SHIP_ORDER` stored procedure:
CREATE OR ALTER PROCEDURE SHIP_ORDER (PO_NUM CHAR(8))
AS
    DECLARE VARIABLE ord_stat CHAR(7);
    DECLARE VARIABLE hold_stat CHAR(1);
    DECLARE VARIABLE cust_no INTEGER;
    DECLARE VARIABLE any_po CHAR(8);
BEGIN
    SELECT
        s.order_status,
        c.on_hold,
        c.cust_no
    FROM
        sales s, customer c
    WHERE
        po_number = :po_num AND
        s.cust_no = c.cust_no
    INTO :ord_stat,
    :hold_stat,
    :cust_no;

    IF (ord_stat = 'shipped') THEN
        EXCEPTION order_already_shipped;
    /* Other statements */
END
CREATE OR ALTER PROCEDURE SHIP_ORDER (PO_NUM CHAR(8))
AS
DECLARE VARIABLE ord_stat CHAR(7);
DECLARE VARIABLE hold_stat CHAR(1);
DECLARE VARIABLE cust_no INTEGER;
DECLARE VARIABLE any_po CHAR(8);
BEGIN
SELECT
  s.order_status,
  c.on_hold,
  c.cust_no
FROM
  sales s, customer c
WHERE
  po_number = :po_num AND
  s.cust_no = c.cust_no
INTO :ord_stat,
       :hold_stat,
       :cust_no;
IF (ord_stat = 'shipped') THEN
  EXCEPTION order_already_shipped
    'Order status is "' || ord_stat || '"';
/* Other statements */
END

3. Using a parameterized exception:

CREATE EXCEPTION EX_BAD_SP_NAME
  'Name of procedures must start with' '@ 1' ': @ 2' ' ;
...
CREATE TRIGGER TRG_SP_CREATE BEFORE CREATE PROCEDURE
AS
  DECLARE SP_NAME VARCHAR(255);
BEGIN
  SP_NAME = RDB$GET_CONTEXT ('DDL_TRIGGER', 'OBJECT_NAME');
  IF (SP_NAME NOT STARTING 'SP_') THEN
    EXCEPTION EX_BAD_SP_NAME USING ('SP_', SP_NAME);
  END
END

4. Logging an error and re-throwing it in the WHEN block:
CREATE PROCEDURE ADD_COUNTRY (  
    ACountryName COUNTRYNAME,
    ACurrency VARCHAR(10))  
AS  
BEGIN  
    INSERT INTO country (country,  
        currency)  
        VALUES (:ACountryName,  
        :ACurrency);  
    WHEN ANY DO  
    BEGIN  
        -- write an error in log  
        IN AUTONOMOUS TRANSACTION DO  
            INSERT INTO ERROR_LOG (PSQL_MODULE,  
                GDSCODE,  
                SQL_CODE,  
                SQLSTATE)  
                VALUES ('ADD_COUNTRY',  
                    GDSCODE,  
                    SQLCODE,  
                    SQLSTATE);  
        -- Re-throw exception  
        EXCEPTION;  
    END  
END

See also
CREATE EXCEPTION, WHEN ... DO

7.8.4. WHEN ... DO

Used for
Catching an exception and handling the error

Available in
PSQL

Syntax

WHEN {<error> [, <error> ...] | ANY}  
DO <compound_statement>

<error> ::=  
    { EXCEPTION exception_name  
        | SQLCODE number  
        | GDSCODE errcode  
        | SQLSTATE sqlstate_code }
Table 117. WHEN … DO Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>exception_name</td>
<td>Exception name</td>
</tr>
<tr>
<td>number</td>
<td>SQLCODE error code</td>
</tr>
<tr>
<td>errcode</td>
<td>Symbolic GDSCODE error name</td>
</tr>
<tr>
<td>sqlstate_code</td>
<td>String literal with the SQLSTATE error code</td>
</tr>
<tr>
<td>compound_statement</td>
<td>A single statement, or a block of statements</td>
</tr>
</tbody>
</table>

The WHEN … DO statement handles Firebird errors and user-defined exceptions. The statement catches all errors and user-defined exceptions listed after the keyword WHEN keyword. If WHEN is followed by the keyword ANY, the statement catches any error or user-defined exception, even if they have already been handled in a WHEN block located higher up.

The WHEN … DO block must be located at the very end of a block of statements, before the block's END statement.

The keyword DO is followed by a statement, or a block of statements inside a BEGIN … END block, that handles the exception. The SQLCODE, GDSCODE, and SQLSTATE context variables are available in the context of this statement or block. The RDB$ERROR function can be used the obtain the SQLCODE, GDSCODE, SQLSTATE, custom exception name and exception message. The EXCEPTION statement, without parameters, can also be used in this context to re-throw the error or exception.

**Targeting GDSCODE**

The argument for the WHEN GDSCODE clause is the symbolic name associated with the internally-defined exception, such as grant_obj_notfound for GDS error 335544551.

In statement or block of statements of the DO clause, a GDSCODE context variable, containing the numeric code, becomes available. That numeric code is required if you want to compare a GDSCODE exception with a targeted error. To compare it with a specific error, you need to use a numeric values, for example 335544551 for grant_obj_notfound.

Similar context variables are available for SQLCODE and SQLSTATE.

The WHEN … DO statement or block is only executed when one of the events targeted by its conditions occurs at run-time. If the WHEN … DO statement is executed, even if it actually does nothing, execution will continue as if no error occurred: the error or user-defined exception neither terminates nor rolls back the operations of the trigger or stored procedure.

However, if the WHEN … DO statement or block does nothing to handle or resolve the error, the DML statement (SELECT, INSERT, UPDATE, DELETE, MERGE) that caused the error will be rolled back and none of the statements below it in the same block of statements are executed.
1. If the error is not caused by one of the DML statements (SELECT, INSERT, UPDATE, DELETE, MERGE), the entire block of statements will be rolled back, not just the one that caused an error. Any operations in the WHEN … DO statement will be rolled back as well. The same limitation applies to the EXECUTE PROCEDURE statement. Read an interesting discussion of the phenomenon in Firebird Tracker ticket firebird#4803.

2. In selectable stored procedures, output rows that were already passed to the client in previous iterations of a FOR SELECT … DO … SUSPEND loop remain available to the client if an exception is thrown subsequently in the process of retrieving rows.

**Scope of a WHEN ⋯ DO Statement**

A WHEN ⋯ DO statement catches errors and exceptions in the current block of statements. It also catches similar exceptions in nested blocks, if those exceptions have not been handled in those nested blocks.

All changes made before the statement that caused the error are visible to a WHEN ⋯ DO statement. However, if you try to log them in an autonomous transaction, those changes are unavailable, because the transaction where the changes took place is not committed at the point when the autonomous transaction is started. Example 4, below, demonstrates this behaviour.

When handling exceptions, it is sometimes desirable to handle the exception by writing a log message to mark the fault and having execution continue past the faulty record. Logs can be written to regular tables, but there is a problem with that: the log records will “disappear” if an unhandled error causes the module to stop executing, and a rollback is performed. Use of external tables can be useful here, as data written to them is transaction-independent. The linked external file will still be there, regardless of whether the overall process succeeds or not.

**Examples using WHEN⋯DO**

1. Replacing the standard error with a custom one:
CREATE EXCEPTION COUNTRY_EXIST '';
SET TERM ^;
CREATE PROCEDURE ADD_COUNTRY (  
    ACountryName COUNTRYNAME,  
    ACurrency VARCHAR(10) )  
AS  
BEGIN  
    INSERT INTO country (country, currency)  
        VALUES (:ACountryName, :ACurrency);
    WHEN SQLCODE -803 DO  
        EXCEPTION COUNTRY_EXIST 'Country already exists!';
END^  
SET TERM ^;

2. Logging an error and re-throwing it in the WHEN block:

CREATE PROCEDURE ADD_COUNTRY (  
    ACountryName COUNTRYNAME,  
    ACurrency VARCHAR(10) )  
AS  
BEGIN  
    INSERT INTO country (country, currency)  
        VALUES (:ACountryName, :ACurrency);
    WHEN ANY DO  
        BEGIN  
            -- write an error in log  
            IN AUTONOMOUS TRANSACTION DO  
                INSERT INTO ERROR_LOG (PSQL_MODULE,  
                    GDS_CODE,  
                    SQL_CODE,  
                    SQL_STATE,  
                    MESSAGE)  
                    VALUES ('ADD_COUNTRY',  
                        GDSCODE,  
                        SQLCODE,  
                        SQLSTATE,  
                        RDB$ERROR(MESSAGE));
            -- Re-throw exception  
            EXCEPTION;
        END
    END

3. Handling several errors in one WHEN block
... WHEN GDSCODE GRANT_OBJ_NOTFOUND,
    GDSCODE GRANT_FLD_NOTFOUND,
    GDSCODE GRANT_NOPRIV,
    GDSCODE GRANT_NOPRIV_ON_BASE
DO
BEGIN
    EXECUTE PROCEDURE LOG_GRANT_ERROR(GDSCODE,
    RDB$ERROR(MESSAGE);
    EXIT;
END
...

4. Catching errors using the SQLSTATE code

EXECUTE BLOCK
AS
    DECLARE VARIABLE I INT;
BEGIN
    BEGIN
        I = 1/0;
        WHEN SQLSTATE '22003' DO
            EXCEPTION E_CUSTOM_EXCEPTION
            'Numeric value out of range.';
        WHEN SQLSTATE '22012' DO
            EXCEPTION E_CUSTOM_EXCEPTION
            'Division by zero.';
        WHEN SQLSTATE '23000' DO
            EXCEPTION E_CUSTOM_EXCEPTION
            'Integrity constraint violation.';
    END
END

See also

    EXCEPTION, CREATE EXCEPTION, SQLCODE and GDSCODE Error Codes and Message Texts and SQLSTATE Codes and Message Texts, GDSCODE, SQLCODE, SQLSTATE, RDB$ERROR()
Chapter 8. Built-in Scalar Functions

Upgraders: PLEASE READ!

Many functions that were implemented as external functions (UDFs) in earlier versions of Firebird have been progressively re-implemented as internal (built-in) functions. If some external function of the same name as a built-in one is declared in your database, it will remain there and it will override any internal function of the same name.

To make the internal function available, you need either to DROP the UDF, or to use ALTER EXTERNAL FUNCTION to change the declared name of the UDF.

8.1. Context Functions

8.1.1. RDB$GET_CONTEXT()

Available in
DSQL, PSQL * As a declared UDF it should be available in ESQL

Result type
VARCHAR(255)

Syntax

RDB$GET_CONTEXT ('<namespace>', <varname>)

<namespace> ::= SYSTEM | USER_SESSION | USER_TRANSACTION | DDL_TRIGGER
<varname>   ::= A case-sensitive quoted string of max. 80 characters

Table 118. RDB$GET_CONTEXT Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>namespace</td>
<td>Namespace</td>
</tr>
<tr>
<td>varname</td>
<td>Variable name. Case-sensitive. Maximum length is 80 characters</td>
</tr>
</tbody>
</table>

Retrieves the value of a context variable from one of the namespaces SYSTEM, USER_SESSION and USER_TRANSACTION.

The namespaces

The USER_SESSION and USER_TRANSACTION namespaces are initially empty. The user can create and set variables in them with RDB$SET_CONTEXT() and retrieve them with RDB$GET_CONTEXT(). The SYSTEM namespace is read-only. The DDL_TRIGGER namespace is only valid in DDL triggers, and is read-only. It contains a number of predefined variables, shown below.

Return values and error behaviour

If the polled variable exists in the given namespace, its value will be returned as a string of max.
The `SYSTEM` Namespace

Context variables in the `SYSTEM` namespace

**CLIENT_ADDRESS**
For TCPv4, this is the IP address. For XNET, the local process ID. For all other protocols this variable is `NULL`.

**CURRENT_ROLE**
Same as global `CURRENT_ROLE` variable.

**CURRENT_USER**
Same as global `CURRENT_USER` variable.

**DB_NAME**
Either the full path to the database or — if connecting via the path is disallowed — its alias.

**ENGINE_VERSION**
The Firebird engine (server) version.

**EXT_CONN_POOL_ACTIVE_COUNT**
Count of active connections associated with the external connection pool

**EXT_CONN_POOL_IDLE_COUNT**
Count of currently inactive connections available in the connection pool

**EXT_CONN_POOL_LIFETIME**
External connection pool idle connection lifetime, in seconds

**EXT_CONN_POOL_SIZE**
External connection pool size

**ISOLATION_LEVEL**
The isolation level of the current transaction: 'READ COMMITTED', 'SNAPSHOT' or 'CONSISTENCY'.

**NETWORK_PROTOCOL**
The protocol used for the connection: 'TCPv4', 'WNET', 'XNET' or `NULL`.

**SESSION_ID**
Same as global `CURRENT_CONNECTION` variable.

**SESSION_IDLE_TIMEOUT**
Connection-level idle timeout, or 0 if no timeout was set. When 0 is reported the database ConnectionIdleTimeout from databases.conf or firebird.conf applies.
SNAPSHOT_NUMBER

Current snapshot number for the transaction executing this statement. For SNAPSHOT and
SNAPSHOT TABLE STABILITY, this number is stable for the duration of the transaction; for READ
COMMITTED this number will change (increment) as concurrent transactions are committed.

STATEMENT_TIMEOUT

Connection-level statement timeout, or 0 if no timeout was set. When 0 is reported the database
StatementTimeout from databases.conf or firebird.conf applies.

TRANSACTION_ID

Same as global CURRENT_TRANSACTION variable.

WIRE_COMPRESSED

Compression status of the current connection. If the connection is compressed, returns TRUE; if it
is not compressed, returns FALSE. Returns NULL if the connection is embedded.

WIRE_ENCRYPTED

Encryption status of the current connection. If the connection is encrypted, returns TRUE; if it is
not encrypted, returns FALSE. Returns NULL if the connection is embedded.

The DDL_TRIGGER Namespace

The DDL_TRIGGER namespace is valid only when a DDL trigger is running. Its use is also valid in
stored procedures and functions called by DDL triggers.

The DDL_TRIGGER context works like a stack. Before a DDL trigger is fired, the values relative to the
executed command are pushed onto this stack. After the trigger finishes, the values are popped. So
in the case of cascade DDL statements, when a user DDL command fires a DDL trigger and this
trigger executes another DDL command with EXECUTE STATEMENT, the values of the DDL_TRIGGER
namespace are the ones relative to the command that fired the last DDL trigger on the call stack.

Context variables in the DDL_TRIGGER namespace

EVENT_TYPE

event type (CREATE, ALTER, DROP)

OBJECT_TYPE

object type (TABLE, VIEW, etc)

DDL_EVENT

event name (<ddl_event_item>), where <ddl_event_item> is EVENT_TYPE || ' ' || OBJECT_TYPE

OBJECT_NAME

metadata object name

OLD_OBJECT_NAME

for tracking the renaming of a domain (see note)
for tracking the renaming of a domain (see note)

\[
\text{ALTER DOMAIN old-name TO new-name sets OLD_OBJECT_NAME and NEW_OBJECT_NAME in both BEFORE and AFTER triggers. For this command, OBJECT_NAME will have the old object name in BEFORE triggers, and the new object name in AFTER triggers.}
\]

Examples

```
select rdb$get_context('SYSTEM', 'DB_NAME') from rdb$database
New.UserAddr = rdb$get_context('SYSTEM', 'CLIENT_ADDRESS');
insert into MyTable (TestField)
    values (rdb$get_context('USER_SESSION', 'MyVar'))
```

See also

RDB$SET_CONTEXT()

8.1.2. RDB$SET_CONTEXT()

Available in

DSQL, PSQL * As a declared UDF it should be available in ESQL

Result type

INTEGER

Syntax

```
RDB$SET_CONTEXT ('<namespace>', <varname>, <value> | NULL)
```

<namespace> ::= USER_SESSION | USER_TRANSACTION  
<varname>   ::= A case-sensitive quoted string of max. 80 characters  
<value>     ::= A value of any type, as long as it's castable to a VARCHAR(255)

Table 119. RDB$SET_CONTEXT Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>namespace</td>
<td>Namespace</td>
</tr>
<tr>
<td>varname</td>
<td>Variable name. Case-sensitive. Maximum length is 80 characters</td>
</tr>
<tr>
<td>value</td>
<td>Data of any type provided it can be cast to VARCHAR(255)</td>
</tr>
</tbody>
</table>

Creates, sets or unsets a variable in one of the user-writable namespaces USER_SESSION and
The namespaces

The USER_SESSION and USER_TRANSACTION namespaces are initially empty. The user can create and set variables in them with `RDB$SET_CONTEXT()` and retrieve them with `RDB$GET_CONTEXT()`. The USER_SESSION context is bound to the current connection. Variables in USER.Transaction only exist in the transaction in which they have been set. When the transaction ends, the context and all the variables defined in it are destroyed.

Return values and error behaviour

The function returns 1 when the variable already existed before the call and 0 when it didn’t. To remove a variable from a context, set it to NULL. If the given namespace doesn’t exist, an error is raised. Both namespace and variable names must be entered as single-quoted, case-sensitive, non-NULL strings.

- The maximum number of variables in any single context is 1000.
- All USER_TRANSACTION variables will survive a ROLLBACK RETAIN (see ROLLBACK Options) or ROLLBACK TO SAVEPOINT unaltered, no matter at which point during the transaction they were set.
- Due to its UDF-like nature, RDB$SET_CONTEXT can — in PSQL only — be called like a void function, without assigning the result, as in the second example above. Regular internal functions don’t allow this type of use.

Examples

```sql
select rdb$set_context('USER_SESSION', 'MyVar', 493) from rdb$database

rdb$set_context('USER_SESSION', 'RecordsFound', RecCounter);

select rdb$set_context('USER_TRANSACTION', 'Savepoints', 'Yes')
    from rdb$database
```

See also

`RDB$GET_CONTEXT()`

8.2. Mathematical Functions

8.2.1. ABS()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type
Numerical

Syntax

\[ \text{ABS (number)} \]

Table 120. \textit{ABS Function Parameter}

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

Returns the absolute value of the argument.

8.2.2. \textit{ACOS()}

\textit{Available in}
DSQL, PSQL

\textit{Possible name conflict}
YES → \textit{Read details}

\textit{Result type}
DOUBLE PRECISION

Syntax

\[ \text{ACOS (number)} \]

Table 121. \textit{ACOS Function Parameter}

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type within the range [-1, 1]</td>
</tr>
</tbody>
</table>

Returns the arc cosine of the argument.

• The result is an angle in the range [0, pi].

\textit{See also}
\textit{COS(), ASIN(), ATAN()}

8.2.3. \textit{ACOSH()}

\textit{Available in}
DSQL, PSQL

\textit{Result type}
DOUBLE PRECISION
Chapter 8. Built-in Scalar Functions

Syntax

ACOSH (number)

Table 122. ACOSH Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>Any non-NULL value in the range [1, INF].</td>
</tr>
</tbody>
</table>

Returns the inverse hyperbolic cosine of the argument.

- The result is in the range [0, INF].

See also

COSH(), ASINH(), ATANH()

8.2.4. ASIN()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

DOUBLE PRECISION

Syntax

ASIN (number)

Table 123. ASIN Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type within the range [-1, 1]</td>
</tr>
</tbody>
</table>

Returns the arc sine of the argument.

- The result is an angle in the range [-pi/2, pi/2].

See also

SIN(), COS(), ATAN()

8.2.5. ASINH()

Available in

DSQL, PSQL

Result type
DOUBLE PRECISION

Syntax

\[
\text{ASINH (number)}
\]

Table 124. ASINH Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>Any non-NULL value in the range [-INF, INF].</td>
</tr>
</tbody>
</table>

Returns the inverse hyperbolic sine of the argument.

- The result is in the range [-INF, INF].

See also

\text{SINH(), ACOSH(), ATANH()}

8.2.6. ATAN()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

DOUBLE PRECISION

Syntax

\[
\text{ATAN (number)}
\]

Table 125. ATAN Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

The function ATAN returns the arc tangent of the argument. The result is an angle in the range \(<-\pi/2, \pi/2>\).

See also

\text{ATAN2(), TAN(), ACOS(), ASIN()}

8.2.7. ATAN2()

Available in

DSQL, PSQL
Possible name conflict
YES → Read details

Result type
DOUBLE PRECISION

Syntax

ATAN2 (y, x)

Table 126. ATAN2 Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>An expression of a numeric type</td>
</tr>
<tr>
<td>x</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

Returns the angle whose sine-to-cosine ratio is given by the two arguments, and whose sine and cosine signs correspond to the signs of the arguments. This allows results across the entire circle, including the angles \(-\pi/2\) and \(\pi/2\).

- The result is an angle in the range \([-\pi, \pi]\).
- If \(x\) is negative, the result is \(\pi\) if \(y\) is 0, and \(-\pi\) if \(y\) is -0.
- If both \(y\) and \(x\) are 0, the result is meaningless. An error will be raised if both arguments are 0.

- A fully equivalent description of this function is the following: \(\text{ATAN2}(y, x)\) is the angle between the positive X-axis and the line from the origin to the point \((x, y)\). This also makes it obvious that \(\text{ATAN2}(0, 0)\) is undefined.
- If \(x\) is greater than 0, \(\text{ATAN2}(y, x)\) is the same as \(\text{ATAN}(y/x)\).
- If both sine and cosine of the angle are already known, \(\text{ATAN2}(\sin, \cos)\) gives the angle.

8.2.8. ATANH()

Available in
DSQL, PSQL

Result type
DOUBLE PRECISION

Syntax

ATANH (number)

Table 127. ATANH Function Parameter
### Parameter Description

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>Any non-NULL value in the range &lt;-1, 1&gt;.</td>
</tr>
</tbody>
</table>

Returns the inverse hyperbolic tangent of the argument.

- The result is a number in the range [-INF, INF].

**See also**

*Tanh(), Acosh(), Asinh()

### 8.2.9. CEIL(), CEILING()

*Available in*

DSQL, PSQL

*Possible name conflict*

YES → [Read details](#) (Affects CEILING only)

*Result type*

BIGINT for exact numeric `number`, or DOUBLE PRECISION for floating point `number`

*Syntax*

```
CEIL[ING] (number)
```

**Table 128. CEIL[ING] Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

Returns the smallest whole number greater than or equal to the argument.

**See also**

*Floor(), Round(), Trunc()

### 8.2.10. COS()

*Available in*

DSQL, PSQL

*Possible name conflict*

YES → [Read details](#)

*Result type*

DOUBLE PRECISION
Syntax

\[
\text{COS (angle)}
\]

### Table 129. COS Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>angle</td>
<td>An angle in radians</td>
</tr>
</tbody>
</table>

Returns an angle’s cosine. The argument must be given in radians.

- Any non-NULL result is — obviously — in the range [-1, 1].

See also

\[\text{ACOS(), COT(), SIN(), TAN()}\]

### 8.2.11. COSH()

**Available in**

DSQL, PSQL

**Possible name conflict**

YES → Read details

**Result type**

DOUBLE PRECISION

Syntax

\[
\text{COSH (number)}
\]

### Table 130. COSH Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>A number of a numeric type</td>
</tr>
</tbody>
</table>

Returns the hyperbolic cosine of the argument.

- Any non-NULL result is in the range [1, INF].

See also

\[\text{ACOSH(), SINH(), TANH()}\]

### 8.2.12. COT()

**Available in**

DSQL, PSQL

**Possible name conflict**
YES → Read details

Result type
DOUBLE PRECISION

Syntax
COT (angle)

Table 131. COT Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>angle</td>
<td>An angle in radians</td>
</tr>
</tbody>
</table>

Returns an angle's cotangent. The argument must be given in radians.

See also
COS(), SIN(), TAN()

8.2.13. EXP()

Available in
DSQL, PSQL

Result type
DOUBLE PRECISION

Syntax
EXP (number)

Table 132. EXP Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>A number of a numeric type</td>
</tr>
</tbody>
</table>

Returns the natural exponential, e^{number}

See also
LN()

8.2.14. FLOOR()

Available in
DSQL, PSQL

Possible name conflict
YES → Read details
Result type
BIGINT for exact numeric number, or DOUBLE PRECISION for floating point number

Syntax

FLOOR (number)

Table 133. FLOOR Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

Returns the largest whole number smaller than or equal to the argument.

See also
CEIL(), CEILING(), ROUND(), TRUNC()

8.2.15. LN()

Available in
DSQL, PSQL

Possible name conflict
YES → Read details

Result type
DOUBLE PRECISION

Syntax

LN (number)

Table 134. LN Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

Returns the natural logarithm of the argument.

- An error is raised if the argument is negative or 0.

See also
EXP(), LOG(), LOG10()

8.2.16. LOG()

Available in
DSQL, PSQL
Possible name conflict
YES → Read details

Result type
DOUBLE PRECISION

Syntax

\[
\text{LOG} \left( x, y \right)
\]

Table 135. LOG Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>Base. An expression of a numeric type</td>
</tr>
<tr>
<td>y</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

Returns the \( x \)-based logarithm of \( y \).

- If either argument is 0 or below, an error is raised. (Before 2.5, this would result in NaN, +/-INF or 0, depending on the exact values of the arguments.)
- If both arguments are 1, NaN is returned.
- If \( x = 1 \) and \( y < 1 \), -INF is returned.
- If \( x = 1 \) and \( y > 1 \), INF is returned.

See also

POWER(), LN(), LOG10()

8.2.17. LOG10()

Available in
DSQL, PSQL

Possible name conflict
YES → Read details

Result type
DOUBLE PRECISION

Syntax

\[
\text{LOG10} \left( \text{number} \right)
\]

Table 136. LOG10 Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>
Returns the 10-based logarithm of the argument.

• An error is raised if the argument is negative or 0. (In versions prior to 2.5, such values would result in NaN and -INF, respectively.)

See also
POWER(), LN(), LOG()

8.2.18. MOD()

Available in
DSQL, PSQL

Possible name conflict
YES → Read details

Result type
SMALLINT, INTEGER or BIGINT depending on the type of a. If a is a floating-point type, the result is a BIGINT.

Syntax
MOD (a, b)

Table 137. MOD Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>An expression of a numeric type</td>
</tr>
<tr>
<td>b</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

Returns the remainder of an integer division.

• Non-integer arguments are rounded before the division takes place. So, “mod(7.5, 2.5)” gives 2 (“mod(8, 3)”), not 0.

8.2.19. PI()

Available in
DSQL, PSQL

Possible name conflict
YES → Read details

Result type
DOUBLE PRECISION
Returns an approximation of the value of \( \pi \).

### 8.2.20. POWER()

**Available in**
DSQL, PSQL

**Possible name conflict**
YES → Read details

**Result type**
DOUBLE PRECISION

**Syntax**

\[
\text{POWER} \left( x, y \right)
\]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x )</td>
<td>An expression of a numeric type</td>
</tr>
<tr>
<td>( y )</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

Returns \( x \) to the power of \( y \) (\( x^y \)).

*See also*

\( \text{EXP()} \), \( \text{LOG()} \), \( \text{LOG10()} \), \( \text{SQRT()} \)

### 8.2.21. RAND()

**Available in**
DSQL, PSQL

**Possible name conflict**
YES → Read details

**Result type**
DOUBLE PRECISION

**Syntax**

\[
\text{RAND} ()
\]

Returns a random number between 0 and 1.
8.2.22. **ROUND()**

*Available in*
DSQL, PSQL

*Possible name conflict*
YES → Read details

*Result type*
INTEGER, (scaled) BIGINT or DOUBLE PRECISION

*Syntax*

```
ROUND (number [, scale])
```

*Table 139. ROUND Function Parameters*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
<tr>
<td>scale</td>
<td>An integer specifying the number of decimal places toward which rounding is to be performed, e.g.:</td>
</tr>
<tr>
<td></td>
<td>• 2 for rounding to the nearest multiple of 0.01</td>
</tr>
<tr>
<td></td>
<td>• 1 for rounding to the nearest multiple of 0.1</td>
</tr>
<tr>
<td></td>
<td>• 0 for rounding to the nearest whole number</td>
</tr>
<tr>
<td></td>
<td>• -1 for rounding to the nearest multiple of 10</td>
</tr>
<tr>
<td></td>
<td>• -2 for rounding to the nearest multiple of 100</td>
</tr>
</tbody>
</table>

Rounds a number to the nearest integer. If the fractional part is exactly 0.5, rounding is upward for positive numbers and downward for negative numbers. With the optional `scale` argument, the number can be rounded to powers-of-ten multiples (tens, hundreds, tenths, hundredths, etc.) instead of just integers.

⚠️ If you are used to the behaviour of the external function `ROUND`, please notice that the *internal* function always rounds halves away from zero, i.e. downward for negative numbers.

**ROUND Examples**

If the `scale` argument is present, the result usually has the same scale as the first argument:

```
ROUND(123.654, 1) -- returns 123.700 (not 123.7)
ROUND(8341.7, -3) -- returns 8000.0 (not 8000)
ROUND(45.1212, 0) -- returns 45.0000 (not 45)
```
Otherwise, the result scale is 0:

```
ROUND(45.1212) -- returns 45
```

See also

CEIL(), CEILING(), FLOOR(), TRUNC()

### 8.2.23. SIGN()

**Available in**

DSQL, PSQL

**Possible name conflict**

YES → [Read details](#)

**Result type**

SMALLINT

**Syntax**

```
SIGN (number)
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

Returns the sign of the argument: -1, 0 or 1.

### 8.2.24. SIN()

**Available in**

DSQL, PSQL

**Possible name conflict**

YES → [Read details](#)

**Result type**

DOUBLE PRECISION

**Syntax**

```
SIN (angle)
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>angle</td>
<td></td>
</tr>
</tbody>
</table>

**Table 141. SIN Function Parameter**
Parameter | Description
---|---
angle | An angle, in radians

Returns an angle's sine. The argument must be given in radians.

- Any non-NULL result is — obviously — in the range [-1, 1].

See also

\textit{ASIN(), COS(), COT(), TAN()}

\textbf{8.2.25. SINH()}

\textit{Available in}

DSQL, PSQL

\textit{Possible name conflict}

YES → \textbf{Read details}

\textit{Result type}

DOUBLE PRECISION

\textit{Syntax}

\texttt{SINH (number)}

\textit{Table 142. SINH Function Parameter}

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

Returns the hyperbolic sine of the argument.

See also

\textit{ASINH(), COSH(), TANH()}

\textbf{8.2.26. SQRT()}

\textit{Available in}

DSQL, PSQL

\textit{Possible name conflict}

YES → \textbf{Read details}

\textit{Result type}

DOUBLE PRECISION
Syntax

\[ \text{SQRT (number)} \]

Table 143. SQRT Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

Returns the square root of the argument.

- If \( \text{number} \) is negative, an error is raised.

See also

\texttt{POWER()}

8.2.27. TAN()

Available in

DSQL, PSQL

Possible name conflict

YES \rightarrow \text{Read details}

Result type

DOUBLE PRECISION

Syntax

\[ \text{TAN (angle)} \]

Table 144. TAN Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>angle</td>
<td>An angle, in radians</td>
</tr>
</tbody>
</table>

Returns an angle’s tangent. The argument must be given in radians.

See also

\texttt{ATAN(), ATAN2(), COS(), COT(), SIN(), TAN()}

8.2.28. TANH()

Available in

DSQL, PSQL

Possible name conflict

YES \rightarrow \text{Read details}
Result type
DOUBLE PRECISION

Syntax

\[
\text{TANH (number)}
\]

Table 145. TANH Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

Returns the hyperbolic tangent of the argument.

- Due to rounding, any non-NULL result is in the range [-1, 1] (mathematically, it’s <-1, 1>).

See also
ATANH(), COSH(), TANH()

8.2.29. TRUNC()

Available in
DSQL, PSQL

Result type
INTEGER, (scaled) BIGINT or DOUBLE PRECISION

Syntax

\[
\text{TRUNC (number [, scale])}
\]

Table 146. TRUNC Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
<tr>
<td>scale</td>
<td>An integer specifying the number of decimal places toward which truncating is to be performed, e.g.:</td>
</tr>
<tr>
<td></td>
<td>- 2 for truncating to the nearest multiple of 0.01</td>
</tr>
<tr>
<td></td>
<td>- 1 for truncating to the nearest multiple of 0.1</td>
</tr>
<tr>
<td></td>
<td>- 0 for truncating to the nearest whole number</td>
</tr>
<tr>
<td></td>
<td>- -1 for truncating to the nearest multiple of 10</td>
</tr>
<tr>
<td></td>
<td>- -2 for truncating to the nearest multiple of 100</td>
</tr>
</tbody>
</table>

Returns the integer part of a number. With the optional scale argument, the number can be truncated to powers-of-ten multiples (tens, hundreds, tenths, hundredths, etc.) instead of just
• If the scale argument is present, the result usually has the same scale as the first argument, e.g.
  ◦ \( \text{TRUNC}(789.2225, 2) \) returns 789.2200 (not 789.22)
  ◦ \( \text{TRUNC}(345.4, -2) \) returns 300.0 (not 300)
  ◦ \( \text{TRUNC}(-163.41, 0) \) returns -163.00 (not -163)

• Otherwise, the result scale is 0:
  ◦ \( \text{TRUNC}(-163.41) \) returns -163

If you are used to the behaviour of the external function \( \text{TRUNCATE} \), please notice that the internal function \( \text{TRUNC} \) always truncates toward zero, i.e. upward for negative numbers.

See also
\( \text{CEIL()}, \text{CEILING()}, \text{FLOOR()}, \text{ROUND()} \)

8.3. String and Binary Functions

8.3.1. ASCII_CHAR()

Available in
DSQL, PSQL

Possible name conflict
YES \( \rightarrow \) Read details

Result type
CHAR(1) CHARACTER SET NONE

Syntax

\[
\text{ASCII_CHAR (code)}
\]

Table 147. ASCII_CHAR Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>code</td>
<td>An integer within the range from 0 to 255</td>
</tr>
</tbody>
</table>

Returns the ASCII character corresponding to the number passed in the argument.

• If you are used to the behaviour of the ASCII_CHAR UDF, which returns an empty string if the argument is 0, please notice that the internal function correctly returns a character with ASCII code 0 here.
8.3.2. ASCII_VAL()

Available in
DSQL, PSQL

Possible name conflict
YES → Read details

Result type
SMALLINT

Syntax

```
ASCII_VAL (ch)
```

Table 148. ASCII_VAL Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ch</td>
<td>A string of the [VAR]CHAR data type or a text BLOB with the maximum size of 32,767 bytes</td>
</tr>
</tbody>
</table>

Returns the ASCII code of the character passed in.

- If the argument is a string with more than one character, the ASCII code of the first character is returned.
- If the argument is an empty string, 0 is returned.
- If the argument is NULL, NULL is returned.
- If the first character of the argument string is multi-byte, an error is raised. (A bug in Firebird 2.1 - 2.1.3 and 2.5.0 causes an error to be raised if any character in the string is multi-byte. This is fixed in versions 2.1.4 and 2.5.1.)

8.3.3. BASE64_DECODE()

Available in
DSQL, PSQL

Result type
VARBINARY or BLOB

Syntax

```
BASE64_DECODE (base64_data)
```

Table 149. BASE64_DECODE Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>base64_data</td>
<td>Base64 encoded data, padded with = to multiples of 4</td>
</tr>
</tbody>
</table>
BASE64_DECODE decodes a string with base64-encoded data, and returns the decoded value as VARBINARY or BLOB as appropriate for the input. If the length of the type of base64_data is not a multiple of 4, an error is raised at prepare time. If the length of the value of base64_data is not a multiple of 4, an error is raised at execution time.

When the input is not BLOB, the length of the resulting type is calculated as \( \text{type_length} \times \frac{3}{4} \), where \( \text{type_length} \) is the maximum length in characters of the input type.

**Example of BASE64_DECODE**

```sql
select cast(base64_decode('VGVzdCBiYXNlNjQ=') as varchar(12))
from rdb$database;
```

CAST
=====
Test base64

**See also**

BASE64_ENCODE(), HEX_DECODE()

### 8.3.4. BASE64_ENCODE()

**Available in**

DSQL, PSQL

**Result type**

VARCHAR CHARACTER SET ASCII or BLOB SUB_TYPE TEXT CHARACTER SET ASCII

**Syntax**

`BASE64_ENCODE (binary_data)`

**Table 150. BASE64_ENCODE Function Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>binary_data</td>
<td>Binary data (or otherwise convertible to binary) to encode</td>
</tr>
</tbody>
</table>

BASE64_ENCODE encodes `binary_data` with base64, and returns the encoded value as a VARCHAR CHARACTER SET ASCII or BLOB SUB_TYPE TEXT CHARACTER SET ASCII as appropriate for the input. The returned value is padded with '=' so its length is a multiple of 4.

When the input is not BLOB, the length of the resulting type is calculated as \( \text{type_length} \times \frac{4}{3} \) rounded up to a multiple of four, where \( \text{type_length} \) is the maximum length in bytes of the input type. If this length exceeds the maximum length of VARCHAR, the function returns a BLOB.

**Example of BASE64_ENCODE**
select base64_encode('Test base64')
from rdb$database;

BASE64_ENCODE
================
VGVzdCBiYXNlNjQ=

See also
BASE64_DECODE(), HEX_ENCODE()

8.3.5. BIT_LENGTH()

Available in
DSQL, PSQL

Result type
INTEGER

Syntax

BIT_LENGTH (string)

Table 151. BIT_LENGTH Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>string</td>
<td>An expression of a string type</td>
</tr>
</tbody>
</table>

Gives the length in bits of the input string. For multi-byte character sets, this may be less than the number of characters times 8 times the “formal” number of bytes per character as found in RDB$CHARACTER_SETS.

With arguments of type CHAR, this function takes the entire formal string length (i.e. the declared length of a field or variable) into account. If you want to obtain the “logical” bit length, not counting the trailing spaces, right-TRIM the argument before passing it to BIT_LENGTH.

BLOB support

Since Firebird 2.1, this function fully supports text BLOBs of any length and character set.

BIT_LENGTH Examples
select bit_length('Hello!') from rdb$database
-- returns 48

select bit_length(_iso8859_1 'Grüß di!') from rdb$database
-- returns 64: ü and ß take up one byte each in ISO8859_1

select bit_length
  (cast (_iso8859_1 'Grüß di!' as varchar(24) character set utf8))
from rdb$database
-- returns 80: ü and ß take up two bytes each in UTF8

select bit_length
  (cast (_iso8859_1 'Grüß di!' as char(24) character set utf8))
from rdb$database
-- returns 208: all 24 CHAR positions count, and two of them are 16-bit

See also
OCTET_LENGTH(), CHAR_LENGTH(), CHARACTER_LENGTH()
**CHAR_LENGTH Examples**

```sql
select char_length('Hello!') from rdb$database
-- returns 6

select char_length(_iso8859_1 'Grüß di!') from rdb$database
-- returns 8

select char_length
  (cast (_iso8859_1 'Grüß di!' as varchar(24) character set utf8))
from rdb$database
-- returns 8; the fact that ü and ß take up two bytes each is irrelevant

select char_length
  (cast (_iso8859_1 'Grüß di!' as char(24) character set utf8))
from rdb$database
-- returns 24: all 24 CHAR positions count
```

*See also*

**BIT_LENGTH()**, **OCTET_LENGTH()**

### 8.3.7. CRYPT_HASH()

*Available in*

DSQL, PSQL

*Result type*

VARBINARY

*Syntax*

```
CRYPT_HASH (value USING <hash>)
```

<hash> ::= MD5 | SHA1 | SHA256 | SHA512

**Table 153. CRYPT_HASH Function Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>Expression of value of any type; non-string or non-binary types are converted to string</td>
</tr>
<tr>
<td>hash</td>
<td>Cryptographic hash algorithm to apply</td>
</tr>
</tbody>
</table>

**CRYPT_HASH** returns a cryptographic hash calculated from the input argument using the specified algorithm. If the input argument is not a string or binary type, it is converted to string before hashing.

This function returns a VARBINARY with the length depending on the specified algorithm.
• The MD5 and SHA1 algorithms are not recommended for security purposes due to known attacks to generate hash collisions. These two algorithms are provided for backward-compatibility only.

• When hashing string or binary values, it is important to take into account the effects of trailing blanks (spaces or NULs). The value 'ab' in a CHAR(5) (3 trailing spaces) has a different hash than if it is stored in a VARCHAR(5) (no trailing spaces) or CHAR(6) (4 trailing spaces).

To avoid this, make sure you always use a variable length data type, or the same fixed length data type, or normalize values before hashing, for example using `TRIM(TRAILING FROM value).

Examples of CRYPT_HASH

Hashing x with the SHA512 algorithm

```sql
select crypt_hash(x using sha512) from y;
```

See also

HASH()

8.3.8. HASH()

Available in

DSQL, PSQL

Result type

INTEGER, BIGINT

Syntax

```sql
HASH (value [USING <hash>])
<hash> ::= CRC32
```

Table 154. HASH Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>Expression of value of any type; non-string or non-binary types are converted to string</td>
</tr>
<tr>
<td>hash</td>
<td>Non-cryptographic hash algorithm to apply</td>
</tr>
</tbody>
</table>

HASH returns a hash value for the input argument. If the input argument is not a string or binary type, it is converted to string before hashing.

The optional USING clause specifies the non-cryptographic hash algorithm to apply. When the USING clause is absent, the legacy PJW algorithm is applied; this is identical to its behaviour in previous
Firebird versions.

This function fully supports text BLOBs of any length and character set.

**Supported algorithms**

**not specified**

When no algorithm is specified, Firebird applies the 64-bit variant of the non-cryptographic **PJW hash function** (also known as ELF64). This is a very fast algorithm for general purposes (hash tables, etc.), but its collision quality is sub-optimal. Other hash functions — specified explicitly in the **USING** clause, or cryptographic hashes through **CRYPT_HASH()** — should be used for more reliable hashing.

The **HASH** function returns **BIGINT** for this algorithm.

**CRC32**

With CRC32, Firebird applies the CRC32 algorithm using the polynomial 0x04C11DB7.

The **HASH** function returns **INTEGER** for this algorithm.

**Examples of HASH**

1. Hashing x with the CRC32 algorithm

   ```sql
   select hash(x using crc32) from y;
   ```

2. Hashing x with the legacy PJW algorithm

   ```sql
   select hash(x) from y;
   ```

**See also**

**CRYPT_HASH()**

### 8.3.9. HEX_DECODE()

**Available in**

DSQL, PSQL

**Result type**

VARBINARY or BLOB

**Syntax**

```
HEX_DECODE (hex_data)
```

**Table 155. HEX_DECODE Function Parameter**
**Parameter** | **Description**
--- | ---
`hex_data` | Hex encoded data

**HEX DECODE** decodes a string with hex-encoded data, and returns the decoded value as VARBINARY or BLOB as appropriate for the input. If the length of the type of `hex_data` is not a multiple of 2, an error is raised at prepare time. If the length of the value of `hex_data` is not a multiple of 2, an error is raised at execution time.

When the input is not BLOB, the length of the resulting type is calculated as `type_length / 2`, where `type_length` is the maximum length in characters of the input type.

**Example of HEX DECODE**

```sql
select cast(hex_decode('48657861646563696D616C') as varchar(12))
from rdb$database;
```

**See also**

**HEX_ENCODE()**, **BASE64_DECODE()**

**8.3.10. HEX_ENCODE()**

**Available in**

DSQL, PSQL

**Result type**

VARCHAR CHARACTER SET ASCII or BLOB SUB_TYPE TEXT CHARACTER SET ASCII

**Syntax**

```
HEX_ENCODE (binary_data)
```

**Table 156. HEX_ENCODE Function Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>binary_data</code></td>
<td>Binary data (or otherwise convertible to binary) to encode</td>
</tr>
</tbody>
</table>

HEX_ENCODE encodes `binary_data` with hex, and returns the encoded value as a VARCHAR CHARACTER SET ASCII or BLOB SUB_TYPE TEXT CHARACTER SET ASCII as appropriate for the input.

When the input is not BLOB, the length of the resulting type is calculated as `type_length * 2`, where `type_length` is the maximum length in bytes of the input type. If this length exceeds the maximum length of VARCHAR, the function returns a BLOB.
Example of HEX_ENCODE

```sql
select hex_encode('Hexadecimal')
from rdb$database;
```

HEX_ENCODE
======================
48657861646563696D616C

See also
HEX_DECODE(), BASE64_ENCODE()

8.3.11. LEFT()

Available in
DSQL, PSQL

Result type
VARCHAR or BLOB

Syntax

```
LEFT (string, length)
```

Table 157. LEFT Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>string</td>
<td>An expression of a string type</td>
</tr>
<tr>
<td>length</td>
<td>Integer expression. Defines the number of characters to return</td>
</tr>
</tbody>
</table>

Returns the leftmost part of the argument string. The number of characters is given in the second argument.

- This function fully supports text BLOBs of any length, including those with a multi-byte character set.
- If `string` is a BLOB, the result is a BLOB. Otherwise, the result is a VARCHAR(n) with n the length of the input string.
- If the `length` argument exceeds the string length, the input string is returned unchanged.
- If the `length` argument is not a whole number, bankers’ rounding (round-to-even) is applied, i.e. 0.5 becomes 0, 1.5 becomes 2, 2.5 becomes 2, 3.5 becomes 4, etc.

See also
RIGHT()
8.3.12. LOWER()

Available in
DSQL, ESQL, PSQL

Possible name conflict
YES → Read details below

Result type
(VAR)CHAR, (VAR)BINARY or BLOB

Syntax

```
LOWER (string)
```

Table 158. LOWER Function ParameterS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>string</td>
<td>An expression of a string type</td>
</tr>
</tbody>
</table>

Returns the lower-case equivalent of the input string. The exact result depends on the character set. With ASCII or NONE for instance, only ASCII characters are lowercased; with character set OCTETS/(VAR)BINARY, the entire string is returned unchanged. Since Firebird 2.1 this function also fully supports text BLOBs of any length and character set.

Name Clash
Because LOWER is a reserved word, the internal function will take precedence even if the external function by that name has also been declared. To call the (inferior!) external function, use double-quotes and the exact capitalisation, as in "LOWER"(string).

LOWER Examples

```
select Sheriff from Towns
where lower(Name) = 'cooper''s valley'
```

See also
UPPER()

8.3.13. LPAD()

Available in
DSQL, PSQL

Possible name conflict
YES → Read details
`Result type`

VARCHAR or BLOB

`Syntax`

```
LPAD (str, endlen [, padstr])
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>str</td>
<td>An expression of a string type</td>
</tr>
<tr>
<td>endlen</td>
<td>Output string length</td>
</tr>
<tr>
<td>padstr</td>
<td>The character or string to be used to pad the source string up to the specified length. Default is space (&quot; &quot; )</td>
</tr>
</tbody>
</table>

Table 159. LPAD Function Parameters

Left-pads a string with spaces or with a user-supplied string until a given length is reached.

- This function fully supports text BLOBs of any length and character set.
- If `str` is a BLOB, the result is a BLOB. Otherwise, the result is a VARCHAR(endlen).
- If `padstr` is given and equals '' (empty string), no padding takes place.
- If endlen is less than the current string length, the string is truncated to endlen, even if padstr is the empty string.

In Firebird 2.1-2.1.3, all non-BLOB results were of type VARCHAR(32765), which made it advisable to cast them to a more modest size. This is no longer the case.

When used on a BLOB, this function may need to load the entire object into memory. Although it does try to limit memory consumption, this may affect performance if huge BLOBs are involved.

LPAD Examples

```
lpad ('Hello', 12)               -- returns '       Hello'
lpad ('Hello', 12, '-')          -- returns '-------Hello'
lpad ('Hello', 12, '')           -- returns 'Hello'
lpad ('Hello', 12, 'abc')        -- returns 'abcabcaHello'
lpad ('Hello', 12, 'abcdefghij') -- returns 'abcdefgHello'
lpad ('Hello', 2)                -- returns 'He'
lpad ('Hello', 2, '-')           -- returns 'He'
lpad ('Hello', 2, '')            -- returns 'He'
```

See also

RPAD()
8.3.14. OCTET_LENGTH()

**Available in**
DSQL, PSQL

**Result type**
INTEGER

**Syntax**

OCTET_LENGTH (string)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>string</td>
<td>An expression of a string type</td>
</tr>
</tbody>
</table>

Gives the length in bytes (octets) of the input string. For multi-byte character sets, this may be less than the number of characters times the “formal” number of bytes per character as found in RDB$CHARACTER_SETS.

With arguments of type CHAR or BINARY, this function takes the entire formal string length (i.e. the declared length of a field or variable) into account. If you want to obtain the “logical” byte length, not counting the trailing spaces, right-TRIM the argument before passing it to OCTET_LENGTH.

**BLOB support**

Since Firebird 2.1, this function fully supports text BLOBs of any length and character set.

**OCTET_LENGTH Examples**

```sql
select octet_length('Hello!') from rdb$database
-- returns 6

select octet_length(_iso8859_1 'Grüß di!') from rdb$database
-- returns 8: ü and ß take up one byte each in ISO8859_1

select octet_length(cast (_iso8859_1 'Grüß di!' as varchar(24) character set utf8))
from rdb$database
-- returns 10: ü and ß take up two bytes each in UTF8

select octet_length(cast (_iso8859_1 'Grüß di!' as char(24) character set utf8))
from rdb$database
-- returns 26: all 24 CHAR positions count, and two of them are 2-byte
```

**See also**
BIT_LENGTH(), CHAR_LENGTH(), CHARACTER_LENGTH()

8.3.15. OVERLAY()

Available in
DSQL, PSQL

Result type
VARCHAR or BLOB

Syntax

OVERLAY (string PLACING replacement FROM pos [FOR length])

Table 161. OVERLAY Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>string</td>
<td>The string into which the replacement takes place</td>
</tr>
<tr>
<td>replacement</td>
<td>Replacement string</td>
</tr>
<tr>
<td>pos</td>
<td>The position from which replacement takes place (starting position)</td>
</tr>
<tr>
<td>length</td>
<td>The number of characters that are to be overwritten</td>
</tr>
</tbody>
</table>

OVERLAY() overwrites part of a string with another string. By default, the number of characters removed from (overwritten in) the host string equals the length of the replacement string. With the optional fourth argument, a different number of characters can be specified for removal.

- This function supports BLOBs of any length.
- If string or replacement is a BLOB, the result is a BLOB. Otherwise, the result is a VARCHAR(n) with n the sum of the lengths of string and replacement.
- As usual in SQL string functions, pos is 1-based.
- If pos is beyond the end of string, replacement is placed directly after string.
- If the number of characters from pos to the end of string is smaller than the length of replacement (or than the length argument, if present), string is truncated at pos and replacement placed after it.
- The effect of a “FOR 0” clause is that replacement is simply inserted into string.
- If any argument is NULL, the result is NULL.
- If pos or length is not a whole number, bankers’ rounding (round-to-even) is applied, i.e. 0.5 becomes 0, 1.5 becomes 2, 2.5 becomes 2, 3.5 becomes 4, etc.

⚠️ When used on a BLOB, this function may need to load the entire object into memory. This may affect performance if huge BLOBs are involved.
OVERLAY Examples

- `overlay ('Goodbye' placing 'Hello' from 2) -- returns 'GHelloe'`
- `overlay ('Goodbye' placing 'Hello' from 5) -- returns 'GoodHello'`
- `overlay ('Goodbye' placing 'Hello' from 8) -- returns 'GoodbyeHello'`
- `overlay ('Goodbye' placing 'Hello' from 20) -- returns 'GoodbyeHello'`
- `overlay ('Goodbye' placing 'Hello' from 2 for 0) -- returns 'GHellooodbye'`
- `overlay ('Goodbye' placing 'Hello' from 2 for 3) -- returns 'GHellobye'`
- `overlay ('Goodbye' placing 'Hello' from 2 for 6) -- returns 'GHello'`
- `overlay ('Goodbye' placing 'Hello' from 2 for 9) -- returns 'GHello'`
- `overlay ('Goodbye' placing '' from 4) -- returns 'Goodbye'`
- `overlay ('Goodbye' placing '' from 4 for 3) -- returns 'Gooe'`
- `overlay ('Goodbye' placing '' from 4 for 20) -- returns 'Goo'`
- `overlay ('' placing 'Hello' from 4) -- returns 'Hello'`
- `overlay ('' placing 'Hello' from 4 for 0) -- returns 'Hello'`
- `overlay ('' placing 'Hello' from 4 for 20) -- returns 'Hello'`

See also
REPLACE()

8.3.16. POSITION()

Available in
DSQL, PSQL

Result type
INTEGER

Syntax

```
POSITION (substr IN string)
| POSITION (substr, string [, startpos])
```

Table 162. POSITION Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>substr</td>
<td>The substring whose position is to be searched for</td>
</tr>
<tr>
<td>string</td>
<td>The string which is to be searched</td>
</tr>
<tr>
<td>startpos</td>
<td>The position in string where the search is to start</td>
</tr>
</tbody>
</table>

Returns the (1-based) position of the first occurrence of a substring in a host string. With the optional third argument, the search starts at a given offset, disregarding any matches that may occur earlier in the string. If no match is found, the result is 0.

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The optional third argument is only supported in the second syntax (comma syntax).

The empty string is considered a substring of every string. Therefore, if \textit{substr} is '' (empty string) and \textit{string} is not \texttt{NULL}, the result is:

\begin{itemize}
  \item 1 if \textit{startpos} is not given;
  \item \textit{startpos} if \textit{startpos} lies within \textit{string};
  \item 0 if \textit{startpos} lies beyond the end of \textit{string}.
\end{itemize}

Notice: A bug in Firebird 2.1 - 2.1.3 and 2.5.0 causes \texttt{POSITION} to \textit{always} return 1 if \textit{substr} is the empty string. This is fixed in 2.1.4 and 2.5.1.

This function fully supports text BLOBs of any size and character set.

When used on a BLOB, this function may need to load the entire object into memory. This may affect performance if huge BLOBs are involved.

\textbf{POSITION Examples}

\begin{verbatim}
position ('be' in 'To be or not to be')   -- returns 4
position ('be', 'To be or not to be')     -- returns 4
position ('be', 'To be or not to be', 4)  -- returns 4
position ('be', 'To be or not to be', 8)  -- returns 17
position ('be', 'To be or not to be', 18) -- returns 0
position ('be' in 'Alas, poor Yorick!')  -- returns 0
\end{verbatim}

\textit{See also}

\texttt{SUBSTRING()}

\textbf{8.3.17. REPLACE()}

Available in
DSQL, PSQL

Result type
VARCHAR or BLOB

Syntax

\begin{verbatim}
REPLACE (str, find, repl)
\end{verbatim}

\textit{Table 163. REPLACE Function Parameters}

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
</table>
| \begin{itemize}
  \item \texttt{str}
  \item \texttt{find}
\end{itemize} | \begin{itemize}
  \item The string in which the replacement is to take place
  \item The string to search for
\end{itemize} |
### REPLACE

Replaces all occurrences of a substring in a string.

- This function fully supports text BLOBs of any length and character set.
- If any argument is a BLOB, the result is a BLOB. Otherwise, the result is a VARCHAR($n$) with $n$ calculated from the lengths of $str$, $find$ and $repl$ in such a way that even the maximum possible number of replacements won't overflow the field.
- If $find$ is the empty string, $str$ is returned unchanged.
- If $repl$ is the empty string, all occurrences of $find$ are deleted from $str$.
- If any argument is NULL, the result is always NULL, even if nothing would have been replaced.

> When used on a BLOB, this function may need to load the entire object into memory. This may affect performance if huge BLOBs are involved.

#### REPLACE Examples

```sql
replace ('Billy Wilder',  'il', 'oog') -- returns 'Boogly Woogder'
replace ('Billy Wilder',  'il',    '') -- returns 'Bly Wder'
replace ('Billy Wilder',  null, 'oog') -- returns NULL
replace ('Billy Wilder',  'il',  null) -- returns NULL (!)
replace ('Billy Wilder', 'xyz',  null) -- returns NULL (!)
replace ('Billy Wilder',    '', 'abc') -- returns 'Billy Wilder'
```

See also

OVERLAY(), SUBSTRING(), POSITION(), CHAR_LENGTH(), CHARACTER_LENGTH()

#### 8.3.18. REVERSE()

Available in

DSQL, PSQL

Result type

VARCHAR

Syntax

```sql
REVERSE (string)
```

Table 164. REVERSE Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>string</td>
<td>An expression of a string type</td>
</tr>
</tbody>
</table>
Returns a string backwards.

**REVERSE Examples**

```sql
reverse ('spoonful')            -- returns 'lufnoops'
reverse ('Was it a cat I saw?') -- returns '?was I tac a ti saW'
```

This function comes in very handy if you want to group, search or order on string endings, e.g. when dealing with domain names or email addresses:

```sql
create index ix_people_email on people
    computed by (reverse(email));

select * from people
    where reverse(email) starting with reverse('.br');
```

### 8.3.19. RIGHT()

*Available in*

DSQL, PSQL

*Possible name conflict*

YES → Read details

*Result type*

VARCHAR or BLOB

*Syntax*

```sql
RIGHT (_string_, _length_)
```

**Table 165. RIGHT Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>string</td>
<td>An expression of a string type</td>
</tr>
<tr>
<td>length</td>
<td>Integer. Defines the number of characters to return</td>
</tr>
</tbody>
</table>

Returns the rightmost part of the argument string. The number of characters is given in the second argument.

- This function supports text BLOBs of any length, but has a bug in versions 2.1 - 2.1.3 and 2.5.0 that makes it fail with text BLOBs larger than 1024 bytes that have a multi-byte character set. This has been fixed in versions 2.1.4 and 2.5.1.
- If `string` is a BLOB, the result is a BLOB. Otherwise, the result is a VARCHAR(n) with n the length of the input string.
• If the \textit{length} argument exceeds the string length, the input string is returned unchanged.

• If the \textit{length} argument is not a whole number, bankers' rounding (round-to-even) is applied, i.e. 0.5 becomes 0, 1.5 becomes 2, 2.5 becomes 2, 3.5 becomes 4, etc.

When used on a BLOB, this function may need to load the entire object into memory. This may affect performance if huge BLOBs are involved.

\textit{See also}
\texttt{LEFT()}, \texttt{SUBSTRING()}

\textbf{8.3.20. RPAD()}

\textit{Available in}
DSQL, PSQL

\textit{Possible name conflict}
YES → \texttt{Read details}

\textit{Result type}
VARCHAR or BLOB

\textit{Syntax}

\begin{verbatim}
RPAD (str, endlen [, padstr])
\end{verbatim}

\textit{Table 166. RPAD Function Parameters}

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>str</td>
<td>An expression of a string type</td>
</tr>
<tr>
<td>endlen</td>
<td>Output string length</td>
</tr>
<tr>
<td>endlen</td>
<td>The character or string to be used to pad the source string up to the specified length. Default is space (' ')</td>
</tr>
</tbody>
</table>

Right-pads a string with spaces or with a user-supplied string until a given length is reached.

• This function fully supports text BLOBs of any length and character set.

• If \textit{str} is a BLOB, the result is a BLOB. Otherwise, the result is a VARCHAR(\textit{endlen}).

• If \textit{padstr} is given and equals ' ' (empty string), no padding takes place.

• If \textit{endlen} is less than the current string length, the string is truncated to \textit{endlen}, even if \textit{padstr} is the empty string.

\begin{itemize}
  \item In Firebird 2.1-2.1.3, all non-BLOB results were of type VARCHAR(32765), which made it advisable to cast them to a more modest size. This is no longer the case.
\end{itemize}
When used on a BLOB, this function may need to load the entire object into memory. Although it does try to limit memory consumption, this may affect performance if huge BLOBs are involved.

**RPAD Examples**

```plaintext
rpad ('Hello', 12)               -- returns 'Hello       '
rpad ('Hello', 12, '-')          -- returns 'Hello------'
rpad ('Hello', 12, '')           -- returns 'Hello'
rpad ('Hello', 12, 'abc')        -- returns 'Helloabcabca'
rpad ('Hello', 12, 'abcdefghij') -- returns 'Helloabcdefg'
rpad ('Hello', 2)                -- returns 'He'
rpad ('Hello', 2, '-')           -- returns 'He'
rpad ('Hello', 2, '')            -- returns 'He'
```

See also

**8.3.21. SUBSTRING()**

*Available in*

DSQL, PSQL

*Result types*

VARCHAR or BLOB

*Syntax*

```plaintext
SUBSTRING ( <substring-args> )

<substring-args> ::=  
                      str FROM startpos [FOR length]  
                      | str SIMILAR <similar-pattern> ESCAPE <escape>

<similar-pattern> ::=  
                      <similar-pattern-R1>
                      <escape> " <similar-pattern-R2> <escape> "
                      <similar-pattern-R3>
```

*Table 167. SUBSTRING Function Parameters*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>str</td>
<td>An expression of a string type</td>
</tr>
<tr>
<td>startpos</td>
<td>Integer expression, the position from which to start retrieving the substring</td>
</tr>
<tr>
<td>length</td>
<td>The number of characters to retrieve after the startpos</td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>similar-pattern</td>
<td>SQL regular expression pattern to search for the substring</td>
</tr>
<tr>
<td>escape</td>
<td>Escape character</td>
</tr>
</tbody>
</table>

Returns a string's substring starting at the given position, either to the end of the string or with a given length, or extracts a substring using an SQL regular expression pattern.

If any argument is NULL, the result is also NULL.

⚠️ When used on a BLOB, this function may need to load the entire object into memory. Although it does try to limit memory consumption, this may affect performance if huge BLOBs are involved.

**Positional SUBSTRING**

In its simple, positional form (with FROM), this function returns the substring starting at character position `startpos` (the first character being 1). Without the FOR argument, it returns all the remaining characters in the string. With FOR, it returns `length` characters or the remainder of the string, whichever is shorter.

Since Firebird 4.0, `startpos` can be smaller than 1. When `startpos` is smaller than 1, substring behaves as if the string has `1 - startpos` extra positions before the actual first character at position 1. The `length` is considered from this imaginary start of the string, so the resulting string could be shorter than the specified `length`, or even empty.

The function fully supports binary and text BLOBs of any length, and with any character set. If `str` is a BLOB, the result is also a BLOB. For any other argument type, the result is a VARCHAR.

For non-BLOB arguments, the width of the result field is always equal to the length of `str`, regardless of `startpos` and `length`. So, `substring('pinhead' from 4 for 2)` will return a VARCHAR(7) containing the string 'he'.
**Example**

```sql
insert into AbbrNames(AbbrName)
    select substring(LongName from 1 for 3) from LongNames;

select substring('abcdef' from 1 for 2) from rdb$database;
-- result: 'ab'

select substring('abcdef' from 2) from rdb$database;
-- result: 'bcdef'

select substring('abcdef' from 0 for 2) from rdb$database;
-- result: 'a'
-- and NOT 'ab', because there is "nothing" at position 0

select substring('abcdef' from -5 for 2) from rdb$database;
-- result: ''
-- length ends before the actual start of the string
```

**Regular Expression SUBSTRING**

In the regular expression form (with SIMILAR), the SUBSTRING function returns part of the string matching an SQL regular expression pattern. If no match is found, NULL is returned.

The SIMILAR pattern is formed from three SQL regular expression patterns, \( R_1 \), \( R_2 \) and \( R_3 \). The entire pattern takes the form of \( R_1 \| 'escape'\| R_2 \| 'escape'\| R_3 \), where \( 'escape' \) is the escape character defined in the ESCAPE clause. \( R_2 \) is the pattern that matches the substring to extract, and is enclosed between escaped double quotes \( 'escape' \), e.g. “#” with escape character ‘#’). \( R_1 \) matches the prefix of the string, and \( R_3 \) the suffix of the string. Both \( R_1 \) and \( R_3 \) are optional (they can be empty), but the pattern must match the entire string. In other words, it is not sufficient to specify a pattern that only finds the substring to extract.

- The escaped double quotes around \( R_2 \) can be compared to defining a single capture group in more common regular expression syntax like PCRE. That is, the full pattern is equivalent to \( R_1(R_2)R_3 \), which must match the entire input string, and the capture group is the substring to be returned.

- If any one of \( R_1 \), \( R_2 \), or \( R_3 \) is not a zero-length string and does not have the format of an SQL regular expression, then an exception is raised.

The full SQL regular expression format is described in **Syntax: SQL Regular Expressions**
Examples

```
substring('abcabc' similar 'a#"bcab"c' escape '#')  -- bcab
substring('abcabc' similar 'a"%"c' escape '#')      -- bcab
substring('abcabc' similar '_"%"_' escape '#')      -- bcab
substring('abcabc' similar '#"(abc)*"' escape '#')  -- abcabc
substring('abcabc' similar '#"abc"' escape '#')     -- <null>
```

See also

`POSITION()`, `LEFT()`, `RIGHT()`, `CHAR_LENGTH()`, `CHARACTER_LENGTH()`, `SIMILAR TO`

### 8.3.22. TRIM()

**Available in**
DSQL, PSQL

**Result type**
VARCHAR or BLOB

**Syntax**

```
TRIM ([<adjust>] str)
```

<adjust> ::= [[<where>] [what]} FROM

<where> ::= BOTH | LEADING | TRAILING

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>str</td>
<td>An expression of a string type</td>
</tr>
<tr>
<td>where</td>
<td>The position the substring is to be removed from — BOTH</td>
</tr>
<tr>
<td>what</td>
<td>The substring that should be removed (multiple times if there are several matches) from the beginning, the end, or both sides of the input string str. By default it is space (’ ’)</td>
</tr>
</tbody>
</table>

Removes leading and/or trailing spaces (or optionally other strings) from the input string. Since Firebird 2.1 this function fully supports text BLOBs of any length and character set.

- **If str is a BLOB, the result is a BLOB. Otherwise, it is a VARCHAR(n) with n the formal length of str.**

- **When used on a BLOB, this function may need to load the entire object into memory. This may affect performance if huge BLOBs are involved.**
### TRIM Examples

```sql
select trim ('  Waste no space   ') from rdb$database
-- returns 'Waste no space'

select trim (leading from '  Waste no space   ') from rdb$database
-- returns 'Waste no space   ' 

select trim (leading '.' from '  Waste no space   ') from rdb$database
-- returns '  Waste no space   '

select trim (trailing '!' from 'Help!!!!') from rdb$database
-- returns 'Help'

select trim ('la' from 'lalala I love you Ella') from rdb$database
-- returns ' I love you El'

select trim ('la' from 'Lalala I love you Ella') from rdb$database
-- returns 'Lalala I love you El'
```

#### 8.3.23. UPPER()

*Available in*
DSQL, ESQL, PSQL

*Result type*

(VAR)CHAR, (VAR)BINARY or BLOB

*Syntax*

```sql
UPPER (str)
```

*Table 169. UPPER Function Parameter*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>str</td>
<td>An expression of a string type</td>
</tr>
</tbody>
</table>

Returns the upper-case equivalent of the input string. The exact result depends on the character set. With ASCII or NONE for instance, only ASCII characters are uppercased; with character set OCTETS /(VAR)BINARY, the entire string is returned unchanged. Since Firebird 2.1 this function also fully supports text BLOBs of any length and character set.

#### UPPER Examples
select upper(_iso8859_1 'Débâcle')
from rdb$database
-- returns 'DÉBÂCLE' (before Firebird 2.0: 'DéBÂCLE')

select upper(_iso8859_1 'Débâcle' collate fr_fr)
from rdb$database
-- returns 'DEBACLE', following French uppercasing rules

See also
LOWER()

8.4. Date and Time Functions

8.4.1. DATEADD()

Available in
DSQL, PSQL

Result type
DATE, TIME or TIMESTAMP

Syntax

DATEADD (<args>)

<args> ::= 
    <amount> <unit> TO <datetime>
    | <unit>, <amount>, <datetime>

<amount> ::= an integer expression (negative to subtract)
<unit> ::= YEAR | MONTH | WEEK | DAY
    | HOUR | MINUTE | SECOND | MILLISECOND
<datetime> ::= a DATE, TIME or TIMESTAMP expression

Table 170. DATEADD Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>amount</td>
<td>An integer expression of the SMALLINT, INTEGER or BIGINT type. For unit MILLISECOND, the type is NUMERIC(18, 1). A negative value is subtracted.</td>
</tr>
<tr>
<td>unit</td>
<td>Date/time unit</td>
</tr>
<tr>
<td>datetime</td>
<td>An expression of the DATE, TIME or TIMESTAMP type</td>
</tr>
</tbody>
</table>

Adds the specified number of years, months, weeks, days, hours, minutes, seconds or milliseonds to a date/time value.

- The result type is determined by the third argument.
• With TIMESTAMP and DATE arguments, all units can be used.
• With TIME arguments, only HOUR, MINUTE, SECOND and MILLISECOND can be used.

**Examples of DATEADD**

```sql
dateadd (28 day to current_date)
dateadd (-6 hour to current_time)
dateadd (month, 9, DateOfConception)
dateadd (-38 week to DateOfBirth)
dateadd (minute, 90, cast('now' as time))
dateadd (? year to date '11-Sep-1973')
```

```sql
select
  cast(dateadd(-1 * extract(millisecond from ts) millisecond to ts) as varchar(30)) as t,
  extract(millisecond from ts) as ms
from (select timestamp '2014-06-09 13:50:17.4971' as ts from rdb$database ) a
```

<table>
<thead>
<tr>
<th>T</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014-06-09 13:50:17.0000</td>
<td>497.1</td>
</tr>
</tbody>
</table>

*See also*

DATEDIFF(), Operations Using Date and Time Values

**8.4.2. DATEDIFF()**

*Available in*

DSQL, PSQL

*Result type*

BIGINT
### Syntax

```sql
DATEDIFF (<args>)
```

<args> ::= 
  <unit> FROM <moment1> TO <moment2>
  | <unit>, <moment1>, <moment2>

<unit> ::= 
  YEAR | MONTH | WEEK | DAY
  | HOUR | MINUTE | SECOND | MILLISECOND

<momentN> ::= a DATE, TIME or TIMESTAMP expression

### Table 171. DATEDIFF Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>unit</td>
<td>Date/time unit</td>
</tr>
<tr>
<td>moment1</td>
<td>An expression of the DATE, TIME or_TIMESTAMP type</td>
</tr>
<tr>
<td>moment2</td>
<td>An expression of the DATE, TIME or_TIMESTAMP type</td>
</tr>
</tbody>
</table>

Returns the number of years, months, weeks, days, hours, minutes, seconds or milliseconds elapsed between two date/time values. (The WEEK unit is new in 2.5.)

- DATE and TIMESTAMP arguments can be combined. No other mixes are allowed.
- With TIMESTAMP and DATE arguments, all units can be used. (Prior to Firebird 2.5, units smaller than DAY were disallowed for DATEs.)
- With TIME arguments, only HOUR, MINUTE, SECOND and MILLISECOND can be used.

### Computation

- **DATEDIFF** doesn't look at any smaller units than the one specified in the first argument. As a result,
  - `DATEDIFF (year, date '1-Jan-2009', date '31-Dec-2009')` returns 0, but
  - `DATEDIFF (year, date '31-Dec-2009', date '1-Jan-2010')` returns 1
- It does, however, look at all the *bigger* units. So:
  - `DATEDIFF (day, date '26-Jun-1908', date '11-Sep-1973')` returns 23818
- A negative result value indicates that `moment2` lies before `moment1`.

### DATEDIFF Examples

- `DATEDIFF (hour from current_timestamp to timestamp '12-Jun-2059 06:00')`
- `DATEDIFF (minute from time '0:00' to current_time)`
- `DATEDIFF (month, current_date, date '1-1-1900')`
- `DATEDIFF (day from current_date to cast(?) as date)"
See also
DATEADD(), Operations Using Date and Time Values

8.4.3. EXTRACT()

Available in
DSQL, ESQL, PSQL

Result type
SMALLINT or NUMERIC

Syntax

EXTRACT (<part> FROM <datetime>)

<part> ::= YEAR | MONTH | WEEK
| DAY | WEEKDAY | YEARDAY
| HOUR | MINUTE | SECOND | MILLISECOND
| TIMEZONE_HOUR | TIMEZONE_MINUTE

<datetime> ::= a DATE, TIME or TIMESTAMP expression

Table 172. EXTRACT Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>part</td>
<td>Date/time unit</td>
</tr>
<tr>
<td>datetime</td>
<td>An expression of the DATE, TIME or TIMESTAMP type</td>
</tr>
</tbody>
</table>

Extracts and returns an element from a DATE, TIME or TIMESTAMP expression.

Returned Data Types and Ranges

The returned data types and possible ranges are shown in the table below. If you try to extract a part that isn’t present in the date/time argument (e.g. SECOND from a DATE or YEAR from a TIME), an error occurs.

Table 173. Types and ranges of EXTRACT results

<table>
<thead>
<tr>
<th>Part</th>
<th>Type</th>
<th>Range</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>YEAR</td>
<td>SMALLINT</td>
<td>1-9999</td>
<td></td>
</tr>
<tr>
<td>MONTH</td>
<td>SMALLINT</td>
<td>1-12</td>
<td></td>
</tr>
<tr>
<td>WEEK</td>
<td>SMALLINT</td>
<td>1-53</td>
<td></td>
</tr>
<tr>
<td>DAY</td>
<td>SMALLINT</td>
<td>1-31</td>
<td></td>
</tr>
<tr>
<td>WEEKDAY</td>
<td>SMALLINT</td>
<td>0-6</td>
<td>0 = Sunday</td>
</tr>
<tr>
<td>YEARDAY</td>
<td>SMALLINT</td>
<td>0-365</td>
<td>0 = January 1</td>
</tr>
<tr>
<td>HOUR</td>
<td>SMALLINT</td>
<td>0-23</td>
<td></td>
</tr>
</tbody>
</table>
### Part | Type | Range | Comment
--- | --- | --- | ---
Minute | SMALLINT | 0-59 |  
Second | NUMERIC(9,4) | 0.0000-59.9999 | includes millisecond as fraction
Millisecond | NUMERIC(9,1) | 0.0-999.9 | broken in 2.1, 2.1.1
TimeZone Hour | SMALLINT | -23 - +23 |  
TimeZone Minute | SMALLINT | -59 - +59 |  

#### Millisecond

Firebird 2.1 and up support extraction of the millisecond from a `TIME` or `TIMESTAMP`. The data type returned is `NUMERIC(9,1)`. If you extract the millisecond from `CURRENT_TIME`, be aware that this variable defaults to seconds precision, so the result will always be 0. Extract from `CURRENT_TIME(3)` or `CURRENT_TIMESTAMP` to get milliseconds precision.

#### Week

Firebird 2.1 and up support extraction of the ISO-8601 week number from a `DATE` or `TIMESTAMP`. ISO-8601 weeks start on a Monday and always have the full seven days. Week 1 is the first week that has a majority (at least 4) of its days in the new year. The first 1-3 days of the year may belong to the last week (52 or 53) of the previous year. Likewise, a year’s final 1-3 days may belong to week 1 of the following year.

Be careful when combining `WEEK` and `YEAR` results. For instance, 30 December 2008 lies in week 1 of 2009, so `extract(week from date '30 Dec 2008')` returns 1. However, extracting `YEAR` always gives the calendar year, which is 2008. In this case, `WEEK` and `YEAR` are at odds with each other. The same happens when the first days of January belong to the last week of the previous year.

Please also notice that `WEEKDAY` is not ISO-8601 compliant: it returns 0 for Sunday, whereas ISO-8601 specifies 7.

See also

Data Types for Dates and Times

8.4.4. **FIRST_DAY()**

*Available in*

DSQL, PSQL

*Result Type*

DATE, TIMESTAMP (with or without time zone)
Syntax

\[ \text{FIRST\_DAY(OF} \ <\text{period}> \ \text{FROM} \ \text{date\_or\_timestamp}) \]

\(<\text{period}> ::= \text{YEAR} \mid \text{MONTH} \mid \text{WEEK} \)

**Table 174. FIRST\_DAY Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>date_or_timestamp</td>
<td>Expression of type DATE, TIMESTAMP WITHOUT TIME ZONE or TIMESTAMP WITH TIME ZONE</td>
</tr>
</tbody>
</table>

FIRST\_DAY returns a date or timestamp (same as the type of \text{date\_or\_timestamp}) with the first day of the year, month or week of a given date or timestamp value.

- The first day of the week is considered as Sunday, following the same rules as for \text{EXTRACT()} with \text{WEEKDAY}.
- When a timestamp is passed, the return value preserves the time part.

**Examples of FIRST\_DAY**

```sql
select first_day(of month from current_date) from rdb$database;
select first_day(of year from current_timestamp) from rdb$database;
select first_day(of week from date '2017-11-01') from rdb$database;
```

---

8.4.5. LAST\_DAY()

**Available in**

DSQL, PSQL

**Result Type**

DATE, TIMESTAMP (with or without time zone)

**Syntax**

\[ \text{LAST\_DAY(OF} \ <\text{period}> \ \text{FROM} \ \text{date\_or\_timestamp}) \]

\(<\text{period}> ::= \text{YEAR} \mid \text{MONTH} \mid \text{WEEK} \)

**Table 175. LAST\_DAY Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>date_or_timestamp</td>
<td>Expression of type DATE, TIMESTAMP WITHOUT TIME ZONE or TIMESTAMP WITH TIME ZONE</td>
</tr>
</tbody>
</table>

LAST\_DAY returns a date or timestamp (same as the type of \text{date\_or\_timestamp}) with the last day of the year, month or week of a given date or timestamp value.
The last day of the week is considered as Saturday, following the same rules as for \texttt{EXTRACT()} with \texttt{WEEKDAY}.

When a timestamp is passed, the return value preserves the time part.

**Examples of \texttt{LAST\_DAY}**

```sql
select last_day(of month from current_date) from rdb$database;
select last_day(of year from current_timestamp) from rdb$database;
select last_day(of week from date '2017-11-01') from rdb$database;
```

## 8.5. Type Casting Functions

### 8.5.1. \texttt{CAST()}

*Available in*

DSQL, ESQL, PSQL

*Result type*

As specified by \textit{target\_type}

**Syntax**

```sql
CAST (<expression> AS <target\_type>)
```

<target\_type> ::= <domain\_or\_non\_array\_type> | <array\_datatype>

<domain\_or\_non\_array\_type> ::= !! See Scalar Data Types Syntax !!

<array\_datatype> ::= !! See Array Data Types Syntax !!

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expression</td>
<td>SQL expression</td>
</tr>
<tr>
<td>sql_datatype</td>
<td>SQL data type</td>
</tr>
</tbody>
</table>

CAST converts an expression to the desired data type or domain. If the conversion is not possible, an error is raised.

*Casting BL0Bs*

Successful casting to and from BL0Bs is possible since Firebird 2.1.
"Shorthand" Syntax

Alternative syntax, supported only when casting a string literal to a DATE, TIME or TIMESTAMP:

```
datatype 'date/timestring'
```

This syntax was already available in InterBase, but was never properly documented. In the SQL standard, this feature is called “datetime literals”.

Since Firebird 4.0 the use of 'NOW', 'YESTERDAY' and 'TOMORROW' in the shorthand cast is no longer allowed; only literals defining a fixed moment in time are supported.

Allowed Type Conversions

The following table shows the type conversions possible with CAST.

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numeric types</td>
<td>Numeric types</td>
</tr>
<tr>
<td>[VAR]CHAR</td>
<td>[VAR]CHAR</td>
</tr>
<tr>
<td>BLOB</td>
<td>BLOB</td>
</tr>
<tr>
<td></td>
<td>Numeric types</td>
</tr>
<tr>
<td></td>
<td>DATE</td>
</tr>
<tr>
<td></td>
<td>TIME</td>
</tr>
<tr>
<td></td>
<td>TIMESTAMP</td>
</tr>
<tr>
<td>[VAR]CHAR</td>
<td>[VAR]CHAR</td>
</tr>
<tr>
<td>BLOB</td>
<td>BLOB</td>
</tr>
<tr>
<td></td>
<td>Numeric types</td>
</tr>
<tr>
<td></td>
<td>DATE</td>
</tr>
<tr>
<td></td>
<td>TIME</td>
</tr>
<tr>
<td></td>
<td>TIMESTAMP</td>
</tr>
<tr>
<td>DATE</td>
<td>[VAR]CHAR</td>
</tr>
<tr>
<td>TIME</td>
<td>BLOB</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td>[VAR]CHAR</td>
</tr>
<tr>
<td></td>
<td>BLOB</td>
</tr>
<tr>
<td></td>
<td>DATE</td>
</tr>
<tr>
<td></td>
<td>TIME</td>
</tr>
</tbody>
</table>

Keep in mind that sometimes information is lost, for instance when you cast a TIMESTAMP to a DATE. Also, the fact that types are CAST-compatible is in itself no guarantee that a conversion will succeed. “CAST(123456789 as SMALLINT)” will definitely result in an error, as will “CAST('Judgement Day' as DATE)”.

Casting Parameters

Since Firebird 2.0, you can cast statement parameters to a data type:
This gives you control over the type of the parameter set up by the engine. Please notice that with statement parameters, you always need a full-syntax cast—shorthand casts are not supported.

**Casting to a Domain or its Type**

Firebird 2.1 and above support casting to a domain or its base type. When casting to a domain, any constraints (NOT NULL and/or CHECK) declared for the domain must be satisfied, or the cast will fail. Please be aware that a CHECK passes if it evaluates to TRUE or NULL! So, given the following statements:

```sql
create domain quint as int check (value >= 5000);
select cast (2000 as quint) from rdb$database; ①
select cast (8000 as quint) from rdb$database; ②
select cast (null as quint) from rdb$database; ③
```

only cast number ① will result in an error.

When the TYPE OF modifier is used, the expression is cast to the base type of the domain, ignoring any constraints. With domain quint defined as above, the following two casts are equivalent and will both succeed:

```sql
select cast (2000 as type of quint) from rdb$database;
select cast (2000 as int) from rdb$database;
```

If TYPE OF is used with a (VAR)CHAR type, its character set and collation are retained:

```sql
create domain iso20 varchar(20) character set iso8859_1;
create domain dunl20 varchar(20) character set iso8859_1 collate du_nl;
create table zinnen (zin varchar(20));
commit;
insert into zinnen values ('Deze');
insert into zinnen values ('Die');
insert into zinnen values ('die');
insert into zinnen values ('dezé');
select cast(zin as type of iso20) from zinnen order by 1;
-- returns Deze -> Die -> deze -> die
select cast(zin as type of dunl20) from zinnen order by 1;
-- returns deze -> Deze -> die -> Die
```

If a domain's definition is changed, existing CASTs to that domain or its type may become invalid. If these CASTs occur in PSQL modules, their invalidation may be detected. See the note *The RDB$VALID_BLR field*, in Appendix A.
Casting to a Column’s Type

In Firebird 2.5 and above, it is possible to cast expressions to the type of an existing table or view column. Only the type itself is used; in the case of string types, this includes the character set but not the collation. Constraints and default values of the source column are not applied.

```
create table ttt (
    s varchar(40) character set utf8 collate unicode_ci_ai
);
commit;

select cast ('Jag har många vänner' as type of column ttt.s) from rdb$database;
```

**Warnings**

If a column’s definition is altered, existing CASTs to that column’s type may become invalid. If these CASTs occur in PSQL modules, their invalidation may be detected. See the note *The RDB$VALID_BLR field*, in Appendix A.

**Cast Examples**

A full-syntax cast:

```
select cast ('12' || '-June-' || '1959' as date) from rdb$database
```

A shorthand string-to-date cast:

```
update People set AgeCat = 'Old'
    where BirthDate < date '1-Jan-1943'
```

Notice that you can drop even the shorthand cast from the example above, as the engine will understand from the context (comparison to a DATE field) how to interpret the string:

```
update People set AgeCat = 'Old'
    where BirthDate < '1-Jan-1943'
```

However, this is not always possible. The cast below cannot be dropped, otherwise the engine would find itself with an integer to be subtracted from a string:

```
select cast('today' as date) - 7 from rdb$database
```
8.6. Bitwise Functions

8.6.1. BIN_AND()

Available in
DSQL, PSQL

Possible name conflict
YES → Read details

Result type
SMALLINT, INTEGER or BIGINT

- SMALLINT result is returned only if all the arguments are explicit SMALLINTs or NUMERIC(\(n\), 0) with \(n \leq 4\); otherwise small integers return an INTEGER result.

Syntax

```
BIN_AND (number, number [, number ...])
```

Table 178. BIN_AND Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>Any integer number (literal, smallint/integer/bigint, numeric/decimal with scale 0)</td>
</tr>
</tbody>
</table>

Returns the result of the bitwise AND operation on the argument(s).

See also

BIN_OR(), BIN_XOR()

8.6.2. BIN_NOT()

Available in
DSQL, PSQL

Result type
SMALLINT, INTEGER or BIGINT

- SMALLINT result is returned only if all the arguments are explicit SMALLINTs or NUMERIC(\(n\), 0) with \(n \leq 4\); otherwise small integers return an INTEGER result.

Syntax

```
BIN_NOT (number)
```

Table 179. BIN_NOT Function Parameter
Parameter Description

number Any integer number (literal, smallint/integer/bigint, numeric/decimal with scale 0)

Returns the result of the bitwise NOT operation on the argument, i.e. one's complement.

See also
BIN_OR(), BIN_XOR() and others in this set.

8.6.3. BIN_OR()

Available in
DSQL, PSQL

Possible name conflict
YES → Read details

Result type
SMALLINT, INTEGER or BIGINT

SMALLINT result is returned only if all the arguments are explicit SMALLINTs or NUMERIC(n, 0) with \( n \leq 4 \); otherwise small integers return an INTEGER result.

Syntax

```sql
BIN_OR (number, number [, number ...])
```

Table 180. BIN_OR Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>Any integer number (literal, smallint/integer/bigint, numeric/decimal with scale 0)</td>
</tr>
</tbody>
</table>

Returns the result of the bitwise OR operation on the argument(s).

See also
BIN_AND(), BIN_XOR()

8.6.4. BIN_SHL()

Available in
DSQL, PSQL

Result type
BIGINT
Syntax

```
BIN_SHL (number, shift)
```

Table 181. BIN_SHL Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>A number of an integer type</td>
</tr>
<tr>
<td>shift</td>
<td>The number of bits the number value is shifted by</td>
</tr>
</tbody>
</table>

Returns the first argument bitwise left-shifted by the second argument, i.e. \( a \ll b \) or \( a \cdot 2^b \).

See also

`BIN_SHR()`

8.6.5. BIN_SHR()

Available in
DSQL, PSQL

Result type
BIGINT

Syntax

```
BIN_SHR (number, shift)
```

Table 182. BIN_SHR Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>A number of an integer type</td>
</tr>
<tr>
<td>shift</td>
<td>The number of bits the number value is shifted by</td>
</tr>
</tbody>
</table>

Returns the first argument bitwise right-shifted by the second argument, i.e. \( a \gg b \) or \( a/2^b \).

- The operation performed is an arithmetic right shift (SAR), meaning that the sign of the first operand is always preserved.

See also

`BIN_SHL()`

8.6.6. BIN_XOR()

Available in
DSQL, PSQL

Possible name conflict
YES → Read details
**Result type**

SMALLINT, INTEGER or BIGINT

- **SMALLINT result is returned only if all the arguments are explicit SMALLINTs or NUMERIC(n, 0) with n <= 4; otherwise small integers return an INTEGER result.**

**Syntax**

```sql
BIN_XOR (number, number [, number ...])
```

**Table 183. BIN_XOR Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>Any integer number (literal, smallint/integer/bigint, numeric/decimal with scale 0)</td>
</tr>
</tbody>
</table>

Returns the result of the bitwise XOR operation on the argument(s).

*See also*

`BIN_AND(), BIN_OR()`

### 8.7. UUID Functions

#### 8.7.1. CHAR_TO_UUID()

**Available in**

DSQL, PSQL

**Result type**

BINARY(16)

**Syntax**

```sql
CHAR_TO_UUID (ascii_uuid)
```

**Table 184. CHAR_TO_UUID Function Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ascii_uuid</td>
<td>A 36-character representation of UUID. ‘-’ (hyphen) in positions 9, 14, 19 and 24; valid hexadecimal digits in any other positions, e.g. 'A0bF4E45-3029-2a44-D493-4998c9b439A3'</td>
</tr>
</tbody>
</table>

Converts a human-readable 36-char UUID string to the corresponding 16-byte UUID.

**CHAR_TO_UUID Examples**
select char_to_uuid('A0bF4E45-3029-2a44-D493-4998c9b439A3') from rdb$database
-- returns A0BF4E4530292A44D4934998C9B439A3 (16-byte string)

select char_to_uuid('A0bF4E45-3029-2A44-X493-4998c9b439A3') from rdb$database
-- error: -Human readable UUID argument for CHAR_TO_UUID must
-- have hex digit at position 20 instead of "X (ASCII 88)"

See also
UUID_TO_CHAR(), GEN_UUID()

8.7.2. GEN_UUID()

Available in
DSQL, PSQL

Result type
BINARY(16)

Syntax

GEN_UUID ()

Returns a universally unique ID as a 16-byte character string.

GEN_UUID Example

select gen_uuid() from rdb$database
-- returns e.g. 017347BFE212B2479C00FA4323B36320 (16-byte string)

See also
UUID_TO_CHAR(), CHAR_TO_UUID()

8.7.3. UUID_TO_CHAR()

Available in
DSQL, PSQL

Result type
CHAR(36)

Syntax

UUID_TO_CHAR (uuid)

Table 185. UUID_TO_CHAR Function Parameters
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>uuid</td>
<td>16-byte UUID</td>
</tr>
</tbody>
</table>

Converts a 16-byte UUID to its 36-character, human-readable ASCII representation.

**UUID_TO_CHAR Examples**

```sql
select uuid_to_char(x'876C45F4569B320DBCB4735AC3509E5F') from rdb$database
-- returns '876C45F4-569B-320D-BCB4-735AC3509E5F'

select uuid_to_char(gen_uuid()) from rdb$database
-- returns e.g. '680D946B-45FF-DB4E-B103-B85711529B86'

select uuid_to_char('Firebird swings!') from rdb$database
-- returns '46697265-6269-7264-2073-77696E677321'
```

See also

CHAR_TO_UUID(), GEN_UUID()

### 8.8. Functions for Sequences (Generators)

#### 8.8.1. GEN_ID()

**Available in**

DSQL, ESQL, PSQL

**Result type**

BIGINT

**Syntax**

```sql
GEN_ID (generator-name, step)
```

#### Table 186. GEN_ID Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>generator-name</td>
<td>Name of a generator (sequence) that exists. If it has been defined in double quotes with a case-sensitive identifier, it must be used in the same form unless the name is all upper-case.</td>
</tr>
<tr>
<td>step</td>
<td>An integer expression</td>
</tr>
</tbody>
</table>

Increments a generator or sequence and returns its new value. If step equals 0, the function will leave the value of the generator unchanged and return its current value.

- From Firebird 2.0 onward, the SQL-compliant **NEXT VALUE FOR** syntax is preferred, except when an increment other than 1 is needed.
If the value of the step parameter is less than zero, it will decrease the value of the generator. Attention! You should be extremely cautious with such manipulations in the database, as they could compromise data integrity.

**GEN_ID Example**

```sql
new.rec_id = gen_id(gen_recnum, 1);
```

**See also**

NEXT VALUE FOR, CREATE SEQUENCE (GENERATOR)

### 8.9. Conditional Functions

#### 8.9.1. COALESCE()

**Available in**

DSQL, PSQL

**Result type**

Depends on input

**Syntax**

```
COALESCE (<exp1>, <exp2> [, <expN> ... ])
```

**Table 187. COALESCE Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>exp1, exp2 ... expN</td>
<td>A list of expressions of any compatible types</td>
</tr>
</tbody>
</table>

The `COALESCE` function takes two or more arguments and returns the value of the first non-NULL argument. If all the arguments evaluate to NULL, the result is NULL.

**COALESCE Examples**

This example picks the Nickname from the Persons table. If it happens to be NULL, it goes on to FirstName. If that too is NULL, “Mr./Mrs.” is used. Finally, it adds the family name. All in all, it tries to use the available data to compose a full name that is as informal as possible. Notice that this scheme only works if absent nicknames and first names are really NULL: if one of them is an empty string instead, `COALESCE` will happily return that to the caller.

```sql
select coalesce (Nickname, FirstName, 'Mr./Mrs.') || ' ' || LastName
    as FullName
from Persons
```
See also
IIF(), NULLIF(), CASE

8.9.2. DECODE()

Available in
DSQL, PSQL

Result type
Depends on input

Syntax

```
DECODE(<testexpr>,
        <expr1>, <result1>
        [<expr2>, <result2> …]
        [, <defaultresult>])
```

The equivalent CASE construct:

```
CASE <testexpr>
    WHEN <expr1> THEN <result1>
    [WHEN <expr2> THEN <result2> …]
    [ELSE <defaultresult>]
END
```

Table 188. DECODE Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>testexpr</td>
<td>An expression of any compatible type that is compared to the expressions</td>
</tr>
<tr>
<td>expr1, expr2, ... exprN</td>
<td>Expressions of any compatible types, to which the testexpr expression is</td>
</tr>
<tr>
<td>result1, result2, ... resultN</td>
<td>Returned values of any type</td>
</tr>
<tr>
<td>defaultresult</td>
<td>The expression to be returned if none of the conditions is met</td>
</tr>
</tbody>
</table>

DECODE is a shorthand for the so-called “simple CASE” construct, in which a given expression is compared to a number of other expressions until a match is found. The result is determined by the value listed after the matching expression. If no match is found, the default result is returned, if present. Otherwise, NULL is returned.

Matching is done with the ‘=’ operator, so if testexpr is NULL, it won’t match any of the exprs, not even those that are NULL.
**DECODE Examples**

```
select name, 
age, 
decode(upper(sex), 
'M', 'Male', 
'F', 'Female', 
'Unknown'), 
religion
from people
```

See also

**CASE, Simple CASE**

**8.9.3. IIF()**

*Available in*

DSQL, PSQL

*Result type*

Depends on input

*Syntax*

```
IIF (<condition>, ResultT, ResultF)
```

*Table 189. IIF Function Parameters*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>condition</td>
<td>A true</td>
</tr>
<tr>
<td>resultT</td>
<td>The value returned if the condition is true</td>
</tr>
<tr>
<td>resultF</td>
<td>The value returned if the condition is false</td>
</tr>
</tbody>
</table>

IIF takes three arguments. If the first evaluates to true, the second argument is returned; otherwise the third is returned.

IIF could be likened to the ternary “?:” operator in C-like languages.

```
IIF(<Cond>, Result1, Result2) is a shorthand for “CASE WHEN <Cond> THEN Result1 ELSE Result2 END”.
```

**IIF Examples**

```
select iif( sex = 'M', 'Sir', 'Madam' ) from Customers
```

See also
CASE, DECODE()

8.9.4. MAXVALUE()

Available in
DSQL, PSQL

Result type
Varies according to input — result will be of the same data type as the first expression in the list (expr1).

Syntax

\[
\text{MAXVALUE} \left( \text{expr1}, \ldots, \text{exprN} \right)
\]

Table 190. MAXVALUE Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr1 … exprN</td>
<td>List of expressions of compatible types</td>
</tr>
</tbody>
</table>

Returns the maximum value from a list of numerical, string, or date/time expressions. This function fully supports text BLOBs of any length and character set.

If one or more expressions resolve to NULL, MAXVALUE returns NULL. This behaviour differs from the aggregate function MAX.

MAXVALUE Examples

\[
\text{SELECT MAXVALUE(PRICE_1, PRICE_2) AS PRICE FROM PRICELIST}
\]

See also
MINVALUE()

8.9.5. MINVALUE()

Available in
DSQL, PSQL

Result type
Varies according to input — result will be of the same data type as the first expression in the list (expr1).

Syntax

\[
\text{MINVALUE} \left( \text{expr1}, \ldots, \text{exprN} \right)
\]
Returns the minimum value from a list of numerical, string, or date/time expressions. This function fully supports text BLOBs of any length and character set.

If one or more expressions resolve to NULL, MINVALUE returns NULL. This behaviour differs from the aggregate function MIN.

**MINVALUE Examples**

```sql
SELECT MINVALUE(PRICE_1, PRICE_2) AS PRICE
FROM PRICELIST
```

**See also**

MAXVALUE()

### 8.9.6. NULLIF()

**Available in**

DSQL, PSQL

**Result type**

Depends on input

**Syntax**

```sql
NULLIF(<exp1>,<exp2>)
```

Returns the value of the first argument, unless it is equal to the second. In that case, NULL is returned.

**NULLIF Example**

```sql
select avg(nullif(Weight, -1)) from FatPeople
```

This will return the average weight of the persons listed in FatPeople, excluding those having a weight of -1, since AVG skips NULL data. Presumably, -1 indicates “weight unknown” in this table. A plain AVG(Weight) would include the -1 weights, thus skewing the result.
See also
COALESCE(), DECODE(), IIF(), CASE

8.10. Special Functions for DECFLOAT

8.10.1. COMPARE_DECFLOAT()

Available in
DSQL, PSQL

Result type
SMALLINT

Syntax

COMPARE_DECFLOAT (decfloat1, decfloat2)

Table 193. COMPARE_DECFLOAT Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>decfloatn</td>
<td>Value or expression of type DECFLOAT, or cast-compatible with DECFLOAT</td>
</tr>
</tbody>
</table>

COMPARE_DECFLOAT compares two DECFLOAT values to be equal, different or unordered. The result is a SMALLINT value, as follows:

0   Values are equal

1   First value is less than second

2   First value is greater than second

3   Values are unordered, i.e. one or both is NaN/sNaN

Unlike the comparison operators (‘<’, ‘=’, ‘>’, etc.), comparison is exact: COMPARE_DECFLOAT(2.17, 2.170) returns 2 not 0.

See also
TOTALORDER()

8.10.2. NORMALIZE_DECFLOAT()

Available in
DSQL, PSQL

Result type
DECFLOAT
Syntax

NORMALIZE_DECFLOAT (decfloat_value)

Table 194. NORMALIZE_DECFLOAT Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>decfloat_value</td>
<td>Value or expression of type DECFLOAT, or cast-compatible with DECFLOAT</td>
</tr>
</tbody>
</table>

NORMALIZE_DECFLOAT takes a single DECFLOAT argument and returns it in its simplest form. That means that for any non-zero value, trailing zeroes are removed with appropriate correction of the exponent.

Examples of NORMALIZE_DECFLOAT

```
-- will return 12
select normalize_decfloat(12.00) from rdb$database;

-- will return 1.2E+2
select normalize_decfloat(120) from rdb$database;
```

8.10.3. QUANTIZE()

Available in

DSQL, PSQL

Syntax

QUANTIZE (decfloat_value, exp_value)

Table 195. QUANTIZE Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>decfloat_value</td>
<td>Value or expression to quantize; needs to be of type DECFLOAT, or cast-compatible with DECFLOAT</td>
</tr>
<tr>
<td>exp_value</td>
<td>Value or expression to use for its exponent; needs to be of type DECFLOAT, or cast-compatible with DECFLOAT</td>
</tr>
</tbody>
</table>

QUANTIZE returns a DECFLOAT value that is equal in value and sign (except for rounding) to `decfloat_value`, and that has an exponent equal to the exponent of `exp_value`. The type of the return value is DECFLOAT(16) if both arguments are DECFLOAT(16), otherwise the result type is DECFLOAT(34).
The target exponent is the exponent used in the Decimal64 or Decimal128 storage format of DECFLOAT of exp_value. This is not necessarily the same as the exponent displayed in tools like isql. For example, the value 1.23E+2 is coefficient 123 and exponent 0, while 1.2 is coefficient 12 and exponent -1.

If the exponent of decfloat_value is greater than the one of exp_value, the coefficient of decfloat_value is multiplied by a power of ten, and its exponent decreased, if the exponent is smaller, then its coefficient is rounded using the current decfloat rounding mode, and its exponent is increased.

When it is not possible to achieve the target exponent because the coefficient would exceed the target precision (16 or 34 decimal digits), either a “Decfloat float invalid operation” error is raised or NaN is returned (depending on the current decfloat traps configuration).

There are almost no restrictions on the exp_value. However, in almost all usages, NaN/sNaN/Infinity will produce an exception (unless allowed by the current decfloat traps configuration), NULL will make the function return NULL, and so on.

**Examples of QUANTIZE**

```sql
select v, pic, quantize(v, pic) from examples;
```

<table>
<thead>
<tr>
<th>V</th>
<th>PIC</th>
<th>QUANTIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.16</td>
<td>0.001</td>
<td>3.160</td>
</tr>
<tr>
<td>3.16</td>
<td>0.01</td>
<td>3.16</td>
</tr>
<tr>
<td>3.16</td>
<td>0.1</td>
<td>3.2</td>
</tr>
<tr>
<td>3.16</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>3.16</td>
<td>1E+1</td>
<td>0E+1</td>
</tr>
<tr>
<td>-0.1</td>
<td>1</td>
<td>-0</td>
</tr>
<tr>
<td>0</td>
<td>1E+5</td>
<td>0E+5</td>
</tr>
<tr>
<td>316</td>
<td>0.1</td>
<td>316.0</td>
</tr>
<tr>
<td>316</td>
<td>1</td>
<td>316</td>
</tr>
<tr>
<td>316</td>
<td>1E+1</td>
<td>3.2E+2</td>
</tr>
<tr>
<td>316</td>
<td>1E+2</td>
<td>3E+2</td>
</tr>
</tbody>
</table>

**8.10.4. TOTALORDER()**

*Available in*
DSQL, PSQL

*Result type*
SMALLINT

*Syntax*

TOTALORDER ( decfloat1, decfloat2)
### Table 196. TOTALORDER Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>decfloatn</td>
<td>Value or expression of type DECFLOAT, or cast-compatible with DECFLOAT</td>
</tr>
</tbody>
</table>

TOTALORDER compares two DECFLOAT values including any special values. The comparison is exact, and returns a SMALLINT, one of:

-1 First value is less than second  
0 Values are equal  
1 First value is greater than second.

For TOTALORDER comparisons, DECFLOAT values are ordered as follows:

- NaN < -sNaN < -INF < -0.1 < -0.10 < -0 < 0 < 0.10 < 0.1 < INF < sNaN < NaN

See also  
COMPARE_DECFLOAT()

### 8.11. Cryptographic Functions

#### 8.11.1. DECRYPT()

**Available in**

DSQL, PSQL

**Result type**

VARBINARY or BLOB

**Syntax**

```
DECRYPT ( encrypted_input
    USING <algorithm> [MODE <mode>]
    KEY key
    [IV iv] [<ctr_type>] [CTR_LENGTH ctr_length]
    [COUNTER initial_counter] )
```

See syntax of <<fblangref40-scalarfuncs-encrypt,ENCRYPT>> for further rules !!

### Table 197. DECRYPT Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>encrypted_input</td>
<td>Encrypted input as a blob or (binary) string</td>
</tr>
</tbody>
</table>

See ENCRYPT Function Parameters for other parameters
DECRYPT decrypts data using a symmetric cipher.

- Sizes of data strings (like encrypted_input, key and iv) must meet the requirements of the selected algorithm and mode.
- This function returns BLOB SUB_TYPE BINARY when the first argument is a BLOB, and VARBINARY for all other text and binary types.
- When the encrypted data was text, it must be explicitly cast to a string type of appropriate character set.
- The ins and outs of the various algorithms are considered beyond the scope of this language reference. We recommend searching the internet for further details on the algorithms.

**DECRYPT Examples**

```sql
select decrypt(x'0154090759DF' using sober128 key 'AbcdAbcdAbcdAbcd' iv '01234567')
from rdb$database;
select decrypt(secret_field using aes mode ofb key '0123456701234567' iv init_vector)
from secure_table;
```

*See also*

ENCRIPT(), RSA_DECRYPT()

**8.11.2. ENCRYPT()**

*Available in*

DSQL, PSQL

*Result type*

VARBINARY or BLOB
Syntax

ENCRIPT ( input
    USING <algorithm> [MODE <mode>]
    KEY key
    [IV iv] [<ctr_type>] [CTR_LENGTH ctr_length]
    [COUNTER initial_counter] )

<algorithm> ::= <block_cipher> | <stream_cipher>

<block_cipher> ::= AES | ANUBIS | BLOWFISH | KHAZAD | RC5 |
                    | RC6 | SAFER+ | TWOFISH | XTEA

<stream_cipher> ::= CHACHA20 | RC4 | SOBER128

<mode> ::= CBC | CFB | CTR | ECB | OFB

<ctr_type> ::= CTR_BIG_ENDIAN | CTR_LITTLE_ENDIAN

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>input</td>
<td>Input to encrypt as a blob or (binary) string</td>
</tr>
<tr>
<td>algorithm</td>
<td>The algorithm to use for decryption</td>
</tr>
<tr>
<td>mode</td>
<td>The algorithm mode; only for block ciphers</td>
</tr>
<tr>
<td>key</td>
<td>The encryption/decryption key</td>
</tr>
<tr>
<td>iv</td>
<td>Initialization vector or nonce; should be specified for block ciphers in all modes except ECB, and all stream ciphers except RC4</td>
</tr>
<tr>
<td>ctr_type</td>
<td>Endianness of the counter; only for CTR mode. Default is CTR_LITTLE_ENDIAN.</td>
</tr>
<tr>
<td>ctr_length</td>
<td>Counter length; only for CTR mode. Default is size of iv.</td>
</tr>
<tr>
<td>initial_counter</td>
<td>Initial counter value; only for CHACHA20. Default is 0.</td>
</tr>
</tbody>
</table>

ENCRIPT can encrypt data using a symmetric cipher.
This function returns **BLOB SUB_TYPE BINARY** when the first argument is a BLOB, and **VARBINARY** for all other text and binary types.

Sizes of data strings (like *key* and *iv*) must meet the requirements of the selected algorithm and mode, see table **Encryption Algorithm Requirements**.

- In general, the size of *iv* must match the block size of the algorithm
- For ECB and CBC mode, *input* must be multiples of the block size, you will need to manually pad with zeroes or spaces as appropriate.

The ins and outs of the various algorithms and modes are considered beyond the scope of this language reference. We recommend searching the internet for further details on the algorithms.

Although specified as separate options in this Language Reference, in the actual Firebird 4.0 syntax **CTR_LENGTH** and **COUNTER** are aliases.

### Table 199. Encryption Algorithm Requirements

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Key size (bytes)</th>
<th>Block size (bytes)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Block Ciphers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AES</td>
<td>16, 24, 32</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>ANUBIS</td>
<td>16 - 40, in steps of 4</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>BLOWFISH</td>
<td>8 - 56</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>KHAZAD</td>
<td>16</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>RC5</td>
<td>8 - 128</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>RC6</td>
<td>8 - 128</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>SAFER+</td>
<td>16, 24, 32</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>TWOFISH</td>
<td>16, 24, 32</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>XTEA</td>
<td>16</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td><strong>Stream Ciphers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHACHA20</td>
<td>16, 32</td>
<td>1</td>
<td>Nonce size (IV) is 8 or 12 bytes. For nonce size 8, <em>initial_counter</em> is a 64-bit integer, for size 12, 32-bit.</td>
</tr>
<tr>
<td>RC4</td>
<td>5 - 256</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>SOBER128</td>
<td>4x</td>
<td>1</td>
<td>Nonce size (IV) is 4y bytes, the length is independent of key size.</td>
</tr>
</tbody>
</table>
select encrypt('897897' using sober128 key 'AbcdAbcdAbcdAbcd' iv '01234567')
from rdb$database;

See also
DECRYPT(), RSA_ENCRYPT()

8.11.3. RSA_DECRYPT()

Available in
DSQL, PSQL

Result type
VARBINARY

Syntax

RSA_DECRYPT (encrypted_input

[LPARAM tag_string]

[HASH <hash>])

<hash> ::= MD5 | SHA1 | SHA256 | SHA512

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>encrypted_input</td>
<td>Input data to decrypt</td>
</tr>
<tr>
<td>private_key</td>
<td>Private key to apply, PKCS#1 format</td>
</tr>
<tr>
<td>tag_string</td>
<td>An additional system-specific tag to identify which system encrypted the message; default is NULL. If the tag does not match what was used during encryption, RSA_DECRYPT will not decrypt the data.</td>
</tr>
<tr>
<td>hash</td>
<td>The hash used for OAEP padding; default is SHA256.</td>
</tr>
</tbody>
</table>

RSA_DECRYPT decrypts encrypted_input using the RSA private key and then OAEP de-pads the resulting data.

- This function returns VARBINARY.
- When the encrypted data was text, it must be explicitly cast to a string type of appropriate character set.

RSA_DECRYPT Examples

- Run the examples of the RSA_PRIVATE and RSA_PUBLIC, RSA_ENCRYPT functions first.
select cast(rsa_decrypt(rdb$get_context('USER_SESSION', 'msg') key rdb$get_context('USER_SESSION', 'private_key')) as varchar(128)) from rdb$database;

See also
RSA_ENCRYPT(), RSA_PRIVATE(), DECRYPT()

8.11.4. RSA_ENCRYPT()

Available in
DSQL, PSQL

Result type
VARBINARY

Syntax

RSA_ENCRYPT (input KEY public_key
            [LPARAM tag_string] [HASH <hash>])

<hash> ::= MD5 | SHA1 | SHA256 | SHA512

Table 201. RSA_ENCRYPT Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>input</td>
<td>Input data to encrypt</td>
</tr>
<tr>
<td>public_key</td>
<td>Public key to apply, PKCS#1 format</td>
</tr>
<tr>
<td>tag_string</td>
<td>An additional system-specific tag to identify which system encrypted the message; default is NULL.</td>
</tr>
<tr>
<td>hash</td>
<td>The hash used for OAEP padding; default is SHA256.</td>
</tr>
</tbody>
</table>

RSA_ENCRYPT pads input using the OAEP padding scheme and then encrypts it using the specified RSA public key. This function is normally used to encrypt short symmetric keys which are then used in block ciphers to encrypt a message.

RSA_ENCRYPT Examples

Run the examples of the RSA_PRIVATE and RSA_PUBLIC functions first.

select rdb$set_context('USER_SESSION', 'msg', rsa_encrypt('Some message' key rdb$get_context('USER_SESSION', 'public_key'))) from rdb$database;

See also
RSA_DECRYPT(), RSA_PUBLIC(), ENCRYPT()
8.11.5. RSA_PRIVATE()

Available in
DSQL, PSQL

Result type
VARBINARY

Syntax

RSA_PRIVATE (key_length)

Table 202. RSA_PRIVATE Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>key_length</td>
<td>Key length in bytes; minimum 4, maximum 1024. A size of 256 bytes (2048 bits) or larger is recommended.</td>
</tr>
</tbody>
</table>

RSA_PRIVATE generates an RSA private key of the specified length (in bytes) in PKCS#1 format.

The larger the length specified, the longer it takes for the function to generate a private key.

RSA_PRIVATE Examples

```sql
select rdb$set_context('USER_SESSION', 'private_key', rsa_private(256))
from rdb$database;
```

Putting private keys in the context variables is not secure. SYSDBA and users with the role RDB$ADMIN or the system privilege MONITOR_ANY_ATTACHMENT can see all context variables from all attachments.

See also
RSA_PUBLIC(), RSA_DECRYPT()

8.11.6. RSA_PUBLIC()

Available in
DSQL, PSQL

Result type
VARBINARY

Syntax

RSA_PUBLIC (private_key)
Table 203. RSA_PUBLIC Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>private_key</td>
<td>RSA private key in PKCS#1 format</td>
</tr>
</tbody>
</table>

RSA_PUBLIC returns the RSA public key in PKCS#1 format for the provided RSA private key (also PKCS#1 format).

**RSA_PUBLIC Examples**

💡 Run the example of the RSA_PRIVATE function first.

```sql
select rdb$set_context('USER_SESSION', 'public_key',
    rsa_public(rdb$get_context('USER_SESSION', 'private_key'))) from rdb$database;
```

See also

RSA_PRIVATE(), RSA_ENCRYPT()

### 8.11.7. RSA_SIGN_HASH()

**Available in**

DSQL, PSQL

**Result type**

VARBINARY

**Syntax**

```sql
RSA_SIGN_HASH (message_digest
    KEY private_key
    [HASH <hash>] [SALT_LENGTH salt_length]

<hash> ::= MD5 | SHA1 | SHA256 | SHA512
```

Table 204. RSA_SIGN_HASH Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>message_digest</td>
<td>Hash of message to sign. The hash algorithm used should match <code>hash</code></td>
</tr>
<tr>
<td>private_key</td>
<td>RSA private key in PKCS#1 format</td>
</tr>
<tr>
<td>hash</td>
<td>Hash to generate PSS encoding; default is SHA256. This should be the same</td>
</tr>
<tr>
<td></td>
<td>hash as used to generate <code>message_digest</code>.</td>
</tr>
<tr>
<td>salt_length</td>
<td>Length of the desired salt in bytes; default is 8; minimum 1, maximum 32.</td>
</tr>
<tr>
<td></td>
<td>The recommended value is between 8 and 16.</td>
</tr>
</tbody>
</table>

RSA_SIGN_HASH performs PSS encoding of the `message_digest` to be signed, and signs using the RSA private key.
This function expects the hash of a message (or message digest), not the actual message. The hash argument should specify the algorithm that was also used to generate that hash.

A function that accepts the actual message to hash might be introduced in a future version of Firebird.

### PSS encoding

Probabilistic Signature Scheme (PSS) is a cryptographic signature scheme specifically developed to allow modern methods of security analysis to prove that its security directly relates to that of the RSA problem. There is no such proof for the traditional PKCS#1 v1.5 scheme.

### RSA_VERIFY_HASH Examples

Run the example of the `RSA_PRIVATE` function first.

```plaintext
select rdb$set_context('USER_SESSION', 'msg',
    rsa_sign_hash(crypt_hash('Test message' using sha256)
    key rdb$get_context('USER_SESSION', 'private_key')))
from rdb$database;
```

See also

`RSA_VERIFY_HASH()`, `RSA_PRIVATE()`, `CRYPT_HASH()`

### 8.11.8. RSA_VERIFY_HASH()

*Available in*

DSQL, PSQL

*Result type*

BOOLEAN

*Syntax*

```plaintext
RSA_VERIFY_HASH (message_digest
    SIGNATURE signature KEY public_key
    [HASH <hash>] [SALT_LENGTH salt_length])
```

<hash> ::= MD5 | SHA1 | SHA256 | SHA512

*Table 205. RSA_VERIFY Function Parameters*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>message_digest</td>
<td>Hash of message to verify. The hash algorithm used should match hash</td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
</tr>
<tr>
<td>---------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>signature</td>
<td>Expected signature of input generated by RSA_SIGN_HASH</td>
</tr>
<tr>
<td>public_key</td>
<td>RSA public key in PKCS#1 format matching the private key used to sign</td>
</tr>
<tr>
<td>hash</td>
<td>Hash to use for the message digest; default is SHA256. This should be the</td>
</tr>
<tr>
<td></td>
<td>same hash as used to generate message_digest, and as used in RSA_SIGN_HASH</td>
</tr>
<tr>
<td>salt_length</td>
<td>Length of the salt in bytes; default is 8; minimum 1, maximum 32. Value</td>
</tr>
<tr>
<td></td>
<td>must match the length used in RSA_SIGN_HASH.</td>
</tr>
</tbody>
</table>

**RSA_VERIFY_HASH** performs PSS encoding of the *message_digest* to be verified, and verifies the digital signature using the provided RSA public key.

This function expects the hash of a message (or message digest), not the actual message. The *hash* argument should specify the algorithm that was also used to generate that hash.

A function that accepts the actual message to hash might be introduced in a future version of Firebird.

**RSA_VERIFY_HASH Examples**

Run the examples of the **RSA_PRIVATE, RSA_PUBLIC** and **RSA_SIGN_HASH** functions first.

```sql
select rsa_verify_hash(
    crypt_hash('Test message' using sha256)
    signature rdb$get_context('USER_SESSION', 'msg')
    key rdb$get_context('USER_SESSION', 'public_key'))
from rdb$database
```

**See also**

**RSA_SIGN_HASH(), RSA_PUBLIC(), CRYPT_HASH()**

**8.12. Other Functions**

Functions that don’t really fit in any other category.

**8.12.1. MAKE_DBKEY()**

*Available in*

DSQL, PSQL

*Result type*

BINARY(8)
Syntax

\[
\text{MAKE\_DBKEY (relation, recnum [, dpnum [, ppnum]])}
\]

Table 206. RDB$GET\_TRANSACTION\_CN Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>relation</td>
<td>Relation name or relation id</td>
</tr>
<tr>
<td>recnum</td>
<td>Record number. Either absolute (if (dpnum) and (ppnum) are absent), or relative (if (dpnum) present)</td>
</tr>
<tr>
<td>dpnum</td>
<td>Data page number. Either absolute (if (ppnum) is absent) or relative (if (ppnum) present)</td>
</tr>
<tr>
<td>ppnum</td>
<td>Pointer page number.</td>
</tr>
</tbody>
</table>

\text{MAKE\_DBKEY} creates a DBKEY value using a relation name or ID, record number, and (optionally) logical numbers of data page and pointer page.

1. If \(relation\) is a string expression or literal, then it is treated as a relation name, and the engine searches for the corresponding relation ID. The search is case-sensitive. In the case of string literal, relation ID is evaluated at query preparation time. In the case of expression, relation ID is evaluated at execution time. If the relation cannot be found, then error \(\text{isc\_relnotdef}\) is raised.

2. If \(relation\) is a numeric expression or literal, then it is treated as a relation ID and used “as is”, without verification against existing relations. If the argument value is negative or greater than the maximum allowed relation ID (65535 currently), then \(\text{NULL}\) is returned.

3. Argument \(recnum\) represents an absolute record number in the relation (if the next arguments \(dpnum\) and \(ppnum\) are missing), or a record number relative to the first record, specified by the next arguments.

4. Argument \(dpnum\) is a logical number of data page in the relation (if the next argument \(ppnum\) is missing), or number of data pages relative to the first data page addressed by the given \(ppnum\).

5. Argument \(ppnum\) is a logical number of pointer page in the relation.

6. All numbers are zero-based. Maximum allowed value for \(dpnum\) and \(ppnum\) is \(2^{32}\) (4294967296). If \(dpnum\) is specified, then \(recnum\) can be negative. If \(dpnum\) is missing and \(recnum\) is negative, then \(\text{NULL}\) is returned. If \(ppnum\) is specified, then \(dpnum\) can be negative. If \(ppnum\) is missing and \(dpnum\) is negative, then \(\text{NULL}\) is returned.

7. If any of specified arguments is \(\text{NULL}\), the result is also \(\text{NULL}\).

8. Argument \(relation\) is described as \text{INTEGER} during query preparation, but it can be overridden by a client application as \text{VARCHAR} or \text{CHAR}. Arguments \(recnum\), \(dpnum\) and \(ppnum\) are described as \text{BIGINT}. 

Chapter 8. Built-in Scalar Functions

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Examples of `MAKE_DBKEY`

1. Select record using relation name (note that relation name is uppercase)

```sql
select *
from rdb$relations
where rdb$db_key = make_dbkey('RDB$RELATIONS', 0)
```

2. Select record using relation ID

```sql
select *
from rdb$relations
where rdb$db_key = make_dbkey(6, 0)
```

3. Select all records physically residing on the first data page

```sql
select *
from rdb$relations
where rdb$db_key >= make_dbkey(6, 0, 0)
and rdb$db_key < make_dbkey(6, 0, 1)
```

4. Select all records physically residing on the first data page of 6th pointer page

```sql
select *
from SOMETABLE
where rdb$db_key >= make_dbkey('SOMETABLE', 0, 0, 5)
and rdb$db_key < make_dbkey('SOMETABLE', 0, 1, 5)
```

### 8.12.2. `RDB$ERROR()`

*Available in*

PSQL

*Result type*

Varies (see table below)

**Syntax**

```
RDB$ERROR (<context>)
```

<context> ::=  
  GDSCODE | SQLCODE | SQLSTATE | EXCEPTION | MESSAGE

*Table 207. Contexts*
### Context

<table>
<thead>
<tr>
<th>Context</th>
<th>Result type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDSCODE</td>
<td>INTEGER</td>
<td>Firebird error code, see also GDSCODE</td>
</tr>
<tr>
<td>SQLCODE</td>
<td>INTEGER</td>
<td>(deprecated) SQL code, see also SQLCODE</td>
</tr>
<tr>
<td>SQLSTATE</td>
<td>CHAR(5) CHARACTER SET ASCII</td>
<td>SQLstate, see also SQLSTATE</td>
</tr>
<tr>
<td>EXCEPTION</td>
<td>VARCHAR(63) CHARACTER SET UTF8</td>
<td>Name of the active user-defined exception or NULL if the active exception is a system exception</td>
</tr>
<tr>
<td>MESSAGE</td>
<td>VARCHAR(1024) CHARACTER SET UTF8</td>
<td>Message text of the active exception</td>
</tr>
</tbody>
</table>

**RDB$ERROR** returns data of the specified context about the active PSQL exception. Its scope is confined to exception-handling blocks in PSQL (WHEN ... DO). Outside the exception handling blocks, RDB$ERROR always returns NULL. This function cannot be called from DSQL.

**Example of RDB$ERROR**

```sql
BEGIN
...
WHEN ANY DO
  EXECUTE PROCEDURE P_LOG_EXCEPTION(RDB$ERROR(MESSAGE));
END
```

**See also**

*Trapping and Handling Errors, GDSCODE, SQLCODE, SQLSTATE*

### 8.12.3. RDB$GET_TRANSACTION_CN()

**Available in**

DSQL, PSQL

**Result type**

BIGINT

**Syntax**

```
RDB$GET_TRANSACTION_CN (transaction_id)
```

**Table 208. RDB$GET_TRANSACTION_CN Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>transaction_id</td>
<td>Transaction id</td>
</tr>
</tbody>
</table>

**RDB$GET_TRANSACTION_CN** returns the commit number (“CN”) of the supplied transaction.

If the return value is greater than 1, it is the actual *CN* of the transaction if it was committed after the database was started.
The function can also return one of the following results, indicating the commit status of the transaction:

-2  Transaction is dead (rolled back)

-1  Transaction is in limbo

0   Transaction is still active

1   Transaction committed before the database started or less than the Oldest Interesting Transaction for the database

NULL Transaction number supplied is NULL or greater than Next Transaction for the database

For more information about CN, consult the Firebird 4.0 Release Notes.

RDB$GET_TRANSACTION_CN  Examples

```sql
select rdb$get_transaction_cn(current_transaction) from rdb$database;
select rdb$get_transaction_cn(123) from rdb$database;
```

8.12.4. RDB$ROLE_IN_USE()

Available in
DSQL, PSQL

Result type
BOOLEAN

Syntax

```sql
RDB$ROLE_IN_USE (role_name)
```

Table 209. RDB$ROLE_IN_USE Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>role_name</td>
<td>String expression for the role to check. Case-sensitive, must match the role name as stored in RDB$ROLES</td>
</tr>
</tbody>
</table>

RDB$ROLE_IN_USE returns TRUE if the specified role is active for the current connection, and FALSE otherwise. Contrary to CURRENT_ROLE — which only returns the explicitly specified role — this function can be used to check for roles that are active by default, or cumulative roles activated by an explicitly specified role.
**RDB$ROLE_IN_USE Examples**

List currently active roles

```sql
select rdb$role_name
from rdb$database
where rdb$role_in_use(rdb$role_name);
```

See also

**CURRENT_ROLE**

**8.12.5. RDB$SYSTEM_PRIVILEGE()**

Available in

DSQL, PSQL

Result type

BOOLEAN

Syntax

```
RDB$SYSTEM_PRIVILEGE (<sys_privilege>)
```

<sys_privilege> ::= ! See CREATE ROLE !

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sys_privilege</td>
<td>System privilege</td>
</tr>
</tbody>
</table>

**Table 210. RDB$SYSTEM_PRIVILEGE Function Parameters**

RDB$SYSTEM_PRIVILEGE accepts a system privilege name and returns TRUE if the current attachment has the given system privilege, and FALSE otherwise.

**RDB$SYSTEM_PRIVILEGE Examples**

```sql
select rdb$system_privilege(user_management) from rdb$database;
```

See also

**Fine-grained System Privileges**
Chapter 9. Aggregate Functions

Aggregate functions operate on groups of records, rather than on individual records or variables. They are often used in combination with a GROUP BY clause.

Syntax

\[
\text{<aggregate\_function> ::= aggregate\_function ([<expr> [, <expr> ...]]) [FILTER (WHERE <condition>)]}
\]

The aggregate functions can also be used as window functions with the OVER () clause. See Window (Analytical) Functions for more information.

9.1. FILTER Clause for Aggregate Functions

The FILTER clause extends aggregate functions (SUM, AVG, COUNT, etc.) with an additional WHERE clause. This limits the rows processed by the aggregate functions to the rows that satisfy the conditions of both the main WHERE clause and those inside the FILTER clause.

It can be thought of as a more explicit form of using an aggregate function with a condition (decode, case, iif) to ignore some values that would otherwise be considered by the aggregation.

The clause can be used with any aggregate functions in aggregate or windowed (OVER) statements, but not with window-only functions like DENSE_RANK.

Example of FILTER

Suppose you need a query to count the number of status = 'A' and the number of status = 'E' as different columns. The old way to do it would be:

```sql
select count(decode(status, 'A', 1)) status_a,
       count(decode(status, 'E', 1)) status_e
from data;
```

The FILTER clause lets you express those conditions more explicitly:

```sql
select count(*) filter (where status = 'A') status_a,
       count(*) filter (where status = 'E') status_e
from data;
```

You can use more than one FILTER modifier in an aggregate query. You could, for example, use 12 filters on totals aggregating sales for a year to produce monthly figures for a pivot set.
9.2. General-purpose Aggregate Functions

9.2.1. AVG()

Available in
DSQL, ESQL, PSQL

Result type
Depends on the input type

Syntax

```
AVG ([ALL | DISTINCT] <expr>)
```

Table 211. AVG Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF that returns a numeric data type. Aggregate functions are not allowed as expressions</td>
</tr>
</tbody>
</table>

AVG returns the average argument value in the group. NULL is ignored.

- Parameter ALL (the default) applies the aggregate function to all values.
- Parameter DISTINCT directs the AVG function to consider only one instance of each unique value, no matter how many times this value occurs.
- If the set of retrieved records is empty or contains only NULL, the result will be NULL.

For exact numeric types, the result type is wider or the same as the input type. It matches the determination of the result type of SUM(). This is probably a bug, see firebird#6845.

AVG Examples

```
SELECT
department,
AVG(salary)
FROM employee
GROUP BY department
```

See also

SELECT

9.2.2. COUNT()
DSQL, ESQL, PSQL

Result type
BIGINT

Syntax

COUNT ([ALL | DISTINCT] <expr> | *)

Table 212. COUNT Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF that returns a numeric data type. Aggregate functions are not allowed as expressions</td>
</tr>
</tbody>
</table>

COUNT returns the number of non-null values in a group.

- ALL is the default: it simply counts all values in the set that are not NULL.
- If DISTINCT is specified, duplicates are excluded from the counted set.
- If COUNT (*) is specified instead of the expression expr, all rows will be counted. COUNT (*) —
  - does not accept parameters
  - cannot be used with the keyword DISTINCT
  - does not take an expr argument, since its context is column-unspecific by definition
  - counts each row separately and returns the number of rows in the specified table or group without omitting duplicate rows
  - counts rows containing NULL
- If the result set is empty or contains only NULL in the specified column(s), the returned count is zero.

COUNT Examples

```
SELECT
  dept_no,
  COUNT(*) AS cnt,
  COUNT(DISTINCT name) AS cnt_name
FROM employee
GROUP BY dept_no
```

See also
SELECT.

9.2.3. LIST()
DSQL, PSQL

**Result type**

BLOB

**Syntax**

```sql
LIST ([ALL | DISTINCT] <expr> [, separator ])
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF that returns the string data type or a BLOB. Fields of numeric and date/time types are converted to strings. Aggregate functions are not allowed as expressions.</td>
</tr>
<tr>
<td>separator</td>
<td>Optional alternative separator, a string expression. Comma is the default separator</td>
</tr>
</tbody>
</table>

LIST returns a string consisting of the non-NULL argument values in the group, separated either by a comma or by a user-supplied separator. If there are no non-NULL values (this includes the case where the group is empty), NULL is returned.

- **ALL** (the default) results in all non-NULL values being listed. With **DISTINCT**, duplicates are removed, except if `expr` is a BLOB.
- In Firebird 2.5 and up, the optional `separator` argument may be any string expression. This makes it possible to specify e.g. `ascii_char(13)` as a separator. (This improvement has also been backported to 2.1.4.)
- The `expr` and `separator` arguments support BLOBs of any size and character set.
- Date/time and numeric arguments are implicitly converted to strings before concatenation.
- The result is a text BLOB, except when `expr` is a BLOB of another subtype.
- The ordering of the list values is undefined — the order in which the strings are concatenated is determined by read order from the source set which, in tables, is not generally defined. If ordering is important, the source data can be pre-sorted using a derived table or similar.

**LIST Examples**

1. Retrieving the list, order undefined:

   ```sql
   SELECT LIST (display_name, '; ') FROM GR_WORK;
   ```

2. Retrieving the list in alphabetical order, using a derived table:
### 9.2.4. MAX()

**Available in**
DSQL, ESQL, PSQL

**Result type**
Returns a result of the same data type the input expression.

**Syntax**

```
MAX ([ALL | DISTINCT] <expr>)
```

**Table 214. MAX Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

MAX returns the maximum non-NULL element in the result set.

- If the group is empty or contains only NULLs, the result is NULL.
- If the input argument is a string, the function will return the value that will be sorted last if COLLATE is used.
- This function fully supports text BLOBs of any size and character set.

ℹ️ The DISTINCT parameter makes no sense if used with MAX() and is implemented only for compliance with the standard.

**MAX Examples**

```
SELECT dept_no, MAX(salary) FROM employee GROUP BY dept_no
```
See also
MIN(), SELECT

9.2.5. MIN()

Available in
DSQL, ESQL, PSQL

Result type
Returns a result of the same data type the input expression.

Syntax

```
MIN ([ALL | DISTINCT] <expr>)
```

Table 215. MIN Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

MIN returns the minimum non-NULL element in the result set.

- If the group is empty or contains only NULLs, the result is NULL.
- If the input argument is a string, the function will return the value that will be sorted first if COLLATE is used.
- This function fully supports text BLOBs of any size and character set.

![Info]
The DISTINCT parameter makes no sense if used with MIN() and is implemented only for compliance with the standard.

MIN Examples

```
SELECT
department_no,
MIN(salary)
FROM employee
GROUP BY department_no
```

See also
MAX(), SELECT

9.2.6. SUM()

Available in
Result type
Depends on the input type

Syntax

```
SUM ([ALL | DISTINCT] <expr>)
```

Table 216. SUM Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

SUM calculates and returns the sum of non-null values in the group.

- If the group is empty or contains only NULLs, the result is NULL.
- ALL is the default option—all values in the set that are not NULL are processed. If DISTINCT is specified, duplicates are removed from the set and the SUM evaluation is done afterwards.

The result type of SUM depends on the input type:

- FLOAT, DOUBLE PRECISION
- SMALLINT, INTEGER
- BIGINT, INT128
- DECIMAL/NUMERIC(p, n) with p < 10
- DECIMAL/NUMERIC(p, n) with p >= 10
- DECFLOAT(16), DECFLOAT(34)
- DOUBLE PRECISION
- BIGINT
- INT128
- DECIMAL/NUMERIC(18, n)
- DECIMAL/NUMERIC(38, n)
- DECFLOAT(34)

**SUM Examples**

```
SELECT dept_no, SUM(salary), FROM employee GROUP BY dept_no
```

See also

SELECT

9.3. Statistical Aggregate Functions
9.3.1. CORR()

Available in
DSQL, PSQL

Result type
DOUBLE PRECISION

Syntax

CORR ( <expr1>, <expr2> )

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>exprN</td>
<td>Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The CORR function return the correlation coefficient for a pair of numerical expressions.

The function CORR(<expr1>, <expr2>) is equivalent to

\[
\frac{\text{COVAR_POP}(<expr1>, <expr2>)}{(\text{STDDEV_POP}(<expr2>) \times \text{STDDEV_POP}(<expr1>))}
\]

This is also known as the Pearson correlation coefficient.

In a statistical sense, correlation is the degree of to which a pair of variables are linearly related. A linear relation between variables means that the value of one variable can to a certain extent predict the value of the other. The correlation coefficient represents the degree of correlation as a number ranging from -1 (high inverse correlation) to 1 (high correlation). A value of 0 corresponds to no correlation.

If the group or window is empty, or contains only NULL values, the result will be NULL.

CORR Examples

```sql
select
    corr(alength, aheight) AS c_corr
from measure
```

See also

COVAR_POP(), STDDEV_POP()

9.3.2. COVAR_POP()

Available in
The function `COVAR_POP` returns the population covariance for a pair of numerical expressions. The function `COVAR_POP(expr1, expr2)` is equivalent to

\[(\text{SUM}(\text{expr1} \times \text{expr2}) - \text{SUM}(\text{expr1}) \times \text{SUM}(\text{expr2}) / \text{COUNT}(*)) / \text{COUNT}(*)\]

If the group or window is empty, or contains only NULL values, the result will be NULL.

**COVAR_POP Examples**

```sql
select
    covar_pop(alength, aheight) AS c_covar_pop
from measure
```

**See also**

`COVAR_SAMP()`, `SUM()`, `COUNT()`

### 9.3.3. COVAR_SAMP()

**Available in**

DSQL, PSQL

**Result type**

DOUBLE PRECISION

**Syntax**

```sql
COVAR_SAMP ( <expr1>, <expr2> )
```

**Table 219. COVAR_SAMP Function Parameters**
### Parameter Description

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>exprN</code></td>
<td>Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function `COVAR_SAMP` returns the sample covariance for a pair of numerical expressions.

The function `COVAR_SAMP(<expr1>, <expr2>)` is equivalent to

\[(\text{SUM}(<expr1> * <expr2>) - \text{SUM}(<expr1>) * \text{SUM}(<expr2>) / \text{COUNT}(*)) / (\text{COUNT}(*) - 1)\]

If the group or window is empty, contains only 1 row, or contains only NULL values, the result will be NULL.

#### COVAR_SAMP Examples

```sql
select
covar_samp(alength, aheight) AS c_covar_samp
from measure
```

See also

`COVAR_POP()`, `SUM()`, `COUNT()`

### 9.3.4. STDDEV_POP()

**Available in**

DSQL, PSQL

**Result type**

DOUBLE PRECISION or NUMERIC depending on the type of `expr`

**Syntax**

```sql
STDDEV_POP ( <expr> )
```

#### Table 220. STDDEV_POP Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>expr</code></td>
<td>Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function `STDDEV_POP` returns the population standard deviation for a group or window. NULL values are skipped.

The function `STDDEV_POP(<expr>)` is equivalent to
If the group or window is empty, or contains only NULL values, the result will be NULL.

**STDDEV_POP Examples**

```sql
select
department_no
    stddev_pop(salary)
from employee
group by department_no
```

See also

STDDEV_SAMP(), VAR_POP(), SQRT

### 9.3.5. STDDEV_SAMP()

*Available in*

DSQL, PSQL

*Result type*

DOUBLE PRECISION or NUMERIC depending on the type of expr

*Syntax*

```sql
STDDEV_POP ( <expr> )
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function STDDEV_SAMP returns the sample standard deviation for a group or window. NULL values are skipped.

The function STDDEV_SAMP(<expr>) is equivalent to

```
SQRT(VAR_SAMP(<expr>))
```

If the group or window is empty, contains only 1 row, or contains only NULL values, the result will be NULL.
**STDDEV_SAMP Examples**

```sql
select
department_no
stddev_samp(salary)
from employee
group by department_no
```

See also

**STDDEV_POP()**, **VAR_SAMP()**, **SQRT**

### 9.3.6. VAR_POP()

*Available in*

DSQL, PSQL

*Result type*

DOUBLE PRECISION or NUMERIC depending on the type of `expr`

*Syntax*

```
VAR_POP ( <expr> )
```

**Table 222. VAR_POP Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>expr</code></td>
<td>Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function **VAR_POP** returns the population variance for a group or window. NULL values are skipped.

The function **VAR_POP(<expr>)** is equivalent to

```
(SUM(<expr> * <expr>) - SUM (<expr>) * SUM (<expr>) / COUNT(<expr>)) / COUNT (<expr>)
```

If the group or window is empty, or contains only NULL values, the result will be NULL.

**VAR_POP Examples**
select
department_number
var_pop(salary)
from employee
group by department_number

See also
VAR_SAMP(), SUM(), COUNT()

9.3.7. VAR_SAMP()

Available in
DSQL, PSQL

Result type
DOUBLE PRECISION or NUMERIC depending on the type of expr

Syntax
VAR_SAMP ( <expr> )

Table 223. VAR_SAMP Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function VAR_POP returns the sample variance for a group or window. NULL values are skipped.

The function VAR_SAMP(<expr>) is equivalent to

\[
\frac{(\sum(<expr> \times <expr>) - \sum(<expr>) \times \sum(<expr>) / \text{COUNT}(<expr>))}{(\text{COUNT}(<expr>) - 1)}
\]

If the group or window is empty, contains only 1 row, or contains only NULL values, the result will be NULL.

VAR_SAMP Examples

select
department_number
var_samp(salary)
from employee
group by department_number
9.4. Linear Regression Aggregate Functions

Linear regression functions are useful for trend line continuation. The trend or regression line is usually a pattern followed by a set of values. Linear regression is useful to predict future values. To continue the regression line, you need to know the slope and the point of intersection with the y-axis. A set of linear functions can be used for calculating these values.

In the function syntax, y is interpreted as an x-dependent variable.

The linear regression aggregate functions take a pair of arguments, the dependent variable expression (y) and the independent variable expression (x), which are both numeric value expressions. Any row in which either argument evaluates to NULL is removed from the rows that qualify. If there are no rows that qualify, then the result of REGR_COUNT is 0 (zero), and the other linear regression aggregate functions result in NULL.

9.4.1. REGR_AVGX()

Available in
DSQL, PSQL

Result type
DOUBLE PRECISION

Syntax

\[
\text{REGR_AVGX}(\ <y>, \ <x> )
\]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
<tr>
<td>x</td>
<td>Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function REGR_AVGX calculates the average of the independent variable (x) of the regression line.

The function REGR_AVGX(\(<y>\), \(<x>\)) is equivalent to
The function \texttt{REGR_AVGY} calculates the average of the dependent variable \((y)\) of the regression line.

The function \texttt{REGR_AVGY}(\(<y>, \,<x>\)) is equivalent to

\[
\frac{\text{SUM}(<\text{exprY}>)}{\text{REGR_COUNT}(<y>, \,<x>)}
\]

\[
<\text{exprY}> :=
\begin{cases}
\text{CASE WHEN } \langle x \rangle \text{ IS NOT NULL AND } \langle y \rangle \text{ IS NOT NULL THEN } \langle y \rangle \end{cases}
\]

\textbf{See also}

\texttt{REGR_AVGY()}, \texttt{REGR_COUNT()}, \texttt{SUM()}

\section{REGR_COUNT()}

\textit{Available in}

DSQL, PSQL

\textit{Result type}

DOUBLE PRECISION

\textit{Syntax}

\texttt{REGR_COUNT (<y>, <x>)}

\begin{table}
\centering
\begin{tabular}{|l|l|}
\hline
\textbf{Parameter} & \textbf{Description} \\
\hline
\textit{y} & Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions. \\
\hline
\textit{x} & Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions. \\
\hline
\end{tabular}
\end{table}

\textbf{See also}

\texttt{REGR_AVGX()}, \texttt{REGR_COUNT()}, \texttt{SUM()}

\section{REGR_AVGX()}

\textit{Available in}

DSQL, PSQL

\section{REGR_AVGX()}

\textit{Available in}

DSQL, PSQL

\section{REGR_AVGX()}

\textit{Result type}

DOUBLE PRECISION

\textit{Syntax}

\texttt{REGR_AVGX (<y>, <x>)}

\begin{table}
\centering
\begin{tabular}{|l|l|}
\hline
\textbf{Parameter} & \textbf{Description} \\
\hline
\textit{y} & Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions. \\
\hline
\textit{x} & Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions. \\
\hline
\end{tabular}
\end{table}

\textbf{See also}

\texttt{REGR_AVGY()}, \texttt{REGR_COUNT()}, \texttt{SUM()}
**Result type**
DOUBLE PRECISION

**Syntax**

\[
\text{REGR\_COUNT} \ ( \ <y> , \ <x> \ )
\]

**Table 226. REGR\_COUNT Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(y)</td>
<td>Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
<tr>
<td>(x)</td>
<td>Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function \(\text{REGR\_COUNT}\) counts the number of non-empty pairs of the regression line.

The function \(\text{REGR\_COUNT}(\ <y>, \ <x> )\) is equivalent to

\[
\frac{\text{SUM(} <\text{exprXY}> \text{) }}{\text{REGR\_COUNT}(\ <y>, \ <x> )}
\]

\(<\text{exprXY}> \ :=
\begin{cases}
\text{CASE WHEN } <x> \text{ IS NOT NULL AND } <y> \text{ IS NOT NULL THEN 1 END}
\end{cases}
\]

**See also**

\(\text{SUM()}\)

**9.4.4. REGR\_INTERCEPT()**

**Available in**
DSQL, PSQL

**Result type**
DOUBLE PRECISION

**Syntax**

\[
\text{REGR\_INTERCEPT} \ ( \ <y> , \ <x> \ )
\]

**Table 227. REGR\_INTERCEPT Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(y)</td>
<td>Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>
The function `REGR_INTERCEPT` calculates the point of intersection of the regression line with the y-axis.

The function `REGR_INTERCEPT(<y>, <x>)` is equivalent to

\[ REGR_AVGY(<y>, <x>) - REGR_SLOPE(<y>, <x>) \times REGR_AVGX(<y>, <x>) \]

**REGR_INTERCEPT Examples**

Forecasting sales volume

```sql
with recursive years (byyear) as (  
  select 1991  
  from rdb$database  
  union all  
  select byyear + 1  
  from years  
  where byyear < 2020  
),  
s as (  
  select  
      extract(year from order_date) as byyear,  
      sum(total_value) as total_value  
  from sales  
  group by 1  
),  
regr as (  
  select  
      regr_intercept(total_value, byyear) as intercept,  
      regr_slope(total_value, byyear) as slope  
  from s  
)  
select  
    years.byyear as byyear,  
    intercept + (slope * years.byyear) as total_value  
from years  
cross join regr
```
### BYYEAR TOTAL_VALUE

<table>
<thead>
<tr>
<th>BYYEAR</th>
<th>TOTAL_VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>118377.35</td>
</tr>
<tr>
<td>1992</td>
<td>414557.62</td>
</tr>
<tr>
<td>1993</td>
<td>710737.89</td>
</tr>
<tr>
<td>1994</td>
<td>1006918.16</td>
</tr>
<tr>
<td>1995</td>
<td>1303098.43</td>
</tr>
<tr>
<td>1996</td>
<td>1599278.69</td>
</tr>
<tr>
<td>1997</td>
<td>1895458.96</td>
</tr>
<tr>
<td>1998</td>
<td>2191639.23</td>
</tr>
<tr>
<td>1999</td>
<td>2487819.50</td>
</tr>
<tr>
<td>2000</td>
<td>2783999.77</td>
</tr>
</tbody>
</table>

See also

REGR_AVGX(), REGR_AVGY(), REGR_SLOPE()

### 9.4.5. REGR_R2()

**Available in**

DSQL, PSQL

**Result type**

DOUBLE PRECISION

**Syntax**

REGR_R2 ( <y>, <x> )

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
<tr>
<td>x</td>
<td>Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The REGR_R2 function calculates the coefficient of determination, or R-squared, of the regression line.

The function REGR_R2(<y>, <x>) is equivalent to

\[ \text{POWER(CORR(<y>, <x>), 2)} \]

See also
**CORR(), POWER**

### 9.4.6. REGR_SLOPE()

*Available in*
DSQL, PSQL

*Result type*
DOUBLE PRECISION

**Syntax**

```sql
define REGR_SLOPE ( <y>, <x> )
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
<tr>
<td>x</td>
<td>Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function `REGR_SLOPE` calculates the slope of the regression line.

The function `REGR_SLOPE(<y>, <x>)` is equivalent to

```sql
COVAR_POP(<y>, <x>) / VAR_POP(<exprX>)
```

<exprX> ::= CASE WHEN <x> IS NOT NULL AND <y> IS NOT NULL THEN <x> END

*See also*
COVAR_POP(), VAR_POP()

### 9.4.7. REGR_SXX()

*Available in*
DSQL, PSQL

*Result type*
DOUBLE PRECISION

**Syntax**

```sql
define REGR_SXX ( <y>, <x> )
```
Table 230. REGR_SXX Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
<tr>
<td>x</td>
<td>Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function `REGR_SXX` calculates the sum of squares of the independent expression variable (x).

The function `REGR_SXX(<y>, <x>)` is equivalent to

```sql
REGR_COUNT(<y>, <x>) * VAR_POP(<exprX>)
```

```
<exprX> :=
    CASE WHEN <x> IS NOT NULL AND <y> IS NOT NULL THEN <x> END
```

See also

`REGR_COUNT()`, `VAR_POP()`

9.4.8. REGR_SXY()

Available in

DSQL, PSQL

Result type

DOUBLE PRECISION

Syntax

```sql
REGR_SXY ( <y>, <x> )
```

Table 231. REGR_SXY Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
<tr>
<td>x</td>
<td>Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function `REGR_SXY` calculates the sum of products of independent variable expression (x) times dependent variable expression (y).
The function `REGR_SXY(<y>, <x>)` is equivalent to

\[
\text{REGR_COUNT(<y>, <x>) * COVAR_POP(<y>, <x>)}
\]

See also

`COVAR_POP()`, `REGR_COUNT()`

### 9.4.9. `REGR_SYY()`

**Available in**

DSQL, PSQL

**Result type**

DOUBLE PRECISION

**Syntax**

\[
\text{REGR_SYY (<y>, <x>)}
\]

**Table 232. `REGR_SYY` Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
<tr>
<td>x</td>
<td>Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function `REGR_SYY` calculates the sum of squares of the dependent variable (y).

The function `REGR_SYY(<y>, <x>)` is equivalent to

\[
\text{REGR_COUNT(<y>, <x>) * VAR_POP(<exprY>)}
\]

\[
<exprY> :=
\quad \text{CASE WHEN <x> IS NOT NULL AND <y> IS NOT NULL THEN <y> END}
\]

See also

`REGR_COUNT()`, `VAR_POP()`
Chapter 10. Window (Analytical) Functions

According to the SQL specification, window functions (also known as analytical functions) are a kind of aggregation, but one that does not “filter” the result set of a query. The rows of aggregated data are mixed with the query result set.

The window functions are used with the OVER clause. They may appear only in the SELECT list, or the ORDER BY clause of a query.

Firebird window functions may be partitioned and ordered.

Syntax

\[ \text{<window_function>} ::= \]
\[ \text{<aggregate_function>} \text{ OVER } \text{<window_name_or_spec>} \]
\[ \mid \text{<window_function_name>} ([\text{<expr>} [, <expr> ...]]) \text{ OVER } \text{<window_name_or_spec>} \]

\[ \text{<aggregate_function>} ::= \]
\[ !! \text{See Aggregate Functions} !! \]

\[ \text{<window_name_or_spec>} ::= \]
\[ \text{<window_specification>} \mid \text{existing_window_name} \]

\[ \text{<window_function_name>} ::= \]
\[ \text{<ranking_function>} \]
\[ \mid \text{<navigational_function>} \]

\[ \text{<ranking_function>} ::= \]
\[ \text{RANK} \mid \text{DENSE_RANK} \mid \text{PERCENT_RANK} \mid \text{ROW_NUMBER} \]
\[ \mid \text{CUME_DIST} \mid \text{NTILE} \]

\[ \text{<navigational_function>} \]
\[ \text{LEAD} \mid \text{LAG} \mid \text{FIRST_VALUE} \mid \text{LAST_VALUE} \mid \text{NTH_VALUE} \]

\[ \text{<window_specification>} ::= \]
\[ ( [\text{<window_order>}]) \]

\[ \text{<window_partition>} ::= \]
\[ \mid \text{<window_frame>} ] \]

\[ \text{<window_order>} ::= \]
\[ \mid \text{ORDER BY } \text{<expr>} [\text{<direction>}] \text{[<nulls_placement>]} \]
\[ [\text{<expr>} [\text{<direction>}] \text{[<nulls_placement>]} \text{...}] \]

\[ \text{<direction>} ::= \{ \text{ASC} \mid \text{DESC} \} \]

\[ \text{<nulls_placement>} ::= \text{NULLS} \{ \text{FIRST} \mid \text{LAST} \} \]
<window_frame> ::= {RANGE | ROWS} <window_frame_extent>

<window_frame_extent> ::= 
   <window_frame_start> | <window_frame_between>

<window_frame_start> ::= 
   UNBOUNDED PRECEDING | <expr> PRECEDING | CURRENT ROW

<window_frame_between> ::= 
   BETWEEN <window_frame_bound_1> AND <window_frame_bound_2>

<window_frame_bound_1> ::= 
   UNBOUNDED PRECEDING | <expr> PRECEDING | CURRENT ROW |
   <expr> FOLLOWING

<window_frame_bound_2> ::= 
   <expr> PRECEDING | CURRENT ROW | <expr> FOLLOWING |
   UNBOUNDED FOLLOWING

Table 233. Window Function Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Expression. May contain a table column, constant, variable, expression, scalar or aggregate function. Window functions are not allowed as an expression.</td>
</tr>
<tr>
<td>aggregate_function</td>
<td>An aggregate function used as a window function</td>
</tr>
<tr>
<td>existing_window_name</td>
<td>A named window defined using the WINDOW clause of the current query specification.</td>
</tr>
</tbody>
</table>

10.1. Aggregate Functions as Window Functions

All aggregate functions—including FILTER clause—can be used as window functions, by adding the OVER clause.

Imagine a table EMPLOYEE with columns ID, NAME and SALARY, and the need to show each employee with their respective salary and the percentage of their salary over the payroll.

A normal query could achieve this, as follows:

```sql
select
   id,
   department,
   salary,
   salary / (select sum(salary) from employee) portion
from employee
order by id;
```
### Results

<table>
<thead>
<tr>
<th>id</th>
<th>department</th>
<th>salary</th>
<th>portion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R &amp; D</td>
<td>10.00</td>
<td>0.2040</td>
</tr>
<tr>
<td>2</td>
<td>SALES</td>
<td>12.00</td>
<td>0.2448</td>
</tr>
<tr>
<td>3</td>
<td>SALES</td>
<td>8.00</td>
<td>0.1632</td>
</tr>
<tr>
<td>4</td>
<td>R &amp; D</td>
<td>9.00</td>
<td>0.1836</td>
</tr>
<tr>
<td>5</td>
<td>R &amp; D</td>
<td>10.00</td>
<td>0.2040</td>
</tr>
</tbody>
</table>

The query is repetitive and lengthy to run, especially if `EMPLOYEE` happens to be a complex view.

The same query could be specified in a much faster and more elegant way using a window function:

```sql
select
id, department, salary, salary / sum(salary) OVER () portion
from employee
order by id;
```

Here, `sum(salary) over ()` is computed with the sum of all `SALARY` from the query (the `EMPLOYEE` table).

### 10.2. Partitioning

Like aggregate functions, that may operate alone or in relation to a group, window functions may also operate on a group, which is called a “partition”.

**Syntax**

```sql
<window function>(...) OVER (PARTITION BY <expr> [, <expr> ...])
```

Aggregation over a group could produce more than one row, so the result set generated by a partition is joined with the main query using the same expression list as the partition.

Continuing the `EMPLOYEE` example, instead of getting the portion of each employee’s salary over the all-employees total, we would like to get the portion based on just the employees in the same department:
```
select
  id,
  department,
  salary,
  salary / sum(salary) OVER (PARTITION BY department) portion
from employee
order by id;
```

### Results

<table>
<thead>
<tr>
<th>id</th>
<th>department</th>
<th>salary</th>
<th>portion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R &amp; D</td>
<td>10.00</td>
<td>0.3448</td>
</tr>
<tr>
<td>2</td>
<td>SALES</td>
<td>12.00</td>
<td>0.6000</td>
</tr>
<tr>
<td>3</td>
<td>SALES</td>
<td>8.00</td>
<td>0.4000</td>
</tr>
<tr>
<td>4</td>
<td>R &amp; D</td>
<td>9.00</td>
<td>0.3103</td>
</tr>
<tr>
<td>5</td>
<td>R &amp; D</td>
<td>10.00</td>
<td>0.3448</td>
</tr>
</tbody>
</table>

### 10.3. Ordering

The `ORDER BY` sub-clause can be used with or without partitions. The `ORDER BY` clause within `OVER` specifies the order in which the window function will process rows. This order does not have to be the same as the order rows appear in the output.

There is an important concept associated with window functions: for each row there is a set of rows in its partition called the **window frame**. By default, when specifying `ORDER BY`, the frame consists of all rows from the beginning of the partition to the current row and rows equal to the current `ORDER BY` expression. Without `ORDER BY`, the default frame consists of all rows in the partition.

As a result, for standard aggregate functions, the `ORDER BY` clause produces partial aggregation results as rows are processed.

**Example**

```
select
  id,
  salary,
  sum(salary) over (order by salary) cumul_salary
from employee
order by salary;
```
Then `cumul_salary` returns the partial/accumulated (or running) aggregation (of the `SUM` function). It may appear strange that 37.00 is repeated for the ids 1 and 5, but that is how it should work. The `ORDER BY` keys are grouped together, and the aggregation is computed once (but summing the two 10.00). To avoid this, you can add the `ID` field to the end of the `ORDER BY` clause.

It's possible to use multiple windows with different orders, and `ORDER BY` parts like `ASC/DESC` and `NULLS FIRST/LAST`.

With a partition, `ORDER BY` works the same way, but at each partition boundary the aggregation is reset.

All aggregation functions can use `ORDER BY`, except for `LIST()`.

## 10.4. Window Frames

A *window frame* specifies which rows to consider for the current row when evaluating the window function.

The frame comprises three pieces: unit, start bound, and end bound. The unit can be `RANGE` or `ROWS`, which defines how the bounds will work.

The bounds are:

- `<expr> PRECEDING`
- `<expr> FOLLOWING`
- `CURRENT ROW`

- With `RANGE`, the `ORDER BY` should specify exactly one expression, and that expression should be of a numeric, date, time, or timestamp type. For `<expr> PRECEDING`, `<expr>` is subtracted from the `ORDER BY` expression, and for `<expr> FOLLOWING`, `<expr>` is added. For `CURRENT ROW`, the expression is used as-is.

  All rows inside the current partition that are between the bounds are considered part of the resulting window frame.

- With `ROWS`, `ORDER BY` expressions are not limited by number or type. For this unit, `<expr> PRECEDING` and `<expr> FOLLOWING` relate to the row position within the current partition, and not the values of the ordering keys.
Both UNBOUNDED PRECEDING and UNBOUNDED FOLLOWING work identical with RANGE and ROWS. UNBOUNDED PRECEDING start at the first row of the current partition, and UNBOUNDED FOLLOWING the last row of the current partition.

The frame syntax with \(<\text{window_frame_start}>\) specifies the start-frame, with the end-frame being `CURRENT ROW`.

Some window functions discard frames:

- ROW_NUMBER, LAG and LEAD always work as ROWS BETWEEN UNBOUNDED PRECEDING AND CURRENT ROW
- DENSE_RANK, RANK, PERCENT_RANK and CUME_DIST always work as RANGE BETWEEN UNBOUNDED PRECEDING AND CURRENT ROW
- FIRST_VALUE, LAST_VALUE and NTH_VALUE respect frames, but the RANGE unit behaviour is identical to ROWS.

Example Using Frame

When the ORDER BY clause is used, but a frame clause is omitted, the default considers the partition up to the current row. When combined with SUM, this results in a running total:

```sql
select
  id,
  salary,
  sum(salary) over (order by salary) sum_salary
from employee
order by salary;
```

Result:

```
<table>
<thead>
<tr>
<th>id</th>
<th>salary</th>
<th>sum_salary</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>8.00</td>
<td>8.00</td>
</tr>
<tr>
<td>4</td>
<td>9.00</td>
<td>17.00</td>
</tr>
<tr>
<td>1</td>
<td>10.00</td>
<td>37.00</td>
</tr>
<tr>
<td>5</td>
<td>10.00</td>
<td>37.00</td>
</tr>
<tr>
<td>2</td>
<td>12.00</td>
<td>49.00</td>
</tr>
</tbody>
</table>
```

On the other hand, if we apply a frame for the entire partition, we get the total for the entire partition.
```
select
  id,
  salary,
  sum(salary) over (  
    order by salary
    ROWS BETWEEN UNBOUNDED PRECEDING AND UNBOUNDED FOLLOWING
  ) sum_salary
from employee
order by salary;
```

Result:

```
<table>
<thead>
<tr>
<th>id</th>
<th align="right">salary</th>
<th align="right">sum_salary</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td align="right">8.00</td>
<td align="right">49.00</td>
</tr>
<tr>
<td>4</td>
<td align="right">9.00</td>
<td align="right">49.00</td>
</tr>
<tr>
<td>1</td>
<td align="right">10.00</td>
<td align="right">49.00</td>
</tr>
<tr>
<td>5</td>
<td align="right">10.00</td>
<td align="right">49.00</td>
</tr>
<tr>
<td>2</td>
<td align="right">12.00</td>
<td align="right">49.00</td>
</tr>
</tbody>
</table>
```

This example is just to demonstrate how this works; the result of this specific example would be simpler to produce with just `sum(salary) over()`.

We can use a range frame to compute the count of employees with salaries between (an employee’s salary - 1) and (their salary + 1) with this query:

```
select
  id,
  salary,
  count(*) over (  
    order by salary
    RANGE BETWEEN 1 PRECEDING AND 1 FOLLOWING
  ) range_count
from employee
order by salary;
```

Result:

```
<table>
<thead>
<tr>
<th>id</th>
<th align="right">salary</th>
<th align="right">range_count</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td align="right">8.00</td>
<td align="right">2</td>
</tr>
<tr>
<td>4</td>
<td align="right">9.00</td>
<td align="right">4</td>
</tr>
<tr>
<td>1</td>
<td align="right">10.00</td>
<td align="right">3</td>
</tr>
<tr>
<td>5</td>
<td align="right">10.00</td>
<td align="right">3</td>
</tr>
<tr>
<td>2</td>
<td align="right">12.00</td>
<td align="right">1</td>
</tr>
</tbody>
</table>
```
10.5. Named Windows

The **WINDOW clause** can be used to explicitly name a window, for example to avoid repetitive or confusing expression.

A named window can be used

a. in the OVER clause to reference a window definition, e.g. `OVER window_name`

b. as a base window of another named or inline (OVER) window, if it is not a window with a frame (ROWS or RANGE clauses)

A window with a base windows cannot have **PARTITION BY**, nor override the ordering (**ORDER BY**) of a base window.

10.6. Ranking Functions

The ranking functions compute the ordinal rank of a row within the window partition.

These functions can be used with or without partitioning and ordering. However, using them without ordering almost never makes sense.

The ranking functions can be used to create different type of incremental counters. Consider `SUM(1) OVER (ORDER BY SALARY)` as an example of what they can do, each of them differently. Following is an example query, also comparing with the **SUM** behavior.

```sql
select
  id,
  salary,
  dense_rank() over (order by salary),
  rank() over (order by salary),
  row_number() over (order by salary),
  sum(1) over (order by salary)
from employee
order by salary;
```

**Results**

<table>
<thead>
<tr>
<th>id</th>
<th>salary</th>
<th>dense_rank</th>
<th>rank</th>
<th>row_number</th>
<th>sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>8.00</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>9.00</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>10.00</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>10.00</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>12.00</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

The difference between **DENSE_RANK** and **RANK** is that there is a gap related to duplicate rows (relative to the window ordering) only in **RANK**. **DENSE_RANK** continues assigning sequential numbers after the
duplicate salary. On the other hand, ROW_NUMBER always assigns sequential numbers, even when there are duplicate values.

10.6.1. CUME_DIST()

Available in
DSQL, PSQL

Result type
DOUBLE PRECISION

Syntax

CUME_DIST () OVER <window_name_or_spec>

The distribution function CUME_DIST computes the relative rank of a row within a window partition. CUME_DIST is calculated as the number of rows preceding or peer of the current row divided by the number of rows in the partition.

In other words, CUME_DIST() OVER <window_name_or_spec> is equivalent to COUNT(*) OVER <window_name_or_spec> / COUNT(*) OVER()

CUME_DIST Examples

```
sel ect
    id,
    salary,
    cume_dist() over (order by salary)
from employee
order by salary;
```

Result

```
id salary cume_dist
--- ------ --------
3  8.00      0.2
4  9.00      0.4
1 10.00      0.8
5 10.00      0.8
2 12.00      1
```

10.6.2. DENSE_RANK()

Available in
DSQL, PSQL

Result type
BIGINT
Syntax

DENSE_RANK () OVER <window_name_or_spec>

Returns the rank of rows in a partition of a result set without ranking gaps. Rows with the same window_order values get the same rank within the partition window_partition, if specified. The dense rank of a row is equal to the number of different rank values in the partition preceding the current row, plus one.

DENSE_RANK Examples

```sql
select
  id,
  salary,
  dense_rank() over (order by salary)
from employee
order by salary;
```

Result

<table>
<thead>
<tr>
<th>id</th>
<th>salary</th>
<th>dense_rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>8.00</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>9.00</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>10.00</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>10.00</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>12.00</td>
<td>4</td>
</tr>
</tbody>
</table>

10.6.3. NTILE()

Available in
DSQL, PSQL

Result type
BIGINT

Syntax

NTILE ( number_of_tiles ) OVER <window_name_or_spec>

Table 234. Arguments of NTILE

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number_of_tiles</td>
<td>Number of tiles (groups). Restricted to a positive integer literal, a named parameter (PSQL), or a positional parameter (DSQL).</td>
</tr>
</tbody>
</table>

NTILE distributes the rows of the current window partition into the specified number of tiles
NTILE Examples

```sql
select
  id,
  salary,
  rank() over (order by salary),
  ntile(3) over (order by salary)
from employee
order by salary;
```

Result

<table>
<thead>
<tr>
<th>ID</th>
<th>SALARY</th>
<th>RANK</th>
<th>NTILE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>8.00</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>9.00</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>10.00</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>10.00</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>12.00</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

### 10.6.4. PERCENT_RANK()

*Available in*

DSQL, PSQL

*Result type*

DOUBLE PRECISION

*Syntax*

```sql
PERCENT_RANK() OVER <window_name_or_spec>
```

The distribution function PERCENT_RANK computes the relative rank of a row within a window partition. PERCENT_RANK is calculated as the RANK() minus 1 of the current row divided by the number of rows in the partition minus 1.

In other words, PERCENT_RANK() OVER <window_name_or_spec> is equivalent to (RANK() OVER <window_name_or_spec> - 1) / CAST(COUNT(*) OVER() - 1 AS DOUBLE PRECISION)

PERCENT_RANK Examples
select
  id,
salary,
  rank() over (order by salary),
  percent_rank() over (order by salary)
from employee
order by salary;

Result

<table>
<thead>
<tr>
<th>id</th>
<th>salary</th>
<th>rank</th>
<th>percent_rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>8.00</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>9.00</td>
<td>2</td>
<td>0.25</td>
</tr>
<tr>
<td>1</td>
<td>10.00</td>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>5</td>
<td>10.00</td>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>12.00</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

10.6.5. RANK()

Available in
DSQL, PSQL

Result type
BIGINT

Syntax
RANK () OVER <window_name_or_spec>

Returns the rank of each row in a partition of the result set. Rows with the same values of window-order get the same rank within the partition_window-partition, if specified. The rank of a row is equal to the number of rank values in the partition preceding the current row, plus one.

RANK Examples

select
  id,
salary,
  rank() over (order by salary)
from employee
order by salary;
See also

**DENSE_RANK(), ROW_NUMBER()**

### 10.6.6. ROW_NUMBER()

**Available in**

DSQL, PSQL

**Result type**

BIGINT

**Syntax**

```
ROW_NUMBER () OVER <window_name_or_spec>
```

Returns the sequential row number in the partition of the result set, where 1 is the first row in each of the partitions.

**ROW_NUMBER Examples**

```
select
  id,
  salary,
  row_number() over (order by salary)
from employee
order by salary;
```

**Result**

```
id salary rank
-- ------ ----
3  8.00     1
4  9.00     2
1 10.00     3
5 10.00     4
2 12.00     5
```
See also
DENSE_RANK(), RANK()

10.7. Navigational Functions

The navigational functions get the simple (non-aggregated) value of an expression from another row of the query, within the same partition.

FIRST_VALUE, LAST_VALUE and NTH_VALUE also operate on a window frame. For navigational functions, Firebird applies a default frame from the first to the current row of the partition, not to the last. In other words, it behaves as if the following frame is specified:

```
RANGE BETWEEN UNBOUNDED PRECEDING AND CURRENT ROW
```

This is likely to produce strange or unexpected results for NTH_VALUE and especially LAST_VALUE.

Example of Navigational Functions

```sql
select
  id,
  salary,
  first_value(salary) over (order by salary),
  last_value(salary) over (order by salary),
  nth_value(salary, 2) over (order by salary),
  lag(salary) over (order by salary),
  lead(salary) over (order by salary)
from employee
order by salary;
```

Results

<table>
<thead>
<tr>
<th>id</th>
<th>salary</th>
<th>first_value</th>
<th>last_value</th>
<th>nth_value</th>
<th>lag</th>
<th>lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
<td>&lt;null&gt;</td>
<td>&lt;null&gt;</td>
<td>9.00</td>
</tr>
<tr>
<td>4</td>
<td>9.00</td>
<td>8.00</td>
<td>9.00</td>
<td>9.00</td>
<td>8.00</td>
<td>10.00</td>
</tr>
<tr>
<td>1</td>
<td>10.00</td>
<td>8.00</td>
<td>10.00</td>
<td>9.00</td>
<td>9.00</td>
<td>10.00</td>
</tr>
<tr>
<td>5</td>
<td>10.00</td>
<td>8.00</td>
<td>10.00</td>
<td>9.00</td>
<td>10.00</td>
<td>12.00</td>
</tr>
<tr>
<td>2</td>
<td>12.00</td>
<td>8.00</td>
<td>12.00</td>
<td>9.00</td>
<td>10.00</td>
<td>&lt;null&gt;</td>
</tr>
</tbody>
</table>

10.7.1. FIRST_VALUE()

Available in
DSQL, PSQL
Result type
The same as type as `expr`

Syntax

\[
\text{FIRST\_VALUE}\left(\text{<expr>}\right)\text{ OVER }\text{<window\_name\_or\_spec>}
\]

### Table 235. Arguments of `FIRST\_VALUE`

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>expr</code></td>
<td>Expression. May contain a table column, constant, variable, expression, scalar function. Aggregate functions are not allowed as an expression.</td>
</tr>
</tbody>
</table>

Returns the first value from the current partition.

See also

`LAST\_VALUE()`, `NTH\_VALUE()`

### 10.7.2. LAG()

Available in

DSQL, PSQL

Result type

The same as type as `expr`

Syntax

\[
\text{LAG}\left(\text{<expr>} [, , \text{offset} [, , \text{default>}]]\right)\text{ OVER }\text{<window\_name\_or\_spec>}
\]

### Table 236. Arguments of `LAG`

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>expr</code></td>
<td>Expression. May contain a table column, constant, variable, expression, scalar function. Aggregate functions are not allowed as an expression.</td>
</tr>
<tr>
<td><code>offset</code></td>
<td>The offset in rows before the current row to get the value identified by <code>expr</code>. If <code>offset</code> is not specified, the default is 1. <code>offset</code> can be a column, subquery or other expression that results in a positive integer value, or another type that can be implicitly converted to <code>BIGINT</code>. <code>offset</code> cannot be negative (use <code>LEAD</code> instead).</td>
</tr>
<tr>
<td><code>default</code></td>
<td>The default value to return if <code>offset</code> points outside the partition. Default is <code>NULL</code>.</td>
</tr>
</tbody>
</table>

The `LAG` function provides access to the row in the current partition with a given `offset` before the current row.
If *offset* points outside the current partition, *default* will be returned, or *NULL* if no default was specified.

**LAG Examples**

Suppose you have `RATE` table that stores the exchange rate for each day. To trace the change of the exchange rate over the past five days you can use the following query.

```
select
  bydate,
  cost,
  cost - lag(cost) over (order by bydate) as change,
  100 * (cost - lag(cost) over (order by bydate)) / 
    lag(cost) over (order by bydate) as percent_change
from rate
where bydate between dateadd(-4 day to current_date)
  and current_date
order by bydate
```

**Result**

<table>
<thead>
<tr>
<th>bydate</th>
<th>cost</th>
<th>change</th>
<th>percent_change</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.10.2014</td>
<td>31.00</td>
<td>&lt;null&gt;</td>
<td>&lt;null&gt;</td>
</tr>
<tr>
<td>28.10.2014</td>
<td>31.53</td>
<td>0.53</td>
<td>1.0419</td>
</tr>
<tr>
<td>29.10.2014</td>
<td>31.40</td>
<td>-0.13</td>
<td>-0.3096</td>
</tr>
<tr>
<td>30.10.2014</td>
<td>31.67</td>
<td>0.27</td>
<td>0.8598</td>
</tr>
<tr>
<td>31.10.2014</td>
<td>32.00</td>
<td>0.33</td>
<td>1.0419</td>
</tr>
</tbody>
</table>

**See also**

LEAD()

### 10.7.3. LAST_VALUE()

**Available in**

DSQL, PSQL

**Result type**

The same as type as *expr*

**Syntax**

```
LAST_VALUE ( <expr> ) OVER <window_name_or_spec>
```

**Table 237. Arguments of LAST_VALUE**
Returns the last value from the current partition.

See also note on frame for navigational functions.

See also
FIRST_VALUE(), NTH_VALUE()

10.7.4. LEAD()

Available in
DSQL, PSQL

Result type
The same as type as expr

Syntax

LEAD ( <expr> [, <offset [ [, <default>]]])
  OVER <window_name_or_spec>

Table 238. Arguments of LEAD

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Expression. May contain a table column, constant, variable, expression, scalar function. Aggregate functions are not allowed as an expression.</td>
</tr>
<tr>
<td>offset</td>
<td>The offset in rows after the current row to get the value identified by expr. If offset is not specified, the default is 1. offset can be a column, subquery or other expression that results in a positive integer value, or another type that can be implicitly converted to BIGINT. offset cannot be negative (use LAG instead).</td>
</tr>
<tr>
<td>default</td>
<td>The default value to return if offset points outside the partition. Default is NULL.</td>
</tr>
</tbody>
</table>

The LEAD function provides access to the row in the current partition with a given offset after the current row.

If offset points outside the current partition, default will be returned, or NULL if no default was specified.

See also
LAG()
10.7.5. NTH_VALUE()

Available in
DSQL, PSQL

Result type
The same as type as expr

Syntax

NTH_VALUE ( <expr>, <offset> )
[FROM {FIRST | LAST}]
OVER <window_name_or_spec>

Table 239. Arguments of NTH_VALUE

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Expression. May contain a table column, constant, variable, expression, scalar function. Aggregate functions are not allowed as an expression.</td>
</tr>
<tr>
<td>offset</td>
<td>The offset in rows from the start (FROM FIRST), or the last (FROM LAST) to get the value identified by expr. offset can be a column, subquery or other expression that results in a positive integer value, or another type that can be implicitly converted to BIGINT. offset cannot be zero or negative.</td>
</tr>
</tbody>
</table>

The NTH_VALUE function returns the Nth value starting from the first (FROM FIRST) or the last (FROM LAST) row of the current frame, see also note on frame for navigational functions. Offset 1 with FROM FIRST is equivalent to FIRST_VALUE, and offset 1 with FROM LAST is equivalent to LAST_VALUE.

See also
FIRST_VALUE(), LAST_VALUE()

10.8. Aggregate Functions Inside Window Specification

It is possible to use aggregate functions (but not window functions) inside the OVER clause. In that case, first the aggregate function is applied to determine the windows, and only then the window functions are applied on those windows.

When using aggregate functions inside OVER, all columns not used in aggregate functions must be specified in the GROUP BY clause of the SELECT.
Using an Aggregate Function in a Window Specification

```sql
select
code_employee_group,
    avg(salary) as avg_salary,
    rank() over (order by avg(salary)) as salary_rank
from employee
group by code_employee_group
```
Chapter 11. Context Variables

11.1. CURRENT_CONNECTION

Availability:
DSQL, PSQl

Type:
INTEGER

Syntax:
CURRENT_CONNECTION

CURRENT_CONNECTION contains the unique identifier of the current connection.

Its value is derived from a counter on the database header page, which is incremented for each new connection. When a database is restored, this counter is reset to zero.

Examples:

```
select current_connection from rdb$database
execute procedure P_Login(current_connection)
```

11.2. CURRENT_DATE

Availability:
DSQL, PSQl, ESQL

Type:
DATE

Syntax:
CURRENT_DATE

CURRENT_DATE returns the current server date.

Within a PSQl module (procedure, trigger or executable block), the value of CURRENT_DATE will remain constant every time it is read. If multiple modules call or trigger each other, the value will remain constant throughout the duration of the outermost module. If you need a progressing value in PSQl (e.g. to measure time intervals), use 'TODAY'.

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11.3. CURRENT_ROLE

Available in
DSQL, PSQL

Type
VARCHAR(63)

Syntax

CURRENT_ROLE

CURRENT_ROLE is a context variable containing the explicitly specified role of the currently connected user. If there is no explicitly specified role, CURRENT_ROLE is 'NONE'.

CURRENT_ROLE always represents a valid role or 'NONE'. If a user connects with a non-existing role, the engine silently resets it to 'NONE' without returning an error.

Roles that are active by default and not explicitly specified on connect or using SET ROLE are not returned by CURRENT_ROLE. Use RDB$ROLE_IN_USE to check for all active roles.

Example

if (current_role <> 'MANAGER')
   then exception only_managers_may_delete;
else
   delete from Customers where custno = :custno;

See also
RDB$ROLE_IN_USE

11.4. CURRENT_TIME

Available in
DSQL, PSQL, ESQL

Type
TIME WITH TIME ZONE
Data type changed in Firebird 4.0 from TIME WITHOUT TIME ZONE to TIME WITH TIME ZONE. Use LOCALTIME to obtain TIME WITHOUT TIME ZONE.

Syntax

```
CURRENT_TIME [ (<precision>) ]
```

<precission> ::= 0 | 1 | 2 | 3

The optional precision argument is not supported in ESQL.

Table 240. CURRENT_TIME Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>precision</td>
<td>Precision. The default value is 0. Not supported in ESQL</td>
</tr>
</tbody>
</table>

CURRENT_TIME returns the current server time in the session time zone. The default is 0 decimals, i.e. seconds precision.

- CURRENT_TIME has a default precision of 0 decimals, where CURRENT_TIMESTAMP has a default precision of 3 decimals. As a result, CURRENT_TIMESTAMP is not the exact sum of CURRENT_DATE and CURRENT_TIME, unless you explicitly specify a precision (i.e. CURRENT_TIME(3) or CURRENT_TIMESTAMP(0)).

- Within a PSQL module (procedure, trigger or executable block), the value of CURRENT_TIME will remain constant every time it is read. If multiple modules call or trigger each other, the value will remain constant throughout the duration of the outermost module. If you need a progressing value in PSQL (e.g. to measure time intervals), use 'NOW'.

CURRENT_TIME and Firebird 4.0 Time Zone Support

Firebird 4.0 added support for time zones. As part of this support, an incompatibility with the CURRENT_TIME expression was introduced compared to previous version.

In Firebird 4.0, CURRENT_TIME returns the TIME WITH TIME ZONE type. In order for your queries to be compatible with database code of Firebird 4.0 and higher, Firebird 3.0.4 and Firebird 2.5.9 introduced the LOCALTIME expression. In Firebird 3.0.4 and Firebird 2.5.9, LOCALTIME is a synonym for CURRENT_TIME.

In Firebird 4.0, LOCALTIME continues to work as it does in Firebird 3.0.4 and higher and Firebird 2.5.9 (returning TIME [WITHOUT TIME ZONE]), while CURRENT_TIME now returns a different data type, TIME WITH TIME ZONE.
Examples

```sql
select current_time from rdb$database
-- returns e.g. 14:20:19.0000

select current_time(2) from rdb$database
-- returns e.g. 14:20:23.1200
```

See also

CURRENT_TIMESTAMP, LOCALTIME, LOCALTIMESTAMP

### 11.5. CURRENT_TIMESTAMP

**Available in**

DSQL, PSQL, ESQL

**Type**

TIMESTAMP WITH TIME ZONE

- Data type changed in Firebird 4.0 from TIMESTAMP WITHOUT TIME ZONE to TIMESTAMP WITH TIME ZONE. Use LOCALTIMESTAMP to obtain TIMESTAMP WITHOUT TIME ZONE.

**Syntax**

```
CURRENT_TIMESTAMP [ (<precision>) ]
```

- `<precision>` ::= 0 | 1 | 2 | 3

The optional `precision` argument is not supported in ESQL.

**Table 241. CURRENT_TIMESTAMP Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>precision</td>
<td>Precision. The default value is 3. Not supported in ESQL</td>
</tr>
</tbody>
</table>

CURRENT_TIMESTAMP returns the current server date and time in the session time zone. The default is 3 decimals, i.e. milliseconds precision.

- The default precision of CURRENT_TIME is 0 decimals, so CURRENT_TIMESTAMP is not the exact sum of CURRENT_DATE and CURRENT_TIME, unless you explicitly specify a precision (i.e. CURRENT_TIME(3) or CURRENT_TIMESTAMP(0)).

- Within a PSQL module (procedure, trigger or executable block), the value of CURRENT_TIMESTAMP will remain constant every time it is read. If multiple modules call or trigger each other, the value will remain constant throughout the duration of the outermost module. If you need a progressing value in PSQL (e.g. to measure time intervals), use 'NOW'.
CURRENT_TIMESTAMP and Firebird 4.0 Time Zone Support

Firebird 4.0 added support for time zones. As part of this support, an incompatibility with the CURRENT_TIMESTAMP expression was introduced compared to previous versions.

In Firebird 4.0, CURRENT_TIMESTAMP returns the TIMESTAMP WITH TIME ZONE type. In order for your queries to be compatible with database code of Firebird 4.0 and higher, Firebird 3.0.4 and Firebird 2.5.9 introduced the LOCALTIMESTAMP expression. In Firebird 3.0.4 and Firebird 2.5.9, LOCALTIMESTAMP is a synonym for CURRENT_TIMESTAMP.

In Firebird 4.0, LOCALTIMESTAMP continues to work as it does in Firebird 3.0.4 and higher and Firebird 2.5.9 (returning TIMESTAMP [WITHOUT TIME ZONE]), while CURRENT_TIMESTAMP now returns a different data type, TIMESTAMP WITH TIME ZONE.

Examples

```
select current_timestamp from rdb$database
-- returns e.g. 2008-08-13 14:20:19.6170

select current_timestamp(2) from rdb$database
-- returns e.g. 2008-08-13 14:20:23.1200
```

See also

CURRENT_TIME, LOCALTIME, LOCALTIMESTAMP

11.6. CURRENT_TRANSACTION

Available in
DSQL, PSQL

Type
BIGINT

Syntax

```
CURRENT_TRANSACTION
```

CURRENT_TRANSACTION contains the unique identifier of the current transaction.

Its value is derived from a counter on the database header page, which is incremented for each new transaction. When a database is restored, this counter is reset to zero.
Examples

```sql
select current_transaction from rdb$database
New.Txn_ID = current_transaction;
```

11.7. CURRENT_USER

Available in
DSQL, PSQL

Type
VARCHAR(63)

Syntax

```
CURRENT_USER
```

CURRENT_USER is a context variable containing the name of the currently connected user. It is fully equivalent to `USER`.

Example

```sql
create trigger bi_customers for customers before insert as
begin
    New.added_by  = CURRENT_USER;
    New.purchases = 0;
end
```

11.8. DELETING

Available in
PSQL

Type
BOOLEAN

Syntax

```
DELETING
```

Available in triggers only, `DELETING` indicates if the trigger fired for a DELETE operation. Intended for use in multi-action triggers.
Example

if (deleting) then
begin
    insert into Removed_Cars (id, make, model, removed)
    values (old.id, old.make, old.model, current_timestamp);
end

11.9. GDSCODE

Available in
PSQL

Type
INTEGER

Syntax

GDSCODE

In a “WHEN … DO” error handling block, the GDSCODE context variable contains the numerical representation of the current Firebird error code. Prior to Firebird 2.0, GDSCODE was only set in WHEN GDSCODE handlers. Now it may also be non-zero in WHEN ANY, WHEN SQLCODE, WHEN SQLSTATE and WHEN EXCEPTION blocks, provided that the condition raising the error corresponds with a Firebird error code. Outside error handlers, GDSCODE is always 0. Outside PSQL, it doesn’t exist at all.

After WHEN GDSCODE, you must use symbolic names like grant_obj_notfound etc. But the GDSCODE context variable is an INTEGER. If you want to compare it against a specific error, the numeric value must be used, e.g. 335544551 for grant_obj_notfound.

Example

when gdscode grant_obj_notfound, gdscode grant_fld_notfound,
    gdscode grant_nopriv, gdscode grant_nopriv_on_base
    gdscode do
        begin
            execute procedure log_grant_error(gdscode);
            exit;
        end

11.10. INSERTING

Available in
PSQL

Type
**BOOLEAN**

**Syntax**

```plaintext
INSERTING
```

Available in triggers only, `INSERTING` indicates if the trigger fired because of an `INSERT` operation. Intended for use in multi-action triggers.

**Example**

```plaintext
if (inserting or updating) then
    begin
        if (new.serial_num is null) then
            new.serial_num = gen_id(gen_serials, 1);
    end
```

---

**11.11. LOCALTIME**

*Available in*

DSQL, PSQL, ESQL

*Type*

TIME WITHOUT TIME ZONE

**Syntax**

```plaintext
LOCALTIME [ (<precision>) ]
```

`<precision>` ::= 0 | 1 | 2 | 3

The optional `precision` argument is not supported in ESQL.

**Table 242. LOCALTIME Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>precision</td>
<td>Precision. The default value is 0. Not supported in ESQL</td>
</tr>
</tbody>
</table>

LOCALTIME returns the current server time in the session time zone. The default is 0 decimals, i.e. seconds precision.
• **LOCALTIME** was introduced in Firebird 3.0.4 and Firebird 2.5.9 as an alias of **CURRENT_TIME**. In Firebird 4.0, **CURRENT_TIME** returns a **TIME WITH TIME ZONE** instead of a **TIME [WITHOUT TIME ZONE]**, while **LOCALTIME** returns **TIME [WITHOUT TIME ZONE]**. It is recommended to use **LOCALTIME** when you do not need time zone information.

• **LOCALTIME** has a default precision of 0 decimals, where **LOCALTIMESTAMP** has a default precision of 3 decimals. As a result, **LOCALTIMESTAMP** is not the exact sum of **CURRENT_DATE** and **LOCALTIME**, unless you explicitly specify a precision (i.e. **LOCALTIME(3)** or **LOCALTIMESTAMP(0)**).

• Within a PSQL module (procedure, trigger or executable block), the value of **LOCALTIME** will remain constant every time it is read. If multiple modules call or trigger each other, the value will remain constant throughout the duration of the outermost module. If you need a progressing value in PSQL (e.g. to measure time intervals), use **’NOW’**.

**Examples**

```sql
select localtime from rdb$database
-- returns e.g. 14:20:19.0000

select localtime(2) from rdb$database
-- returns e.g. 14:20:23.1200
```

**See also**

**CURRENT_TIME**, **LOCALTIMESTAMP**

### 11.12. **LOCALTIMESTAMP**

**Available in**

DSQL, PSQL, ESQL

**Type**

**TIMESTAMP WITHOUT TIME ZONE**

**Syntax**

```sql
LOCALTIMESTAMP [ (<precision>) ]
```

<pre>
<precision> ::= 0 | 1 | 2 | 3
</pre>

The optional **precision** argument is not supported in ESQL.

**Table 243. LOCALTIMESTAMP Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>precision</td>
<td>Precision. The default value is 3. Not supported in ESQL</td>
</tr>
</tbody>
</table>
LOCALTIMESTAMP returns the current server date and time in the session time zone. The default is 3 decimals, i.e. milliseconds precision.

- LOCALTIMESTAMP was introduced in Firebird 3.0.4 and Firebird 2.5.9 as a synonym of CURRENT_TIMESTAMP. In Firebird 4.0, CURRENT_TIMESTAMP returns a TIMESTAMP WITH TIME ZONE instead of a TIMESTAMP [WITHOUT TIME ZONE], while LOCALTIMESTAMP returns TIMESTAMP [WITHOUT TIME ZONE]. It is recommended to use LOCALTIMESTAMP when you do not need time zone information.

- The default precision of LOCALTIME is 0 decimals, so LOCALTIMESTAMP is not the exact sum of CURRENT_DATE and LOCALTIME, unless you explicitly specify a precision (i.e. LOCATIME(3) or LOCALTIMESTAMP(0)).

- Within a PSQL module (procedure, trigger or executable block), the value of LOCALTIMESTAMP will remain constant every time it is read. If multiple modules call or trigger each other, the value will remain constant throughout the duration of the outermost module. If you need a progressing value in PSQL (e.g. to measure time intervals), use 'NOW'.

Examples

```sql
select localtimestamp from rdb$database
-- returns e.g. 2008-08-13 14:20:19.6170

select localtimestamp(2) from rdb$database
-- returns e.g. 2008-08-13 14:20:23.1200
```

See also

CURRENT_TIMESTAMP, LOCALTIME

11.13. NEW

Available in
PSQL, triggers only

Type
Record type

Syntax

```
NEW.column_name
```

Table 244. NEW Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>column_name</td>
<td>Column name to access</td>
</tr>
</tbody>
</table>

NEW contains the new version of a database record that has just been inserted or updated. Starting
with Firebird 2.0 it is read-only in AFTER triggers.

In multi-action triggers—introduced in Firebird 1.5—NEW is always available. However, if the trigger is fired by a DELETE, there will be no new version of the record. In that situation, reading from NEW will always return NULL; writing to it will cause a runtime exception.

11.14. 'NOW'

Available in
DSQL, PSQL, ESQL

Type
CHAR(3)

'NOW' is not a variable, but a string literal or datetime mnemonic. It is, however, special in the sense that when you CAST() it to a date/time type, you will get the current date and/or time. Since Firebird 2.0 the precision is 3 decimals, i.e. milliseconds. 'NOW' is case-insensitive, and the engine ignores leading or trailing spaces when casting.

- 'NOW' always returns the actual date/time, even in PSQL modules, where CURRENT_DATE, CURRENT_TIME and CURRENT_TIMESTAMP return the same value throughout the duration of the outermost routine. This makes 'NOW' useful for measuring time intervals in triggers, procedures and executable blocks.
- Except in the situation mentioned above, reading CURRENT_DATE, CURRENT_TIME and CURRENT_TIMESTAMP is generally preferable to casting 'NOW'. Be aware though that CURRENT_TIME defaults to seconds precision; to get milliseconds precision, use CURRENT_TIME(3).
- Firebird 3.0 and earlier allowed the use of 'NOW' in datetime literals (a.k.a. "shorthand casts"), this is no longer allowed in Firebird 4.0.

Examples

```sql
select 'Now' from rdb$database
-- returns 'Now'

select cast('Now' as date) from rdb$database
-- returns e.g. 2008-08-13

select cast('now' as time) from rdb$database
-- returns e.g. 14:20:19.6170

select cast('NOW' as timestamp) from rdb$database
-- returns e.g. 2008-08-13 14:20:19.6170
```
11.15. OLD

Available in
PSQL, triggers only

Type
Record type

Syntax

OLD.column_name

Table 245. OLD Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>column_name</td>
<td>Column name to access</td>
</tr>
</tbody>
</table>

OLD contains the existing version of a database record just before a deletion or update. Starting with Firebird 2.0 it is read-only.

In multi-action triggers—introduced in Firebird 1.5—OLD is always available. However, if the trigger is fired by an INSERT, there is obviously no pre-existing version of the record. In that situation, reading from OLD will always return NULL; writing to it will cause a runtime exception.

11.16. RESETTING

Available in
PSQL

Type
BOOLEAN

Syntax

RESETTING

Available in triggers only, RESETTING indicates if the trigger fired during a session reset. Its value is TRUE if session reset is in progress and FALSE otherwise. Intended for use in ON DISCONNECT and ON CONNECT database triggers to detect an ALTER SESSION RESET.

11.17. ROW_COUNT

Available in
PSQL

Type
The `ROW_COUNT` context variable contains the number of rows affected by the most recent DML statement (INSERT, UPDATE, DELETE, SELECT or FETCH) in the current trigger, stored procedure or executable block.

**Behaviour with SELECT and FETCH**

- After a singleton SELECT, `ROW_COUNT` is 1 if a data row was retrieved and 0 otherwise.
- In a FOR SELECT loop, `ROW_COUNT` is incremented with every iteration (starting at 0 before the first).
- After a FETCH from a cursor, `ROW_COUNT` is 1 if a data row was retrieved and 0 otherwise. Fetching more records from the same cursor does not increment `ROW_COUNT` beyond 1.
- In Firebird 1.5.x, `ROW_COUNT` is 0 after any type of SELECT statement.

`ROW_COUNT` cannot be used to determine the number of rows affected by an EXECUTE STATEMENT or EXECUTE PROCEDURE command.

**Example**

```sql
update Figures set Number = 0 where id = :id;
if (row_count = 0) then
    insert into Figures (id, Number) values (:id, 0);
```

## 11.18. SQLCODE

**Available in**

PSQL

**Deprecated in**

2.5.1

**Type**

INTEGER

**Syntax**

```sql
SQLCODE
```

In a “WHEN … DO” error handling block, the `SQLCODE` context variable contains the current SQL error code. Prior to Firebird 2.0, `SQLCODE` was only set in WHEN SQLCODE and WHEN ANY handlers. Now it may also be non-zero in WHEN GDSCODE, WHEN SQLSTATE and WHEN EXCEPTION blocks, provided that the condition raising the error corresponds with an SQL error code. Outside error handlers, `SQLCODE` is
always 0. Outside PSQL, it doesn't exist at all.

SQLCODE is now deprecated in favour of the SQL-2003-compliant SQLSTATE status code. Support for SQLCODE and WHEN SQLCODE will be discontinued in some future version of Firebird.

Example

```plaintext
when any
do
begin
  if (sqlcode <> 0) then
    Msg = 'An SQL error occurred!';
  else
    Msg = 'Something bad happened!';
exception ex_custom Msg;
end
```

11.19. SQLSTATE

Available in
PSQL

Added in
2.5.1

Type
CHAR(5)

Syntax

```
SQLSTATE
```

In a “WHEN … DO” error handler, the SQLSTATE context variable contains the 5-character, SQL-2003-compliant status code resulting from the statement that raised the error. Outside error handlers, SQLSTATE is always '00000'. Outside PSQL, it is not available at all.
• SQLSTATE is destined to replace SQLCODE. The latter is now deprecated in Firebird and will disappear in some future version.

• Firebird does not (yet) support the syntax “WHEN SQLSTATE … DO”. You have to use WHEN ANY and test the SQLSTATE variable within the handler.

• Each SQLSTATE code is the concatenation of a 2-character class and a 3-character subclass. Classes 00 (successful completion), 01 (warning) and 02 (no data) represent completion conditions. Every status code outside these classes is an exception. Because classes 00, 01 and 02 don’t raise an error, they won’t ever show up in the SQLSTATE variable.

• For a complete listing of SQLSTATE codes, consult the SQLSTATE Codes and Message Texts section in Appendix B: Exception Handling, Codes and Messages.

Example

```sql
when any
  do
  begin
    Msg = case sqlstate
      when '22003' then 'Numeric value out of range.'
      when '22012' then 'Division by zero.'
      when '23000' then 'Integrity constraint violation.'
      else 'Something bad happened! SQLSTATE = ' || sqlstate
    end;
  exception ex_custom Msg;
end
```

11.20. 'TODAY'

Available in
DSQL, PSQL, ESQL

Type
CHAR(5)

'TODAY' is not a variable, but a string literal or date mnemonic. It is, however, special in the sense that when you CAST() it to a date/time type, you will get the current date. 'TODAY' is case-insensitive, and the engine ignores leading or trailing spaces when casting.
• 'TODAY' always returns the actual date, even in PSQL modules, where CURRENT_DATE, CURRENT_TIME and CURRENT_TIMESTAMP return the same value throughout the duration of the outermost routine. This makes 'TODAY' useful for measuring time intervals in triggers, procedures and executable blocks (at least if your procedures are running for days).

• Except in the situation mentioned above, reading CURRENT_DATE, is generally preferable to casting 'TODAY'.

• Firebird 3.0 and earlier allowed the use of 'TODAY' in datetime literals (a.k.a. "shorthand casts"), this is no longer allowed in Firebird 4.0.

Examples

```
select 'Today' from rdb$database
-- returns 'Today'

select cast('Today' as date) from rdb$database
-- returns e.g. 2011-10-03

select cast('TODAY' as timestamp) from rdb$database
-- returns e.g. 2011-10-03 00:00:00.0000
```

11.21. 'TOMORROW'

Available in
DSQL, PSQL, ESQL

Type
CHAR(8)

'TOMORROW' is not a variable, but a string literal. It is, however, special in the sense that when you CAST() it to a date/time type, you will get the date of the next day. See also 'TODAY'.

Examples

```
select 'Tomorrow' from rdb$database
-- returns 'Tomorrow'

select cast('Tomorrow' as date) from rdb$database
-- returns e.g. 2011-10-04

select cast('TOMORROW' as timestamp) from rdb$database
-- returns e.g. 2011-10-04 00:00:00.0000
```

11.22. UPDATING

Available in
**PSQL**

*Type*

BOOLEAN

*Syntax*

UPDATING

Available in triggers only, **UPDATING** indicates if the trigger fired because of an UPDATE operation. Intended for use in **multi-action triggers**.

*Example*

```sql
if (inserting or updating) then
  begin
    if (new.serial_num is null) then
      new.serial_num = gen_id(gen_serials, 1);
    end
```

### 11.23. 'YESTERDAY'

*Available in*

DSQL, PSQL, ESQL

*Type*

CHAR(9)

'YESTERDAY' is not a variable, but a string literal. It is, however, special in the sense that when you CAST() it to a date/time type, you will get the date of the day before. See also 'TODAY'.

*Examples*

```sql
select 'Yesterday' from rdb$database
  -- returns 'Yesterday'

select cast('Yesterday as date) from rdb$database
  -- returns e.g. 2011-10-02

select cast('YESTERDAY' as timestamp) from rdb$database
  -- returns e.g. 2011-10-02 00:00:00.0000
```

### 11.24. USER

*Available in*

DSQL, PSQL

*Type*
USER is a context variable containing the name of the currently connected user. It is fully equivalent to `CURRENT_USER`.

Example

```sql
create trigger bi_customers for customers before insert as
begin
    New.added_by  = USER;
    New.purchases = 0;
end
```
Chapter 12. Transaction Control

Everything in Firebird happens in transactions. Units of work are isolated between a start point and end point. Changes to data remain reversible until the moment the client application instructs the server to commit them.

12.1. Transaction Statements

Firebird has a small lexicon of SQL statements that are used by client applications to start, manage, commit and reverse (roll back) the transactions that form the boundaries of all database tasks:

**SET TRANSACTION**

for configuring and starting a transaction

**COMMIT**

to signal the end of a unit of work and write changes permanently to the database

**ROLLBACK**

to reverse the changes performed in the transaction

**SAVEPOINT**

to mark a position in the log of work done, in case a partial rollback is needed

**RELEASE SAVEPOINT**

to erase a savepoint

12.1.1. SET TRANSACTION

*Used for*
Configuring and starting a transaction

*Available in*
DSQL, ESQL
Syntax

```
SET TRANSACTION
  [NAME tr_name]
  [<tr_option> ...]

<tr_option> ::= 
  READ {ONLY | WRITE}
  | [NO] WAIT
  | [ISOLATION LEVEL] <isolation_level>
  | NO AUTO UNDO
  | RESTART REQUESTS
  | AUTO COMMIT
  | IGNORE LIMBO
  | LOCK TIMEOUT seconds
  | RESERVING <tables>
  | USING <dbhandles>

=isolation_level> ::= 
  SNAPSHOT [AT NUMBER snapshot_number]
  | SNAPSHOT TABLE [STABILITY]
  | READ {UNCOMMITTED | COMMITTED} [<read-commited-opt>]

<read-commited-opt> ::= 
  [NO] RECORD_VERSION | READ CONSISTENCY

<tables> ::= <table_spec> [, <table_spec> ...]

<table_spec> ::= tablename [, tablename ...]
  [FOR [SHARED | PROTECTED] {READ | WRITE}]

<dbhandles> ::= dbhandle [, dbhandle ...]
```

Table 246. SET TRANSACTION Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tr_name</td>
<td>Transaction name. Available only in ESQL</td>
</tr>
<tr>
<td>tr_option</td>
<td>Optional transaction option. Each option should be specified at most once,</td>
</tr>
<tr>
<td></td>
<td>some options are mutually exclusive (e.g. READ ONLY vs READ WRITE, WAIT vs</td>
</tr>
<tr>
<td></td>
<td>NO WAIT)</td>
</tr>
<tr>
<td>seconds</td>
<td>The time in seconds for the statement to wait in case a conflict occurs.</td>
</tr>
<tr>
<td></td>
<td>Has to be greater than or equal to 0.</td>
</tr>
<tr>
<td>snapshot_number</td>
<td>Snapshot number to use for this transaction</td>
</tr>
<tr>
<td>tables</td>
<td>The list of tables to reserve</td>
</tr>
<tr>
<td>dbhandles</td>
<td>The list of databases the database can access. Available only in ESQL</td>
</tr>
<tr>
<td>table_spec</td>
<td>Table reservation specification</td>
</tr>
<tr>
<td>tablename</td>
<td>The name of the table to reserve</td>
</tr>
</tbody>
</table>
The **SET TRANSACTION** statement configures the transaction and starts it. As a rule, only client applications start transactions. The exceptions are the occasions when the server starts an autonomous transaction or transactions for certain background system threads/processes, such as sweeping.

A client application can start any number of concurrently running transactions. A single connection can have multiple concurrent active transactions (though not all drivers or access components support this). A limit does exist, for the total number of running transactions in all client applications working with one particular database from the moment the database was restored from its backup copy or from the moment the database was created originally. The limit is $2^{48} - 281,474,976,710,656$ — in Firebird 3.0 and higher, and $2^{31} - 1$ — or 2,147,483,647 — in earlier versions.

All clauses in the **SET TRANSACTION** statement are optional. If the statement starting a transaction has no clauses specified in it, the transaction will be started with default values for access mode, lock resolution mode and isolation level, which are:

```sql
SET TRANSACTION
  READ WRITE
  waits
  ISOLATION LEVEL SNAPSHOT;
```

Database drivers or access components may use different defaults. Check their documentation for details.

The server assigns integer numbers to transactions sequentially. Whenever a client starts any transaction, either explicitly defined or by default, the server sends the transaction ID to the client. This number can be retrieved in SQL using the context variable `CURRENT_TRANSACTION`.

Some database drivers—or their governing specifications—require that you configure and start transaction through API methods. In that case, using **SET TRANSACTION** is either not supported, or may result in unspecified behaviour. An example of this is JDBC and the Firebird JDBC driver Jaybird.

Check the documentation of your driver for details.

The **NAME** and **USING** clauses are only valid in ESQL.

**Transaction Name**

The optional **NAME** attribute defines the name of a transaction. Use of this attribute is available only in Embedded SQL. In ESQL applications, named transactions make it possible to have several transactions active simultaneously in one application. If named transactions are used, a host-
language variable with the same name must be declared and initialized for each named transaction. This is a limitation that prevents dynamic specification of transaction names and thus, rules out transaction naming in DSQL.

**Transaction Parameters**

The main parameters of a transaction are:

- data access mode (READ WRITE, READ ONLY)
- lock resolution mode (WAIT, NO WAIT) with an optional LOCK TIMEOUT specification
- isolation level (READ COMMITTED, SNAPSHOT, SNAPSHOT TABLE STABILITY).

The READ UNCOMMITTED isolation level is a synonym for READ COMMITTED, and provided only for syntax compatibility. It provides the exact same semantics as READ COMMITTED, and does not allow you to view uncommitted changes of other transactions.

- a mechanism for reserving or releasing tables (the RESERVING clause)

**Access Mode**

The two database access modes for transactions are READ WRITE and READ ONLY.

- If the access mode is READ WRITE, operations in the context of this transaction can be both read operations and data update operations. This is the default mode.
- If the access mode is READ ONLY, only SELECT operations can be executed in the context of this transaction. Any attempt to change data in the context of such a transaction will result in database exceptions. However, this does not apply to global temporary tables (GTT), which are allowed to be changed in READ ONLY transactions, see *Global Temporary Tables (GTT)* in Chapter *Data Definition (DDL) Statements* for details.

**Lock Resolution Mode**

When several client processes work with the same database, locks may occur when one process makes uncommitted changes in a table row, or deletes a row, and another process tries to update or delete the same row. Such locks are called *update conflicts*.

Locks may occur in other situations when multiple transaction isolation levels are used.

The two lock resolution modes are WAIT and NO WAIT.

**WAIT Mode**

In the WAIT mode (the default mode), if a conflict occurs between two parallel processes executing concurrent data updates in the same database, a WAIT transaction will wait till the other transaction has finished — by committing (COMMIT) or rolling back (ROLLBACK). The client application with the WAIT transaction will be put on hold until the conflict is resolved.

If a LOCK TIMEOUT is specified for the WAIT transaction, waiting will continue only for the number of
seconds specified in this clause. If the lock is unresolved at the end of the specified interval, the 
error message “Lock time-out on wait transaction” is returned to the client.

Lock resolution behaviour can vary a little, depending on the transaction isolation level.

**NO WAIT Mode**

In the NO WAIT mode, a transaction will immediately throw a database exception if a conflict occurs.

---

**LOCK TIMEOUT** is a separate transaction option, but can only be used for WAIT 
transactions. Specifying LOCK TIMEOUT with a NO WAIT transaction will raise an error 
“invalid parameter in transaction parameter block -Option isc_tpb_lock_timeout is 
not valid if isc_tpb_nowait was used previously in TPB”

---

**Isolation Level**

Keeping the work of one database task separated from others is what isolation is about. Changes 
made by one statement become visible to all remaining statements executing within the same 
transaction, regardless of its isolation level. Changes that are in progress within other transactions 
remain invisible to the current transaction as long as they remain uncommitted. The isolation level 
and, sometimes, other attributes, determine how transactions will interact when another 
transaction wants to commit work.

The ISOLATION LEVEL attribute defines the isolation level for the transaction being started. It is the 
most significant transaction parameter for determining its behavior towards other concurrently 
running transactions.

The three isolation levels supported in Firebird are:

- **SNAPSHOT**
- **SNAPSHOT TABLE STABILITY**
- **READ COMMITTED** with two specifications (NO RECORD_VERSION and RECORD_VERSION)

---

**SNAPSHOT Isolation Level**

SNAPSHOT isolation level — the default level — allows the transaction to see only those changes that 
were committed before it was started. Any committed changes made by concurrent transactions 
will not be seen in a SNAPSHOT transaction while it is active. The changes will become visible to a 
new transaction once the current transaction is either committed or rolled back completely, but not 
if it is just rolled back to a savepoint.

The SNAPSHOT isolation level is also known as “concurrency”.

---

**Autonomous Transactions**

Changes made by autonomous transactions are not seen in the context of the 
SNAPSHOT transaction that launched it.

---

**Sharing Snapshot Transactions**
Using SNAPSHOT AT NUMBER `snapshot_number`, a SNAPSHOT transaction can be started sharing the snapshot of another transaction. With this feature it’s possible to create parallel processes (using different attachments) reading consistent data from a database. For example, a backup process may create multiple threads reading data from the database in parallel. Or a web service may dispatch distributed sub-services doing some processing in parallel.

Alternatively, this feature can also be used via the API, using Transaction Parameter Buffer item `isc_tpb_at_snapshot_number`.

The `snapshot_number` from an active transaction can be obtained with `RDB$GET_CONTEXT('SYSTEM', 'SNAPSHOT_NUMBER')` in SQL or using the transaction information API call with `fb_info_tra_snapshot_number` information tag. The `snapshot_number` passed to the new transaction must be a snapshot of a currently active transaction.

To share a stable view between transactions, the other transaction also needs to have isolation level SNAPSHOT. With READ COMMITTED, the snapshot number will move forward.

**Example**

```
SET TRANSACTION SNAPSHOT AT NUMBER 12345;
```

**SNAPSHOT TABLE STABILITY Isolation Level**

The SNAPSHOT TABLE STABILITY—or SNAPSHOT TABLE—isolation level is the most restrictive. As in SNAPSHOT, a transaction in SNAPSHOT TABLE STABILITY isolation sees only those changes that were committed before the current transaction was started. After a SNAPSHOT TABLE STABILITY is started, no other transactions can make any changes to any table in the database that has changes pending for this transaction. Other transactions are able to read other data, but any attempt at inserting, updating or deleting by a parallel process will cause conflict exceptions.

The RESERVING clause can be used to allow other transactions to change data in some tables.

If any other transaction has an uncommitted change pending in any (non-SHARED) table listed in the RESERVING clause, trying to start a SNAPSHOT TABLE STABILITY transaction will result in an indefinite wait (default or explicit WAIT), or an exception (NO WAIT or after expiration of the LOCK TIMEOUT).

The SNAPSHOT TABLE STABILITY isolation level is also known as “consistency”.

**READ COMMITTED Isolation Level**

The READ COMMITTED isolation level allows all data changes that other transactions have committed since it started to be seen immediately by the uncommitted current transaction. Uncommitted changes are not visible to a READ COMMITTED transaction.

To retrieve the updated list of rows in the table you are interested in—“refresh”—the SELECT statement just needs to be requested again, whilst still in the uncommitted READ COMMITTED transaction.
Variants of READ COMMITTED

One of three modifying parameters can be specified for READ COMMITTED transactions, depending on the kind of conflict resolution desired: READ CONSISTENCY, RECORD_VERSION or NO RECORD_VERSION. When the ReadConsistency setting is set to 1 in firebird.conf (the default) or in databases.conf, these variants are effectively ignored and behave as READ CONSISTENCY. Otherwise, these variants are mutually exclusive.

- **NO RECORD_VERSION** (the default if ReadConsistency = 0) is a kind of two-phase locking mechanism: it will make the transaction unable to write to any row that has an update pending from another transaction.
  - if NO WAIT is the lock resolution strategy specified, it will throw a lock conflict error immediately
  - with WAIT specified, it will wait until the other transaction either commits or is rolled back. If the other transaction is rolled back, or if it is committed and its transaction ID is older than the current transaction’s ID, then the current transaction’s change is allowed. A lock conflict error is returned if the other transaction was committed and its ID was newer than that of the current transaction.

- With RECORD_VERSION specified, the transaction reads the latest committed version of the row, regardless of other pending versions of the row. The lock resolution strategy (WAIT or NO WAIT) does not affect the behavior of the transaction at its start in any way.

- With READ CONSISTENCY specified (or ReadConsistency = 1), the execution of a statement obtains a snapshot of the database to ensure a consistent read at the statement-level of the transactions committed when execution started.

The other two variants can result in statement-level inconsistent reads as they may read some but not all changes of a concurrent transaction if that transaction commits during statement execution. For example, a SELECT COUNT(*) could read some, but not all inserted records of another transaction if the commit of that transaction occurs while the statement is reading records.

This statement-level snapshot is obtained for the execution of a top-level statement, nested statements (triggers, stored procedures and functions, dynamics statements, etc) use the statement-level snapshot created for the top-level statement.

- Obtaining a snapshot for READ CONSISTENCY is a very cheap action.
- Setting ReadConsistency is set to 1 by default in firebird.conf.
Handling of Update Conflicts with READ CONSISTENCY

When a statement executes in a READ COMMITTED READ CONSISTENCY transaction, its database view is retained in a fashion similar to a SNAPSHOT transaction. This makes it pointless to wait for the concurrent transaction to commit, in the hope of being able to read the newly-committed record version. So, when a READ COMMITTED READ CONSISTENCY transaction reads data, it behaves similarly to a READ COMMITTED RECORD VERSION transaction: it walks the back versions chain looking for a record version visible to the current snapshot.

When an update conflict occurs, the behaviour of a READ COMMITTED READ CONSISTENCY transaction is different to that of one in READ COMMITTED RECORD VERSION. The following actions are performed:

1. Transaction isolation mode is temporarily switched to READ COMMITTED NO RECORD VERSION.
2. A write-lock is taken for the conflicting record.
3. Remaining records of the current UPDATE/DELETE cursor are processed, and they are write-locked too.
4. Once the cursor is fetched, all modifications performed since the top-level statement was started are undone, already taken write-locks for every updated/deleted/locked record are preserved, all inserted records are removed.
5. Transaction isolation mode is restored to READ COMMITTED READ CONSISTENCY, a new statement-level snapshot is created, and the top-level statement is restarted.

This algorithm ensures that already updated records remain locked after restart, they are visible to the new snapshot, and could be updated again with no further conflicts. Also, due to READ CONSISTENCY nature, the modified record set remains consistent.
This restart algorithm is applied to UPDATE, DELETE, SELECT WITH LOCK and MERGE statements, with or without the RETURNING clause, executed directly by a client application or inside some PSQL object (stored procedure/function, trigger, EXECUTE BLOCK, etc).

If an UPDATE/DELETE statement is positioned on some explicit cursor (using the WHERE CURRENT OF clause), then the step (3) above is skipped, i.e. remaining cursor records are not fetched and write-locked.

If the top-level statement is selectable and update conflict happens after one or more records were returned to the client side, then an update conflict error is reported as usual and restart is not initiated.

Restart does not happen for statements executed inside autonomous blocks (IN AUTONOMOUS TRANSACTION DO …).

After 10 unsuccessful attempts the restart algorithm is aborted, all write locks are released, transaction isolation mode is restored to READ COMMITTED READ CONSISTENCY, and an update conflict error is raised.

Any error not handled at step (3) above aborts the restart algorithm and statement execution continues normally.

UPDATE/DELETE triggers fire multiple times for the same record if the statement execution was restarted and record is updated/deleted again.

Statement restart is usually fully transparent to client applications and no special actions should be taken by developers to handle it in any way. The only exception is the code with side effects that are outside the transactional control, for example:

- usage of external tables, sequences or context variables
- sending e-mails using UDF
- usage of autonomous transactions or external queries

and so on. Beware that such code could be executed more than once if update conflict happens.

There is no way to detect whether a restart happened, but it could be done manually using code with side effects as described above, for example using a context variable.

Due to historical reasons, error isc_update_conflict is reported as the secondary error code, with the primary error code being isc_deadlock.

**NO AUTO UNDO**

The NO AUTO UNDO option affects the handling of record versions (garbage) produced by the transaction in the event of rollback. With NO AUTO UNDO flagged, the ROLLBACK statement just marks the transaction as rolled back without deleting the record versions created in the transaction. They are left to be mopped up later by garbage collection.

NO AUTO UNDO might be useful when a lot of separate statements are executed that change data in...
conditions where the transaction is likely to be committed successfully most of the time.

The NO AUTO UNDO option is ignored for transactions where no changes are made.

**RESTART REQUESTS**

According to the Firebird sources, this will

```
  Restart all requests in the current attachment to utilize the passed transaction.
```

— src/jrd/tra.cpp

The exact semantics and effects of this clause are not clear, and we recommend you do not use this clause.

**AUTO COMMIT**

Specifying AUTO COMMIT enables auto-commit mode for the transaction. In auto-commit mode, Firebird will internally execute the equivalent of COMMIT RETAIN after each statement execution.

This is not a generally useful auto-commit mode; the same transaction context is retained until the transaction is ended through a commit or rollback. In other words, when you use SNAPSHOT or SNAPSHOT TABLE STABILITY, this auto-commit will not change record visibility (effects of transactions that were committed after this transaction was started will not be visible).

For READ COMMITTED, the same warnings apply as for commit retaining: prolonged use of a single transaction in auto-commit mode can inhibit garbage collection and degrade performance.

**IGNORE LIMBO**

This flag is used to signal that records created by limbo transactions are to be ignored. Transactions are left “in limbo” if the second stage of a two-phase commit fails.

**Historical Note**

IGNORE LIMBO surfaces the TPB parameter isc_tpb_ignore_limbo, available in the API since InterBase times and is mainly used by gfix.

**RESERVING**

The RESERVING clause in the SET TRANSACTION statement reserves tables specified in the table list. Reserving a table prevents other transactions from making changes in them or even, with the inclusion of certain parameters, from reading data from them while this transaction is running.

A RESERVING clause can also be used to specify a list of tables that can be changed by other transactions, even if the transaction is started with the SNAPSHOT TABLE STABILITY isolation level.

One RESERVING clause is used to specify as many reserved tables as required.
**Options for RESERVING Clause**

If one of the keywords SHARED or PROTECTED is omitted, SHARED is assumed. If the whole FOR clause is omitted, FOR SHARED READ is assumed. The names and compatibility of the four access options for reserving tables are not obvious.

**Table 247. Compatibility of Access Options for RESERVING**

<table>
<thead>
<tr>
<th></th>
<th>SHARED READ</th>
<th>SHARED WRITE</th>
<th>PROTECTED READ</th>
<th>PROTECTED WRITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHARED READ</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>SHARED WRITE</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>PROTECTED READ</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>PROTECTED WRITE</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

The combinations of these RESERVING clause flags for concurrent access depend on the isolation levels of the concurrent transactions:

- **SNAPSHOT isolation**
  - Concurrent SNAPSHOT transactions with SHARED READ do not affect one other's access
  - A concurrent mix of SNAPSHOT and READ COMMITTED transactions with SHARED WRITE do not affect one another's access, but they block transactions with SNAPSHOT TABLE STABILITY isolation from either reading from or writing to the specified table(s)
  - Concurrent transactions with any isolation level and PROTECTED READ can only read data from the reserved tables. Any attempt to write to them will cause an exception
  - With PROTECTED WRITE, concurrent transactions with SNAPSHOT and READ COMMITTED isolation cannot write to the specified tables. Transactions with SNAPSHOT TABLE STABILITY isolation cannot read from or write to the reserved tables at all.

- **SNAPSHOT TABLE STABILITY isolation**
  - All concurrent transactions with SHARED READ, regardless of their isolation levels, can read from or write (if in READ WRITE mode) to the reserved tables
  - Concurrent transactions with SNAPSHOT and READ COMMITTED isolation levels and SHARED WRITE can read data from and write (if in READ WRITE mode) to the specified tables but concurrent access to those tables from transactions with SNAPSHOT TABLE STABILITY is blocked completely whilst these transactions are active
  - Concurrent transactions with any isolation level and PROTECTED READ can only read from the reserved tables
  - With PROTECTED WRITE, concurrent SNAPSHOT and READ COMMITTED transactions can read from but not write to the reserved tables. Access by transactions with the SNAPSHOT TABLE STABILITY isolation level is blocked completely.

- **READ COMMITTED isolation**
  - With SHARED READ, all concurrent transactions with any isolation level can both read from
and write (if in READ WRITE mode) to the reserved tables

- **SHARE WRITE** allows all transactions in SNAPSHOT and READ COMMITTED isolation to read from and write (if in READ WRITE mode) to the specified tables and blocks access completely from transactions with SNAPSHOT TABLE STABILITY isolation
- With **PROTECTED READ**, concurrent transactions with any isolation level can only read from the reserved tables
- With **PROTECTED WRITE**, concurrent transactions in SNAPSHOT and READ COMMITTED isolation can read from but not write to the specified tables. Access from transactions in SNAPSHOT TABLE STABILITY isolation is blocked completely.

In Embedded SQL, the **USING** clause can be used to conserve system resources by limiting the number of databases a transaction can access. **USING** is mutually exclusive with **RESERVING**. A **USING** clause in SET TRANSACTION syntax is not supported in DSQL.

*See also*

**COMMIT, ROLLBACK**

### 12.1.2. COMMIT

**Used for**

Committing a transaction

**Available in**

DSQL, ESQL

**Syntax**

```sql
COMMIT [TRANSACTION tr_name] [WORK]
[RETAIN [SNAPSHOT] | RELEASE];
```

*Table 248. COMMIT Statement Parameter*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tr_name</td>
<td>Transaction name. Available only in ESQL</td>
</tr>
</tbody>
</table>

The **COMMIT** statement commits all work carried out in the context of this transaction (inserts, updates, deletes, selects, execution of procedures). New record versions become available to other transactions and, unless the RETAIN clause is employed, all server resources allocated to its work are released.

If any conflicts or other errors occur in the database during the process of committing the transaction, the transaction is not committed, and the reasons are passed back to the user application for handling, and the opportunity to attempt another commit or to roll the transaction back.

The **TRANSACTION** and **RELEASE** clauses are only valid in ESQL.
COMMIT Options

- The optional TRANSACTION `tr_name` clause, available only in Embedded SQL, specifies the name of the transaction to be committed. With no TRANSACTION clause, COMMIT is applied to the default transaction.

  In ESQL applications, named transactions make it possible to have several transactions active simultaneously in one application. If named transactions are used, a host-language variable with the same name must be declared and initialized for each named transaction. This is a limitation that prevents dynamic specification of transaction names and thus, rules out transaction naming in DSQL.

- The optional keyword WORK is supported just for compatibility with other relational database management systems that require it.

- The keyword RELEASE is available only in Embedded SQL and enables disconnection from all databases after the transaction is committed. RELEASE is retained in Firebird only for compatibility with legacy versions of InterBase. It has been superseded in ESQL by the DISCONNECT statement.

- The RETAIN [SNAPSHOT] clause is used for the “soft” commit, variously referred to amongst host languages and their practitioners as COMMIT WITH RETAIN, “CommitRetaining”, “warm commit”, et al. The transaction is committed, but some server resources are retained and a new transaction is restarted transparently with the same Transaction ID. The state of row caches and cursors is kept as it was before the soft commit.

  For soft-committed transactions whose isolation level is SNAPSHOT or SNAPSHOT TABLE STABILITY, the view of database state is not updated to reflect changes by other transactions, and the user of the application instance continues to have the same view as when the transaction started originally. Changes made during the life of the retained transaction are visible to that transaction, of course.

Recommendation

Use of the COMMIT statement in preference to ROLLBACK is recommended for ending transactions that only read data from the database, because COMMIT consumes fewer server resources and helps to optimize the performance of subsequent transactions.

See also

SET TRANSACTION, ROLLBACK

12.1.3. ROLLBACK

Used for
Rolling back a transaction

Available in
DSQL, ESQL
Syntax

ROLLBACK [TRANSACTION tr_name] [WORK]
[RETAIN [SNAPSHOT] | RELEASE]
| ROLLBACK [WORK] TO [SAVEPOINT] sp_name

Table 249. ROLLBACK Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tr_name</td>
<td>Transaction name. Available only in ESQL</td>
</tr>
<tr>
<td>sp_name</td>
<td>Savepoint name. Available only in DSQL</td>
</tr>
</tbody>
</table>

The ROLLBACK statement rolls back all work carried out in the context of this transaction (inserts, updates, deletes, selects, execution of procedures). ROLLBACK never fails and, thus, never causes exceptions. Unless the RETAIN clause is employed, all server resources allocated to the work of the transaction are released.

The TRANSACTION and RELEASE clauses are only valid in ESQL. The ROLLBACK TO SAVEPOINT statement is not available in ESQL.

ROLLBACK Options

- The optional TRANSACTION tr_name clause, available only in Embedded SQL, specifies the name of the transaction to be committed. With no TRANSACTION clause, ROLLBACK is applied to the default transaction.

  In ESQL applications, named transactions make it possible to have several transactions active simultaneously in one application. If named transactions are used, a host-language variable with the same name must be declared and initialized for each named transaction. This is a limitation that prevents dynamic specification of transaction names and thus, rules out transaction naming in DSQL.

- The optional keyword WORK is supported just for compatibility with other relational database management systems that require it.

- The keyword RETAIN keyword specifies that, although all work of the transaction is to be rolled back, the transaction context is to be retained. Some server resources are retained, and the transaction is restarted transparently with the same Transaction ID. The state of row caches and cursors is kept as it was before the “soft” rollback.

  For transactions whose isolation level is SNAPSHOT or SNAPSHOT TABLE STABILITY, the view of database state is not updated by the soft rollback to reflect changes by other transactions. The user of the application instance continues to have the same view as when the transaction started originally. Changes that were made and soft-committed during the life of the retained transaction are visible to that transaction, of course.

See also
The alternative ROLLBACK TO SAVEPOINT statement specifies the name of a savepoint to which changes are to be rolled back. The effect is to roll back all changes made within the transaction, from the specified savepoint forward until the point when ROLLBACK TO SAVEPOINT is requested.

ROLLBACK TO SAVEPOINT performs the following operations:

- Any database mutations performed since the savepoint was created are undone. User variables set with RDB$SET_CONTEXT() remain unchanged.
- Any savepoints that were created after the one named are destroyed. Savepoints earlier than the one named are preserved, along with the named savepoint itself. Repeated rollbacks to the same savepoint are thus allowed.
- All implicit and explicit record locks that were acquired since the savepoint are released. Other transactions that have requested access to rows locked after the savepoint must continue to wait until the transaction is committed or rolled back. Other transactions that have not already requested the rows can request and access the unlocked rows immediately.

See also
SAVEPOINT, RELEASE SAVEPOINT

12.1.4. SAVEPOINT

Used for
Creating a savepoint

Available in
DSQL

Syntax

SAVEPOINT sp_name

Table 250. SAVEPOINT Statement Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sp_name</td>
<td>Savepoint name. Available only in DSQL</td>
</tr>
</tbody>
</table>

The SAVEPOINT statement creates an SQL:99-compliant savepoint that acts as a marker in the “stack” of data activities within a transaction. Subsequently, the tasks performed in the “stack” can be undone back to this savepoint, leaving the earlier work and older savepoints untouched. Savepoint mechanisms are sometimes characterised as “nested transactions”.

If a savepoint already exists with the same name as the name supplied for the new one, the existing savepoint is released, and a new one is created using the supplied name.

To roll changes back to the savepoint, the statement ROLLBACK TO SAVEPOINT is used.
Memory Considerations
The internal mechanism beneath savepoints can consume large amounts of memory, especially if the same rows receive multiple updates in one transaction. When a savepoint is no longer needed, but the transaction still has work to do, a RELEASE SAVEPOINT statement will erase it and thus free the resources.

Sample DSQL session with savepoints

```sql
CREATE TABLE TEST (ID INTEGER);
COMMIT;
INSERT INTO TEST VALUES (1);
COMMIT;
INSERT INTO TEST VALUES (2);
SAVEPOINT Y;
DELETE FROM TEST;
SELECT * FROM TEST; -- returns no rows
ROLLBACK TO Y;
SELECT * FROM TEST; -- returns two rows
ROLLBACK;
SELECT * FROM TEST; -- returns one row
```

See also
ROLLBACK TO SAVEPOINT, RELEASE SAVEPOINT

12.1.5. RELEASE SAVEPOINT

Used for
Erasing a savepoint

Available in
DSQL

Syntax

```
RELEASE SAVEPOINT sp_name [ONLY]
```

Table 251. RELEASE SAVEPOINT Statement Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sp_name</td>
<td>Savepoint name. Available only in DSQL</td>
</tr>
</tbody>
</table>

The statement RELEASE SAVEPOINT erases a named savepoint, freeing up all the resources it encompasses. By default, all the savepoints created after the named savepoint are released as well. The qualifier ONLY directs the engine to release only the named savepoint.

See also
SAVEPOINT
12.1.6. Internal Savepoints

By default, the engine uses an automatic transaction-level system savepoint to perform transaction rollback. When a ROLLBACK statement is issued, all changes performed in this transaction are backed out via a transaction-level savepoint, and the transaction is then committed. This logic reduces the amount of garbage collection caused by rolled back transactions.

When the volume of changes performed under a transaction-level savepoint is getting large (~50000 records affected), the engine releases the transaction-level savepoint and uses the Transaction Inventory Page (TIP) as a mechanism to roll back the transaction if needed.

If you expect the volume of changes in your transaction to be large, you can specify the NO AUTO UNDO option in your SET TRANSACTION statement to block the creation of the transaction-level savepoint. Using the API instead, you would set the TPB flag isc_tpb_no_auto.undo.

12.1.7. Savepoints and PSQL

Transaction control statements are not allowed in PSQL, as that would break the atomicity of the statement that calls the procedure. However, Firebird does support the raising and handling of exceptions in PSQL, so that actions performed in stored procedures and triggers can be selectively undone without the entire procedure failing.

Internally, automatic savepoints are used to:

- undo all actions in the BEGIN…END block where an exception occurs
- undo all actions performed by the procedure or trigger or, in a selectable procedure, all actions performed since the last SUSPEND, when execution terminates prematurely because of an uncaught error or exception

Each PSQL exception handling block is also bounded by automatic system savepoints.

A BEGIN…END block does not itself create an automatic savepoint. A savepoint is created only in blocks that contain the WHEN statement for handling exceptions.
Chapter 13. Security

Databases must be secure and so must the data stored in them. Firebird provides three levels of data security: user authentication at the server level, SQL privileges within databases, and—optionally—database encryption. This chapter describes how to manage security at these three levels.

There is also a fourth level of data security: wire protocol encryption, which encrypts data in transit between client and server. Wire protocol encryption is out of scope for this Language Reference.

13.1. User Authentication

The security of the entire database depends on identifying a user and verifying its authority, a procedure known as authentication. User authentication can be performed in several ways, depending on the setting of the AuthServer parameter in the firebird.conf configuration file. This parameter contains the list of authentication plugins that can be used when connecting to the server. If the first plugin fails when authenticating, then the client can proceed with the next plugin, etc. When no plugin could authenticate the user, the user receives an error message.

The information about users authorised to access a specific Firebird server is stored in a special security database named security4.fdb. Each record in security4.fdb is a user account for one user. For each database, the security database can be overridden in the databases.conf file (parameter SecurityDatabase). Any database can be a security database, even for that database itself.

A username, with a maximum length of 63 characters, is an identifier, following the normal rules for identifiers (unquoted case-insensitive, double-quoted case-sensitive). For backwards compatibility, some statements (e.g. isql CONNECT) accept usernames enclosed in single quotes, which will behave as normal, unquoted identifiers.

The maximum password length depends on the user manager plugin (parameter UserManager, in firebird.conf or databases.conf). Passwords are case-sensitive. The default user manager is the first plugin in the UserManager list, but this can be overridden in the SQL user management statements. For the Srp plugin, the maximum password length is 255 characters, for an effective length of 20 bytes (see also Why is the effective password length of SRP 20 bytes?). For the Legacy_UserManager plugin only the first eight bytes are significant; whilst it is valid to enter a password longer than eight bytes for Legacy_UserManager, any subsequent characters are ignored.
Why is the effective password length of SRP 20 bytes?

The SRP plugin does not actually have a 20 byte limit on password length, and longer passwords can be used. Hashes of different passwords longer than 20 bytes are also—usually—different. This effective limit comes from the limited hash length in SHA1 (used inside Firebird's SRP implementation), 20 bytes or 160 bits, and the “pigeonhole principle”. Sooner or later, there will be a shorter (or longer) password that has the same hash (e.g. in a brute force attack). That is why often the effective password length for the SHA1 algorithm is said to be 20 bytes.

The embedded version of the server does not use authentication. However, the username, and—if necessary—the role, must be specified in the connection parameters, as they control access to database objects.

SYSDBA or the owner of the database get unrestricted access to all objects of the database. Users with the RDB$ADMIN role get similar unrestricted access if they specify the role when connecting.

13.1.1. Specially Privileged Users

In Firebird, the SYSDBA account is a “Superuser” that exists beyond any security restrictions. It has complete access to all objects in all regular databases on the server, and full read/write access to the accounts in the security database security4.fdb. No user has access to the metadata of the security database.

For Srp, the SYSDBA account does not exist by default; it will need to be created using an embedded connection. For Legacy_Auth, the default SYSDBA password on Windows and MacOS is “masterkey” — or “masterke”, to be exact, because of the 8-character length limit.

Extremely Important!

The default password “masterkey” is known across the universe. It should be changed as soon as the Firebird server installation is complete.

Other users can acquire elevated privileges in several ways, some of which are dependent on the operating system platform. These are discussed in the sections that follow and are summarised in Administrators and Fine-grained System Privileges.

POSIX Hosts

On POSIX systems, including MacOS, the POSIX username will be used as the Firebird Embedded username if username is not explicitly specified.

The SYSDBA User on POSIX

On POSIX hosts, other than MacOSX, the SYSDBA user does not have a default password. If the full installation is done using the standard scripts, a one-off password will be created and stored in a text file in the same directory as security4.fdb, commonly /opt/firebird/. The name of the password file is SYSDBA.password.
In an installation performed by a distribution-specific installer, the location of the security database and the password file may be different from the standard one.

**The root User**

The **root** user can act directly as SYSDBA on Firebird Embedded. Firebird will treat **root** as though it were SYSDBA, and it provides access to all databases on the server.

**Windows Hosts**

On Windows server-capable operating systems, operating system accounts can be used. Windows authentication (also known as “trusted authentication”) can be enabled by including the Win_Sspi plugin in the AuthServer list in `firebird.conf`. The plugin must also be present in the AuthClient setting at the client-side.

Windows operating system administrators are not automatically granted SYSDBA privileges when connecting to a database. To make that happen, the internally-created role RDB$ADMIN must be altered by SYSDBA or the database owner, to enable it. For details, refer to the later section entitled **AUTO ADMIN MAPPING**.

Prior to Firebird 3.0, with trusted authentication enabled, users who passed the default checks were automatically mapped to `CURRENT_USER`. In Firebird 3.0 and later, the mapping must be done explicitly using `CREATE MAPPING`.

**The Database Owner**

The “owner” of a database is either the user who was `CURRENT_USER` at the time of creation (or restore) of the database or, if the `USER` parameter was supplied in the `CREATE DATABASE` statement, the specified user.

“Owner” is not a username. The user who is the owner of a database has full administrator privileges with respect to that database, including the right to drop it, to restore it from a backup and to enable or disable the **AUTO ADMIN MAPPING** capability.

Prior to Firebird 2.1, the owner had no automatic privileges over any database objects that were created by other users.

**Users with the USER_MANAGEMENT System Privilege**

A user with the **USER_MANAGEMENT** system privilege in the security database can create, alter and drop users. To receive the **USER_MANAGEMENT** privilege, the security database must have a role with that privilege:

```sql
create role MANAGE_USERS
set system privileges to USER_MANAGEMENT;
```

There are two options for the user to exercise these privileges:
1. Grant the role as a default role. The user will always be able to create, alter or drop users.

   ```sql
   grant default MANAGE_USERS to user ALEX;
   ```

2. Grant the role as a normal role. The user will only be able to create, alter or drop users when the role is specified explicitly on login or using `SET ROLE`.

   ```sql
   grant MANAGE_USERS to user ALEX;
   ```

If the security database is a different database than the user connects to — which is usually the case when using `security4.fdb` — then a role with the same name must also exist and be granted to the user in that database for the user to be able to activate the role. The role in the other database does not need any system privileges or other privileges.

---

The `USER_MANAGEMENT` system privilege does not allow a user to grant or revoke the admin role. This requires the `RDB$ADMIN` role.

### 13.1.2. RDB$ADMIN Role

The internally-created role `RDB$ADMIN` is present in all databases. Assigning the `RDB$ADMIN` role to a regular user in a database grants that user the privileges of the `SYSDBA`, in that database only.

The elevated privileges take effect when the user is logged in to that regular database under the `RDB$ADMIN` role, and gives full control over all objects in that database.

Being granted the `RDB$ADMIN` role in the security database confers the authority to create, edit and delete user accounts.

In both cases, the user with the elevated privileges can assign `RDB$ADMIN` role to any other user. In other words, specifying `WITH ADMIN OPTION` is unnecessary because it is built into the role.

**Granting the RDB$ADMIN Role in the Security Database**

Since nobody — not even `SYSDBA` — can connect to the security database remotely, the `GRANT` and `REVOKE` statements are of no use for this task. Instead, the `RDB$ADMIN` role is granted and revoked using the SQL statements for user management:

```sql
CREATE USER new_user
   PASSWORD 'password'
   GRANT ADMIN ROLE;

ALTER USER existing_user
   GRANT ADMIN ROLE;

ALTER USER existing_user
   REVOKE ADMIN ROLE;
```
GRANT ADMIN ROLE and REVOKE ADMIN ROLE are not statements in the GRANT and REVOKE lexicon. They are three-word clauses to the statements CREATE USER and ALTER USER.

Table 252. Parameters for RDB$ADMIN Role GRANT and REVOKE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>new_user</td>
<td>Name for the new user</td>
</tr>
<tr>
<td>existing_user</td>
<td>Name of an existing user</td>
</tr>
<tr>
<td>password</td>
<td>User password</td>
</tr>
</tbody>
</table>

The grantor must be logged in as an administrator.

See also
CREATE USER, ALTER USER, GRANT, REVOKE

Doing the Same Task Using gsec

With Firebird 3.0, gsec was deprecated. It is recommended to use the SQL user management statements instead.

An alternative is to use gsec with the -admin parameter to store the RDB$ADMIN attribute on the user’s record:

```
gsec -add new_user -pw password -admin yes
```

```
gsec -mo existing_user -admin yes
```

```
gsec -mo existing_user -admin no
```

Depending on the administrative status of the current user, more parameters may be needed when invoking gsec, e.g. -user and -pass, or -trusted.

Using the RDB$ADMIN Role in the Security Database

To manage user accounts through SQL, the grantee must specify the RDB$ADMIN role when connecting or through SET ROLE. No user can connect to the security database remotely, so the solution is that the user connects to a regular database where they also have RDB$ADMIN rights, supplying the RDB$ADMIN role in their login parameters. From there, they can submit any SQL user management command.

If there is no regular database where the user has the RDB$ADMIN role, then account management via SQL queries is not possible, unless they connect directly to the security database using an embedded connection.

Using gsec with RDB$ADMIN Rights

To perform user management with gsec, the user must provide the extra switch -role rdb$admin.
Granting the RDB$ADMIN Role in a Regular Database

In a regular database, the RDB$ADMIN role is granted and revoked with the usual syntax for granting and revoking roles:

```
GRANT [ROLE] RDB$ADMIN TO username

REVOKE [ROLE] RDB$ADMIN FROM username
```

Table 253. Parameters for RDB$ADMIN Role GRANT and REVOKE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>username</td>
<td>Name of the user</td>
</tr>
</tbody>
</table>

In order to grant and revoke the RDB$ADMIN role, the grantor must be logged in as an administrator.

See also

GRANT, REVOKE

Using the RDB$ADMIN Role in a Regular Database

To exercise their RDB$ADMIN privileges, the grantee has to include the role in the connection attributes when connecting to the database, or specify it later using SET ROLE.

AUTO ADMIN MAPPING

Windows Administrators are not automatically granted RDB$ADMIN privileges when connecting to a database (if Win_Sspi is enabled, of course) The AUTO ADMIN MAPPING switch now determines whether Administrators have automatic RDB$ADMIN rights, on a database-by-database basis. By default, when a database is created, it is disabled.

If AUTO ADMIN MAPPING is enabled in the database, it will take effect whenever a Windows Administrator connects:

a. using Win_Sspi authentication, and
b. without specifying any role

After a successful “auto admin” connection, the current role is set to RDB$ADMIN.

If an explicit role was specified on connect, the RDB$ADMIN role can be assumed later in the session using SET TRUSTED ROLE.

Auto Admin Mapping in Regular Databases

To enable and disable automatic mapping in a regular database:
ALTER ROLE RDB$ADMIN
  SET AUTO ADMIN MAPPING;  -- enable it

ALTER ROLE RDB$ADMIN
  DROP AUTO ADMIN MAPPING; -- disable it

Either statement must be issued by a user with sufficient rights, that is:

- The database owner
- An administrator
- A user with the ALTER ANY ROLE privilege

The statement

```
ALTER ROLE RDB$ADMIN
  SET AUTO ADMIN MAPPING;
```

is a simplified form of a CREATE MAPPING statement to create a mapping of the predefined group DOMAIN_ANY_RID_ADMINS to the role of RDB$ADMIN:

```
CREATE MAPPING WIN_ADMINS
  USING PLUGIN WIN_SSPI
  FROM Predefined_Group DOMAIN_ANY_RID_ADMINS
  TO ROLE RDB$ADMIN;
```

Accordingly, the statement

```
ALTER ROLE RDB$ADMIN
  DROP AUTO ADMIN MAPPING
```

is equivalent to the statement

```
DROP MAPPING WIN_ADMINS;
```

For details, see **Mapping of Users to Objects**

In a regular database, the status of AUTO ADMIN MAPPING is checked only at connect time. If an Administrator has the RDB$ADMIN role because auto-mapping was on when they logged in, they will keep that role for the duration of the session, even if they or someone else turns off the mapping in the meantime.

Likewise, switching on AUTO ADMIN MAPPING will not change the current role to RDB$ADMIN for Administrators who were already connected.
Auto Admin Mapping in the Security Database

The ALTER ROLE RDB$ADMIN statement cannot enable or disable AUTO ADMIN MAPPING in the security database. However, you can create a global mapping for the predefined group DOMAIN_ANY_RID_ADMINS to the role RDB$ADMIN in the following way:

```sql
CREATE GLOBAL MAPPING WIN_ADMINS
    USING PLUGIN WIN_SSPI
    FROM Predefined_Group DOMAIN_ANY_RID_ADMINS
    TO ROLE RDB$ADMIN;
```

Additionally, you can use `gsec`:

```
gsec -mapping set

gsec -mapping drop
```

Depending on the administrative status of the current user, more parameters may be needed when invoking `gsec`, e.g. `-user` and `-pass`, or `-trusted`.

Only SYSDBA can enable AUTO ADMIN MAPPING if it is disabled, but any administrator can turn it off.

When turning off AUTO ADMIN MAPPING in `gsec`, the user turns off the mechanism itself which gave them access, and thus they would not be able to re-enable AUTO ADMIN MAPPING. Even in an interactive `gsec` session, the new flag setting takes effect immediately.

13.1.3. Administrators

As a general description, an administrator is a user that has sufficient rights to read, write to, create, alter or delete any object in a database to which that user's administrator status applies. The table summarises how “Superuser” privileges are enabled in the various Firebird security contexts.

<table>
<thead>
<tr>
<th>User</th>
<th>RDB$ADMIN Role</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSDBA</td>
<td>Auto</td>
<td>Exists automatically at server level. Has full privileges to all objects in all databases. Can create, alter and drop users, but has no direct remote access to the security database</td>
</tr>
<tr>
<td>root user on POSIX</td>
<td>Auto</td>
<td>Exactly like SYSDBA. Firebird Embedded only.</td>
</tr>
<tr>
<td>Superuser on POSIX</td>
<td>Auto</td>
<td>Exactly like SYSDBA. Firebird Embedded only.</td>
</tr>
<tr>
<td>User</td>
<td>RDB$ADMIN Role</td>
<td>Comments</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Windows Administrator</td>
<td>Set as CURRENT_ROLE if login succeeds</td>
<td>Exactly like SYSDBA if all of the following are true:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• In firebird.conf file, AuthServer includes Win_Sspi, and Win_Sspi is present in the client-side plugins (AuthClient) configuration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• In databases where AUTO ADMIN MAPPING is enabled, or an equivalent mapping of the predefined group DOMAIN_ANY_RID_ADMINS for the role RDB$ADMIN exists</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• No role is specified at login</td>
</tr>
<tr>
<td>Database owner</td>
<td>Auto</td>
<td>Like SYSDBA, but only in the databases they own</td>
</tr>
<tr>
<td>Regular user</td>
<td>Must be previously granted; must be supplied at login</td>
<td>Like SYSDBA, but only in the databases where the role is granted</td>
</tr>
<tr>
<td>POSIX OS user</td>
<td>Must be previously granted; must be supplied at login</td>
<td>Like SYSDBA, but only in the databases where the role is granted. Firebird Embedded only.</td>
</tr>
<tr>
<td>Windows user</td>
<td>Must be previously granted; must be supplied at login</td>
<td>Like SYSDBA, but only in the databases where the role is granted. Only available if in firebird.conf file, AuthServer includes Win_Sspi, and Win_Sspi is present in the client-side plugins (AuthClient) configuration</td>
</tr>
</tbody>
</table>

### 13.1.4. Fine-grained System Privileges

In addition to granting users full administrative privileges, Firebird 4.0 introduced system privileges which makes it possible to grant regular users a subset of administrative privileges that have historically been limited to SYSDBA and administrators only. For example:

- Run utilities such as `gbak`, `gfix`, `nbackup` and so on
- Shut down a database and bring it online
- Trace other users' attachments
- Access the monitoring tables
- Run `management statements`

The implementation defines a set of system privileges, analogous to object privileges, from which lists of privileged tasks can be assigned to roles.

It is also possible to grant normal privileges to a system privilege, making the system privilege act like a special role type.

The system privileges are assigned through `CREATE ROLE` and `ALTER ROLE`.
Be aware that each system privilege provides a very thin level of control. For some tasks it may be necessary to give the user more than one privilege to perform some task. For example, add **IGNORE_DB_TRIGGERS** to **USE_GSTAT_UTILITY** because **gstat** needs to ignore database triggers.

### List of Valid System Privileges

The following table lists the names of the valid system privileges that can be granted to and revoked from roles.

<table>
<thead>
<tr>
<th>Privilege</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>USER_MANAGEMENT</td>
<td>Manage users (given in the security database)</td>
</tr>
<tr>
<td>READ_RAW_PAGES</td>
<td>Read pages in raw format using Attachment::getInfo()</td>
</tr>
<tr>
<td>CREATE_USER_TYPES</td>
<td>Add/change/delete non-system records in RDB$TYPES</td>
</tr>
<tr>
<td>USE_NBACKUP_UTILITY</td>
<td>Use <code>nbackup</code> to create database copies</td>
</tr>
<tr>
<td>CHANGE_SHUTDOWN_MODE</td>
<td>Shut down database and bring online</td>
</tr>
<tr>
<td>TRACE_ANY_ATTACHMENT</td>
<td>Trace other users' attachments</td>
</tr>
<tr>
<td>MONITOR_ANY_ATTACHMENT</td>
<td>Monitor (tables MON$) other users' attachments</td>
</tr>
<tr>
<td>ACCESS_SHUTDOWN_DATABASE</td>
<td>Access database when it is shut down</td>
</tr>
<tr>
<td>CREATE_DATABASE</td>
<td>Create new databases (given in security.db)</td>
</tr>
<tr>
<td>DROP_DATABASE</td>
<td>Drop this database</td>
</tr>
<tr>
<td>USE_GBAK.Utility</td>
<td>Use <code>gbak</code> utility</td>
</tr>
<tr>
<td>USE_GSTAT_UTILITY</td>
<td>Use <code>gstat</code> utility</td>
</tr>
<tr>
<td>USE_GFIX_UTILITY</td>
<td>Use <code>gfix</code> utility</td>
</tr>
<tr>
<td>IGNORE_DB_TRIGGERS</td>
<td>Instruct engine not to run DB-level triggers</td>
</tr>
<tr>
<td>CHANGE_HEADER_SETTINGS</td>
<td>Modify parameters in DB header page</td>
</tr>
<tr>
<td>SELECT_ANY_OBJECT_IN_DATABASE</td>
<td>Use <code>SELECT</code> for any selectable object</td>
</tr>
<tr>
<td>ACCESS_ANY_OBJECT_IN_DATABASE</td>
<td>Access (in any possible way) any object</td>
</tr>
</tbody>
</table>
13.2. SQL Statements for User Management

This section describes the SQL statements for creating, modifying and deleting Firebird user accounts. These statements can be executed by the following users:

- SYSDBA
- Any user with the RDB$ADMIN role in the security database
- When the AUTO ADMIN MAPPING flag is enabled in the security database (security4.fdb or whatever is the security database configured for the current database in the databases.conf), any Windows Administrator - assuming Win_Sspi was used to connect without specifying roles.
- Any user with the system privilege USER_MANAGEMENT in the security database

For a Windows Administrator, AUTO ADMIN MAPPING enabled only in a regular database is not sufficient to permit management of other users. For instructions to enable it in the security database, see Auto Admin Mapping in the Security Database.

Non-privileged users can use only the ALTER USER statement, and then only to edit some data of their own account.

13.2.1. CREATE USER

Used for
Creating a Firebird user account

Available in
DSQL
Syntax

```sql
CREATE USER username
    <user_option> [ <user_option> ... ]
    [ TAGS ( <user_var> [ , <user_var> ... ] ) ]

<user_option> ::= 
    PASSWORD 'password'
    | FIRSTNAME 'firstname'
    | MIDDLENAME 'middlename'
    | LASTNAME 'lastname'
    | {GRANT | REVOKE} ADMIN ROLE
    | {ACTIVE | INACTIVE}
    | USING PLUGIN plugin_name

<user_var> ::= 
    tag_name = 'tag_value'
    | DROP tag_name
```

Table 255. CREATE USER Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>username</td>
<td>Username. The maximum length is 63 characters, following the rules for Firebird identifiers.</td>
</tr>
<tr>
<td>password</td>
<td>User password. Valid or effective password length depends on the user manager plugin. Case-sensitive.</td>
</tr>
<tr>
<td>firstname</td>
<td>Optional: User’s first name. Maximum length 32 characters</td>
</tr>
<tr>
<td>middlename</td>
<td>Optional: User’s middle name. Maximum length 32 characters</td>
</tr>
<tr>
<td>plugin_name</td>
<td>Name of the user manager plugin.</td>
</tr>
<tr>
<td>tag_name</td>
<td>Name of a custom attribute. The maximum length is 63 characters, following the rules for Firebird regular identifiers.</td>
</tr>
<tr>
<td>tag_value</td>
<td>Value of the custom attribute. The maximum length is 255 characters.</td>
</tr>
</tbody>
</table>

The `CREATE USER` statement creates a new Firebird user account. If the user already exist in the Firebird security database for the specified user manager plugin, an appropriate error be raised. It is possible to create multiple users with the same name: one per user manager plugin.

The `username` argument must follow the rules for Firebird regular identifiers: see `Identifiers` in the `Structure` chapter. Usernames are case-sensitive when double-quoted (in other words, they follow the same rules as other delimited identifiers).
Usernames follow the general rules and syntax of identifiers. Thus, a user named "Alex" is distinct from a user named "ALEX"

```
CREATE USER ALEX PASSWORD 'bz23ds';
- this user is the same as the first one
CREATE USER Alex PASSWORD 'bz23ds';
- this user is the same as the first one
CREATE USER "ALEX" PASSWORD 'bz23ds';
- and this is a different user
CREATE USER "Alex" PASSWORD 'bz23ds';
```

The PASSWORD clause specifies the user's password, and is required. The valid or effective password length depends on the user manager plugin, see also User Authentication.

The optional FIRSTNAME, MIDDLENAME and LASTNAME clauses can be used to specify additional user properties, such as the person’s first name, middle name and last name, respectively. They are just simple VARCHAR(32) fields and can be used to store anything you prefer.

If the GRANT ADMIN ROLE clause is specified, the new user account is created with the privileges of the RDB$ADMIN role in the security database (security4.fdb or database-specific). It allows the new user to manage user accounts from any regular database they log into, but it does not grant the user any special privileges on objects in those databases.

The REVOKE ADMIN ROLE clause is syntactically valid in a CREATE USER statement, but has no effect. It is not possible to specify GRANT ADMIN ROLE and REVOKE ADMIN ROLE in one statement.

The ACTIVE clause specifies the user is active and can log in, this is the default.

The INACTIVE clause specifies the user is inactive and cannot log in. It is not possible to specify ACTIVE and INACTIVE in one statement. The ACTIVE/INACTIVE option is not supported by the Legacy_UserManager and will be ignored.

The USING PLUGIN clause explicitly specifies the user manager plugin to use for creating the user. Only plugins listed in the UserManager configuration for this database (firebird.conf, or overridden in databases.conf) are valid. The default user manager (first in the UserManager configuration) is applied when this clause is not specified.

Users of the same name created using different user manager plugins are different objects. Therefore, the user created with one user manager plugin can only be altered or dropped by that same plugin.

From the perspective of ownership, and privileges and roles granted in a databases, different user objects with the same name are considered one and the same user.
The TAGS clause can be used to specify additional user attributes. Custom attributes are not supported (silently ignored) by the Legacy_UserManager. Custom attributes names follow the rules of Firebird identifiers, but are handled case-insensitive (for example, specifying both "A BC" and "a bc" will raise an error). The value of a custom attribute can be a string of maximum 255 characters. The DROP tag_name option is syntactically valid in CREATE USER, but behaves as if the property is not specified.

Users can view and alter their own custom attributes.

CREATE/ALTER/DROP USER are DDL statements, and only take effect at commit. Remember to COMMIT your work. In isql, the command SET AUTO ON will enable autocommit on DDL statements. In third-party tools and other user applications, this may not be the case.

Who Can Create a User

To create a user account, the current user must have

- administrator privileges in the security database
- the USER_MANAGEMENT system privilege in the security database. Users with the USER_MANAGEMENT system privilege can not grant or revoke the admin role.

CREATE USER Examples

1. Creating a user with the username bigshot:

```
CREATE USER bigshot PASSWORD 'buckshot';
```

2. Creating a user with the Legacy_UserManager user manager plugin

```
CREATE USER godzilla PASSWORD 'robot'
    USING PLUGIN Legacy_UserManager;
```

3. Creating the user john with custom attributes:

```
CREATE USER john PASSWORD 'fYe_3Ksw'
    FIRSTNAME 'John' LASTNAME 'Doe'
    TAGS (BIRTHYEAR='1970', CITY='New York');
```

4. Creating an inactive user:

```
CREATE USER john PASSWORD 'fYe_3Ksw'
    INACTIVE;
```
5. Creating the user superuser with user management privileges:

```sql
CREATE USER superuser PASSWORD 'kMn8Kjh'
GRANT ADMIN ROLE;
```

See also

`ALTER USER`, `CREATE OR ALTER USER`, `DROP USER`

### 13.2.2. ALTER USER

**Used for**

Modifying a Firebird user account

**Available in**

DSQL

**Syntax**

```sql
ALTER {USER username | CURRENT USER}
[SET] [<user_option> [<user_option> ...]]
[TAGS (<user_var> [, <user_var> ...]])

<user_option> ::=  
  PASSWORD 'password'
  | FIRSTNAME 'firstname'
  | MIDDLENAME 'middlename'
  | LASTNAME 'lastname'
  | {GRANT | REVOKE} ADMIN ROLE
  | {ACTIVE | INACTIVE}
  | USING PLUGIN plugin_name

<user_var> ::=  
  tag_name = 'tag_value'
  | DROP tag_name
```

See `CREATE USER` for details on the statement parameters.

The `ALTER USER` statement changes the details in the named Firebird user account. The `ALTER USER` statement must contain at least one of the optional clauses other than `USING PLUGIN`.

Any user can alter his or her own account, except that only an administrator may use `GRANT/REVOKE ADMIN ROLE` and `ACTIVE/INACTIVE`.

All clauses are optional, but at least one other than `USING PLUGIN` must be present:

- The `PASSWORD` parameter is for changing the password for the user
- `FIRSTNAME`, `MIDDLENAME` and `LASTNAME` update these optional user properties, such as the person’s first name, middle name and last name respectively
• GRANT ADMIN ROLE grants the user the privileges of the RDB$ADMIN role in the security database (security4.fdb), enabling them to manage the accounts of other users. It does not grant the user any special privileges in regular databases.

• REVOKE ADMIN ROLE removes the user’s administrator in the security database which, once the transaction is committed, will deny that user the ability to alter any user account except their own

• ACTIVE will enable a disabled account (not supported for Legacy_UserManager)

• INACTIVE will disable an account (not supported for Legacy_UserManager). This is convenient to temporarily disable an account without deleting it.

• USING PLUGIN specifies the user manager plugin to use

• TAGS can be used to add, update or remove (DROP) additional custom attributes (not supported for Legacy_UserManager). Attributes not listed will not be changed.

See CREATE USER for more details on the clauses.

If you need to change your own account, then instead of specifying the name of the current user, you can use the CURRENT USER clause.

The ALTER CURRENT USER statement follows the normal rules for selecting the user manager plugin. If the current user was created with a non-default user manager plugin, they will need to explicitly specify the user manager plugins with USING PLUGIN plugin_name, or they will receive an error that the user is not found. Or, if a user with the same name exists for the default user manager, they will alter that user instead.

Remember to commit your work if you are working in an application that does not auto-commit DDL.

Who Can Alter a User?

To modify the account of another user, the current user must have

• administrator privileges in the security database

• the USER_MANAGEMENT system privilege in the security database Users with the USER_MANAGEMENT system privilege can not grant or revoke the admin role.

Anyone can modify their own account, except for the GRANT/REVOKE ADMIN ROLE and ACTIVE/INACTIVE options, which require administrative privileges to change.

ALTER USER Examples

1. Changing the password for the user bobby and granting them user management privileges:

   ```sql
   ALTER USER bobby PASSWORD '67-UiT_68'
   GRANT ADMIN ROLE;
   ```
2. Editing the optional properties (the first and last names) of the user dan:

```sql
ALTER USER dan
FIRSTNAME 'No_Jack'
LASTNAME 'Kennedy';
```

3. Revoking user management privileges from user dumbbell:

```sql
ALTER USER dumbbell
DROP ADMIN ROLE;
```

See also

CREATE USER, DROP USER

13.2.3. CREATE OR ALTER USER

Used for

Creating a new or modifying an existing Firebird user account

Available in

DSQL

Syntax

```
CREATE OR ALTER USER username
  [SET] [<user_option> [<user_option> ...]]
  [TAGS (<user_var> [, <user_var> ...])]

[user_option> ::= 
  PASSWORD 'password'
  | FIRSTNAME 'firstname'
  | MIDDLENAME 'middlename'
  | LASTNAME 'lastname'
  | {GRANT | REVOKE} ADMIN ROLE
  | {ACTIVE | INACTIVE}
  | USING PLUGIN plugin_name

[user_var> ::= 
  tag_name = 'tag_value'
  | DROP tag_name
```

See CREATE USER and ALTER USER for details on the statement parameters.

The CREATE OR ALTER USER statement creates a new or changes the details in the named Firebird user account. If the user does not exist, it will be created as if executing the CREATE USER statement. If the user already exists, it will be modified as if executing the ALTER USER statement. The CREATE OR ALTER USER statement must contain at least one of the optional clauses other than USING PLUGIN. If
the user does not exist yet, the PASSWORD clause is required.

Remember to commit your work if you are working in an application that does not auto-commit DDL.

CREATE OR ALTER USER **Examples**

Creating or altering a user

```
CREATE OR ALTER USER john PASSWORD 'fYe_3Ksw'
FIRSTNAME 'John'
LASTNAME 'Doe'
INACTIVE;
```

See also

CREATE USER, ALTER USER, DROP USER

13.2.4. DROP USER

**Used for**

Deleting a Firebird user account

**Available in**

DSQL

**Syntax**

```
DROP USER username
  [USING PLUGIN plugin_name]
```

**Table 256. DROP USER Statement Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>username</td>
<td>Username</td>
</tr>
<tr>
<td>plugin_name</td>
<td>Name of the user manager plugin</td>
</tr>
</tbody>
</table>

The **DROP USER** statement deletes a Firebird user account.

The optional USING PLUGIN clause explicitly specifies the user manager plugin to use for dropping the user. Only plugins listed in the `UserManager` configuration for this database (`firebird.conf`, or overridden in `databases.conf`) are valid. The default user manager (first in the `UserManager` configuration) is applied when this clause is not specified.

Users of the same name created using different user manager plugins are different objects. Therefore, the user created with one user manager plugin can only be dropped by that same plugin.
Remember to commit your work if you are working in an application that does not auto-commit DDL.

**Who Can Drop a User?**

To drop a user, the current user must have

- administrator privileges in the security database
- the USER_MANAGEMENT system privilege in the security database

**DROP USER Example**

1. Deleting the user bobby:

   ```sql
   DROP USER bobby;
   ```

2. Removing a user created with the Legacy_UserManager plugin:

   ```sql
   DROP USER Godzilla
   USING PLUGIN Legacy_UserManager;
   ```

*See also*

CREATE USER, ALTER USER

### 13.3. SQL Privileges

The second level of Firebird’s security model is SQL privileges. Whilst a successful login — the first level — authorises a user’s access to the server and to all databases under that server, it does not imply that the user has access to any objects in any databases. When an object is created, only the user that created it (its owner) and administrators have access to it. The user needs privileges on each object they need to access. As a general rule, privileges must be granted explicitly to a user by the object owner or an administrator of the database.

A privilege comprises a DML access type (SELECT, INSERT, UPDATE, DELETE, EXECUTE and REFERENCES), the name of a database object (table, view, procedure, role) and the name of the grantee (user, procedure, trigger, role). Various means are available to grant multiple types of access on an object to multiple users in a single GRANT statement. Privileges may be revoked from a user with REVOKE statements.

An additional type of privileges, DDL privileges, provide rights to create, alter or drop specific types of metadata objects

Privileges are stored in the database to which they apply and are not applicable to any other database, except the DATABASE DDL privileges, which are stored in the security database.
13.3.1. The Object Owner

The user who created a database object becomes its owner. Only the owner of an object and users with administrator privileges in the database, including the database owner, can alter or drop the database object.

Administrators, the database owner or the object owner can grant privileges to and revoke them from other users, including privileges to grant privileges to other users. The process of granting and revoking SQL privileges is implemented with two statements, `GRANT` and `REVOKE`.

13.4. ROLE

A role is a database object that packages a set of privileges. Roles implement the concept of access control at a group level. Multiple privileges are granted to the role and then that role can be granted to or revoked from one or many users.

A user that is granted a role must supply that role in their login credentials in order to exercise the associated privileges. Any other privileges granted to the user directly are not affected by their login with the role. Logging in with multiple roles simultaneously is not supported.

In this section the tasks of creating and dropping roles are discussed.

13.4.1. CREATE ROLE

*Used for*

Creating a new ROLE object

*Available in*

DSQL, ESQL
Syntax

```
CREATE ROLE rolename
  [SET SYSTEM PRIVILEGES TO <sys_privileges>]

<sys_privileges> ::=<sys_privilege> [, <sys_privilege> ...]

<sys_privilege> ::= USER_MANAGEMENT | READ_RAW_PAGES
                   | CREATE_USER_TYPES | USE_NBACKUPUTILITY
                   | CHANGE_SHUTDOWN_MODE | TRACE_ANY_ATTACHMENT
                   | MONITOR_ANY_ATTACHMENT | ACCESS_SHUTDOWN_DATABASE
                   | CREATE_DATABASE | DROP_DATABASE
                   | USE_GBAKUTILITY | USE_GSTATUTILITY
                   | USE_GFIXUTILITY | IGNORE_DB_TRIGGERS
                   | CHANGE_HEADER_SETTINGS
                   | SELECT_ANY_OBJECT_IN_DATABASE
                   | ACCESS_ANY_OBJECT_IN_DATABASE
                   | MODIFY_ANY_OBJECT_IN_DATABASE
                   | CHANGE_MAPPING_RULES | USE_GRANTED_BY_CLAUSE
                   | GRANT_REVOKE_ON_ANY_OBJECT
                   | GRANT_REVOKE_ANY_DDL_RIGHT
                   | CREATE_PRIVILEGED_ROLES | GET_DBCRYPT_INFO
                   | MODIFY_EXT_CONN_POOL | REPLICATE INTO DATABASE
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>rolename</td>
<td>Role name. The maximum length is 63 characters</td>
</tr>
<tr>
<td>sys_privilege</td>
<td>System privilege to grant</td>
</tr>
</tbody>
</table>

The statement `CREATE ROLE` creates a new role object, to which one or more privileges can be granted subsequently. The name of a role must be unique among the names of roles in the current database.

It is advisable to make the name of a role unique among usernames as well. The system will not prevent the creation of a role whose name clashes with an existing username but, if it happens, the user will be unable to connect to the database.

Who Can Create a Role

The `CREATE ROLE` statement can be executed by:

- **Administrators**
- Users with the `CREATE ROLE` privilege, with the following caveats
  - Setting system privileges also requires the system privilege `CREATE_PRIVILEGED_ROLES`
The user executing the `CREATE ROLE` statement becomes the owner of the role.

### CREATE ROLE Examples

**Creating a role named SELLERS**

```sql
CREATE ROLE SELLERS;
```

**Creating a role SELECT_ALL with the system privilege to select from any selectable object**

```sql
CREATE ROLE SELECT_ALL
  SET SYSTEM PRIVILEGES TO SELECT_ANY_OBJECT_IN_DATABASE;
```

See also

`ALTER ROLE`, `DROP ROLE`, `GRANT`, `REVOKE`, Fine-grained System Privileges

### 13.4.2. ALTER ROLE

**Used for**

Altering a role

**Available in**

DSQL

**Syntax**

```sql
ALTER ROLE rolename
  { SET SYSTEM PRIVILEGES TO <sys_privileges>
    | DROP SYSTEM PRIVILEGES
    | {SET | DROP} AUTO ADMIN MAPPING }

<sys_privileges> ::= ! See CREATE ROLE !!
```

**Table 258. ALTER ROLE Statement Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>rolename</td>
<td>Role name; specifying anything other than RDB$ADMIN will fail</td>
</tr>
<tr>
<td>sys_privilege</td>
<td>System privilege to grant</td>
</tr>
</tbody>
</table>

`ALTER ROLE` can be used to grant or revoke system privileges from a role, or enable and disable the capability for Windows Administrators to assume administrator privileges automatically when logging in.

This last capability can affect only one role: the system-generated role RDB$ADMIN that exists in every database of ODS 11.2 or higher.

For details on auto admin mapping, see **AUTO ADMIN MAPPING**.
It is not possible to selectively grant or revoke system privileges. Only the privileges listed in the SET 
SYSTEM PRIVILEGES clause will be available to the role after commit, and DROP SYSTEM PRIVILEGES will 
remove all system privileges from this role.

**Who Can Alter a Role**

The ALTER ROLE statement can be executed by:

- **Administrators**
- Users with the ALTER ANY ROLE privilege, with the following caveats
  - Setting or dropping system privileges also requires the system privilege CREATE_PRIVILEGED_ROLES
  - Setting or dropping auto admin mapping also requires the system privilege CHANGE_MAPPING_RULES

**ALTER ROLE Examples**

*Drop all system privileges from a role named SELECT_ALL*

```sql
ALTER ROLE SELLERS
    DROP SYSTEM PRIVILEGES;
```

*Grant a role SELECT_ALL the system privilege to select from any selectable object*

```sql
ALTER ROLE SELECT_ALL
    SET SYSTEM PRIVILEGES TO SELECT_ANY_OBJECT_IN_DATABASE;
```

*See also*

CREATE ROLE, GRANT, REVOKE, Fine-grained System Privileges

**13.4.3. DROP ROLE**

*Used for*

Deleting a role

*Available in*

DSQL, ESQL

*Syntax*

```sql
DROP ROLE rolename
```

The statement DROP ROLE deletes an existing role. It takes just a single argument, the name of the 
role. Once the role is deleted, the entire set of privileges is revoked from all users and objects that 
were granted the role.
Who Can Drop a Role

The DROP ROLE statement can be executed by:

- Administrators
- The owner of the role
- Users with the DROP ANY ROLE privilege

DROP ROLE Examples

Deleting the role SELLERS

DROP ROLE SELLERS;

See also

CREATE ROLE, GRANT, REVOKE

13.5. Statements for Granting Privileges

A GRANT statement is used for granting privileges—including roles—to users and other database objects.

13.5.1. GRANT

Used for
Granting privileges and assigning roles

Available in
DSQL, ESQL

Syntax (granting privileges)

```
GRANT <privileges>
TO <grantee_list>
[WITH GRANT OPTION]
[GRANTED BY | AS] [USER] grantor

<privileges> ::=<table_privileges> | <execute_privilege>
| <usage_privilege> | <ddl_privileges>
| <db_ddl_privilege>

<table_privileges> ::= {ALL [PRIVILEGES] | <table_privilege_list> }
ON [TABLE] {table_name | view_name}

<table_privilege_list> ::=<table_privilege> [, <table_privilege> ...]
```
<table_privilege> ::= 
    SELECT | DELETE | INSERT 
    | UPDATE [(col [, col ...])]
    | REFERENCES [(col [, col ...)]}

<execute_privilege> ::= EXECUTE ON 
    { PROCEDURE proc_name | FUNCTION func_name 
    | PACKAGE package_name }

<usage_privilege> ::= USAGE ON 
    { EXCEPTION exception_name 
    | \{GENERATOR | SEQUENCE\} sequence_name }

<ddl_privileges> ::= 
    {ALL [PRIVILEGES] | <ddl_privilege_list>} <object_type>

<ddl_privilege_list> ::= 
    <ddl_privilege> [, <ddl_privilege> ...]

<ddl_privilege> ::= CREATE | ALTER ANY | DROP ANY

<object_type> ::= CREATE | ALTER ANY | DROP

    CHARACTER SET | COLLATION | DOMAIN | EXCEPTION 
    | FILTER | FUNCTION | GENERATOR | PACKAGE 
    | PROCEDURE | ROLE | SEQUENCE | TABLE | VIEW

<db_ddl_privileges> ::= 
    {ALL [PRIVILEGES] | <db_ddl_privilege_list>} \{DATABASE | SCHEMA\}

<db_ddl_privilege_list> ::= 
    <db_ddl_privilege> [, <db_ddl_privilege> ...]

<db_ddl_privilege> ::= CREATE | ALTER | DROP

<grantee_list> ::= <grantee> [, <grantee> ...]

<grantee> ::= 
    PROCEDURE proc_name | FUNCTION func_name 
    | PACKAGE package_name | TRIGGER trig_name 
    | VIEW view_name | ROLE role_name 
    | \[USER\] username | GROUP Unix_group 
    | SYSTEM PRIVILEGE <sys_privilege>

<sys_privilege> ::= 
    !! See CREATE ROLE !!
Syntax (granting roles)

```plaintext
GRANT <role_granted_list>
  TO <role_grantee_list>
  [WITH ADMIN OPTION]
  [GRANTED BY | AS] [USER] grantor

<role_granted_list> ::= <role_granted> [, <role_granted> ...]

<role_granted> ::= [DEFAULT] role_name

<role_grantee_list> ::= <role_grantee> [, <role_grantee> ...]

<role_grantee> ::= user_or_role_name
                  | USER username
                  | ROLE role_name
```

Table 259. GRANT Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>grantor</td>
<td>The user granting the privilege(s)</td>
</tr>
<tr>
<td>table_name</td>
<td>The name of a table</td>
</tr>
<tr>
<td>view_name</td>
<td>The name of a view</td>
</tr>
<tr>
<td>col</td>
<td>The name of table column</td>
</tr>
<tr>
<td>proc_name</td>
<td>The name of a stored procedure</td>
</tr>
<tr>
<td>func_name</td>
<td>The name of a stored function (or UDF)</td>
</tr>
<tr>
<td>package_name</td>
<td>The name of a package</td>
</tr>
<tr>
<td>exception_name</td>
<td>The name of an exception</td>
</tr>
<tr>
<td>sequence_name</td>
<td>The name of a sequence (generator)</td>
</tr>
<tr>
<td>object_type</td>
<td>The type of metadata object</td>
</tr>
<tr>
<td>trig_name</td>
<td>The name of a trigger</td>
</tr>
<tr>
<td>role_name</td>
<td>Role name</td>
</tr>
<tr>
<td>username</td>
<td>The username to which the privileges are granted to or to which the role is assigned. If the USER keyword is absent, it can also be a role.</td>
</tr>
<tr>
<td>Unix_group</td>
<td>The name of a user group in a POSIX operating system</td>
</tr>
<tr>
<td>sys_privilege</td>
<td>A system privilege</td>
</tr>
<tr>
<td>user_or_role_name</td>
<td>Name of a user or role</td>
</tr>
</tbody>
</table>

The `GRANT` statement grants one or more privileges on database objects to users, roles, or other database objects.
A regular, authenticated user has no privileges on any database object until they are explicitly granted to that individual user, to a role granted to the user as a default role, or to all users bundled as the user PUBLIC. When an object is created, only its creator (the owner) and administrators have privileges to it, and can grant privileges to other users, roles, or objects.

Different sets of privileges apply to different types of metadata objects. The different types of privileges will be described separately later in this section.

**SCHEMA** is currently a synonym for **DATABASE**; this may change in a future version, so we recommend to always use **DATABASE**.

**The **TO** Clause**

The **TO** clause specifies the users, roles, and other database objects that are to be granted the privileges enumerated in **privileges**. The clause is mandatory.

The optional **USER** keyword in the **TO** clause allow you to specify exactly who or what is granted the privilege. If a **USER** (or **ROLE**) keyword is not specified, the server first checks for a role with this name and, if there is no such role, the privileges are granted to the user with that name without further checking.

- When a **GRANT** statement is executed, the security database is not checked for the existence of the grantee user. This is not a bug: SQL permissions are concerned with controlling data access for authenticated users, both native and trusted, and trusted operating system users are not stored in the security database.

- When granting a privilege to a database object other than user or role, such as a procedure, trigger or view, you must specify the object type.

- Although the **USER** keyword is optional, it is advisable to use it, in order to avoid ambiguity with roles.

- Privileges granted to a system privilege will be applied when the user is logged in with a role that has that system privilege.

**Packaging Privileges in a **ROLE** Object**

A role is a “container” object that can be used to package a collection of privileges. Use of the role is then granted to each user or role that requires those privileges. A role can also be granted to a list of users or roles.

The role must exist before privileges can be granted to it. See **CREATE ROLE** for the syntax and rules. The role is maintained by granting privileges to it and, when required, revoking privileges from it. When a role is dropped — see **DROP ROLE** — all users lose the privileges acquired through the role. Any privileges that were granted additionally to an affected user by way of a different grant statement are retained.
Unless the role is granted as a default role, a user that is granted a role must explicitly specify that role, either with their login credentials or activating it using SET ROLE, in order to exercise the associated privileges. Any other privileges granted to the user or received through default roles are not affected by explicitly specifying a role.

More than one role can be granted to the same user. Although only one role can be explicitly specified, multiple roles can be active for a user, either as default roles, or as roles granted to the current role.

A role can be granted to a user or to another role.

**Cumulative Roles**

The ability to grant roles to other roles and default roles results in so-called cumulative roles. Multiple roles can be active for a user, and the user receives the cumulative privileges of all those roles.

When a role is explicitly specified on connect or using SET ROLE, the user will assume all privileges granted to that role, including those privileges granted to the secondary roles (including roles granted on that secondary role, etc). Or in other words, when the primary role is explicitly specified, the secondary roles are also activated. The function RDB$ROLE_IN_USE can be used to check if a role is currently active.

See also Default Roles for the effects of DEFAULT with cumulative roles, and The WITH ADMIN OPTION Clause for effects on granting.

**Default Roles**

A role can be granted as a default role by prefixing the role with DEFAULT in the GRANT statement. Granting roles as a default role to users simplifies management of privileges, as this makes it possible to group privileges on a role and granting that group of privileges to a user without requiring the user to explicitly specify the role. Users can receive multiple default roles, granting them all privileges of those default roles.

The effects of a default role depend on whether the role is granted to a user or to another role:

- When a role is granted to a user as a default role, the role will be activated automatically, and its privileges will be applied to the user without the need to explicitly specify the role.

  Roles that are active by default are not returned from CURRENT_ROLE, but the function RDB$ROLE_IN_USE can be used to check if a role is currently active.

- When a role is granted to another role as a default role, the rights of that role will only be automatically applied to the user if the primary role is granted as a default role to the user, otherwise the primary role needs to be specified explicitly (in other words, it behaves the same as when the secondary role was granted without the DEFAULT clause).

  For a string of granted roles, all roles need to be granted as a default role for them to be applied automatically. That is, for GRANT DEFAULT ROLEA TO ROLE ROLEB, GRANT ROLEB TO ROLE ROLEC, GRANT DEFAULT ROLEC TO USER USER1 only ROLEC is active by default for USER1. To assume the privileges of ROLEA and ROLEB, ROLEC needs to be explicitly specified, or ROLEB needs to be granted DEFAULT to
The User \texttt{PUBLIC}

Firebird has a predefined user named \texttt{PUBLIC}, that represents all users. Privileges for operations on a particular object that are granted to the user \texttt{PUBLIC} can be exercised by any authenticated user.

\begin{itemize}
  \item If privileges are granted to the user \texttt{PUBLIC}, they should be revoked from the user \texttt{PUBLIC} as well.
\end{itemize}

The \texttt{WITH GRANT OPTION} Clause

The optional \texttt{WITH GRANT OPTION} clause allows the users specified in the user list to grant the privileges specified in the privilege list to other users.

\begin{itemize}
  \item It is possible to assign this option to the user \texttt{PUBLIC}. Do not do this!
\end{itemize}

The \texttt{GRANTED BY} Clause

By default, when privileges are granted in a database, the current user is recorded as the grantor. The \texttt{GRANTED BY} clause enables the current user to grant those privileges as another user.

When using the \texttt{REVOKE} statement, it will fail if the current user is not the user that was named in the \texttt{GRANTED BY} clause.

The \texttt{GRANTED BY} (and \texttt{AS}) clause can be used only by the database owner and other \texttt{administrators}. The object owner cannot use \texttt{GRANTED BY} unless they also have administrator privileges.

Alternative Syntax Using \texttt{AS username}

The non-standard \texttt{AS} clause is supported as a synonym of the \texttt{GRANTED BY} clause to simplify migration from other database systems.

Privileges on Tables and Views

For tables and views, unlike other metadata objects, it is possible to grant several privileges at once.

List of Privileges on Tables

- **SELECT**
  - Permits the user or object to \texttt{SELECT} data from the table or view

- **INSERT**
  - Permits the user or object to \texttt{INSERT} rows into the table or view

- **DELETE**
  - Permits the user or object to \texttt{DELETE} rows from the table or view

- **UPDATE**
  - Permits the user or object to \texttt{UPDATE} rows in the table or view, optionally restricted to specific
REFERENCES
Permits the user or object to reference the table via a foreign key, optionally restricted to the specified columns. If the primary or unique key referenced by the foreign key of the other table is composite then all columns of the key must be specified.

ALL [PRIVILEGES]
Combines SELECT, INSERT, UPDATE, DELETE and REFERENCES privileges in a single package

Examples of GRANT <privilege> on Tables

1. SELECT and INSERT privileges to the user ALEX:

   GRANT SELECT, INSERT ON TABLE SALES
   TO USER ALEX;

2. The SELECT privilege to the MANAGER, ENGINEER roles and to the user IVAN:

   GRANT SELECT ON TABLE CUSTOMER
   TO ROLE MANAGER, ROLE ENGINEER, USER IVAN;

3. All privileges to the ADMINISTRATOR role, together with the authority to grant the same privileges to others:

   GRANT ALL ON TABLE CUSTOMER
   TO ROLE ADMINISTRATOR
   WITH GRANT OPTION;

4. The SELECT and REFERENCES privileges on the NAME column to all users and objects:

   GRANT SELECT, REFERENCES (NAME) ON TABLE COUNTRY
   TO PUBLIC;

5. The SELECT privilege being granted to the user IVAN by the user ALEX:

   GRANT SELECT ON TABLE EMPLOYEE
   TO USER IVAN
   GRANTED BY ALEX;

6. Granting the UPDATE privilege on the FIRST_NAME, LAST_NAME columns:
7. Granting the INSERT privilege to the stored procedure ADD_EMP_PROJ:

GRANT INSERT ON EMPLOYEE_PROJECT TO PROCEDURE ADD_EMP_PROJ;

**The EXECUTE Privilege**

The EXECUTE privilege applies to stored procedures, stored functions (including UDFs), and packages. It allows the grantee to execute the specified object, and, if applicable, to retrieve its output.

In the case of selectable stored procedures, it acts somewhat like a SELECT privilege, insofar as this style of stored procedure is executed in response to a SELECT statement.

> For packages, the EXECUTE privilege can only be granted for the package as a whole, not for individual subroutines.

**Examples of Granting the EXECUTE Privilege**

1. Granting the EXECUTE privilege on a stored procedure to a role:

```sql
GRANT EXECUTE ON PROCEDURE ADD_EMP_PROJ TO ROLE MANAGER;
```

2. Granting the EXECUTE privilege on a stored function to a role:

```sql
GRANT EXECUTE ON FUNCTION GET_BEGIN_DATE TO ROLE MANAGER;
```

3. Granting the EXECUTE privilege on a package to user PUBLIC:

```sql
GRANT EXECUTE ON PACKAGE APP_VAR TO USER PUBLIC;
```

4. Granting the EXECUTE privilege on a function to a package:

```sql
GRANT EXECUTE ON FUNCTION GET_BEGIN_DATE TO PACKAGE APP_VAR;
```
The USAGE Privilege

To be able to use metadata objects other than tables, views, stored procedures or functions, triggers and packages, it is necessary to grant the user (or database object like trigger, procedure or function) the USAGE privilege on these objects.

Since Firebird executes stored procedures and functions, triggers, and package routines with the privileges of the caller, it is necessary that either the user or otherwise the routine itself has been granted the USAGE privilege.

In Firebird 3.0 and Firebird 4.0, the USAGE privilege is only available for exceptions and sequences (in gen_id(gen_name, n) or `next value for gen_name). Support for the USAGE privilege for other metadata objects may be added in future releases.

For sequences (generators), the USAGE privilege only grants the right to increment the sequence using the GEN_ID function or NEXT VALUE FOR. The SET GENERATOR statement is a synonym for ALTER SEQUENCE ... RESTART WITH ..., and is considered a DDL statement. By default, only the owner of the sequence and administrators have the rights to such operations. The right to set the initial value of any sequence can be granted with GRANT ALTER ANY SEQUENCE, which is not recommend for general users.

Examples of Granting the USAGE Privilege

1. Granting the USAGE privilege on a sequence to a role:

   ```sql
   GRANT USAGE ON SEQUENCE GEN_AGE
   TO ROLE MANAGER;
   ```

2. Granting the USAGE privilege on a sequence to a trigger:

   ```sql
   GRANT USAGE ON SEQUENCE GEN_AGE
   TO TRIGGER TR_AGE_BI;
   ```

3. Granting the USAGE privilege on an exception to a package:

   ```sql
   GRANT USAGE ON EXCEPTION
   TO PACKAGE PKG_BILL;
   ```

DDL Privileges

By default, only administrators can create new metadata objects; altering or dropping these objects is restricted to the owner of the object (its creator) and administrators. DDL privileges can be used to grant privileges for these operations to other users.

Available DDL Privileges
CREATE
Allows creation of an object of the specified type

ALTER ANY
Allows modification of any object of the specified type

DROP ANY
Allows deletion of any object of the specified type

ALL [PRIVILEGES]
Combines the CREATE, ALTER ANY and DROP ANY privileges for the specified type

There are no separate DDL privileges for triggers and indexes. The necessary privileges are inherited from the table or view. Creating, altering or dropping a trigger or index requires the ALTER ANY TABLE or ALTER ANY VIEW privilege.

Examples of Granting DDL Privileges

1. Allow user JOE to create tables

   GRANT CREATE TABLE
   TO USER Joe;

2. Allow user JOE to alter any procedure

   GRANT ALTER ANY PROCEDURE
   TO USER Joe;

Database DDL Privileges

The syntax for granting privileges to create, alter or drop a database deviates from the normal syntax of granting DDL privileges for other object types.

Available Database DDL Privileges

CREATE
Allows creation of a database

ALTER
Allows modification of the current database

DROP
Allows deletion of the current database

ALL [PRIVILEGES]
Combines the ALTER and DROP privileges. ALL does not include the CREATE privilege.
The ALTER DATABASE and DROP DATABASE privileges apply only to the current database, whereas DDL privileges ALTER ANY and DROP ANY on other object types apply to all objects of the specified type in the current database. The privilege to alter or drop the current database can only be granted by administrators.

The CREATE DATABASE privilege is a special kind of privilege as it is saved in the security database. A list of users with the CREATE DATABASE privilege is available from the virtual table SEC$DB_CREATORS. Only administrators in the security database can grant the privilege to create a new database.

SCHEMA is currently a synonym for DATABASE; this may change in a future version, so we recommend to always use DATABASE

Examples of Granting Database DDL Privileges

1. Granting SUPERUSER the privilege to create databases:

   GRANT CREATE DATABASE
   TO USER Superuser;

2. Granting JOE the privilege to execute ALTER DATABASE for the current database:

   GRANT ALTER DATABASE
   TO USER Joe;

3. Granting FEDOR the privilege to drop the current database:

   GRANT DROP DATABASE
   TO USER Fedor;

Assigning Roles

Assigning a role is similar to granting a privilege. One or more roles can be assigned to one or more users, including the user PUBLIC, using one GRANT statement.

The WITH ADMIN OPTION Clause

The optional WITH ADMIN OPTION clause allows the users specified in the user list to grant the role(s) specified to other users or roles.

It is possible to assign this option to PUBLIC. Do not do this!

For cumulative roles, a user can only exercise the WITH ADMIN OPTION of a secondary role if all intermediate roles are also granted WITH ADMIN OPTION. That is, GRANT ROLEA TO ROLE ROLEB WITH ADMIN OPTION, GRANT ROLEB TO ROLE ROLEC, GRANT ROLEC TO USER USER1 WITH ADMIN OPTION only allows USER1 to grant ROLEC to other users or roles, while using GRANT ROLEB TO ROLE ROLEC WITH ADMIN OPTION allows USER1 to grant ROLEA, ROLEB and ROLEC to other users.
Examples of Role Assignment

1. Assigning the DIRECTOR and MANAGER roles to the user IVAN:

   GRANT DIRECTOR, MANAGER TO USER IVAN;

2. Assigning the MANAGER role to the user ALEX with the authority to assign this role to other users:

   GRANT MANAGER TO USER ALEX WITH ADMIN OPTION;

3. Assigning the DIRECTOR role to user ALEX as a default role:

   GRANT DEFAULT DIRECTOR TO USER ALEX;

4. Assigning the MANAGER role to role DIRECTOR:

   GRANT MANAGER TO ROLE DIRECTOR;

See also

REVOKE

13.6. Statements for Revoking Privileges

A REVOKE statement is used for revoking privileges—including roles—from users and other database objects.

13.6.1. REVOKE

Used for
Revoking privileges or role assignments

Available in
DSQL, ESQL
Syntax (revoking privileges)

REVOKE [GRANT OPTION FOR] <privileges>
    FROM <grantee_list>
    [{GRANTED BY | AS} [USER] grantor]

<privileges> ::=  
    !! See GRANT syntax !!

Syntax (revoking roles)

REVOKE [ADMIN OPTION FOR] <role_granted_list>
    FROM <role_grantee_list>
    [{GRANTED BY | AS} [USER] grantor]

<role_granted_list> ::=  
    !! See GRANT syntax !!

<role_grantee_list> ::=  
    !! See GRANT syntax !!

Syntax (revoking all)

REVOKE ALL ON ALL FROM <grantee_list>

<grantee_list> ::=  
    !! See GRANT syntax !!

Table 260. REVOKE Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>grantor</td>
<td>The grantor user on whose behalf the privilege(s) are being revoked</td>
</tr>
</tbody>
</table>

The REVOKE statement revokes privileges that were granted using the GRANT statement from users, roles, and other database objects. See GRANT for detailed descriptions of the various types of privileges.

Only the user who granted the privilege can revoke it.

The **DEFAULT Clause**

When the DEFAULT clause is specified, the role itself is not revoked, only its DEFAULT property is removed without revoking the role itself.

The **FROM Clause**

The FROM clause specifies a list of users, roles and other database objects that will have the enumerated privileges revoked. The optional USER keyword in the FROM clause allow you to specify exactly which type is to have the privilege revoked. If a USER (or ROLE) keyword is not specified, the
server first checks for a role with this name and, if there is no such role, the privileges are revoked from the user with that name without further checking.

- Although the USER keyword is optional, it is advisable to use them in order to avoid ambiguity with roles.
- The REVOKE statement does not check for the existence of the user from which the privileges are being revoked.
- When revoking a privilege from a database object other than USER or ROLE, you must specify its object type.

**Revoking Privileges from user** PUBLIC

Privileges that were granted to the special user named PUBLIC must be revoked from the user PUBLIC. User PUBLIC provides a way to grant privileges to all users at once, but it is not “a group of users”.

**Revoking the GRANT OPTION**

The optional GRANT OPTION FOR clause revokes the user’s privilege to grant the specified privileges to other users, roles, or database objects (as previously granted with the WITH GRANT OPTION). It does not revoke the specified privilege itself.

**Removing the Privilege to One or More Roles**

One usage of the REVOKE statement is to remove roles that were assigned to a user, or a group of users, by a GRANT statement. In the case of multiple roles and/or multiple grantees, the REVOKE verb is followed by the list of roles that will be removed from the list of users specified after the FROM clause.

The optional ADMIN OPTION FOR clause provides the means to revoke the grantee’s “administrator” privilege, the ability to assign the same role to other users, without revoking the grantee’s privilege to the role.

Multiple roles and grantees can be processed in a single statement.

**Revoking Privileges That Were GRANTED BY**

A privilege that has been granted using the GRANTED BY clause is internally attributed explicitly to the grantor designated by that original GRANT statement. Only that user can revoke the granted privilege. Using the GRANTED BY clause you can revoke privileges as if you are the specified user. To revoke a privilege with GRANTED BY, the current user must be logged in either with full administrative privileges, or as the user designated as grantor by that GRANTED BY clause.

Not even the owner of a role can use GRANTED BY unless they have administrative privileges.

The non-standard AS clause is supported as a synonym of the GRANTED BY clause to simplify migration from other database systems.
Revoking ALL ON ALL

The REVOKE ALL ON ALL statement allows a user to revoke all privileges (including roles) on all object from one or more users, roles or other database objects. It is a quick way to “clear” privileges when access to the database must be blocked for a particular user or role.

When the current user is logged in with full administrator privileges in the database, the REVOKE ALL ON ALL will remove all privileges, no matter who granted them. Otherwise, only the privileges granted by the current user are removed.

The GRANTED BY clause is not supported

Examples using REVOKE

1. Revoking the privileges for selecting and inserting into the table (or view) SALES

   ```
   REVOKE SELECT, INSERT ON TABLE SALES
   FROM USER ALEX;
   ```

2. Revoking the privilege for selecting from the CUSTOMER table from the MANAGER and ENGINEER roles and from the user IVAN:

   ```
   REVOKE SELECT ON TABLE CUSTOMER
   FROM ROLE MANAGER, ROLE ENGINEER, USER IVAN;
   ```

3. Revoking from the ADMINISTRATOR role the privilege to grant any privileges on the CUSTOMER table to other users or roles:

   ```
   REVOKE GRANT OPTION FOR ALL ON TABLE CUSTOMER
   FROM ROLE ADMINISTRATOR;
   ```

4. Revoking the privilege for selecting from the COUNTRY table and the privilege to reference the NAME column of the COUNTRY table from any user, via the special user PUBLIC:

   ```
   REVOKE SELECT, REFERENCES (NAME) ON TABLE COUNTRY
   FROM PUBLIC;
   ```

5. Revoking the privilege for selecting from the EMPLOYEE table from the user IVAN, that was granted by the user ALEX:

   ```
   REVOKE SELECT ON TABLE EMPLOYEE
   FROM USER IVAN GRANTED BY ALEX;
   ```

6. Revoking the privilege for updating the FIRST_NAME and LAST_NAME columns of the EMPLOYEE table
from the user IVAN:

```
REVOKE UPDATE (FIRST_NAME, LAST_NAME) ON TABLE EMPLOYEE
FROM USER IVAN;
```

7. Revoking the privilege for inserting records into the `EMPLOYEE_PROJECT` table from the `ADD_EMP_PROJ` procedure:

```
REVOKE INSERT ON EMPLOYEE_PROJECT
FROM PROCEDURE ADD_EMP_PROJ;
```

8. Revoking the privilege for executing the procedure `ADD_EMP_PROJ` from the `MANAGER` role:

```
REVOKE EXECUTE ON PROCEDURE ADD_EMP_PROJ
FROM ROLE MANAGER;
```

9. Revoking the privilege to grant the `EXECUTE` privilege for the function `GET_BEGIN_DATE` to other users from the role `MANAGER`:

```
REVOKE GRANT OPTION FOR EXECUTE
ON FUNCTION GET_BEGIN_DATE
FROM ROLE MANAGER;
```

10. Revoking the `EXECUTE` privilege on the package `DATE_UTILS` from user `ALEX`:

```
REVOKE EXECUTE ON PACKAGE DATE_UTILS
FROM USER ALEX;
```

11. Revoking the `USAGE` privilege on the sequence `GEN_AGE` from the role `MANAGER`:

```
REVOKE USAGE ON SEQUENCE GEN_AGE
FROM ROLE MANAGER;
```

12. Revoking the `USAGE` privilege on the sequence `GEN_AGE` from the trigger `TR_AGE_BI`:

```
REVOKE USAGE ON SEQUENCE GEN_AGE
FROM TRIGGER TR_AGE_BI;
```

13. Revoking the `USAGE` privilege on the exception `E_ACCESS_DENIED` from the package `PKG_BILL`:
14. Revoking the privilege to create tables from user JOE:

```sql
REVOKE CREATE TABLE
FROM USER Joe;
```

15. Revoking the privilege to alter any procedure from user JOE:

```sql
REVOKE ALTER ANY PROCEDURE
FROM USER Joe;
```

16. Revoking the privilege to create databases from user SUPERUSER:

```sql
REVOKE CREATE DATABASE
FROM USER Superuser;
```

17. Revoking the DIRECTOR and MANAGER roles from the user IVAN:

```sql
REVOKE DIRECTOR, MANAGER FROM USER IVAN;
```

18. Revoke from the user ALEX the privilege to grant the MANAGER role to other users:

```sql
REVOKE ADMIN OPTION FOR MANAGER FROM USER ALEX;
```

19. Revoking all privileges (including roles) on all objects from the user IVAN:

```sql
REVOKE ALL ON ALL
FROM USER IVAN;
```

After this statement is executed by an administrator, the user IVAN will have no privileges whatsoever, except those granted through PUBLIC.

20. Revoking the DEFAULT property of the DIRECTOR role from user ALEX, while the role itself remains granted:

```sql
REVOKE DEFAULT DIRECTOR
FROM USER ALEX;
```

See also
13.7. Mapping of Users to Objects

With Firebird now supporting multiple security databases, some new problems arise that could not occur with a single, global security database. Clusters of databases using the same security database were efficiently separated. Mappings provide the means to achieve the same efficiency when multiple databases are using their own security databases. Some cases require control for limited interaction between such clusters. For example:

- when `EXECUTE STATEMENT ON EXTERNAL DATA SOURCE` requires some data exchange between clusters
- when server-wide SYSDBA access to databases is needed from other clusters, using services.
- comparable problems that have existed on Firebird 2.1 and 2.5 for Windows, due to support for Trusted User authentication: two separate lists of users—one in the security database and another in Windows, with cases where it was necessary to relate them. An example is the demand for a `ROLE` granted to a Windows group to be assigned automatically to members of that group.

The single solution for all such cases is mapping the login information assigned to a user when it connects to a Firebird server to internal security objects in a database—`CURRENT_USER` and `CURRENT_ROLE`.

13.7.1. The Mapping Rule

The mapping rule consists of four pieces of information:

1. mapping scope—whether the mapping is local to the current database or whether its effect is to be global, affecting all databases in the cluster, including security databases
2. mapping name—an SQL identifier, since mappings are objects in a database, like any other
3. the object `FROM` which the mapping maps. It consists of four items:
   - The authentication source
     - plugin name *or*
     - the product of a mapping in another database *or*
     - use of server-wide authentication *or*
     - any method
   - The name of the database where authentication succeeded
   - The name of the object from which mapping is performed
   - The type of that name—username, role, or OS group—depending upon the plugin that added that name during authentication.

   Any item is accepted but only type is required.
4. the object `TO` which the mapping maps. It consists of two items:
13.7.2. CREATE MAPPING

Used for
Creating a mapping of a security object

Available in
DSQL

Syntax

```
CREATE [GLOBAL] MAPPING name
  USING
    { PLUGIN plugin_name [IN database]
    | ANY PLUGIN [IN database | SERVERWIDE]
    | MAPPING [IN database] | '*' [IN database] }
  FROM {ANY type | type from_name}
  TO {USER | ROLE} [to_name]
```

Table 261. CREATE MAPPING Statement Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>Mapping name The maximum length is 63 characters. Must be unique among all mapping names in the context (local or GLOBAL).</td>
</tr>
<tr>
<td>plugin_name</td>
<td>Authentication plugin name</td>
</tr>
<tr>
<td>database</td>
<td>Name of the database that authenticated against</td>
</tr>
<tr>
<td>type</td>
<td>The type of object to be mapped. Possible types are plugin-specific.</td>
</tr>
<tr>
<td>from_name</td>
<td>The name of the object to be mapped</td>
</tr>
<tr>
<td>to_name</td>
<td>The name of the user or role to map to</td>
</tr>
</tbody>
</table>

The CREATE MAPPING statement creates a mapping of security objects (e.g. users, groups, roles) of one or more authentication plugins to internal security objects - CURRENT_USER and CURRENT_ROLE.

If the GLOBAL clause is present, then the mapping will be applied not only for the current database, but for all databases in the same cluster, including security databases.

There can be global and local mappings with the same name. They are distinct objects.

Global mapping works best if a Firebird 3.0 or higher version database is used as the security database. If you plan to use another database for this purpose — using your own provider, for example — then you should create a table in it named RDB$MAP, with the same structure as RDB$MAP in a Firebird 3.0 or higher database and with SYSDBA-only write access.
The `USING` clause describes the mapping source. It has a very complex set of options:

- an explicit plugin name (`PLUGIN plugin_name`) means it applies only for that plugin
- it can use any available plugin (`ANY PLUGIN`); although not if the source is the product of a previous mapping
- it can be made to work only with server-wide plugins (`SERVERWIDE`)
- it can be made to work only with previous mapping results (`MAPPING`)
- you can omit to use of a specific method by using the asterisk (`*`) argument
- it can specify the name of the database that defined the mapping for the `FROM` object (`IN database`)

  This argument is not valid for mapping server-wide authentication.

The `FROM` clause describes the object to map. The `FROM` clause has a mandatory argument, the `type` of the object named. It has the following options:

- When mapping names from plugins, `type` is defined by the plugin
- When mapping the product of a previous mapping, `type` can be only `USER` or `ROLE`
- If an explicit `from_name` is provided, it will be taken into account by this mapping
- Use the `ANY` keyword to work with any name of the given type.

The `TO` clause specifies the user or role that is the result of the mapping. The `to_name` is optional. If it is not specified, then the original name of the mapped object will be used.

For roles, the role defined by a mapping rule is only applied when the user does not explicitly specify a role on connect. The mapped role can be assumed later in the session using `SET TRUSTED ROLE`, even when the mapped role is not explicitly granted to the user.

**Who Can Create a Mapping**

The `CREATE MAPPING` statement can be executed by:

- **Administrators**
- The database owner — if the mapping is local

**CREATE MAPPING examples**

1. Enable use of Windows trusted authentication in all databases that use the current security database:

```sql
CREATE GLOBAL MAPPING TRUSTED_AUTH
    USING PLUGIN WIN_SSPI
    FROM ANY USER
    TO USER;
```
2. Enable RDB$ADMIN access for windows admins in the current database:

```sql
CREATE MAPPING WIN_ADMINS
    USING PLUGIN WIN_SSPI
    FROM Predefined_Group
    DOMAIN_ANY_RID_ADMINS
    TO ROLE RDB$ADMIN;
```

The group DOMAIN_ANY_RID_ADMINS does not exist in Windows, but such a name would be added by the Win_Sspi plugin to provide exact backwards compatibility.

3. Enable a particular user from another database to access the current database with another name:

```sql
CREATE MAPPING FROM_RT
    USING PLUGIN SRP IN "rt"
    FROM USER U1 TO USER U2;
```

Database names or aliases will need to be enclosed in double quotes on operating systems that have case-sensitive file names.

4. Enable the server's SYSDBA (from the main security database) to access the current database. (Assume that the database is using a non-default security database):

```sql
CREATE MAPPING DEF_SYSDBA
    USING PLUGIN SRP IN "security.db"
    FROM USER SYSDBA
    TO USER;
```

5. Ensure users who logged in using the legacy authentication plugin do not have too many privileges:

```sql
CREATE MAPPING LEGACY_2_GUEST
    USING PLUGIN legacy_auth
    FROM ANY USER
    TO USER GUEST;
```

See also

ALTER MAPPING, CREATE OR ALTER MAPPING, DROP MAPPING

13.7.3. ALTER MAPPING

Used for
Altering a mapping of a security object

Available in DSQL

Syntax

```
ALTER [GLOBAL] MAPPING name
USING
  { PLUGIN plugin_name [IN database]
  | ANY PLUGIN [IN database | SERVERWIDE]
  | MAPPING [IN database] | '*' [IN database] }
FROM {ANY type | type from_name}
TO {USER | ROLE} [to_name]
```

For details on the options, see `CREATE MAPPING`.

The ALTER MAPPING statement allows you to modify any of the existing mapping options, but a local mapping cannot be changed to GLOBAL or vice versa.

Global and local mappings of the same name are different objects.

Who Can Alter a Mapping

The ALTER MAPPING statement can be executed by:

- Administrators
- The database owner — if the mapping is local

**ALTER MAPPING examples**

Alter mapping

```
ALTER MAPPING FROM_RT
  USING PLUGIN SRP IN "rt"
  FROM USER U1 TO USER U3;
```

See also

`CREATE MAPPING, CREATE OR ALTER MAPPING, DROP MAPPING`

**13.7.4. CREATE OR ALTER MAPPING**

Used for
Creating a new or altering an existing mapping of a security object

Available in
DSQL
Syntax

```
CREATE OR ALTER [GLOBAL] MAPPING name
    USING
        { PLUGIN plugin_name [IN database] |
        ANY PLUGIN [IN database | SERVERWIDE] |
        MAPPING [IN database] | '*' [IN database] }
    FROM {ANY type | type from_name}
    TO {USER | ROLE} [to_name]
```

For details on the options, see CREATE MAPPING.

The CREATE OR ALTER MAPPING statement creates a new or modifies an existing mapping.

Global and local mappings of the same name are different objects.

CREATE OR ALTER MAPPING examples

Creating or altering a mapping

```
CREATE OR ALTER MAPPING FROM_RT
    USING PLUGIN SRP IN "rt"
    FROM USER U1 TO USER U4;
```

See also

CREATE MAPPING, ALTER MAPPING, DROP MAPPING

13.7.5. DROP MAPPING

Used for

Dropping (removing) a mapping of a security object

Available in

DSQL

Syntax

```
DROP [GLOBAL] MAPPING name
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>Mapping name</td>
</tr>
</tbody>
</table>

The DROP MAPPING statement removes an existing mapping. If GLOBAL is specified, then a global mapping will be removed.
Global and local mappings of the same name are different objects.

Who Can Drop a Mapping

The DROP MAPPING statement can be executed by:

- Administrators
- The database owner — if the mapping is local

DROP MAPPING examples

Alter mapping

DROP MAPPING FROM_RT;

See also
CREATE MAPPING

13.8. Database Encryption

Firebird provides a plugin mechanism to encrypt the data stored in the database. This mechanism does not encrypt the entire database, but only data pages, index pages, and blob pages.

In order to make database encryption possible, you need to obtain or write a database encryption plugin.

Out of the box, Firebird does not include a database encryption plugin.

The encryption plugin example in examples/dbcrypt does not perform real encryption, it is only intended as an example how such a plugin can be written.

On Linux, an example plugin named libDbCrypt_example.so can be found in plugins/.

The main problem with database encryption is how to store the secret key. Firebird provides support for transferring the key from the client, but this does not mean that storing the key on the client is the best way; it is just one of the possible alternatives. However, keeping encryption keys on the same disk as the database is an insecure option.

For efficient separation of encryption and key access, the database encryption plugin data is divided into two parts, the encryption itself and the holder of the secret key. This can be an efficient approach when you want to use some good encryption algorithm, but you have your own custom method of storing the keys.

Once you have decided on the plugin and key holder, you can perform the encryption.
13.8.1. Encrypting a Database

Syntax

ALTER {DATABASE | SCHEMA} ENCRYPT WITH plugin_name [KEY key_name]

Table 263. ALTER DATABASE ENCRYPT Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>plugin_name</td>
<td>The name of the encryption plugin</td>
</tr>
<tr>
<td>key_name</td>
<td>The name of the encryption key</td>
</tr>
</tbody>
</table>

Encrypts the database using the specified encryption plugin. Encryption starts immediately after this statement completes, and will be performed in the background. Normal operations of the database are not disturbed during encryption.

The optional KEY clause specifies the name of the key for the encryption plugin. The plugin decides what to do with this key name.

The encryption process can be monitored using the MON$CRYPT_PAGE field in the MON$DATABASE virtual table, or viewed in the database header page using gstat -e. gstat -h will also provide limited information about the encryption status.

For example, the following query will display the progress of the encryption process as a percentage.

```
select MON$CRYPT_PAGE * 100 / MON$PAGES from MON$DATABASE;
```

SCHEMA is currently a synonym for DATABASE; this may change in a future version, so we recommend to always use DATABASE

See also

Decrypting a Database, ALTER DATABASE

13.8.2. Decrypting a Database

Syntax

ALTER {DATABASE | SCHEMA} DECRYPT

Decrypts the database using the configured plugin and key. Decryption starts immediately after this statement completes, and will be performed in the background. Normal operations of the database are not disturbed during decryption.
SCHEMA is currently a synonym for DATABASE; this may change in a future version, so we recommend to always use DATABASE

See also
Encrypting a Database, ALTER DATABASE

13.9. SQL Security

The SQL SECURITY clause of various DDL statements enables executable objects (triggers, stored procedures, stored functions) to be defined to run in a specific context of privileges.

The SQL Security feature has two contexts: INVOKER and DEFINER. The INVOKER context corresponds to the privileges available to the current user or the calling object, while DEFINER corresponds to those available to the owner of the object.

The SQL SECURITY property is an optional part of an object’s definition that can be applied to the object with DDL statements. The property cannot be dropped, but it can be changed from INVOKER to DEFINER and vice versa.

This is not the same thing as SQL privileges, which are applied to users and some types of database objects to give them various types of access to other database objects. When an executable object is Firebird needs access to a table, view or another executable object, the target object is not accessible if the invoker does not have the necessary privileges on that object. That has been the situation in previous Firebird versions and remains so in Firebird 4.0. That is, by default all executable objects have the SQL SECURITY INVOKER property, and any caller lacking the necessary privileges will be rejected. The default SQL Security behaviour of a database can be overridden using ALTER DATABASE.

If a routine has the SQL SECURITY DEFINER property applied, the invoking user or routine will be able to execute it if the required privileges have been granted to its owner, without the need for the caller to be granted those privileges as well.

In summary:

- If INVOKER is set, the access rights for executing the call to an executable object are determined by checking the current user’s active set of privileges
- If DEFINER is set, the access rights of the object owner will be applied instead, regardless of the current user’s active set of privileges.
Chapter 14. Management Statements

Since Firebird 3.0 a new class of DSQL statement has emerged in Firebird’s SQL lexicon, usually for administering aspects of the client/server environment. Typically, such statements start with the verb SET.

The isql tool also has a collection of SET commands. Those commands are not part of Firebird’s SQL lexicon. For information on isql’s SET commands, see Isql Set Commands in Firebird Interactive SQL Utility.

Management statements can run anywhere DSQL can run but, typically, the developer will want to run a management statement in a database trigger. In past releases, management statements were treated in PSQL like DDL, precluding them from running directly inside a PSQL module. From Firebird 4.0 forward, a pre-determined set of them can be used directly in PSQL modules without the need to wrap them in an EXECUTE STATEMENT block. For more details of the current set, see Management Statements in PSQL in the PSQL chapter.

Most of the management statements affect the current connection (attachment, or “session”) only, and do not require any authorization over and above the login privileges of the current user without elevated privileges.

Some management statements operate beyond the scope of the current session. Examples are the ALTER DATABASE {BEGIN | END} BACKUP statements to control nBackup, or the ALTER EXTERNAL CONNECTIONS POOL statements introduced in Firebird 4.0 to manage connection pooling. A new set of system privileges, analogous with SQL privileges granted for database objects, is provided to enable the required authority to run a specific management statement in this category.

Some statements of this class use the verb ALTER, although management statements should not be confused with DDL ALTER statements that modify database objects like tables, views, procedures, roles, et al.

Although some ALTER DATABASE clauses (BEGIN BACKUP) can be considered as management statements, they are documented in the DDL chapter.

14.1. Data Type Behaviour

14.1.1. SET BIND (Data Type Coercion Rules)

Used for
Configuring data type coercion rules

Available in
DSQL, PSQL
SET BIND OF <type_from> TO <type_to>

Syntax

```
<type_from> ::=  
    <scalar_datatype>  
    | <blob_datatype>  
    | TIME ZONE  
    | VARCHAR | {CHARACTER | CHAR} VARYING

<type_to> ::=  
    <scalar_datatype>  
    | <blob_datatype>  
    | VARCHAR | {CHARACTER | CHAR} VARYING  
    | LEGACY | NATIVE | EXTENDED  
    | EXTENDED TIME WITH TIME ZONE  
    | EXTENDED TIMESTAMP WITH TIME ZONE

<scalar_datatype> ::=  
    !! See Scalar Data Types Syntax !!

<blob_datatype> ::=  
    !! See BLOB Data Types Syntax !!
```

SET BIND configures data type coercion rules for the current session. This statement makes it possible to substitute one data type with another when performing client-server interactions. In other words, `type_from` returned by the engine is represented as `type_to` in the client API.

Only fields returned by the database engine in regular messages are substituted according to these rules. Variables returned as an array slice are not affected by the SET BIND statement.

When an incomplete type definition is used (i.e. simply CHAR instead of CHAR(n)) in `from_type`, the coercion is performed for all CHAR columns. The special incomplete type TIME ZONE stands for TIME WITH TIME ZONE and TIMESTAMP WITH TIME ZONE. When an incomplete type definition is used in `to_type`, the engine defines missing details about that type automatically based on source column.

Changing the binding of any NUMERIC or DECIMAL data type does not affect the underlying integer type. In contrast, changing the binding of an integer data type also affects appropriate NUMERICs/DECIMALs (e.g. SET BIND OF INT128 TO DOUBLE PRECISION will also map NUMERIC and DECIMAL with precision greater than 19 as these types use INT128 as their underlying type).

The special type LEGACY is used when a data type, missing in previous Firebird version, should be represented in a way, understandable by old client software (possibly with some data loss). The coercion rules applied in this case are shown in the table below.

*Table 264. Native to LEGACY coercion rules*
<table>
<thead>
<tr>
<th>Native data type</th>
<th>Legacy data type</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOOLEAN</td>
<td>CHAR(5)</td>
</tr>
<tr>
<td>DECFLOAT</td>
<td>DOUBLE PRECISION</td>
</tr>
<tr>
<td>INT128</td>
<td>BIGINT</td>
</tr>
<tr>
<td>TIME WITH TIME ZONE</td>
<td>TIME WITHOUT TIME ZONE</td>
</tr>
<tr>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>TIMESTAMP WITHOUT TIME ZONE</td>
</tr>
</tbody>
</table>

Using **EXTENDED** for `type_to` causes the engine to coerce to an extended form of the `type_from` data type. Currently, this works only for `TIME/TIMESTAMP WITH TIME ZONE`, they are coerced to `EXTENDED TIME/TIMESTAMP WITH TIME ZONE`. The `EXTENDED` type contains both the time zone name, and the corresponding GMT offset, so it remains usable if the client application cannot process named time zones properly (e.g. due to the missing ICU library).

Setting a binding to **NATIVE** resets the existing coercion rule for this data type and returns it in its native format.

The initial bind rules of a connection be configured through the DPB by providing a semi-colon separated list of `<type_from> TO <type_to>` options as the string value of `isc_dpb_set_bind`.

Execution of **ALTER SESSION RESET** will revert to the binding rules configured through the DPB, or otherwise the system default.

It is also possible to configure a default set of data type coercion rules for all clients through the `DataTypeCompatibility` configuration option, either as a global configuration in `firebird.conf` or per database in `databases.conf`.

`DataTypeCompatibility` currently has two possible values: 3.0 and 2.5. The 3.0 option maps data types introduced after Firebird 3.0—in particular `DECIMAL /NUMERIC` with precision 19 or higher, `DECFLOAT`, `TIME/TIMESTAMP WITH TIME ZONE`—to data types supported in Firebird 3.0. The 2.5 option also converts the `BOOLEAN` data type.

See the **Native to LEGACY coercion rules** for details. This setting allows legacy client applications to work with Firebird 4.0 without recompiling or otherwise adjusting them to understand the new data types.
-- native
SELECT CAST('123.45' AS DECFLOAT(16)) FROM RDB$DATABASE;

CAST
=======================
123.45

-- double
SET BIND OF DECFLOAT TO DOUBLE PRECISION;
SELECT CAST('123.45' AS DECFLOAT(16)) FROM RDB$DATABASE;

CAST
=======================
123.4500000000000

-- still double
SET BIND OF DECFLOAT(34) TO CHAR;
SELECT CAST('123.45' AS DECFLOAT(16)) FROM RDB$DATABASE;

CAST
=======================
123.4500000000000

-- text
SELECT CAST('123.45' AS DECFLOAT(34)) FROM RDB$DATABASE;

CAST
==========================================
123.45

In the case of missing ICU on the client side:

SELECT CURRENT_TIMESTAMP FROM RDB$DATABASE;

CURRENT_TIMESTAMP
========================================================
2020-02-21 16:26:48.0230 GMT*

SET BIND OF TIME ZONE TO EXTENDED;
SELECT CURRENT_TIMESTAMP FROM RDB$DATABASE;

CURRENT_TIMESTAMP
========================================================
2020-02-21 19:26:55.6820 +03:00

14.1.2. SET DECFLOAT

Used for
Configuring DECFLOAT rounding and error behaviour

*Available in*

DSQL, PSQL

**Syntax**

```
SET DECFLOAT
{ ROUND <round_mode>
| TRAPS TO [ (<trap_opt> [, <trap_opt> ...]) ] }
```

```
<round_mode> ::= 
  CEILING | UP | HALF_UP | HALF_EVEN 
  | HALF_DOWN | DOWN | FLOOR | REROUND
```

```
<trap_opt> ::= 
  DIVISION_BY ZERO | INEXACT | INVALID_OPERATION 
  | OVERFLOW | UNDERFLOW
```

SET DECFLOAT configures the rounding and error behaviour of operations on DECFLOAT types in the current session.

### 14.1.3. SET DECFLOAT ROUND

SET DECFLOAT ROUND changes the rounding behaviour of operations on DECFLOAT. The default rounding mode is **HALF_UP**. The initial configuration of a connection can also be specified using the DPB tag `isc_dpb_decfloat_round` with the desired `round_mode` as string value.

The valid rounding modes are:

- **CEILING**: towards +infinity
- **UP**: away from 0
- **HALF_UP**: to nearest, if equidistant, then up (default)
- **HALF_EVEN**: to nearest, if equidistant, ensure last digit in the result will be even
- **HALF_DOWN**: to nearest, if equidistant, then down
- **DOWN**: towards 0
- **FLOOR**: towards -infinity
- **REROUND**: up if digit to be rounded is 0 or 5, down in other cases

Execution of **ALTER SESSION RESET** will revert to the value configured through the DPB, or otherwise
14.1.4. SET DECFLOAT TRAPS

SET DECFLOAT TRAPS changes the error behaviour of operations on DECFLOAT. The default traps are DIVISION_BY_ZERO, INVALID_OPERATION, OVERFLOW; this default matches the behaviour specified in the SQL:2016 standard for DECFLOAT. This statement controls whether certain exceptional conditions result in an error (“trap”) or alternative handling (for example, an underflow returns 0 when not set, or an overflow returns an infinity). The initial configuration of a connection can also be specified using the DPB tag isc_dpb_decfloat_traps with the desired comma-separated trap_opt values as a string value.

Valid trap options (exceptional conditions) are:

- **Division_by_zero** (set by default)
- **Inexact**
- **Invalid_operation** (set by default)
- **Overflow** (set by default)
- **Underflow**

Execution of `ALTER SESSION RESET` will revert to the value configured through the DPB, or otherwise the system default.

14.2. Connections Pool Management

Management statements to manage the external connections pool.

14.2.1. ALTER EXTERNAL CONNECTIONS POOL

*Used for*

Managing the external connections pool

*Available in*

DSQL
Syntax

```
ALTER EXTERNAL CONNECTIONS POOL
{ CLEAR ALL
  | CLEAR OLDEST
  | SET LIFETIME lifetime <time-unit>
  | SET SIZE size }

<time-unit> ::= SECOND | MINUTE | HOUR
```

Table 265. ALTER EXTERNAL CONNECTIONS POOL Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>lifetime</td>
<td>Maximum lifetime of a connection in the pool. Minimum values is 1 SECOND, maximum is 24 HOUR.</td>
</tr>
<tr>
<td>size</td>
<td>Maximum size of the connection pool. Range 0 - 1000. Setting to 0 disables the external connections pool.</td>
</tr>
</tbody>
</table>

When prepared it is described like a DDL statement but its effect is immediate — it is executed immediately and completely, without waiting for transaction commit.

The statements can be issued from any connection, and changes are applied to the in-memory instance of the pool in the current Firebird process. If the process is a Classic one, a change submitted there does not affect other Classic processes.

Changes made with ALTER EXTERNAL CONNECTIONS POOL are not persistent: after a restart, Firebird will use the pool settings configured in firebird.conf by ExtConnPoolSize and ExtConnPoolLifeTime.

**Clauses of ALTER EXTERNAL CONNECTIONS POOL**

**CLEAR ALL**

Closes all idle connections and disassociates currently active connections so they are immediately closed when unused.

**CLEAR OLDEST**

Closes expired connections

**SET LIFETIME**

Configures the maximum lifetime of an idle connection in the pool. The default value (in seconds) is set using the parameter ExtConnPoolLifetime in firebird.conf.

**SET SIZE**

Configures the maximum number of idle connections in the pool. The default value is set using the parameter ExtConnPoolSize in firebird.conf.

**How the Connection Pool Works**

Every successful connection is associated with a pool, which maintains two lists — one for idle connections and one for active connections. When a connection in the “active” list has no active
requests and no active transactions, it is assumed to be “unused”. A reset of the unused connection is attempted using an ALTER SESSION RESET statement and,

- if the reset succeeds (no errors occur) the connection is moved into the “idle” list;
- if the reset fails, the connection is closed;
- if the pool has reached its maximum size, the oldest idle connection is closed.
- When the lifetime of an idle connection expires, it is deleted from the pool and closed.

New Connections

When the engine is asked to create a new external connection, the pool first looks for a candidate in the “idle” list. The search, which is case-sensitive, involves four parameters:

1. connection string
2. username
3. password
4. role

If suitable connection is found, it is tested to check that it is still alive.

- If it fails the check, it is deleted, and the search is repeated, without reporting any error to the client
- Otherwise, the live connection is moved from the “idle” list to the “active” list and returned to the caller
- If there are multiple suitable connections, the most recently used one is chosen
- If there is no suitable connection, a new one is created and added to the “active” list.

Who Can Alter the External Connections Pool

The ALTER EXTERNAL CONNECTIONS POOL statement can be executed by:

- Administrators
- Users with the MODIFY_EXT_CONN_POOL privilege

See also
RDB$GET_CONTEXT

14.3. Changing the Current Role

14.3.1. SET ROLE

Used for
Changing the role of the current session

Available in
DSQL
Syntax

\[
\text{SET ROLE} \ {\text{role\_name} | \ \text{NONE}}
\]

Table 266. SET ROLE Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>role_name</td>
<td>The name of the role to apply</td>
</tr>
</tbody>
</table>

The SET ROLE statement allows a user to assume a different role; it sets the CURRENT\_ROLE context variable to \textit{role\_name}, if that role has been granted to the CURRENT\_USER. For this session, the user receives the privileges granted by that role. Any rights granted to the previous role are removed from the session. Use NONE instead of \textit{role\_name} to clear the CURRENT\_ROLE.

When the specified role does not exist or has not been explicitly granted to the user, the error “\textit{Role role\_name is invalid or unavailable}” is raised.

SET ROLE Examples

1. Change the current role to MANAGER

\[
\begin{align*}
\text{SET ROLE} & \ \text{manager;} \\
\text{select current\_role from rdb\$database;} \\
\text{ROLE} & \\
\text{=======================} \\
\text{MANAGER}
\end{align*}
\]

2. Clear the current role

\[
\begin{align*}
\text{SET ROLE} & \ \text{NONE;} \\
\text{select current\_role from rdb\$database;} \\
\text{ROLE} & \\
\text{=======================} \\
\text{NONE}
\end{align*}
\]

See also

SET TRUSTED ROLE, GRANT

14.3.2. SET TRUSTED ROLE

Used for
Changes role of the current session to the trusted role

Available in
DSQL

Syntax

```sql
SET TRUSTED ROLE
```

The `SET TRUSTED ROLE` statement makes it possible to assume the role assigned to the user through a mapping rule (see Mapping of Users to Objects). The role assigned through a mapping rule is assumed automatically on connect, if the user hasn’t specified an explicit role. The `SET TRUSTED ROLE` statement makes it possible to assume the mapped (or “trusted”) role at a later time, or to assume it again after the current role was changed using `SET ROLE`.

A trusted role is not a specific type of role, but can be any role that was created using `CREATE ROLE`, or a predefined system role such as `RDB$ADMIN`. An attachment (session) has a trusted role when the security objects mapping subsystem finds a match between the authentication result passed from the plugin and a local or global mapping to a role for the current database. The role may be one that is not granted explicitly to that user.

When a session has no trusted role, executing `SET TRUSTED ROLE` will raise error “Your attachment has no trusted role”.

While the `CURRENT_ROLE` can be changed using `SET ROLE`, it is not always possible to revert to a trusted role using the same command, because `SET ROLE` checks if the role has been granted to the user. With `SET TRUSTED ROLE`, the trusted role can be assumed again even when `SET ROLE` fails.

`SET TRUSTED ROLE` Examples

1. Assuming a mapping rule that assigns the role `ROLE1` to a user `ALEX`:
CONNECT 'employee' USER ALEX PASSWORD 'password';
SELECT CURRENT_ROLE FROM RDB$DATABASE;

ROLE
===============================
ROLE1

SET ROLE ROLE2;
SELECT CURRENT_ROLE FROM RDB$DATABASE;

ROLE
===============================
ROLE2

SET TRUSTED ROLE;
SELECT CURRENT_ROLE FROM RDB$DATABASE;

ROLE
===============================
ROLE1

See also
SET ROLE, Mapping of Users to Objects

14.4. Session Timeouts

Statements for management of timeouts of the current connection.

14.4.1. SET SESSION IDLE TIMEOUT

Used for
Changing the session idle timeout

Available in
DSQL, PSQL

Syntax

SET SESSION IDLE TIMEOUT value [<time-unit>]

<time-unit> ::= MINUTE | HOUR | SECOND

Table 267. SET SESSION IDLE TIMEOUT Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>The timeout duration expressed in time-unit. A value of 0 defers to connection idle timeout configured for the database.</td>
</tr>
</tbody>
</table>
### Parameter Description

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>time-unit</td>
<td>Time unit of the timeout. Defaults to MINUTE.</td>
</tr>
</tbody>
</table>

The `SET SESSION IDLE TIMEOUT` sets an idle timeout at connection level and takes effect immediately. The statement can run outside transaction control (without an active transaction).

Setting a value larger than configured for the database is allowed, but is effectively ignored, see also *Determining the Timeout that is In Effect.*

The current timeout set for the session can be retrieved through `RDB$GET_CONTEXT`, namespace SYSTEM and variable `SESSION_IDLE_TIMEOUT`. Information is also available from `MON$ATTACHMENTS`:

- **MON$IDLE_TIMEOUT**
  - Connection-level idle timeout in seconds; 0 if timeout is not set.

- **MON$IDLE_TIMER**
  - Idle timer expiration time; contains NULL if an idle timeout was not set, or if a timer is not running.

Both `RDB$GET_CONTEXT('SYSTEM', 'SESSION_IDLE_TIMEOUT')` and `MON$ATTACHMENTS.MON$IDLE_TIMEOUT` report the idle timeout configured for the connection; they do not report the effective idle timeout.

The session idle timeout is reset when `ALTER SESSION RESET` is executed.

### Idle Session Timeouts

An idle session timeout allows a user connection to close automatically after a specified period of inactivity. A database administrator can use it to enforce closure of old connections that have become inactive, to reduce unnecessary consumption of resources. It can also be used by application and tools developers as an alternative to writing their own modules for controlling connection lifetime.

By default, the idle timeout is not enabled. No minimum or maximum limit is imposed, but a reasonably large period — such as a few hours — is recommended.

### How the Idle Session Timeout Works

- When the user API call leaves the engine (returns to the calling connection) a special idle timer associated with the current connection is started.
- When another user API call from that connection enters the engine, the idle timer is stopped and reset to zero.
- If the maximum idle time is exceeded, the engine immediately closes the connection in the same way as with asynchronous connection cancellation:
  - all active statements and cursors are closed
  - all active transactions are rolled back
  - The network connection remains open at this point, allowing the client application to get the exact error code on the next API call. The network connection will be closed on the server.
side, after an error is reported or in due course as a result of a network timeout from a client-side disconnection.

Whenever a connection is cancelled, the next user API call returns the error `isc_att_shutdown` with a secondary error specifying the exact reason. Now, we have

- `isc_att_shut_idle`
  - Idle timeout expired
- `isc_att_shut_killed`
  - Killed by database administrator
- `isc_att_shut_db_down`
  - Database is shut down
- `isc_att_shut_engine`
  - Engine is shut down

### Setting the Idle Session Timeout

The idle timer will not start if the timeout period is set to zero.

An idle session timeout can be set:

- At database level, the database administrator can set the configuration parameter `ConnectionIdleTimeout`, an integer value **in minutes**. The default value of zero means no timeout is set. It is configurable per-database, so it may be set globally in `firebird.conf` and overridden for individual databases in `databases.conf` as required.

  The scope of this method is all user connections, except system connections (garbage collector, cache writer, etc.).

- at connection level, the idle session timeout is supported by both the `SET SESSION IDLE TIMEOUT` statement and the API (`setIdleTimeout`). The scope of this method is specific to the supplied connection (attachment). Its value in the API is **in seconds**. In the SQL syntax it can be hours, minutes or seconds. Scope for this method is the connection to which it is applied.

  For more information about the API calls, consult the *Firebird 4.0 Release Notes*.

### Determining the Timeout that is In Effect

The effective idle timeout value is determined whenever a user API call leaves the engine, checking first at connection level and then at database level. A connection-level timeout can override the value of a database-level setting, as long as the period of time for the connection-level setting is no longer than any non-zero timeout that is applicable at database level.
Take note of the difference between the time units at each level. At database level, in the configuration files, the unit for `SessionTimeout` is minutes. In SQL, the default unit is minutes but can be expressed in hours or seconds explicitly. At the API level, the unit is seconds.

Absolute precision is not guaranteed in any case, especially when the system load is high, but timeouts are guaranteed not to expire earlier than the moment specified.

### 14.4.2. SET STATEMENT TIMEOUT

*Used for*

Changing the statement timeout for a connection

*Available in*

DSQL, PSQL

*Syntax*

```
SET STATEMENT TIMEOUT value [<time-unit>]
```

<time-unit> ::= SECOND | MILLISECOND | MINUTE | HOUR

*Table 268. SET STATEMENT TIMEOUT Statement Parameters*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>The timeout duration expressed in <code>time-unit</code>. A value of 0 defers to statement timeout configured for the database.</td>
</tr>
<tr>
<td>time-unit</td>
<td>Time unit of the timeout. Defaults to SECOND.</td>
</tr>
</tbody>
</table>

The `SET SESSION IDLE TIMEOUT` sets an idle timeout at connection level and takes effect immediately. The statement can run outside transaction control (without an active transaction).

Setting a value larger than configured for the database is allowed, but is effectively ignored, see also *Determining the Statement Timeout that is In Effect*.

The current statement timeout set for the session can be retrieved through `RDB$GET_CONTEXT`, namespace `SYSTEM` and variable `STATEMENT_TIMEOUT`. Information is also available from `MON$ATTACHMENTS`:

**MON$STATEMENT_TIMEOUT**

Connection-level statement timeout in milliseconds; 0 if timeout is not set.

In **MON$STATEMENTS**:

**MON$STATEMENT_TIMEOUT**

Statement-level statement timeout in milliseconds; 0 if timeout is not set.
Statement Timers

Timeout timer expiration time; contains NULL if an idle timeout was not set, or if a timer is not running.

Both RDB$GET_CONTEXT('SYSTEM', 'SESSION_IDLE_TIMEOUT') and MON$ATTACHMENTS.MON$IDLE_TIMEOUT report the idle timeout configured for the connection, and MON$STATEMENTS$STATEMENT_TIMEOUT for the statement; they do not report the effective statement timeout.

The statement timeout is reset when ALTER SESSION RESET is executed.

Statement Timeouts

The statement timeout feature allows execution of a statement to be stopped automatically when it has been running longer than a given timeout period. It gives the database administrator an instrument for limiting excessive resource consumption from heavy queries.

Statement timeouts can also be useful to application developers when creating and debugging complex queries without advance knowledge of execution time. Testers and others could find them handy for detecting long-running queries and establishing finite run times for test suites.

How the Statement Timeout Works

When the statement starts execution, or a cursor is opened, the engine starts a special timer. It is stopped when the statement completes execution, or the last record has been fetched by the cursor.

A fetch does not reset this timer.

When the timeout point is reached:

- if statement execution is active, it stops at closest possible moment
- if statement is not active currently (between fetches, for example), it is marked as cancelled, and the next fetch will actually break execution and return an error

Statement types excluded from timeouts

Statement timeouts are not applicable to some types of statement and will simply be ignored:

- All DDL statements
- All internal queries issued by the engine itself

Setting a Statement Timeout

The timer will not start if the timeout period is set to zero.

A statement timeout can be set:

- at database level, by the database administrator, by setting the configuration parameter StatementTimeout in firebird.conf or databases.conf. StatementTimeout is an integer representing the number of seconds after which statement execution will be cancelled automatically by the
engine. Zero means no timeout is set. A non-zero setting will affect all statements in all connections.

- at connection level, using SET STATEMENT TIMEOUT or the API for setting a statement timeout (setStatementTimeout). A connection-level setting (via SQL or the API) affects all statements for the given connection; units for the timeout period at this level can be specified to any granularity from hours to milliseconds.

- at statement level, using the API, in milliseconds

**Determining the Statement Timeout that is In Effect**

The statement timeout value that is in effect is determined whenever a statement starts executing, or a cursor is opened. In searching out the timeout in effect, the engine goes up through the levels, from statement through to database and/or global levels until it finds a non-zero value. If the value in effect turns out to be zero then no statement timer is running and no timeout applies.

A statement-level or connection-level timeout can override the value of a database-level setting, as long as the period of time for the lower-level setting is no longer than any non-zero timeout that is applicable at database level.

Take note of the difference between the time units at each level. At database level, in the conf file, the unit for StatementTimeout is seconds. In SQL, the default unit is seconds but can be expressed in hours, minutes or milliseconds explicitly. At the API level, the unit is milliseconds.

Absolute precision is not guaranteed in any case, especially when the system load is high, but timeouts are guaranteed not to expire earlier than the moment specified.

Whenever a statement times out and is cancelled, the next user API call returns the error isc_cancelled with a secondary error specifying the exact reason, viz.,

- **isc_cfg_stmt_timeout**
  - Config level timeout expired

- **isc_att_stmt_timeout**
  - Attachment level timeout expired

- **isc_req_stmt_timeout**
  - Statement level timeout expired
Notes about Statement Timeouts

1. A client application could wait longer than the time set by the timeout value if the engine needs to undo a large number of actions as a result of the statement cancellation.

2. When the engine runs an `EXECUTE STATEMENT` statement, it passes the remainder of the currently active timeout to the new statement. If the external (remote) engine does not support statement timeouts, the local engine silently ignores any corresponding error.

3. When the engine acquires some lock from the lock manager, it tries to lower the value of the lock timeout using the remainder of the currently active statement timeout, if possible. Due to lock manager internals, any statement timeout remainder will be rounded up to whole seconds.

14.5. Time Zone Management

Statements for management of time zone features of the current connections.

14.5.1. `SET TIME ZONE`

*Used for*

Changing the session time zone

*Available in*

DSQL, PSQL

*Syntax*

```
SET TIME ZONE { time_zone_string | LOCAL }
```

Changes the session time zone to the specified time zone. Specifying `LOCAL` will revert to initial session time zone of the session (either the default or as specified through connection property `isc_dpb_session_time_zone`).

Executing `ALTER SESSION RESET` has the same effect on the session time zone as `SET TIME ZONE LOCAL`, but will also reset other session properties.

**SET TIME ZONE Examples**

```
set time zone '-02:00';
set time zone 'America/Sao_Paulo';
set time zone local;
```

14.6. Reset Session State
14.6.1. ALTER SESSION RESET

Used for
Resetting session state to its initial values

Available in
DSQL, PSQL

Syntax

ALTER SESSION RESET

ALTER SESSION RESET resets the current user session to its initial state. It can be useful for reusing the connection by a client application (for example, by a client-side connection pool). When this statement is executed, all user context variables are cleared, contents of global temporary tables are cleared, and all session-level settings are reset to their initial values.

It is possible to execute ALTER SESSION RESET without a transaction.

Execution of ALTER SESSION RESET performs the following steps:

- Error isc_ses_reset_err (335545206) is raised if any transaction is active in the current session other than the current transaction (the one executing ALTER SESSION RESET) and two-phase transactions in the prepared state.
- System variable RESETTING is set to TRUE.
- ON DISCONNECT database triggers are fired, if present and if database triggers are not disabled for the current connection.
- The current transaction (the one executing ALTER SESSION RESET), if present, is rolled back. A warning is reported if this transaction modified data before resetting the session.
- Session configuration is reset to their initial values. This includes, but is not limited to:
  - DECFLOAT parameters (TRAP and ROUND) and reset to the initial values defined using the DPB at connect time, or otherwise the system default.
  - Session and statement timeouts are reset to zero.
  - The current role is restored to the initial value defined using DPB at connect time, and — if the role changed — the security classes cache is cleared.
  - The session time zone is reset to the initial value defined using the DPB at connect time, or otherwise the system default.
  - The bind configuration is reset to the initial value defined using the DPB at connect time, or otherwise the database or system default.
  - In general, configuration values should revert to the values configured using DPB at connect time, or otherwise the database or system default.
- Context variables defined for the USER_SESSION namespace are removed.
- Global temporary tables defined as ON COMMIT PRESERVE ROWS are truncated (their contents is cleared).
• ON CONNECT database triggers are fired, if present and if database triggers are not disabled for the current connection.

• A new transaction is implicitly started with the same parameters as the transaction that was rolled back (if there was a transaction)

• System variable RESETTING is set to FALSE.

  • The context variables CURRENT_USER and CURRENT_CONNECTION will not be changed.
  • As isql starts multiple transactions for a single connection, ALTER SESSION RESET cannot be executed in isql.

Error Handling

Any error raised by ON DISCONNECT triggers aborts the session reset and leave the session state unchanged. Such errors are reported using primary error code isc_session_reset_err (335545206) and error text “Cannot reset user session”.

Any error raised after ON DISCONNECT triggers (including the ones raised by ON CONNECT triggers) aborts both the session reset and the connection itself. Such errors are reported using primary error code isc_ses_reset_failed (335545272) and error text “Reset of user session failed. Connection is shut down.”. Subsequent operations on the connection (except detach) will fail with error isc_att_shutdown (335544856).
Appendix A: Supplementary Information

In this Appendix are topics that developers may wish to refer to, to enhance understanding of features or changes.

The RDB$VALID_BLR Field

The field RDB$VALID_BLR was added to the system tables RDB$PROCEDURES and RDB$TRIGGERS in Firebird 2.1. Its purpose is to signal possible invalidation of a PSQL module after alteration of a domain or table column on which the module depends. RDB$VALID_BLR is set to 0 for any procedure or trigger whose code is made invalid by such a change.

How Invalidation Works

In triggers and procedures, dependencies arise on the definitions of table columns accessed and also on any parameter or variable that has been defined in the module using the TYPE OF clause.

After the engine has altered any domain, including the implicit domains created internally behind column definitions and output parameters, the engine internally recompiles all of its dependencies.

In v2.x these comprise procedures and triggers but not blocks coded in DML statements for run-time execution with EXECUTE BLOCK. Firebird 3 will encompass more module types (stored functions, packages).

Any module that fails to recompile because of an incompatibility arising from a domain change is marked as invalid (“invalidated” by setting the RDB$VALID_BLR in its system record (in RDB$PROCEDURES or RDB$TRIGGERS, as appropriate) to zero.

Revalidation (setting RDB$VALID_BLR to 1) occurs when

1. the domain is altered again and the new definition is compatible with the previously invalidated module definition; OR
2. the previously invalidated module is altered to match the new domain definition

The following query will find the modules that depend on a specific domain and report the state of their RDB$VALID_BLR fields:
The following query will find the modules that depend on a specific table column and report the state of their RDB$VALID_BLR fields:

```sql
SELECT * FROM (  
SELECT  
    'Procedure',  
    rdb$procedure_name,  
    rdb$valid_blr  
FROM rdb$procedures  
UNION ALL  
SELECT  
    'Trigger',  
    rdb$trigger_name,  
    rdb$valid_blr  
FROM rdb$triggers  
) (type, name, valid)  
WHERE EXISTS  
(SELECT * from rdb$dependencies  
    WHERE rdb$dependent_name = name  
    AND rdb$depended_on_name = 'MYDOMAIN')  
/* Replace MYDOMAIN with the actual domain name.  
   Use all-caps if the domain was created  
   case-insensitively. Otherwise, use the exact  
   capitalisation. */
```
All PSQL invalidations caused by domain/column changes are reflected in the RDB$VALID_BLR field. However, other kinds of changes, such as the number of input or output parameters, called routines and so on, do not affect the validation field even though they potentially invalidate the module. A typical such scenario might be one of the following:

1. A procedure (B) is defined, that calls another procedure (A) and reads output parameters from it. In this case, a dependency is registered in RDB$DEPENDENCIES. Subsequently, the called procedure (A) is altered to change or remove one or more of those output parameters. The ALTER PROCEDURE A statement will fail with an error when commit is attempted.

2. A procedure (B) calls procedure A, supplying values for its input parameters. No dependency is registered in RDB$DEPENDENCIES. Subsequent modification of the input parameters in procedure A will be allowed. Failure will occur at runtime, when B calls A with the mismatched input parameter set.

**Other Notes**

- For PSQL modules inherited from earlier Firebird versions (including a number of system triggers, even if the database was created under Firebird 2.1 or higher), RDB$VALID_BLR is NULL. This does not imply that their BLR is invalid.

- The `isql` commands `SHOW PROCEDURES` and `SHOW TRIGGERS` display an asterisk in the RDB$VALID_BLR column for any module for which the value is zero (i.e., invalid). However, `SHOW PROCEDURE <proname>` and `SHOW TRIGGER <trigname>`, which display individual PSQL modules, do not signal invalid BLR at all.

**A Note on Equality**

This note about equality and inequality operators applies everywhere in Firebird’s SQL language.

The “=” operator, which is explicitly used in many conditions, only matches values to values. According to the SQL standard, NULL is not a value and hence two NULLs are neither equal nor unequal to one another. If you need NULLs to match each other in a condition, use the IS NOT DISTINCT FROM operator. This operator returns true if the operands have the same value or if they are both NULL.

```sql
select *
from A join B
on A.id is not distinct from B.code
```

Likewise, in cases where you want to test against NULL for a condition of inequality, use IS DISTINCT FROM, not “<>”. If you want NULL to be considered different from any value and two NULLs to be considered equal:
select *
from A join B
on A.id is distinct from B.code
Appendix B: Exception Codes and Messages

This appendix includes:

- SQLSTATE Error Codes and Descriptions
- GDSCODE Error Codes, SQLCODEs and Descriptions

Custom Exceptions

Firebird DDL provides a simple syntax for creating custom exceptions for use in PSQL modules, with message text of up to 1,021 characters. For more information, see CREATE EXCEPTION in DDL Statements and, for usage, the statement EXCEPTION in PSQL Statements.

The Firebird SQLCODE error codes do not correlate with the standards-compliant SQLSTATE codes. SQLCODE has been used for many years and should be considered as deprecated now. Support for SQLCODE is likely to be dropped in a future version.

SQLSTATE Error Codes and Descriptions

This table provides the error codes and message texts for the SQLSTATE context variables.

The structure of an SQLSTATE error code is five characters comprising the SQL error class (2 characters) and the SQL subclass (3 characters).

Table 269. SQLSTATE Codes and Message Texts

<table>
<thead>
<tr>
<th>SQLSTATE</th>
<th>Mapped Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQLCLASS 00 (Success)</td>
<td></td>
</tr>
<tr>
<td>00000</td>
<td>Success</td>
</tr>
<tr>
<td>SQLCLASS 01 (Warning)</td>
<td></td>
</tr>
<tr>
<td>01000</td>
<td>General warning</td>
</tr>
<tr>
<td>01001</td>
<td>Cursor operation conflict</td>
</tr>
<tr>
<td>01002</td>
<td>Disconnect error</td>
</tr>
<tr>
<td>01003</td>
<td>NULL value eliminated in set function</td>
</tr>
<tr>
<td>01004</td>
<td>String data, right-truncated</td>
</tr>
<tr>
<td>01005</td>
<td>Insufficient item descriptor areas</td>
</tr>
<tr>
<td>01006</td>
<td>Privilege not revoked</td>
</tr>
<tr>
<td>01007</td>
<td>Privilege not granted</td>
</tr>
<tr>
<td>01008</td>
<td>Implicit zero-bit padding</td>
</tr>
<tr>
<td>01100</td>
<td>Statement reset to unprepared</td>
</tr>
<tr>
<td>01101</td>
<td>Ongoing transaction has been committed</td>
</tr>
<tr>
<td>SQLSTATE</td>
<td>Mapped Message</td>
</tr>
<tr>
<td>----------</td>
<td>----------------</td>
</tr>
<tr>
<td>01102</td>
<td>Ongoing transaction has been rolled back</td>
</tr>
<tr>
<td>02000</td>
<td>No data found or no rows affected</td>
</tr>
<tr>
<td>07000</td>
<td>Dynamic SQL error</td>
</tr>
<tr>
<td>07001</td>
<td>Wrong number of input parameters</td>
</tr>
<tr>
<td>07002</td>
<td>Wrong number of output parameters</td>
</tr>
<tr>
<td>07003</td>
<td>Cursor specification cannot be executed</td>
</tr>
<tr>
<td>07004</td>
<td>USING clause required for dynamic parameters</td>
</tr>
<tr>
<td>07005</td>
<td>Prepared statement not a cursor-specification</td>
</tr>
<tr>
<td>07006</td>
<td>Restricted data type attribute violation</td>
</tr>
<tr>
<td>07007</td>
<td>USING clause required for result fields</td>
</tr>
<tr>
<td>07008</td>
<td>Invalid descriptor count</td>
</tr>
<tr>
<td>07009</td>
<td>Invalid descriptor index</td>
</tr>
<tr>
<td>08001</td>
<td>Client unable to establish connection</td>
</tr>
<tr>
<td>08002</td>
<td>Connection name in use</td>
</tr>
<tr>
<td>08003</td>
<td>Connection does not exist</td>
</tr>
<tr>
<td>08004</td>
<td>Server rejected the connection</td>
</tr>
<tr>
<td>08006</td>
<td>Connection failure</td>
</tr>
<tr>
<td>08007</td>
<td>Transaction resolution unknown</td>
</tr>
<tr>
<td>0A000</td>
<td>Feature Not Supported</td>
</tr>
<tr>
<td>0B000</td>
<td>Invalid transaction initiation</td>
</tr>
<tr>
<td>0L000</td>
<td>Invalid grantor</td>
</tr>
<tr>
<td>0P000</td>
<td>Invalid role specification</td>
</tr>
<tr>
<td>0U000</td>
<td>Attempt to assign to non-updatable column</td>
</tr>
<tr>
<td>0V000</td>
<td>Attempt to assign to Ordering column</td>
</tr>
<tr>
<td>SQLSTATE</td>
<td>Mapped Message</td>
</tr>
<tr>
<td>----------</td>
<td>----------------</td>
</tr>
<tr>
<td>20000</td>
<td>Case not found for case statement</td>
</tr>
<tr>
<td>21000</td>
<td>Cardinality violation</td>
</tr>
<tr>
<td>21S01</td>
<td>Insert value list does not match column list</td>
</tr>
<tr>
<td>21S02</td>
<td>Degree of derived table does not match column list</td>
</tr>
<tr>
<td>22000</td>
<td>Data exception</td>
</tr>
<tr>
<td>22001</td>
<td>String data, right truncation</td>
</tr>
<tr>
<td>22002</td>
<td>Null value, no indicator parameter</td>
</tr>
<tr>
<td>22003</td>
<td>Numeric value out of range</td>
</tr>
<tr>
<td>22004</td>
<td>Null value not allowed</td>
</tr>
<tr>
<td>22005</td>
<td>Error in assignment</td>
</tr>
<tr>
<td>22006</td>
<td>Null value in field reference</td>
</tr>
<tr>
<td>22007</td>
<td>Invalid datetime format</td>
</tr>
<tr>
<td>22008</td>
<td>Datetime field overflow</td>
</tr>
<tr>
<td>22009</td>
<td>Invalid time zone displacement value</td>
</tr>
<tr>
<td>2200A</td>
<td>Null value in reference target</td>
</tr>
<tr>
<td>2200B</td>
<td>Escape character conflict</td>
</tr>
<tr>
<td>2200C</td>
<td>Invalid use of escape character</td>
</tr>
<tr>
<td>2200D</td>
<td>Invalid escape octet</td>
</tr>
<tr>
<td>2200E</td>
<td>Null value in array target</td>
</tr>
<tr>
<td>2200F</td>
<td>Zero-length character string</td>
</tr>
<tr>
<td>2200G</td>
<td>Most specific type mismatch</td>
</tr>
<tr>
<td>22010</td>
<td>Invalid indicator parameter value</td>
</tr>
<tr>
<td>22011</td>
<td>Substring error</td>
</tr>
<tr>
<td>22012</td>
<td>Division by zero</td>
</tr>
<tr>
<td>22014</td>
<td>Invalid update value</td>
</tr>
<tr>
<td>22015</td>
<td>Interval field overflow</td>
</tr>
<tr>
<td>22018</td>
<td>Invalid character value for cast</td>
</tr>
<tr>
<td>22019</td>
<td>Invalid escape character</td>
</tr>
<tr>
<td>2201B</td>
<td>Invalid regular expression</td>
</tr>
<tr>
<td>2201C</td>
<td>Null row not permitted in table</td>
</tr>
<tr>
<td>SQLSTATE</td>
<td>Mapped Message</td>
</tr>
<tr>
<td>----------</td>
<td>----------------</td>
</tr>
<tr>
<td>22012</td>
<td>Division by zero</td>
</tr>
<tr>
<td>22020</td>
<td>Invalid limit value</td>
</tr>
<tr>
<td>22021</td>
<td>Character not in repertoire</td>
</tr>
<tr>
<td>22022</td>
<td>Indicator overflow</td>
</tr>
<tr>
<td>22023</td>
<td>Invalid parameter value</td>
</tr>
<tr>
<td>22024</td>
<td>Character string not properly terminated</td>
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<tr>
<td>22025</td>
<td>Invalid escape sequence</td>
</tr>
<tr>
<td>22026</td>
<td>String data, length mismatch</td>
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<td>22027</td>
<td>Trim error</td>
</tr>
<tr>
<td>22028</td>
<td>Row already exists</td>
</tr>
<tr>
<td>2202D</td>
<td>Null instance used in mutator function</td>
</tr>
<tr>
<td>2202E</td>
<td>Array element error</td>
</tr>
<tr>
<td>2202F</td>
<td>Array data, right truncation</td>
</tr>
<tr>
<td>23000</td>
<td>Integrity constraint violation</td>
</tr>
<tr>
<td>24000</td>
<td>Invalid cursor state</td>
</tr>
<tr>
<td>24504</td>
<td>The cursor identified in the UPDATE, DELETE, SET, or GET statement is not positioned on a row</td>
</tr>
<tr>
<td>25000</td>
<td>Invalid transaction state</td>
</tr>
<tr>
<td>25S01</td>
<td>Transaction state</td>
</tr>
<tr>
<td>25S02</td>
<td>Transaction is still active</td>
</tr>
<tr>
<td>25S03</td>
<td>Transaction is rolled back</td>
</tr>
<tr>
<td>26000</td>
<td>Invalid SQL statement name</td>
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<td>27000</td>
<td>Triggered data change violation</td>
</tr>
<tr>
<td>28000</td>
<td>Invalid authorization specification</td>
</tr>
<tr>
<td>2B000</td>
<td>Dependent privilege descriptors still exist</td>
</tr>
<tr>
<td>2C000</td>
<td>Invalid character set name</td>
</tr>
<tr>
<td>SQLSTATE</td>
<td>Mapped Message</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>2D000</td>
<td>Invalid transaction termination</td>
</tr>
<tr>
<td>2E000</td>
<td>Invalid connection name</td>
</tr>
<tr>
<td>2F000</td>
<td>SQL routine exception</td>
</tr>
<tr>
<td>2F002</td>
<td>Modifying SQL-data not permitted</td>
</tr>
<tr>
<td>2F003</td>
<td>Prohibited SQL-statement attempted</td>
</tr>
<tr>
<td>2F004</td>
<td>Reading SQL-data not permitted</td>
</tr>
<tr>
<td>2F005</td>
<td>Function executed no return statement</td>
</tr>
<tr>
<td>33000</td>
<td>Invalid SQL descriptor name</td>
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<tr>
<td>34000</td>
<td>Invalid cursor name</td>
</tr>
<tr>
<td>35000</td>
<td>Invalid condition number</td>
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<td>Request rejected</td>
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<td>36002</td>
<td>Request failed</td>
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<td>Invalid identifier</td>
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<td>Identifier too long</td>
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<td>38000</td>
<td>External routine exception</td>
</tr>
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<td>39000</td>
<td>External routine invocation exception</td>
</tr>
<tr>
<td>3B000</td>
<td>Invalid save point</td>
</tr>
<tr>
<td>3C000</td>
<td>Ambiguous cursor name</td>
</tr>
<tr>
<td>3D000</td>
<td>Invalid catalog name</td>
</tr>
<tr>
<td>3D001</td>
<td>Catalog name not found</td>
</tr>
<tr>
<td>SQLSTATE</td>
<td>Mapped Message</td>
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<td>-------------------</td>
<td>-----------------------------------------------------</td>
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<tr>
<td>SQLCLASS 3F</td>
<td>Invalid Schema Name</td>
</tr>
<tr>
<td>3F000</td>
<td>Invalid schema name</td>
</tr>
<tr>
<td>SQLCLASS 40</td>
<td>Transaction Rollback</td>
</tr>
<tr>
<td>40000</td>
<td>Ongoing transaction has been rolled back</td>
</tr>
<tr>
<td>40001</td>
<td>Serialization failure</td>
</tr>
<tr>
<td>40002</td>
<td>Transaction integrity constraint violation</td>
</tr>
<tr>
<td>40003</td>
<td>Statement completion unknown</td>
</tr>
<tr>
<td>SQLCLASS 42</td>
<td>Syntax Error or Access Violation</td>
</tr>
<tr>
<td>42000</td>
<td>Syntax error or access violation</td>
</tr>
<tr>
<td>42702</td>
<td>Ambiguous column reference</td>
</tr>
<tr>
<td>42725</td>
<td>Ambiguous function reference</td>
</tr>
<tr>
<td>42818</td>
<td>The operands of an operator or function are not compatible</td>
</tr>
<tr>
<td>42S01</td>
<td>Base table or view already exists</td>
</tr>
<tr>
<td>42S02</td>
<td>Base table or view not found</td>
</tr>
<tr>
<td>42S11</td>
<td>Index already exists</td>
</tr>
<tr>
<td>42S12</td>
<td>Index not found</td>
</tr>
<tr>
<td>42S21</td>
<td>Column already exists</td>
</tr>
<tr>
<td>42S22</td>
<td>Column not found</td>
</tr>
<tr>
<td>SQLCLASS 44</td>
<td>With Check Option Violation</td>
</tr>
<tr>
<td>44000</td>
<td>WITH CHECK OPTION Violation</td>
</tr>
<tr>
<td>SQLCLASS 45</td>
<td>Unhandled User-defined Exception</td>
</tr>
<tr>
<td>45000</td>
<td>Unhandled user-defined exception</td>
</tr>
<tr>
<td>SQLCLASS 54</td>
<td>Program Limit Exceeded</td>
</tr>
<tr>
<td>54000</td>
<td>Program limit exceeded</td>
</tr>
<tr>
<td>54001</td>
<td>Statement too complex</td>
</tr>
<tr>
<td>54011</td>
<td>Too many columns</td>
</tr>
<tr>
<td>54023</td>
<td>Too many arguments</td>
</tr>
<tr>
<td>SQLCLASS HY</td>
<td>CLI-specific Condition</td>
</tr>
<tr>
<td>HY000</td>
<td>CLI-specific condition</td>
</tr>
<tr>
<td>HY001</td>
<td>Memory allocation error</td>
</tr>
<tr>
<td>HY003</td>
<td>Invalid data type in application descriptor</td>
</tr>
<tr>
<td>HY004</td>
<td>Invalid data type</td>
</tr>
<tr>
<td>HY007</td>
<td>Associated statement is not prepared</td>
</tr>
</tbody>
</table>
### Appendix B: Exception Codes and Messages

<table>
<thead>
<tr>
<th>SQLSTATE</th>
<th>Mapped Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>HY008</td>
<td>Operation canceled</td>
</tr>
<tr>
<td>HY009</td>
<td>Invalid use of null pointer</td>
</tr>
<tr>
<td>HY010</td>
<td>Function sequence error</td>
</tr>
<tr>
<td>HY011</td>
<td>Attribute cannot be set now</td>
</tr>
<tr>
<td>HY012</td>
<td>Invalid transaction operation code</td>
</tr>
<tr>
<td>HY013</td>
<td>Memory management error</td>
</tr>
<tr>
<td>HY014</td>
<td>Limit on the number of handles exceeded</td>
</tr>
<tr>
<td>HY015</td>
<td>No cursor name available</td>
</tr>
<tr>
<td>HY016</td>
<td>Cannot modify an implementation row descriptor</td>
</tr>
<tr>
<td>HY017</td>
<td>Invalid use of an automatically allocated descriptor handle</td>
</tr>
<tr>
<td>HY018</td>
<td>Server declined the cancellation request</td>
</tr>
<tr>
<td>HY019</td>
<td>Non-string data cannot be sent in pieces</td>
</tr>
<tr>
<td>HY020</td>
<td>Attempt to concatenate a null value</td>
</tr>
<tr>
<td>HY021</td>
<td>Inconsistent descriptor information</td>
</tr>
<tr>
<td>HY024</td>
<td>Invalid attribute value</td>
</tr>
<tr>
<td>HY055</td>
<td>Non-string data cannot be used with string routine</td>
</tr>
<tr>
<td>HY090</td>
<td>Invalid string length or buffer length</td>
</tr>
<tr>
<td>HY091</td>
<td>Invalid descriptor field identifier</td>
</tr>
<tr>
<td>HY092</td>
<td>Invalid attribute identifier</td>
</tr>
<tr>
<td>HY095</td>
<td>Invalid Function ID specified</td>
</tr>
<tr>
<td>HY096</td>
<td>Invalid information type</td>
</tr>
<tr>
<td>HY097</td>
<td>Column type out of range</td>
</tr>
<tr>
<td>HY098</td>
<td>Scope out of range</td>
</tr>
<tr>
<td>HY099</td>
<td>Nullable type out of range</td>
</tr>
<tr>
<td>HY100</td>
<td>Uniqueness option type out of range</td>
</tr>
<tr>
<td>HY101</td>
<td>Accuracy option type out of range</td>
</tr>
<tr>
<td>HY103</td>
<td>Invalid retrieval code</td>
</tr>
<tr>
<td>HY104</td>
<td>Invalid Length/Precision value</td>
</tr>
<tr>
<td>HY105</td>
<td>Invalid parameter type</td>
</tr>
<tr>
<td>HY106</td>
<td>Invalid fetch orientation</td>
</tr>
<tr>
<td>HY107</td>
<td>Row value out of range</td>
</tr>
<tr>
<td>HY109</td>
<td>Invalid cursor position</td>
</tr>
<tr>
<td>HY110</td>
<td>Invalid driver completion</td>
</tr>
</tbody>
</table>
### SQLSTATE

<table>
<thead>
<tr>
<th>SQLSTATE</th>
<th>Mapped Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>HY111</td>
<td>Invalid bookmark value</td>
</tr>
<tr>
<td>HYC00</td>
<td>Optional feature not implemented</td>
</tr>
<tr>
<td>HYT00</td>
<td>Timeout expired</td>
</tr>
<tr>
<td>HYT01</td>
<td>Connection timeout expired</td>
</tr>
</tbody>
</table>

### SQLCLASS XX (Internal Error)

<table>
<thead>
<tr>
<th>SQLCLASS</th>
<th>Error Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>XX000</td>
<td>Internal error</td>
</tr>
<tr>
<td>XX001</td>
<td>Data corrupted</td>
</tr>
<tr>
<td>XX002</td>
<td>Index corrupted</td>
</tr>
</tbody>
</table>

### SQLCODE and GDSCODE Error Codes and Descriptions

The table provides the SQLCODE groupings, the numeric and symbolic values for the GDSCODE errors and the message texts.

> SQLCODE has been used for many years and should be considered as deprecated now. Support for SQLCODE is likely to be dropped in a future version.

<table>
<thead>
<tr>
<th>SQLCODE</th>
<th>GDSCODE</th>
<th>Symbol</th>
<th>Message Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>501</td>
<td>335544802</td>
<td>dialect_reset_warning</td>
<td>Database dialect being changed from 3 to 1</td>
</tr>
<tr>
<td>304</td>
<td>335545266</td>
<td>truncate_warn</td>
<td>String truncated warning due to the following reason</td>
</tr>
<tr>
<td>304</td>
<td>335545267</td>
<td>truncate_monitor</td>
<td>Monitoring data does not fit into the field</td>
</tr>
<tr>
<td>304</td>
<td>335545268</td>
<td>truncate_context</td>
<td>Engine data does not fit into return value of system function</td>
</tr>
<tr>
<td>301</td>
<td>335544808</td>
<td>dtype_renamed</td>
<td>DATE data type is now called TIMESTAMP</td>
</tr>
<tr>
<td>301</td>
<td>336003076</td>
<td>dsql_dialect_warning_expr</td>
<td>Use of @1 expression that returns different results in dialect 1 and dialect 3</td>
</tr>
<tr>
<td>301</td>
<td>336003080</td>
<td>dsql_warning_number_ambiguous</td>
<td>WARNING: Numeric literal @1 is interpreted as a floating-point</td>
</tr>
<tr>
<td>301</td>
<td>336003081</td>
<td>dsql_warning_number_ambiguous</td>
<td>value in SQL dialect 1, but as an exact numeric value in SQL dialect 3.</td>
</tr>
</tbody>
</table>
Appendix B: Exception Codes and Messages

<table>
<thead>
<tr>
<th>SQL-CODE</th>
<th>GDSCODE</th>
<th>Symbol</th>
<th>Message Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>301</td>
<td>336003082</td>
<td>dsql_warn_precision_ambiguous</td>
<td>WARNING: NUMERIC and DECIMAL fields with precision 10 or greater are stored</td>
</tr>
<tr>
<td>301</td>
<td>336003083</td>
<td>dsql_warn_precision_ambiguous1</td>
<td>as approximate floating-point values in SQL dialect 1, but as 64-bit integers in SQL dialect 3.</td>
</tr>
<tr>
<td>301</td>
<td>336003084</td>
<td>dsql_warn_precision_ambiguous2</td>
<td>SQL warning code = @1</td>
</tr>
<tr>
<td>106</td>
<td>336068855</td>
<td>dyn_miss_priv_warning</td>
<td>Warning: @1 on @2 is not granted to @3.</td>
</tr>
<tr>
<td>101</td>
<td>33554366</td>
<td>segment</td>
<td>segment buffer length shorter than expected</td>
</tr>
<tr>
<td>100</td>
<td>33554338</td>
<td>from_no_match</td>
<td>no match for first value expression</td>
</tr>
<tr>
<td>100</td>
<td>33554354</td>
<td>no_record</td>
<td>invalid database key</td>
</tr>
<tr>
<td>100</td>
<td>33554367</td>
<td>segstr_eof</td>
<td>attempted retrieval of more segments than exist</td>
</tr>
<tr>
<td>0</td>
<td>335544875</td>
<td>bad_debug_format</td>
<td>Bad debug info format</td>
</tr>
<tr>
<td>0</td>
<td>33554931</td>
<td>montabexh</td>
<td>Monitoring table space exhausted</td>
</tr>
<tr>
<td>-84</td>
<td>33554554</td>
<td>nonsql_security_rel</td>
<td>object has non-SQL security class defined</td>
</tr>
<tr>
<td>-84</td>
<td>33554555</td>
<td>nonsql_security_fld</td>
<td>column has non-SQL security class defined</td>
</tr>
<tr>
<td>-84</td>
<td>33554668</td>
<td>dsql_procedure_use_err</td>
<td>procedure @1 does not return any values</td>
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<tr>
<td>-85</td>
<td>33554747</td>
<td>username_too_long</td>
<td>The username entered is too long. Maximum length is 31 bytes.</td>
</tr>
<tr>
<td>-85</td>
<td>33554748</td>
<td>password_too_long</td>
<td>The password specified is too long. Maximum length is 8 bytes.</td>
</tr>
<tr>
<td>-85</td>
<td>33554749</td>
<td>username_required</td>
<td>A username is required for this operation.</td>
</tr>
<tr>
<td>-85</td>
<td>33554750</td>
<td>password_required</td>
<td>A password is required for this operation.</td>
</tr>
<tr>
<td>-85</td>
<td>33554751</td>
<td>bad_protocol</td>
<td>The network protocol specified is invalid</td>
</tr>
<tr>
<td>-85</td>
<td>33554752</td>
<td>dup_usrename_found</td>
<td>A duplicate user name was found in the security database</td>
</tr>
<tr>
<td>-85</td>
<td>33554753</td>
<td>usrename_not_found</td>
<td>The user name specified was not found in the security database</td>
</tr>
<tr>
<td>SQL- CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
</tr>
<tr>
<td>----------</td>
<td>---------</td>
<td>-------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>-85</td>
<td>335544754</td>
<td>error_adding_sec_record</td>
<td>An error occurred while attempting to add the user.</td>
</tr>
<tr>
<td>-85</td>
<td>335544755</td>
<td>error_modifying_sec_record</td>
<td>An error occurred while attempting to modify the user record.</td>
</tr>
<tr>
<td>-85</td>
<td>335544756</td>
<td>error_deleting_sec_record</td>
<td>An error occurred while attempting to delete the user record.</td>
</tr>
<tr>
<td>-85</td>
<td>335544757</td>
<td>error_updating_sec_db</td>
<td>An error occurred while updating the security database.</td>
</tr>
<tr>
<td>-103</td>
<td>335544571</td>
<td>dsql_constant_err</td>
<td>Data type for constant unknown</td>
</tr>
<tr>
<td>-104</td>
<td>335544343</td>
<td>invalid_blr</td>
<td>invalid request BLR at offset @1</td>
</tr>
<tr>
<td>-104</td>
<td>335544390</td>
<td>syntaxerr</td>
<td>BLR syntax error: expected @1 at offset @2, encountered @3</td>
</tr>
<tr>
<td>-104</td>
<td>335544425</td>
<td>ctxinuse</td>
<td>context already in use (BLR error)</td>
</tr>
<tr>
<td>-104</td>
<td>335544426</td>
<td>ctxnotdef</td>
<td>context not defined (BLR error)</td>
</tr>
<tr>
<td>-104</td>
<td>335544429</td>
<td>badparnum</td>
<td>undefined parameter number</td>
</tr>
<tr>
<td>-104</td>
<td>335544440</td>
<td>bad_msg_vec</td>
<td></td>
</tr>
<tr>
<td>-104</td>
<td>335544456</td>
<td>invalid_sdl</td>
<td>invalid slice description language at offset @1</td>
</tr>
<tr>
<td>-104</td>
<td>335544570</td>
<td>dsql_command_err</td>
<td>Invalid command</td>
</tr>
<tr>
<td>-104</td>
<td>335544579</td>
<td>dsql_internal_err</td>
<td>Internal error</td>
</tr>
<tr>
<td>-104</td>
<td>335544590</td>
<td>dsql_dup_option</td>
<td>Option specified more than once</td>
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<tr>
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<td>335544591</td>
<td>dsql_tran_err</td>
<td>Unknown transaction option</td>
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<td>-104</td>
<td>335544592</td>
<td>dsql_invalid_array</td>
<td>Invalid array reference</td>
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<td>335544608</td>
<td>command_end_err</td>
<td>Unexpected end of command</td>
</tr>
<tr>
<td>-104</td>
<td>335544612</td>
<td>token_err</td>
<td>Token unknown</td>
</tr>
<tr>
<td>-104</td>
<td>335544634</td>
<td>dsql_token_unk_err</td>
<td>Token unknown - line @1, column @2</td>
</tr>
<tr>
<td>-104</td>
<td>335544709</td>
<td>dsql_agg_ref_err</td>
<td>Invalid aggregate reference</td>
</tr>
<tr>
<td>-104</td>
<td>335544714</td>
<td>invalid_array_id</td>
<td>invalid blob id</td>
</tr>
<tr>
<td>-104</td>
<td>335544730</td>
<td>cse_not_supported</td>
<td>Client/Server Express not supported in this release</td>
</tr>
<tr>
<td>-104</td>
<td>335544743</td>
<td>token_too_long</td>
<td>token size exceeds limit</td>
</tr>
<tr>
<td>-104</td>
<td>335544763</td>
<td>invalid_string_constant</td>
<td>a string constant is delimited by double quotes</td>
</tr>
<tr>
<td>-104</td>
<td>335544764</td>
<td>transitional_date</td>
<td>DATE must be changed to TIMESTAMP</td>
</tr>
<tr>
<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
</tr>
<tr>
<td>----------</td>
<td>-----------</td>
<td>------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
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<td>335544796</td>
<td>sql_dialect_datatype_unsupport</td>
<td>Client SQL dialect @1 does not support reference to @2 datatype</td>
</tr>
<tr>
<td>-104</td>
<td>335544798</td>
<td>depend_on_uncommitted_rel</td>
<td>You created an indirect dependency on uncommitted metadata. You must roll back the current transaction.</td>
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<tr>
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<td>335544821</td>
<td>dsq1_column_pos_err</td>
<td>Invalid column position used in the @1 clause</td>
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<tr>
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<td>335544822</td>
<td>dsq1_agg_where_err</td>
<td>Cannot use an aggregate or window function in a WHERE clause, use HAVING (for aggregate only) instead</td>
</tr>
<tr>
<td>-104</td>
<td>335544823</td>
<td>dsq1_agg_group_err</td>
<td>Cannot use an aggregate or window function in a GROUP BY clause</td>
</tr>
<tr>
<td>-104</td>
<td>335544824</td>
<td>dsq1_agg_column_err</td>
<td>Invalid expression in the @1 (not contained in either an aggregate function or the GROUP BY clause)</td>
</tr>
<tr>
<td>-104</td>
<td>335544825</td>
<td>dsq1_agg_having_err</td>
<td>Invalid expression in the @1 (neither an aggregate function nor a part of the GROUP BY clause)</td>
</tr>
<tr>
<td>-104</td>
<td>335544826</td>
<td>dsq1_agg_nested_err</td>
<td>Nested aggregate and window functions are not allowed</td>
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<tr>
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<td>335544849</td>
<td>malformed_string</td>
<td>Malformed string</td>
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<td>335544851</td>
<td>command_end_err2</td>
<td>Unexpected end of command - line @1, column @2</td>
</tr>
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<td>-104</td>
<td>335544930</td>
<td>too_big_blr</td>
<td>BLR stream length @1 exceeds implementation limit @2</td>
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<tr>
<td>-104</td>
<td>335544980</td>
<td>internal_rejected_params</td>
<td>Incorrect parameters provided to internal function @1</td>
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<tr>
<td>-104</td>
<td>335545022</td>
<td>cannot_copy_stmt</td>
<td>Cannot copy statement @1</td>
</tr>
<tr>
<td>-104</td>
<td>335545023</td>
<td>invalid_boolean_usage</td>
<td>Invalid usage of boolean expression</td>
</tr>
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<td>-104</td>
<td>335545035</td>
<td>svc_no_stdin</td>
<td>No isc_info_svc_stdin in user request, but service thread requested stdin data</td>
</tr>
<tr>
<td>-104</td>
<td>335545037</td>
<td>svc_no_switches</td>
<td>All services except for getting server log require switches</td>
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<td>-104</td>
<td>335545038</td>
<td>svc_bad_size</td>
<td>Size of stdin data is more than was requested from client</td>
</tr>
<tr>
<td>-104</td>
<td>335545039</td>
<td>no_crypt_plugin</td>
<td>Crypt plugin @1 failed to load</td>
</tr>
<tr>
<td>-104</td>
<td>335545040</td>
<td>cp_name_too_long</td>
<td>Length of crypt plugin name should not exceed @1 bytes</td>
</tr>
<tr>
<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
</tr>
<tr>
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<td>-----------------------------------------------------------------------------</td>
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<tr>
<td>-104</td>
<td>335545045</td>
<td>null_spb</td>
<td>NULL data with non-zero SPB length</td>
</tr>
<tr>
<td>-104</td>
<td>335545116</td>
<td>dsq1_window_incompat_frames</td>
<td>If &lt;window frame bound 1&gt; specifies @1, then &lt;window frame bound 2&gt; shall not specify @2</td>
</tr>
<tr>
<td>-104</td>
<td>335545117</td>
<td>dsq1_window_range_multi_key</td>
<td>RANGE based window with &lt;expr&gt; {preceding</td>
</tr>
<tr>
<td>-104</td>
<td>335545118</td>
<td>dsq1_window_range_inv_key_type</td>
<td>RANGE based window must have an ORDER BY key of numerical, date, time or timestamp types</td>
</tr>
<tr>
<td>-104</td>
<td>335545119</td>
<td>dsq1_window_frame_value_inv_type</td>
<td>Window RANGE/ROWS PRECEDING/FOLLOWING value must be of a numerical type</td>
</tr>
<tr>
<td>-104</td>
<td>335545205</td>
<td>no_keyholder_plugin</td>
<td>Key holder plugin @1 failed to load</td>
</tr>
<tr>
<td>-104</td>
<td>336003075</td>
<td>dsq1_transitional_numeric</td>
<td>Precision 10 to 18 changed from DOUBLE PRECISION in SQL dialect 1 to 64-bit scaled integer in SQL dialect 3</td>
</tr>
<tr>
<td>-104</td>
<td>336003077</td>
<td>sql_db_dialect_dtype_unsupport</td>
<td>Database SQL dialect @1 does not support reference to @2 datatype</td>
</tr>
<tr>
<td>-104</td>
<td>336003087</td>
<td>dsq1_invalid_label</td>
<td>Label @1 @2 in the current scope</td>
</tr>
<tr>
<td>-104</td>
<td>336003088</td>
<td>dsq1_datatypes_not_comparable</td>
<td>Datatypes @1 are not comparable in expression @2</td>
</tr>
<tr>
<td>-104</td>
<td>336397215</td>
<td>dsq1_max_sort_items</td>
<td>cannot sort on more than 255 items</td>
</tr>
<tr>
<td>-104</td>
<td>336397216</td>
<td>dsq1_max_group_items</td>
<td>cannot group on more than 255 items</td>
</tr>
<tr>
<td>-104</td>
<td>336397217</td>
<td>dsq1_conflicting_sort_field</td>
<td>Cannot include the same field (@1.@2) twice in the ORDER BY clause with conflicting sorting options</td>
</tr>
<tr>
<td>-104</td>
<td>336397218</td>
<td>dsq1-derived_table_more_columns</td>
<td>column list from derived table @1 has more columns than the number of items in its SELECT statement</td>
</tr>
<tr>
<td>-104</td>
<td>336397219</td>
<td>dsq1-derived_table_less_columns</td>
<td>column list from derived table @1 has less columns than the number of items in its SELECT statement</td>
</tr>
<tr>
<td>-104</td>
<td>336397220</td>
<td>dsq1-derived_field_unnamed</td>
<td>no column name specified for column number @1 in derived table @2</td>
</tr>
<tr>
<td>-104</td>
<td>336397221</td>
<td>dsq1-derived_field_dup_name</td>
<td>column @1 was specified multiple times for derived table @2</td>
</tr>
<tr>
<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
</tr>
<tr>
<td>----------</td>
<td>-----------</td>
<td>--------------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>-104</td>
<td>336397222</td>
<td>dsq-derived_alias_select</td>
<td>Internal dsq error: alias type expected by pass1_expand_select_node</td>
</tr>
<tr>
<td>-104</td>
<td>336397223</td>
<td>dsq-derived_alias_field</td>
<td>Internal dsq error: alias type expected by pass1_field</td>
</tr>
<tr>
<td>-104</td>
<td>336397224</td>
<td>dsq-auto_field_bad_pos</td>
<td>Internal dsq error: column position out of range in pass1_union_auto_cast</td>
</tr>
<tr>
<td>-104</td>
<td>336397225</td>
<td>dsq.cte_wrong_reference</td>
<td>Recursive CTE member (@1) can refer itself only in FROM clause</td>
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<td>CTE '@1' has cyclic dependencies</td>
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<td>Recursive member of CTE can't be member of an outer join</td>
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<td>Recursive CTE (@1) must be an UNION</td>
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<td>CTE &quot;@1&quot; is not used in query</td>
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<td>Return mode by value not allowed for this data type</td>
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<td>Array data type can use up to @1 dimensions</td>
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<td>there is no alias or table named @1 at this scope level</td>
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<td>there is no index @1 for table @2</td>
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<td>Invalid use of CHARACTER SET or COLLATE</td>
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<td>Too many Contexts of Relation/Procedure/Views. Maximum allowed is 256</td>
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<td>Blob sub_types bigger than 1 (text) are for internal use only</td>
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<td>could not find column for GRANT</td>
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<td>dsq1_line_col_error</td>
<td>At line @1, column @2</td>
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<td>dsq1_unknown_pos</td>
<td>At unknown line and column</td>
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<td>Log file header of @1 too small</td>
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<td>Invalid version of log file @1</td>
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<td>logh_open_flag</td>
<td>Log file @1 not latest in the chain but open flag still set</td>
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<td>Database name in the log file @1 is different</td>
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<td>Unexpected end of log file @1 at offset @2</td>
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<td>Incomplete log record at offset @1 in log file @2</td>
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<td>Log record header too small at offset @1 in log file @2</td>
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<td>Log block too small at offset @1 in log file @2</td>
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<td>Insufficient memory to allocate page buffer cache</td>
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<td>log_too_small</td>
<td>Log size too small</td>
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<td>Log partition size too small</td>
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<td>Illegal attempt to attach to an uninitialized WAL segment for @1</td>
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<td>Invalid WAL parameter block option @1</td>
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<td>Cannot roll over to the next log file @1</td>
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<td>no_wal</td>
<td>database does not use Write-ahead Log</td>
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<td>WAL subsystem corrupted</td>
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<td>walBugcheck</td>
<td>Database @1: WAL subsystem bug for pid @2 @3</td>
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<td>Could not expand the WAL segment for database @1</td>
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<td>Unable to roll over please see Firebird log</td>
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<td>WAL writer - Journal server communication error. Please see Firebird log.</td>
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<td>WAL buffers cannot be increased. Please see Firebird log.</td>
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<td>wal_err_setup</td>
<td>WAL setup error. Please see Firebird log.</td>
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<td>obsolete</td>
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<td>wal_err_ww_start</td>
<td>Cannot start WAL writer for the database @1</td>
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<td>wal_cache_err</td>
<td>Write-ahead Log without shared cache configuration not allowed</td>
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<td>start_cm_for_wal</td>
<td>WAL defined; Cache Manager must be started first</td>
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<td>wal_ovflow_log_required</td>
<td>Overflow log specification required for round-robin log</td>
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<td>Cache redefined</td>
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<td>Partitions not supported in series of log file specification</td>
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<td>no_stream_plan</td>
<td>table @1 is not referenced in plan</td>
</tr>
<tr>
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<td>table @1 is referenced more than once in plan; use aliases to distinguish</td>
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<td>the table @1 is referenced twice; use aliases to differentiate</td>
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<tr>
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<td>table @1 is referenced twice in view; use an alias to distinguish</td>
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<td>view @1 has more than one base table; use aliases to distinguish</td>
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<td>navigational stream @1 references a view with more than one base table</td>
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<td>table @1 is referenced in the plan but not the from list</td>
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<td>Cannot transliterate character between character sets</td>
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<td>Message Text</td>
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<td>Subscript @1 out of bounds [@2, @3]</td>
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<td>dsql_cursor_redefined</td>
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<td>Cursor @1 is not found in the current context</td>
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<td>Cursor @1 already exists in the current context</td>
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<td>Relation @1 is not found in cursor @2</td>
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<td>dsql_cursor_not_open</td>
<td>Cursor is not open</td>
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<td>no_cur_rec</td>
<td>no current record for fetch operation</td>
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## Appendix B: Exception Codes and Messages

<table>
<thead>
<tr>
<th>SQL CODE</th>
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<th>Symbol</th>
<th>Message Text</th>
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<tr>
<td>-510</td>
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<td>dsq1_cursor_update_err</td>
<td>Cursor @1 is not updatable</td>
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<td>dsq1_request_err</td>
<td>Request unknown</td>
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<td>dsq1_open_cursor_request</td>
<td>The prepare statement identifies a prepare statement with an open cursor</td>
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<td>violation of FOREIGN KEY constraint &quot;@1&quot; on table &quot;@2&quot;</td>
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<td>foreign_key_target_doesnt_exist</td>
<td>Foreign key reference target does not exist</td>
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<td>foreign_key_references_present</td>
<td>Foreign key references are present for the record</td>
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<td>Cannot prepare a CREATE DATABASE/SHEMA statement</td>
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<td>trans_invalid</td>
<td>transaction marked invalid and cannot be committed</td>
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<td>Attachment is in use</td>
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<td>transaction_in_use</td>
<td>Transaction is in use</td>
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<td>async_active</td>
<td>Asynchronous call is already running for this attachment</td>
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<td>no_priv</td>
<td>no permission for @1 access to @2 @3</td>
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<td>insufficient_svc_privileges</td>
<td>Service @1 requires SYSDBA permissions. Reattach to the Service Manager using the SYSDBA account.</td>
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<td>expected length @1, actual @2</td>
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<td>info_access</td>
<td>Wrong info requested in isc_svc_query() for anonymous service</td>
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<td>svc_start_failed</td>
<td>Start request for anonymous service is impossible</td>
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<td>-551</td>
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<td>effective_user</td>
<td>Effective user is @1</td>
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<td>not_rel_owner</td>
<td>only the owner of a table may reassign ownership</td>
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<td>grant_nopriv</td>
<td>user does not have GRANT privileges for operation</td>
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<td>grant_nopriv_on_base</td>
<td>user does not have GRANT privileges on base table/view for operation</td>
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<td>Only the owner can change the ownership</td>
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<td>cannot modify an existing user privilege</td>
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<tr>
<td>SQL-CODE</td>
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<td>Symbol</td>
<td>Message Text</td>
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<td>stream_crack</td>
<td>the current position is on a crack</td>
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<td>stream_eof</td>
<td>attempt to fetch past the last record in a record stream</td>
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<td>stream_bof</td>
<td>attempt to fetch before the first record in a record stream</td>
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<td>Preceding file did not specify length, so @1 must include starting page number</td>
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<td>gen.c: node not supported</td>
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<td>A node name is not permitted in a secondary, shadow, cache or log file name</td>
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<td>database or file exists</td>
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<td>Array declared with too many dimensions</td>
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<td>Inappropriate self-reference of column</td>
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<td>no_meta_update</td>
<td>unsuccessful metadata update</td>
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<td>cannot modify or erase a system trigger</td>
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<td>Array/BLOB/DATE data types not allowed in arithmetic</td>
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<td>&quot;REFERENCES table&quot; without &quot;(column)&quot; requires PRIMARY KEY on referenced table</td>
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<td>udf_name</td>
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<td>lock on table @1 conflicts with existing lock</td>
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<td>drop_wal</td>
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<td>refresh range number @1 already in use</td>
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<td>Cannot delete PRIMARY KEY being used in FOREIGN KEY definition.</td>
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<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
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<td>there are @1 dependencies</td>
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<td>Cannot deactivate index used by an integrity constraint</td>
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<td>Too many concurrent executions of the same request</td>
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<td>arithmetic exception, numeric overflow, or string truncation</td>
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<td>SQLDA version expected between @1 and @2, found @3</td>
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<td>attempt to store duplicate value (visible to active transactions) in unique index &quot;@1&quot;</td>
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<td>Message length passed from user application does not match set of columns</td>
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<td>ResultSet is missing output format information</td>
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<td>Message metadata not ready - item @1 is not finished</td>
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<td>Interface @3 version too old: expected @1, found @2</td>
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<td>Cannot insert because the file is readonly or is on a read only medium.</td>
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<td>attempted update during read-only transaction</td>
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<td>SQL dialect @1 is not supported in this database</td>
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<td>Metadata update statement is not allowed by the current database SQL dialect @1</td>
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<td>minor version too high found @1 expected @2</td>
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<td>Difference file name should be set explicitly for database on raw device</td>
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<td>New size specified for column @1 must be at least @2 characters.</td>
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<td>Attempt to define a second PRIMARY KEY for the same table</td>
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<td>FOREIGN KEY column count does not match PRIMARY KEY</td>
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<td>value exceeds the range for valid dates</td>
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<td>Invalid data type in DATE/TIME/TIMESTAMP addition or subtraction in add_datetime()</td>
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<td>Only a TIME value can be added to a DATE value</td>
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<td>TIMESTAMP values can be subtracted only from another TIMESTAMP value</td>
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<td>Only one operand can be of type TIMESTAMP</td>
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<td>Only HOUR, MINUTE, SECOND and MILLISECOND can be extracted from TIME values</td>
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<td>Invalid argument for EXTRACT() not being of DATE/TIME/TIMESTAMP type</td>
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<td>Arguments for @1 must be integral types or NUMERIC/DECIMAL without scale</td>
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<td>Human readable UUID argument for @1 must be of string type</td>
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<td>Human readable UUID argument for @2 must be of exact length @1</td>
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<td>Invalid data type in addition of part to DATE/TIME/TIMESTAMP in @1</td>
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<td>Expected DATE/TIME/TIMESTAMP type in evlDateAdd() result</td>
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<td>The result of TIME-&lt;value&gt; in @1 cannot be expressed in YEAR, MONTH, DAY or WEEK</td>
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<td>The numeric scale must be between -128 and 127 in @1</td>
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### Appendix B: Exception Codes and Messages

<table>
<thead>
<tr>
<th>SQL-CODE</th>
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<td>DecFloat precision must be 16 or 34</td>
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<td>action cancelled by trigger (@1) to preserve data integrity</td>
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<td>lock conflict on no wait transaction</td>
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<td>program attempted to exit without finishing database</td>
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<td>cannot disconnect database with open transactions (@1 active)</td>
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### Appendix B: Exception Codes and Messages

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<th>SQL CODE</th>
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<td>Specified domain or source column @1 does not exist</td>
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<td>dsql_var_conflict</td>
<td>variable @1 conflicts with parameter in same procedure</td>
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<td>srvr_version_too_old</td>
<td>server version too old to support all CREATE DATABASE options</td>
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<td>cannot delete</td>
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<td>sort error</td>
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<td>svcnoexe</td>
<td>service @1 does not have an associated executable</td>
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<td>335544704</td>
<td>net_lookup_err</td>
<td>Failed to locate host machine.</td>
</tr>
<tr>
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<td>335544705</td>
<td>service_unknown</td>
<td>Undefined service @1/@2.</td>
</tr>
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<td>host_unknown</td>
<td>The specified name was not found in the hosts file or Domain Name Services.</td>
</tr>
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<td>unprepared_stmt</td>
<td>Attempt to execute an unprepared dynamic SQL statement.</td>
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<td>335544716</td>
<td>svc_in_use</td>
<td>Service is currently busy: @1</td>
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<td>335544719</td>
<td>net_init_error</td>
<td>Error initializing the network software.</td>
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<td>loadlib_failure</td>
<td>Unable to load required library @1.</td>
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<td>tra_must_sweep</td>
<td>A fatal exception occurred during the execution of a user defined function.</td>
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<td>udf_exception</td>
<td>A fatal exception occurred during the execution of a user defined function.</td>
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<td>connection lost to database</td>
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<td>no_write_user_priv</td>
<td>User cannot write to RDB$USER_PRIVILEGES</td>
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<td>SQLCODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
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<td>blob_filter_exception</td>
<td>A fatal exception occurred during the execution of a blob filter.</td>
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<td>exception_access_violation</td>
<td>Access violation. The code attempted to access a virtual address without privilege to do so.</td>
</tr>
<tr>
<td>-901</td>
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<td>exception_datatype_mismatch</td>
<td>Datatype misalignment. The attempted to read or write a value that was not stored on a memory boundary.</td>
</tr>
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<td>Array bounds exceeded. The code attempted to access an array element that is out of bounds.</td>
</tr>
<tr>
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<td>335544771</td>
<td>exception_float_denormal_operand</td>
<td>Float denormal operand. One of the floating-point operands is too small to represent a standard float value.</td>
</tr>
<tr>
<td>-901</td>
<td>335544772</td>
<td>exception_float_divide_by_zero</td>
<td>Floating-point divide by zero. The code attempted to divide a floating-point value by zero.</td>
</tr>
<tr>
<td>-901</td>
<td>335544773</td>
<td>exception_float_inexact_result</td>
<td>Floating-point inexact result. The result of a floating-point operation cannot be represented as a decimal fraction.</td>
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<td>335544774</td>
<td>exception_float_invalid_operand</td>
<td>Floating-point invalid operand. An indeterminant error occurred during a floating-point operation.</td>
</tr>
<tr>
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<td>335544775</td>
<td>exception_float_overflow</td>
<td>Floating-point overflow. The exponent of a floating-point operation is greater than the magnitude allowed.</td>
</tr>
<tr>
<td>-901</td>
<td>335544776</td>
<td>exception_float_stack_check</td>
<td>Floating-point stack check. The stack overflowed or underflowed as the result of a floating-point operation.</td>
</tr>
<tr>
<td>-901</td>
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<td>exception_float_underflow</td>
<td>Floating-point underflow. The exponent of a floating-point operation is less than the magnitude allowed.</td>
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<tr>
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<td>exception_integer_divide_by_zero</td>
<td>Integer divide by zero. The code attempted to divide an integer value by an integer divisor of zero.</td>
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<td>-901</td>
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<td>exception_integer_overflow</td>
<td>Integer overflow. The result of an integer operation caused the most significant bit of the result to carry.</td>
</tr>
<tr>
<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
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<tr>
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<td>335544780</td>
<td>exception_unknown</td>
<td>An exception occurred that does not have a description. Exception number @1.</td>
</tr>
<tr>
<td>-901</td>
<td>335544781</td>
<td>exception_stack_overflow</td>
<td>Stack overflow. The resource requirements of the runtime stack have exceeded the memory available to it.</td>
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<tr>
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<td>335544782</td>
<td>exception_sigsegv</td>
<td>Segmentation Fault. The code attempted to access memory without privileges.</td>
</tr>
<tr>
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<td>335544783</td>
<td>exception_sigill</td>
<td>Illegal Instruction. The Code attempted to perform an illegal operation.</td>
</tr>
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<td>-901</td>
<td>335544784</td>
<td>exception_sigbus</td>
<td>Bus Error. The Code caused a system bus error.</td>
</tr>
<tr>
<td>-901</td>
<td>335544785</td>
<td>exception_sigfpe</td>
<td>Floating Point Error. The Code caused an Arithmetic Exception or a floating point exception.</td>
</tr>
<tr>
<td>-901</td>
<td>335544786</td>
<td>ext_file_delete</td>
<td>Cannot delete rows from external files.</td>
</tr>
<tr>
<td>-901</td>
<td>335544787</td>
<td>ext_file_modify</td>
<td>Cannot update rows in external files.</td>
</tr>
<tr>
<td>-901</td>
<td>335544788</td>
<td>adm_task_denied</td>
<td>Unable to perform operation</td>
</tr>
<tr>
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<td>335544794</td>
<td>cancelled</td>
<td>operation was cancelled</td>
</tr>
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<td>svcnouser</td>
<td>user name and password are required while attaching to the services manager</td>
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<tr>
<td>-901</td>
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<td>datatype_notsup</td>
<td>data type not supported for arithmetic</td>
</tr>
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<td>335544803</td>
<td>dialect_not_changed</td>
<td>Database dialect not changed.</td>
</tr>
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<td>database_create_failed</td>
<td>Unable to create database @1</td>
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<tr>
<td>-901</td>
<td>335544805</td>
<td>inv_dialect_specified</td>
<td>Database dialect @1 is not a valid dialect.</td>
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<tr>
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<td>335544806</td>
<td>valid_db_dialects</td>
<td>Valid database dialects are @1.</td>
</tr>
<tr>
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<td>inv_client_dialect_specified</td>
<td>passed client dialect @1 is not a valid dialect.</td>
</tr>
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<td>valid_client_dialects</td>
<td>Valid client dialects are @1.</td>
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<td>service_not_supported</td>
<td>Services functionality will be supported in a later version of the product</td>
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<td>invalid_savepoint</td>
<td>Unable to find savepoint with name @1 in transaction context</td>
</tr>
<tr>
<td>-901</td>
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<td>bad_shutdown_mode</td>
<td>Target shutdown mode is invalid for database &quot;@1&quot;</td>
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<td>cannot update</td>
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<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
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<td>stack_trace</td>
<td>@1</td>
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<td>ctx_var_not_found</td>
<td>Context variable @1 is not found in namespace @2</td>
</tr>
<tr>
<td>-901</td>
<td>335544844</td>
<td>ctx_namespace_invalid</td>
<td>Invalid namespace name @1 passed to @2</td>
</tr>
<tr>
<td>-901</td>
<td>335544845</td>
<td>ctx_too_big</td>
<td>Too many context variables</td>
</tr>
<tr>
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<td>ctx_bad_argument</td>
<td>BLR syntax error. Identifier @1... is too long</td>
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<td>-901</td>
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<td>identifier_too_long</td>
<td>@1 cannot depend on @2</td>
</tr>
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<td>335544848</td>
<td>illegal_prc_type</td>
<td>Procedure @1 is not selectable (it does not contain a SUSPEND statement)</td>
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<tr>
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<td>invalid_sort_datatype</td>
<td>Datatype @1 is not supported for sorting operation</td>
</tr>
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<td>collation_name</td>
<td>COLLATION @1</td>
</tr>
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<td>-901</td>
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<td>domain_name</td>
<td>DOMAIN @1</td>
</tr>
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<td>max_db_per_trans_allowed</td>
<td>A multi database transaction cannot span more than @1 databases</td>
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<td>bad_proc_BLR</td>
<td>Error while parsing procedure @1's BLR</td>
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<td>key_too_big</td>
<td>index key too big</td>
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<td>Invalid TEB format</td>
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<td>tpb_multiple_txn_isolation</td>
<td>Found more than one transaction isolation in TPB</td>
</tr>
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<td>tpb_reserv_before_table</td>
<td>Table reservation lock type @1 requires table name before in TPB</td>
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<td>tpb_multiple_spec</td>
<td>Found more than one @1 specification in TPB</td>
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<td>tpb_option_without_rc</td>
<td>Option @1 requires READ COMMITTED isolation in TPB</td>
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<td>335544860</td>
<td>tpb_conflicting_options</td>
<td>Option @1 is not valid if @2 was used previously in TPB</td>
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<td>tpb_reserv_missing_tlen</td>
<td>Table name length missing after table reservation @1 in TPB</td>
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<tr>
<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
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<td>tpb_reserv_long_tlen</td>
<td>Table name length @1 is too long after table reservation @2 in TPB</td>
</tr>
<tr>
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<td>335544893</td>
<td>tpb_reserv_missing_tname</td>
<td>Table name length @1 without table name after table reservation @2 in TPB</td>
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<tr>
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<td>tpb_reserv_corrup_tlen</td>
<td>Table name length @1 goes beyond the remaining TPB size after table reservation @2</td>
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<td>tpb_reserv_null_tlen</td>
<td>Table name length is zero after table reservation @1 in TPB</td>
</tr>
<tr>
<td>-901</td>
<td>335544896</td>
<td>tpb_reserv_relnotfound</td>
<td>Table or view @1 not defined in system tables after table reservation @2 in TPB</td>
</tr>
<tr>
<td>-901</td>
<td>335544897</td>
<td>tpb_reserv_baserelnotfound</td>
<td>Base table or view @1 for view @2 not defined in system tables after table reservation @3 in TPB</td>
</tr>
<tr>
<td>-901</td>
<td>335544898</td>
<td>tpb_missing_len</td>
<td>Option length missing after option @1 in TPB</td>
</tr>
<tr>
<td>-901</td>
<td>335544899</td>
<td>tpb_missing_value</td>
<td>Option length @1 without value after option @2 in TPB</td>
</tr>
<tr>
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<td>335544900</td>
<td>tpb_corrupt_len</td>
<td>Option length @1 goes beyond the remaining TPB size after option @2</td>
</tr>
<tr>
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<td>tpb_null_len</td>
<td>Option length is zero after table reservation @1 in TPB</td>
</tr>
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<td>tpb_overflow_len</td>
<td>Option length @1 exceeds the range for option @2 in TPB</td>
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<td>tpb_invalid_value</td>
<td>Option value @1 is invalid for the option @2 in TPB</td>
</tr>
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<td>tpb_reserv_stronger_wng</td>
<td>Preserving previous table reservation @1 for table @2, stronger than new @3 in TPB</td>
</tr>
<tr>
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<td>335544905</td>
<td>tpb_reserv_stronger</td>
<td>Table reservation @1 for table @2 already specified and is stronger than new @3 in TPB</td>
</tr>
<tr>
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<td>335544906</td>
<td>tpb_reserv_max_recursion</td>
<td>Table reservation reached maximum recursion of @1 when expanding views in TPB</td>
</tr>
<tr>
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<td>335544907</td>
<td>tpb_reserv_virtualtbl</td>
<td>Table reservation in TPB cannot be applied to @1 because it’s a virtual table</td>
</tr>
<tr>
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<td>335544908</td>
<td>tpb_reserv_systbl</td>
<td>Table reservation in TPB cannot be applied to @1 because it’s a system table</td>
</tr>
<tr>
<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
</tr>
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<td>tpb_reserv_temptbl</td>
<td>Table reservation @1 or @2 in TPB cannot be applied to @3 because it’s a temporary table</td>
</tr>
<tr>
<td>-901</td>
<td>335544910</td>
<td>tpb_readtxn_after_writelock</td>
<td>Cannot set the transaction in read only mode after a table reservation isc_tpb_lock_write in TPB</td>
</tr>
<tr>
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<td>335544911</td>
<td>tpb_writelock_after_readtxn</td>
<td>Cannot take a table reservation isc_tpb_lock_write in TPB because the transaction is in read only mode</td>
</tr>
<tr>
<td>-901</td>
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<td>shutdown_timeout</td>
<td>Firebird shutdown is still in progress after the specified timeout</td>
</tr>
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<td>att_handle_busy</td>
<td>Attachment handle is busy</td>
</tr>
<tr>
<td>-901</td>
<td>335544919</td>
<td>bad_udf_freeit</td>
<td>Bad written UDF detected: pointer returned in FREE_IT function was not allocated by ib_util_malloc</td>
</tr>
<tr>
<td>-901</td>
<td>335544920</td>
<td>eds_provider_not_found</td>
<td>External Data Source provider ’@1’ not found</td>
</tr>
<tr>
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<td>335544921</td>
<td>eds_connection</td>
<td>Execute statement error at @1 : @2Data source : @3</td>
</tr>
<tr>
<td>-901</td>
<td>335544922</td>
<td>eds_preprocess</td>
<td>Execute statement preprocess SQL error</td>
</tr>
<tr>
<td>-901</td>
<td>335544923</td>
<td>eds_stmt_expected</td>
<td>Statement expected</td>
</tr>
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<td>-901</td>
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<td>eds_prm_name_expected</td>
<td>Parameter name expected</td>
</tr>
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<td>-901</td>
<td>335544925</td>
<td>eds_unclosed_comment</td>
<td>Unclosed comment found near ’@1’</td>
</tr>
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<td>-901</td>
<td>335544926</td>
<td>eds_statement</td>
<td>Execute statement error at @1 : @2Statement : @3 Data source : @4</td>
</tr>
<tr>
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<td>eds_input_prm_mismatch</td>
<td>Input parameters mismatch</td>
</tr>
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<td>335544928</td>
<td>eds_output_prm_mismatch</td>
<td>Output parameters mismatch</td>
</tr>
<tr>
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<td>335544929</td>
<td>eds_input_prm_not_set</td>
<td>Input parameter ’@1’ have no value set</td>
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<td>nothing_to_cancel</td>
<td>nothing to cancel</td>
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<td>ibutil_not_loaded</td>
<td>ib_util library has not been loaded to deallocate memory returned by FREE_IT function</td>
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<td>bad_epb_form</td>
<td>Unrecognized events block</td>
</tr>
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<td>335544982</td>
<td>udf_fp_overflow</td>
<td>Floating point overflow in result from UDF @1</td>
</tr>
<tr>
<td>-901</td>
<td>335544983</td>
<td>udf_fp_nan</td>
<td>Invalid floating point value returned by UDF @1</td>
</tr>
<tr>
<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
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<td>-----------------------------------------------------------------------------</td>
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<tr>
<td>-901</td>
<td>335544985</td>
<td>out_of_temp_space</td>
<td>No free space found in temporary directories</td>
</tr>
<tr>
<td>-901</td>
<td>335544986</td>
<td>eds_expl_tran_ctrl</td>
<td>Explicit transaction control is not allowed</td>
</tr>
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<td>-901</td>
<td>335544988</td>
<td>package_name</td>
<td>PACKAGE @1</td>
</tr>
<tr>
<td>-901</td>
<td>335544989</td>
<td>cannot_make_not_null</td>
<td>Cannot make field @1 of table @2 NOT NULL because there are NULLs present</td>
</tr>
<tr>
<td>-901</td>
<td>335544990</td>
<td>feature_removed</td>
<td>Feature @1 is not supported anymore</td>
</tr>
<tr>
<td>-901</td>
<td>335544991</td>
<td>view_name</td>
<td>VIEW @1</td>
</tr>
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<td>invalid_fetch_option</td>
<td>Fetch option @1 is invalid for a non-scrollable cursor</td>
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<td>Error while parsing function @1’s BLR</td>
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<td>func_pack_not_implemented</td>
<td>Cannot execute function @1 of the unimplemented package @2</td>
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<td>External function @1 not returned by the external engine plugin @2</td>
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<td>Error loading plugin @1</td>
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<td>Loadable module @1 not found</td>
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<td>Standard plugin entrypoint does not exist in module @1</td>
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<td>pman_module_bad</td>
<td>Module @1 exists but can not be loaded</td>
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<td>Module @1 does not contain plugin @2 type @3</td>
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<td>Value is NULL but isNull parameter was not informed</td>
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<td>Type @1 is incompatible with BLOB</td>
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<td>invalid events id (handle)</td>
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<td>missing service ID in spb</td>
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<td>External BLR message mismatch: invalid null descriptor at field @1</td>
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<td>Libtommath error code @1 in function @2</td>
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<td>Crypt failed - already crypting database</td>
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<td>cp_already_crypted</td>
<td>Crypt failed - database is already in requested state</td>
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<td>Invalid resultset interface</td>
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<td>undefined variable number</td>
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<td>Attempt to get information about an unprepared dynamic SQL statement.</td>
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<td>Problematic key value is @1</td>
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<td>Cannot select virtual table @1 for update WITH LOCK</td>
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<td>Cannot select system table @1 for update WITH LOCK</td>
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<td>Cannot select temporary table @1 for update WITH LOCK</td>
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<td>cant_modify_sysobj</td>
<td>System @1 @2 cannot be modified</td>
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<td>Server misconfigured - contact administrator please</td>
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<td>Symbol</td>
<td>Message Text</td>
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<td>Deprecated backward compatibility ALTERNATIVE ... SET/DROP AUTO ADMIN mapping may be used only for RDB$ADMIN role</td>
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<td>Mapping @1 already exists</td>
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<td>Mapping @1 does not exist</td>
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<td>map_load</td>
<td>@1 failed when loading mapping cache</td>
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<td>map_aster</td>
<td>Invalid name &lt;*&gt; in authentication block</td>
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<td>map_multi</td>
<td>Multiple maps found for @1</td>
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<td>map_undefined</td>
<td>Undefined mapping result - more than one different results found</td>
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<td>map_noddb</td>
<td>Global mapping is not available when database @1 is not present</td>
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<td>map_notable</td>
<td>Global mapping is not available when table RDB$MAP is not present in database @1</td>
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<td>Your attachment has no trusted role</td>
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<td>set_invalid_role</td>
<td>Role @1 is invalid or unavailable</td>
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<td>Duplicated user attribute @1</td>
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<td>dyn_no_priv</td>
<td>There is no privilege for this operation</td>
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<td>Using GRANT OPTION on @1 not allowed</td>
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<td>@1 failed when working with CREATE DATABASE grants</td>
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<td>CREATE DATABASE grants check is not possible when database @1 is not present</td>
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<td>Error during savepoint backout - transaction invalidated</td>
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<td>map_down</td>
<td>Some database(s) were shutdown when trying to read mapping data</td>
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<td>Page requires encryption but crypt plugin is missing</td>
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<td>System privilege @1 does not exist</td>
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<td>Cannot open cursor for non-SELECT statement</td>
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<td>Decimal float divide by zero. The code</td>
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<td>attempted to divide a DECFLOAT value by zero.</td>
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<td>Decimal float inexact result. The result</td>
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<td>of an operation cannot be represented as a decimal fraction.</td>
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<td>indeterminant error occurred during an operation.</td>
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<td>Decimal float overflow. The exponent of a result is</td>
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<td>greater than the magnitude allowed.</td>
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<td>decfloat_underflow</td>
<td>Decimal float underflow. The exponent of a result is</td>
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<td>Sub-function @1 has not been defined</td>
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<td>subproc_notdef</td>
<td>Sub-procedure @1 has not been defined</td>
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<td>Sub-function @1 has a signature mismatch with its forward declaration</td>
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<td>Default values for parameters are not allowed in</td>
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<td>definition of the previously declared sub-function @1</td>
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<td>Sub-function @1 was declared but not implemented</td>
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<td>Sub-procedure @1 was declared but not implemented</td>
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<td>Invalid HASH algorithm @1</td>
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<td>Expression evaluation error for index &quot;@1&quot; on table &quot;@2&quot;</td>
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<td>Invalid decfloat trap state @1</td>
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<td>invalid_decfloat_round</td>
<td>Invalid decfloat rounding mode @1</td>
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<td>invalid batch handle</td>
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<td>Bad international character in tag @1</td>
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<td>null_block</td>
<td>Null data in parameters block with non-zero length</td>
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<td>mixed_info</td>
<td>Items working with running service and getting generic server information should not be mixed in single info block</td>
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<td>unknown_info</td>
<td>Unknown information item, code @1</td>
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<td>bpb_version</td>
<td>Wrong version of blob parameters block @1, should be @2</td>
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<td>User management plugin is missing or failed to load</td>
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<td>Name @1 not found in system MetadataBuilder</td>
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<td>Parse to tokens error</td>
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<td>Message @1 is out of range, only @2 messages in batch</td>
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<td>batch_compl_detail</td>
<td>Detailed error info for message @1 is missing in batch</td>
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<td>Segment size (@1) should not exceed 65535 (64K - 1) when using segmented blob</td>
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<td>Invalid blob policy in the batch for @1() call</td>
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<td>batch_defbpb</td>
<td>Can’t change default BPB after adding any data to batch</td>
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<td>batch_align</td>
<td>Unexpected info buffer structure querying for default blob alignment</td>
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<td>multi_segment_dup</td>
<td>Duplicated segment @1 in multisegment connect block parameter</td>
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<td>message_format</td>
<td>Error parsing message format</td>
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<td>batch_param_version</td>
<td>Wrong version of batch parameters block @1, should be @2</td>
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<td>batch_msg_long</td>
<td>Message size (@1) in batch exceeds internal buffer size (@2)</td>
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<td>batch_open</td>
<td>Batch already opened for this statement</td>
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<td>batch_type</td>
<td>Invalid type of statement used in batch</td>
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<td>batch_param</td>
<td>Statement used in batch must have parameters</td>
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<td>batch_blobs</td>
<td>There are no blobs in associated with batch statement</td>
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<td>batch_blob_append</td>
<td>appendBlobData() is used to append data to last blob but no such blob was added to the batch</td>
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<td>batch_stream_align</td>
<td>Portions of data, passed as blob stream, should have size multiple to the alignment required for blobs</td>
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<td>Repeated blob id @1 in registerBlob()</td>
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<td>batch_blob_buf</td>
<td>Blob buffer format error</td>
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<td>batch_small_data</td>
<td>Unusable (too small) data remained in @1 buffer</td>
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<td>batch_cont_bpb</td>
<td>Blob continuation should not contain BPB</td>
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<td>batch_big_bpb</td>
<td>Size of BPB (@1) greater than remaining data (@2)</td>
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<td>batch_big_segment</td>
<td>Size of segment (@1) greater than current BLOB data (@2)</td>
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<td>batch_big_seg2</td>
<td>Size of segment (@1) greater than available data (@2)</td>
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<td>Unknown blob ID @1 in the batch message</td>
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<td>batch_too_big</td>
<td>Internal buffer overflow - batch too big</td>
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<td>num_literal</td>
<td>Numeric literal too long</td>
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<td>hdr_overflow</td>
<td>Header page overflow - too many clumplets on it</td>
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<td>335545203</td>
<td>vld_plugins</td>
<td>No matching client/server authentication plugins configured for execute statement in embedded datasource</td>
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<tr>
<td>-901</td>
<td>335545206</td>
<td>ses_reset_err</td>
<td>Cannot reset user session</td>
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</table>
### Appendix B: Exception Codes and Messages

<table>
<thead>
<tr>
<th>SQL-CODE</th>
<th>GDSCODE</th>
<th>Symbol</th>
<th>Message Text</th>
</tr>
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<tbody>
<tr>
<td>-901</td>
<td>335545207</td>
<td>ses_reset_open_trans</td>
<td>There are open transactions (@1 active)</td>
</tr>
<tr>
<td>-901</td>
<td>335545208</td>
<td>ses_reset_warn</td>
<td>Session was reset with warning(s)</td>
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<td>ses_reset_tran_rollback</td>
<td>Transaction is rolled back due to session reset, all changes are lost</td>
</tr>
<tr>
<td>-901</td>
<td>335545210</td>
<td>plugin_name</td>
<td>Plugin @1:</td>
</tr>
<tr>
<td>-901</td>
<td>335545211</td>
<td>parameter_name</td>
<td>PARAMETER @1</td>
</tr>
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<td>file_starting_page_err</td>
<td>Starting page number for file @1 must be @2 or greater</td>
</tr>
<tr>
<td>-901</td>
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<td>invalid_timezone_offset</td>
<td>Invalid time zone offset: @1 - must use format +/-hours:minutes and be between -14:00 and +14:00</td>
</tr>
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<td>invalid_timezone_region</td>
<td>Invalid time zone region: @1</td>
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<td>invalid_timezone_id</td>
<td>Invalid time zone ID: @1</td>
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<td>Wrong base64 text length @1, should be multiple of 4</td>
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<td>tom_strblob</td>
<td>Invalid first parameter datatype - need string or blob</td>
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<td>tom_reg</td>
<td>Error registering @1 - probably bad tomcrypt library</td>
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<td>tom_algorithm</td>
<td>Unknown crypt algorithm @1 in USING clause</td>
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<td>335545220</td>
<td>tom_mode_miss</td>
<td>Should specify mode parameter for symmetric cipher</td>
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<td>tom_mode_bad</td>
<td>Unknown symmetric crypt mode specified</td>
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<td>335545222</td>
<td>tom_no_mode</td>
<td>Mode parameter makes no sense for chosen cipher</td>
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<td>tom_iv_miss</td>
<td>Should specify initialization vector (IV) for chosen cipher and/or mode</td>
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<td>Initialization vector (IV) makes no sense for chosen cipher and/or mode</td>
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<td>tom_ctrtype_bad</td>
<td>Invalid counter endianess @1</td>
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<td>tom_noCtrtype</td>
<td>Counter endianess parameter is not used in mode @1</td>
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<td>tom_ctr_big</td>
<td>Too big counter value @1, maximum @2 can be used</td>
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<tr>
<td>SQL-CODE</td>
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<td>Symbol</td>
<td>Message Text</td>
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<td>Counter length/value parameter is not used with @1 @2</td>
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<td>Invalid initialization vector (IV) length @1, need @2</td>
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<td>tom_error</td>
<td>TomCrypt library error: @1</td>
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<td>tom_yarrow_start</td>
<td>Starting PRNG yarrow</td>
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<td>tom_yarrow_setup</td>
<td>Setting up PRNG yarrow</td>
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<td>tom_init_mode</td>
<td>Initializing @1 mode</td>
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<td>tom_crypt_mode</td>
<td>Encrypting in @1 mode</td>
</tr>
<tr>
<td>-901</td>
<td>335545235</td>
<td>tom_decrypt_mode</td>
<td>Decrypting in @1 mode</td>
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<td>Initializing cipher @1</td>
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<td>Encrypting using cipher @1</td>
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<td>Decrypting using cipher @1</td>
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<td>Setting initialization vector (IV) for @1</td>
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<td>Invalid initialization vector (IV) length @1, need 8 or 12</td>
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<td>Encoding @1</td>
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<td>Decoding @1</td>
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<td>Importing RSA key</td>
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<td>tom_oaep</td>
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<td>Making RSA key</td>
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<td>Exporting @1 RSA key</td>
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<td>Invalid time zone bind mode @1</td>
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<td>Invalid decfloat bind mode @1</td>
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<td>SQL-CODE</td>
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<td>Symbol</td>
<td>Message Text</td>
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<td>Invalid hex digit @1 at position @2</td>
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<td>bind_convert</td>
<td>Can not convert @1 to @2</td>
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<td>No permission for CREATE @1 operation</td>
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<td>suspend_without_returns</td>
<td>SUSPEND could not be used without RETURNS clause in PROCEDURE or EXECUTE BLOCK</td>
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<td>BLOB Filter @1 not found</td>
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<td>Function @1 not found</td>
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<td>Index not found</td>
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<td>View @1 not found</td>
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<td>Domain not found</td>
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<td>Triggers created automatically cannot be modified</td>
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<td>dyn_dup_table</td>
<td>Table @1 already exists</td>
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<td>dyn_proc_not_found</td>
<td>Procedure @1 not found</td>
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<td>dyn_exception_not_found</td>
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<td>Parameter @1 in procedure @2 not found</td>
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<td>Trigger @1 not found</td>
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<td>Character set @1 not found</td>
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<td>Collation @1 not found</td>
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<td>Role @1 not found</td>
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<td>dyn_name_longer</td>
<td>Name longer than database column size</td>
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<td>dyn_column_does_not_exist</td>
<td>column @1 does not exist in table/view @2</td>
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<td>336068796</td>
<td>dyn_role_does_not_exist</td>
<td>SQL role @1 does not exist</td>
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<td>dyn_no_grant_admin_opt</td>
<td>user @1 has no grant admin option on SQL role @2</td>
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<td>dyn_user_not_role_member</td>
<td>user @1 is not a member of SQL role @2</td>
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<tr>
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<td>dyn_delete_role_failed</td>
<td>@1 is not the owner of SQL role @2</td>
</tr>
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<td>-901</td>
<td>336068800</td>
<td>dyn_grant_role_to_user</td>
<td>@1 is a SQL role and not a user</td>
</tr>
</tbody>
</table>
## Appendix B: Exception Codes and Messages

<table>
<thead>
<tr>
<th>SQL-CODE</th>
<th>GDSCODE</th>
<th>Symbol</th>
<th>Message Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>-901</td>
<td>336068801</td>
<td>dyn_inv_sql_role_name</td>
<td>user name @1 could not be used for SQL role</td>
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<td>336068802</td>
<td>dyn_dup_sql_role</td>
<td>SQL role @1 already exists</td>
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<td>dyn_kywd_spec_for_role</td>
<td>keyword @1 can not be used as a SQL role name</td>
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<td>dyn_roles_not_supported</td>
<td>SQL roles are not supported in on older versions of the database. A backup and restore of the database is required.</td>
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<td>336068820</td>
<td>dyn_zero_len_id</td>
<td>Zero length identifiers are not allowed</td>
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<td>336068822</td>
<td>dyn_gen_not_found</td>
<td>Sequence @1 not found</td>
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<tr>
<td>-901</td>
<td>336068840</td>
<td>dyn_wrong_gtt_scope</td>
<td>@1 cannot reference @2</td>
</tr>
<tr>
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<td>336068843</td>
<td>dyn_coll_used_table</td>
<td>Collation @1 is used in table @2 (field name @3) and cannot be dropped</td>
</tr>
<tr>
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<td>336068844</td>
<td>dyn_coll_used_domain</td>
<td>Collation @1 is used in domain @2 and cannot be dropped</td>
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<td>336068846</td>
<td>dyn_cannot_del_def_coll</td>
<td>Cannot delete default collation of CHARACTER SET @1</td>
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<td>336068849</td>
<td>dyn_table_not_found</td>
<td>Table @1 not found</td>
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<td>dyn_coll_used_procedure</td>
<td>Collation @1 is used in procedure @2 (parameter name @3) and cannot be dropped</td>
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<td>dyn_ods_not_supp_feature</td>
<td>Feature '@1' is not supported in ODS @2.@3</td>
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<td>336068858</td>
<td>dyn_no_empty_pw</td>
<td>Password should not be empty string</td>
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<td>Index @1 already exists</td>
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<td>Package @1 not found</td>
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<td>dyn_schema_not_found</td>
<td>Schema @1 not found</td>
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<td>336068871</td>
<td>dyn_funcnotdef_package</td>
<td>Function @1 has not been defined on the package body @2</td>
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<td>dyn_procnotdef_package</td>
<td>Procedure @1 has not been defined on the package body @2</td>
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<td>dyn_funcsignat_package</td>
<td>Function @1 has a signature mismatch on package body @2</td>
</tr>
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<td>dyn_procsignat_package</td>
<td>Procedure @1 has a signature mismatch on package body @2</td>
</tr>
<tr>
<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
</tr>
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<td>dyn_defvaldecl_package_proc</td>
<td>Default values for parameters are not allowed in the definition of a previously declared packaged procedure @1.@2</td>
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<td>dyn_package_body_exists</td>
<td>Package body @1 already exists</td>
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<tr>
<td>-901</td>
<td>336068879</td>
<td>dyn_newfc_oldsyntax</td>
<td>Cannot alter new style function @1 with ALTER EXTERNAL FUNCTION. Use ALTER FUNCTION instead.</td>
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<td>Parameter @1 in function @2 not found</td>
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<td>dyn_routine_param_not_found</td>
<td>Parameter @1 of routine @2 not found</td>
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<td>dyn_routine_param_ambiguous</td>
<td>Parameter @1 of routine @2 is ambiguous (found in both procedures and functions). Use a specifier keyword.</td>
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<td>Collation @1 is used in function @2 (parameter name @3) and cannot be dropped</td>
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<td>dyn_domain_used_function</td>
<td>Domain @1 is used in function @2 (parameter name @3) and cannot be dropped</td>
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<td>dyn_alter_user_no_clause</td>
<td>ALTER USER requires at least one clause to be specified</td>
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<td>dyn_duplicate_package_item</td>
<td>Duplicate @1 @2</td>
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<td>dyn_cant_modify_sysobj</td>
<td>System @1 @2 cannot be modified</td>
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<td>dyn_cant_use_zero_increment</td>
<td>INCREMENT BY 0 is an illegal option for sequence @1</td>
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<td>dyn_cant_use_in_foreignkey</td>
<td>Can’t use @1 in FOREIGN KEY constraint</td>
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<td>role @1 can not be granted to role @2</td>
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<td>INCREMENT BY 0 is an illegal option for identity column @1 of table @2</td>
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<td>no @1 privilege with grant option on DDL @2</td>
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<td>dyn_no_grant_opt_priv</td>
<td>no @1 privilege with grant option on object @2</td>
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<td>SQL-CODE</td>
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<td>-902</td>
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<td>shutfail</td>
<td>database shutdown unsuccessful</td>
</tr>
<tr>
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<td>no_jrn</td>
<td>long-term journaling not enabled</td>
</tr>
<tr>
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<td>dsq_error</td>
<td>Dynamic SQL Error</td>
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<td>psw_attach</td>
<td>cannot attach to password database</td>
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<td>psw_start_trans</td>
<td>cannot start transaction for password database</td>
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<td>stack size insufficient to execute current request</td>
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<td>network_error</td>
<td>Unable to complete network request to host &quot;@1&quot;.</td>
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<tr>
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<td>Failed to establish a connection.</td>
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<td>net_connect_listen_err</td>
<td>Error while listening for an incoming connection.</td>
</tr>
<tr>
<td>SQL-CODE</td>
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<td>Symbol</td>
<td>Message Text</td>
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<td>net_event_connect_err</td>
<td>Failed to establish a secondary connection for event processing.</td>
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<td>Error while listening for an incoming event connection request.</td>
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<td>net_read_err</td>
<td>Error reading data from the connection.</td>
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<td>net_write_err</td>
<td>Error writing data to the connection.</td>
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<td>unsupported_network_drive</td>
<td>Access to databases on file servers is not supported.</td>
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<td>io_create_err</td>
<td>Error while trying to create file</td>
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<td>Error while trying to open file</td>
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<td>io_close_err</td>
<td>Error while trying to close file</td>
</tr>
<tr>
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<td>io_read_err</td>
<td>Error while trying to read from file</td>
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<td>io_write_err</td>
<td>Error while trying to write to file</td>
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<td>io_delete_err</td>
<td>Error while trying to delete file</td>
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<td>io_access_err</td>
<td>Error while trying to access file</td>
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<td>login_same_as_role_name</td>
<td>Your login @1 is same as one of the SQL role name. Ask your database administrator to set up a valid Firebird login.</td>
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<td>The file @1 is currently in use by another process. Try again later.</td>
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<td>unexpected item in service parameter block, expected @1</td>
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<td>Function @1 is in @2, which is not in a permitted directory for external functions.</td>
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<tr>
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<td>File exceeded maximum size of 2GB. Add another database file or use a 64 bit I/O version of Firebird.</td>
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<td>Use of @1 at location @2 is not allowed by server configuration</td>
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<td>cursor_not_open</td>
<td>Cursor is not open</td>
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<td>cursor_already_open</td>
<td>Cursor is already open</td>
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<td>att_shutdown</td>
<td>connection shutdown</td>
</tr>
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<td>-902</td>
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<td>long_login</td>
<td>Login name too long (@1 characters, maximum allowed @2)</td>
</tr>
<tr>
<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
</tr>
<tr>
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<td>psw_db_error</td>
<td>Security database error</td>
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<td>335544970</td>
<td>missing_required_spb</td>
<td>Missing required item @1 in service parameter block</td>
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<tr>
<td>-902</td>
<td>335544971</td>
<td>net_server_shutdown</td>
<td>@1 server is shutdown</td>
</tr>
<tr>
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<td>335544974</td>
<td>no_threads</td>
<td>Could not start first worker thread - shutdown server</td>
</tr>
<tr>
<td>-902</td>
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<td>Timeout occurred while waiting for a secondary connection for event processing</td>
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<td>Database is probably already opened by another engine instance in another Windows session</td>
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<tr>
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<td>no_trusted_spb</td>
<td>Use of TRUSTED switches in spb_command_line is prohibited</td>
</tr>
<tr>
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<td>335545029</td>
<td>missing_data_structures</td>
<td>Install incomplete. To complete security database initialization please CREATE USER. For details read doc/README.security_database.txt.</td>
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<tr>
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<td>protect_sys_tab</td>
<td>@1 operation is not allowed for system table @2</td>
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<tr>
<td>-902</td>
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<td>wroblrver2</td>
<td>unsupported BLR version (expected between @1 and @2, encountered @3)</td>
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<tr>
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<td>decrypt_error</td>
<td>Missing crypt plugin, but page appears encrypted</td>
</tr>
<tr>
<td>-902</td>
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<td>no_providers</td>
<td>No providers loaded</td>
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<tr>
<td>-902</td>
<td>335545053</td>
<td>miss_config</td>
<td>Missing configuration file: @1</td>
</tr>
<tr>
<td>-902</td>
<td>335545054</td>
<td>conf_line</td>
<td>@1: illegal line <a href="mailto:$@2">$@2</a></td>
</tr>
<tr>
<td>-902</td>
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<td>conf_include</td>
<td>Invalid include operator in @1 for <a href="mailto:$@2">$@2</a></td>
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<td>335545056</td>
<td>include_depth</td>
<td>Include depth too big</td>
</tr>
<tr>
<td>-902</td>
<td>335545057</td>
<td>include_miss</td>
<td>File to include not found</td>
</tr>
<tr>
<td>-902</td>
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<td>sec_context</td>
<td>Missing security context for @1</td>
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<tr>
<td>-902</td>
<td>335545061</td>
<td>multi_segment</td>
<td>Missing segment @1 in multisegment connect block parameter</td>
</tr>
<tr>
<td>-902</td>
<td>335545062</td>
<td>login_changed</td>
<td>Different logins in connect and attach packets - client library error</td>
</tr>
<tr>
<td>-902</td>
<td>335545063</td>
<td>auth_handshake_limit</td>
<td>Exceeded exchange limit during authentication handshake</td>
</tr>
</tbody>
</table>
**Appendix B: Exception Codes and Messages**

<table>
<thead>
<tr>
<th>SQL-CODE</th>
<th>GDSCODE</th>
<th>Symbol</th>
<th>Message Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>-902</td>
<td>335545064</td>
<td>wirecrypt_incompatible</td>
<td>Incompatible wire encryption levels requested on client and server</td>
</tr>
<tr>
<td>-902</td>
<td>335545065</td>
<td>miss_wirecrypt</td>
<td>Client attempted to attach unencrypted but wire encryption is required</td>
</tr>
<tr>
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<td>wirecrypt_key</td>
<td>Client attempted to start wire encryption using unknown key @1</td>
</tr>
<tr>
<td>-902</td>
<td>335545067</td>
<td>wirecrypt_plugin</td>
<td>Client attempted to start wire encryption using unsupported plugin @1</td>
</tr>
<tr>
<td>-902</td>
<td>335545068</td>
<td>secdb_name</td>
<td>Error getting security database name from configuration file</td>
</tr>
<tr>
<td>-902</td>
<td>335545069</td>
<td>auth_data</td>
<td>Client authentication plugin is missing required data from server</td>
</tr>
<tr>
<td>-902</td>
<td>335545070</td>
<td>auth_datalength</td>
<td>Client authentication plugin expected @2 bytes of @3 from server, got @1</td>
</tr>
<tr>
<td>-902</td>
<td>335545106</td>
<td>login_error</td>
<td>Error occurred during login, please check server firebird.log for details</td>
</tr>
<tr>
<td>-902</td>
<td>335545107</td>
<td>already_opened</td>
<td>Database already opened with engine instance, incompatible with current</td>
</tr>
<tr>
<td>-902</td>
<td>335545108</td>
<td>bad_crypt_key</td>
<td>Invalid crypt key @1</td>
</tr>
<tr>
<td>-902</td>
<td>335545112</td>
<td>miss_prvlg</td>
<td>System privilege @1 is missing</td>
</tr>
<tr>
<td>-902</td>
<td>335545113</td>
<td>crypt_checksum</td>
<td>Invalid or missing checksum of encrypted database</td>
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<tr>
<td>-902</td>
<td>335545114</td>
<td>not_dba</td>
<td>You must have SYSDBA rights at this server</td>
</tr>
<tr>
<td>-902</td>
<td>335545126</td>
<td>sql_too_long</td>
<td>SQL statement is too long. Maximum size is @1 bytes.</td>
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<tr>
<td>-902</td>
<td>335545130</td>
<td>att_shut_killed</td>
<td>Killed by database administrator.</td>
</tr>
<tr>
<td>-902</td>
<td>335545131</td>
<td>att_shut_idle</td>
<td>Idle timeout expired.</td>
</tr>
<tr>
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<td>att_shut_db_down</td>
<td>Database is shutdown.</td>
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<td>335545133</td>
<td>att_shut_engine</td>
<td>Engine is shutdown.</td>
</tr>
<tr>
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<td>overriding_without_identity</td>
<td>OVERRIDING clause can be used only when an identity column is present in the INSERT's field list for table/view @1</td>
</tr>
<tr>
<td>-902</td>
<td>335545135</td>
<td>overriding_system_invalid</td>
<td>OVERRIDING SYSTEM VALUE can be used only for identity column defined as 'GENERATED ALWAYS' in INSERT for table/view @1</td>
</tr>
<tr>
<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
</tr>
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<td>OVERRIDING USER VALUE can be used only for identity column defined as 'GENERATED BY DEFAULT' in INSERT for table/view @1</td>
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<td>overriding_system_missing</td>
<td>OVERRIDING SYSTEM VALUE should be used to override the value of an identity column defined as 'GENERATED ALWAYS' in table/view @1</td>
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<td>335545166</td>
<td>icu_entrypoint</td>
<td>Missing entrypoint @1 in ICU library</td>
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<tr>
<td>-902</td>
<td>335545167</td>
<td>icu_library</td>
<td>Could not find acceptable ICU library</td>
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<tr>
<td>-902</td>
<td>335545170</td>
<td>icnv_open</td>
<td>Error opening international conversion descriptor from @1 to @2</td>
</tr>
<tr>
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<td>335545173</td>
<td>deflate_init</td>
<td>Compression stream init error @1</td>
</tr>
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<td>inflate_init</td>
<td>Decompression stream init error @1</td>
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<td>335545180</td>
<td>non_plugin_protocol</td>
<td>Plugin not supported by network protocol</td>
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<td>-902</td>
<td>335545200</td>
<td>map_event</td>
<td>Error using events in mapping shared memory: @1</td>
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<tr>
<td>-902</td>
<td>335545201</td>
<td>map_overflow</td>
<td>Global mapping memory overflow</td>
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<tr>
<td>-902</td>
<td>335545204</td>
<td>db_crypt_key</td>
<td>Missing database encryption key for your attachment</td>
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<tr>
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<td>335545259</td>
<td>bind_err</td>
<td>Error processing isc_dpb_set_bind clumplet &quot;@1&quot;</td>
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<td>-902</td>
<td>335545260</td>
<td>bind_statement</td>
<td>The following statement failed: @1</td>
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<td>335545270</td>
<td>wrong_page</td>
<td>RDB$PAGES written by non-system transaction, DB appears to be damaged</td>
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<td>repl_error</td>
<td>Replication error</td>
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<td>335545272</td>
<td>ses_reset_failed</td>
<td>Reset of user session failed. Connection is shut down.</td>
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<td>block_size</td>
<td>File size is less than expected</td>
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<td>bad_db_handle</td>
<td>invalid database handle (no active connection)</td>
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<td>unavailable</td>
<td>unavailable database</td>
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<td>imp_exc</td>
<td>Implementation limit exceeded</td>
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<td>335544386</td>
<td>nopoolids</td>
<td>too many requests</td>
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<td>bufexh</td>
<td>buffer exhausted</td>
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<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
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<td>request in use</td>
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<td>no_lock_mgr</td>
<td>no lock manager available</td>
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<td>virmemexh</td>
<td>unable to allocate memory from operating system</td>
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<td>update_conflict</td>
<td>update conflicts with concurrent update</td>
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<td>obj_in_use</td>
<td>object @1 is in use</td>
</tr>
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<td>335544455</td>
<td>shadow_accessed</td>
<td>cannot attach active shadow file</td>
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<tr>
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<td>335544460</td>
<td>shadow_missing</td>
<td>a file in manual shadow @1 is unavailable</td>
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<td>335544461</td>
<td>index_root_page_full</td>
<td>cannot add index, index root page is full.</td>
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<td>sort error: not enough memory</td>
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<td>req_depth_exceeded</td>
<td>request depth exceeded. (Recursive definition?)</td>
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<td>sort_rec_size_err</td>
<td>sort record size of @1 bytes is too big</td>
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<td>too_many_handles</td>
<td>too many open handles to database</td>
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<td>optimizer_blk_exc</td>
<td>size of optimizer block exceeded</td>
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<td>-904</td>
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<td>service_att_err</td>
<td>Cannot attach to services manager</td>
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<td>svc_name_missing</td>
<td>The service name was not specified.</td>
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<td>Unsupported field type specified in BETWEEN predicate.</td>
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<td>Invalid argument in EXECUTE STATEMENT - cannot convert to string</td>
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<td>exec_sql_invalid_req</td>
<td>Wrong request type in EXECUTE STATEMENT '@1'</td>
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<tr>
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<td>exec_sql_invalid_var</td>
<td>Variable type (position @1) in EXECUTE STATEMENT '@2' INTO does not match returned column type</td>
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<td>exec_sql_max_call_exceeded</td>
<td>Too many recursion levels of EXECUTE STATEMENT</td>
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<td>3355444832</td>
<td>wrong_backup_state</td>
<td>Cannot change difference file name while database is in backup mode</td>
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<td>3355444833</td>
<td>wal_backup_err</td>
<td>Physical backup is not allowed while Write-Ahead Log is in use</td>
</tr>
<tr>
<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
</tr>
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<td>----------</td>
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<td>-----------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
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<td>partner_idx_incompat_type</td>
<td>partner index segment no @1 has incompatible data type</td>
</tr>
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<td>blobtoobig</td>
<td>Maximum BLOB size exceeded</td>
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<td>335544862</td>
<td>record_lock_not_supp</td>
<td>Stream does not support record locking</td>
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<td>-904</td>
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<td>partner_idx_not_found</td>
<td>Cannot create foreign key constraint @1. Partner index does not exist or is inactive.</td>
</tr>
<tr>
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<td>335544864</td>
<td>tra_num_exc</td>
<td>Transactions count exceeded. Perform backup and restore to make database operable again</td>
</tr>
<tr>
<td>-904</td>
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Appendix C: Reserved Words and Keywords

Reserved words are part of the Firebird SQL language. They cannot be used as identifiers (e.g. as table or procedure names), except when enclosed in double quotes in Dialect 3. However, you should avoid this unless you have a compelling reason.

Keywords are also part of the language. They have a special meaning when used in the proper context, but they are not reserved for Firebird's own and exclusive use. You can use them as identifiers without double-quoting.

Reserved words

Full list of reserved words in Firebird 4.0:

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Appendix C: Reserved Words and Keywords

HAVING HOUR IN
INDEX INNER INSENSITIVE
INSERT INSERTING INT
INT128 INTEGER INTO
IS JOIN LATERAL
LEADING LEFT LIKE
LOCAL LOCALTIME LOCALTIMESTAMP
LONG LOWER MAX
MERGE MIN MINUTE
MONTH NATIONAL NATURAL
NCHAR NO NOT
NULL NUMERIC OCTET_LENGTH
OF OFFSET ON
ONLY OPEN OR
ORDER OUTER OVER
PARAMETER PLAN POSITION
POST_EVENT PRECISION PRIMARY
PROCEDURE PUBLICATION RDB$DB_KEY
RDB$ERROR RDB$GET_CONTEXT RDB$GET_TRANSACTION_CN
RDB$RECORD_VERSION RDB$ROLE_IN_USE RDB$SET_CONTEXT
RDB$SYSTEM_PRIVILEGE REAL RECORD_VERSION
RECREATE RECURSIVE REFERENCES
REGR_AVGX REGR_AVGY REGR_COUNT
REGR_INTERCEPT REGR_R2 REGR_SLOPE
REGR_SXX REGR_SXY REGR_SYY
RELEASE RESETING RETURN
RETURNING_VALUES RETURNS REVOKE
RIGHT ROLLBACK ROW
ROWS ROW_COUNT SAVEPOINT
SCROLL SECOND SELECT
SENSITIVE SET SIMILAR
SMALLINT SOME SQLCODE
SQLSTATE START STDDEV_POP
STDDEV_SAMP SUM TABLE
THEN TIME TIMESTAMP
TIMEZONE_HOUR TIMEZONE_MINUTE TO
TRAILING TRIGGER TRIM
TRUE UNBOUNDED UNION
UNIQUE UNKNOWN UPDATE

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Keywords

The following terms have a special meaning in Firebird 4.0 DSQL. Some of them are also reserved words, others are not.

!< ^< ^=
^> , :=
!= !> ( 
) < ⇐
<> = >
=> || ~<
~= ~> ABS
ABSOLUTE ACCENT ACOS
ACOSH ACTION ACTIVE
ADD ADMIN AFTER
ALL ALTER ALWAYS
AND ANY AS
ASC ASCENDING ASCII_CHAR
ASCII_VAL ASIN ASINH
AT ATAN ATAN2
ATANH AUTO AUTONOMOUS
AVG BACKUP BASE64_DECODE
BASE64_ENCODE BEFORE BEGIN
BETWEEN BIGINT BINARY
BIND BIN_AND BIN_NOT
BIN_OR BIN_SHL BIN_SHR
BIN_XOR BIN_LENGTH BLOB
BLOCK BODY BOOLEAN
both BREAK BY
caller CASCADE CASE
cast CEIL CEILING
char CHARACTER CHARACTER_LENGTH
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</tbody>
</table>
Appendix D: System Tables

When you create a database, the Firebird engine creates a lot of system tables. Metadata — the descriptions and attributes of all database objects — are stored in these system tables.

System table identifiers all begin with the prefix RDB$.

List of System Tables

- **RDB$AUTH_MAPPING**: Stores authentication and other security mappings
- **RDB$BACKUP_HISTORY**: History of backups performed using nBackup
- **RDB$CHARACTER_SETS**: Names and describes the character sets available in the database
- **RDB$CHECK_CONSTRAINTS**: Cross references between the names of constraints (NOT NULL constraints, CHECK constraints and ON UPDATE and ON DELETE clauses in foreign key constraints) and their associated system-generated triggers
- **RDB$COLLATIONS**: Collation sequences for all character sets
- **RDB$CONFIG**: Virtual table with configuration settings applied for the current database
- **RDB$DATABASE**: Basic information about the database
- **RDB$DB_CREATORS**: A list of users granted the CREATE DATABASE privilege when using the specified database as a security database
- **RDB$DEPENDENCIES**: Information about dependencies between database objects
- **RDB$EXCEPTIONS**: Custom database exceptions
- **RDB$FIELDS**: Column and domain definitions, both system and custom
- **RDB$FIELD_DIMENSIONS**: Dimensions of array columns
RDB$FILES
  Information about secondary files and shadow files

RDB$FILTERS
  Information about BLOB filters

RDB$FORMATS
  Information about changes in the formats of tables

RDB$FUNCTIONS
  Information about external functions

RDB$FUNCTION_ARGUMENTS
  Attributes of the parameters of external functions

RDB$GENERATORS
  Information about generators (sequences)

RDB$INDEX_SEGMENTS
  Segments and index positions

RDB$INDICES
  Definitions of all indexes in the database (system- or user-defined)

RDB$LOG_FILES
  Not used in the current version

RDB$PACKAGES
  Stores the definition (header and body) of SQL packages

RDB$PAGES
  Information about database pages

RDB$PROCEDURES
  Definitions of stored procedures

RDB$PROCEDURE_PARAMETERS
  Parameters of stored procedures

RDB$REF_CONSTRAINTS
  Definitions of referential constraints (foreign keys)

RDB$RELATIONS
  Headers of tables and views

RDB$RELATION_CONSTRAINTS
  Definitions of all table-level constraints
**RDB$RELATION_FIELDS**
Top-level definitions of table columns

**RDB$ROLES**
Role definitions

**RDB$SECURITY_CLASSES**
Access control lists

**RDB$TIME_ZONES**
Time zones

**RDB$TRANSACTIONS**
State of multi-database transactions

**RDB$TRIGGERS**
Trigger definitions

**RDB$TRIGGER_MESSAGES**
Trigger messages

**RDB$TYPES**
Definitions of enumerated data types

**RDB$USER_PRIVILEGES**
SQL privileges granted to system users

**RDB$VIEW_RELATIONS**
Tables that are referred to in view definitions: one record for each table in a view

**RDB$AUTH_MAPPING**

**RDB$AUTH_MAPPING** stores authentication and other security mappings.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$MAP_NAME</td>
<td>CHAR(63)</td>
<td>Name of the mapping</td>
</tr>
<tr>
<td>RDB$MAP_USING</td>
<td>CHAR(1)</td>
<td>Using definition:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P - plugin (specific or any)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S - any plugin serverwide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M - mapping</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* - any method</td>
</tr>
<tr>
<td>RDB$MAP_PLUGIN</td>
<td>CHAR(63)</td>
<td>Mapping applies for authentication information from this specific plugin</td>
</tr>
<tr>
<td>RDB$MAP_DB</td>
<td>CHAR(63)</td>
<td>Mapping applies for authentication information from this specific database</td>
</tr>
</tbody>
</table>
### RDB$MAP_FROM_TYPE
- **Column Name**: RDB$MAP_FROM_TYPE
- **Data Type**: CHAR(63)
- **Description**: The type of authentication object (defined by plugin) to map from, or * for any type

### RDB$MAP_FROM
- **Column Name**: RDB$MAP_FROM
- **Data Type**: CHAR(255)
- **Description**: The name of the authentication object to map from

### RDB$MAP_TO_TYPE
- **Column Name**: RDB$MAP_TO_TYPE
- **Data Type**: SMALLINT
- **Description**: The type to map to
  - 0 - USER
  - 1 - ROLE

### RDB$MAP_TO
- **Column Name**: RDB$MAP_TO
- **Data Type**: CHAR(63)
- **Description**: The name to map to

### RDB$SYSTEM_FLAG
- **Column Name**: RDB$SYSTEM_FLAG
- **Data Type**: SMALLINT
- **Description**: Flag:
  - 0 - user-defined
  - 1 or higher - system-defined

### RDB$DESCRIPTION
- **Column Name**: RDB$DESCRIPTION
- **Data Type**: BLOB TEXT
- **Description**: Optional description of the mapping (comment)

---

### RDB$BACKUP_HISTORY

**RDB$BACKUP_HISTORY** stores the history of backups performed using the nBackup utility.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$BACKUP_ID</td>
<td>INTEGER</td>
<td>The identifier assigned by the engine</td>
</tr>
<tr>
<td>RDB$TIMESTAMP</td>
<td>TIMESTAMP</td>
<td>Backup date and time</td>
</tr>
<tr>
<td>RDB$BACKUP_LEVEL</td>
<td>INTEGER</td>
<td>Backup level</td>
</tr>
<tr>
<td>RDB$GUID</td>
<td>CHAR(38)</td>
<td>Unique identifier</td>
</tr>
<tr>
<td>RDB$SCN</td>
<td>INTEGER</td>
<td>System (scan) number</td>
</tr>
<tr>
<td>RDB$FILE_NAME</td>
<td>VARCHAR(255)</td>
<td>Full path and file name of backup file</td>
</tr>
</tbody>
</table>

---

### RDB$CHARACTER_SETS

**RDB$CHARACTER_SETS** names and describes the character sets available in the database.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$CHARACTER_SET_NAME</td>
<td>CHAR(63)</td>
<td>Character set name</td>
</tr>
<tr>
<td>RDB$FORM_OF_USE</td>
<td>CHAR(63)</td>
<td>Not used</td>
</tr>
<tr>
<td>RDB$NUMBER_OF_CHARACTERS</td>
<td>INTEGER</td>
<td>The number of characters in the set. Not used for existing character sets</td>
</tr>
<tr>
<td>RDB$DEFAULT_COLLATE_NAME</td>
<td>CHAR(63)</td>
<td>The name of the default collation sequence for the character set</td>
</tr>
</tbody>
</table>
### Appendix D: System Tables

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$CHARACTER_SET_ID</td>
<td>SMALLINT</td>
<td>Unique character set identifier</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>System flag: value is 1 if the character set is defined in the system when the database is created; value is 0 for a user-defined character set</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Could store text description of the character set</td>
</tr>
<tr>
<td>RDB$FUNCTION_NAME</td>
<td>CHAR(63)</td>
<td>For a user-defined character set that is accessed via an external function, the name of the external function</td>
</tr>
<tr>
<td>RDB$BYTES_PER_CHARACTER</td>
<td>SMALLINT</td>
<td>The maximum number of bytes representing one character</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May reference a security class defined in the table RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this character set</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The user name of the user who created the character set originally</td>
</tr>
</tbody>
</table>

**RDB$CHECK_CONSTRAINTS**

RDB$CHECK_CONSTRAINTS provides the cross references between the names of system-generated triggers for constraints and the names of the associated constraints (NOT NULL constraints, CHECK constraints and the ON UPDATE and ON DELETE clauses in foreign key constraints).

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$CONSTRAINT_NAME</td>
<td>CHAR(63)</td>
<td>Constraint name, defined by the user or automatically generated by the system</td>
</tr>
<tr>
<td>RDB$TRIGGER_NAME</td>
<td>CHAR(63)</td>
<td>For a CHECK constraint, it is the name of the trigger that enforces this constraint. For a NOT NULL constraint, it is the name of the table the constraint is applied to. For a foreign key constraint, it is the name of the trigger that enforces the ON UPDATE, ON DELETE clauses.</td>
</tr>
</tbody>
</table>

**RDB$COLLATIONS**

RDB$COLLATIONS stores collation sequences for all character sets.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$COLLATION_NAME</td>
<td>CHAR(63)</td>
<td>Collation sequence name</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$COLLATION_ID</td>
<td>SMALLINT</td>
<td>Collation sequence identifier. Together with the character set identifier, it is a unique collation sequence identifier</td>
</tr>
<tr>
<td>RDB$CHARACTER_SET_ID</td>
<td>SMALLINT</td>
<td>Character set identifier. Together with the collection sequence identifier, it is a unique identifier</td>
</tr>
<tr>
<td>RDB$COLLATION_ATTRIBUTES</td>
<td>SMALLINT</td>
<td>Collation attributes. It is a bit mask where the first bit shows whether trailing spaces should be taken into account in collations (0 - NO PAD; 1 - PAD SPACE); the second bit shows whether the collation is case-sensitive (0 - CASE SENSITIVE, 1 - CASE INSENSITIVE); the third bit shows whether the collation is accent-sensitive (0 - ACCENT SENSITIVE, 1 - ACCENT SENSITIVE). Thus, the value of 5 means that the collation does not take into account trailing spaces and is accent-insensitive</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag: the value of 0 means it is user-defined; the value of 1 means it is system-defined</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Could store text description of the collation sequence</td>
</tr>
<tr>
<td>RDB$FUNCTION_NAME</td>
<td>CHAR(63)</td>
<td>Not currently used</td>
</tr>
<tr>
<td>RDB$BASE_COLLATION_NAME</td>
<td>CHAR(63)</td>
<td>The name of the base collation sequence for this collation sequence</td>
</tr>
<tr>
<td>RDB$SPECIFIC_ATTRIBUTES</td>
<td>BLOB TEXT</td>
<td>Describes specific attributes</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May reference a security class defined in the table RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this collation</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The user name of the user who created the collation originally</td>
</tr>
</tbody>
</table>

**RDB$CONFIG**

RDB$CONFIG is a virtual table showing the configuration settings of the current database for the current connection.

Table RDB$CONFIG is populated from in-memory structures upon request and its instance is preserved for the SQL query lifetime. For security reasons, access to this table is allowed for
administrators only. Non-privileged users see no rows in this table (and no error is raised).

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>RDB$CONFIG_ID</td>
<td>INTEGER</td>
<td>Unique row identifier, no special meaning</td>
</tr>
<tr>
<td>RDB$CONFIG_NAME</td>
<td>VARCHAR(63)</td>
<td>Setting name (e.g. TempCacheLimit)</td>
</tr>
<tr>
<td>RDB$CONFIG_VALUE</td>
<td>VARCHAR(255)</td>
<td>Actual value of setting</td>
</tr>
<tr>
<td>RDB$CONFIG_DEFAULT</td>
<td>VARCHAR(255)</td>
<td>Default value of setting (defined in the Firebird code)</td>
</tr>
<tr>
<td>RDB$CONFIG_IS_SET</td>
<td>BOOLEAN</td>
<td>TRUE if value is explicitly configured, FALSE when default</td>
</tr>
<tr>
<td>RDB$CONFIG_SOURCE</td>
<td>VARCHAR(255)</td>
<td>Name of the configuration file (relative to the Firebird root directory)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>where this setting was taken from, or special value DPB if the setting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>was specified by the client application via API.</td>
</tr>
</tbody>
</table>

**RDB$DATABASE**

RDB$DATABASE stores basic information about the database. It contains only one record.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Database comment text</td>
</tr>
<tr>
<td>RDB$RELATION_ID</td>
<td>SMALLINT</td>
<td>A number that steps up by one each time a table or view is added to the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>database</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>The security class defined in RDB$SECURITY_CLASSES in order to apply</td>
</tr>
<tr>
<td></td>
<td></td>
<td>access control limits common to the entire database</td>
</tr>
<tr>
<td>RDB$CHARACTER_SET_NAME</td>
<td>CHAR(63)</td>
<td>The name of the default character set for the database set in the DEFAULT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CHARACTER SET clause when the database is created. NULL for character set</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NONE.</td>
</tr>
<tr>
<td>RDB$LINGER</td>
<td>INTEGER</td>
<td>Number of seconds &quot;delay&quot; (established with the ALTER DATABASE SET LINGER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>statement) until the database file is closed after the last connection to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>this database is closed (in SuperServer). NULL if no delay is set.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$SQL_SECURITY</td>
<td>BOOLEAN</td>
<td>The default SQL SECURITY mode (DEFINER or INVOKER) applied to newly created objects:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NULL - initial default (INVOKER)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TRUE - DEFINER</td>
</tr>
</tbody>
</table>

**RDB$DB_CREATORS**

RDB$DB_CREATORS contains a list of users granted the CREATE DATABASE privilege when using the specified database as a security database.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$USER</td>
<td>CHAR(63)</td>
<td>User or role name</td>
</tr>
<tr>
<td>RDB$USER_TYPE</td>
<td>SMALLINT</td>
<td>Type of user</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - user</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13 - role</td>
</tr>
</tbody>
</table>

**RDB$DEPENDENCIES**

RDB$DEPENDENCIES stores the dependencies between database objects.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$DEPENDENT_NAME</td>
<td>CHAR(63)</td>
<td>The name of the view, procedure, trigger, CHECK constraint or computed column the dependency is defined for, i.e., the dependent object</td>
</tr>
<tr>
<td>RDB$DEPENDED_ON_NAME</td>
<td>CHAR(63)</td>
<td>The name of the object that the defined object — the table, view, procedure, trigger, CHECK constraint or computed column — depends on</td>
</tr>
<tr>
<td>RDB$FIELD_NAME</td>
<td>CHAR(63)</td>
<td>The column name in the depended-on object that is referred to by the dependent view, procedure, trigger, CHECK constraint or computed column</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$DEPENDENT_TYPE</td>
<td>SMALLINT</td>
<td>Identifies the type of the dependent object:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - table</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - view</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - trigger</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - computed column</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - CHECK constraint</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - procedure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 - index expression</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 - exception</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - user</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 - column</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 - index</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 - stored function</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18 - package header</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19 - package body</td>
</tr>
<tr>
<td>RDB$DEPENDED_ON_TYPE</td>
<td>SMALLINT</td>
<td>Identifies the type of the object depended on:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - table (or a column in it)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - view</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - trigger</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - computed column</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - CHECK constraint</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - procedure (or its parameter(s))</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 - index expression</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 - exception</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - user</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 - column</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 - index</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 - generator (sequence)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 - UDF or stored function</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17 - collation 18 - package header</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19 - package body</td>
</tr>
<tr>
<td>RDB$PACKAGE_NAME</td>
<td>CHAR(63)</td>
<td>The package of a procedure or function for which this describes the dependency.</td>
</tr>
</tbody>
</table>

**RDB$EXCEPTIONS**

RDB$EXCEPTIONS stores custom database exceptions.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$EXCEPTION_NAME</td>
<td>CHAR(63)</td>
<td>Custom exception name</td>
</tr>
</tbody>
</table>
### RDB$FIELDS

RDB$FIELDS stores definitions of columns and domains, both system and custom. This is where the detailed data attributes are stored for all columns.

The column `RDB$FIELDS.RDB$FIELD_NAME` links to `RDB$RELATION_FIELDS.RDB$FIELD_SOURCE`, not to `RDB$RELATION_FIELDS.RDB$FIELD_NAME`.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$FIELD_NAME</td>
<td>CHAR(63)</td>
<td>The unique name of the domain created by the user or of the domain automatically built for the table column by the system. System-created domain names start with the “RDB$” prefix.</td>
</tr>
<tr>
<td>RDB$QUERY_NAME</td>
<td>CHAR(63)</td>
<td>Not used</td>
</tr>
<tr>
<td>RDB$VALIDATION_BLR</td>
<td>BLOB BLR</td>
<td>The binary language representation (BLR) of the SQL expression specifying the check of the CHECK value in the domain</td>
</tr>
<tr>
<td>RDB$VALIDATION_SOURCE</td>
<td>BLOB TEXT</td>
<td>The original source text in the SQL language specifying the check of the CHECK value</td>
</tr>
<tr>
<td>RDB$COMPUTED_BLR</td>
<td>BLOB BLR</td>
<td>The binary language representation (BLR) of the SQL expression the database server uses for evaluation when accessing a COMPUTED BY column</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$COMPUTED_SOURCE</td>
<td>BLOB TEXT</td>
<td>The original source text of the expression that defines a COMPUTED BY column</td>
</tr>
<tr>
<td>RDB$DEFAULT_VALUE</td>
<td>BLOB BLR</td>
<td>The default value, if any, for the field or domain, in binary language representation (BLR)</td>
</tr>
<tr>
<td>RDB$DEFAULT_SOURCE</td>
<td>BLOB TEXT</td>
<td>The default value in the source code, as an SQL constant or expression</td>
</tr>
<tr>
<td>RDB$FIELD_LENGTH</td>
<td>SMALLINT</td>
<td>Column size in bytes. BOOLEAN occupies 1 byte. FLOAT, DATE, TIME, INTEGER occupy 4 bytes. DOUBLE PRECISION, BIGINT, DATE, TIME WITH TIME ZONE, TIMESTAMP, TIMESTAM, DECIMAL and BLOB identifiers occupy 8 bytes. TIMESTAMP WITH TIME ZONE occupies 12 bytes. INT128 and DECFLOAT(34) occupy 16 bytes. For the CHAR and VARCHAR data types, the column stores the maximum number of bytes specified when a string domain (column) is defined</td>
</tr>
<tr>
<td>RDB$FIELD_SCALE</td>
<td>SMALLINT</td>
<td>The negative number that specifies the scale for DECIMAL and NUMERIC columns — the number of digits after the decimal point</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>-------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$FIELD_TYPE</td>
<td>SMALLINT</td>
<td>Data type code for the column:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 - SMALLINT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - INTEGER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 - FLOAT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 - DATE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13 - TIME</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 - CHAR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 - BIGINT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23 - BOOLEAN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 - DECFLOAT(16)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 - DECFLOAT(34)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26 - INT128</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27 - DOUBLE PRECISION</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28 - TIME WITH TIME ZONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>29 - TIMESTAMP WITH TIME ZONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35 - TIMESTAMP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>37 - VARCHAR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>261 - BLOB</td>
</tr>
</tbody>
</table>

Codes for DECIMAL and NUMERIC are the same as for the integer types used for storage.
<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$FIELD_SUB_TYPE</td>
<td>SMALLINT</td>
<td>Specifies the subtype for the BLOB data type:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - untyped</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - text</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - BLR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - access control list</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - reserved for future use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - encoded table metadata description</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 - for storing the details of a cross-database transaction that ends abnormally</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 - external file description</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - debug information (for PSQL)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Specifies for the CHAR data type:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - untyped data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - fixed binary data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Specifies the particular data type for the integer data types (SMALLINT,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>INTEGER, BIGINT, INT128)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 or NULL - the data type matches the value in the RDB$FIELD_TYPE field</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - NUMERIC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - DECIMAL</td>
</tr>
<tr>
<td>RDB$MISSING_VALUE</td>
<td>BLOB BLR</td>
<td>Not used</td>
</tr>
<tr>
<td>RDB$MISSING_SOURCE</td>
<td>BLOB TEXT</td>
<td>Not used</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Any domain (table column) comment text</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag: the value of 1 means the domain is automatically created by the system,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the value of 0 means that the domain is defined by the user</td>
</tr>
<tr>
<td>RDB$QUERY_HEADER</td>
<td>BLOB TEXT</td>
<td>Not used</td>
</tr>
<tr>
<td>RDB$SEGMENT_LENGTH</td>
<td>SMALLINT</td>
<td>Specifies the length of the BLOB buffer in bytes for BLOB columns. Stores</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NULL for all other data types</td>
</tr>
<tr>
<td>RDB$EDIT_STRING</td>
<td>VARCHAR(127)</td>
<td>Not used</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-----------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$EXTERNAL_LENGTH</td>
<td>SMALLINT</td>
<td>The length of the column in bytes if it belongs to an external table. Always NULL for regular tables</td>
</tr>
<tr>
<td>RDB$EXTERNAL_SCALE</td>
<td>SMALLINT</td>
<td>The scale factor of an integer-type field in an external table; represents the power of 10 by which the integer is multiplied</td>
</tr>
<tr>
<td>RDB$EXTERNAL_TYPE</td>
<td>SMALLINT</td>
<td>The data type of the field as it is represented in an external table:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 - SMALLINT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - INTEGER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 - FLOAT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 - DATE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13 - TIME</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 - CHAR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 - BIGINT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23 - BOOLEAN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 - DECFLOAT(16)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 - DECFLOAT(34)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26 - INT128</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27 - DOUBLE PRECISION</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28 - TIME WITH TIME ZONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>29 - TIMESTAMP WITH TIME ZONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35 - TIMESTAMP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>37 - VARCHAR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>261 - BLOB</td>
</tr>
<tr>
<td>RDB$DIMENSIONS</td>
<td>SMALLINT</td>
<td>Defines the number of dimensions in an array if the column is defined as an array. Always NULL for columns that are not arrays</td>
</tr>
<tr>
<td>RDB$NULL_FLAG</td>
<td>SMALLINT</td>
<td>Specifies whether the column can take an empty value (the field will contain NULL) or not (the field will contain the value of 1)</td>
</tr>
<tr>
<td>RDB$CHARACTER_LENGTH</td>
<td>SMALLINT</td>
<td>The length of CHAR or VARCHAR columns in characters (not in bytes)</td>
</tr>
<tr>
<td>RDB$COLLATION_ID</td>
<td>SMALLINT</td>
<td>The identifier of the collation sequence for a character column or domain. If it is not defined, the value of the field will be 0</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$CHARACTER_SET_ID</td>
<td>SMALLINT</td>
<td>The identifier of the character set for a character column, BLOB TEXT column or domain</td>
</tr>
<tr>
<td>RDB$FIELD_PRECISION</td>
<td>SMALLINT</td>
<td>Specifies the total number of digits for the fixed-point numeric data type (DECIMAL and NUMERIC). The value is 0 for the integer data types, NULL is for other data types</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May reference a security class defined in the table RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this domain</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The username of the user who created the domain originally</td>
</tr>
</tbody>
</table>

**RDB$FIELD_DIMENSIONS**

RDB$FIELD_DIMENSIONS stores the dimensions of array columns.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$FIELD_NAME</td>
<td>CHAR(63)</td>
<td>The name of the array column. It must be present in the RDB$FIELD_NAME field of the RDB$FIELDS table</td>
</tr>
<tr>
<td>RDB$DIMENSION</td>
<td>SMALLINT</td>
<td>Identifies one dimension in the array column. The numbering of dimensions starts with 0</td>
</tr>
<tr>
<td>RDB$LOWER_BOUND</td>
<td>INTEGER</td>
<td>The lower bound of this dimension</td>
</tr>
<tr>
<td>RDB$UPPER_BOUND</td>
<td>INTEGER</td>
<td>The upper bound of this dimension</td>
</tr>
</tbody>
</table>

**RDB$FILES**

RDB$FILES stores information about secondary files and shadow files.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$FILE_NAME</td>
<td>VARCHAR(255)</td>
<td>The full path to the file and the name of either</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• the database secondary file in a multi-file database, or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• the shadow file</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$FILE_SEQUENCE</td>
<td>SMALLINT</td>
<td>The sequential number of the secondary file in a sequence or of the shadow file in a shadow file set</td>
</tr>
<tr>
<td>RDB$FILE_START</td>
<td>INTEGER</td>
<td>The initial page number in the secondary file or shadow file</td>
</tr>
<tr>
<td>RDB$FILE_LENGTH</td>
<td>INTEGER</td>
<td>File length in database pages</td>
</tr>
<tr>
<td>RDB$FILE_FLAGS</td>
<td>SMALLINT</td>
<td>For internal use</td>
</tr>
<tr>
<td>RDB$SHADOW_NUMBER</td>
<td>SMALLINT</td>
<td>Shadow set number. If the row describes a database secondary file, the field will be NULL or its value will be 0</td>
</tr>
</tbody>
</table>

**RDB$FILTERS**

RDB$FILTERS stores information about BLOB filters.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$FUNCTION_NAME</td>
<td>CHAR(63)</td>
<td>The unique identifier of the BLOB filter</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Documentation about the BLOB filter and the two subtypes it is used with, written by the user</td>
</tr>
<tr>
<td>RDB$MODULE_NAME</td>
<td>VARCHAR(255)</td>
<td>The name of the dynamic library or shared object where the code of the BLOB filter is located</td>
</tr>
<tr>
<td>RDB$ENTRYPOINT</td>
<td>CHAR(255)</td>
<td>The exported name of the BLOB filter in the filter library. Note, this is often not the same as RDB$FUNCTION_NAME, which is the identifier with which the BLOB filter is declared to the database</td>
</tr>
<tr>
<td>RDB$INPUT_SUB_TYPE</td>
<td>SMALLINT</td>
<td>The BLOB subtype of the data to be converted by the function</td>
</tr>
<tr>
<td>RDB$OUTPUT_SUB_TYPE</td>
<td>SMALLINT</td>
<td>The BLOB subtype of the converted data</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag indicating whether the filter is user-defined or internally defined:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - user-defined</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 or greater - internally defined</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May reference a security class defined in the table RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this filter</td>
</tr>
</tbody>
</table>
### RDB$FORMATS

RDB$FORMATS stores information about changes in tables. Each time any metadata change to a table is committed, it gets a new format number. When the format number of any table reaches 255, or any view 32,000, the entire database becomes inoperable. To return to normal, the database must be backed up with the `gbak` utility and restored from that backup copy.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$RELATION_ID</td>
<td>SMALLINT</td>
<td>Table or view identifier</td>
</tr>
<tr>
<td>RDB$FORMAT</td>
<td>SMALLINT</td>
<td>Table format identifier — maximum 255 for tables, 32,000 for views. The critical time comes when this number approaches 255 for any table or 32,000 for any view</td>
</tr>
<tr>
<td>RDB$DESCRIPTOR</td>
<td>BLOB FORMAT</td>
<td>Stores column names and data attributes as BLOB, as they were at the time the format record was created</td>
</tr>
</tbody>
</table>

### RDB$FUNCTIONS

RDB$FUNCTIONS stores the information needed by the engine about stored functions and external functions (user-defined functions, UDFs).

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$FUNCTION_NAME</td>
<td>CHAR(63)</td>
<td>The unique (declared) name of the external function</td>
</tr>
<tr>
<td>RDB$FUNCTION_TYPE</td>
<td>SMALLINT</td>
<td>Not currently used</td>
</tr>
<tr>
<td>RDB$QUERY_NAME</td>
<td>CHAR(63)</td>
<td>Not currently used</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Any text with comments related to the external function</td>
</tr>
<tr>
<td>RDB$MODULE_NAME</td>
<td>VARCHAR(255)</td>
<td>The name of the dynamic library or shared object where the code of the external function is located</td>
</tr>
<tr>
<td>RDB$ENTRYPOINT</td>
<td>CHAR(255)</td>
<td>The exported name of the external function in the function library. Note, this is often not the same as RDB$FUNCTION_NAME, which is the identifier with which the external function is declared to the database</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$RETURN_ARGUMENT</td>
<td>SMALLINT</td>
<td>The position number of the returned argument in the list of parameters corresponding to input arguments</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag indicating whether the filter is user-defined or internally defined: 0 - user-defined, 1 - internally defined</td>
</tr>
<tr>
<td>RDB$ENGINE_NAME</td>
<td>CHAR(63)</td>
<td>Engine for external functions. 'UDR' for UDR functions. NULL for legacy UDF or PSQL functions</td>
</tr>
<tr>
<td>RDB$PACKAGE_NAME</td>
<td>CHAR(63)</td>
<td>Package that contains this function (or NULL)</td>
</tr>
<tr>
<td>RDB$PRIVATE_FLAG</td>
<td>SMALLINT</td>
<td>NULL for normal (top-level) functions, 0 for package function defined in the header, 1 for package function only defined in the package body</td>
</tr>
<tr>
<td>RDB$FUNCTION_SOURCE</td>
<td>BLOB TEXT</td>
<td>The PSQL sourcecode of the function</td>
</tr>
<tr>
<td>RDB$FUNCTION_ID</td>
<td>SMALLINT</td>
<td>Unique identifier of the function</td>
</tr>
<tr>
<td>RDB$FUNCTION_BLR</td>
<td>BLOB BLR</td>
<td>The binary language representation (BLR) of the function code (PSQL function only)</td>
</tr>
<tr>
<td>RDB$VALID_BLR</td>
<td>SMALLINT</td>
<td>Indicates whether the source PSQL of the stored procedure remains valid after the latest ALTER FUNCTION modification.</td>
</tr>
<tr>
<td>RDB$DEBUG_INFO</td>
<td>BLOB DEBUG_INFORMATION</td>
<td>Contains debugging information about variables used in the function (PSQL function only)</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May reference a security class defined in the table RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this function</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The user name of the user who created the function originally</td>
</tr>
<tr>
<td>RDB$LEGACY_FLAG</td>
<td>SMALLINT</td>
<td>The legacy style attribute of the function. 1 - if the function is described in legacy style (DECLARE EXTERNAL FUNCTION), otherwise CREATE FUNCTION.</td>
</tr>
<tr>
<td>RDB$DETERMINISTIC_FLAG</td>
<td>SMALLINT</td>
<td>Deterministic flag. 1 - if function is deterministic</td>
</tr>
</tbody>
</table>
### RDB$SQL_SECURITY

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$SQL_SECURITY</td>
<td>BOOLEAN</td>
<td>The SQL SECURITY mode (DEFINER or INVOKER):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NULL - initial default (INVOKER)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FALSE - INVOKER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TRUE - DEFINER</td>
</tr>
</tbody>
</table>

### RDB$FUNCTION_ARGUMENTS

RDB$FUNCTION_ARGUMENTS stores the parameters of functions and their attributes.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$FUNCTION_NAME</td>
<td>CHAR(63)</td>
<td>The unique name (declared identifier) of the function</td>
</tr>
<tr>
<td>RDB$ARGUMENT_POSITION</td>
<td>SMALLINT</td>
<td>The position of the argument in the list of arguments</td>
</tr>
<tr>
<td>RDB$MECHANISM</td>
<td>SMALLINT</td>
<td>Flag: how this argument is passed:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - by value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - by reference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - by descriptor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - by BLOB descriptor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only for legacy external functions.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$FIELD_TYPE</td>
<td>SMALLINT</td>
<td>Data type code defined for the column:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 - SMALLINT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - INTEGER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 - FLOAT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 - DATE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13 - TIME</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 - CHAR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 - BIGINT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23 - BOOLEAN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 - DECFLOAT(16)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 - DECFLOAT(34)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26 - INT128</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27 - DOUBLE PRECISION</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28 - TIME WITH TIME ZONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>29 - TIMESTAMP WITH TIME ZONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35 - TIMESTAMP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>37 - VARCHAR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 - CSTRING (null-terminated text)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>45 - BLOB_ID</td>
</tr>
<tr>
<td></td>
<td></td>
<td>261 - BLOB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only for legacy external functions.</td>
</tr>
<tr>
<td>RDB$FIELD_SCALE</td>
<td>SMALLINT</td>
<td>The scale of an integer or a fixed-point argument. It is an exponent of 10.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only for legacy external functions.</td>
</tr>
<tr>
<td>RDB$FIELD_LENGTH</td>
<td>SMALLINT</td>
<td>Argument length in bytes:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BOOLEAN = 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SMALLINT = 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>INTEGER = 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DATE = 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TIME = 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BIGINT = 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DECFLOAT(16) = 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DOUBLE PRECISION = 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TIMESTAMP = 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TIME WITH TIME ZONE = 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BLOB_ID = 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TIMESTAMP WITH TIME ZONE = 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>INT128 = 16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DECFLOAT(34) = 16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only for legacy external functions.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$FIELD_SUB_TYPE</td>
<td>SMALLINT</td>
<td>Stores the BLOB subtype for an argument of a BLOB data type.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only for legacy external functions.</td>
</tr>
<tr>
<td>RDB$CHARACTER_SET_ID</td>
<td>SMALLINT</td>
<td>The identifier of the character set for a character argument.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only for legacy external functions.</td>
</tr>
<tr>
<td>RDB$FIELD_PRECISION</td>
<td>SMALLINT</td>
<td>The number of digits of precision available for the data type of the argument.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only for legacy external functions.</td>
</tr>
<tr>
<td>RDB$CHARACTER_LENGTH</td>
<td>SMALLINT</td>
<td>The length of a CHAR or VARCHAR argument in characters (not in bytes).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only for legacy external functions.</td>
</tr>
<tr>
<td>RDB$PACKAGE_NAME</td>
<td>CHAR(63)</td>
<td>Package name of the function (or NULL for a top-level function)</td>
</tr>
<tr>
<td>RDB$ARGUMENT_NAME</td>
<td>CHAR(63)</td>
<td>Parameter name</td>
</tr>
<tr>
<td>RDB$FIELD_SOURCE</td>
<td>CHAR(63)</td>
<td>The name of the user-created domain, when a domain is referenced instead of a data type. If the name starts with the prefix “RDB$”, it is the name of the domain automatically generated by the system for the parameter.</td>
</tr>
<tr>
<td>RDB$DEFAULT_VALUE</td>
<td>BLOB BLR</td>
<td>The default value for the parameter, in the binary language representation (BLR)</td>
</tr>
<tr>
<td>RDB$DEFAULT_SOURCE</td>
<td>BLOB TEXT</td>
<td>The default value for the parameter, in PSQL code</td>
</tr>
<tr>
<td>RDB$COLLATION_ID</td>
<td>SMALLINT</td>
<td>The identifier of the collation sequence used for a character parameter</td>
</tr>
<tr>
<td>RDB$NULL_FLAG</td>
<td>SMALLINT</td>
<td>The flag indicating whether NULL is allowable</td>
</tr>
<tr>
<td>RDB$ARGUMENT_MECHANISM</td>
<td>SMALLINT</td>
<td>Parameter passing mechanism for non-legacy functions:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - by value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - by reference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - through a descriptor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - via the BLOB descriptor</td>
</tr>
</tbody>
</table>
## Column Name | Data Type | Description
---|---|---
RDB$FIELD_NAME | CHAR(63) | The name of the column the parameter references, if it was declared using TYPE OF COLUMN instead of a regular data type. Used in conjunction with RDB$RELATION_NAME (see next).
RDB$RELATION_NAME | CHAR(63) | The name of the table the parameter references, if it was declared using TYPE OF COLUMN instead of a regular data type.
RDB$SYSTEM_FLAG | SMALLINT | Flag:
  0 - user-defined
  1 or higher - system-defined
RDB$DESCRIPTION | BLOB TEXT | Optional description of the function argument (comment)

### RDB$GENERATORS

RDB$GENERATORS stores generators (sequences) and keeps them up-to-date.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$GENERATOR_NAME</td>
<td>CHAR(63)</td>
<td>The unique name of the generator</td>
</tr>
<tr>
<td>RDB$GENERATOR_ID</td>
<td>SMALLINT</td>
<td>The unique identifier assigned to the generator by the system</td>
</tr>
</tbody>
</table>
| RDB$SYSTEM_FLAG | SMALLINT | Flag:
  0 - user-defined
  1 or greater - system-defined
  6 - internal generator for identity column |
| RDB$DESCRIPTION | BLOB TEXT | Could store comments related to the generator |
| RDB$SECURITY_CLASS | CHAR(63) | May reference a security class defined in the table RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this generator |
| RDB$OWNER_NAME | CHAR(63) | The user name of the user who created the generator originally |
| RDB$INITIAL_VALUE | BIGINT | Stores the initial value (START WITH value) of the generator |
| RDB$GENERATOR_INCREMENT | INTEGER | Stores the increment of the value (INCREMENT BY value) of the generator |
RDB$INDICES stores definitions of both system- and user-defined indexes. The attributes of each column belonging to an index are stored in one row of the table RDB$INDEX_SEGMENTS.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$INDEX_NAME</td>
<td>CHAR(63)</td>
<td>The unique name of the index specified by the user or automatically generated by the system</td>
</tr>
<tr>
<td>RDB$RELATION_NAME</td>
<td>CHAR(63)</td>
<td>The name of the table to which the index belongs. It corresponds to an identifier in RDB$RELATION_NAME.RDB$RELATIONS</td>
</tr>
<tr>
<td>RDB$INDEX_ID</td>
<td>SMALLINT</td>
<td>The internal (system) identifier of the index</td>
</tr>
<tr>
<td>RDB$UNIQUE_FLAG</td>
<td>SMALLINT</td>
<td>Specifies whether the index is unique:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - not unique</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - unique</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Could store comments concerning the index</td>
</tr>
<tr>
<td>RDB$SEGMENT_COUNT</td>
<td>SMALLINT</td>
<td>The number of segments (columns) in the index</td>
</tr>
<tr>
<td>RDB$INDEX_INACTIVE</td>
<td>SMALLINT</td>
<td>Indicates whether the index is currently active:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - active</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - inactive</td>
</tr>
<tr>
<td>RDB$INDEX_TYPE</td>
<td>SMALLINT</td>
<td>Distinguishes between an expression index (1) and a regular index (0 or null). Not used in databases created before Firebird 2.0; hence, regular indexes in upgraded databases are more more likely to store null in this column</td>
</tr>
<tr>
<td>RDB$FOREIGN_KEY</td>
<td>CHAR(63)</td>
<td>The name of the associated Foreign Key constraint, if any</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Indicates whether the index is system-defined or user-defined:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - user-defined</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 or greater - system-defined</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$EXPRESSION_BLR</td>
<td>BLOB BLR</td>
<td>Expression for an expression index, written in the binary language representation (BLR), used for calculating the values for the index at runtime.</td>
</tr>
<tr>
<td>RDB$EXPRESSION_SOURCE</td>
<td>BLOB TEXT</td>
<td>The source code of the expression for an expression index</td>
</tr>
<tr>
<td>RDB$STATISTICS</td>
<td>DOUBLE PRECISION</td>
<td>Stores the last known selectivity of the entire index, calculated by execution of a SET STATISTICS statement over the index. It is also recalculated whenever the database is first opened by the server. The selectivity of each separate segment of the index is stored in RDB$INDEX_SEGMENTS.</td>
</tr>
</tbody>
</table>

**RDB$INDEX_SEGMENTS**

RDB$INDEX_SEGMENTS stores the segments (table columns) of indexes and their positions in the key. A separate row is stored for each column in an index.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$INDEX_NAME</td>
<td>CHAR(63)</td>
<td>The name of the index this segment is related to. The master record is RDB$INDICES.RDB$INDEX_NAME.</td>
</tr>
<tr>
<td>RDB$FIELD_NAME</td>
<td>CHAR(63)</td>
<td>The name of a column belonging to the index, corresponding to an identifier for the table and that column in RDB$RELATION_FIELDS.RDB$FIELD_NAME.</td>
</tr>
<tr>
<td>RDB$FIELD_POSITION</td>
<td>SMALLINT</td>
<td>The column position in the index. Positions are numbered left-to-right, starting at zero</td>
</tr>
<tr>
<td>RDB$STATISTICS</td>
<td>DOUBLE PRECISION</td>
<td>The last known (calculated) selectivity of this column in the index. The higher the number, the lower the selectivity.</td>
</tr>
</tbody>
</table>

**RDB$LOG_FILES**

RDB$LOG_FILES is not currently used.

**RDB$PACKAGES**

RDB$PACKAGES stores the definition (header and body) of SQL packages.
<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$PACKAGE_NAME</td>
<td>CHAR(63)</td>
<td>Name of the package</td>
</tr>
<tr>
<td>RDB$PACKAGE_HEADER_SOURCE</td>
<td>BLOB TEXT</td>
<td>The PSQL sourcecode of the package header</td>
</tr>
<tr>
<td>RDB$PACKAGE_BODY_SOURCE</td>
<td>BLOB TEXT</td>
<td>The PSQL sourcecode of the package body</td>
</tr>
<tr>
<td>RDB$VALID_BODY_FLAG</td>
<td>SMALLINT</td>
<td>Indicates whether the body of the package is still valid. NULL or 0 indicates the body is not valid.</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May reference a security class defined in the table RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this package</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The user name of the user who created the package originally</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - user-defined</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 or higher - system-defined</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Optional description of the package (comment)</td>
</tr>
<tr>
<td>RDB$SQL_SECURITY</td>
<td>BOOLEAN</td>
<td>The SQL SECURITY mode (DEFINER or INVOKER):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NULL - initial default (INVOKER)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FALSE - INVOKER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TRUE - DEFINER</td>
</tr>
</tbody>
</table>

**RDB$PAGES**

RDB$PAGES stores and maintains information about database pages and their usage.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$PAGE_NUMBER</td>
<td>INTEGER</td>
<td>The unique number of a physically created database page</td>
</tr>
<tr>
<td>RDB$RELATION_ID</td>
<td>SMALLINT</td>
<td>The identifier of the table to which the page is allocated</td>
</tr>
<tr>
<td>RDB$PAGE_SEQUENCE</td>
<td>INTEGER</td>
<td>The number of the page in the sequence of all pages allocated to this table</td>
</tr>
<tr>
<td>RDB$PAGE_TYPE</td>
<td>SMALLINT</td>
<td>Indicates the page type (data, index, BLOB, etc.). For system use</td>
</tr>
</tbody>
</table>
RDB$PROCEDURES stores the definitions of stored procedures, including their PSQL source code and the binary language representation (BLR) of it. The next table, RDB$PROCEDURE_PARAMETERS, stores the definitions of input and output parameters.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$PROCEDURE_NAME</td>
<td>CHAR(63)</td>
<td>Stored procedure name (identifier)</td>
</tr>
<tr>
<td>RDB$PROCEDURE_ID</td>
<td>SMALLINT</td>
<td>The procedure’s unique, system-generated identifier</td>
</tr>
<tr>
<td>RDB$PROCEDURE_INPUTS</td>
<td>SMALLINT</td>
<td>Indicates the number of input parameters. NULL if there are none</td>
</tr>
<tr>
<td>RDB$PROCEDURE_OUTPUTS</td>
<td>SMALLINT</td>
<td>Indicates the number of output parameters. NULL if there are none</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Any text comments related to the procedure</td>
</tr>
<tr>
<td>RDB$PROCEDURE_SOURCE</td>
<td>BLOB TEXT</td>
<td>The PSQL source code of the procedure</td>
</tr>
<tr>
<td>RDB$PROCEDURE_BLR</td>
<td>BLOB BLR</td>
<td>The binary language representation (BLR) of the procedure code</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May point to the security class defined in the system table RDB$SECURITY_CLASSES in order to apply access control limits</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The user name of the procedure’s Owner — the user who was CURRENT_USER when the procedure was first created. It may or may not be the user name of the author.</td>
</tr>
<tr>
<td>RDB$RUNTIME</td>
<td>BLOB</td>
<td>A metadata description of the procedure, used internally for optimization</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Indicates whether the procedure is defined by a user (value 0) or by the system (a value of 1 or greater)</td>
</tr>
<tr>
<td>RDB$PROCEDURE_TYPE</td>
<td>SMALLINT</td>
<td>Procedure type:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - selectable stored procedure (contains a SUSPEND statement)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - executable stored procedure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NULL - not known *</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* for procedures created before Firebird 1.5</td>
</tr>
</tbody>
</table>
## RDB$VALID_BLR
- **Data Type**: SMALLINT
- **Description**: Indicates whether the source PSQL of the stored procedure remains valid after the latest ALTER PROCEDURE modification.

## RDB$DEBUG_INFO
- **Data Type**: BLOB
- **Description**: DEBUG_INFORMATION
- **Description**: Contains debugging information about variables used in the stored procedure.

## RDB$ENGINE_NAME
- **Data Type**: CHAR(63)
- **Description**: Engine for external functions. 'UDR' for UDR procedures. NULL for PSQL stored procedures.

## RDB$ENTRYPOINT
- **Data Type**: CHAR(255)
- **Description**: The exported name of the external function in the procedure library. Note, this is often not the same as RDB$PROCEDURE_NAME, which is the identifier with which the external stored procedure is declared to the database.

## RDB$PACKAGE_NAME
- **Data Type**: CHAR(63)
- **Description**: Package name of the procedure (or NULL for a top-level stored procedure).

## RDB$PRIVATE_FLAG
- **Data Type**: SMALLINT
- **Description**: NULL for normal (top-level) stored procedures, 0 for package procedures defined in the header, 1 for package procedures only defined in the package body.

## RDB$SQL_SECURITY
- **Data Type**: BOOLEAN
- **Description**: The SQL SECURITY mode (DEFINER or INVOKER):
- NULL - initial default (INVOKER)
- FALSE - INVOKER
- TRUE - DEFINER

### RDB$PROCEDURE_PARAMETERS

RDB$PROCEDURE_PARAMETERS stores the parameters of stored procedures and their attributes. It holds one row for each parameter.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$PARAMETER_NAME</td>
<td>CHAR(63)</td>
<td>Parameter name</td>
</tr>
<tr>
<td>RDB$PROCEDURE_NAME</td>
<td>CHAR(63)</td>
<td>The name of the procedure where the parameter is defined</td>
</tr>
<tr>
<td>RDB$PARAMETER_NUMBER</td>
<td>SMALLINT</td>
<td>The sequential number of the parameter</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$PARAMETER_TYPE</td>
<td>SMALLINT</td>
<td>Indicates whether the parameter is for input (value 0) or output (value 1)</td>
</tr>
<tr>
<td>RDB$FIELD_SOURCE</td>
<td>CHAR(63)</td>
<td>The name of the user-created domain, when a domain is referenced instead of a data type. If the name starts with the prefix “RDB$”, it is the name of the domain automatically generated by the system for the parameter.</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Could store comments related to the parameter</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Indicates whether the parameter was defined by the system (value or greater) or by a user (value 0)</td>
</tr>
<tr>
<td>RDB$DEFAULT_VALUE</td>
<td>BLOB BLR</td>
<td>The default value for the parameter, in the binary language representation (BLR)</td>
</tr>
<tr>
<td>RDB$DEFAULT_SOURCE</td>
<td>BLOB TEXT</td>
<td>The default value for the parameter, in PSQL code</td>
</tr>
<tr>
<td>RDB$COLLATION_ID</td>
<td>SMALLINT</td>
<td>The identifier of the collation sequence used for a character parameter</td>
</tr>
<tr>
<td>RDB$NULL_FLAG</td>
<td>SMALLINT</td>
<td>The flag indicating whether NULL is allowable</td>
</tr>
<tr>
<td>RDB$PARAMETER_MECHANISM</td>
<td>SMALLINT</td>
<td>Flag: indicates how this parameter is passed:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - by value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - by reference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - by descriptor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - by BLOB descriptor</td>
</tr>
<tr>
<td>RDB$FIELD_NAME</td>
<td>CHAR(63)</td>
<td>The name of the column the parameter references, if it was declared using TYPE OF COLUMN instead of a regular data type. Used in conjunction with RDB$RELATION_NAME (see next).</td>
</tr>
<tr>
<td>RDB$RELATION_NAME</td>
<td>CHAR(63)</td>
<td>The name of the table the parameter references, if it was declared using TYPE OF COLUMN instead of a regular data type</td>
</tr>
<tr>
<td>RDB$PACKAGE_NAME</td>
<td>CHAR(63)</td>
<td>Package name of the procedure (or NULL for a top-level stored procedure)</td>
</tr>
</tbody>
</table>
RDB$PUBLICATIONS

RDB$PUBLICATIONS stores the replication publications defined in the database.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$PUBLICATION_NAME</td>
<td>CHAR(63)</td>
<td>Publication name</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The username of the user who created the publication</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - user-defined</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 or higher - system-defined</td>
</tr>
<tr>
<td>RDB$ACTIVE_FLAG</td>
<td>SMALLINT</td>
<td>Inactive (0) or active (1)</td>
</tr>
<tr>
<td>RDB$AUTO_ENABLE</td>
<td>SMALLINT</td>
<td>Automatically add new tables to publication:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - disabled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - enabled (tables are automatically added to this publication)</td>
</tr>
</tbody>
</table>

In Firebird 4.0 there is a single (pre-defined) publication named RDB$DEFAULT. User-defined publications will be available in future Firebird releases.

RDB$PUBLICATION_TABLES

RDB$PUBLICATION_TABLES stores the names of tables that are replicated as part of a publication.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$PUBLICATION_NAME</td>
<td>CHAR(63)</td>
<td>Publication name</td>
</tr>
<tr>
<td>RDB$TABLE_NAME</td>
<td>CHAR(63)</td>
<td>Table name</td>
</tr>
</tbody>
</table>

RDB$REF_CONSTRAINTS

RDB$REF_CONSTRAINTS stores the attributes of the referential constraints — Foreign Key relationships and referential actions.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$CONSTRAINT_NAME</td>
<td>CHAR(63)</td>
<td>Foreign key constraint name, defined by the user or automatically generated by the system</td>
</tr>
<tr>
<td>RDB$CONST_NAME_UQ</td>
<td>CHAR(63)</td>
<td>The name of the primary or unique key constraint linked by the REFERENCES clause in the constraint definition</td>
</tr>
</tbody>
</table>
### RDB$relations

RDB$relations stores the top-level definitions and attributes of all tables and views in the system.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$VIEW_BLR</td>
<td>BLOB BLR</td>
<td>Stores the query specification for a view, in the binary language representation (BLR). The field stores NULL for a table</td>
</tr>
<tr>
<td>RDB$VIEW_SOURCE</td>
<td>BLOB TEXT</td>
<td>Contains the original source text of the query for a view, in SQL language. User comments are included. The field stores NULL for a table</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Could store comments related to the table or view</td>
</tr>
<tr>
<td>RDB$RELATION_ID</td>
<td>SMALLINT</td>
<td>Internal identifier of the table or view</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Indicates whether the table or view is user-defined (value 0) or system-defined (value 1 or greater)</td>
</tr>
<tr>
<td>RDB$DBKEY_LENGTH</td>
<td>SMALLINT</td>
<td>The total length of the database key. For a table: 8 bytes. For a view, the length is 8 multiplied by the number of tables referenced by the view</td>
</tr>
<tr>
<td>RDB$FORMAT</td>
<td>SMALLINT</td>
<td>Internal use, points to the relation’s record in RDB$FORMATS — do not modify</td>
</tr>
<tr>
<td>RDB$FIELD_ID</td>
<td>SMALLINT</td>
<td>The field ID for the next column to be added. The number is not decremented when a column is dropped.</td>
</tr>
<tr>
<td>RDB$RELATION_NAME</td>
<td>CHAR(63)</td>
<td>Table or view name</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>----------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May reference a security class defined in the table RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this table or view</td>
</tr>
<tr>
<td>RDB$EXTERNAL_FILE</td>
<td>VARCHAR(255)</td>
<td>The full path to the external data file if the table is defined with the EXTERNAL FILE clause</td>
</tr>
<tr>
<td>RDB$RUNTIME</td>
<td>BLOB</td>
<td>Table metadata description, used internally for optimization</td>
</tr>
<tr>
<td>RDB$EXTERNAL_DESCRIPTION</td>
<td>BLOB</td>
<td>Could store comments related to the external file of an external table</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The user name of the user who created the table or view originally</td>
</tr>
<tr>
<td>RDB$DEFAULT_CLASS</td>
<td>CHAR(63)</td>
<td>Default security class, used when a new column is added to the table</td>
</tr>
<tr>
<td>RDB$FLAGS</td>
<td>SMALLINT</td>
<td>Internal flags</td>
</tr>
<tr>
<td>RDB$RELATION_TYPE</td>
<td>SMALLINT</td>
<td>The type of the relation object being described:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - system or user-defined table</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - view</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - external table</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - monitoring table</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - connection-level GTT (PRESERVE ROWS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - transaction-level GTT (DELETE ROWS)</td>
</tr>
<tr>
<td>RDB$SQL_SECURITY</td>
<td>BOOLEAN</td>
<td>The SQL SECURITY mode (DEFINER or INVOKER):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NULL - initial default (INVOKER)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FALSE - INVOKER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TRUE - DEFINER</td>
</tr>
</tbody>
</table>

**RDB$RELATION_CONSTRAINTS**

RDB$RELATION_CONSTRAINTS stores the definitions of all table-level constraints: primary, unique, foreign key, CHECK, NOT NULL constraints.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$CONSTRAINT_NAME</td>
<td>CHAR(63)</td>
<td>The name of the table-level constraint defined by the user, or otherwise automatically generated by the system</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>----------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$CONSTRAINT_TYPE</td>
<td>CHAR(11)</td>
<td>The name of the constraint type: PRIMARY KEY, UNIQUE, FOREIGN KEY, CHECK or NOT NULL</td>
</tr>
<tr>
<td>RDB$RELATION_NAME</td>
<td>CHAR(63)</td>
<td>The name of the table this constraint applies to</td>
</tr>
<tr>
<td>RDB$DEFERRABLE</td>
<td>CHAR(3)</td>
<td>Currently NO in all cases: Firebird does not yet support deferrable constraints</td>
</tr>
<tr>
<td>RDB$INITIALLY_DEFERRED</td>
<td>CHAR(3)</td>
<td>Currently NO in all cases</td>
</tr>
<tr>
<td>RDB$INDEX_NAME</td>
<td>CHAR(63)</td>
<td>The name of the index that supports this constraint. For a CHECK or a NOT NULL constraint, it is NULL.</td>
</tr>
</tbody>
</table>

### RDB$RELATION_FIELDS

RDB$RELATION_FIELDS stores the definitions of table and view columns.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$FIELD_NAME</td>
<td>CHAR(63)</td>
<td>Column name</td>
</tr>
<tr>
<td>RDB$RELATION_NAME</td>
<td>CHAR(63)</td>
<td>The name of the table or view that the column belongs to</td>
</tr>
<tr>
<td>RDB$FIELD_SOURCE</td>
<td>CHAR(63)</td>
<td>Domain name on which the column is based, either a user-defined one specified in the table definition or one created automatically by the system using the set of attributes defined. The attributes are in the table RDB$FIELDS: this column matches RDB$FIELDS.RDB$FIELD_NAME.</td>
</tr>
<tr>
<td>RDB$QUERY_NAME</td>
<td>CHAR(63)</td>
<td>Not currently used</td>
</tr>
<tr>
<td>RDB$BASE_FIELD</td>
<td>CHAR(63)</td>
<td>Only populated for a view, it is the name of the column from the base table</td>
</tr>
<tr>
<td>RDB$EDIT_STRING</td>
<td>VARCHAR(127)</td>
<td>Not used</td>
</tr>
<tr>
<td>RDB$FIELD_POSITION</td>
<td>SMALLINT</td>
<td>The zero-based ordinal position of the column in the table or view, numbering from left to right</td>
</tr>
<tr>
<td>RDB$QUERY_HEADER</td>
<td>BLOB TEXT</td>
<td>Not used</td>
</tr>
<tr>
<td>RDB$UPDATE_FLAG</td>
<td>SMALLINT</td>
<td>Indicates whether the column is a regular one (value 1) or a computed one (value 0)</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$FIELD_ID</td>
<td>SMALLINT</td>
<td>An ID assigned from RDB$RELATIONS.RDB$FIELD_ID at the time the column was added to the table or view. It should always be treated as transient.</td>
</tr>
<tr>
<td>RDB$VIEW_CONTEXT</td>
<td>SMALLINT</td>
<td>For a view column, the internal identifier of the base table from which this field derives.</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Comments related to the table or view column.㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜㎜mmo</td>
</tr>
<tr>
<td>RDB$DEFAULT_VALUE</td>
<td>BLOB BLR</td>
<td>The value stored for the DEFAULT clause for this column, if there is one, written in binary language representation (BLR).</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Indicates whether the column is user-defined (value 0) or system-defined (value 1 or greater).</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May reference a security class defined in RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this column.</td>
</tr>
<tr>
<td>RDB$COMPLEX_NAME</td>
<td>CHAR(63)</td>
<td>Not used</td>
</tr>
<tr>
<td>RDB$NULL_FLAG</td>
<td>SMALLINT</td>
<td>Indicates whether the column is nullable (NULL) non-nullable (value 1).</td>
</tr>
<tr>
<td>RDB$DEFAULT_SOURCE</td>
<td>BLOB TEXT</td>
<td>The source text of the DEFAULT clause, if any.</td>
</tr>
<tr>
<td>RDB$COLLATION_ID</td>
<td>SMALLINT</td>
<td>The identifier of the collation sequence in the character set for the column, if it is not the default collation.</td>
</tr>
<tr>
<td>RDB$GENERATOR_NAME</td>
<td>CHAR(63)</td>
<td>Internal generator name for generating an identity value for the column.</td>
</tr>
<tr>
<td>RDB$IDENTITY_TYPE</td>
<td>SMALLINT</td>
<td>The identity type of the column.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NULL - not an identity column</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - identity column, GENERATED BY DEFAULT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - identity column, GENERATED ALWAYS</td>
</tr>
</tbody>
</table>

**RDB$ROLES**

RDB$ROLES stores the roles that have been defined in this database.
<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$ROLE_NAME</td>
<td>CHAR(63)</td>
<td>Role name</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The user name of the role owner</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Could store comments related to the role</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>System flag</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May reference a security class defined in the table RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this role</td>
</tr>
<tr>
<td>RDB$SYSTEM_PRIVILEGES</td>
<td>BINARY(8)</td>
<td>Bitset with the system privileges granted to a role, with the following bits</td>
</tr>
</tbody>
</table>

0 - unused  
1 - USER_MANAGEMENT  
2 - READ_RAW_PAGES  
3 - CREATE_USER_TYPES  
4 - USE_NBACKUPUTILITY  
5 - CHANGE_SHUTDOWN_MODE  
6 - TRACE_ANY_ATTACHMENT  
7 - MONITOR_ANY_ATTACHMENT  
8 - ACCESS_SHUTDOWN_DATABASE  
9 - CREATE_DATABASE  
10 - DROP_DATABASE  
11 - USE_GBAKUTILITY  
12 - USE_GSTATUTILITY  
13 - USE_GFIXUTILITY  
14 - IGNORE_DB_TRIGGERS  
15 - CHANGE_HEADER_SETTINGS  
16 - SELECT_ANY_OBJECT_IN_DATABASE  
17 - ACCESS_ANY_OBJECT_IN_DATABASE  
18 - MODIFY_ANY_OBJECT_IN_DATABASE  
19 - CHANGE_MAPPING_RULES  
20 - USE_GRANTED_BY_CLAUSE  
21 - GRANT_REVOKE_ON_ANY_OBJECT  
22 - GRANT_REVOKE_ANY_DDL_RIGHT  
23 - CREATE_PRIVILEGED_ROLES  
24 - GET_DBCRYPT_INFO  
25 - MODIFY_EXT_CONN_POOL  
26 - REPLICATE_INTO_DATABASE

**RDB$SECURITY_CLASSES**

RDB$SECURITY_CLASSES stores the access control lists
### RDB$SECURITY_CLASS

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>Security class name</td>
</tr>
</tbody>
</table>

### RDB$ACL

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$ACL</td>
<td>BLOB ACL</td>
<td>The access control list related to the security class. It enumerates users and their privileges</td>
</tr>
</tbody>
</table>

### RDB$DESCRIPTION

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Could store comments related to the security class</td>
</tr>
</tbody>
</table>

### RDB$TIME_ZONES

RDB$TIME_ZONES lists the named time zones supported by the engine. It is a virtual table that is populated using the current time zone database of the Firebird engine.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$TIME_ZONE_ID</td>
<td>INTEGER</td>
<td>The unique identifier of the time zone as used by Firebird. For example, this identifier is used in the time_zone field of the ISC_TIMESTAMP_TZ struct if the value has a named zone instead of an offset.</td>
</tr>
<tr>
<td>RDB$TIME_ZONE_NAME</td>
<td>CHAR(63)</td>
<td>Name of the time zone as specified by the time zone database</td>
</tr>
</tbody>
</table>

### RDB$TRANSACTIONS

RDB$TRANSACTIONS stores the states of distributed transactions and other transactions that were prepared for two-phase commit with an explicit prepare message.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$TRANSACTION_ID</td>
<td>INTEGER</td>
<td>The unique identifier of the transaction being tracked</td>
</tr>
<tr>
<td>RDB$TRANSACTION_STATE</td>
<td>SMALLINT</td>
<td>Transaction state:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - in limbo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - committed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - rolled back</td>
</tr>
<tr>
<td>RDB$TIMESTAMP</td>
<td>TIMESTAMP</td>
<td>Not used</td>
</tr>
<tr>
<td>RDB$TRANSACTION_DESCRIPTION</td>
<td>BLOB</td>
<td>Describes the prepared transaction and could be a custom message supplied to isc_prepare_transaction2, even if it is not a distributed transaction. It may be used when a lost connection cannot be restored</td>
</tr>
</tbody>
</table>
RDB$TRIGGERS

RDB$TRIGGERS stores the trigger definitions for all tables and views.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$TRIGGER_NAME</td>
<td>CHAR(63)</td>
<td>Trigger name</td>
</tr>
<tr>
<td>RDB$RELATION_NAME</td>
<td>CHAR(63)</td>
<td>The name of the table or view the trigger applies to. NULL if the trigger is applicable to a database event (&quot;database trigger&quot;)</td>
</tr>
<tr>
<td>RDB$TRIGGER_SEQUENCE</td>
<td>SMALLINT</td>
<td>Position of this trigger in the sequence. Zero usually means that no sequence position is specified</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$TRIGGER_TYPE</td>
<td>BIGINT</td>
<td>The event the trigger fires on:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - before insert</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - after insert</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - before update</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - after update</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - before delete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 - after delete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17 - before insert or update</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18 - after insert or update</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 - before insert or delete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26 - after insert or delete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27 - before update or delete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28 - after update or delete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>113 - before insert or update or delete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>114 - after insert or update or delete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8192 - on connect</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8193 - on disconnect</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8194 - on transaction start</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8195 - on transaction commit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8196 - on transaction rollback</td>
</tr>
</tbody>
</table>

For DDL triggers, the trigger type is obtained by bitwise OR above the event phase (0 - BEFORE, 1 AFTER) and all listed types events:

0x00000000000004002 - CREATE TABLE
0x00000000000004004 - ALTER TABLE
0x00000000000004008 - DROP TABLE
0x00000000000004010 - CREATE PROCEDURE
0x00000000000004020 - ALTER PROCEDURE
0x00000000000004040 - DROP PROCEDURE
0x00000000000004080 - CREATE FUNCTION
0x00000000000004100 - ALTER FUNCTION
0x00000000000004200 - DROP FUNCTION
0x00000000000004400 - CREATE TRIGGER
0x00000000000004800 - ALTER TRIGGER
0x00000000000005000 - DROP TRIGGER
0x00000000000014000 - CREATE EXCEPTION
0x00000000000024000 - ALTER EXCEPTION
0x00000000000044000 - DROP EXCEPTION
0x00000000000084000 - CREATE VIEW
0x00000000000104000 - ALTER VIEW
0x00000000000204000 - DROP VIEW
0x00000000000404000 - CREATE DOMAIN
<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$TRIGGER_SOURCE</td>
<td>BLOB TEXT</td>
<td>Stores the source code of the trigger in PSQL</td>
</tr>
<tr>
<td>RDB$TRIGGER_BLR</td>
<td>BLOB BLR</td>
<td>Stores the trigger in the binary language representation (BLR)</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Trigger comment text</td>
</tr>
<tr>
<td>RDB$TRIGGER_INACTIVE</td>
<td>SMALLINT</td>
<td>Indicates whether the trigger is currently inactive (1) or active (0)</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag: indicates whether the trigger is user-defined (value 0) or system-defined (value 1 or greater)</td>
</tr>
<tr>
<td>RDB$FLAGS</td>
<td>SMALLINT</td>
<td>Internal use</td>
</tr>
<tr>
<td>RDB$VALID_BLR</td>
<td>SMALLINT</td>
<td>Indicates whether the text of the trigger remains valid after the latest modification by the the ALTER TRIGGER statement</td>
</tr>
<tr>
<td>RDB$DEBUG_INFO</td>
<td>BLOB</td>
<td>Contains debugging information about variables used in the trigger</td>
</tr>
<tr>
<td>RDB$ENGINE_NAME</td>
<td>CHAR(63)</td>
<td>Engine for external triggers. 'UDR' for UDR triggers. NULL for PSQL triggers</td>
</tr>
<tr>
<td>RDB$ENTRYPOINT</td>
<td>CHAR(255)</td>
<td>The exported name of the external trigger in the trigger library. Note, this is often not the same as RDB$TRIGGER_NAME, which is the identifier with which the trigger is declared to the database</td>
</tr>
<tr>
<td>RDB$SQL_SECURITY</td>
<td>BOOLEAN</td>
<td>The SQL SECURITY mode (DEFINER or INVOKER): NULL - initial default (INVOKER) FALSE - INVOKER TRUE - DEFINER</td>
</tr>
</tbody>
</table>

**RDB$TRIGGER_MESSAGES**

RDB$TRIGGER_MESSAGES stores the trigger messages.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$TRIGGER_NAME</td>
<td>CHAR(63)</td>
<td>The name of the trigger the message is associated with</td>
</tr>
</tbody>
</table>
### RDB$TYPES

RDB$TYPES stores the defining sets of enumerated types used throughout the system.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$FIELD_NAME</td>
<td>CHAR(63)</td>
<td>Enumerated type name. Each type name masters its own set of types, e.g., object types, data types, character sets, trigger types, blob subtypes, etc.</td>
</tr>
</tbody>
</table>
| RDB$TYPE        | SMALLINT  | The object type identifier. A unique series of numbers is used within each separate enumerated type. For example, in this selection from the set mastered under RDB$OBJECT_TYPE in RDB$FIELD_NAME, some object types are enumerated:  
  0 - TABLE  
  1 - VIEW  
  2 - TRIGGER  
  3 - COMPUTED_FIELD  
  4 - VALIDATION  
  5 - PROCEDURE  
  ... |
| RDB$TYPE_NAME   | CHAR(63)  | The name of a member of an enumerated type, e.g., TABLE, VIEW, TRIGGER, etc. in the example above. In the RDB$CHARACTER_SET enumerated type, RDB$TYPE_NAME stores the names of the character sets. |
| RDB$DESCRIPTION | BLOB TEXT | Any text comments related to the enumerated type |
| RDB$SYSTEM_FLAG | SMALLINT  | Flag: indicates whether the type-member is user-defined (value 0) or system-defined (value 1 or greater) |

### RDB$USER_PRIVILEGES

RDB$USER_PRIVILEGES stores the SQL access privileges for Firebird users and privileged objects.
<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$USER</td>
<td>CHAR(63)</td>
<td>The user or object that is granted this privilege</td>
</tr>
<tr>
<td>RDB$GRANTOR</td>
<td>CHAR(63)</td>
<td>The user who grants the privilege</td>
</tr>
<tr>
<td>RDB$PRIVILEGE</td>
<td>CHAR(6)</td>
<td>The privilege granted hereby:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A - all (all privileges)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S - select (selecting data)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I - insert (inserting rows)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D - delete (deleting rows)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R - references (foreign key)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U - update (updating data)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X - executing (procedure)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G - usage (of other object types)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M - role membership</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C - DDL privilege create</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L - DDL privilege alter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - DDL privilege drop</td>
</tr>
<tr>
<td>RDB$GRANT_OPTION</td>
<td>SMALLINT</td>
<td>Whether the WITH GRANT OPTION authority is included with the privilege:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - not included</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - included</td>
</tr>
<tr>
<td>RDB$RELATION_NAME</td>
<td>CHAR(63)</td>
<td>The name of the object (table, view, procedure or role) the privilege is</td>
</tr>
<tr>
<td></td>
<td></td>
<td>granted ON</td>
</tr>
<tr>
<td>RDB$FIELD_NAME</td>
<td>CHAR(63)</td>
<td>The name of the column the privilege is applicable to, for a column-level</td>
</tr>
<tr>
<td></td>
<td></td>
<td>privilege (an UPDATE or REFERENCES privilege)</td>
</tr>
<tr>
<td>RDB$USER_TYPE</td>
<td>SMALLINT</td>
<td>Identifies the type of user the privilege is granted TO (a user, a procedure,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a view, etc.)</td>
</tr>
</tbody>
</table>
### RDB$OBJECT_TYPE

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$OBJECT_TYPE</td>
<td>SMALLINT</td>
<td>Identifies the type of the object the privilege is granted ON</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - table</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - view</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - trigger</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - procedure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 - exception</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - user</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 - domain</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11 - character set</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13 - role</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 - generator (sequence)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 - function</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 - BLOB filter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17 - collation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18 - package</td>
</tr>
</tbody>
</table>

### RDB$VIEW_RELATIONS

RDB$VIEW_RELATIONS stores the tables that are referred to in view definitions. There is one record for each table in a view.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$VIEW_NAME</td>
<td>CHAR(63)</td>
<td>View name</td>
</tr>
<tr>
<td>RDB$RELATION_NAME</td>
<td>CHAR(63)</td>
<td>The name of the table, view or stored procedure the view references</td>
</tr>
<tr>
<td>RDB$VIEW_CONTEXT</td>
<td>SMALLINT</td>
<td>The alias used to reference the view column in the BLR code of the query definition</td>
</tr>
<tr>
<td>RDB$CONTEXT_NAME</td>
<td>CHAR(255)</td>
<td>The text associated with the alias reported in the RDB$VIEW_CONTEXT column</td>
</tr>
<tr>
<td>RDB$CONTEXT_TYPE</td>
<td>SMALLINT</td>
<td>Context type:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - table</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - view</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - stored procedure</td>
</tr>
<tr>
<td>RDB$PACKAGE_NAME</td>
<td>CHAR(63)</td>
<td>Package name for a stored procedure in a package</td>
</tr>
</tbody>
</table>
Appendix E: Monitoring Tables

The Firebird engine can monitor activities in a database and make them available for user queries via the monitoring tables. The definitions of these tables are always present in the database, all named with the prefix MON$. The tables are virtual: they are populated with data only at the moment when the user queries them. That is also one good reason why it is no use trying to create triggers for them!

The key notion in understanding the monitoring feature is an activity snapshot. The activity snapshot represents the current state of the database at the start of the transaction in which the monitoring table query runs. It delivers a lot of information about the database itself, active connections, users, transactions prepared, running queries and more.

The snapshot is created when any monitoring table is queried for the first time. It is preserved until the end of the current transaction to maintain a stable, consistent view for queries across multiple tables, such as a master-detail query. In other words, monitoring tables always behave as though they were in SNAPSHOT TABLE STABILITY ("consistency") isolation, even if the current transaction is started with a lower isolation level.

To refresh the snapshot, the current transaction must be completed and the monitoring tables must be re-queried in a new transaction context.

Access Security

- SYSDBA and the database owner have full access to all information available from the monitoring tables
- Regular users can see information about their own connections; other connections are not visible to them

⚠️ In a highly loaded environment, collecting information via the monitoring tables could have a negative impact on system performance.

List of Monitoring Tables

**MON$ATTACHMENTS**
Information about active attachments to the database

**MON$CALL_STACK**
Calls to the stack by active queries of stored procedures and triggers

**MON$CONTEXT_VARIABLES**
Information about custom context variables

**MON$DATABASE**
Information about the database to which the CURRENT_CONNECTION is attached

**MON$IO_STATS**
Input/output statistics
### MON$ATTACHMENTS

MON$ATTACHMENTS displays information about active attachments to the database.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$ATTACHMENT_ID</td>
<td>BIGINT</td>
<td>Connection identifier</td>
</tr>
<tr>
<td>MON$SERVER_PID</td>
<td>INTEGER</td>
<td>Server process identifier</td>
</tr>
</tbody>
</table>
| MON$STATE                  | SMALLINT           | Connection state:  
|                            |                    | 0 - idle  
<p>|                            |                    | 1 - active                                                                  |
| MON$ATTACHMENT_NAME        | VARCHAR(255)       | Connection string — the file name and full path to the primary database file |
| MON$USER                   | CHAR(63)           | The name of the user who is using this connection                           |
| MON$ROLE                   | CHAR(63)           | The role name specified when the connection was established. If no role was specified when the connection was established, the field contains the text NONE |
| MON$REMOTE_PROTOCOL        | VARCHAR(10)        | Remote protocol name                                                        |
| MON$REMOTE_ADDRESS         | VARCHAR(255)       | Remote address (address and server name)                                   |
| MON$REMOTE_PID             | INTEGER            | Remote client process identifier                                            |
| MON$CHARACTER_SET_ID       | SMALLINT           | Connection character set identifier (see RDB$CHARACTER_SET in system table RDB$TYPES) |
| MON$TIMESTAMP              | TIMESTAMP          | The date and time when the connection was started                           |</p>
<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$GARBAGE_COLLECTION</td>
<td>SMALLINT</td>
<td>Garbage collection flag (as specified in the attachment’s DPB): 1=allowed, 0=not allowed</td>
</tr>
<tr>
<td>MON$REMOTE_PROCESS</td>
<td>VARCHAR(255)</td>
<td>The full file name and path to the executable file that established this connection</td>
</tr>
<tr>
<td>MON$STAT_ID</td>
<td>INTEGER</td>
<td>Statistics identifier</td>
</tr>
<tr>
<td>MON$CLIENT_VERSION</td>
<td>VARCHAR(255)</td>
<td>Client library version</td>
</tr>
<tr>
<td>MON$REMOTE_VERSION</td>
<td>VARCHAR(255)</td>
<td>Remote protocol version</td>
</tr>
<tr>
<td>MON$REMOTE_HOST</td>
<td>VARCHAR(255)</td>
<td>Name of the remote host</td>
</tr>
<tr>
<td>MON$REMOTE_OS_USER</td>
<td>VARCHAR(255)</td>
<td>Name of remote user</td>
</tr>
<tr>
<td>MON$AUTH_METHOD</td>
<td>VARCHAR(255)</td>
<td>Name of authentication plugin used to connect</td>
</tr>
<tr>
<td>MON$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag that indicates the type of connection:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - normal connection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - system connection</td>
</tr>
<tr>
<td>MON$IDLE_TIMEOUT</td>
<td>INTEGER</td>
<td>Connection-level idle timeout in seconds. When 0 is reported the database ConnectionIdleTimeout from databases.conf or firebird.conf applies.</td>
</tr>
<tr>
<td>MON$IDLE_TIMER</td>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>Idle timer expiration time</td>
</tr>
<tr>
<td>MON$STATEMENT_TIMEOUT</td>
<td>INTEGER</td>
<td>Connection-level statement timeout in milliseconds. When 0 is reported the database StatementTimeout from databases.conf or firebird.conf applies.</td>
</tr>
<tr>
<td>MON$WIRE_COMPRESSED</td>
<td>BOOLEAN</td>
<td>Wire compression active (TRUE) or inactive (FALSE)</td>
</tr>
<tr>
<td>MON$WIRE_ENCRYPTED</td>
<td>BOOLEAN</td>
<td>Wire encryption active (TRUE) or inactive (FALSE)</td>
</tr>
<tr>
<td>MON$WIRE_CRYPT_PLUGIN</td>
<td>VARCHAR(63)</td>
<td>Name of the wire encryption plugin used</td>
</tr>
</tbody>
</table>

Retrieving information about client applications

```sql
SELECT MON$USER, MON$REMOTE_ADDRESS, MON$REMOTE_PID, MON$TIMESTAMP
FROM MON$ATTACHMENTS
WHERE MON$ATTACHMENT_ID <> CURRENT_CONNECTION
```
Using MON$ATTACHMENTS to Kill a Connection

Monitoring tables are read-only. However, the server has a built-in mechanism for deleting (and only deleting) records in the MON$ATTACHMENTS table, which makes it possible to close a connection to the database.

**Notes**
- All the current activity in the connection being deleted is immediately stopped and all active transactions are rolled back
- The closed connection will return an error with the isc_att_shutdown code to the application
- Subsequent attempts to use this connection (i.e., use its handle in API calls) will return errors
- Termination of system connections (MON$SYSTEM_FLAG = 1) is not possible. The server will skip system connections in a DELETE FROM MON$ATTACHMENTS.

**Closing all connections except for your own (current):**

```
DELETE FROM MON$ATTACHMENTS
WHERE MON$ATTACHMENT_ID <> CURRENT_CONNECTION
```

**MON$_CALL_STACK**

**MON$_CALL_STACK** displays calls to the stack from queries executing in stored procedures and triggers.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$CALL_ID</td>
<td>BIGINT</td>
<td>Call identifier</td>
</tr>
<tr>
<td>MON$STATEMENT_ID</td>
<td>BIGINT</td>
<td>The identifier of the top-level SQL statement, the one that initiated the chain of calls. Use this identifier to find the records about the active statement in the MON$STATEMENTS table</td>
</tr>
<tr>
<td>MON$CALLER_ID</td>
<td>BIGINT</td>
<td>The identifier of the calling trigger or stored procedure</td>
</tr>
<tr>
<td>MON$OBJECT_NAME</td>
<td>CHAR(63)</td>
<td>PSQL object (module) name</td>
</tr>
</tbody>
</table>
| MON$OBJECT_TYPE   | SMALLINT    | PSQL object type (trigger or stored procedure):
|                   |             | 2 - trigger
|                   |             | 5 - stored procedure
|                   |             | 15 - stored function                                                        |
| MON$TIMESTAMP     | TIMESTAMP   | The date and time when the call was started                                 |
Information about calls during the execution of the \texttt{EXECUTE STATEMENT} statement does not get into the call stack.

\textit{Get the call stack for all connections except your own}

\begin{verbatim}
WITH RECURSIVE
  HEAD AS ( 
    SELECT 
      CALL.MON$STATEMENT_ID, CALL.MON$CALL_ID,
      CALL.MON$OBJECT_NAME, CALL.MON$OBJECT_TYPE
    FROM MON$CALL_STACK CALL
    WHERE CALL.MON$CALLER_ID IS NULL
    UNION ALL
    SELECT 
      CALL.MON$STATEMENT_ID, CALL.MON$CALL_ID,
      CALL.MON$OBJECT_NAME, CALL.MON$OBJECT_TYPE
    FROM MON$CALL_STACK CALL
    JOIN HEAD ON CALL.MON$CALLER_ID = HEAD.MON$CALL_ID
  )
SELECT MON$ATTACHMENT_ID, MON$OBJECT_NAME, MON$OBJECT_TYPE
FROM HEAD
JOIN MON$STATEMENTS STMT ON STMT.MON$STATEMENT_ID = HEAD.MON$STATEMENT_ID
WHERE STMT.MON$ATTACHMENT_ID <> CURRENT_CONNECTION
\end{verbatim}

\textbf{MON$CONTEXT_VARIABLES}

\texttt{MON$CONTEXT_VARIABLES} displays information about custom context variables.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$ATTACHMENT_ID</td>
<td>BIGINT</td>
<td>Connection identifier. It contains a valid value only for a connection-level context variable. For transaction-level variables it is NULL.</td>
</tr>
</tbody>
</table>
### MON$TRANSACTION_ID
- **Data Type**: BIGINT
- **Description**: Transaction identifier. It contains a valid value only for transaction-level context variables. For connection-level variables it is NULL.

### MON$VARIABLE_NAME
- **Data Type**: VARCHAR(80)
- **Description**: Context variable name

### MON$VARIABLE_VALUE
- **Data Type**: VARCHAR(32765)
- **Description**: Context variable value

**Retrieving all session context variables for the current connection**

```sql
SELECT
    VAR.MON$VARIABLE_NAME,
    VAR.MON$VARIABLE_VALUE
FROM MON$CONTEXT_VARIABLES VAR
WHERE VAR.MON$ATTACHMENT_ID = CURRENT_CONNECTION
```

### MON$DATABASE

**MON$DATABASE** displays the header information from the database the current user is connected to.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$DATABASE_NAME</td>
<td>VARCHAR(255)</td>
<td>The file name and full path of the primary database file, or the database alias</td>
</tr>
<tr>
<td>MON$PAGE_SIZE</td>
<td>SMALLINT</td>
<td>Database page size in bytes</td>
</tr>
<tr>
<td>MON$ODS_MAJOR</td>
<td>SMALLINT</td>
<td>Major ODS version, e.g., 11</td>
</tr>
<tr>
<td>MON$ODS_MINOR</td>
<td>SMALLINT</td>
<td>Minor ODS version, e.g., 2</td>
</tr>
<tr>
<td>MON$OLDEST_TRANSACTION</td>
<td>BIGINT</td>
<td>The number of the oldest [interesting] transaction (OIT)</td>
</tr>
<tr>
<td>MON$OLDEST_ACTIVE</td>
<td>BIGINT</td>
<td>The number of the oldest active transaction (OAT)</td>
</tr>
<tr>
<td>MON$OLDEST_SNAPSHOT</td>
<td>BIGINT</td>
<td>The number of the transaction that was active at the moment when the OAT was started — oldest snapshot transaction (OST)</td>
</tr>
<tr>
<td>MON$NEXT_TRANSACTION</td>
<td>BIGINT</td>
<td>The number of the next transaction, as it stood when the monitoring snapshot was taken</td>
</tr>
<tr>
<td>MON$PAGE_BUFFERS</td>
<td>INTEGER</td>
<td>The number of pages allocated in RAM for the database page cache</td>
</tr>
<tr>
<td>MON$SQL_DIALECT</td>
<td>SMALLINT</td>
<td>Database SQL Dialect: 1 or 3</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>MON$SHUTDOWN_MODE</td>
<td>SMALLINT</td>
<td>The current shutdown state of the database: 0 - the database is online 1 - multi-user shutdown 2 - single-user shutdown 3 - full shutdown</td>
</tr>
<tr>
<td>MON$SWEEP_INTERVAL</td>
<td>INTEGER</td>
<td>Sweep interval</td>
</tr>
<tr>
<td>MON$READ_ONLY</td>
<td>SMALLINT</td>
<td>Flag indicating whether the database is read-only (value 1) or read-write (value 0)</td>
</tr>
<tr>
<td>MON$FORCED_WRITES</td>
<td>SMALLINT</td>
<td>Indicates whether the write mode of the database is set for synchronous write (forced writes ON, value is 1) or asynchronous write (forced writes OFF, value is 0)</td>
</tr>
<tr>
<td>MON$RESERVE_SPACE</td>
<td>SMALLINT</td>
<td>The flag indicating reserve_space (value 1) or use_all_space (value 0) for filling database pages</td>
</tr>
<tr>
<td>MON$CREATION_DATE</td>
<td>TIMESTAMP</td>
<td>The date and time when the database was created or was last restored</td>
</tr>
<tr>
<td>MON$PAGES</td>
<td>BIGINT</td>
<td>The number of pages allocated for the database on an external device</td>
</tr>
<tr>
<td>MON$STAT_ID</td>
<td>INTEGER</td>
<td>Statistics identifier</td>
</tr>
<tr>
<td>MON$BACKUP_STATE</td>
<td>SMALLINT</td>
<td>Current physical backup (nBackup) state: 0 - normal 1 - stalled 2 - merge</td>
</tr>
<tr>
<td>MON$CRYPT_PAGE</td>
<td>BIGINT</td>
<td>Number of encrypted pages</td>
</tr>
<tr>
<td>MON$OWNER</td>
<td>CHAR(63)</td>
<td>Username of the database owner</td>
</tr>
<tr>
<td>MON$SEC_DATABASE</td>
<td>CHAR(7)</td>
<td>Displays what type of security database is used: Default - default security database, i.e. security4.fdb Self - current database is used as security database Other - another database is used as security database (not itself or security4.fdb)</td>
</tr>
</tbody>
</table>
## Appendix E: Monitoring Tables

### MON$CRYPT_STATE
- **MON$CRYPT_STATE**: SMALLINT
- **Description**: Current state of database encryption
  - 0 - not encrypted
  - 1 - encrypted
  - 2 - decryption in progress
  - 3 - encryption in progress

### MON$GUID
- **MON$GUID**: CHAR(38)
- **Description**: Database GUID (persistent until restore/fixup)

### MON$FILE_ID
- **MON$FILE_ID**: VARCHAR(255)
- **Description**: Unique ID of the database file at the filesystem level

### MON$NEXT_ATTACHMENT
- **MON$NEXT_ATTACHMENT**: BIGINT
- **Description**: Current value of the next attachment ID counter

### MON$NEXT_STATEMENT
- **MON$NEXT_STATEMENT**: BIGINT
- **Description**: Current value of the next statement ID counter

### MON$REPLICA_MODE
- **MON$REPLICA_MODE**: SMALLINT
- **Description**: Database replica mode
  - 0 - not a replica
  - 1 - read-only replica
  - 2 - read-write replica

### MON$IO_STATS
**MON$IO_STATS** displays input/output statistics. The counters are cumulative, by group, for each group of statistics.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$STAT_ID</td>
<td>INTEGER</td>
<td>Statistics identifier</td>
</tr>
<tr>
<td>MON$STAT_GROUP</td>
<td>SMALLINT</td>
<td>Statistics group:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - database</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - connection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - transaction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - statement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - call</td>
</tr>
<tr>
<td>MON$PAGE_READS</td>
<td>BIGINT</td>
<td>Count of database pages read</td>
</tr>
<tr>
<td>MON$PAGE_WRITES</td>
<td>BIGINT</td>
<td>Count of database pages written to</td>
</tr>
<tr>
<td>MON$PAGE_FETCHES</td>
<td>BIGINT</td>
<td>Count of database pages fetched</td>
</tr>
<tr>
<td>MON$PAGE_MARKS</td>
<td>BIGINT</td>
<td>Count of database pages marked</td>
</tr>
</tbody>
</table>
MON$MEMORY_USAGE displays memory usage statistics.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$STAT_ID</td>
<td>INTEGER</td>
<td>Statistics identifier</td>
</tr>
</tbody>
</table>
| MON$STAT_GROUP      | SMALLINT       | Statistics group:  
0 - database  
1 - connection  
2 - transaction  
3 - operator  
4 - call                                                             |
| MON$MEMORY_USED     | BIGINT         | The amount of memory in use, in bytes. This data is about the high-level memory allocation performed by the server. It can be useful to track down memory leaks and excessive memory usage in connections, procedures, etc. |
| MON$MEMORY_ALLOCATED| BIGINT         | The amount of memory allocated by the operating system, in bytes. This data is about the low-level memory allocation performed by the Firebird memory manager — the amount of memory allocated by the operating system — which can allow you to control the physical memory usage. |
| MON$MAX_MEMORY_USED | BIGINT         | The maximum number of bytes used by this object                                                                                             |
| MON$MAX_MEMORY_ALLOCATED | BIGINT       | The maximum number of bytes allocated for this object by the operating system                                                                 |

Counters associated with database-level records MON$DATABASE (MON$STAT_GROUP = 0), display memory allocation for all connections. In the Classic and SuperClassic zero values of the counters indicate that these architectures have no common cache.

Minor memory allocations are not accrued here but are added to the database memory pool instead.
Getting 10 requests consuming the most memory

```sql
SELECT 
    STMT.MON$ATTACHMENT_ID, 
    STMT.MON$SQL_TEXT, 
    MEM.MON$MEMORY_USED 
FROM MON$MEMORY_USAGE MEM 
    NATURAL JOIN MON$STATEMENTS STMT 
ORDER BY MEM.MON$MEMORY_USED DESC 
FETCH FIRST 10 ROWS ONLY
```

**MON$RECORD_STATS**

MON$RECORD_STATS displays record-level statistics. The counters are cumulative, by group, for each group of statistics.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$STAT_ID</td>
<td>INTEGER</td>
<td>Statistics identifier</td>
</tr>
<tr>
<td>MON$STAT_GROUP</td>
<td>SMALLINT</td>
<td>Statistics group:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - database</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - connection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - transaction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - statement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - call</td>
</tr>
<tr>
<td>MON$RECORD_SEQ_READS</td>
<td>BIGINT</td>
<td>Count of records read sequentially</td>
</tr>
<tr>
<td>MON$RECORD_IDX_READS</td>
<td>BIGINT</td>
<td>Count of records read via an index</td>
</tr>
<tr>
<td>MON$RECORD_INSERTS</td>
<td>BIGINT</td>
<td>Count of inserted records</td>
</tr>
<tr>
<td>MON$RECORD_UPDATES</td>
<td>BIGINT</td>
<td>Count of updated records</td>
</tr>
<tr>
<td>MON$RECORD_DELETES</td>
<td>BIGINT</td>
<td>Count of deleted records</td>
</tr>
<tr>
<td>MON$RECORD_BACKOUTS</td>
<td>BIGINT</td>
<td>Count of records backed out</td>
</tr>
<tr>
<td>MON$RECORD_PURGES</td>
<td>BIGINT</td>
<td>Count of records purged</td>
</tr>
<tr>
<td>MON$RECORD_EXPUNGE</td>
<td>BIGINT</td>
<td>Count of records expunged</td>
</tr>
<tr>
<td>MON$RECORD_LOCKS</td>
<td>BIGINT</td>
<td>Number of records locked</td>
</tr>
<tr>
<td>MON$RECORD_WAITS</td>
<td>BIGINT</td>
<td>Number of update, delete or lock attempts on records owned by other active transactions. Transaction is in WAIT mode.</td>
</tr>
<tr>
<td>MON$RECORD_CONFLICTS</td>
<td>BIGINT</td>
<td>Number of unsuccessful update, delete or lock attempts on records owned by other active transactions. These are reported as update conflicts.</td>
</tr>
</tbody>
</table>
### MON$STATEMENTS

MON$STATEMENTS displays statements prepared for execution.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$STATEMENT_ID</td>
<td>BIGINT</td>
<td>Statement identifier</td>
</tr>
<tr>
<td>MON$ATTACHMENT_ID</td>
<td>BIGINT</td>
<td>Connection identifier</td>
</tr>
<tr>
<td>MON$TRANSACTION_ID</td>
<td>BIGINT</td>
<td>Transaction identifier</td>
</tr>
<tr>
<td>MON$STATE</td>
<td>SMALLINT</td>
<td>Statement state:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - idle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - active</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - stalled</td>
</tr>
<tr>
<td>MON$TIMESTAMP</td>
<td>TIMESTAMP</td>
<td>The date and time when the statement was prepared</td>
</tr>
<tr>
<td>MON$SQL_TEXT</td>
<td>BLOB TEXT</td>
<td>Statement text in SQL</td>
</tr>
<tr>
<td>MON$STAT_ID</td>
<td>INTEGER</td>
<td>Statistics identifier</td>
</tr>
<tr>
<td>MON$EXPLAINED_PLAN</td>
<td>BLOB TEXT</td>
<td>Explained execution plan</td>
</tr>
<tr>
<td>MON$STATEMENT_TIMEOUT</td>
<td>INTEGER</td>
<td>Connection-level statement timeout in milliseconds. When 0 is reported the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>timeout of MON$ATTACHMENT.MON$STATEMENT_TIMEOUT for this connection applies.</td>
</tr>
<tr>
<td>MON$IDLE_TIMER</td>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>Statement timer expiration time</td>
</tr>
</tbody>
</table>
Display active queries, excluding those running in your connection

```
SELECT
  ATT.MON$USER,
  ATT.MON$REMOTE_ADDRESS,
  STMT.MON$SQL_TEXT,
  STMT.MON$TIMESTAMP
FROM MON$ATTACHMENTS ATT
JOIN MON$STATEMENTS STMT ON ATT.MON$ATTACHMENT_ID = STMT.MON$ATTACHMENT_ID
WHERE ATT.MON$ATTACHMENT_ID <> CURRENT_CONNECTION
  AND STMT.MON$STATE = 1
```

Using MON$STATEMENTS to Cancel a Query

Monitoring tables are read-only. However, the server has a built-in mechanism for deleting (and only deleting) records in the MON$STATEMENTS table, which makes it possible to cancel a running query.

Notes

- If no statements are currently being executed in the connection, any attempt to cancel queries will not proceed
- After a query is cancelled, calling execute/fetch API functions will return an error with the isc_cancelled code
- Subsequent queries from this connection will proceed as normal
- Cancellation of the statement does not occur synchronously, it only marks the request for cancellation, and the cancellation itself is done asynchronously by the server

Example

Cancelling all active queries for the specified connection:

```
DELETE FROM MON$STATEMENTS
WHERE MON$ATTACHMENT_ID = 32
```

MON$TABLE_STATS

MON$TABLE_STATS reports table-level statistics.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$STAT_ID</td>
<td>INTEGER</td>
<td>Statistics identifier</td>
</tr>
</tbody>
</table>
###MON$STAT_GROUP

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$STAT_GROUP</td>
<td>SMALLINT</td>
<td>Statistics group:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - database</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - connection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - transaction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - statement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - call</td>
</tr>
</tbody>
</table>

###MON$TABLE_NAME

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$TABLE_NAME</td>
<td>CHAR(63)</td>
<td>Name of the table</td>
</tr>
</tbody>
</table>

###MON$RECORD_STAT_ID

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$RECORD_STAT_ID</td>
<td>INTEGER</td>
<td>Link to MON$RECORD_STATS</td>
</tr>
</tbody>
</table>

###Getting statistics at the record level for each table for the current connection

```sql
SELECT t.mon$table_name,
       r.mon$record_inserts,
       r.mon$record_updates,
       r.mon$record_deletes,
       r.mon$record_backouts,
       r.mon$record_purges,
       r.mon$record_expunges,
       r.mon$record_seq_reads,
       r.mon$record_idx_reads,
       r.mon$record_rpt_reads,
       r.mon$backversion_reads,
       r.mon$fragment_reads,
       r.mon$record_locks,
       r.mon$record_waits,
       r.mon$record_conflicts,
       a.mon$stat_id
FROM mon$record_stats r
JOIN mon$table_stats t ON r.mon$stat_id = t.mon$record_stat_id
JOIN mon$attachments a ON t.mon$stat_id = a.mon$stat_id
WHERE a.mon$attachment_id = CURRENT_CONNECTION
```

###MON$TRANSACTIONS

**MON$TRANSACTIONS** reports started transactions.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$TRANSACTION_ID</td>
<td>BIGINT</td>
<td>Transaction identifier (number)</td>
</tr>
<tr>
<td>MON$ATTACHMENT_ID</td>
<td>BIGINT</td>
<td>Connection identifier</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------</td>
<td>------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>MON$STATE</td>
<td>SMALLINT</td>
<td>Transaction state:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - idle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - active</td>
</tr>
<tr>
<td>MON$TIMESTAMP</td>
<td>TIMESTAMP</td>
<td>The date and time when the transaction was started</td>
</tr>
<tr>
<td>MON$TOP_TRANSACTION</td>
<td>BIGINT</td>
<td>Top-level transaction identifier (number)</td>
</tr>
<tr>
<td>MON$OLDEST_TRANSACTION</td>
<td>BIGINT</td>
<td>Transaction ID of the oldest [interesting] transaction (OIT)</td>
</tr>
<tr>
<td>MON$OLDEST_ACTIVE</td>
<td>BIGINT</td>
<td>Transaction ID of the oldest active transaction (OAT)</td>
</tr>
<tr>
<td>MON$ISOLATION_MODE</td>
<td>SMALLINT</td>
<td>Isolation mode (level):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - consistency (snapshot table stability)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - concurrency (snapshot)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - read committed record version</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - read committed no record version</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - read committed read consistency</td>
</tr>
<tr>
<td>MON$LOCK_TIMEOUT</td>
<td>SMALLINT</td>
<td>Lock timeout:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-1 - wait forever</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - no waiting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 or greater - lock timeout in seconds</td>
</tr>
<tr>
<td>MON$READ_ONLY</td>
<td>SMALLINT</td>
<td>Flag indicating whether the transaction is read-only (value 1) or read-write (value 0)</td>
</tr>
<tr>
<td>MON$AUTO_COMMIT</td>
<td>SMALLINT</td>
<td>Flag indicating whether automatic commit is used for the transaction (value 1) or not (value 0)</td>
</tr>
<tr>
<td>MON$AUTO_UNDO</td>
<td>SMALLINT</td>
<td>Flag indicating whether the logging mechanism automatic undo is used for the transaction (value 1) or not (value 0)</td>
</tr>
<tr>
<td>MON$STAT_ID</td>
<td>INTEGER</td>
<td>Statistics identifier</td>
</tr>
</tbody>
</table>

**Getting all connections that started Read Write transactions with isolation level above Read Committed**

```sql
SELECT DISTINCT a.*
FROM mon$attachments a
JOIN mon$transactions t ON a.mon$attachment_id = t.mon$attachment_id
WHERE NOT (t.mon$read_only = 1 AND t.mon$isolation_mode >= 2)
```
Appendix F: Security tables

The names of the security tables have `SEC$` as prefix. They display data from the current security database. These tables are virtual in the sense that before access by the user, no data is recorded in them. They are filled with data at the time of user request. However, the descriptions of these tables are constantly present in the database. In this sense, these virtual tables are like tables of the `MON$`-family used to monitor the server.

Security

- SYSDBA, users with the `RDB$ADMIN` role in the security database and the current database, and the owner of the security database have full access to all information provided by the security tables.
- Regular users can only see information on themselves, other users are not visible.

These features are highly dependent on the user management plugin. Keep in mind that some options are ignored when using a legacy control plugin users.

List of security tables

**SEC$DB_CREATORS**
Lists users and roles granted the `CREATE DATABASE` privilege

**SEC$GLOBAL_AUTH_MAPPING**
Information about global authentication mappings

**SEC$USERS**
Lists users in the current security database

**SEC$USER_ATTRIBUTES**
Additional attributes of users

**SEC$DB_CREATORS**
Lists users and roles granted the `CREATE DATABASE` privilege.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEC$USER</td>
<td>CHAR(63)</td>
<td>Name of the user or role</td>
</tr>
<tr>
<td>SEC$USER_TYPE</td>
<td>SMALLINT</td>
<td>Type of user:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - user</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13 - role</td>
</tr>
</tbody>
</table>

**SEC$GLOBAL_AUTH_MAPPING**
Lists users and roles granted the `CREATE DATABASE` privilege.
## Appendix F: Security tables

### SEC$MAP_NAME
- **Column Name**: SEC$MAP_NAME
- **Data Type**: CHAR(63)
- **Description**: Name of the mapping

### SEC$MAP_USING
- **Column Name**: SEC$MAP_USING
- **Data Type**: CHAR(1)
- **Description**: Using definition:
  - P - plugin (specific or any)
  - S - any plugin serverwide
  - M - mapping
  - * - any method

### SEC$MAP_PLUGIN
- **Column Name**: SEC$MAP_PLUGIN
- **Data Type**: CHAR(63)
- **Description**: Mapping applies for authentication information from this specific plugin

### SEC$MAP_DB
- **Column Name**: SEC$MAP_DB
- **Data Type**: CHAR(63)
- **Description**: Mapping applies for authentication information from this specific database

### SEC$MAP_FROM_TYPE
- **Column Name**: SEC$MAP_FROM_TYPE
- **Data Type**: CHAR(63)
- **Description**: The type of authentication object (defined by plugin) to map from, or * for any type

### SEC$MAP_FROM
- **Column Name**: SEC$MAP_FROM
- **Data Type**: CHAR(255)
- **Description**: The name of the authentication object to map from

### SEC$MAP_TO_TYPE
- **Column Name**: SEC$MAP_TO_TYPE
- **Data Type**: SMALLINT Nullable
- **Description**: The type to map to
  - 0 - USER
  - 1 - ROLE

### SEC$MAP_TO
- **Column Name**: SEC$MAP_TO
- **Data Type**: CHAR(63)
- **Description**: The name to map to

## SEC$USERS

Lists users in the current security database.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEC$USER_NAME</td>
<td>CHAR(63)</td>
<td>Username</td>
</tr>
<tr>
<td>SEC$FIRST_NAME</td>
<td>VARCHAR(32)</td>
<td>First name</td>
</tr>
<tr>
<td>SEC$MIDDLE_NAME</td>
<td>VARCHAR(32)</td>
<td>Middle name</td>
</tr>
<tr>
<td>SEC$LAST_NAME</td>
<td>VARCHAR(32)</td>
<td>Last name</td>
</tr>
<tr>
<td>SEC$ACTIVE</td>
<td>BOOLEAN</td>
<td>true - active, false - inactive</td>
</tr>
<tr>
<td>SEC$ADMIN</td>
<td>BOOLEAN</td>
<td>true - user has admin role in security database, false otherwise</td>
</tr>
<tr>
<td>SEC$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Description (comment) on the user</td>
</tr>
<tr>
<td>SEC$PLUGIN</td>
<td>CHAR(63)</td>
<td>Authentication plugin name that manages this user</td>
</tr>
</tbody>
</table>

⚠️ Multiple users can exist with the same username, each managed by a different authentication plugin.
Additional attributes of users

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEC$USER_NAME</td>
<td>CHAR(63)</td>
<td>Username</td>
</tr>
<tr>
<td>SEC$KEY</td>
<td>VARCHAR(63)</td>
<td>Attribute name</td>
</tr>
<tr>
<td>SEC$VALUE</td>
<td>VARCHAR(255)</td>
<td>Attribute value</td>
</tr>
<tr>
<td>SEC$PLUGIN</td>
<td>CHAR(63)</td>
<td>Authentication plugin name that manages this user</td>
</tr>
</tbody>
</table>

Displaying a list of users and their attributes

```sql
SELECT
    U.SEC$USER_NAME AS LOGIN,
    A.SEC$KEY AS TAG,
    A.SEC$VALUE AS "VALUE",
    U.SEC$PLUGIN AS "PLUGIN"
FROM SEC$USERS U
LEFT JOIN SEC$USER_ATTRIBUTES A
    ON U.SEC$USER_NAME = A.SEC$USER_NAME
    AND U.SEC$PLUGIN = A.SEC$PLUGIN;
```

<table>
<thead>
<tr>
<th>LOGIN</th>
<th>TAG</th>
<th>VALUE</th>
<th>PLUGIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSDBA</td>
<td>&lt;null&gt;</td>
<td>&lt;null&gt;</td>
<td>Srp</td>
</tr>
<tr>
<td>ALEX</td>
<td>B</td>
<td>x</td>
<td>Srp</td>
</tr>
<tr>
<td>ALEX</td>
<td>C</td>
<td>sample</td>
<td>Srp</td>
</tr>
<tr>
<td>SYSDBA</td>
<td>&lt;null&gt;</td>
<td>&lt;null&gt;</td>
<td>Legacy_UserManager</td>
</tr>
</tbody>
</table>

Appendix F: Security tables
# Appendix G: Character Sets and Collation Sequences

<table>
<thead>
<tr>
<th>Character Set</th>
<th>ID</th>
<th>Bytes per Char</th>
<th>Collation</th>
<th>Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASCII</td>
<td>2</td>
<td>1</td>
<td>ASCII</td>
<td>English</td>
</tr>
<tr>
<td>BIG_5</td>
<td>56</td>
<td>2</td>
<td>BIG_5</td>
<td>Chinese, Vietnamese, Korean</td>
</tr>
<tr>
<td>CP943C</td>
<td>68</td>
<td>2</td>
<td>CP943C</td>
<td>Japanese</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CP943C_UNICODE</td>
<td>Japanese</td>
</tr>
<tr>
<td>CYRL</td>
<td>50</td>
<td>1</td>
<td>CYRL</td>
<td>Russian</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_RUS</td>
<td>Russian dBase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PDOX_CYRL</td>
<td>Russian Paradox</td>
</tr>
<tr>
<td>DOS437</td>
<td>10</td>
<td>1</td>
<td>DOS437</td>
<td>U.S. English</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_DEU437</td>
<td>German dBase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_ESP437</td>
<td>Spanish dBase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_FIN437</td>
<td>Finnish dBase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_FRA437</td>
<td>French dBase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_ITA437</td>
<td>Italian dBase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_NLD437</td>
<td>Dutch dBase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_SVE437</td>
<td>Swedish dBase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_UK437</td>
<td>English (Great Britain) dBase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_US437</td>
<td>U.S. English dBase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PDOX_ASCII</td>
<td>Code page Paradox-ASCII</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PDOX_INTL</td>
<td>International English Paradox</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PDOX_SWEDFIN</td>
<td>Swedish / Finnish Paradox</td>
</tr>
<tr>
<td>DOS737</td>
<td>9</td>
<td>1</td>
<td>DOS737</td>
<td>Greek</td>
</tr>
<tr>
<td>DOS775</td>
<td>15</td>
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<td>DOS775</td>
<td>Baltic</td>
</tr>
<tr>
<td>DOS850</td>
<td>11</td>
<td>1</td>
<td>DOS850</td>
<td>Latin I (no Euro symbol)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_DEU850</td>
<td>German</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_ESP850</td>
<td>Spanish</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_FRA850</td>
<td>French</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_FRC850</td>
<td>French-Canada</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_ITA850</td>
<td>Italian</td>
</tr>
<tr>
<td>Character Set</td>
<td>ID</td>
<td>Bytes per Char</td>
<td>Collation</td>
<td>Language</td>
</tr>
<tr>
<td>--------------</td>
<td>----</td>
<td>----------------</td>
<td>-----------</td>
<td>----------------</td>
</tr>
<tr>
<td>DB_NLD850</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>Dutch</td>
</tr>
<tr>
<td>DB_PT850</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>Portuguese-Brazil</td>
</tr>
<tr>
<td>DB_SVE850</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>Swedish</td>
</tr>
<tr>
<td>DB_UK850</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>English-Great Britain</td>
</tr>
<tr>
<td>DB_US850</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>U.S. English</td>
</tr>
<tr>
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<td>DOS852</td>
<td>Latin II</td>
</tr>
<tr>
<td>DB_CSY</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>Czech dBase</td>
</tr>
<tr>
<td>DB_PLK</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>Polish dBase</td>
</tr>
<tr>
<td>DB_SLO</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>Slovene dBase</td>
</tr>
<tr>
<td>PDOX_CSY</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>Czech Paradox</td>
</tr>
<tr>
<td>PDOX_HUN</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>Hungarian Paradox</td>
</tr>
<tr>
<td>PDOX_PLK</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>Polish Paradox</td>
</tr>
<tr>
<td>PDOX_SLO</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>Slovene Paradox</td>
</tr>
<tr>
<td>DOS857</td>
<td>46</td>
<td>1</td>
<td>DOS857</td>
<td>Turkish</td>
</tr>
<tr>
<td>DB_TRK</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>Turkish dBase</td>
</tr>
<tr>
<td>DOS858</td>
<td>16</td>
<td>1</td>
<td>DOS858</td>
<td>Latin I (with Euro symbol)</td>
</tr>
<tr>
<td>DOS860</td>
<td>13</td>
<td>1</td>
<td>DOS860</td>
<td>Portuguese</td>
</tr>
<tr>
<td>DB_PT860</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>Portuguese dBase</td>
</tr>
<tr>
<td>DOS861</td>
<td>47</td>
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<td>DOS861</td>
<td>Icelandic</td>
</tr>
<tr>
<td>PDOX_ISL</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>Icelandic Paradox</td>
</tr>
<tr>
<td>DOS862</td>
<td>17</td>
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<td>DOS862</td>
<td>Hebrew</td>
</tr>
<tr>
<td>DOS863</td>
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<td>DOS863</td>
<td>French-Canada</td>
</tr>
<tr>
<td>DB_FRC863</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>French dBase-Canada</td>
</tr>
<tr>
<td>DOS864</td>
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<td>DOS864</td>
<td>Arabic</td>
</tr>
<tr>
<td>DOS865</td>
<td>12</td>
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<td>DOS865</td>
<td>Scandinavian</td>
</tr>
<tr>
<td>DB_DAN865</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>Danish dBase</td>
</tr>
<tr>
<td>DB_NOR865</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>Norwegian dBase</td>
</tr>
<tr>
<td>PDOX_NORDAN4</td>
<td>//</td>
<td>//</td>
<td>//</td>
<td>Paradox Norway and Denmark</td>
</tr>
<tr>
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<td>DOS866</td>
<td>Russian</td>
</tr>
<tr>
<td>DOS869</td>
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<td>DOS869</td>
<td>Modern Greek</td>
</tr>
<tr>
<td>EUCJ_0208</td>
<td>6</td>
<td>2</td>
<td>EUCJ_0208</td>
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<td>Latin 2 — Central Europe (Croatian, Czech, Hungarian, Polish, Romanian, Serbian, Slovak, Slovenian)</td>
</tr>
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- **GB18030_UNICODE**: Chinese
- **GBK**: Chinese
- **GBK_UNICODE**: Chinese
- **DA_DA**: Danish
- **DE_DE**: German
- **DU_NL**: Dutch
- **EN_UK**: English-Great Britain
- **EN_US**: U.S. English
- **ES_ES**: Spanish
- **ES_ES_CI_AI**: Spanish — case insensitive and + accent-insensitive
- **FI_FI**: Finnish
- **FR_CA**: French-Canada
- **FR_CA_CI_AI**: French-Canada — case insensitive + accent insensitive
- **FR_FR**: French
- **FR.FR_CI.AI**: French — case insensitive + accent insensitive
- **IS.IS**: Icelandic
- **IT.IT**: Italian
- **NO.NO**: Norwegian
- **PT_BR**: Portuguese-Brazil
- **PT_PT**: Portuguese
- **SV.SV**: Swedish
- **ISO_HUN**: Hungarian — case insensitive, accent sensitive
## Appendix G: Character Sets and Collation Sequences

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<thead>
<tr>
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<th>Language</th>
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Appendix H: License notice

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The Original Documentation is titled Firebird 4.0 Language Reference. This Documentation was derived from Firebird 3.0 Language Reference.

The Initial Writers of the Original Documentation are: Paul Vinkenoog, Dmitry Yemanov, Thomas Woinke and Mark Rotteveel. Writers of text originally in Russian are Denis Simonov, Dmitry Filippov, Alexander Karpeykin, Alexey Kovyazin and Dmitry Kuzmenko.

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Contributor(s): Mark Rotteveel.

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Appendix I: Document History

The exact file history is recorded in our git repository; see https://github.com/FirebirdSQL/firebird-documentation

Revision History

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<td>M</td>
<td>Fix behaviour documented for SNAPSHOT TABLE STABILITY (#158)</td>
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<td>• Documented determination of result type of SUM</td>
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<td>• Added mention of increment of sequence to NEXT VALUE FOR</td>
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### Revision History

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<td>23 May 2021</td>
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<td>- Documented USING PLUGIN clause of COMMENT ON USER</td>
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<td>- Documented changes in start/restart behaviour of sequences</td>
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<td>- Applied consistent version naming (e.g. Firebird 4.0, not Firebird 4)</td>
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<td>- Add missing links</td>
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<td>- Correct or clarify some issues previously annotated with TODO</td>
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<td>- Document key and block size of ENCRYPT algorithms</td>
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<td>- Fix section levels, and some reorganization of triggers</td>
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