



# Firebird 2.5 Language Reference

*Beta Release 1*

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# Firebird 2.5 Language Reference

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11 August 2016, document version 0.906

by Dmitry Filippov, Alexander Karpeykin, Alexey Kovyazin, Dmitry Kuzmenko, Denis Simonov, Paul Vinkenoog, and Dmitry Yemanov

The source of much copied reference material: Paul Vinkenoog

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## **Abstract**

This volume represents a compilation of topics concerning Firebird's SQL language written by members of the Russian-speaking community of Firebird developers and users. In 2014, it culminated in a language reference manual, in Russian. At the instigation of Alexey Kovyazin, a campaign was launched amongst Firebird users world-wide to raise funds to pay for a professional translation into English, from which translations into other languages would proceed under the auspices of the Firebird Documentation Project.

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## Chapter 1

# About the Firebird SQL Language Reference

*for Firebird 2.5*

**This Firebird SQL Language Reference is the first 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. It has a long history.**

## Subject Matter

The subject matter 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, triggers and dynamically-executable code blocks. These are the areas addressed in this volume.

## Authorship

The material for assembling this Language Reference has been accumulating in the tribal lore of the open source community of Firebird core developers and user-developers for 15 years. The gift of the InterBase 6 open source codebase in July 2000 from the (then) Inprise/Borland conglomerate was warmly welcomed. However, it came without rights to existing documentation. Once the code base had been forked by its owners for private, commercial development, it became clear that the open source, non-commercial Firebird community would never be granted right of use.

The two important books from the InterBase 6 published set were the *Data Definition Guide* and the *Language Reference*. The former covered the data definition language (DDL) subset of the SQL language, while the latter covered most of the rest. Fortunately for Firebird users over the years, both have been easy to find on-line as PDF books.

## Language Reference Updates

The *Data Definition Guide*, covering the creation and maintenance of metadata for databases, was “good enough” for several years: the data definition language (DDL) of a DBMS is stable and grows slowly in comparison to the data manipulation language (DML) employed for queries and the PSQL used for server-based programming.

The leader of the Firebird Project's documentation team, Paul Vinkenoog, took up the cause for documenting the huge volume of improvements and additions to DML and PSQL as Firebird advanced through its releases. Paul was personally responsible for collating, assembling and, to a great extent, authoring a cumulative series of “Language Reference Updates”—one for every major release from v.1.5 forward.

## ***Gestation of the Big Book***

From around 2010, Paul, with Firebird Project lead Dmitry Yemanov and a documenter colleague Thomas Woinke, set about the task of designing and assembling a complete SQL language reference for Firebird. They began with the material from the LangRef Updates, which is voluminous. It was going to be a big job but, for all concerned, a spare-time one.

Then, in 2013-4, two benefactor companies—MICEX and IBSurgeon—funded three writers to take up this stalled book outline and publish a Firebird 2.5 Language Reference in Russian. They wrote the bulk of the missing DDL section from scratch and wrote, translated or reused DML and PSQL material from the LangRef Updates, Russian language support forums, Firebird release notes, read-me files and other sources. By the end of 2014, they had the task almost complete, in the form of a Microsoft Word document.

## **Translation . . .**

The Russian sponsors, recognising that their efforts needed to be shared with the world-wide Firebird community, asked some Project members to initiate a crowd-funding campaign to have the Russian text professionally translated into English. The translated text would be edited and converted to the Project's standard DocBook format for addition to the open document library of the Firebird Project. From there, the source text would be available for translation into other languages for addition to the library.

The fund-raising campaign happened at the end of 2014 and was successful. In June, 2015, professional translator Dmitry Borodin began translating the Russian text. From him, the raw English text went in stages for editing and DocBook conversion by Helen Borrie—and here is *The Firebird SQL Language Reference for V.2.5*, by...everyone!

## **. . . and More Translation**

Once the DocBook source appears in CVS, we hope the trusty translators will start making versions in German, Japanese, Italian, French, Portuguese, Spanish, Czech. Certainly, we never have enough translators so please, you Firebirders who have English as a second language, do consider translating some sections into your first language.

## ***Contributors***

### **Direct Content**

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- Helen Borrie
- and others

### Translation

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## Chapter 2

# SQL Language Structure

This reference describes the SQL language supported by Firebird.

## Background to Firebird's SQL Language

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

### 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.

#### Note

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.

## 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 entitled [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.

**Important**

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.

## Error Conditions

Processing of every SQL statement either completes successfully or fails due to a specific error condition.

## 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.

```
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.

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

Refer to the list of reserved words and keywords in the chapter [Reserved Words and Keywords](#).

## Identifiers

All database objects have names, often called *identifiers*. 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:

### *Rules for Regular Object Identifiers:*

- Length cannot exceed 31 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
```

### *Rules for Delimited Object Identifiers:*

- Length cannot exceed 31 characters
- The entire string must be enclosed in double-quotes, e.g. "anIdentifier"
- It may contain characters from any Latin 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 Dialect](#)

Delimited name syntax

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

**Note**

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 all regular names 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.

## Literals

Literals are used to represent data in a direct format. Examples of standard types of literals are:

```
integer - 0, -34, 45, 0X080000000;  
real - 0.0, -3.14, 3.23e-23;  
string - 'text', 'don''t!';  
date - DATE '10.01.2014';  
time - TIME '15:12:56';  
timestamp - TIMESTAMP '10.01.2014 13:32:02';  
null state - null
```

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

## 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:*

```
<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](#).

## 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:*

```
<comment> ::= <block comment> | <single-line comment>  
  
<block comment> ::=  
/* <ASCII char>[<ASCII char> ...] */  
  
<single-line comment> ::=  
-- <ASCII char>[<ASCII char> ...]<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
```





# 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 3.1. Overview of Data Types**

Name	Size	Precision & Limits	Description
BIGINT	64 bits	From $-2^{63}$ to $(2^{63} - 1)$	The data type is available in Dialect 3 only
BLOB	Varying	The size of a BLOB segment is limited to 64K. The maximum size of a BLOB field is 4 GB	A data type of a dynamically 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
CHAR(n), CHARACTER(n)	n characters. Size in bytes depends on the encoding, the number of bytes in a character	from 1 to 32,767 bytes	A fixed-length character data type. When its data is displayed, trailing spaces are added to the string up to the specified length. Trailing spaces are not stored in the database but are restored to match the defined length when the column is displayed on the client side. Network traffic is reduced by not sending spaces over the LAN. If the number of characters is not specified, 1 is used by default.
DATE	32 bits	From 01.01.0001 AD to 31.12.9999 AD	ISC_DATE. Date only, no time element
DECIMAL ( <i>precision</i> , <i>scale</i> )	Varying (16, 32 or 64 bits)	<i>precision</i> =from 1 to 18, defines the least possible number of digits to store;	A number with a decimal point that has <i>scale</i> digits after the point. <i>scale</i> must be less than or equal to <i>precision</i> . Example: DECIMAL(10,3) con-

Name	Size	Precision & Limits	Description
		<i>scale</i> = from 0 to 18, defines the number of digits after the decimal point	tains a number in exactly the following format: ppppppp.sss
DOUBLE PRECISION	64 bits	$2.225 * 10^{-308}$ to $1.797 * 10^{308}$	Double-precision IEEE, ~15 digits, reliable size depends on the platform
FLOAT	32 bits	$1.175 * 10^{-38}$ to $3.402 * 10^{38}$	Single-precision IEEE, ~7 digits
INTEGER, INT	32 bits	-2,147,483,648 up to 2,147,483,647	Signed long
NUMERIC ( <i>precision, scale</i> )	Varying (16, 32 or 64 bits)	<i>precision</i> =from 1 to 18, defines the exact number of digits to store; <i>scale</i> = from 0 to 18, defines the number of digits after the decimal point	A number with a decimal point that has <i>scale</i> digits after the point. <i>scale</i> must be less than or equal to <i>precision</i> . Example: NUMERIC(10,3) contains a number in exactly the following format: ppppppp.sss
SMALLINT	16 bits	-32,768 to 32,767	Signed short (word)
TIME	32 bits	0:00 to 23:59:59.9999	ISC_TIME. Time of day. It cannot be used to store an interval of time
TIMESTAMP	64 bits (2 X 32 bits)	From start of day 01.01.0001 AD to end of day 31.12.9999 AD	Date and time of day
VARCHAR(n), CHAR VARYING, CHARACTER VARYING	n characters. Size in bytes depends on the encoding, the number of bytes in a character	from 1 to 32,765 bytes	Variable length string type. The total size of characters in bytes cannot be larger than (32KB-3), taking into account their encoding. The two trailing bytes store the declared length. There is no default size: the <i>n</i> 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.

#### 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.

## Integer Data Types

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

### 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 for storing them. 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:*

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

CREATE DOMAIN RGB_VALUE AS SMALLINT;
```

### 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:*

```
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) )
```

### 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.

## Hexadecimal Format for Integer Numbers

Starting from Firebird 2.5, constants of the three integer types can be specified in 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 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:*

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

INSERT INTO MYBIGINTS VALUES (
  -236453287458723,
  328832607832,
  22,
  -56786237632476,
  0X6F55A09D42, -- 478177959234
  0X7FFFFFFFFFFFFFFF, -- 9223372036854775807
  0XFFFFFFFFFFFFFFF, -- -1
  0X80000000, -- -2147483648, an INTEGER
  0X080000000, -- 2147483648, a BIGINT
  0XFFFFFFFF, -- -1, an INTEGER
  0X0FFFFFFFFF -- 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 0x080000000 (9 digits) will be saved as different BIGINT values.

## Floating-Point Data Types

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**

This data type has an approximate precision of 7 digits after the decimal point. To ensure the safety of storage, rely on 6 digits.

## **DOUBLE PRECISION**

This data type is stored with an approximate precision of 15 digits.

## **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.

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 DBMS depends on several factors: declared precision, database dialect, declaration type.

**Table 3.2. Method of Physical Storage for Real Numbers**

Scale	Data type	Dialect 1	Dialect 3
1 - 4	NUMERIC	SMALLINT	SMALLINT
1 - 4	DECIMAL	INTEGER	INTEGER
5 - 9	NUMERIC OR DECIMAL	INTEGER	INTEGER
10 - 18	NUMERIC OR DECIMAL	DOUBLE PRECISION	BIGINT

## NUMERIC

*Data Declaration Format:*

`NUMERIC(p, s)`

*Storage Examples:* Further to the explanation above, the DBMS will store NUMERIC data according the declared precision (*p*) and scale (*s*). Some more examples are:

```
NUMERIC(4) stored as      SMALLINT (exact data)
NUMERIC(4,2)              SMALLINT (data * 102)
NUMERIC(10,4) (Dialect 1) DOUBLE PRECISION
                        (Dialect 3) BIGINT (data * 104)
```

### Caution

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.

## DECIMAL

*Data Declaration Format:*

`DECIMAL(p, s)`

*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:

```
DECIMAL(4) stored as      INTEGER (exact data)
DECIMAL(4,2)              INTEGER (data * 102)
DECIMAL(10,4) (Dialect 1) DOUBLE PRECISION
                        (Dialect 3) BIGINT (data * 104)
```

## Data Types for Dates and Times

The DATE, TIME and TIMESTAMP data types are used to work with data containing dates and times. Dialect 3 supports all the three 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.

**Note**

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 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 decimillisecons precision and time values are stored as the number of deci-millisecons elapsed since midnight. The actual precision of values stored in or read from time(stamp) functions and variables is:

- *CURRENT\_TIME* defaults to seconds precision and can be specified up to milliseconds precision with `CURRENT_TIME (0|1|2|3)`
- *CURRENT\_TIMESTAMP* milliseconds precision. Precision from seconds to milliseconds can be specified with `CURRENT_TIMESTAMP (0|1|2|3)`
- Literal 'NOW': milliseconds precision
- Functions *DATEADD()* and *DATEDIFF()* support up to milliseconds precision. Deci-millisecons can be specified but they are rounded to the nearest integer before any operation is performed
- The *EXTRACT()* function returns up to deci-millisecons precision with the SECOND and MILLISECOND arguments
- For *TIME* and *TIMESTAMP* literals Firebird happily accepts up to deci-millisecons precision, but truncates (not rounds) the time part to the nearest lower or equal millisecond. Try, for example, `SELECT TIME '14:37:54.1249' FROM rdb$database`
- the '+' and '-' operators work with deci-millisecons precision, but only *within* the expression. As soon as something is stored or even just SELECTed from RDB\$DATABASE, it reverts to milliseconds precision. Deci-millisecons precision is rare and is not currently stored in columns or variables. 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-millisecons ( $10^{-4}$  seconds) elapsed since midnight, the actual precision could vary from seconds to milliseconds.

## 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.



**Tip**

In Dialect 1, date literals without a time part, as well as '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 '25.12.2016 00:00:00.0000'. However, '25.12.2016' would have precisely the same effect, with fewer keystrokes!

## TIME

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():*

```
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 and Variables*.

## TIMESTAMP

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.

## 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 3.3. Arithmetic Operations for Date and Time Data Types**

Operand 1	Operation	Operand 2	Result
DATE	+	TIME	TIMESTAMP

Operand 1	Operation	Operand 2	Result
DATE	+	Numeric value $n$	DATE increased by $n$ whole days. Broken values are rounded (not floored) to the nearest integer
TIME	+	DATE	TIMESTAMP
TIME	+	Numeric value $n$	TIME increased by $n$ seconds. The fractional part is taken into account
TIMESTAMP	+	Numeric value $n$	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
DATE	-	DATE	Number of days elapsed, within the range DECIMAL(9, 0)
DATE	-	Numeric value $n$	DATE reduced by $n$ whole days. Broken values are rounded (not floored) to the nearest integer
TIME	-	TIME	Number of seconds elapsed, within the range DECIMAL(9, 4)
TIME	-	Numeric value $n$	TIME reduced by $n$ seconds. The fractional part is taken into account
TIMESTAMP	-	TIMESTAMP	Number of days and part-day, within the range DECIMAL(18, 9)
TIMESTAMP	-	Numeric value $n$	TIMESTAMP where the date will retreat by the number of days and part of a day represented by number $n$ —so “- 2.25” will reduce the date by 2 days and 6 hours

**Notes**

The DATE type is considered as TIMESTAMP in Dialect 1.

See also: [DATEADD](#), [DATEADD](#)

## 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.

## 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).

### Note

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, 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.

## 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.

## 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.

## 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 collation` 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:

```
...
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:

```
...
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 3.4. Collation Sequences for Character Set UTF8**

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

*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).

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

## 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 to 4,096 bytes. 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 3.5. Maximum Index Lengths by Page Size and Character Size**

Page Size	Bytes per character				
	1	2	3	4	6
4,096	1,015	507	338	253	169
8,192	2,039	1,019	679	509	339
16,384	4,087	2,043	1,362	1,021	682

### Note

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](#)

## Character Types in Detail

### CHAR

CHAR is a fixed-length data type. If the entered number of characters is less than the declared length, trailing spaces will be added to the field. 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 zero.

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.

*Declaration Syntax:*

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

#### Note

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

A valid *length* is from 1 to the maximum number of characters that can be accommodated within 32,767 bytes.

### VARCHAR

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. However, trailing spaces are not stored: they will be restored upon retrieval, up to the recorded length of the string.

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

*Syntax:*

```
VARCHAR (length) [CHARACTER SET <set>] [COLLATE <name>]
```

### NCHAR

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.

*Syntax:*

```
NCHAR (length)
```

The synonymous name is NATIONAL CHAR. A similar data type is available for the variable-length string type: NATIONAL CHARACTER VARYING.

## Binary 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>]
```

*Shortened syntax:*

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

*Segment Size:* Specifying the BLOB segment 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.

## 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.

*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.

## 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,
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	returns several NULL values by mistake if they are present
ORDER BY	—
GROUP BY	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](#)

## ARRAY Type

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 multidimensional 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.

## 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>]
```

## Adding More Dimensions

A new dimension is added after 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 DBMS does not offer much in the way of language or tools for working with the contents of arrays. 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:

*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
```

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.

## Special Data Types

“Special” data types ...

### 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:

```
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.

## 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.

### Explicit Data Type Conversion

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

*Syntax:*

```
CAST ( { <value> | NULL } AS <data_type> )

<data_type> ::= sql_datatype |
              [TYPE OF] domain |
```

```
TYPE OF COLUMN relname.colname
```

## 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:*

```
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 3.6. Conversions with CAST**

From Data Type	To Data Type
Numeric types	Numeric types, [VAR]CHAR, BLOB
[VAR]CHAR	[VAR]CHAR, BLOB, Numeric types, DATE, TIME, TIMESTAMP
BLOB	[VAR]CHAR, BLOB, Numeric types, DATE, TIME, TIMESTAMP
DATE, TIME	[VAR]CHAR, BLOB, TIMESTAMP
TIMESTAMP	[VAR]CHAR, BLOB, DATE, TIME

### Important

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.

## Literal 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 date and time literals (see Table 3.7) or a representation of the date in one of the allowed *date-time literal* formats:

```

<datetime_literal> ::= {
  [ YYYY<p> ]MM<p>DD[ <p>HH[ <p>mm[ <p>SS[ <p>NNNN ] ] ] ] |
  MM<p>DD[ <p>YYYY[ <p>HH[ <p>mm[ <p>SS[ <p>NNNN ] ] ] ] |
  DD<p>MM[ <p>YYYY[ <p>HH[ <p>mm[ <p>SS[ <p>NNNN ] ] ] ] |
  MM<p>DD[ <p>YY[ <p>HH[ <p>mm[ <p>SS[ <p>NNNN ] ] ] ] |
  DD<p>MM[ <p>YY[ <p>HH[ <p>mm[ <p>SS[ <p>NNNN ] ] ] ] |
  NOW |
  TODAY |
  TOMORROW |
  YESTERDAY
}

<date_literal> ::= {
  [ YYYY<p> ]MM<p>DD |
  MM<p>DD[ <p>YYYY ] |
  DD<p>MM[ <p>YYYY ] |
  MM<p>DD[ <p>YY ] |
  DD<p>MM[ <p>YY ] |
  TODAY |
  TOMORROW |
  YESTERDAY
}

<time_literal> := HH[ <p>mm[ <p>SS[ <p>NNNN ] ] ]

<p> ::= whitespace | . | : | , | - | /

```

**Table 3.7. Date and Time Literal Format Arguments**

Argument	Description
datetime_literal	Date and time literal
time_literal	Time literal
date_literal	Date literal
YYYY	Four-digit year
YY	Two-digit year
MM	Month. It may contain 1 or 2 digits (1-12 or 01-12). You can also specify the three-letter shorthand name or the full name of a month in English. Case-insensitive
DD	Day. It may contain 1 or 2 digits (1-31 or 01-31)

Argument	Description
HH	Hour. It may contain 1 or 2 digits (0-23 or 00-23)
mm	Minutes. It may contain 1 or 2 digits (0-59 or 00-59)
SS	Seconds. It may contain 1 or 2 digits (0-59 or 00-59)
NNNN	Ten-thousandths of a second. It may contain from 1 to 4 digits (0-9999)
p	A separator, any of permitted characters. Leading and trailing spaces are ignored

Table 3.8. Literals with Predefined Values of Date and Time

Literal	Description	Data Type	
		Dialect 1	Dialect 3
'NOW'	Current date and time	DATE	TIMESTAMP
'TODAY'	Current date	DATE with zero time	DATE
'TOMORROW'	Current date + 1 (day)	DATE with zero time	DATE
'YESTERDAY'	Current date - 1 (day)	DATE with zero time	DATE

**Important**

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.

*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('04,12,2014' as date) as d5,  -- MM,DD,YYYY
  cast('04.12.14' as date) as d6,    -- DD.MM.YY
  -- DD.MM with current year
  cast('04.12' as date) as d7,
  -- MM/DD with current year
  cast('04/12' as date) as d8,
  cast('2014/12/04' as date) as d9,  -- YYYY/MM/DD
  cast('2014 12 04' as date) as d10, -- YYYY MM DD
  cast('2014.12.04' as date) as d11, -- YYYY.MM.DD
  cast('2014-12-04' as date) as d12, -- YYYY-MM-DD
  cast('4 Jan 2014' as date) as d13, -- DD MM YYYY
  cast('2014 Jan 4' as date) as dt14, -- YYYY MM DD
  cast('Jan 4, 2014' as date) as dt15, -- 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
```

```
cast('11.37.12' as time) as t4, -- HH.mm.ss
-- 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.nnnn
cast('04.12.2014 11:31:12.1234' as timestamp) as dt3,
-- MM/DD/YYYY HH.mm.ss
cast('04/12/2014 11.37.12' as timestamp) as dt4
from rdb$database
```

## Shorthand Casts for Date and Time Data Types

Firebird allows the use of a shorthand “C-style” type syntax for casts from string to the types DATE, TIME and TIMESTAMP.

*Syntax:*

```
data_type 'date_literal_string'
```

*Example:*

```
-- 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 'today' + 2, TIME '16:00');

-- 3
NEW.LASTMOD = TIMESTAMP 'now';
```

### Note

These shorthand expressions are evaluated directly during parsing, as though the statement were already prepared for execution. Thus, even if the query is run several times, the value of, for instance, `timestamp 'now'` remains the same no matter how much time passes.

If you need the time to be evaluated at each execution, use the full CAST syntax. An example of using such an expression in a trigger:

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

## 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:

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

and 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:

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

or, with the short cast:

```
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:

```
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:*

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

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



## 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.

### 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.

### 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 3.9. Rules for Overriding Domain Attributes in Column Definition**

Attribute	Override?	Comments
Data type	No	
Default value	Yes	

Attribute	Override?	Comments
Text character set	Yes	It can be also used to restore the default database values for the column
Text collation sequence	Yes	
CHECK constraints	Yes	To add new conditions to the check, you can use the corresponding CHECK clauses in the CREATE and ALTER statements at the table level.
NOT NULL	No	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.

## 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
- delete the current default value
- set a new default value
- delete 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}]  
[{ADD [CONSTRAINT] CHECK (<dom_condition>) |  
DROP CONSTRAINT}]  
[{TYPE <datatype>}];
```

When planning to alter 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!

**Important**

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.

*Syntax:*

```
DROP DOMAIN name
```

**Important**

Any user connected to the database can delete a domain.

*Example:*

```
DROP DOMAIN Test_Domain
```

See also: [DROP DOMAIN](#) in the Data Definition Language (DDL) section.

# 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 assertions about data and the *predicates* that test the truth of those assertions.

## 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.

**Table 4.1. Description of Expression Elements**

Element	Description
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., <code>&lt;array_name&gt;[s]</code> , where <i>s</i> is the subscript of the member in the array <code>&lt;array_name&gt;</code>
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 assertions
Comparison operators	The symbols =, <>, !=, ~=, ^=, <, <=, >, >=, !<, ~<, ^<, !>, ~> and ^>
Comparison predicates	LIKE, STARTING WITH, CONTAINING, SIMILAR TO, BETWEEN, IS [NOT] NULL 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	A number; or a string literal enclosed in apostrophes
Date/time literal	An expression, similar to a string literal enclosed in apostrophes, that can be interpreted as a date, time or timestamp value. Date literals can be pre-defined literals ('TODAY', 'NOW', etc.) or strings of characters and numerals, such as '25.12.2016 15:30:35', that can be resolved as date and/or time strings

Element	Description
Context variable	An internally-defined <a href="#">context variable</a>
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 ( <code>CAST ( &lt;value&gt; AS &lt;datatype&gt; )</code> ). For date/time literals only, the shorthand syntax <code>&lt;datatype&gt; &lt;value&gt;</code> is also supported ( <code>DATE '25.12.2016'</code> )
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 <i>sequence</i>	Expression for obtaining the next value of a specified generator (sequence). The internal GEN_ID() function does the same

## Constants

A 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 Constants (Literals)

A string constant is a series of characters enclosed between a pair of apostrophes (“single quotes”). The maximum length of a string is 32,767 bytes; the maximum character count will be determined by the number of bytes used to encode each character.

#### Note

- Double quotes are *NOT VALID* for quoting strings. SQL reserves a different purpose for them.
- 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 home-made hooch'`.
- Care should be taken with the string length if the value is to be written to a VARCHAR column. The maximum length for a VARCHAR 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 Constants 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 have character set OCTETS by default but the *introducer syntax* can be used to force a string to be interpreted as another character set.

*Syntax:*

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

<hexstring>> ::= an even number of <hexdigit>
<hexdigit>   ::= one of 0..9, A..F, a..f
```

*Examples:*

```
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.

### **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*

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

## Number Constants

A number constant 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 (full-stop, dot) character and 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.

### Hexadecimal Notation for Numerals

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 0x6FAA0D3 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).

## 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 4.2. Operator Type Precedence**

Operator Type	Precedence	Explanation
Concatenation	1	Strings are concatenated before any other operations take place
Arithmetic	2	Arithmetic operations are performed after strings are concatenated, but before comparison and logical operations
Comparison	3	Comparison operations take place after string concatenation and arithmetic operations, but before logical operations
Logical	4	Logical operators are executed after all other types of operators

### 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:*



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

### Arithmetic Operators

**Table 4.3. Arithmetic Operator Precedence**

Operator	Purpose	Precedence
<b>+</b> <i>signed_number</i>	Unary plus	1
<b>-</b> <i>signed_number</i>	Unary minus	1
<b>*</b>	Multiplication	2
<b>/</b>	Division	2
<b>+</b>	Addition	3
<b>-</b>	Subtraction	3

*Example:*

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

#### Note

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

### Comparison Operators

**Table 4.4. Comparison Operator Precedence**

Operator	Purpose	Precedence
<b>=</b>	Is equal to, is identical to	1
<b>&lt;&gt;, !=, ~=, ^=</b>	Is not equal to	1
<b>&gt;</b>	Is greater than	1
<b>&lt;</b>	Is less than	1
<b>&gt;=</b>	Is greater than or equal to	1
<b>&lt;=</b>	Is less than or equal to	1
<b>!&gt;, ~&gt;, ^&gt;</b>	Is not greater than	1
<b>!&lt;, ~&lt;, ^&lt;</b>	Is not less than	1

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

*Example:*

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

*See also:* [Other Comparison Predicates](#).

## Logical Operators

**Table 4.5. Logical Operator Precedence**

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

*Example:*

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

## NEXT VALUE FOR

*Available:* DSQL, PSQL

NEXT VALUE FOR returns the next value of a sequence. SEQUENCE is an SQL-compliant term for a generator in Firebird and its ancestor, InterBase. The NEXT VALUE FOR operator is equivalent to the legacy GEN\_ID (... , 1) function and is the recommended syntax for retrieving the next sequence value.

*Syntax for NEXT VALUE FOR:*

```
NEXT VALUE FOR sequence-name
```

*Example:*

```
NEW.CUST_ID = NEXT VALUE FOR CUSTSEQ;
```

**Note**

Unlike `GEN_ID (... , 1)`, the `NEXT VALUE FOR` variant 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 more than 1. `GEN_ID (... , <step value>)` is still needed for these tasks. A `<step value>` of 0 returns the current sequence value.

See also: [SEQUENCE \(GENERATOR\)](#), [GEN\\_ID\(\)](#)

## 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: DSQL, PSQL

The `CASE` construct returns a single value from a number of possible ones. 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:

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

When this variant is used, `<test-expr>` is compared to `<expr> 1`, `<exp> 2` etc., 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 used in the [DECODE](#) function.

### **Searched CASE**

*Syntax:*

```
CASE
  WHEN <bool_expr> THEN <result>
  [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
```

## **NULL in Expressions**

NULL is not a value in SQL, but a *state* indicating that the value of the element either *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*.

**Important to Note**

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
```

Up to and including Firebird 2.5.x, there is no implementation for a logical (Boolean) data type—that is coming in Firebird 3. However, there are logical expressions (predicates) that can return true, false or unknown.

*Examples:*

```
(1 = NULL) or (1 <> 1) -- returns NULL
(1 = NULL) or (1 = 1) -- returns TRUE
(1 = NULL) or (1 = NULL) -- returns NULL
(1 = NULL) and (1 <> 1) -- returns FALSE
(1 = NULL) and (1 = 1) -- returns NULL
(1 = NULL) and (1 = NULL) -- returns NULL
```

## 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.odate = 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.

## 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...”).

### Note

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
    )
```

## 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  $\text{NOT}(P)$  will return TRUE. On the other hand, if  $P$  returns NULL (unknown), then  $\text{NOT}(P)$  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.

## Assertions

An assertion is a statement about the data that, like a predicate, can resolve to TRUE, FALSE or NULL. Assertions 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 of the ultimate assertion is resolved.

## Comparison Predicates

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

=, >, <, >=, <=, <>

(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:

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

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

```
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:

```
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:

```
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:* DSQL, PSQL, ESQL



*Syntax:*

```
<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:

```
<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:*

```
SELECT *  
FROM EMPLOYEE  
WHERE HIRE_DATE BETWEEN date '01.01.1992' AND CURRENT_DATE
```

## **LIKE**

*Available:* DSQL, PSQL, ESQL

*Syntax:*

```
<match value> [NOT] LIKE <pattern>  
    [ESCAPE <escape character>]  
  
<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”:

```
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.

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%'
```

**Note**

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 specified 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: 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 search is case-sensitive.

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”:

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

See also: [LIKE](#)

**CONTAINING**

Available: 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.

When CONTAINING 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.

*Examples:*

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

```
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):

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

*See also:* [LIKE](#)

## **SIMILAR TO**

*Available:* DSQL, PSQL

*Syntax:*

```
string-expression [NOT] SIMILAR TO <pattern> [ESCAPE <escape-char>]
<pattern> ::= an SQL regular expression
<escape-char> ::= 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.

```
<regular expression> ::= <regular term> ['|' <regular term> ...]

<regular term> ::= <regular factor> ...

<regular factor> ::= <regular primary> [<quantifier>]

<quantifier> ::= ?
                | *
                | +
                | '{' <m> [, <n>]] '}'

<m>, <n> ::= unsigned int, with <m> <= <n> if both present

<regular primary> ::= <character>
                    | <character class>
                    | %
                    | (<regular expression>)

<character> ::= <escaped character>
               | <non-escaped character>

<escaped character> ::= <escape-char> <special character>
                    | <escape-char> <escape-char>

<special character> ::= any of the characters []()|^+*%_?{

<non-escaped character> ::= any character that is not a <special character>
                          and not equal to <escape-char> (if defined)

<character class> ::= '_'
                   | '[' <member> ... ']'
                   | '[' ^ <non-member> ... ']'
                   | '[' <member> ... '^' <non-member> ... ']'

<member>, <non-member> ::= <character>
                        | <range>
                        | <predefined class>

<range> ::= <character>-<character>

<predefined class> ::= '[' <predefined class name> ':'

<predefined class name> ::= ALPHA | UPPER | LOWER | DIGIT
                        | ALNUM | SPACE | WHITESPACE
```

## 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 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 vertical tab (ASCII 9), linefeed (ASCII 10), horizontal 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 'Erd[a[: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:

```
'Grapefruit' similar to 'Grap[a-m^f-i]fruit'    -- true
'Grapefruit' similar to 'Grap[abc^xyz]fruit'    -- false
'Grapefruit' similar to 'Grap[abc^de]fruit'     -- false
'Grapefruit' similar to 'Grap[abe^de]fruit'     -- false

'3' similar to '[[[:DIGIT:]]^4-8]'              -- true
'6' similar to '[[[:DIGIT:]]^4-8]'              -- false
```

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 'Hall?on'           -- true
'Hallon' similar to 'Hall?on'           -- false
'Hallon' similar to 'Halx?on'           -- 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 'I_*'               -- true
'Icaque' similar to 'I[[: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, it must be repeated exactly that number of times in order to match:

```
'Kiwi' similar to 'Ki{2}wi'             -- false
'Kiwi' similar to 'K[ipw]{2}i'          -- true
'Kiwi' similar to 'K[ipw]{2}'           -- false
'Kiwi' similar to 'K[ipw]{3}'           -- true
```

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[nezm]{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-pl]{2,5}rijn' -- true
'Mandarijn' similar to 'M[a-pl]{2,3}rijn' -- false
'Mandarijn' similar to 'M[a-pl]{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. 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: DSQL, PSQL

Syntax:

```
operand1 IS [NOT] DISTINCT FROM operand2
```

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

See also: [IS \[NOT\] NULL](#)

### **IS [NOT] NULL**

Available: 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 the assertion 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:

```
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.

## 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 assertion, returning TRUE if the existence or non-existence is confirmed or FALSE otherwise.

### EXISTS

*Available:* DSQL, PSQL, ESQL

*Syntax:*

```
[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.

**Note**

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.

```
SELECT *
FROM employee
```

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

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:* 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 could be replaced with the following equivalent form:

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

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:

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

can be replaced with a similar one using the EXISTS predicate:

```
SELECT
  model, speed, hd
FROM PC
WHERE
  EXISTS (SELECT *
          FROM product
          WHERE maker = 'A'
          AND product.model = PC.model);
```

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:

1. when the test value is NULL and the IN () list is not empty
2. 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:

```
-- 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:

```
-- 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.

**Advice**

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”:

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

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

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

*See also:* [EXISTS](#)

## SINGULAR

*Available:* DSQL, PSQL, ESQL

*Syntax:*

```
[NOT] SINGULAR(<select_stmt>)
```

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.

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

## Quantified Subquery Predicates

A quantifier is a logical operator that sets the number of objects for which this assertion is true. It is not a numeric quantity, but a logical one that connects the assertion 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:* 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.

```
SELECT c1.*
FROM Customers c1
WHERE c1.rating > ALL
      (SELECT c2.rating
       FROM Customers c2
       WHERE c2.city = 'Paris')
```

#### Important

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:* 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.

## 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.

### CREATE DATABASE

*Used for:* Creating a new database

*Available in:* DSQL, ESQL

*Syntax:*

```
CREATE {DATABASE | SCHEMA} '<filespec>'
[USER 'username' [PASSWORD 'password']]
[PAGE_SIZE [=] size]
[LENGTH [=] num [PAGE[S]]]
[SET NAMES 'charset']
[DEFAULT CHARACTER SET default_charset
 [COLLATION collation]] -- not supported in ESQL
[<sec_file> [<sec_file> ...]]
[DIFFERENCE FILE 'diff_file']; -- not supported in ESQL

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

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

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



**Table 5.1. CREATE DATABASE Statement Parameters**

Parameter	Description
filespec	File specification for primary database file
server_spec	Remote server specification in TCP/IP or Windows Networking style. Optionally includes a port number or service name
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.
db_alias	Database alias previously created in the <code>aliases.conf</code> file
servername	Host name or IP address of the server where the database is to be created
username	User name of the owner of the new database. It may consist of up to 31 characters. Case-insensitive
password	Password of the user name as the database owner. The maximum length is 31 characters; however only the first 8 characters are considered. Case-sensitive
size	Page size for the database, in bytes. Possible values are 4096 (the default), 8192 and 16384
num	Maximum size of the primary database file, or a secondary file, in pages
charset	Specifies the character set of the connection available to a client connecting after the database is successfully created. Single quotes are required
default_charset	Specifies the default character set for string data types
collation	Default collation for the default character set
sec_file	File specification for a secondary file
pagenum	Starting page number for a secondary database file
diff_file	File path and name for DIFFERENCE files (.delta files)

The CREATE DATABASE statement creates a new database. You can use CREATE DATABASE or CREATE SCHEMA. They are synonymous.

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 a throwback. 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 when 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 the absolute path, when creating either the database or an *alias* for it.

## Using a Database Alias

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

```
alias = filepath
```

## Creating a Database Remotely

If you create a database on a remote server, you should 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:

```
servername[/ {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:

```
\\servername\ {filepath | db_alias}
```

## Optional Parameters for CREATE DATABASE

*Optional USER and PASSWORD:* Clauses for specifying the user name and the password, respectively, of an existing user in the security database `security2.fdb`. 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.

*Optional 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 changed automatically to the default page size, 4,096. Other values not equal to either 4,096, 8,192 or 16,384 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 4,096.

*Optional 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.

*Optional 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).

*Optional DEFAULT CHARACTER SET:* Clause specifying the default character set for creating data structures of string data types. Character sets are applied to `CHAR`, `VARCHAR` and `BLOB 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.

**Optional 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.

**SET SQL 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. *isql*, before the CREATE DATABASE statement.

## Examples Using CREATE DATABASE

1. Creating a database in Windows, located on disk D with a page size of 8,192. The owner of the database will be the user *wizard*. The database will be in Dialect 1 and it will use WIN1251 as its default character set.

```
SET SQL DIALECT 1;
CREATE DATABASE 'D:\test.fdb'
USER 'wizard' PASSWORD 'player'
PAGE_SIZE = 8192 DEFAULT CHARACTER SET WIN1251;
```

2. Creating a database in the Linux operating system with a page size of 4,096. The owner of the database will be the user *wizard*. The database will be in Dialect 3 and it will use UTF8 as its default character set, with UNICODE\_CI\_AI as the default collation.

```
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 *aliases.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.

```
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.

```
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](#)

## ALTER DATABASE

*Used for:* Altering the file organisation of a database or toggling its “copy-safe” state

*Available in:* DSQL—both functions. ESQL—file reorganisation only

*Syntax:*

```
ALTER {DATABASE | SCHEMA}
[<add_sec_clause> [<add_sec_clause> ...]]
[ADD DIFFERENCE FILE 'diff_file' | DROP DIFFERENCE FILE]
[ {BEGIN | END} BACKUP];

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

<sec_file> ::= FILE 'filepath'

ADD FILE <sec_file>

        [STARTING [AT [PAGE]] pagenum]
        [LENGTH [=] num [PAGE[S]]]
```

**Note**

Multiple files can be added in one ADD clause:

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

Multiple ADD FILE clauses are allowed; and 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 incorrectly documented in the old *InterBase 6 Language Reference*.

**Table 5.2. ALTER DATABASE Statement Parameters**

Parameter	Description
add_sec_clause	Adding a secondary database file
sec_file	File specification for secondary file
filepath	Full path and file name of the delta file or the secondary database file
pagenum	Page number from which the secondary database file is to start
num	Maximum size of the secondary file in pages
diff_file	File path and name of the .delta file (difference file)

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)

Only [administrators](#) have the authority to use ALTER DATABASE.

## Parameters for ALTER DATABASE

*The ADD FILE clause:* adds a secondary file 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.

*The ADD DIFFERENCE FILE clause:* 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.

**Caution**

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:** This is the clause that 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:** This is the clause that 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.

**Important**

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:** is the clause used to switch 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.

**Warning**

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 to run *gbak* while the database is in LOCKED or MERGE state.

**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`.

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

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

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

3. Deleting the description of the delta file:

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

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

```
ALTER DATABASE  
BEGIN BACKUP;
```

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

```
ALTER DATABASE  
END BACKUP;
```

See also: [CREATE DATABASE](#), [DROP DATABASE](#)

## ***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](#).

Only [administrators](#) have the authority to use DROP DATABASE.

*Example:* Deleting the database the client is connected to.

```
DROP DATABASE;
```

See also: [CREATE DATABASE](#), [ALTER DATABASE](#)

## **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.

## 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> ...];

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

**Table 5.3. CREATE SHADOW Statement Parameters**

Parameter	Description
sh_num	Shadow number—a positive number identifying the shadow set
filepath	The name of the shadow file and the path to it, in accord with the rules of the operating system
num	Maximum shadow size, in pages
secondary_file	Secondary file specification
page_num	The number of the page at which the secondary shadow file should start

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

*Optional LENGTH:* Clause specifying 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 increasing in size as long as it is necessary.

*STARTING AT:* Clause specifying 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.

Only [administrators](#) have the authority to use CREATE SHADOW.

### Tip

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;

*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](#)

## DROP SHADOW

*Used for:* Deleting a shadow from the current database

Available in: DSQL, ESQL

Syntax:

```
DROP SHADOW sh_num
```

**Table 5.4. DROP SHADOW Statement Parameter**

Parameter	Description
sh_num	Shadow number—a positive number identifying the shadow set

The DROP SHADOW statement deletes the specified shadow for the database one is connected to. When a shadow is dropped, all files related to it are deleted and shadowing to the specified *sh\_num* ceases.

Only [administrators](#) have the authority to use DROP SHADOW.

*Example of Dropping a Shadow:* Deleting “shadow number 1”.

```
DROP SHADOW 1 ;
```

See also: [CREATE SHADOW](#)

## 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](#).

### 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> ::=
    {SMALLINT | INTEGER | BIGINT} [<array_dim>]
    | {FLOAT | DOUBLE PRECISION} [<array_dim>]
    | {DATE | TIME | TIMESTAMP} [<array_dim>]
    | {DECIMAL | NUMERIC} [(precision [, scale])] [<array_dim>]
    | {CHAR | CHARACTER | CHARACTER VARYING | VARCHAR} [(size)]
    | [<array_dim>] [CHARACTER SET charset_name]
    | {NCHAR | NATIONAL CHARACTER | NATIONAL CHAR} [VARYING]
    | [(size)] [<array_dim>]
    | BLOB [SUB_TYPE {subtype_num | subtype_name}]
    | [SEGMENT SIZE seglen] [CHARACTER SET charset_name]
    | BLOB [(seglen [, subtype_num])]

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

<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 <datatype>)
    | (<select_one>)
    | func([<val> [, <val> ...]])

```

Table 5.5. CREATE DOMAIN Statement Parameters

Parameter	Description
name	Domain name consisting of up to 31 characters

Parameter	Description
<code>datatype</code>	SQL data type
<code>literal</code>	A literal value that is compatible with <i>datatype</i>
<code>context_var</code>	Any context variable whose type is compatible with <i>datatype</i>
<code>dom_condition</code>	Domain condition
<code>collation_name</code>	Name of a collation sequence that is valid for <i>charset_name</i> , if it is supplied with <i>datatype</i> or, otherwise, is valid for the default character set of the database
<code>array_dim</code>	Array dimensions
<code>m, n</code>	INTEGER numbers defining the index range of an array dimension
<code>precision</code>	The total number of significant digits that a value of the <i>datatype</i> can hold (1..18)
<code>scale</code>	The number of digits after the decimal point (0.. <i>precision</i> )
<code>size</code>	The maximum size of a string in characters
<code>charset_name</code>	The name of a valid character set, if the character set of the domain is to be different to the default character set of the database
<code>subtype_num</code>	BLOB subtype number
<code>subtype_name</code>	BLOB subtype mnemonic name
<code>seglen</code>	Segment size (max. 65535)
<code>select_one</code>	A scalar SELECT statement—selecting one column and returning only one row
<code>select_list</code>	A SELECT statement selecting one column and returning zero or more rows
<code>select_expr</code>	A SELECT statement selecting one or more columns and returning zero or more rows
<code>expression</code>	An expression resolving to a value that is compatible with <i>datatype</i>
<code>genname</code>	Sequence (generator) name
<code>func</code>	Internal function or UDF

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 boldface 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.

**CHARACTER 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 in creating 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.

**Warning**

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*.

**Caution**

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.

Any user connected to the database can create a domain.

## 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];
```

### Note

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));
```

**Note**

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](#)

## 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]
  [ADD [CONSTRAINT] CHECK (<dom_condition>) | DROP CONSTRAINT]

<datatype> ::=
  {SMALLINT | INTEGER | BIGINT}
| {FLOAT | DOUBLE PRECISION}
| {DATE | TIME | TIMESTAMP}
| {DECIMAL | NUMERIC} [(precision [, scale])]
| {CHAR | CHARACTER | CHARACTER VARYING | VARCHAR} [(size)]
  [CHARACTER SET charset_name]
| {NCHAR | NATIONAL CHARACTER | NATIONAL CHAR} [VARYING] [(size)]
| BLOB [SUB_TYPE {subtype_num | subtype_name}]
  [SEGMENT SIZE seglen] [CHARACTER SET charset_name]
| BLOB [(seglen [, subtype_num])]

<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 <datatype>)
    | (<select_one>)
    | func([<val> [, <val> ...]])

```

**Table 5.6. ALTER DOMAIN Statement Parameters**

Parameter	Description
new_name	New name for domain, consisting of up to 31 characters
datatype	SQL data type
literal	A literal value that is compatible with <i>datatype</i>
context_var	Any context variable whose type is compatible with <i>datatype</i>
precision	The total number of significant digits that a value of the <i>datatype</i> can hold (1..18)
scale	The number of digits after the decimal point (0.. <i>precision</i> )
size	The maximum size of a string in characters
charset_name	The name of a valid character set, if the character set of the domain is to be changed
subtype_num	BLOB subtype number
subtype_name	BLOB subtype mnemonic name
seglen	Segment size (max. 65535)
select_one	A scalar SELECT statement—selecting one column and returning only one row
select_list	A SELECT statement selecting one column and returning zero or more rows
select_expr	A SELECT statement selecting one or more columns and returning zero or more rows
expression	An expression resolving to a value that is compatible with <i>datatype</i>
genname	Sequence (generator) name
func	Internal function or UDF

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.



**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.

**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.

### Important

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.

Any user connected to the database can alter a domain, provided it is not prevented by dependencies from objects to which that user does not have sufficient privileges.

## 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.
- In Firebird 2.5 and lower, the NOT NULL constraint can be neither enabled nor disabled for a domain.
- There is no way to change the default collation without dropping the domain and recreating it with the desired attributes.

## 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;
```

See also: [CREATE DOMAIN](#), [DROP DOMAIN](#)

## ***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.

Any user connected to the database can drop a domain.

### ***Example***

Deleting the COUNTRYNAME domain:

```
DROP DOMAIN COUNTRYNAME;
```

See also: [CREATE DOMAIN](#), [ALTER DOMAIN](#)

## 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.

### 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>} ...])
  [ON COMMIT {DELETE | PRESERVE} ROWS];

<col_def> ::= <regular_col_def> | <computed_col_def>

<regular_col_def> ::=
  colname {<datatype> | domainname}
  [DEFAULT {literal | NULL | <context_var>}]
  [NOT NULL]
  [<col_constraint>]
  [COLLATE collation_name]

<computed_col_def> ::=
  colname [<datatype>]
  {COMPUTED [BY] | GENERATED ALWAYS AS} (<expression>)

<datatype> ::=
  {SMALLINT | INTEGER | BIGINT} [<array_dim>]
  | {FLOAT | DOUBLE PRECISION} [<array_dim>]
  | {DATE | TIME | TIMESTAMP} [<array_dim>]
  | {DECIMAL | NUMERIC} [(precision [, scale])] [<array_dim>]
  | {CHAR | CHARACTER | CHARACTER VARYING | VARCHAR} [(size)]
  [<array_dim>] [CHARACTER SET charset_name]
  | {NCHAR | NATIONAL CHARACTER | NATIONAL CHAR} [VARYING]
  [(size)] [<array_dim>]
  | BLOB [SUB_TYPE {subtype_num | subtype_name}]
  [SEGMENT SIZE seglen] [CHARACTER SET charset_name]
  | BLOB [(seglen [, subtype_num])]

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

```

<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>) }

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

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

```

**Table 5.7. CREATE TABLE Statement Parameters**

Parameter	Description
tablename	Name (identifier) for the table. It may consist of up to 31 characters and must be unique in the database.
filespec	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.
colname	Name (identifier) for a column in the table. May consist of up to 31 characters and must be unique in the table.
datatype	SQL data type
col_constraint	Column constraint
tconstraint	Table constraint
constr_name	The name (identifier) of a constraint. May consist of up to 31 characters.
other_table	The name of the table referenced by the foreign key constraint
other_col	The name of the column in <i>other_table</i> that is referenced by the foreign key
literal	A literal value that is allowed in the given context
context_var	Any context variable whose data type is allowed in the given context
check_condition	The condition applied to a CHECK constraint, that will resolve as either true, false or NULL
collation	Collation
array_dim	Array dimensions
m, n	INTEGER numbers defining the index range of an array dimension
precision	The total number of significant digits that a value of the datatype can hold (1..18)
scale	The number of digits after the decimal point (0.. <i>precision</i> )
size	The maximum size of a string in characters
charset_name	The name of a valid character set, if the character set of the column is to be different to the default character set of the database
subtype_num	BLOB subtype number
subtype_name	BLOB subtype mnemonic name
seglen	Segment size (max. 65535)
select_one	A scalar SELECT statement—selecting one column and returning only one row
select_list	A SELECT statement selecting one column and returning zero or more rows
select_expr	A SELECT statement selecting one or more columns and returning zero or more rows

Parameter	Description
expression	An expression resolving to a value that is allowed in the given context
genname	Sequence (generator) name
func	Internal function or UDF

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.

## Making a Column Non-nullable

In Firebird, columns are nullable by default. The optional NOT NULL clause specifies that the column cannot take NULL in place of a value.

## 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 character set specified during the creation of the database will be used by default. If no character set was specified during the creation of the database, the NONE character set is applied by default. 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 collation sequence that is default for the specified character set during the creation of the column is applied by default.

## 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.

### Important

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 to make the domain nullable and apply NOT NULL in the downstream column definitions and variable declarations.

## 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.

### Tip

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 boldface 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

Four types of constraints can be specified. They are:

- Primary key (PRIMARY KEY)
- Unique key (UNIQUE)
- Foreign key (REFERENCES)
- CHECK constraint (CHECK)

Constraints can be specified at column level (“column constraints”) or at table level (“table constraints”). Table-level constraints are needed when keys (uniqueness constraint, Primary Key, Foreign Key) are to be formed across multiple columns and when a CHECK constraint involves other columns in the row besides the column being defined. Syntax for some types of constraint may differ slightly according to whether the constraint is being defined at 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
- Table-level constraints are specified after all of the column definitions. They 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 INTEG\_n, where n represents one or more numerals
- The index name has the form RDB\$PRIMARYn (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 numerals

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. 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*, each column having the NOT NULL constraint specified for it. 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:

*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.

#### Note

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:*

```
...
```

```
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).

#### **Important**

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 conditions—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)
);
```

### **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 name
  (<column_def> [, {<column_def> | <table_constraint>} ...])
  [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

**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

**Tip**

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:

```
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:

```
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.

**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.

**Important**

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. It creates a security vulnerability and is not recommended.

### External File Format

The “row” format of the external table is fixed length. 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 will appear to external applications as unparseable “alphabeti”.

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:

```
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:

```
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):

```
insert into ext_log (message)
values('Shall I compare thee to a summer's day?');
insert into ext_log (message)
values('Thou art more lovely and more temperate')
```

The output:

```
2015-10-07 15:19:03.4110Shall I compare thee to a summer's day?
2015-10-07 15:19:58.7600Thou art more lovely and more temperate
```

## CREATE TABLE Examples

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
);
```

5. Creating the SALARY\_HISTORY table with two computed fields. The first one is declared according to the SQL:2003 standard, while the second one is declared according to the traditional declaration of computed fields in Firebird.

```
CREATE TABLE SALARY_HISTORY (
    EMP_NO           EMPNO NOT NULL,
    CHANGE_DATE      TIMESTAMP DEFAULT 'NOW' NOT NULL,
    UPDATER_ID       VARCHAR(20) NOT NULL,
    OLD_SALARY       SALARY NOT NULL,
    PERCENT_CHANGE   DOUBLE PRECISION DEFAULT 0 NOT NULL,
    SALARY_CHANGE    GENERATED ALWAYS AS
        (OLD_SALARY * PERCENT_CHANGE / 100),
    NEW_SALARY       COMPUTED BY
```

```
(OLD_SALARY + OLD_SALARY * PERCENT_CHANGE / 100)
);
```

6. Creating a connection-scoped global temporary table.

```
CREATE GLOBAL TEMPORARY TABLE MYCONNGTT (
    ID INTEGER NOT NULL PRIMARY KEY,
    TXT VARCHAR(32),
    TS TIMESTAMP DEFAULT CURRENT_TIMESTAMP)
ON COMMIT PRESERVE ROWS;
```

7. 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.

```
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;
```

## 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>

<col_def> ::= <regular_col_def> | <computed_col_def>

<regular_col_def> ::=
    colname {<datatype> | domainname}
    [DEFAULT {literal | NULL | <context_var>}]
    [NOT NULL]
    [<col_constraint>]
    [COLLATE collation_name]

<computed_col_def> ::=
    colname [<datatype>]
```



```
{COMPUTED [BY] | GENERATED ALWAYS AS} (<expression>)

<col_mod> ::= <regular_col_mod> | <computed_col_mod>

<regular_col_mod> ::=
    TO newname
  | POSITION newpos
  | TYPE {<datatype> | domainname}
  | SET DEFAULT {literal | NULL | <context_var>}
  | DROP DEFAULT

<computed_col_mod> ::=
    TO newname
  | POSITION newpos
  | [TYPE <datatype>] {COMPUTED [BY] | GENERATED ALWAYS AS} (<expression>)

<datatype> ::=
    {SMALLINT | INTEGER | BIGINT} [<array_dim>]
  | {FLOAT | DOUBLE PRECISION} [<array_dim>]
  | {DATE | TIME | TIMESTAMP} [<array_dim>]
  | {DECIMAL | NUMERIC} [(precision [, scale])] [<array_dim>]
  | {CHAR | CHARACTER | CHARACTER VARYING | VARCHAR} [(size)]
    [<array_dim>] [CHARACTER SET charset_name]
  | {NCHAR | NATIONAL CHARACTER | NATIONAL CHAR} [VARYING]
    [(size)] [<array_dim>]
  | BLOB [SUB_TYPE {subtype_num | subtype_name}]
    [SEGMENT SIZE seglen] [CHARACTER SET charset_name]
  | BLOB [(seglen [, subtype_num])]

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

<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>) }

<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>)
| (<search_condition>)
| NOT <search_condition>
| <search_condition> OR <search_condition>
| <search_condition> AND <search_condition>

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

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

```

**Table 5.8. ALTER TABLE Statement Parameters**

Parameter	Description
tablename	Name (identifier) of the table
operation	One of the available operations altering the structure of the table
colname	Name (identifier) for a column in the table, max. 31 characters. Must be unique in the table.
newname	New name (identifier) for the column, max. 31 characters. Must be unique in the table.
newpos	The new column position (an integer between 1 and the number of columns in the table)
col_constraint	Column constraint
tconstraint	Table constraint
constr_name	The name (identifier) of a constraint. May consist of up to 31 characters.
other_table	The name of the table referenced by the foreign key constraint
literal	A literal value that is allowed in the given context
context_var	A context variable whose type is allowed in the given context

Parameter	Description
check_condition	The condition of a CHECK constraint that will be satisfied if it evaluates to TRUE or UNKNOWN/NULL
collation	Name of a collation sequence that is valid for <i>charset_name</i> , if it is supplied with <i>datatype</i> or, otherwise, is valid for the default character set of the database
array_dim	Array dimensions
m, n	INTEGER numbers defining the index range of an array dimension
precision	The total number of significant digits that a value of the <i>datatype</i> can hold (1..18)
scale	The number of digits after the decimal point (0.. <i>precision</i> )
size	The maximum size of a string in characters
charset_name	The name of a valid character set, if the character set of the column is to be different to the default character set of the database
subtype_num	BLOB subtype number
subtype_name	BLOB subtype mnemonic name
seglen	Segment size (max. 65535)
select_one	A scalar SELECT statement—selecting one column and returning only one row
select_list	A SELECT statement selecting one column and returning zero or more rows
select_expr	A SELECT statement selecting one or more columns and returning zero or more rows
expression	An expression resolving to a value that is allowed in the given context
genname	Sequence (generator) name
func	Internal function or UDF

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. Once the counter reaches the 255 limit, you will not be able to make any further changes to the structure of the table without resetting the counter.

*To reset the metadata change counter:* You should 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 grows by one
- Adding a new table constraint does not increase the metadata change counter

### Points to Be Aware of

1. Be careful about adding a new column with the NOT NULL constraint set. It may lead to breaking the logical integrity of data, since you will have existing records containing NULL in a non-nullable column. When adding a non-nullable column, it is recommended either to set a default value for it or to update the column in existing rows with a non-null value.
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.

## The DROP Clause

The DROP *<column name>* 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)
- 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)

## Renaming a Column: the TO Keyword

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 Keyword

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 Keyword

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 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.

## Attributes that Cannot Be Altered

The following alterations are not supported:

- Enabling or disabling the NOT NULL constraint on a column
- Changing the default collation for a character type column

Only the table owner and [administrators](#) have the authority to use ALTER TABLE.

## Examples Using ALTER TABLE

1. Adding the CAPITAL column to the COUNTRY table.

```
ALTER TABLE COUNTRY
ADD CAPITAL VARCHAR(25);
```

2. Adding the CAPITAL column with the UNIQUE constraint and deleting the CURRENCY column.

```
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.

```
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.

```
ALTER TABLE STOCK
ALTER COLUMN MODEL SET DEFAULT 1,
ALTER COLUMN ITEMID TYPE BIGINT,
ALTER COLUMN MODELNAME TO NAME;
```

5. Changing the computed columns NEW\_SALARY and SALARY\_CHANGE.

```
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](#)

## ***DROP TABLE***

*Used for:* deleting a table

*Available in:* DSQL, ESQL

*Syntax:*

```
drop table tablename;
```

**Table 5.9. DROP TABLE Statement Parameter**

Parameter	Description
tablename	Name (identifier) of the table

The DROP TABLE statement 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 triggers for its events and indexes built for its fields will be deleted as well.

Only the table owner and [administrators](#) have the authority to use DROP TABLE.

*Example:* Deleting the COUNTRY table.

```
DROP TABLE COUNTRY;
```

See also: [CREATE TABLE](#), [ALTER TABLE](#), [RECREATE TABLE](#)

## ***RECREATE TABLE***

*Used for:* creating a new table (relation) or recreating an existing one

*Available in:* DSQL

*Syntax:*

```
RECREATE [GLOBAL TEMPORARY] TABLE tablename
  [EXTERNAL [FILE] '<filespec>']
  (<col_def> [, {<col_def> | <tconstraint>} ...])
  [ON COMMIT {DELETE | PRESERVE} ROWS]
```

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:* Creating or recreating the COUNTRY table.

```
RECREATE TABLE COUNTRY (
  COUNTRY COUNTRYNAME NOT NULL PRIMARY KEY,
  CURRENCY VARCHAR(10) NOT NULL);
```

*See also:* [CREATE TABLE](#), [DROP TABLE](#)

## INDEX

An index is a database object used for faster data retrieval from a table or for speeding up the sorting of 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.

### CREATE INDEX

*Used for:* Creating an index for a table

*Available in:* DSQL, ESQL

*Syntax:*

```
CREATE [UNIQUE] [ASC[ENDING] | DESC[ENDING]]
INDEX indexname ON tablename
{(col [, col ...]) | COMPUTED BY (<expression>)};
```



**Table 5.10. CREATE INDEX Statement Parameters**

Parameter	Description
indexname	Index name. It may consist of up to 31 characters
tablename	The name of the table for which the index is to be built
col	Name of a column in the table. Columns of the types BLOB and ARRAY and computed fields cannot be used in an index
expression	The expression that will compute the values for a computed index, also known as an “expression index”

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);
```

## 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.

### Tip

A descending index can be useful on a column that will be subjected to searches on the high values (“newest”, maximum, etc.)

## 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.

### Note

You can actually create a computed index on a computed field, but the 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  $\frac{1}{4}$  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 5.11. Maximum Indexes per Table**

Page Size	Number of Indexes Depending on Column Count		
	Single	2-Column	3-Column
4096	203	145	113
8192	408	291	227
16384	818	584	454

### 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 5.12. Maximum indexable (VAR)CHAR length**

Page Size	Maximum Indexable String Length by Charset Type			
	1 byte/char	2 bytes/char	3 bytes/char	4 bytes/char
4096	1015	507	338	253

Page Size	Maximum Indexable String Length by Charset Type			
	1 byte/char	2 bytes/char	3 bytes/char	4 bytes/char
8192	2039	1019	679	509
16384	4087	2043	1362	1021

Only the table owner and [administrators](#) have the authority to use CREATE INDEX.

## Examples Using CREATE INDEX

1. Creating an index for the UPDATER\_ID table in the SALARY\_HISTORY table

```
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

```
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

```
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

```
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](#)

## ALTER INDEX

*Used for:* Activating or deactivating an index; rebuilding an index

*Available in:* DSQL, ESQL

*Syntax:*

```
ALTER INDEX indexname {ACTIVE | INACTIVE};
```

**Table 5.13. ALTER INDEX Statement Parameter**

Parameter	Description
indexname	Index name

The ALTER INDEX statement activates or deactivates an index. There is no facility on this statement for altering any attributes of the index.

- 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 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/NO WAIT 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.

- 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.

## Use of ALTER INDEX on a Constraint Index

Altering the enforcing 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.

Only the table owner and [administrators](#) have the authority to use ALTER INDEX.

*ALTER INDEX Examples:*

1. Deactivating the IDX\_UPDATER index

```
ALTER INDEX IDX_UPDATER INACTIVE;
```

2. Switching the IDX\_UPDATER index back to the active state and rebuilding it

```
ALTER INDEX IDX_UPDATER ACTIVE;
```

See also: [CREATE INDEX](#), [DROP INDEX](#), [SET STATISTICS](#)

## DROP INDEX

*Used for:* Deleting an index

*Available in:* DSQL, ESQL

*Syntax:*

```
DROP INDEX indexname;
```

**Table 5.14. DROP INDEX Statement Parameter**

Parameter	Description
indexname	Index name

The DROP INDEX statement deletes an the named index from the database.

### Note

A constraint index cannot be deleted using DROP INDEX. Constraint indexes are dropped during the process of executing the command ALTER TABLE ... DROP CONSTRAINT ....

Only the table owner and [administrators](#) have the authority to use DROP INDEX.

*DROP INDEX Example:* Deleting the IDX\_UPDATER index

```
DROP INDEX IDX_UPDATER;
```

See also: [CREATE INDEX](#), [ALTER INDEX](#)

## SET STATISTICS

*Used for:* Recalculating the selectivity of an index

*Available in:* DSQL, ESQL

*Syntax:*

```
SET STATISTICS indexname
```

**Table 5.15. SET STATISTICS Statement Parameter**

Parameter	Description
indexname	Index name

The SET STATISTICS statement recalculates the selectivity of the specified index.

## 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.

### Note

The statements CREATE INDEX and ALTER INDEX ACTIVE both store index statistics that completely correspond to the contents of the newly-[re]built index.

The selectivity of an index can be recalculated by the owner of the table or an [administrator](#). 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](#)

## VIEW

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.

### 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 5.16. CREATE VIEW Statement Parameters**

Parameter	Description
viewname	View name, maximum 31 characters
select_statement	SELECT statement
full_column_list	The list of columns in the view
colname	View column name. Duplicate column names are not allowed.

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 this 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 of 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 updateable 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 of 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 is covered by 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, such as MIN, MAX, AVG, SUM, COUNT, LIST
- the SELECT statement contains no ORDER BY or GROUP BY clause
- the SELECT statement does not include the keyword DISTINCT or row-restrictive keywords such as ROWS, FIRST, SKIP

## **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 as to 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 present to restrict the output of the main SELECT statement. An error message is returned otherwise.

**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.

## Ownership of a View

The creator of a view becomes its owner.

To create a view, a non-admin user 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 base object(s).

Granting other users privileges on the view is only possible if the view owner himself 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.

```
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](#)

## **ALTER VIEW**

*Used for:* Modifying an existing view

*Available in:* DSQL

*Syntax:*

```
ALTER VIEW viewname [<full_column_list>]
AS <select_statement>
[WITH CHECK OPTION];

<full_column_list> ::= (colname [, colname ...])
```

**Table 5.17. ALTER VIEW Statement Parameters**

Parameter	Description
viewname	Name of an existing view
select_statement	SELECT statement
full_column_list	The list of columns in the view
colname	View column name. Duplicate column names are not allowed.

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.

**Caution**

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.

Only the view owner and [administrators](#) have the authority to use ALTER VIEW.

*Example using ALTER VIEW:* Altering the 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](#)

## 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 5.18. CREATE OR ALTER VIEW Statement Parameters**

Parameter	Description
viewname	Name of a view which may or may not exist
select_statement	SELECT statement
full_column_list	The list of columns in the view
colname	View column name. Duplicate column names are not allowed.

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:* 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_WITH_MARKUP
) AS
SELECT
    CODE_PRICE,
    COST,
    COST * 1.15
FROM PRICE;
```

*See also:* [CREATE VIEW](#), [ALTER VIEW](#), [RECREATE VIEW](#)

## ***DROP VIEW***

*Used for:* Deleting (dropping) a view

*Available in:* DSQL

*Syntax:*

```
DROP VIEW viewname;
```

**Table 5.19. DROP VIEW Statement Parameter**

Parameter	Description
viewname	View name

The DROP VIEW statement deletes an existing view. The statement will fail if the view has dependencies.

Only the view owner and [administrators](#) have the authority to use DROP VIEW.

*Example:* Deleting the PRICE\_WITH\_MARKUP view.

```
DROP VIEW PRICE_WITH_MARKUP;
```

See also: [CREATE VIEW](#), [RECREATE VIEW](#), [CREATE OR ALTER VIEW](#)

## 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 5.20. RECREATE VIEW Statement Parameters**

Parameter	Description
viewname	View name, maximum 31 characters
select_statement	SELECT statement
full_column_list	The list of columns in the view
colname	View column name. Duplicate column names are not allowed.

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:* Creating the new view PRICE\_WITH\_MARKUP view or recreating it, if it already exists.

```
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](#)

## 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 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.

Another form of trigger—known as a “database trigger”—can be specified to fire in association with the start or end of a user session (connection) or a user transaction.

### CREATE TRIGGER

*Used for:* Creating a new trigger

*Available in:* DSQL, ESQL

*Syntax:*

```
CREATE TRIGGER trigname {
    <relation_trigger_legacy> |
    <relation_trigger_sql2003> |
    <database_trigger> }
AS
    [<declarations>]
BEGIN
    [<PSQL_statements>]
END

<relation_trigger_legacy> ::=
    FOR {tablename | viewname}
    [ACTIVE | INACTIVE]
    {BEFORE | AFTER} <mutation_list>
    [POSITION number]

<relation_trigger_sql2003> ::=
    [ACTIVE | INACTIVE]
    {BEFORE | AFTER} <mutation_list>
    [POSITION number]
    ON {tablename | viewname}
```

```

<database_trigger> ::=
    [ACTIVE | INACTIVE] ON db_event [POSITION number]

<mutation_list> ::=
    <mutation> [OR <mutation> [OR <mutation>]]

<mutation> ::= { INSERT | UPDATE | DELETE }

<db_event> ::= {
    CONNECT |
    DISCONNECT |
    TRANSACTION START |
    TRANSACTION COMMIT |
    TRANSACTION ROLLBACK
}

<declarations> ::= {<declare_var> | <declare_cursor>};
    [{<declare_var> | <declare_cursor>}; ...]

```

**Table 5.21. CREATE TRIGGER Statement Parameters**

Parameter	Description
trigname	Trigger name consisting of up to 31 characters. It must be unique among all trigger names in the database.
relation_trigger_legacy	Legacy style of trigger declaration for a relation trigger
relation_trigger_sql2003	Relation trigger declaration compliant with the SQL:2003 standard
database_trigger	Database trigger declaration
tablename	Name of the table with which the relation trigger is associated
viewname	Name of the view with which the relation trigger is associated
mutation_list	List of relation (table   view) events
number	Position of the trigger in the firing order. From 0 to 32,767
db_event	Connection or transaction event
declarations	Section for declaring local variables and named cursors
declare_var	Local variable declaration
declare_cursor	Named cursor declaration
PSQL_statements	Statements in Firebird's programming language (PSQL)

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), or for a *database 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 relation trigger), the phase of the trigger and the event[s] it applies to. The 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.

## 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](#).

## Relation Triggers (on Tables or Views)

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.

### 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.



### Variable Declarations

The optional declarations section beneath the keyword AS in the header of the trigger is for defining variables and named cursors that are local to the trigger. For more details, see [DECLARE VARIABLE](#) and [DECLARE CURSOR](#) in the [Procedural SQL](#) chapter.

### The Trigger Body

The local declarations (if any) are the final part of a trigger's header section. The trigger body follows, where one or more blocks of PSQL statements are enclosed in a structure that starts with the keyword BEGIN and terminates with the keyword END.

Only the owner of the view or table and [administrators](#) have the authority to use CREATE TRIGGER.

*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.

```
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 POSITION 0 ON customer
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 fire after either inserting, updating or deleting a record in the CUSTOMER table.

```
CREATE TRIGGER TR_CUST_LOG
ACTIVE AFTER INSERT OR UPDATE OR DELETE POSITION 10
ON CUSTOMER
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
```

## 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

### *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.

### *Trigger Suppression*

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 commit.

## Some Caveats

1. The use of the IN AUTONOMOUS TRANSACTION DO statement in the database event triggers related to transactions (TRANSACTION START, TRANSACTION ROLLBACK, TRANSACTION COMMIT) may cause the autonomous transaction to enter an infinite loop
2. The DISCONNECT and TRANSACTION ROLLBACK event triggers will not be executed when clients are disconnected via monitoring tables (DELETE FROM MON\$ATTACHMENTS)

Only the database owner and [administrators](#) have the authority to create database triggers.

*Examples of 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.

```
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.

```
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
```

See also: [ALTER TRIGGER](#), [CREATE OR ALTER TRIGGER](#), [RECREATE TRIGGER](#), [DROP TRIGGER](#)

## ALTER TRIGGER

*Used for:* Modifying and deactivating an existing trigger

*Available in:* DSQL, ESQL

*Syntax:*

```
ALTER TRIGGER triname
[ACTIVE | INACTIVE]
[{BEFORE | AFTER} <mutation_list> | ON db_event]
[POSITION number]
[
  AS
  [<declarations>]
  BEGIN
    [<PSQL_statements>]
  END
]

<mutation_list> ::=
  <mutation> [OR <mutation> [OR <mutation>]]

<mutation> ::= { INSERT | UPDATE | DELETE }

<db_event> ::= {
  CONNECT |
  DISCONNECT |
  TRANSACTION START |
  TRANSACTION COMMIT |
  TRANSACTION ROLLBACK
}

<declarations> ::= {<declare_var> | <declare_cursor>};
[ {<declare_var> | <declare_cursor>}; ...]
```

**Table 5.22. ALTER TRIGGER Statement Parameters**

Parameter	Description
triname	Name of an existing trigger
mutation_list	List of relation (table   view) events
number	Position of the trigger in the firing order. From 0 to 32,767
declarations	Section for declaring local variables and named cursors
declare_var	Local variable declaration
declare_cursor	Named cursor declaration
PSQL_statements	Statements in Firebird's programming language (PSQL)

The ALTER TRIGGER statement allows certain changes to the header and body of a trigger.

## Permitted Changes to Triggers

- Status (ACTIVE | INACTIVE)
- Phase (BEFORE | AFTER)
- Events; but relation trigger events cannot be changed to database trigger events, nor vice versa
- Position in the firing order
- Modifications to code in the trigger body

If some element was not specified, it remains unchanged.

### 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 relation 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.

**Administrators** and the following users have the authority to use ALTER TRIGGER:

- For relation triggers, the owner of the table
- For database triggers, the owner of the database

*Examples using ALTER TRIGGER:*

1. Deactivating the set\_cust\_no trigger (switching it to the inactive status).

```
ALTER TRIGGER set_cust_no INACTIVE;
```

2. Changing the firing order position of the set\_cust\_no trigger.

```
ALTER TRIGGER set_cust_no POSITION 14;
```

3. Switching the TR\_CUST\_LOG trigger to the inactive status and modifying the list of events.

```
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.

```
ALTER TRIGGER tr_log_connect
ACTIVE POSITION 1
AS
BEGIN
    INSERT INTO LOG_CONNECT (ID,
                            USERNAME,
                            ROLENAM,
                            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](#)

## 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> }
AS
[<declarations>]
BEGIN
[<PSQL_statements>]
END
```

For the full detail of the syntax, see [CREATE TRIGGER](#).

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 using 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 POSITION 0 ON customer
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](#)

## ***DROP TRIGGER***

*Used for:* Deleting an existing trigger

*Available in:* DSQL, ESQL

*Syntax:*

```
DROP TRIGGER trigname
```

**Table 5.23. DROP TRIGGER Statement Parameter**

Parameter	Description
trigname	Trigger name

The DROP TRIGGER statement deletes an existing trigger.

[Administrators](#) and the following users have the authority to use DROP TRIGGER:

- For relation triggers, the owner of the table
- For database triggers, the owner of the database

*Example using DROP TRIGGER:* Deleting the set\_cust\_no trigger.

```
DROP TRIGGER set_cust_no;
```

See also: [CREATE TRIGGER](#), [RECREATE TRIGGER](#)

## ***RECREATE TRIGGER***

*Used for:* Creating a new trigger or recreating an existing trigger

*Available in:* DSQL

*Syntax:*

```
RECREATE TRIGGER trigname {  
    <relation_trigger_legacy> |  
    <relation_trigger_sql2003> |  
    <database_trigger> }  
AS  
[<declarations>]  
BEGIN
```

```
[<PSQL_statements>]  
END
```

For the full detail of the syntax, see [CREATE TRIGGER](#).

The RECREATE TRIGGER statement creates a new trigger if no trigger with the specified name exists; otherwise the RECREATE TRIGGER statement tries to delete the existing trigger and create a new one. The operation will fail on COMMIT if the trigger dependencies.

**Warning**

Be aware that dependency errors are not detected until the COMMIT phase of this operation.

*Example using RECREATE TRIGGER:* Creating or recreating the set\_cust\_no trigger.

```
RECREATE TRIGGER set_cust_no  
ACTIVE BEFORE INSERT POSITION 0 ON customer  
AS  
BEGIN  
  IF (NEW.cust_no IS NULL) THEN  
    NEW.cust_no = GEN_ID(cust_no_gen, 1);  
  END  
END
```

See also: [CREATE TRIGGER](#), [DROP TRIGGER](#), [CREATE OR ALTER TRIGGER](#)

## PROCEDURE

A stored procedure is a software module that can be called from a client, another procedure, an executable block or a trigger. Stored procedures, executable blocks and triggers are written in procedural SQL (PSQL). Most SQL statements are available in PSQL as well, sometimes with limitations or extensions. Among notable exceptions are DDL and transaction control statements.

Stored procedures can have many input and output parameters.

### CREATE PROCEDURE

*Used for:* Creating a new stored procedure

*Available in:* DSQL, ESQL

*Syntax:*

```
CREATE PROCEDURE procname  
[(<inparam> [, <inparam> ...])] [<RETURNES> (<outparam> [, <outparam> ...])]  
AS  
[<declarations>]
```



```

BEGIN
[<PSQL_statements>]
END

<inparam> ::= <param_decl> [{= | DEFAULT} <value>]

<outparam> ::= <param_decl>

<value> ::= {literal | NULL | context_var}

<param_decl> ::= paramname <type> [NOT NULL]
[COLLATE collation]

<type> ::=
  <datatype> |
  [TYPE OF] domain |
  TYPE OF COLUMN rel.col

<datatype> ::=
  {SMALLINT | INT[EGER] | BIGINT}
  | {FLOAT | DOUBLE PRECISION}
  | {DATE | TIME | TIMESTAMP}
  | {DECIMAL | NUMERIC} [(precision [, scale])]
  | {CHAR | CHARACTER | CHARACTER VARYING | VARCHAR} [(size)]
  [CHARACTER SET charset]
  | {NCHAR | NATIONAL CHARACTER | NATIONAL CHAR} [VARYING]
  [(size)]
  | BLOB [SUB_TYPE {subtype_num | subtype_name}]
  [SEGMENT SIZE seglen] [CHARACTER SET charset]
  | BLOB [(seglen [, subtype_num])]

<declarations> ::=
  {<declare_var> | <declare_cursor>};
  [{<declare_var> | <declare_cursor>}; ...]

```

**Table 5.24. CREATE PROCEDURE Statement Parameters**

Parameter	Description
procname	Stored procedure name consisting of up to 31 characters. Must be unique among all table, view and procedure names in the database
inparam	Input parameter description
outparam	Output parameter description
declarations	Section for declaring local variables and named cursors
declare_var	Local variable declaration
declare_cursor	Named cursor declaration
PSQL_statements	Procedural SQL statements
literal	A literal value that is assignment-compatible with the data type of the parameter
context_var	Any context variable whose type is compatible with the data type of the parameter

Parameter	Description
paramname	The name of an input or output parameter of the procedure. It may consist of up to 31 characters. The name of the parameter must be unique among input and output parameters of the procedure and its local variables
datatype	SQL data type
collation	Collation sequence
domain	Domain name
rel	Table or view name
col	Table or view column name
precision	The total number of significant digits that the parameter should be able to hold (1..18)
scale	The number of digits after the decimal point (0.. <i>precision</i> )
size	The maximum size of a string type parameter or variable, in characters
charset	Character set of a string type parameter or variable
subtype_num	BLOB subtype number
subtype_name	BLOB subtype mnemonic name
seglen	Segment size (max. 65535)

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 specified for it. 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 procedure. They are passed into the procedure as values, so anything that changes them inside the procedure has no effect on the parameters in the calling program.

Input parameters may have default values. Those that do have values specified for them must be located 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.

### ***Use of Domains in Declarations***

A domain name can be specified as the type of a parameter. The parameter will inherit all domain attributes. If a default value is specified for the parameter, 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 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 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.

#### **Bug warning for pre-Firebird 3 versions:**

For input parameters, the collation that comes with the column's type is ignored in comparisons (e.g. equality tests). For local variables, the behaviour varies.

The bug was fixed for Firebird 3.

### ***Variable and Cursor Declarations***

The optional declarations section, located last in the header section of the procedure definition, defines variables local to the procedure and its named cursors. Local variable declarations follow the same rules as parameters regarding specification of the data type. See details in the [PSQL chapter](#) for [DECLARE VARIABLE](#) and [DECLARE CURSOR](#).

The header section is followed by the procedure 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.

Any user connected to the database can create a new stored procedure. The user who creates a stored procedure becomes its owner.

*Examples:* 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
```

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  
  INTO :customer, :first_name, :last_name, :addr1, :addr2,  
    :city, :state, :country, :postcode;  
  
  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;
  line6 = country || ' ' || postcode;
END

SUSPEND; -- the statement that sends an output row to the buffer
         -- and makes the procedure "selectable"
END
```

See also: [CREATE OR ALTER PROCEDURE](#), [ALTER PROCEDURE](#), [RECREATE PROCEDURE](#), [DROP PROCEDURE](#)

## ALTER PROCEDURE

*Used for:* Modifying an existing stored procedure

*Available in:* DSQL, ESQL

*Syntax:*

```
ALTER PROCEDURE procname
[(<inparam> [, <inparam> ...])]
[RETURNS (<outparam> [, <outparam> ...])]
AS
[<declarations>]
BEGIN
[<PSQL_statements>]
END

<inparam> ::= <param_decl> [{= | DEFAULT} value]

<outparam> ::= <param_decl>

<param_decl> ::= paramname <type> [NOT NULL]
```

```

[COLLATE collation]

<type> ::=
  <datatype> |
  [TYPE OF] domain |
  TYPE OF COLUMN rel.col

<datatype> ::=
  {SMALLINT | INT[EGER] | BIGINT}
  | {FLOAT | DOUBLE PRECISION}
  | {DATE | TIME | TIMESTAMP}
  | {DECIMAL | NUMERIC} [(precision [, scale])]
  | {CHAR | CHARACTER | CHARACTER VARYING | VARCHAR} [(size)]
  [CHARACTER SET charset]
  | {NCHAR | NATIONAL CHARACTER | NATIONAL CHAR} [VARYING]
  [(size)]
  | BLOB [SUB_TYPE {subtype_num | subtype_name}]
  [SEGMENT SIZE seglen] [CHARACTER SET charset]
  | BLOB [(seglen [, subtype_num])]

<declarations> ::= {<declare_var> | <declare_cursor>};
[ {<declare_var> | <declare_cursor>}; ...]

```

**Table 5.25. ALTER PROCEDURE Statement Parameters**

Parameter	Description
procname	Name of an existing stored procedure
inparam	Input parameter description
outparam	Output parameter description
declarations	Section for declaring local variables and named cursors
declare_var	Local variable declaration
declare_cursor	Named cursor declaration
PSQL_statements	Procedural SQL statements
literal	A literal value that is assignment-compatible with the data type of the parameter
context_var	Any context variable whose type is compatible with the data type of the parameter
paramname	The name of an input or output parameter of the procedure. It may consist of up to 31 characters. The name of the parameter must be unique among input and output parameters of the procedure and its local variables
datatype	SQL data type
collation	Collation sequence
domain	Domain name
rel	Table or view name
col	Table or view column name

Parameter	Description
precision	The total number of significant digits that the parameter should be able to hold (1..18)
scale	The number of digits after the decimal point (0.. <i>precision</i> )
size	The maximum size of a string type parameter or variable, in characters
charset	Character set of a string type parameter or variable
subtype_num	BLOB subtype number
subtype_name	BLOB subtype mnemonic name
seglen	Segment size (max. 65535)

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.

#### Caution

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.

The procedure owner and [Administrators](#) have the authority to use ALTER PROCEDURE.

*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](#)

## CREATE OR ALTER PROCEDURE

*Used for:* Creating a new stored procedure or altering an existing one

*Available in:* DSQL

*Syntax:*

```
CREATE OR ALTER PROCEDURE procname
[(<inparam> [, <inparam> ...])]
[RETURNS (<outparam> [, <outparam> ...])]
AS
[<declarations>]
BEGIN
[<PSQL_statements>]
END
```

For the full syntax detail, see [CREATE DATABASE](#).

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.

*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](#)

## DROP PROCEDURE

*Used for:* Deleting a stored procedure

*Available in:* DSQL, ESQL



*Syntax:*

```
DROP PROCEDURE procname
```

**Table 5.26. DROP PROCEDURE Statement Parameter**

Parameter	Description
procname	Name of an existing stored procedure

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.

The procedure owner and [Administrators](#) have the authority to use DROP PROCEDURE.

*Example:* Deleting the GET\_EMP\_PROJ stored procedure.

```
DROP PROCEDURE GET_EMP_PROJ ;
```

See also: [CREATE PROCEDURE](#), [RECREATE PROCEDURE](#)

## RECREATE PROCEDURE

*Used for:* Creating a new stored procedure or recreating an existing one

*Available in:* DSQL

*Syntax:*

```
RECREATE PROCEDURE procname
[(<inparam> [, <inparam> ...])]
[RETURNS (<outparam> [, <outparam> ...])]
AS
[<declarations>]
BEGIN
[<PSQL_statements>]
END
```

For the full syntax detail, see [CREATE PROCEDURE](#).

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.

### Warning

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.

*Example:* Creating the new GET\_EMP\_PROJ stored procedure or recreating the existing GET\_EMP\_PROJ stored procedure.

```
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](#)

## EXTERNAL FUNCTION

### REVIEW STATUS

All sections from this point forward to the end of the chapter are awaiting technical and editorial review.

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 to a database, they become available in dynamic and procedural statements as though they were implemented in the SQL language internally.

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 `DECLARE EXTERNAL FUNCTION`.

The library containing a function is loaded when any function included in it is called.

### Note

External functions may be contained in more than one library—or “module”, as it is referred to in the syntax.

## DECLARE EXTERNAL FUNCTION

*Used for:* Declaring a user-defined function (UDF) to the database

Available in: DSQL, ESQL

Syntax:

```
DECLARE EXTERNAL FUNCTION funcname
[<arg_type_decl> [, <arg_type_decl> ...]]
RETURNS {
  sqltype [BY {DESCRIPTOR | VALUE}] |
  CSTRING(length) |
  PARAMETER param_num }
[FREE_IT]
ENTRY_POINT 'entry_point' MODULE_NAME 'library_name';

<arg_type_decl> ::=
  sqltype [{BY DESCRIPTOR} | NULL] |
  CSTRING(length) [NULL]
```

**Table 5.27. DECLARE EXTERNAL FUNCTION Statement Parameters**

Parameter	Description
funcname	Function name in the database. It may consist of up to 31 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.
entry_point	The exported name of the function
library_name	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.
sqltype	SQL data type. It cannot be an array or an array element
length	The maximum length of a null-terminated string, specified in bytes
param_num	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

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. As well as the SQL types, the CSTRING type is available for specifying a null-terminated string with a maximum length of LENGTH bytes.

By default, input parameters are passed *by reference*. The BY DESCRIPTOR clause may be specified instead, if the input parameter is passed by descriptor. Passing a parameter by descriptor makes it possible to process NULLs.

### **Clauses and Keywords**

**RETURNS clause:** (Required) specifies the output parameter returned by the function. A function is scalar: it returns one and only one 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).

*Examples using DECLARE EXTERNAL FUNCTION:*

1. Declaring the `addDate` 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](#)

## 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 5.28. ALTER EXTERNAL FUNCTION Statement Parameters**

Parameter	Description
<code>funcname</code>	Function name in the database
<code>new_entry_point</code>	The new exported name of the function
<code>new_library_name</code>	The new name of the module ( <code>MODULE_NAME</code> from which the function is exported. This will be the name of the file, without the “.dll” or “.so” file extension.

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.

*Examples using **ALTER EXTERNAL FUNCTION**:*

1. Changing the entry point for an external function

```
ALTER EXTERNAL FUNCTION invl ENTRY_POINT 'intNvl';
```

2. Changing the module name for an external function

```
ALTER EXTERNAL FUNCTION invl MODULE_NAME 'fbudf2';
```

*See also:* [DECLARE EXTERNAL FUNCTION](#), [DROP EXTERNAL FUNCTION](#)

## ***DROP EXTERNAL FUNCTION***

*Used for:* Removing a user-defined function (UDF) from a database

*Available in:* DSQL, ESQL

*Syntax:*

```
DROP EXTERNAL FUNCTION funcname
```

**Table 5.29. DROP EXTERNAL FUNCTION Statement Parameter**

Parameter	Description
funcname	Function name in the database

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.

*Example using **DROP EXTERNAL FUNCTION**:* Deleting the declaration of the addDay function.

```
DROP EXTERNAL FUNCTION addDay;
```

*See also:* [DECLARE EXTERNAL FUNCTION](#)

## FILTER

A BLOB FILTER filter is a database object that is actually 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](#).

### 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 5.30. DECLARE FILTER Statement Parameters**

Parameter	Description
filtername	Filter name in the database. It may consist of up to 31 characters. It need not be the same name as the name exported from the filter library via ENTRY_POINT.
sub_type	BLOB subtype
number	BLOB SUB_TYPE number (must be negative)
mnemonic	BLOB SUB_TYPE mnemonic name
function_name	The exported name (entry point) of the function
library_name	The name of the module where the filter is located
user_defined	User-define BLOB SUB_TYPE mnemonic name

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.

### Note

Mnemonic names can be defined for custom BLOB subtypes and inserted manually into the system table `RDB$TYPES` system table:

```
INSERT INTO RDB$TYPES (RDB$FIELD_NAME, RDB$TYPE, RDB$TYPE_NAME)
VALUES ( 'RDB$FIELD_SUB_TYPE', -33, 'MIDI' );
```

After the transaction is confirmed, 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 mnemonic names in upper case, they can be used case-insensitively and without quotation marks when a filter is declared.

*Warning:* From Firebird 3 onward, the system tables will no longer be writable by users.

## 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.

*Examples:*

1. Creating a BLOB filter using subtype numbers.

```
DECLARE FILTER DESC_FILTER
INPUT_TYPE 1
OUTPUT_TYPE -4
ENTRY_POINT 'desc_filter'
MODULE_NAME 'FILTERLIB';
```

2. Creating a BLOB filter using subtype mnemonic names.



```
DECLARE FILTER FUNNEL
INPUT_TYPE blr OUTPUT_TYPE text
ENTRY_POINT 'blr2asc' MODULE_NAME 'myfilterlib';
```

See also: [DROP FILTER](#)

## ***DROP FILTER***

*Used for:* Removing a BLOB filter declaration from the database

*Available in:* DSQL, ESQL

*Syntax:*

```
DROP FILTER filtername;
```

**Table 5.31. DROP FILTER Statement Parameter**

Parameter	Description
filtername	Filter name in the database

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.

Any user connected to the database can drop a BLOB filter.

*Example:* Deleting a BLOB filter.

```
DROP FILTER DESC_FILTER;
```

See also: [DECLARE FILTER](#)

---

## **SEQUENCE (GENERATOR)**

A sequence or a 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”. Both terms are implemented in Firebird, which recognises and has syntax for both terms.

Sequences (or generators) are always stored as 64-bit integers, regardless of the SQL dialect of the database.

**Caution**

If a client is connected using Dialect 1, the server sends sequence values to it 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 keep cutting the values, which will compromise the uniqueness of the series.

This section describes how to create, set and delete sequences.

## CREATE SEQUENCE

*Used for:* Creating a new SEQUENCE (GENERATOR)

*Available in:* DSQL, ESQL

*Syntax:*

```
CREATE {SEQUENCE | GENERATOR} seq_name
```

**Table 5.32. CREATE SEQUENCE | CREATE GENERATOR Statement Parameter**

Parameter	Description
seq_name	Sequence (generator) name. It may consist of up to 31 characters

The statements CREATE SEQUENCE and CREATE GENERATOR are synonymous—both create a new sequence. Either can be used but CREATE SEQUENCE is recommended if standards-compliant metadata management is important.

When a sequence is created, its value is set to 0. Each time the [NEXT VALUE FOR seq\\_name](#) operator is used with that sequence, its value increases by 1. The GEN\_ID(seq\_name, <step>) function can be called instead, to “step” the series by a different integer number.

Any user connected to the database can create a sequence (generator).

*Examples:*

1. Creating the EMP\_NO\_GEN series using CREATE SEQUENCE.

```
CREATE SEQUENCE EMP_NO_GEN;
```

2. Creating the EMP\_NO\_GEN series using CREATE GENERATOR.

```
CREATE GENERATOR EMP_NO_GEN;
```

See also: [ALTER SEQUENCE](#), [SET GENERATOR](#), [DROP SEQUENCE \(GENERATOR\)](#), [NEXT VALUE FOR, GEN\\_ID\(\)](#) function

## ALTER SEQUENCE

*Used for:* Setting the value of a sequence or generator to a specified value

*Available in:* DSQL

*Syntax:*

```
ALTER SEQUENCE seq_name RESTART WITH new_val
```

**Table 5.33. ALTER SEQUENCE Statement Parameters**

Parameter	Description
seq_name	Sequence (generator) name
new_val	New sequence (generator) value. A 64-bit integer from $-2^{63}$ to $2^{63}-1$ .

The ALTER SEQUENCE statement sets the current value of a sequence or generator to the specified value.

### Warning

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.

Any user connected to the database can set the sequence (generator) value.

*Examples:*

1. Setting the value of the EMP\_NO\_GEN sequence to 145.

```
ALTER SEQUENCE EMP_NO_GEN RESTART WITH 145;
```

2. Doing the same thing, using SET GENERATOR:

```
SET GENERATOR EMP_NO_GEN TO 145;
```

See also: [SET GENERATOR](#), [CREATE SEQUENCE \(GENERATOR\)](#), [DROP SEQUENCE \(GENERATOR\)](#), [NEXT VALUE FOR, GEN\\_ID\(\)](#) function

## SET GENERATOR

*Used for:* Setting the value of a sequence or generator to a specified value

*Available in:* DSQL, ESQL

*Syntax:*

```
SET GENERATOR seq_name TO new_val
```

**Table 5.34. SET GENERATOR Statement Parameters**

Parameter	Description
seq_name	Generator (sequence) name
new_val	New sequence (generator) value. A 64-bit integer from $-2^{63}$ to $2^{63}-1$ .

The SET GENERATOR statement sets the current value of a sequence or generator to the specified value.

### Note

Although SET GENERATOR is considered outdated, it is retained for backward compatibility. Using the standards-compliant ALTER SEQUENCE is current and is recommended.

Any user connected to the database can set the sequence (generator) value.

*Examples:*

1. Setting the value of the EMP\_NO\_GEN sequence to 145:

```
SET GENERATOR EMP_NO_GEN TO 145;
```

2. Doing the same thing, using ALTER SEQUENCE:

```
ALTER SEQUENCE EMP_NO_GEN RESTART WITH 145;
```

*See also:* [ALTER SEQUENCE](#), [CREATE SEQUENCE \(GENERATOR\)](#)

## DROP SEQUENCE

*Used for:* Deleting SEQUENCE (GENERATOR)

*Available in:* DSQL, ESQL

*Syntax:*

```
DROP {SEQUENCE | GENERATOR} seq_name
```

**Table 5.35. DROP SEQUENCE | DROP GENERATOR Statement Parameter**

Parameter	Description
seq_name	Sequence (generator) name. It may consist of up to 31 characters

The statements DROP SEQUENCE and DROP GENERATOR statements are equivalent: both delete an existing sequence (generator). Either is valid but DROP SEQUENCE, being current, is recommended.

The statements will fail if the sequence (generator) has dependencies.

Any user connected to the database can drop a sequence (generator).

*Example:* Dropping the EMP\_NO\_GEN series:

```
DROP SEQUENCE EMP_NO_GEN;
```

*See also:* [CREATE SEQUENCE \(GENERATOR\)](#), [ALTER SEQUENCE](#), [SET GENERATOR](#)

## EXCEPTION

This section describes how to create, modify and delete *custom exceptions* for use in error handlers in PSQL modules.

### CREATE EXCEPTION

*Used for:* Creating a new exception for use in PSQL modules

*Available in:* DSQL, ESQL

*Syntax:*

```
CREATE EXCEPTION exception_name 'message'
```

**Table 5.36. CREATE EXCEPTION Statement Parameters**

Parameter	Description
exception_name	Exception name. The maximum length is 31 characters

Parameter	Description
message	Default error message. The maximum length is 1,021 characters

The statement `CREATE EXCEPTION` creates a new exception for use in PSQL modules. If an exception of 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.

Any user connected to the database can create an exception.

*Examples:*

1. Creating an exception named `E_LARGE_VALUE`:

```
CREATE EXCEPTION E_LARGE_VALUE
    'The value is out of range';
```

2. Creating an exception named `ERROR_REFIN_RATE`:

```
CREATE EXCEPTION ERROR_REFIN_RATE
    'Error detected in the spread of discount rates';
```

#### **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.

Custom exceptions are stored in the system table [RDB\\$EXCEPTIONS](#).

*See also:* [ALTER EXCEPTION](#), [CREATE OR ALTER EXCEPTION](#), [DROP EXCEPTION](#), [RECREATE EXCEPTION](#)

## **ALTER EXCEPTION**

*Used for:* Modifying a the message returned from a custom exception

*Available in:* DSQL, ESQL

*Syntax:*

```
ALTER EXCEPTION exception_name 'message'
```

**Table 5.37. ALTER EXCEPTION Statement Parameters**

Parameter	Description
exception_name	Exception name
message	New default error message. The maximum length is 1,021 characters

The statement ALTER EXCEPTION can be used at any time, to modify the default text of the message. Any user connected to the database can alter an exception message.

*Examples:*

1. Changing the default message for the exception E\_LARGE\_VALUE:

```
ALTER EXCEPTION E_LARGE_VALUE  
    'The value exceeds the prescribed limit of 32,765 bytes';
```

2. Changing the default message for the exception ERROR\_REFIN\_RATE:

```
ALTER EXCEPTION ERROR_REFIN_RATE 'Rate is outside the allowed range';
```

See also: [CREATE EXCEPTION](#), [CREATE OR ALTER EXCEPTION](#), [DROP EXCEPTION](#), [RECREATE EXCEPTION](#)

## CREATE OR ALTER EXCEPTION

*Used for:* Modifying a the message returned from a custom exception, if the exception exists; otherwise, creating a new exception

*Available in:* DSQL

*Syntax:*

```
CREATE OR ALTER EXCEPTION exception_name 'message'
```

**Table 5.38. CREATE OR ALTER EXCEPTION Statement Parameters**

Parameter	Description
exception_name	Exception name
message	Error message. The maximum length is limited to 1,021 characters

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.

Any user connected to the database can use this statement to create an exception or alter the text of one that already exists.

*Example:* Changing the message for the exception E\_LARGE\_VALUE:

```
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](#)

## ***DROP EXCEPTION***

*Used for:* Deleting a custom exception

*Available in:* DSQL, ESQL

*Syntax:*

```
DROP EXCEPTION exception_name
```

**Table 5.39. DROP EXCEPTION Statement Parameter**

Parameter	Description
exception_name	Exception name

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.

If an exception is used only in stored procedures, it can be deleted at any time. If it is used in a trigger, it cannot be deleted.

In planning to delete an exception, all references to it should first be removed from the code of stored procedures, to avoid its absence causing errors.

Any user connected to the database can delete an exception.

*Examples:*

1. Deleting exception ERROR\_REFIN\_RATE:

```
DROP EXCEPTION ERROR_REFIN_RATE;
```

2. Deleting exception E\_LARGE\_VALUE:

```
DELETE EXCEPTION E_LARGE_VALUE;
```



See also: [CREATE EXCEPTION](#), [RECREATE EXCEPTION](#)

## RECREATE EXCEPTION

*Used for:* Creating a new custom exception or recreating an existing one

*Available in:* DSQL

*Syntax:*

```
RECREATE EXCEPTION exception_name 'message'
```

**Table 5.40. RECREATE EXCEPTION Statement Parameters**

Parameter	Description
exception_name	Exception name. The maximum length is 31 characters
message	Error message. The maximum length is limited to 1,021 characters

The statement `RECREATE EXCEPTION` creates a new exception for use in PSQL modules. If an exception of the same name exists already, the `RECREATE EXCEPTION` statement will try to delete 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.

Any user connected to the database can [re]create an exception.

*Example:* Recreating the `E_LARGE_VALUE` exception:

```
RECREATE EXCEPTION E_LARGE_VALUE  
    'The value exceeds its limit';
```

See also: [CREATE EXCEPTION](#), [DROP EXCEPTION](#), [CREATE OR ALTER EXCEPTION](#)

---

# COLLATION

## CREATE COLLATION

*Used for:* Making a new collation for a supported character set available to the database

*Available in:* DSQL

*Syntax:*

```
CREATE COLLATION collname
FOR charset
[FROM basecoll | FROM EXTERNAL ('extname')]
[NO PAD | PAD SPACE]
[CASE [IN]SENSITIVE]
[ACCENT [IN]SENSITIVE]
['<specific-attributes>'];

<specific-attributes> ::= <attribute> [; <attribute> ...]

<attribute> ::= attrname=attrvalue
```

**Table 5.41. CREATE COLLATION Statement Parameters**

Parameter	Description
collname	The name to use for the new collation. The maximum length is 31 characters
charset	A character set present in the database
basecoll	A collation already present in the database
extname	The collation name used in the <code>.conf</code> file

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

If no FROM clause is present, Firebird will scan the `.conf` file(s) in the `intl` subdirectory for a collation with the name specified as the object of 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.

## Specific Attributes

The available specific attributes are listed in the table below. Not all specific attributes apply to every collation, even if specifying them does not cause an error.

### Important

Specific attributes 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). “UNI” stands for “UNICODE collations”.

**Table 5.42. Specific Collation Attributes**

Attribute	Values	Valid for	Comment
DISABLE-COMPRESSIONS	0, 1	1 bpc	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
DISABLE-EXPANSIONS	0, 1	1 bpc	Disables expansions. Expansions cause certain characters (e.g. ligatures or unlauted vowels) to be treated as character sequences and sorted accordingly
ICU-VERSION	default or M.m	UNI	Specifies the ICU library version to use. Valid values are the ones defined in the applicable <intl_module> element in <code>intl/fbintl.conf</code> . Format: either the string literal “default” or a major+minor version number like “3.0” (both unquoted).
LOCALE	xx_YY	UNI	Specifies the collation locale. Requires complete version of ICU libraries. Format: a locale string like “du_NL” (unquoted)
MULTI-LEVEL	0, 1	1 bpc	Uses more than one ordering level
NUMERIC-SORT	0, 1	UNI	Treats contiguous groups of decimal digits in the string as atomic units and sorts them numerically. (This is also known as natural sorting)
SPECIALS-FIRST	0, 1	1 bpc	Orders special characters (spaces, symbols etc.) before alphanumeric characters

#### Tip

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.

**Note:** 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.

Any user connected to the database can use `CREATE COLLATION` to add a new collation.

*Examples using `CREATE COLLATION`:*

1. Creating a collation using the name found in the `fbintl.conf` file (case-sensitive).

```
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).

```
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.

```
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.

```
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](#)

## ***DROP COLLATION***

*Used for:* Removing a collation from the database

*Available in:* DSQL

*Syntax:*

```
DROP COLLATION collname
```

**Table 5.43. DROP COLLATION Statement Parameters**

Parameter	Description
collname	The name of the collation

The DROP COLLATION statement removes the specified collation from the database, if it is there. An error will be raised if the specified collation is not present.

**Tip**

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.

Any user connected to the database can use DROP COLLATION to remove a collation.

*Example using DROP COLLATION:* Deleting the ES\_ES\_NOPAD\_CI collation.

```
DROP COLLATION ES_ES_NOPAD_CI ;
```

See also: [CREATE COLLATION](#)

## CHARACTER SET

### 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 5.44. ALTER CHARACTER SET Statement Parameters**

Parameter	Description
charset	Character set identifier

Parameter	Description
collation	The name of the collation

The statement `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.

**NOTES**

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.

*Example of use:* Setting the default `UNICODE_CI_AI` collation for the UTF8 encoding.

```
ALTER CHARACTER SET UTF8
    SET DEFAULT COLLATION UNICODE_CI_AI;
```

## ROLE

A role is a database object that packages a set of [SQL 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 his login credentials in order to exercise the associated privileges. Any other privileges granted to the user are not affected by his 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.

## CREATE ROLE

*Used for:* Creating a new `ROLE` object

*Available in:* `DSQL`, `ESQL`

*Syntax:*

```
CREATE ROLE rolename;
```

**Table 5.45. CREATE ROLE Statement Parameter**

Parameter	Description
rolename	Role name. The maximum length is 31 characters

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.

**Warning**

It is advisable to make the name of a role unique among user names as well. The system will not prevent the creation of a role whose name clashes with an existing user name but, if it happens, the user will be unable to connect to the database.

Any user connected to the database can create a role. The user that creates a role becomes its owner.

*Example:* Creating a role named `SELLERS`:

```
CREATE ROLE SELLERS;
```

See also: [DROP ROLE](#), [GRANT](#), [REVOKE](#)

## ALTER ROLE

`ALTER ROLE` has no place in the create-alter-drop paradigm for database objects since a role has no attributes that can be modified. Its actual effect is to alter an attribute of the database: Firebird uses it to enable and disable the capability for Windows Administrators to assume [administrator privileges](#) automatically when logging in.

This procedure can affect only one role: the system-generated role `RDB$ADMIN` that exists in every database of ODS 11.2 or higher. Several factors are involved in enabling this feature.

For details, see [AUTO ADMIN MAPPING](#) in the *Security* chapter.

## DROP ROLE

*Used for:* Deleting a role

*Available in:* DSQL, ESQL

*Syntax:*

```
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.

A role can be deleted by its owner or by an [administrator](#).

*Example:* Deleting the role `SELLERS`:

```
DROP ROLE SELLERS;
```

*See also:* [CREATE ROLE](#), [GRANT](#), [REVOKE](#)

## COMMENTS

Database objects and a database itself may contain 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.

### COMMENT ON

*Used for:* Documenting metadata

*Available in:* DSQL

*Syntax:*

```
COMMENT ON <object> IS {'sometext' | NULL}

<object> ::=
    DATABASE
  | <basic-type> objectname
  | COLUMN relationname.fieldname
  | PARAMETER procname.paramname

<basic-type> ::=
    CHARACTER SET |
    COLLATION |
    DOMAIN |
    EXCEPTION |
    EXTERNAL FUNCTION |
    FILTER |
    GENERATOR |
    INDEX |
    PROCEDURE |
    ROLE |
    SEQUENCE |
    TABLE |
    TRIGGER |
    VIEW
```



**Table 5.46. COMMENT ON Statement Parameters**

Parameter	Description
sometext	Comment text
basic-type	Metadata object type
objectname	Metadata object name
relationname	Name of table or view
procname	Name of stored procedure
paramname	Name of a stored procedure parameter

The COMMENT ON statement adds comments for database objects (metadata). Comments are saved to text fields of the BLOB type in the RDB\$DESCRIPTION column of the corresponding system tables. Client applications can view comments from these fields.

**Note**

If you add an empty comment ("), it will be saved as NULL in the database.

The table or procedure owner and [Administrators](#) have the authority to use COMMENT ON.

*Examples using COMMENT ON:*

1. Adding a comment for the current database

```
COMMENT ON DATABASE IS 'It is a test ('my.fdb') 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';
```

---

## Chapter 6

# Data Manipulation (DML) Statements

### REVIEW STATUS

All sections from this point forward to the end of the chapter are awaiting technical and editorial review.

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 `INSERT OR UPDATE` all modify data in various ways.

## SELECT

*Used for:* Retrieving data

*Available in:* DSQL, ESQL, PSQL

*Global syntax:*

```
SELECT
[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>]]
[PLAN <plan-expr>]
[UNION [DISTINCT | ALL] <other-select>]
[ORDER BY <ordering-list>]
[ROWS m [TO n]]
[FOR UPDATE [OF <columns>]]
[WITH LOCK]
[INTO <variables>]

<variables> ::= [:]varname [, [:]varname ...]
```

## Description

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, the rows retrieved are often limited by a WHERE clause. The result set may be sorted by an ORDER BY clause, and FIRST, SKIP or ROWS may further limit the number of output rows. 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.

## 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 6.1. Arguments for the FIRST and SKIP Clauses**

Argument	Description
integer literal	Integer literal
query parameter	Query parameter place-holder. ? in DSQL and :paramname in PSQL
integer-expression	Expression returning an integer value

**FIRST and SKIP are non-standard syntax**

FIRST and SKIP are Firebird-specific, non-SQL-compliant keywords. You are advised to use the [ROWS](#) syntax wherever possible.

**Description**

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.

**Caution**

An error occurs when you use FIRST in subqueries. This query

```
DELETE FROM MYTABLE
  WHERE ID IN (SELECT FIRST 10 ID FROM MYTABLE)
```

will delete ALL records from the table. The subquery retrieves 10 rows each time, deletes them and the operation is repeated until the table is empty. Keep it in mind! Or, better, use the [ROWS](#) clause in the DELETE statement.

**Examples**

The following query will return the first 10 names from the People table:

```
select first 10 id, name from People
order by name asc
```

The following query will return everything *but* the first 10 names:

```
select skip 10 id, name from People
order by name asc
```

And this one returns the last 10 rows. Notice the double parentheses:

```
select skip ((select count(*) - 10 from People))
  id, name from People
 order by name asc
```

This query returns rows 81 to 100 of the People table:

```
select first 20 skip 80 id, name from People
 order by name asc
```

See also: [ROWS](#)

## 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”) 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] <output-column> [, <output-column> ...]
  [...]
  FROM ...

<output-column>      ::=  [qualifier.]*
                        | <value-expression> [COLLATE collation] [[AS] alias]

<value-expression>  ::=  [qualifier.]table-column
                        | [qualifier.]view-column
                        | [qualifier.]selectable-SP-outparm
                        | constant
                        | 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
collation            ::=  a valid collation name (only for character type columns)
```

**Table 6.2. Arguments for the *SELECT* Columns List**

Argument	Description
qualifier	Name of relation (view, stored procedure, derived table); or an alias for it
collation	Only for character-type columns: a collation name that exists and is valid for the character set of the data
alias	Column or field alias

Argument	Description
table-column	Name of a table column
view-column	Name of a view column
selectable-SP-outparm	Declared name of an output parameter of a selectable stored procedure
constant	A constant
context-variable	Context variable
function-call	Scalar or aggregate function call expression
single-value-subselect	A subquery returning one scalar value (singleton)
CASE-construct	CASE construct setting conditions for a return value
other-single-value-expr	Any other expression returning a single value of a Firebird data type; or NULL

### Description

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. e.g., `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.

#### Important

Aliases obfuscate 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:

```
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
from pupils p
join classes c on c.id = p.class
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
```

Querying a selectable stored procedure:

```
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   (select r.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)
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 any 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: [Scalar Functions](#), [Aggregate Functions](#), [Context Variables](#), [CASE](#), [Subqueries](#)

## 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. But 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 concentrates 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>  
              | <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 6.3. Arguments for the FROM Clause**

Argument	Description
table	Name of a table



Argument	Description
view	Name of a view
selectable-stored-procedure	Name of a selectable stored procedure
args	Selectable stored procedure arguments
derived table	Derived table query expression
cte-def	Common table expression (CTE) definition, including an “ad hoc” name
select-statement	Any SELECT statement
column-aliases	Alias for a column in a relation, CTE or derived table
name	The “ad hoc” name for a CTE
alias	The alias of a data source (table, view, procedure, CTE, derived table)

## Selecting FROM a table or view

When selecting from a single table or view, the FROM clause need not contain anything 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

```
select id, name, sex, age from actors
  where state = 'Ohio'
```

```
select * from birds
  where type = 'flightless'
 order by family, genus, species
```

```
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:

```
select name, az, alt from visible_stars('Brugge', current_date, '22:30')
where alt >= 20
order by az, alt
```

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:

```
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:

```
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:

```
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 parameter list should be omitted:

```
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.

### Sample 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. 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:

```
SELECT
    DBINFO.DESCR, DBINFO.DEF_CHARSET
FROM (SELECT *
      FROM RDB$DATABASE) DBINFO
    (DESCR, REL_ID, SEC_CLASS, DEF_CHARSET)
```

### 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:

```
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:

```
select
  iif (D >= 0, (-b - sqrt(D)) / denom, null) sol_1,
  iif (D > 0, (-b + sqrt(D)) / denom, null) sol_2
from
  (select b, b*b - 4*a*c, 2*a from coeffs) (b, D, denom)
```

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:

```
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.

## Selecting FROM a 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. But 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.

See also: *Common Table Expressions* (“*WITH ... AS ... SELECT*”).

## 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:*

```
SELECT
  ...
FROM <source>
[<joins>]
[...]
```

**<source>** ::= {table  
                  | view  
                  | selectable-stored-procedure [(args)]  
                  | 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 6.4. Arguments for JOIN Clauses**

Argument	Description
table	Name of a table
view	name of a view
selectable-stored-procedure	Name of a selectable stored procedure
args	Selectable stored procedure input parameter[s]

Argument	Description
derived-table	Reference, by name, to a derived table
common-table-expression	Reference, by name, to a common table expression (CTE)
alias	An alias for a data source (table, view, procedure, CTE, derived table)
condition	Join condition (criterion)
column-list	The list of columns used for an equi-join

## 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:

ID	S
87	Just some text
235	Silence

Table B:

CODE	X
-23	56.7735
87	416.0

If we join these tables like this:

```
select *
  from A
 join B on A.id = B.code
```

then the result set will be:

ID	S	CODE	X
87	Just some text	87	416.0

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:

```
select *  
  from A  
 inner join B on A.id = B.code
```

However, since INNER is the default, this is rarely done.

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:

ID	S	CODE	X
87	Just some text	87	416.0
87	Just some text	87	-1.0
-23	Don't know	-23	56.7735
-23	Still don't know	-23	56.7735
-23	I give up	-23	56.7735

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 NULLs.

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:

```
select *  
  from A  
left [outer] join B on A.id = B.code
```

ID	S	CODE	X
87	Just some text	87	416.0
235	Silence	<null>	<null>

```
select *  
  from A  
right [outer] join B on A.id = B.code
```



ID	S	CODE	X
<null>	<null>	-23	56.7735
87	Just some text	87	416.0

```
select *
  from A
 full [outer] join B on A.id = B.code
```

ID	S	CODE	X
<null>	<null>	-23	56.7735
87	Just some text	87	416.0
235	Silence	<null>	<null>

## 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*.

#### Note

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 that 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.

## 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.

### Note

Natural joins are not supported in Dialect 1 databases.

*Syntax:*

```
<natural-join> ::= NATURAL [<join-type>] JOIN <source>
<join-type>    ::= INNER | {LEFT | RIGHT | FULL} [OUTER]
```

Given these two tables:

```
create table TA (
  a bigint,
  s varchar(12),
  ins_date date
)
```

```
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:

```
select * from TA
  natural join TB
```

```
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.

Caution: 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.

## A Note on Equality

### Important

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:

```
select *
  from A join B
 on A.id is distinct from B.code
```

## 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
```

## 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:

```
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:

```
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.

**Tip**

This quirk has been recognised as a bug in the optimizer and will be fixed in the next version of Firebird.

## 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>
[... ]

<search-condition> ::= a boolean expression returning
                     TRUE, FALSE or possibly UNKNOWN (NULL)
```

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'
```

```
select name from wrestlers
  where region = 'Europe'
     and weight > all (select weight from shot_putters
                       where region = 'Africa')
```

```
select id, name from players
  where team_id = (select id from teams where name = 'Buffaloes')
```

```
select sum (population) from towns
  where name like '%dam'
     and province containing 'land'
```

```
select password from usertable
  where username = current_user
```

The following example shows what can happen if the search condition evaluates to 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:

CHILD	MARBLES
Anita	23
Bob E.	12
Chris	<null>
Deirdre	1
Eve	17
Fritz	0
Gerry	21
Hadassah	<null>
Isaac	6

First, please notice the difference between NULL and 0: Fritz is *known* to have no marbles at all, Chris's and Hadassah's marble counts are unknown.

Now, if you issue this SQL statement:

```
select list(child) from marbletable where marbles > 10
```

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.

## ***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:

```

SELECT ... FROM ...
  GROUP BY <grouping-item> [, <grouping-item> ...]
  [HAVING <grouped-row-condition>]
  ...

<grouping-item>      ::= <non-aggr-select-item>
                        | <non-aggr-expression>

<non-aggr-select-item> ::= column-copy
                        | column-alias
                        | column-position

```

**Table 6.5. Arguments for the GROUP BY Clause**

Argument	Description
non-aggr-expression	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
column-copy	A literal copy, from the SELECT list, of an expression that contains no aggregate function
column-alias	The alias, from the SELECT list, of an expression (column) that contains no aggregate function
column-position	The position number, in the SELECT list, of an expression (column) that contains no aggregate function

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.

**Note**

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. But 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:

```
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:

```
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:

```
select count(*), avg(age) from students
where sex = 'M'
group by class
```

and 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:

```
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:

CLASS	COUNT	AVG
2A	12	13.5
2B	9	13.9
3A	11	14.6

CLASS	COUNT	AVG
3B	12	14.4
...	...	...

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:

```
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:

CLASS	SEX	BOARDING_TYPE	NUMBER	AVG_AGE
2A	F	BOARDING	9	13.3
2A	F	DAY	6	13.5
2A	M	BOARDING	7	13.6
2A	M	DAY	5	13.4
2B	F	BOARDING	11	13.7
2B	F	DAY	5	13.7
2B	M	BOARDING	6	13.8
...	...	...	...	...

Each row in the result set corresponds to one particular combination of the variables 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 subclause 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 alternative.
- 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:

```
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:

```
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 `min(age)` and `max(age)` – or the expression “`max(age) - min(age)`” – in the select list as well!

To include only 3rd classes:

```
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
```

## 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:*

```
PLAN <plan-expr>

<plan-expr>      ::=  (<plan-item> [, <plan-item> ...])
                   |  <sorted-item>
                   |  <joined-item>
                   |  <merged-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> ...])

<plan-item>      ::=  <basic-item> | <plan-expr>

<basic-item>     ::=  <relation>
                   { NATURAL
                     | INDEX (<indexlist>)
                     | ORDER index [INDEX (<indexlist>)] }

<relation>       ::=  table
                   | view [table]

<indexlist>      ::=  index [, index ...]
```

**Table 6.6. Arguments for the *PLAN* Clause**

Argument	Description
table	Table name or its alias

Argument	Description
view	View name
index	Index name

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.

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. E.g., for an unsorted single-table select without a WHERE clause:

```
select * from students
plan (students natural)
```

If there's a WHERE or a HAVING clause, you can specify the index to be used for finding matches:

```
select * from students
  where class = '3C'
plan (students index (ix_stud_class))
```

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:

```
select * from students
plan (students order pk_students)
order by id
```

ORDER and INDEX can be combined:

```
select * from students
  where class >= '3'
plan (students order pk_students index (ix_stud_class))
order by id
```

It is perfectly OK if ORDER and INDEX specify the same index:

```
select * from students
  where class >= '3'
plan (students order ix_stud_class index (ix_stud_class))
order by class
```

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:

```
select * from students
  plan sort (students natural)
  order by name
```

Or when an index is used for the search:

```
select * from students
  where class >= '3'
  plan sort (students index (ix_stud_class))
  order by name
```

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)
```

Or, for instance:

```
select * from freshmen
  where id > 10
  plan sort (freshmen students index (pk_students))
  order by name desc
```

### Important

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:

```
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))
```

The same join, sorted on an indexed column:

```
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
```

And on a non-indexed column:

```
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
```

With a search added:

```
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
```

As a left outer join:

```
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
```

If there is no index available to match the join criteria (or if you don't want to use it), the plan must first sort both streams on their join column(s) and then merge them. This is achieved with the SORT directive (which we've already met) and MERGE instead of JOIN:

```
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:

```
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:

```
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.



**Warning**

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

```
MERGE (unsorted stream, unsorted stream)
```

It is advisable to treat such a plan as “deprecated”.

## UNION

A UNION 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.

*Syntax:*

```
<union> ::= <individual-select>
          UNION [DISTINCT | ALL]
          <individual-select>
          [UNION [DISTINCT | ALL]
          <individual-select>
          ...]
          [<union-wide-clauses>]

<individual-select> ::= SELECT
          [TRANSACTION name]
          [FIRST <m>] [SKIP <n>]
          [DISTINCT | ALL] <columns>
          [INTO <host-varlist>]
          FROM source [[AS] alias]
          [<joins>]
          [WHERE <condition>]
          [GROUP BY <grouping-list>]
          [HAVING <aggregate-condition>]]
          [PLAN <plan-expr>]

<union-wide-clauses> ::= [ORDER BY <ordering-list>]
          [ROWS m [TO n]]
          [FOR UPDATE [OF <columns>]]
          [WITH LOCK]
          [INTO <PSQL-varlist>]
```

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:

```
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:

```
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.

```
select name, phone from translators
union distinct
select name, telephone from proofreaders
```

A UNION within a subquery:

```
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
```

## 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. To specify a 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}  
  [COLLATE collation-name]  
  [ASC[ENDING] | DESC[ENDING]]  
  [NULLS {FIRST|LAST}]
```

**Table 6.7. Arguments for the ORDER BY Clause**

Argument	Description
col-name	Full column name
col-alias	Column alias
col-position	Column position in the SELECT list
expression	Any expression
collation-name	Collation name (sorting order for string types)

### Description

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 there. The ordinal position number of the column in the , 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.

#### Note

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 the 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 one that has been 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

Sorting the result set in ascending order, ordering by the `RDB$CHARACTER_SET_ID`, `RDB$COLLATION_ID` columns of the `DB$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:

```
SELECT
    BOOKS.*,
    FILMS.DIRECTOR
FROM BOOKS, FILMS
ORDER BY 2
```

### Caution

Expressions whose calculation results are non-negative integers will be interpreted as column position numbers and will cause an exception if they fall outside the range from 1 to the number of columns.

*Example:*

```
SELECT
    X, Y, NOTE
FROM PAIRS
ORDER BY X+Y DESC
```

- The number returned by a function or a procedure is unpredictable, regardless of whether the sort order is defined by the expression itself or by the column number
- Only non-negative integers are interpreted as column numbers
- An integer obtained by one-time evaluation of an expression or by parameter substitution is saved as a constant, because this value applies to all rows.

### Examples, continued

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
```

## 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 6.8. Arguments for the ROWS Clause**

Argument	Description
m, n	Any integer expressions

*Description:* Limits the amount of rows returned by the SELECT statement to a specified number or range.

The FIRST and SKIP clauses do the same job as ROWS are not SQL-compliant. Using ROWS is thus preferable in new code. Unlike FIRST and SKIP, 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.

### Important

- Numbering of rows in the intermediate set—the overall set cached on disk before the “slice” is extracted—starts at 1.
- Both FIRST/SKIP and ROWS can 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 random 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 `ROWS m` retrieves the first  $m$  records from the set specified.

#### **Characteristics of using `ROWS m` without a `TO` clause:**

- If  $m$  is greater than the total number of records in the intermediate data set, the entire set is returned
- If  $m = 0$ , an empty set is returned
- If  $m < 0$ , the `SELECT` statement call fails with an error

Calling `ROWS m TO n` retrieves the rows from the set, starting at row  $m$  and ending after row  $n$ —the set is inclusive.

#### **Characteristics of using `ROWS m` with a `TO` clause:**

- If  $m$  is greater than the total number of rows in the intermediate set and  $n \geq m$ , an empty set is returned
- If  $m$  is not greater than  $n$  and  $n$  is greater than the total number of rows in the intermediate set, the result set will be limited to rows starting from  $m$ , up to the end of the set
- If  $m < 1$  and  $n < 1$ , the `SELECT` statement call fails with an error
- If  $n = m - 1$ , an empty set is returned
- If  $n < m - 1$ , the `SELECT` statement call fails with an error

#### **Using a `TO` clause without a `ROWS` clause:**

While `ROWS` replaces the non-standard `FIRST` and `SKIP` syntax, there is one situation where the standard syntax does not provide the same behaviour: specifying `SKIP n` on its own returns the entire intermediate set, without the first  $n$  rows. The `ROWS...TO` syntax needs a little help to achieve this.

With the `ROWS` syntax, you need a `ROWS` clause *in association with* the `TO` clause and deliberately make the second ( $n$ ) argument greater than the size of the intermediate data set. This is achieved by creating an expression for  $n$  that uses a subquery to retrieve the count of rows in the intermediate set and adds 1 to it.

## **Mixing `ROWS` and `FIRST/SKIP`**

`ROWS` syntax cannot be mixed with `FIRST/SKIP` syntax 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**

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:

```
SELECT id, name
FROM People
ORDER BY name ASC
ROWS 1 TO 10
```

or its equivalent

```
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
```

### Note

ROWS can also be used with the **UPDATE** and **DELETE** statements.

## ***FOR UPDATE [OF]***

*Syntax:*

```
SELECT ... FROM single_table
```



```
[WHERE ...]  
[FOR UPDATE [OF ...]]
```

FOR UPDATE does not do what it suggests. Its only effect currently is to disable the pre-fetch buffer.

**Tip**

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.

## WITH LOCK

*Available in:* DSQL, PSQL

*Used for:* Limited pessimistic locking

*Description:* WITH LOCK provides a limited explicit pessimistic locking capability for cautious use in conditions where the affected row set is:

- a. extremely small (ideally, a 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.

*Syntax:*

```
SELECT ... FROM single_table  
  [WHERE ...]  
  [FOR UPDATE [OF ...]]  
  WITH LOCK
```

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

*Editor's note :: Should be in here, too?*

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 6.9. How TPB settings affect explicit locking**

TPB mode	Behaviour
isc_tpb_consistency	Explicit locks are overridden by implicit or explicit table-level locks and are ignored.
isc_tpb_concurrency + isc_tpb_nowait	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.
isc_tpb_concurrency + isc_tpb_wait	<p>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.</p> <p>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.</p>
isc_tpb_read_committed + isc_tpb_nowait	If there is an active transaction holding ownership on this record (via explicit locking or normal update), an update conflict exception is raised immediately.
isc_tpb_read_committed + isc_tpb_wait	<p>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.</p> <p>Update conflict exceptions can never be raised by an explicit lock statement in this TPB mode.</p>

## 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.

**Tip**

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-names>**

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 transaction.

No special gdscores 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.

**Note**

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, where 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:

```
SELECT * FROM DOCUMENT WHERE PARENT_ID=?  
FOR UPDATE WITH LOCK
```

## INTO

*Used for:* Passing SELECT output into variables

*Available in:* PSQL

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. 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.

*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 ...]
```

### Note

The colon prefix before local variable names in PSQL is optional.

### Examples

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;
```

**Note**

The 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.

A PSQL trigger that retrieves two values as a BLOB field (using the LIST() function) and assigns it INTO a third field:

```
select list(name, ', ')
  from persons p
 where p.id in (new.father, new.mother)
 into new.parentnames;
```

## Common Table Expressions (“WITH ... AS ... SELECT”)

Available in: DSQL, PSQL

A common table expression or 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 CTEs defined in the preamble as if they were regular tables or views. CTEs can be recursive, i.e. self-referencing, but they cannot be nested.

Syntax:

```
<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 ...]
```

**Table 6.10. Arguments for Common Table Expressions**

Argument	Description
cte-stmt	Any SELECT statement, including UNION
main-query	The main SELECT statement, which can refer to the CTEs defined in the preamble
name	Alias for a table expression
column-alias	Alias for a column in a table expression

Example:

```
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
)
```

### CTE Notes

- A CTE definition can contain any legal SELECT statement, as long as it doesn't have a “WITH...” preamble of its own (no nesting).
- 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:

```
for
  with my_rivers as (select * from rivers where owner = 'me')
  select name, length from my_rivers into :rname, :rlen
do
begin
  ..
end
```

#### Important

If a CTE is declared, it must be used later: otherwise, you will get an error like this: 'CTE "AAA" is not used in query'.

### 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_YEAR_BUDGET 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_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)
```

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.

## INSERT

*Used for:* Inserting rows of data into a table

*Available in:* DSQL, ESQL, PSQL

*Syntax:*

```

INSERT INTO target
{DEFAULT VALUES | [(<column_list>)] <value_source>}
[RETURNING <returning_list> [INTO <variables>]]

<column_list> ::= colname [, colname ...]

<value_source> ::= VALUES (<value_list>) | <select_stmt>

<value_list> ::= value [, value ...]

<returning_list> ::= ret_value [, ret_value ...]
<variables> ::= [:]varname [, [:]varname ...]

```

**Table 6.11. Arguments for the INSERT Statement Parameters**

Argument	Description
target	The name of the table or view to which a new row, or batch of rows, should be added
colname	Column in the table or view
value	An expression whose value is used for inserting into the table
ret_value	The expression to be returned in the RETURNING clause
varname	Name of a PSQL local variable

*Description:* 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.

## 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).

**Note**

[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:*

```
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')
```

## 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:*

```
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.

## The “Unstable Cursor” Problem

In Firebird, up to and including this version, it is necessary to be aware of an implementation fault that affects this style of inserts when the objective is to duplicate rows in the same table. For example

```
INSERT INTO T
  SELECT * FROM T
```

known affectionately as the “infinite insertion loop”, will continuously select rows and insert them, over and over, until the system runs out of storage space.

This is a quirk that affects all data-changing DML operations, with a variety of effects. It happens because, in the execution layers, DML statements use implicit cursors for performing the operations. Thus, using our simple example, execution works as follows:

```
FOR SELECT <values> FROM T INTO <tmp_vars>
DO
```

```
INSERT INTO T VALUES (<tmp_vars>)
```

The implementation results in behaviour that does not accord with the SQL standards. Future versions of Firebird will comply with the standard.

## ***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.

*Example:*

```
INSERT INTO journal
  DEFAULT VALUES
RETURNING entry_id
```

## ***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.

### **ALERT :: 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:*

```
INSERT INTO Scholars (
  firstname,
  lastname,
  address,
  phone,
  email)
VALUES (
  'Henry',
  'Higgins',
  '27A Wimpole Street',
  '3231212',
  NULL)
RETURNING lastname, fullname, id;

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;
```

*Notes:*

- RETURNING is only supported for 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.

*Editor's note :: These notes were missing from the raw translation: perhaps they were overlooked by the translator?*

*Editor's note :: And the following section as well!*

## 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 text string of no more than 32767 bytes.

### Caution

If the value is not a string literal, beware of concatenations, as the output from the expression may exceed the maximum length.

3. You are using the “INSERT ... SELECT” form and one or more columns in the result set are BLOBs.

## UPDATE

*Used for:* Modifying rows in tables and views

*Available in:* DSQL, ESQL, PSQL

*Syntax:*

```
UPDATE target [[AS] alias]
SET col = newval [, col = newval ...]
[WHERE {search-conditions | CURRENT OF cursorname}]
[PLAN plan_items]
[ORDER BY sort_items]
[ROWS <m> [TO <n>]]
```

```
[RETURNING <returning_list> [INTO <variables>]]

<returning_list>      ::=  ret_value [, ret_value ...]
<variables>          ::=  :varname [, :varname ...]
```

**Table 6.12. Arguments for the UPDATE Statement Parameters**

Argument	Description
target	The name of the table or view where the records are updated
alias	Alias for the table or view
col	Name or alias of a column in the table or view
newval	New value for a column that is to be updated in the table or view by the statement
search-conditions	A search condition limiting the set of the rows to be updated
cursorname	The name of the cursor through which the row[s] to be updated are positioned
plan_items	Clauses in the query plan
sort_items	Columns listed in an ORDER BY clause
m, n	Integer expressions for limiting the number of rows to be updated
ret_value	A value to be returned in the RETURNING clause
varname	Name of a PSQL local variable

*Description:* 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.

## 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.

*Examples:*

Correct usage:

```
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:

```
update Fruit F set Fruit.soort = 'pisang' where ...
```

## 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.

Here is an example: Data in the TSET table:

A	B
1	0
2	0

The statement

```
UPDATE tset SET a = 5, b = a
```

will change the values to

A	B
5	1
5	2

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).

### Note

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 future.

## 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*.

**Note**

The WHERE CURRENT OF clause is available only in PSQL, since there is no statement for creating and manipulating an explicit cursor in DSQL. Searched updates are also available in PSQL, of course.

*Examples:*

```
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:

```
-- notice the '_' prefix

UPDATE People
SET name = _ISO8859_1 'Hans-Jörg Schäfer'
WHERE id = 53662
```

## The “Unstable Cursor” Problem

In Firebird, up to and including this version, it is necessary to be aware of an implementation fault that affects updates when the WHERE conditions use the IN (*select-expr*) and the *select-expr* is of the form SELECT FIRST *n* or SELECT ... ROWS. For example

```
UPDATE T
  SET ...
  WHERE ID IN (SELECT FIRST 1 ID FROM T)
```

known affectionately as the “infinite update loop”, will continuously update rows, over and over, and give the impression that the server has hung.

Quirks like this can affect any data-changing DML operations, most often when the selection conditions involve a subquery. Cases have been reported where sort order interferes with expectations, without involving a sub-



query. It happens because, in the execution layers, instead of establishing a stable “target set” and then executing the data changes to each set member, DML statements use implicit cursors for performing the operations on whatever row currently meets the conditions, without knowledge of whether that row formerly failed the condition or was updated already. Thus, using a simple example pattern:

```
UPDATE T SET <fields> = <values>
WHERE <conditions>
```

the execution works as:

```
FOR SELECT <values> FROM T
WHERE <conditions>
INTO <tmp_vars> AS CURSOR <cursor>
DO
    UPDATE T SET <fields> = <tmp_vars>
    WHERE CURRENT OF <cursor>
```

Firebird's implementation does not accord with the SQL standards, which require that a stable set be established before any data are changed. Versions of Firebird from V.3 onward will comply with the standard.

## 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:*

```
UPDATE employees
SET salary = salary + 50
ORDER BY salary ASC
ROWS 20
```

## 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 row, not necessarily the one that is currently being updated. It can include literals not associated with columns, if there is a need for that.

When the RETURNING set contains data from the current row, the returned values report changes made in the BEFORE UPDATE triggers, but not those made in AFTER UPDATE triggers.

The context variables OLD.fieldname and NEW.fieldname can be used as column names. If OLD. or NEW. is not specified, the column values returned are the NEW. ones.

In DSQL, a statement with RETURNING always returns a single row. If the statement updates no records, the returned values contain NULL. This behaviour may change in future Firebird versions.

## The INTO Sub-clause

In PSQL, the 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 RETURNING will keep their previous values.

### Note

When a value is returned and assigned to a NEW context variable, it is not valid to use a colon prefix on it. For example, this is invalid:

```
...  
into :var1, :var2, :new.id
```

and this is valid:

```
...  
into :var1, :var2, new.id
```

*RETURNING Example (DSQL):*

```
UPDATE Scholars  
SET firstname = 'Hugh', lastname = 'Pickering'  
WHERE firstname = 'Henry' and lastname = 'Higgins'  
RETURNING id, old.lastname, new.lastname
```

## 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 *modus operandi* is application-specific and outside the scope of this manual.
2. The new value is a text string of at most 32767 bytes. Please notice: if the value is not a string literal, beware of concatenations, as these may exceed the maximum length.
3. The source is itself a BLOB column or, more generally, an expression that returns a BLOB.
4. You use the INSERT CURSOR statement (ESQL only).

## 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)]
VALUES (value_list)
[MATCHING (column_list)]
[RETURNING values [INTO variables]]

column_list      ::= colname [, colname ...]
value_list       ::= value  [, value   ...]
ret_values      ::= ret_value [, ret_value ...]
variables       ::= :varname [, :varname ...]
```

**Table 6.13. 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
colname	Name of a column in the table or view
value	An expression whose value is to be used for inserting or updating the table
ret_value	An expression returned in the RETURNING clause
varname	Variable name—PSQL only

*Description:* 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.

MATCHING PK IS NOT DISTINCT NULL

**Restrictions**

- If the table has no PK, the MATCHING clause becomes 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 (“:”).

## 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.

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 is raised. This behaviour may change in a later version of Firebird.

*Example:* 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 not optional.

```
UPDATE OR INSERT INTO Cows (Name, Number, Location)
VALUES ('Suzy Creamcheese', 3278823, 'Green Pastures')
MATCHING (Number)
RETURNING rec_id into :id;
```

**The “Unstable Cursor” Problem**

Because of the way the execution of data-changing DML is implemented in Firebird, up to and including this version, the sets targeted for updating sometimes produce unexpected results. For more information, refer to [The “Unstable Cursor” Problem](#) in the UPDATE section.

## DELETE

*Used for:* Deleting rows from a table or view

*Available in:* DSQL, ESQL, PSQL

*Syntax:*

```
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>]]

<m>, <n>      ::= Any expression evaluating to an integer.
<returning_list> ::= ret_value [, ret_value ...]
```

```
<variables> ::= :varname [ , :varname ... ]
```

**Table 6.14. Arguments for the DELETE Statement Parameters**

Argument	Description
target	The name of the table or view from which the records are to be deleted
alias	Alias for the target table or view
search-conditions	Search condition limiting the set of rows being targeted for deletion
cursorname	The name of the cursor in which current record is positioned for deletion
plan_items	Query plan clause
sort_items	ORDER BY clause
m, n	Integer expressions for limiting the number of rows being deleted
ret_value	An expression to be returned in the RETURNING clause
varname	Name of a PSQL variable

*Description:* 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.

## 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:

```
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:

```
delete from Cities C where Cities.name starting 'Alex'
```

## 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 update*.

**Note**

The WHERE CURRENT OF clause is available only in PSQL and ESQL, since there is no statement for creating and manipulating an explicit cursor in DSQL. Searched deletes are also available in PSQL, of course.

*Examples:*

```
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
```

## PLAN

A PLAN clause allows the user to optimize the operation manually.

*Example:*

```
DELETE FROM Submissions
WHERE date_entered < '1-Jan-2002'
PLAN (Submissions INDEX ix_subm_date);
```

## 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:

```
DELETE FROM Purchases
ORDER BY date ROWS 1
```

Deleting the highest custno(s):

```
DELETE FROM Sales
ORDER BY custno DESC ROWS 1 to 10
```

Deleting all sales, ORDER BY clause pointless:

```
DELETE FROM Sales
ORDER BY custno DESC
```

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
```

## 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.

### Notes

- In DSQL, a statement with RETURNING always returns a singleton, never a mult-row set. 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 Dumbbells
ORDER BY iq DESC
ROWS 1
RETURNING lastname, iq into :lname, :iq;
```

### The “Unstable Cursor” Problem

Because of the way the execution of data-changing DML is implemented in Firebird, up to and including this version, the sets targeted for deletion sometimes produce unexpected results. For more information, refer to [The “Unstable Cursor” Problem](#) in the UPDATE section.

---

## 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
```



```

WHEN MATCHED THEN UPDATE SET colname = value [, colname = value ...]
WHEN NOT MATCHED THEN INSERT [( <columns> ) ] VALUES ( <values> )

```

```

<columns> ::= colname [, colname ...]

```

```

<values> ::= value [, value ...]

```

**Table 6.15. Arguments for the MERGE Statement Parameters**

Argument	Description
target	Name of target relation (table or updatable view)
source	Data source. It can be a table, a view, a stored procedure or a derived table
target-alias	Alias for the target relation (table or updatable view)
source-alias	Alias for the source relation or set
join-conditions	The (ON) condition[s] for matching the source records with those in the target
colname	Name of a column in the target relation
value	The value assigned to a column in the target table. It is an expression that may be a literal value, a PSQL variable, a column from the source or a compatible context variable

**Description**

The MERGE statement merges data into a 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, or neither.

The action taken depends on the supplied join condition and the WHEN clause(s). The condition will typically contain a comparison of fields in the source and target relations.

**Notes**

Only one of each WHEN clause can be supplied. This will change in the next major version of Firebird, when compound matching conditions will be supported.

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 that 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 [Tracker ticket CORE-4400](#).

**ALERT :: Another irregularity!**

If the WHEN MATCHED clause is present and several records match a single record in the target table, an UPDATE will be executed on that one target record for each one of the matching source records, with each successive update overwriting the previous one. This behaviour does not comply with the SQL:2003 standard, which requires that this situation throw an exception (an error).

*Examples:*

```
MERGE INTO books b
  USING purchases p
  ON p.title = b.title and p.type = 'bk'
  WHEN MATCHED THEN
    UPDATE SET b.desc = b.desc || ';' || p.desc
  WHEN NOT MATCHED THEN
    INSERT (title, desc, bought) values (p.title, p.desc, p.bought)
```

```
MERGE 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)
```

```
MERGE 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);
```

### The “Unstable Cursor” Problem

Because of the way the execution of data-changing DML is implemented in Firebird, up to and including this version, the sets targeted for merging sometimes produce unexpected results. For more information, refer to [The “Unstable Cursor” Problem](#) in the UPDATE section.

---

## EXECUTE PROCEDURE

*Used for:* Executing a stored procedure

*Available in:* DSQL, ESQL, PSQL

*Syntax:*

```
EXECUTE PROCEDURE procname
  [<inparam> [, <inparam> ...] | [(<inparam> [, <inparam> ...])]
  [RETURNING_VALUES <outvar> [, <outvar> ...] | (<outvar> [, <outvar> ...])]
```

```
<outvar> ::= [:]varname
```

*Editor's note :: Notice I added the non-parenthesised option for return parameters, after an exchange with Dmitry Y.*

**Table 6.16. Arguments for the EXECUTE PROCEDURE Statement Parameters**

Argument	Description
procname	Name of the stored procedure
inparam	An expression evaluating to the declared data type of an input parameter
varname	A PSQL variable to receive the return value

*Description:* 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.

## “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.

### Notes

- 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.

*Examples:*

In PSQL, with optional colons and without optional parentheses:

```
EXECUTE PROCEDURE MakeFullName
    :FirstName, :MiddleName, :LastName
RETURNING_VALUES :FullName;
```

In Firebird's command-line utility *isql*, with literal parameters and optional parentheses:

```
EXECUTE PROCEDURE MakeFullName ('J', 'Edgar', 'Hoover');
```

**Note:** In *isql*, RETURNING\_VALUES is not used. Any output values are captured by the application and displayed automatically.

A PSQL example with expression parameters and optional parentheses:

```
EXECUTE PROCEDURE MakeFullName
    ('Mr./Mrs. ' || FirstName, MiddleName, upper(LastName))
RETURNING_VALUES (FullName);
```

## EXECUTE BLOCK

*Used for:* Creating an “anonymous” block of PSQL code in DSQL for immediate execution

*Available in:* DSQL

*Syntax:*

```
EXECUTE BLOCK [(<inparams>)]
    [RETURNS (<outparams>)]
AS
    [<declarations>]
BEGIN
    [<PSQL statements>]
END

<inparams>          ::= <param_decl> = ? [, <inparams> ]
<outparams>         ::= <param_decl>          [, <outparams>]
<param_decl>        ::= paramname <type> [NOT NULL] [COLLATE collation]
<type>              ::= datatype | [TYPE OF] domain | TYPE OF COLUMN rel.col

datatype ::=
    {SMALLINT | INTEGER | BIGINT}
  | {FLOAT | DOUBLE PRECISION}
  | {DATE | TIME | TIMESTAMP}
  | {DECIMAL | NUMERIC} [(precision [, scale])]
  | {CHAR | CHARACTER | CHARACTER VARYING | VARCHAR} [(size)]
  | [CHARACTER SET charset]
  | {NCHAR | NATIONAL CHARACTER | NATIONAL CHAR} [VARYING] [(size)]
```

```

| BLOB [SUB_TYPE {subtype_num | subtype_name}]
| [SEGMENT SIZE seglen] [CHARACTER SET charset]
| BLOB [(seglen [, subtype_num])]

<declarations>      ::= declare_item [declare_item ...]
declare_item ::= declare_var; | declare_cursor

```

**Table 6.17. Arguments for the EXECUTE BLOCK Statement Parameters**

Argument	Description
param_decl	Name and description of an input or output parameter
declarations	A section for declaring local variables and named cursors
declare_var	Local variable declaration
declare_cursor	Declaration of a named cursor
paramname	The name of an input or output parameter of the procedural block, up to 31 characters long. The name must be unique among input and output parameters and local variables in the block
datatype	SQL data type
collation	Collation sequence
domain	Domain
rel	Name of a table or view
col	Name of a column in a table or view
precision	Precision. From 1 to 18
scale	Scale. From 0 to 18. It must be less than or equal to <i>precision</i>
size	The maximum size of a string, in characters
charset	Character set
subtype_num	BLOB subtype number
subtype_name	BLOB subtype mnemonic name
seglen	Segment size, it cannot be greater than 65,535

*Description:* 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.

*Examples:*

```

This example injects the numbers 0 through 127 and their
corresponding ASCII characters into the table
ASCIITABLE:

```

```
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
```

The next example calculates the geometric mean of two numbers and returns it to the user:

```
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.

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.

## ***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 parameter and variable declarations, and *<PSQL statements>* consult Chapter 7, *Procedural SQL (PSQL) Statements*.

For *<declarations>* in particular, see [DECLARE \[VARIABLE\]](#) and [DECLARE CURSOR](#) for the exact syntax.

## 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](#).

# Procedural SQL (PSQL) Statements

### REVIEW STATUS

All sections from this point forward to the end of the chapter are awaiting technical and editorial review.

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 slight modifications to syntax in some cases.

## Elements of PSQL

A procedural extension may contain declarations of local variables 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.

### *DML Statements with Parameters*

If DML statements (SELECT, INSERT, UPDATE, DELETE, etc.) in the body of the module (procedure, trigger or block) use parameters, only named parameters can be used and they must “exist” before the statements can use them. They can be made available by being declared either as input or output parameters in the module's header or as local variables, in DECLARE [VARIABLE] statements at the bottom of the 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. The colon prefix on parameters is not required when calling stored procedures from within another PSQL module or in DSQL.

### *Transactions*

Stored procedures 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.

## 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 parameters and variables that are used in the body. Stored procedures and PSQL blocks may have input and output parameters. 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 body of a PSQL module is a block of statements that run in a logical sequence, like a program. A block of statements is contained within a BEGIN and an END statement. The main BEGIN...END block may contain any number of other BEGIN...END blocks, both embedded and sequential. 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 7.1. SET TERM Parameters**

Argument	Description
new_terminator	New terminator
old_terminator	Old terminator

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:

```
SET TERM ^;

CREATE OR ALTER PROCEDURE SHIP_ORDER (
    PO_NUM CHAR(8))
AS
BEGIN
    /* Stored procedure body */
END^

/* Other stored procedures and triggers */

SET TERM ;^

/* Other DDL statements */
```

## Stored Procedures

A stored procedure is a program stored in the database metadata for execution on the server. A stored procedure can be called by stored procedures (including itself), triggers and client applications. A procedure that calls itself is known as *recursive*.

### Benefits of Stored Procedures

Stored procedures have the following advantages:

1. **Modularity**—applications working with the database can use the same stored procedure, thereby reducing the size of the application code and avoiding code duplication.
2. **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.
3. **Enhanced Performance**—since stored procedures are executed on a server instead of at the client, network traffic is reduced, which improves performance.

### 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 DSQL 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.

## 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.

*Syntax (partial):*

```
CREATE PROCEDURE procname
[(
```

The header of a stored procedure must contain the procedure name, and it must be unique among the names of stored procedures, tables, and views. It may also define some input and output parameters. Input parameters are listed after the procedure name inside a pair of brackets. Output parameters, which are mandatory for selectable procedures, are bracketed inside one RETURNS clause.

The final item in the header (or the first item in the body, depending on your opinion of where the border lies) is one or more declarations of any local variables and/or named cursors that your procedure might require.

Following the declarations is the main BEGIN...END block that delineates the procedure's PSQL code. Within that block could be PSQL and DML statements, flow-of-control blocks, sequences of other BEGIN...END blocks, including embedded blocks. Blocks, including the main block, may be empty and the procedure will still compile. It is not unusual to develop a procedure in stages, from an outline.

*For more information about creating stored procedures:* See [CREATE PROCEDURE](#) in Chapter 5, *Data Definition (DDL) Statements*.

## Modifying a Stored Procedure

An existing stored procedure can be altered, to change the sets of input and output parameters and anything in the procedure body.

*Syntax (partial):*

```
ALTER PROCEDURE procname
[(
```

```
[<PSQL_statements>]  
END
```

For more information about modifying stored procedures: See [ALTER PROCEDURE](#), [CREATE OR ALTER PROCEDURE](#), [RECREATE PROCEDURE](#), in Chapter 5, *Data Definition (DDL) Statements*.

## Deleting a Stored Procedure

The DROP PROCEDURE statement is used to delete stored procedures.

*Syntax (complete):*

```
DROP PROCEDURE procname;
```

For more information about deleting stored procedures: See [DROP PROCEDURE](#) in Chapter 5, *Data Definition (DDL) Statements*.

## Stored Functions

Stored PSQL scalar functions are not supported in this version but they are coming in Firebird 3. In Firebird 2.5 and below, you can instead write a selectable stored procedure that returns a scalar result and SELECT it from your DML query or subquery.

*Example:*

```
SELECT  
    PSQL_FUNC(T.col1, T.col2) AS col3,  
    col3  
FROM T
```

can be replaced with

```
SELECT  
    (SELECT output_column FROM PSQL_PROC(T.col1)) AS col3,  
    col2  
FROM T
```

or

```
SELECT  
    output_column AS col3,  
    col2,  
FROM T  
LEFT JOIN PSQL_PROC(T.col1)
```

## 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 variable and cursor declarations; and a block of PSQL statements follows.

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):*

```
EXECUTE BLOCK
[(<inparam> = ? [, <inparam> = ? ...])]
[RETURNS (<outparam> [, <outparam> ...])]
AS
[<declarations>]
BEGIN
[<PSQL_statements>]
END
```

**Table 7.2. PSQL Block Parameters**

Argument	Description
inparam	Input parameter description
outparam	Output parameter description
declarations	A section for declaring local variables and named cursors
PSQL statements	PSQL and DML statements

*Read more:* See [EXECUTE BLOCK](#) for details.

## 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.

One trigger applies to exactly one table or view and only one *phase* in an event (BEFORE or AFTER the event). A single trigger might be written to fire only when one specific data-changing event occurs (INSERT/UPDATE/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 some of them, a default transaction is started.

## ***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.

## ***DML Triggers***

DML triggers are those that fire when a DML operation changes the state of data: modifies rows in tables, inserts new rows or deletes 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.

### **Note**

“Multi-phase” triggers, such as BEFORE OR AFTER..., are not possible.

## 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

## Database Triggers

A trigger associated with a database or transaction event can be defined for the following events:

Connecting to a database	(ON CONNECT)	Before the trigger is executed, a default transaction is automatically started
Disconnecting from a database	(ON DISCONNECT)	Before the trigger is executed, a default transaction is automatically started
When a transaction is started	(ON TRANSACTION START)	The trigger is executed in the current transaction context
When a transaction is committed	(ON TRANSACTION COMMIT)	The trigger is executed in the current transaction context
When a transaction is cancelled	(ON TRANSACTION ROLLBACK)	The trigger is executed in the current transaction context

## Creating Triggers

*Syntax:*

```
CREATE TRIGGER trigname {  
    <relation_trigger_legacy>  
    | <relation_trigger_sql2003>  
    | <database_trigger> }
```



```
AS
[<declarations>]
BEGIN
[<PSQL_statements>]
END

<relation_trigger_legacy> ::= FOR {tablename | viewname}
[ACTIVE | INACTIVE]
{BEFORE | AFTER} <mutation_list>
[POSITION number]

<relation_trigger_sql2003> ::= [ACTIVE | INACTIVE]
{BEFORE | AFTER} <mutation_list>
[POSITION number]
ON {tablename | viewname}

<database_trigger> ::= [ACTIVE | INACTIVE]
ON db_event
[POSITION number]

<mutation_list> ::= <mutation> [OR <mutation>
    [OR <mutation>]]

<mutation> ::= { INSERT | UPDATE | DELETE }

<db_event> ::=
    CONNECT
    | DISCONNECT
    | TRANSACTION START
    | TRANSACTION COMMIT
    | TRANSACTION ROLLBACK
```

The header must contain a name for the trigger that is unique among trigger names. It must include the event or events that will fire the trigger. Also, for a DML trigger it is mandatory to specify the event phase and the name of the table or view that is to “own” the trigger.

The body of the trigger can be headed by the declarations of local variables and cursors, if any. Within the enclosing main BEGIN...END wrapper will be one or more blocks of PSQL statements, which may be empty.

*For more information about creating triggers: See ">[CREATE TRIGGER](#) in Chapter 5, *Data Definition (DDL) Statements*.*

## Modifying Triggers

Altering the status, phase, table or view event(s), firing position and code in the body of a DML trigger are all possible. However, you cannot modify a DML trigger to convert it to a database trigger, nor vice versa. Any element not specified is left unchanged by ALTER TRIGGER. The alternative statements CREATE OR ALTER TRIGGER and RECREATE TRIGGER will replace the original trigger definition entirely.

*Syntax:*

```
ALTER TRIGGER trigrname
[ACTIVE | INACTIVE]
```

```
[{BEFORE | AFTER} <mutation_list>]
[POSITION number]
[
  AS
  [<declarations>]
  BEGIN
  [<PSQL_statements>]
  END
]

<mutation_list> ::=
  <mutation> [OR <mutation> [OR <mutation>]]

<mutation> ::= { INSERT | UPDATE | DELETE }

<db_event> ::=
  CONNECT
  | DISCONNECT
  | TRANSACTION START
  | TRANSACTION COMMIT
  | TRANSACTION ROLLBACK
```

For more information about modifying triggers: See [ALTER TRIGGER](#), [CREATE OR ALTER TRIGGER](#), [RECREATE TRIGGER](#) in Chapter 5, *Data Definition (DDL) Statements*.

## Deleting a Trigger

The DROP TRIGGER statement is used to delete stored procedures.

*Syntax (complete):*

```
DROP TRIGGER trigname;
```

For more information about deleting triggers: See [DROP TRIGGER](#) in Chapter 5, *Data Definition (DDL) Statements*.

## 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 code and it should never be applied to context variables.

## Assignment Statements

*Used for:* Assigning a value to a variable

*Available in:* PSQL

*Syntax:*

```
varname = <value_expr>
```

**Table 7.3. Assignment Statement Parameters**

Argument	Description
varname	Name of a parameter or local variable
value_expr	An expression, constant or variable whose value resolves to the same data type as <varname>

PSQL uses the equivalence 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 or to 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](#)

## DECLARE CURSOR

*Used for:* Declaring a named cursor

*Available in:* PSQL

*Syntax:*

```
DECLARE [VARIABLE] cursorname CURSOR FOR (<select>) [FOR UPDATE]
```

**Table 7.4. DECLARE CURSOR Statement Parameters**

Argument	Description
cursorname	Cursor name
select	SELECT statement

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 walk 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 statement.

## 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 checks it 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:

```
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.

### Attention!

If the value of a PSQL variable used in the SELECT statement changes during the loop, its new value may (but not always) be used for the remaining rows. It is better to avoid having such situations arise unintentionally. If you really need this behaviour, you should test your code carefully to be certain that you know exactly how changes in the variable affect the result.

Note particularly that the behaviour may depend on the query plan, specifically on the indexes being used. No strict rules are in place for situations like this currently, but that could change in future versions of Firebird.

## Examples Using Named Cursors

1. Declaring a named cursor in the trigger.

```
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. A collection of scripts for creating views with a PSQL block using named cursors.

```
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;

        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;
            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 || SOURCE;

        SUSPEND;
    END
    CLOSE CUR_R;
END
```

See also: [OPEN](#), [FETCH](#), [CLOSE](#)

## **DECLARE VARIABLE**

Used for: Declaring a local variable

Available in: PSQL

Syntax:

```
DECLARE [VARIABLE] <varname>
    {<datatype> | <domain> | TYPE OF {<domain> | COLUMN <rel.col>}}
    [NOT NULL] [CHARACTER SET <charset>] [COLLATE <collation>]
    [{DEFAULT | = } <initvalue>];

<datatype> ::=
    {SMALLINT | INTEGER | BIGINT}
    | {FLOAT | DOUBLE PRECISION}
    | {DATE | TIME | TIMESTAMP}
    | {DECIMAL | NUMERIC} [(precision [, scale])]
    | {CHAR | CHARACTER | CHARACTER VARYING | VARCHAR} [(size)]
    [CHARACTER SET charset]
    | {NCHAR | NATIONAL CHARACTER | NATIONAL CHAR} [VARYING]
    [(size)]
    | BLOB [SUB_TYPE {subtype_num | subtype_name}]
    [SEGMENT SIZE seglen] [CHARACTER SET charset]
    | BLOB [(seglen [, subtype_num])]

<initvalue> ::= <literal> | <context_var>
```

**Table 7.5. DECLARE VARIABLE Statement Parameters**

Argument	Description
varname	Name of the local variable
datatype	An SQL data type
domain	The name of an existing domain in this database
rel.col	Relation name (table or view) in this database and the name of a column in that relation
precision	Precision. From 1 to 18
scale	Scale. From 0 to 18, it must be less than or equal to precision
size	The maximum size of a string in characters
subtype_num	BLOB subtype number
subtype_name	BLOB subtype mnemonic name
seglen	Segment size, not greater than 65,535
initvalue	Initial value for this variable
literal	Literal of a type compatible with the type of the local variable
context_var	Any context variable whose type is compatible with the type of the local variable
charset	Character set
collation	Collation sequence

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.

## 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 and 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:* The variable can be constrained `NOT NULL` if required. If a domain has been specified as the data type and already carries the `NOT NULL` constraint, it will not be necessary. With the other forms, including use of a domain that is nullable, the `NOT NULL` attribute should 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>`. The value can be any type-compatible literal or context variable.

### Important

Be sure to use this clause for any variables that are constrained to be `NOT NULL` 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](#)

## **BEGIN ... END**

*Used for:* Delineating a block of statements

*Available in:* PSQL

*Syntax:*

```
<block> ::=  
BEGIN  
  <compound_statement>  
  [ <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 to unlimited depth. They may be empty, allowing them to act as stubs, without the need to write dummy statements.

The BEGIN and END statements have no line terminators. However, when defining or altering a PSQL module in the *isql* utility, that application requires that the last END statement be followed by its own terminator character, that was previously switched, using SET TERM, to some string other than a semicolon. That terminator is not part of the PSQL syntax.

The final, or outermost, END statement in a trigger terminates the trigger. What the final END statement does in a stored procedure depends on the type of procedure:

- In a selectable procedure, the final 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 END statement returns control to the caller, along with the current values of any output parameters defined.

*Example:* A sample procedure from the `employee.fdb` database, showing simple usage of BEGIN...END blocks:

```
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^
SET TERM ;^
```

See also: [EXIT](#), [LEAVE](#), [SET TERM](#)

## ***IF ... THEN ... ELSE***

*Used for:* Conditional jumps

*Available in:* PSQL

*Syntax:*

```

IF (<condition>)
  THEN <single_statement> ; | BEGIN <compound_statement> END
[ELSE <single_statement> ; | BEGIN <compound_statement> END]

```

**Table 7.6. IF ... THEN ... ELSE Parameters**

Argument	Description
condition	A logical condition returning TRUE, FALSE or UNKNOWN
single_statement	A single statement terminated with a semicolon
compound_statement	Two or more statements wrapped in BEGIN ... END

The conditional jump statement IF ... THEN is used to branch the execution process in a PSQL module. The condition is always enclosed in parentheses. If it 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 Jumps

PSQL does not provide multi-branch jumps, such as CASE or SWITCH. Nevertheless, the CASE search statement from DSQL is available in PSQL and is able to satisfy at least some use cases in the manner of a switch:

```

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:*

```

...
C = CASE
  WHEN A=2 THEN 1
  WHEN A=1 THEN 3
  ELSE 0
END;
...

```

*Example:* An example using the IF statement. Assume that the FIRST, LINE2 and LAST variables were declared earlier.

```
...  
IF (FIRST IS NOT NULL) THEN  
    LINE2 = FIRST || ' ' || LAST;  
ELSE  
    LINE2 = LAST;  
...  

```

See also: [WHILE ... DO](#), [CASE](#)

## WHILE ... DO

*Used for:* Looping constructs

*Available in:* PSQL

*Syntax:*

```
WHILE <condition> DO  
<single_statement> ; | BEGIN <compound_statement> END
```

**Table 7.7. WHILE ... DO Parameters**

Argument	Description
condition	A logical condition returning TRUE, FALSE or UNKNOWN
single_statement	A single statement terminated with a semicolon
compound_statement	Two or more statements wrapped in BEGIN ... END

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.

*Example:* 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
```

Executing the procedure in *isql*:

```
EXECUTE PROCEDURE SUM_INT(4);
```

the result is:

```
S
=====
10
```

See also: [IF ... THEN ... ELSE](#), [LEAVE](#), [EXIT](#), [FOR SELECT](#), [FOR EXECUTE STATEMENT](#)

## LEAVE

*Used for:* Terminating a loop

*Available in:* PSQL

*Syntax:*

```
[label:]
<loop>
BEGIN
  ...
  LEAVE [label];
  ...
END
<loop_stmt> ::=
  FOR <select_stmt> INTO <var_list> DO
  | FOR EXECUTE STATEMENT ... INTO <var_list> DO
  | WHILE (<condition>)} DO
```

**Table 7.8. LEAVE Statement Parameters**

Argument	Description
label	Label
select_stmt	SELECT statement
condition	A logical condition returning TRUE, FALSE or UNKNOWN

A LEAVE statement immediately terminates the inner loop of a WHILE or FOR looping statement. The LABEL parameter is optional.

LEAVE can cause an exit from outer loops as well. Code continues to be executed from the first statement after the termination of the outer loop block.

*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.

```
...
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. A 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.

```
...
STMT1 = 'SELECT NAME FROM FARMS';
LOOPA:
FOR EXECUTE STATEMENT :STMT1
INTO :FARM DO
BEGIN
    STMT2 = 'SELECT NAME ' || 'FROM ANIMALS WHERE FARM = ' || :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
...
```

See also: [EXIT](#)

## EXIT

*Used for:* Terminating module execution

*Available in:* PSQL

*Syntax:*

```
EXIT;
```

The EXIT statement causes execution of the procedure or trigger to jump to the final END statement from any point in the code, thus terminating the program.

*Example:* 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
```

*See also:* [LEAVE](#), [SUSPEND](#)

## 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. Applications using interfaces that wrap the API perform the fetches from selectable procedures transparently.
2. When a SUSPEND statement is executed in an executable stored procedure, it is the same as executing the EXIT statement, resulting in immediate termination of the procedure.
3. 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.

*Example:* Using the SUSPEND 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
```

See also: [EXIT](#)

## 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> ::= paramname := value_expr
    [, 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] <connect_string>

<connect_string> ::= [<hostspec>] {filepath | db_alias}

<hostspec> ::= <tcpip_hostspec> | <NamedPipes_hostspec>

<tcpip_hostspec> ::= hostname:

<NamePipes_hostspec> ::= \\hostname\

<variables> ::= [:]varname [, [:]varname ...]

```

**Table 7.9. EXECUTE STATEMENT Statement Parameters**

Argument	Description
paramless_stmt	Literal string or variable containing a non-parameterized SQL query
stmt_with_params	Literal string or variable containing a parameterized SQL query
paramname	SQL query parameter name
value_expr	SQL expression resolving to a value
user	User name. It can be a string, CURRENT_USER or a string variable
password	Password. It can be a string or a string variable
role	Role. It can be a string, CURRENT_ROLE or a string variable
connection_string	Connection string. It can be a string or a string variable
filepath	Path to the primary database file
db_alias	Database alias
hostname	Computer name or IP address
varname	Variable

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. 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
3. Each named parameter must be prefixed by a colon (:) in the statement string itself, but not when the parameter is assigned a value
4. Positional parameters must be assigned their values in the same order as they appear in the query text
5. The assignment operator for parameters is the special operator ":", similar to the assignment operator in Pascal
6. Each named parameter can be used in the statement more than once, but its value must be assigned only once *Editor note: I suspect something got lost in translation here. Needs confirmation or correction.*
7. With positional parameters, the number of assigned values must match the number of parameter placeholders (question marks) in the statement exactly

*Examples:* 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;
    ...
```

The same code with positional parameters:

```
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;
            ...
        END
    END
```

## WITH {AUTONOMOUS | COMMON} TRANSACTION

Traditionally, the executed SQL statement always ran within the current transaction, and this is still the default. WITH AUTONOMOUS TRANSACTION causes a separate transaction to be started, with the same parameters as the current transaction. It will be committed if the statement runs to completion without errors and rolled back otherwise. WITH COMMON TRANSACTION uses the current transaction if possible.

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 adds to this the privileges of the calling procedure or trigger, just as if the statement were executed

directly by the routine. WITH 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 the connect 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 the connect 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
- Notice that statements 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 un-committed 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

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.

#### Note

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 log-in and whether a separate connection is open depend 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 the connect string). No defaults are used for missing parameters
  - If all three are absent and the connect string contains no hostname, then the new connection is established on the local host 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 the connect 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 user name (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

### Notice

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 launched 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](#)

## FOR SELECT

*Used for:* Looping row-by-row through a selected result set

Available in: PSQL

Syntax:

```
FOR <select_stmt> [AS CURSOR cursorname]  
DO {<single_statement> | BEGIN <compound_statement> END}
```

**Table 7.10. FOR SELECT Statement Parameters**

Argument	Description
select_stmt	SELECT statement
cursorname	Cursor name. It must be unique among cursor names in the PSQL module (stored procedure, trigger or PSQL block)
single_statement	A single statement, terminated with a colon, that performs all the processing for this FOR loop
compound_statement	A block of statements wrapped in BEGIN...END, that performs all the processing for this FOR loop

A FOR SELECT statement

- retrieves each row sequentially from the result set and executes the statement or block of statements on the 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 carry 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 that is located at the end of the SELECT ... FROM ... specification. In each iteration of the loop, the field values in 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 LEAVE 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 iteration.

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 body code, 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:

```
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
```

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
```

See also: [DECLARE CURSOR](#), [LEAVE](#), [SELECT](#), [UPDATE](#), [DELETE](#)

## FOR EXECUTE STATEMENT

*Used for:* Executing dynamically created SQL statements that return a row set

*Available in:* PSQL

*Syntax:*

```
FOR <execute_statement> DO {<single_statement> | BEGIN <compound_statement> END}
```

**Table 7.11. FOR EXECUTE STATEMENT Statement Parameters**

Argument	Description
execute_stmt	An EXECUTE STATEMENT string
single_statement	A single statement, terminated with a colon, that performs all the processing for this FOR loop
compound_statement	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.

*Example:* Executing a dynamically constructed `SELECT` query that returns a data set:

```
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
```

See also: [EXECUTE STATEMENT](#)

## OPEN

*Used for:* Opening a declared cursor

*Available in:* PSQL

*Syntax:*

```
OPEN cursorname;
```

**Table 7.12. OPEN Statement Parameter**

Argument	Description
cursorname	Cursor name. A cursor with this name must be previously declared with a <code>DECLARE CURSOR</code> statement

An `OPEN` statement opens a previously declared cursor, executes the `SELECT` statement declared for it and makes the first record the result data set ready to fetch. `OPEN` can be applied only to cursors previously declared in a `DECLARE VARIABLE` statement.

**Note**

If the SELECT statement declared for 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.

*Examples:*

1. Using the OPEN statement:

```
SET TERM ^;

CREATE OR ALTER PROCEDURE GET_RELATIONS_NAMES
RETURNS (
    RNAME CHAR(31)
)
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
    CLOSE C;
END^

SET TERM ;^
```

2. A collection of scripts for creating views using a PSQL block with named cursors:

```
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;
    -- 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 shall 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
        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](#)

## FETCH

*Used for:* Fetching successive records from a data set retrieved by a cursor

*Available in:* PSQL

*Syntax:*

```
FETCH cursorname INTO [:]varname [, [:]varname ...];
```

**Table 7.13. FETCH Statement Parameters**

Argument	Description
cursorname	Cursor name. A cursor with this name must be previously declared with a DECLARE CURSOR statement and opened by an OPEN statement.
varname	Variable name

A 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.

The INTO clause gets data from the current row of the cursor and loads them into PSQL variables.

For checking whether all of the the data set rows have been fetched, the context variable ROW\_COUNT returns the number of rows fetched by the statement. It is positive until all rows have been checked. A ROW\_COUNT of 1 indicates that the next fetch will be the last.

*Example:* Using the FETCH statement:

```
SET TERM ^;

CREATE OR ALTER PROCEDURE GET_RELATIONS_NAMES
RETURNS (
    RNAME CHAR(31)
)
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
    CLOSE C;
END^

SET TERM ;^
```

See also: [DECLARE CURSOR](#), [OPEN](#), [CLOSE](#)

## CLOSE

*Used for:* Closing a declared cursor

Available in: PSQL

Syntax:

```
CLOSE cursorname;
```

**Table 7.14. CLOSE Statement Parameter**

Argument	Description
cursorname	Cursor name. A cursor with this name must be previously declared with a DECLARE CURSOR statement and opened by an OPEN statement

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.

*Example:* Using the CLOSE statement:

```
SET TERM ^;

CREATE OR ALTER PROCEDURE GET_RELATIONS_NAMES
RETURNS (
    RNAME CHAR(31)
)
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
    CLOSE C;
END^
```

See also: [DECLARE CURSOR](#), [OPEN](#), [FETCH](#)

## 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 7.15. IN AUTONOMOUS TRANSACTION Statement Parameter**

Argument	Description
compound_statement	A statement or a block of statements

An 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. It might be needed 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 made changes being cancelled. If the code executes successfully, the autonomous transaction will be committed.

*Example:* Using an autonomous transaction in a trigger for the database ON CONNECT event, in order to log all connection attempts, including those that failed:

```
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 (CURRENT_USER IN (SELECT
                        USERNAME
                        FROM
                        BLOCKED_USERS)) 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](#)

## POST\_EVENT

*Used for:* Notifying listening clients about database events in a module

Available in: PSQL

Syntax:

```
POST_EVENT event_name ;
```

**Table 7.16. POST\_EVENT Statement Parameter**

Argument	Description
event_name	Event name (message) limited to 127 bytes

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.

*Example:* Notifying the listening applications about inserting a record into the SALES table:

```
SET TERM ^;  
CREATE TRIGGER POST_NEW_ORDER FOR SALES  
ACTIVE AFTER INSERT POSITION 0  
AS  
BEGIN  
    POST_EVENT 'new_order' ;  
END^  
SET TERM ;^
```

## Trapping and Handling Errors

Firebird has a useful lexicon of PSQL statements and resources for trapping errors in modules and for handling them. Internally-implemented exceptions exist for stalling execution when every sort of standard error occurs in DDL, DSQL and the physical environment.

### 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](#)

## Custom Exceptions

Custom exceptions can be declared in the database as persistent objects and called in the PSQL code to signal specific errors; for instance, to enforce certain business rules. A custom exception consists of an identifier and a default message of approximately 1000 bytes. For details, see [CREATE EXCEPTION](#).

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 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.

## EXCEPTION

*Used for:* Throwing a user-defined exception or re-throwing an exception

*Available in:* PSQL

*Syntax:*

```
EXCEPTION [exception_name [custom_message]]
```

**Table 7.17. EXCEPTION Statement Parameters**

Argument	Description
exception_name	Exception name
custom_message	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

An EXCEPTION statement 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 exception can be handled in the statement, by just leaving it with no specific WHEN ... DO handler and allowing the trigger or stored procedure to terminate and roll back all operations. The calling application gets the alternative message text, if any was specified; otherwise, it receives the message originally defined for that exception.

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.



**Note**

Custom exceptions are stored in the system table `RDB$EXCEPTIONS`.

*Examples:*

1. Throwing an exception with dynamically generated text:

```
...  
EXCEPTION EX_BAD_TYPE  
    'Incorrect record type with id ' || new.id;  
...
```

2. 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
```

3. Throwing an exception upon a condition and replacing the original message with an alternative message:

```
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

```

#### 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,
                                GDS_CODE,
                                SQL_CODE,
                                SQL_STATE)
VALUES ('ADD_COUNTRY',
        GDSCODE,
        SQLCODE,
        SQLSTATE);
        -- Re-throw exception
    EXCEPTION;
    END
END

```

See also: [CREATE EXCEPTION, WHEN ... DO](#)

## 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  
}
```

**Table 7.18. WHEN ... DO Statement Parameters**

Argument	Description
exception_name	Exception name
number	SQLCODE error code
errcode	Symbolic GDSCODE error name
compound_statement	A statement or a block of statements

The WHEN ... DO statement is used to handle 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 wrapper, that handle the exception. The SQLCODE, GDSCODE, and SQLSTATE context variables are available in the context of this statement or block. The EXCEPTION statement, with no 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.

After the DO clause, another GDSCODE context variable, containing the numeric code, becomes available for use in the statement or the block of statements that code the error handler. That numeric code is required if you want to compare a GDSCODE exception with a targeted error.

The WHEN ... DO statement or block is never executed unless one of the events targeted by its conditions occurs in run-time. If the 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.

**Important**

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 [CORE-4483](#).
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 them.

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.

**Tip**

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 ensues. 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)
            VALUES ('ADD_COUNTRY',
                    GDSCODE,
                    SQLCODE,
                    SQLSTATE);
        -- 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);
    EXIT;
END
...
```

*See also:* [EXCEPTION](#), [CREATE EXCEPTION](#), [SQLCODE](#) and [GDSCODE](#) Error Codes and Message Texts and [SQLSTATE](#) Codes and Message Texts

# Built-in functions and Variables

## REVIEW STATUS

All sections from this point forward to the end of the chapter are awaiting technical and editorial review.

Here, the large collection of context variables, scalar functions and aggregate functions are described.

## Context variables

### ***CURRENT\_CONNECTION***

*Available in:* DSQL, PSQL

*Description:* CURRENT\_CONNECTION contains the unique identifier of the current connection.

*Type:* INTEGER

*Examples:*

```
select current_connection from rdb$database
```

```
execute procedure P_Login(current_connection)
```

The value of CURRENT\_CONNECTION is stored on the database header page and reset to 0 upon restore. Since version 2.1, it is incremented upon every new connection. (In previous versions, it was only incremented if the client read it during a session.) As a result, CURRENT\_CONNECTION now indicates the number of connections since the creation—or most recent restoration—of the database.

### ***CURRENT\_DATE***

*Available in:* DSQL, PSQL, ESQL

*Description:* CURRENT\_DATE returns the current server date.

*Type:* DATE

*Syntax:*

```
CURRENT_DATE
```

*Examples:*

```
select current_date from rdb$database  
-- returns e.g. 2011-10-03
```

*Notes:*

- 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'.

## CURRENT\_ROLE

*Available in:* DSQL, PSQL

*Description:* CURRENT\_ROLE is a context variable containing the role of the currently connected user. If there is no active role, CURRENT\_ROLE is NONE.

*Type:* VARCHAR(31)

*Example:*

```
if (current_role <> 'MANAGER')  
    then exception only_managers_may_delete;  
else  
    delete from Customers where custno = :custno;
```

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.

## CURRENT\_TIME

*Available in:* DSQL, PSQL, ESQL

*Description:* CURRENT\_TIME returns the current server time. In versions prior to 2.0, the fractional part used to be always “.0000”, giving an effective precision of 0 decimals. From Firebird 2.0 onward you can specify a precision when polling this variable. The default is still 0 decimals, i.e. seconds precision.

*Type:* TIME

*Syntax:*

```
CURRENT_TIME [(precision)]  
  
precision ::= 0 | 1 | 2 | 3
```

The optional *precision* argument is not supported in ESQL.

**Table 8.1. CURRENT\_TIME Parameter**

Parameter	Description
precision	Precision. The default value is 0. Not supported in ESQL

*Examples:*

```
select current_time from rdb$database
-- returns e.g. 14:20:19.6170
```

```
select current_time(2) from rdb$database
-- returns e.g. 14:20:23.1200
```

*Notes:*

- Unlike CURRENT\_TIME, the default precision of CURRENT\_TIMESTAMP has changed to 3 decimals. As a result, CURRENT\_TIMESTAMP is no longer the exact sum of CURRENT\_DATE and CURRENT\_TIME, unless you explicitly specify a precision.
- 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\_TIMESTAMP

*Available in:* DSQL, PSQL, ESQL

*Description:* CURRENT\_TIMESTAMP returns the current server date and time. In versions prior to 2.0, the fractional part used to be always “.0000”, giving an effective precision of 0 decimals. From Firebird 2.0 onward you can specify a precision when polling this variable. The default is 3 decimals, i.e. milliseconds precision.

*Type:* TIMESTAMP

*Syntax:*

```
CURRENT_TIMESTAMP [(precision)]
precision ::= 0 | 1 | 2 | 3
```

The optional *precision* argument is not supported in ESQL.

**Table 8.2. CURRENT\_TIME Parameter**

Parameter	Description
precision	Precision. The default value is 0. Not supported in ESQL



*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
```

*Notes:*

- The default precision of CURRENT\_TIME is still 0 decimals, so in Firebird 2.0 and up CURRENT\_TIMESTAMP is no longer the exact sum of CURRENT\_DATE and CURRENT\_TIME, unless you explicitly specify a precision.
- 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\_TRANSACTION**

*Available in:* DSQL, PSQL

*Description:* CURRENT\_TRANSACTION contains the unique identifier of the current transaction.

*Type:* INTEGER

*Examples:*

```
select current_transaction from rdb$database
```

```
New.Txn_ID = current_transaction;
```

The value of CURRENT\_TRANSACTION is stored on the database header page and reset to 0 upon restore. It is incremented with every new transaction.

## **CURRENT\_USER**

*Available in:* DSQL, PSQL

*Description:* CURRENT\_USER is a context variable containing the name of the currently connected user. It is fully equivalent to **USER**.

*Type:* VARCHAR(31)

*Example:*

```
create trigger bi_customers for customers before insert as
begin
  New.added_by  = CURRENT_USER;
  New.purchases = 0;
end
```

## DELETING

Available in: PSQL

*Description:* Available in triggers only, DELETING indicates if the trigger fired because of a DELETE operation. Intended for use in [multi-action triggers](#).

*Type:* boolean

*Example:*

```
if (deleting) then
begin
  insert into Removed_Cars (id, make, model, removed)
    values (old.id, old.make, old.model, current_timestamp);
end
```

## GDSCODE

Available in: PSQL

*Description:* 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 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.

*Type:* INTEGER

*Example:*

```
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);
  exit;
end
```

### Notice

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.

## INSERTING

Available in: PSQL

*Description:* Available in triggers only, INSERTING indicates if the trigger fired because of an INSERT operation. Intended for use in [multi-action triggers](#).

*Type:* boolean

*Example:*

```
if (inserting or updating) then
begin
  if (new.serial_num is null) then
    new.serial_num = gen_id(gen_serials, 1);
end
```

## NEW

*Available in:* PSQL, triggers only

*Description:* 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.

*Type:* Data row

### Note

In multi-action triggers—introduced in Firebird 1.5—NEW is always available. But 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.

## 'NOW'

*Available in:* DSQL, PSQL, ESQL

*Changed in:* 2.0

*Description:* 'NOW' 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 current date and/or time. The fractional part of the time used to be always “.0000”, giving an effective seconds precision. 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.

*Note:* Please be advised that these shorthand expressions are evaluated immediately at parse time and stay the same as long as the statement remains prepared. Thus, even if a query is executed multiple times, the value for e.g. “timestamp 'now'” won't change, no matter how much time passes. If you need the value to progress (i.e. be evaluated upon every call), use a full cast.

*Type:* CHAR(3)

*Examples:*

```
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
```

**Shorthand syntax** for the last three statements:

```
select date 'Now' from rdb$database
select time 'now' from rdb$database
select timestamp 'NOW' from rdb$database
```

#### Notes:

- '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)`.

## OLD

*Available in:* PSQL, triggers only

*Description:* OLD contains the existing version of a database record just before a deletion or update. Starting with Firebird 2.0 it is read-only.

*Type:* Data row

### Note

In multi-action triggers —introduced in Firebird 1.5—OLD is always available. But 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.

## ROW\_COUNT

*Available in:* PSQL

*Changed in:* 2.0

*Description:* 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.

*Type:* INTEGER

*Example:*

```
update Figures set Number = 0 where id = :id;
if (row_count = 0) then
    insert into Figures (id, Number) values (:id, 0);
```

*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.

#### Note

ROW\_COUNT cannot be used to determine the number of rows affected by an EXECUTE STATEMENT or EXECUTE PROCEDURE command.

## SQLCODE

*Available in:* PSQL

*Deprecated in:* 2.5.1

*Description:* 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 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.

*Type:* INTEGER

*Example:*

```
when any
do
begin
    if (sqlcode <> 0) then
        Msg = 'An SQL error occurred!';
    else
        Msg = 'Something bad happened!';
    exception ex_custom Msg;
end
```

*Important notice:* 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.

## SQLSTATE

Available in: PSQL

Added in: 2.5.1

*Description:* 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.

*Type:* CHAR(5)

*Example:*

```
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
```

*Notes:*

- 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*.

## 'TODAY'

Available in: DSQL, PSQL, ESQL

*Description:* 'TODAY' 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 current date. 'TODAY' is case-insensitive, and the engine ignores leading or trailing spaces when casting.

*Type:* CHAR(5)

*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
```

**Shorthand syntax** for the last two statements:

```
select date 'Today' from rdb$database
select timestamp 'TODAY' from rdb$database
```

*Notes:*

- '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 'NOW'.

## 'TOMORROW'

*Available in:* DSQL, PSQL, ESQL

*Description:* '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'.

*Type:* CHAR(8)

*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
```

**Shorthand syntax** for the last two statements:

```
select date 'Tomorrow' from rdb$database
select timestamp 'TOMORROW' from rdb$database
```

## UPDATING

*Available in:* PSQL

*Description:* Available in triggers only, UPDATING indicates if the trigger fired because of an UPDATE operation. Intended for use in [multi-action triggers](#).

*Type:* boolean

*Example:*

```
if (inserting or updating) then
begin
  if (new.serial_num is null) then
    new.serial_num = gen_id(gen_serials, 1);
end
```

## 'YESTERDAY'

*Available in:* DSQL, PSQL, ESQL

*Description:* '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](#).

*Type:* CHAR(9)

*Examples:*

```
select 'Yesterday' from rdb$database
-- returns 'Tomorrow'
```

```
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
```

[Shorthand syntax](#) for the last two statements:

```
select date 'Yesterday' from rdb$database
select timestamp 'YESTERDAY' from rdb$database
```

## USER

*Available in:* DSQL, PSQL

*Description:* USER is a context variable containing the name of the currently connected user. It is fully equivalent to [CURRENT\\_USER](#).

*Type:* VARCHAR(31)

*Example:*

```
create trigger bi_customers for customers before insert as
begin
  New.added_by = USER;
```



```
New.purchases = 0;
end
```

## Scalar Functions

### Upgraders: PLEASE READ!

A large number of 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.

## Functions for Working with Context Variables

### RDB\$GET\_CONTEXT()

#### Note

RDB\$GET\_CONTEXT and its counterpart RDB\$SET\_CONTEXT are actually predeclared UDFs. They are listed here as internal functions because they are always present—the user doesn't have to do anything to make them available.

*Available in:* DSQL, PSQL \* As a declared UDF it should be available in ESQL

*Description:* Retrieves the value of a context variable from one of the namespaces SYSTEM, USER\_SESSION and USER\_TRANSACTION.

*Syntax:*

```
RDB$GET_CONTEXT ( '<namespace>', '<varname>' )

<namespace>  ::=  SYSTEM | USER_SESSION | USER_TRANSACTION
<varname>    ::=  A case-sensitive string of max. 80 characters
```

**Table 8.3. RDB\$GET\_CONTEXT Function Parameters**

Parameter	Description
namespace	Namespace
varname	Variable name. Case-sensitive. Maximum length is 80 characters

*Result type:* VARCHAR(255)

*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. It contains a number of predefined variables, shown in the table below.

**Table 8.4. Context variables in the SYSTEM namespace**

DB_NAME	Either the full path to the database or—if connecting via the path is disallowed—its alias.
NETWORK_PROTOCOL	The protocol used for the connection: 'TCPv4', 'WNET', 'XNET' or NULL.
CLIENT_ADDRESS	For TCPv4, this is the IP address. For XNET, the local process ID. For all other protocols this variable is NULL.
CURRENT_USER	Same as global <a href="#">CURRENT_USER</a> variable.
CURRENT_ROLE	Same as global <a href="#">CURRENT_ROLE</a> variable.
SESSION_ID	Same as global <a href="#">CURRENT_CONNECTION</a> variable.
TRANSACTION_ID	Same as global <a href="#">CURRENT_TRANSACTION</a> variable.
ISOLATION_LEVEL	The isolation level of the current transaction: 'READ COMMITTED', 'SNAPSHOT' or 'CONSISTENCY'.
ENGINE_VERSION	The Firebird engine (server) version. Added in 2.1.

*Return values and error behaviour:* If the polled variable exists in the given namespace, its value will be returned as a string of max. 255 characters. If the namespace doesn't exist or if you try to access a non-existing variable in the SYSTEM namespace, an error is raised. If you poll a non-existing variable in one of the other namespaces, NULL is returned. Both namespace and variable names must be given as single-quoted, case-sensitive, non-NULL strings.

*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\(\)](#)

## RDB\$SET\_CONTEXT()

### Note

RDB\$SET\_CONTEXT and its counterpart RDB\$GET\_CONTEXT are actually predeclared UDFs. They are listed here as internal functions because they are always present—the user doesn't have to do anything to make them available.

Available in: DSQL, PSQL \* As a declared UDF it should be available in ESQL

*Description:* Creates, sets or unsets a variable in one of the user-writable namespaces USER\_SESSION and USER\_TRANSACTION.

*Syntax:*

```
RDB$SET_CONTEXT ('<namespace>', '<varname>', <value> | NULL)

<namespace> ::= USER_SESSION | USER_TRANSACTION
<varname>   ::= A case-sensitive string of max. 80 characters
<value>     ::= A value of any type, as long as it's castable
               to a VARCHAR(255)
```

**Table 8.5. RDB\$SET\_CONTEXT Function Parameters**

Parameter	Description
namespace	Namespace
varname	Variable name. Case-sensitive. Maximum length is 80 characters
value	Data of any type provided it can be cast to VARCHAR(255)

*Result type:* INTEGER

*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 if the variable already existed before the call and 0 if 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.

*Examples:*

```
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
```

*Notes:*

- 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.

See also: [RDB\\$GET\\_CONTEXT\(\)](#)

## Mathematical Functions

### ABS()

Available in: DSQL, PSQL

Possible name conflict: YES—>[Read details](#)

Syntax:

```
ABS (number)
```

**Table 8.6. ABS Function Parameter**

Parameter	Description
value	An expression of a numeric type

Result type: Numerical

Description: Returns the absolute value of the argument.

### ACOS()

Available in: DSQL, PSQL

Possible name conflict: YES—>[Read details](#)

Syntax:

```
ACOS (number)
```

**Table 8.7. ACOS Function Parameter**

Parameter	Description
value	An expression of a numeric type within the range [-1; 1]

Result type: DOUBLE PRECISION

Description: Returns the arc cosine of the argument.

- The result is an angle in the range [0, pi].
- If the argument is outside the range [-1, 1], NaN is returned.

## ASIN()

Available in: DSQL, PSQL

Possible name conflict: YES—>[Read details](#)

Syntax:

```
ASIN ( number )
```

**Table 8.8. ASIN Function Parameter**

Parameter	Description
value	An expression of a numeric type within the range [-1; 1]

Result type: DOUBLE PRECISION

Description: Returns the arc sine of the argument.

- The result is an angle in the range [-pi/2, pi/2].
- If the argument is outside the range [-1, 1], NaN is returned.

## ATAN()

Available in: DSQL, PSQL

Possible name conflict: YES—>[Read details](#)

Syntax:

```
ATAN ( number )
```

**Table 8.9. ATAN Function Parameter**

Parameter	Description
value	An expression of a numeric type

Result type: DOUBLE PRECISION

Description: The function ATAN returns the arc tangent of the argument. The result is an angle in the range <-pi/2, pi/2>.

## ATAN2()

Available in: DSQL, PSQL

Possible name conflict: YES—>[Read details](#)

Syntax:

```
ATAN2 (y, x)
```

**Table 8.10. ATAN2 Function Parameters**

Parameter	Description
x	An expression of a numeric type
y	An expression of a numeric type

*Result type:* DOUBLE PRECISION

*Description:* 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. Starting with Firebird 3, an error will be raised if both arguments are 0. At v.2.5.4, it is still not fixed in lower versions. For more details, visit [Tracker ticket CORE-3201](#).

*Notes:*

- 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.

## CEIL(), CEILING()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#) (Affects CEILING only)

Syntax:

```
CEIL[ING] (number)
```

**Table 8.11. CEIL[ING] Function Parameters**

Parameter	Description
number	An expression of a numeric type

*Result type:* BIGINT or DOUBLE PRECISION

*Description:* Returns the smallest whole number greater than or equal to the argument.

*See also:* [FLOOR\(\)](#)

## COS()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
COS ( angle )
```

**Table 8.12. COS Function Parameter**

Parameter	Description
angle	An angle in radians

*Result type:* DOUBLE PRECISION

*Description:* Returns an angle's cosine. The argument must be given in radians.

- Any non-NULL result is—obviously—in the range [-1, 1].

## COSH()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
COSH ( number )
```

**Table 8.13. COSH Function Parameter**

Parameter	Description
number	A number of a numeric type

*Result type:* DOUBLE PRECISION

*Description:* Returns the hyperbolic cosine of the argument.

- Any non-NULL result is in the range [1, INF].

## COT()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
COT (angle)
```

**Table 8.14. COT Function Parameter**

Parameter	Description
angle	An angle in radians

*Result type:* DOUBLE PRECISION

*Description:* Returns an angle's cotangent. The argument must be given in radians.

## EXP()

*Available in:* DSQL, PSQL

*Syntax:*

```
EXP (number)
```

**Table 8.15. EXP Function Parameter**

Parameter	Description
number	A number of a numeric type

*Result type:* DOUBLE PRECISION

*Description:* Returns the natural exponential,  $e^{number}$

*See also:* [LN\(\)](#)

## FLOOR()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
FLOOR (number)
```

**Table 8.16. FLOOR Function Parameter**

Parameter	Description
number	An expression of a numeric type



*Result type:* BIGINT or DOUBLE PRECISION

*Description:* Returns the largest whole number smaller than or equal to the argument.

*See also:* [CEIL\(\)](#) / [CEILING\(\)](#)

## LN()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
LN ( number )
```

**Table 8.17. LN Function Parameter**

Parameter	Description
number	An expression of a numeric type

*Description:* Returns the natural logarithm of the argument.

- An error is raised if the argument is negative or 0.

*Result type:* DOUBLE PRECISION

*See also:* [EXP\(\)](#)

## LOG()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
LOG ( x, y )
```

**Table 8.18. LOG Function Parameters**

Parameter	Description
x	Base. An expression of a numeric type
y	An expression of a numeric type

*Result type:* DOUBLE PRECISION

*Description:* 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,  $\pm\text{INF}$  or 0, depending on the exact values of the arguments.)
- If both arguments are 1, NaN is returned.
- If  $x = 1$  and  $y < 1$ ,  $-\text{INF}$  is returned.
- If  $x = 1$  and  $y > 1$ ,  $\text{INF}$  is returned.

## LOG10()

Available in: DSQL, PSQL

Changed in: 2.5

Possible name conflict: YES—>[Read details](#)

Syntax:

```
LOG10 (number)
```

**Table 8.19. LOG10 Function Parameter**

Parameter	Description
number	An expression of a numeric type

Result type: DOUBLE PRECISION

Description: 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  $-\text{INF}$ , respectively.)

## MOD()

Available in: DSQL, PSQL

Possible name conflict: YES—>[Read details](#)

Syntax:

```
MOD (a, b)
```

**Table 8.20. MOD Function Parameters**

Parameter	Description
a	An expression of a numeric type
b	An expression of a numeric type

*Result type:* INTEGER or BIGINT

*Description:* Returns the remainder of an integer division.

- Non-integer arguments are rounded before the division takes place. So, “7.5 mod 2.5” gives 2 (8 mod 3), not 0.

## PI()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
PI ( )
```

*Result type:* DOUBLE PRECISION

*Description:* Returns an approximation of the value of `pi`.

## POWER()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
POWER (x, y)
```

**Table 8.21. POWER Function Parameters**

Parameter	Description
x	An expression of a numeric type
y	An expression of a numeric type

*Result type:* DOUBLE PRECISION

*Description:* Returns `x` to the power of `y`.

- If `x` negative, an error is raised.

## RAND()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
RAND ( )
```

*Result type:* DOUBLE PRECISION

*Description:* Returns a random number between 0 and 1.

## ROUND()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
ROUND (<number> [ , <scale>])
```

**Table 8.22. ROUND Function Parameters**

Parameter	Description
number	An expression of a numeric type
scale	<p>An integer specifying the number of decimal places toward which rounding is to be performed, e.g.:</p> <ul style="list-style-type: none"> <li>2 for rounding to the nearest multiple of 0.01</li> <li>1 for rounding to the nearest multiple of 0.1</li> <li>0 for rounding to the nearest whole number</li> <li>-1 for rounding to the nearest multiple of 10</li> <li>-2 for rounding to the nearest multiple of 100</li> </ul>

*Result type:* INTEGER, (scaled) BIGINT or DOUBLE PRECISION

*Description:* 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.

### Important

- 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.

*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
```

## SIGN()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
SIGN ( number )
```

**Table 8.23. SIGN Function Parameter**

Parameter	Description
number	An expression of a numeric type

*Result type:* SMALLINT

*Description:* Returns the sign of the argument: -1, 0 or 1.

## SIN()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
SIN ( angle )
```

**Table 8.24. SIN Function Parameter**

Parameter	Description
angle	An angle, in radians

*Result type:* DOUBLE PRECISION

*Description:* Returns an angle's sine. The argument must be given in radians.

- Any non-NULL result is—obviously—in the range [-1, 1].

## SINH()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
SINH (number)
```

**Table 8.25. SINH Function Parameter**

Parameter	Description
number	An expression of a numeric type

*Result type:* DOUBLE PRECISION

*Description:* Returns the hyperbolic sine of the argument.

## SQRT()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
SQRT (number)
```

**Table 8.26. SQRT Function Parameter**

Parameter	Description
number	An expression of a numeric type

*Result type:* DOUBLE PRECISION

*Description:* Returns the square root of the argument.

## TAN()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
TAN (angle)
```

**Table 8.27. TAN Function Parameter**

Parameter	Description
angle	An angle, in radians

*Result type:* DOUBLE PRECISION

*Description:* Returns an angle's tangent. The argument must be given in radians.

## TANH()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
TANH ( number )
```

**Table 8.28. TANH Function Parameters**

Parameter	Description
number	An expression of a numeric type

*Result type:* DOUBLE PRECISION

*Description:* 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>).

## TRUNC()

*Available in:* DSQL, PSQL

*Syntax:*

```
TRUNC (<number> [ , <scale> ] )
```

**Table 8.29. TRUNC Function Parameters**

Parameter	Description
number	An expression of a numeric type
	An integer specifying the number of decimal places toward which truncating is to be performed, e.g.:  2 for truncating to the nearest multiple of 0.01 1 for truncating to the nearest multiple of 0.1 0 for truncating to the nearest whole number -1 for truncating to the nearest multiple of 10

Parameter	Description
	-2 for truncating to the nearest multiple of 100

*Result type:* INTEGER, (scaled) BIGINT or DOUBLE PRECISION

*Description:* 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 integers.

*Notes:*

- If the *scale* argument is present, the result usually has the same scale as the first argument, e.g.
  - TRUNC(789.2225, 2) returns 789.2200 (not 789.22)
  - TRUNC(345.4, -2) returns 300.0 (not 300)
  - TRUNC(-163.41, 0) returns -163.00 (not -163)

Otherwise, the result scale is 0:

- TRUNC(-163.41) returns -163

#### Important

If you are used to the behaviour of the [external function TRUNCATE](#), please notice that the *internal* function TRUNC always truncates toward zero, i.e. upward for negative numbers.

## Functions for Working with Strings

### ASCII\_CHAR()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
ASCII_CHAR (<code>)
```

**Table 8.30. ASCII\_CHAR Function Parameter**

Parameter	Description
code	An integer within the range from 0 to 255

*Result type:* [VAR]CHAR(1) CHARACTER SET NONE

*Description:* Returns the ASCII character corresponding to the number passed in the argument.



**Important**

- 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.

## ASCII\_VAL()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
ASCII_VAL (ch)
```

**Table 8.31. ASCII\_VAL Function Parameter**

Parameter	Description
ch	A string of the [VAR]CHAR data type or a text BLOB with the maximum size of 32,767 bytes

*Result type:* SMALLINT

*Description:* 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 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.)

## BIT\_LENGTH()

*Available in:* DSQL, PSQL

*Syntax:*

```
BIT_LENGTH (string)
```

**Table 8.32. BIT\_LENGTH Function Parameter**

Parameter	Description
string	An expression of a string type

*Result type:* INTEGER

*Description:* 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.

**Note**

With arguments of type CHAR, this function takes the entire formal string length (e.g. 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.

*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\(\)](#), [CHARACTER\\_LENGTH\(\)](#)

## CHAR\_LENGTH(), CHARACTER\_LENGTH()

*Available in:* DSQL, PSQL

*Syntax:*

```
CHAR_LENGTH (str)
CHARACTER_LENGTH (string)
```

**Table 8.33. CHAR[ACTER]\_LENGTH Function Parameter**

Parameter	Description
string	An expression of a string type

*Result type:* INTEGER

*Description:* Gives the length in characters of the input string.

**Notes**

- With arguments of type CHAR, this function returns the formal string length (i.e. the declared length of a field or variable). If you want to obtain the “logical” length, not counting the trailing spaces, right-[TRIM](#) the argument before passing it to CHAR[ACTER]\_LENGTH.
- **>BLOB support:** Since Firebird 2.1, this function fully supports text BLOBs of any length and character set.

*Examples:*

```
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\(\)](#)

## HASH()

Available in: DSQL, PSQL

*Syntax:*

```
HASH (string)
```

**Table 8.34. HASH Function Parameter**

Parameter	Description
string	An expression of a string type

*Description:* Returns a hash value for the input string. This function fully supports text BLOBs of any length and character set.

*Result type:* BIGINT

## LEFT()

Available in: DSQL, PSQL

*Syntax:*

```
LEFT (string, length)
```

**Table 8.35. LEFT Function Parameters**

Parameter	Description
string	An expression of a string type
number	Integer. Defines the number of characters to return

*Result type:* VARCHAR or BLOB

*Description:* 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\(\)](#)

## LOWER()

*Available in:* DSQL, ESQL, PSQL

*Possible name conflict:* YES—>[Read details below](#)

*Syntax:*

```
LOWER (string)
```

**Table 8.36. LOWER Function Parameters**

Parameter	Description
string	An expression of a string type

*Result type:* (VAR)CHAR or BLOB

*Description:* 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 OCTETS, 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"(*str*).

*Example:*

```
select Sheriff from Towns
where lower(Name) = 'cooper''s valley'
```

*See also:* [UPPER](#)

**LPAD()**

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
LPAD (str, endlen [, padstr])
```

**Table 8.37. LPAD Function Parameters**

Parameter	Description
<i>str</i>	An expression of a string type
<i>endlen</i>	Output string length
<i>padstr</i>	The character or string to be used to pad the source string up to the specified length. Default is space (' ')

*Result type:* VARCHAR or BLOB

*Description:* 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.

**Note**

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.

**Warning**

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.

*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 'abcdefghHello'
lpad ('Hello', 2)          -- returns 'He'
lpad ('Hello', 2, '-')     -- returns 'He'
lpad ('Hello', 2, '')      -- returns 'He'
```

*See also:* [RPAD\(\)](#)

**OCTET\_LENGTH()**

*Available in:* DSQL, PSQL

*Syntax:*

```
OCTET_LENGTH (string)
```

**Table 8.38. OCTET\_LENGTH Function Parameter**

Parameter	Description
string	An expression of a string type

*Result type:* INTEGER

*Description:* 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 “logical” number of bytes per character as found in RDB \$CHARACTER\_SETS.

**Note**

With arguments of type CHAR, this function takes the entire formal string length (e.g. 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.

*Examples:*

```
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\(\)](#), [CHARACTER\\_LENGTH\(\)](#)

## OVERLAY()

Available in: DSQL, PSQL

Syntax:

```
OVERLAY (string PLACING replacement FROM pos [FOR length])
```

**Table 8.39. OVERLAY Function Parameters**

Parameter	Description
<i>string</i>	The string into which the replacement takes place
<i>replacement</i>	Replacement string
<i>pos</i>	The position from which replacement takes place (starting position)
<i>length</i>	The number of characters that are to be overwritten

*Result type:* VARCHAR or BLOB

*Description:* 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.

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) -- r. 'GHellooodbye'
overlay ('Goodbye' placing 'Hello' from 2 for 3) -- r. 'GHellobye'
overlay ('Goodbye' placing 'Hello' from 2 for 6) -- r. 'GHello'
overlay ('Goodbye' placing 'Hello' from 2 for 9) -- r. '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'
```

#### Warning

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.

See also: [REPLACE\(\)](#)

## POSITION()

Available in: DSQL, PSQL

Syntax:

```
POSITION (substr IN string)
| POSITION (substr, string [, startpos])
```

**Table 8.40. POSITION Function Parameters**

Parameter	Description
substr	The substring whose position is to be searched for
string	The string which is to be searched
startpos	The position in <i>string</i> where the search is to start



*Result type:* INTEGER

*Description:* 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.

*Notes:*

- 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 *substr* is "" (empty string) and *string* is not NULL, the result is:
  - 1 if *startpos* is not given;
  - *startpos* if *startpos* lies within *string*;
  - 0 if *startpos* lies beyond the end of *string*.

**Notice:** A bug in Firebird 2.1—2.1.3 and 2.5 causes POSITION to *always* return 1 if *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.

*Examples:*

```
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
```

### Warning

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.

*See also:* [SUBSTRING](#)

## REPLACE()

*Available in:* DSQL, PSQL

*Syntax:*

```
REPLACE (str, find, repl)
```

**Table 8.41. REPLACE Function Parameters**

Parameter	Description
str	The string in which the replacement is to take place
find	The string to search for

Parameter	Description
repl	The replacement string

*Result type:* VARCHAR or BLOB

*Description:* 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.

*Examples:*

```
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', 'xyz', 'abc')     -- returns 'Billy Wilder'
replace ('Billy Wilder', '', 'abc')        -- returns 'Billy Wilder'
```

#### Warning

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.

See also: [OVERLAY\(\)](#), [SUBSTRING\(\)](#), [POSITION\(\)](#), [CHAR\[ACTER\]\\_LENGTH\(\)](#)

## REVERSE()

*Available in:* DSQL, PSQL

*Syntax:*

```
REVERSE (str)
```

**Table 8.42. REVERSE Function Parameter**

Parameter	Description
string	An expression of a string type

*Result type:* VARCHAR

*Description:* Returns a string backwards.

*Examples:*

```
reverse ('spoonful')           -- returns 'lufnoops'
reverse ('Was it a cat I saw?') -- returns '?was I tac a ti saW'
```

#### Tip

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:

```
create index ix_people_email on people
  computed by (reverse(email));

select * from people
  where reverse(email) starting with reverse('.br');
```

## RIGHT()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
RIGHT (string, length)
```

**Table 8.43. RIGHT Function Parameters**

Parameter	Description
string	An expression of a string type
length	Integer. Defines the number of characters to return

*Result type:* VARCHAR or BLOB

*Description:* 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 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 *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.

**Warning**

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.

See also: [LEFT\(\)](#), [SUBSTRING\(\)](#)

**RPAD()**

Available in: DSQL, PSQL

Changed in: 2.5 (backported to 2.1.4)

Possible name conflict: YES—>[Read details](#)

Syntax:

```
RPAD (str, endlen [, padstr])
```

**Table 8.44. RPAD Function Parameters**

Parameter	Description
str	An expression of a string type
endlen	Output string length
endlen	The character or string to be used to pad the source string up to the specified length. Default is space (' ')

Result type: VARCHAR or BLOB

Description: 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 *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.

**Note**

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.

Examples:

```

rpad ('Hello', 12)           -- returns 'Hello      '
rpad ('Hello', 12, '-')     -- returns 'Hello-----'
rpad ('Hello', 12, ' ')     -- returns 'Hello'

```

```

rpad ('Hello', 12, 'abc')      -- returns 'Helloabcbca'
rpad ('Hello', 12, 'abcdefghij') -- returns 'Helloabcdefgh'
rpad ('Hello', 2)             -- returns 'He'
rpad ('Hello', 2, '-')        -- returns 'He'
rpad ('Hello', 2, '')         -- returns 'He'

```

**Warning**

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.

See also: [LPAD\(\)](#)

**SUBSTRING()**

Available in: DSQL, PSQL

Changed in: 2.5.1

Syntax:

```
SUBSTRING (str FROM startpos [FOR length])
```

**Table 8.45. SUBSTRING Function Parameters**

Parameter	Description
str	An expression of a string type
startpos	Integer expression, the position from which to start retrieving the substring
length	The number of characters to retrieve after the <startpos>

*Result types:* VARCHAR(*n*) or BLOB

*Description:* Returns a string's substring starting at the given position, either to the end of the string or with a given length.

This function returns the substring starting at character position *startpos* (the first position 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.

In Firebird 1.x, *startpos* and *length* must be integer literals. In 2.0 and above they can be any valid integer expression.

Starting with Firebird 2.1, this function fully supports binary and text BLOBs of any length and character set. If *str* is a BLOB, the result is also a BLOB. For any other argument type, the result is a VARCHAR(*n*). Previously, the result type used to be CHAR(*n*) if the argument was a CHAR(*n*) or a string literal.

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'.

If any argument is NULL, the result is NULL.

**Bugs**

- If *str* is a BLOB and the *length* argument is not present, the output is limited to 32767 characters. Workaround: with long BLOBs, always specify `char_length(str)`—or a sufficiently high integer—as the third argument, unless you are sure that the requested substring fits within 32767 characters.

This bug has been fixed in version 2.5.1; the fix was also backported to 2.1.5.

- An older bug in Firebird 2.0, which caused the function to return “false emptystrings” if *startpos* or *length* was NULL, was fixed.

*Example:*

```
insert into AbbrNames(AbbrName)
select substring(LongName from 1 for 3) from LongNames
```

**Warning**

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.

*See also:* [POSITION](#), [LEFT](#), [RIGHT](#), [CHAR\[ACTER\]\\_LENGTH](#)

**TRIM()**

*Available in:* DSQL, PSQL

*Syntax:*

```
TRIM ([<adjust>] str)

<adjust> ::=  { [<where>] [what] } FROM

<where> ::=  BOTH | LEADING | TRAILING
```

**Table 8.46. TRIM Function Parameters**

Parameter	Description
<code>str</code>	An expression of a string type
<code>where</code>	The position the substring is to be removed from—BOTH   LEADING   TRAILING. BOTH is the default
<code>what</code>	The substring that should be removed (multiple times if there are several matches) from the beginning   the end   both sides of the input string <code>&lt;str&gt;</code> . By default it is space ( ' ')

*Result type:* VARCHAR(*n*) or BLOB

*Description:* 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.

*Examples:*

```
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'
```

*Notes:*

- If *str* is a BLOB, the result is a BLOB. Otherwise, it is a VARCHAR(*n*) with *n* the formal length of *str*.
- The substring to be removed, if specified, may not be bigger than 32767 bytes. However, if this substring is *repeated* at *str*'s head or tail, the total number of bytes removed may be far greater. (The restriction on the size of the substring will be lifted in Firebird 3.)

**Warning**

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.

## UPPER()

Available in: DSQL, ESQL, PSQL

*Syntax:*

```
UPPER (str)
```

**Table 8.47. UPPER Function Parameter**

Parameter	Description
<i>str</i>	An expression of a string type

*Result type:* (VAR)CHAR or BLOB

*Description:* 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 OCTETS, the entire string is returned unchanged. Since Firebird 2.1 this function also fully supports text BLOBs of any length and character set.

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](#)

## Date and Time Functions

### DATEADD()

Available in: DSQL, PSQL

Changed in: 2.5

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 8.48. DATEADD Function Parameters**

Parameter	Description
amount	An integer expression of the SMALLINT, INTEGER or BIGINT type. A negative value is subtracted
unit	Date/time unit
datetime	An expression of the DATE, TIME or TIMESTAMP type

*Result type:* DATE, TIME or TIMESTAMP

*Description:* Adds the specified number of years, months, weeks, days, hours, minutes, seconds or milliseconds to a date/time value. (The WEEK unit is new in 2.5.)

- The result type is determined by the third argument.
- 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.

*Examples:*

```
dateadd (28 day to current_date)
dateadd (-6 hour to current_time)
dateadd (month, 9, DateOfConception)
dateadd (-38 week to DateOfBirth)
dateadd (minute, 90, time 'now')
dateadd (? year to date '11-Sep-1973')
```

*See also:* [DATEDIFF](#), [Operations Using Date and Time Values](#)

## DATEDIFF()

*Available in:* DSQL, PSQL

*Changed in:* 2.5

*Syntax:*

```
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 8.49. DATEDIFF Function Parameters**

Parameter	Description
unit	Date/time unit
moment1	An expression of the DATE, TIME or TIMESTAMP type
moment2	An expression of the DATE, TIME or TIMESTAMP type

*Result type:* BIGINT

*Description:* 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*.

*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](#)

## EXTRACT()

Available in: DSQL, ESQL, PSQL

*Syntax:*

```
EXTRACT (<part> FROM <datetime>)
```

<b>&lt;part&gt;</b>	<b>::=</b>	YEAR   MONTH   WEEK
		DAY   WEEKDAY   YEARDAY
		HOUR   MINUTE   SECOND   MILLISECOND
<b>&lt;datetime&gt;</b>	<b>::=</b>	a DATE, TIME or TIMESTAMP expression

**Table 8.50. EXTRACT Function Parameters**

Parameter	Description
part	Date/time unit
datetime	An expression of the DATE, TIME or TIMESTAMP type

*Result type:* SMALLINT or NUMERIC

*Description:* Extracts and returns an element from a DATE, TIME or TIMESTAMP expression. This function was already added in InterBase 6, but not documented in the *Language Reference* at the time.

### *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 8.51. Types and ranges of EXTRACT results**

Part	Type	Range	Comment
YEAR	SMALLINT	1—9999	
MONTH	SMALLINT	1—12	
WEEK	SMALLINT	1—53	
DAY	SMALLINT	1—31	
WEEKDAY	SMALLINT	0—6	0 = Sunday
YEARDAY	SMALLINT	0—365	0 = January 1
HOURL	SMALLINT	0—23	
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

### MILLISECOND

*Description:* Firebird 2.1 and up support extraction of the millisecond from a TIME or TIMESTAMP. The datatype returned is NUMERIC(9,1).

#### Note

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

*Description:* 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.

#### Caution

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](#)

## Type Casting Functions

### CAST()

Available in: DSQL, ESQL, PSQL

Changed in: 2.5

Syntax:

```
CAST (expression AS <target_type>)

<target_type> ::= sql_datatype
                | [TYPE OF] domain
                | TYPE OF COLUMN relname.colname
```

**Table 8.52. CAST Function Parameters**

Parameter	Description
value	SQL expression
datatype	SQL data type
domain	
colname	Table or view column name
precision	Precision. From 1 to 18
scale	Scale. From 0 to 18—it must be less than or equal to precision
size	The maximum size of a string in characters
charset	Character set
subtype_num	BLOB subtype number
subtype_name	BLOB subtype mnemonic name
seglen	Segment size—it cannot be greater than 65,535

*Result type:* User-chosen.

*Description:* CAST converts an expression to the desired datatype or domain. If the conversion is not possible, an error is raised.

### “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.

#### Note

The short syntax is evaluated immediately at parse time, causing the value to stay the same until the statement is unprepared. For datetime literals like '12-Oct-2012' this makes no difference. For the pseudo-variables 'NOW', 'YESTERDAY', 'TODAY' and 'TOMORROW', this may not be what you want. If you need the value to be evaluated at every call, use the full CAST() syntax.

#### 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'
```

But 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 date 'today' - 7 from rdb$database
```

The following table shows the type conversions possible with CAST.

**Table 8.53. Possible Type-castings with CAST**

From	To
Numeric types	Numeric types [VAR]CHAR BLOB
[VAR]CHAR BLOB	[VAR]CHAR BLOB Numeric types DATE TIME TIMESTAMP
DATE TIME	[VAR]CHAR BLOB TIMESTAMP
TIMESTAMP	[VAR]CHAR BLOB DATE

From	To
	TIME

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 input fields:* Since Firebird 2.0, you can cast statement parameters to a datatype:

```
cast (? as integer)
```

This gives you control over the type of input field 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:

```
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:

```
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:

```
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 ('deze');

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
```

### Warning

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

- For text types, character set and collation are preserved by the cast—just as when casting to a domain. However, due to a bug, the collation is not always taken into consideration when comparisons (e.g. equality tests) are made. In cases where the collation is of importance, test your code thoroughly before deploying! This bug is fixed for Firebird 3.
- 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.

*Casting BLOBs:* Successful casting to and from BLOBs is possible since Firebird 2.1.

## Functions for Bitwise Operations

### BIN\_AND()

Available in: DSQL, PSQL

Possible name conflict: YES—>[Read details](#)

Syntax:

```
BIN_AND (number, number [, number ...])
```

**Table 8.54. BIN\_AND Function Parameters**

Parameter	Description
number	Any integer number (literal, smallint/integer/bigint, numeric/decimal with scale 0)

*Result type:* SMALLINT, INTEGER or BIGINT

### Note

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.

*Description:* Returns the result of the bitwise AND operation on the argument(s).

*See also:* [BIN\\_OR](#), [BIN\\_XOR](#)

## **BIN\_NOT()**

*Available in:* DSQL, PSQL

*Possible name conflict:* NO

*Syntax:*

```
BIN_NOT (number)
```

**Table 8.55. BIN\_NOT Function Parameter**

Parameter	Description
number	Any integer number (literal, smallint/integer/bigint, numeric/decimal with scale 0)

*Result type:* SMALLINT, INTEGER or BIGINT

### **Note**

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.

*Description:* Returns the result of the bitwise NOT operation on the argument, i.e., *ones complement*.

*See also:* [BIN\\_OR](#), [BIN\\_XOR](#) and others in this set.

## **BIN\_OR()**

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
BIN_OR (number, number [, number ...])
```

**Table 8.56. BIN\_OR Function Parameters**

Parameter	Description
number	Any integer number (literal, smallint/integer/bigint, numeric/decimal with scale 0)



*Result type:* SMALLINT, INTEGER or BIGINT

**Note**

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.

*Description:* Returns the result of the bitwise OR operation on the argument(s).

*See also:* [BIN\\_AND](#), [BIN\\_XOR](#)

## **BIN\_SHL()**

*Available in:* DSQL, PSQL

*Syntax:*

```
BIN_SHL (number, shift)
```

**Table 8.57. BIN\_SHL Function Parameters**

Parameter	Description
number	A number of an integer type
shift	The number of bits the number value is shifted by

*Result type:* BIGINT

*Description:* 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](#)

## **BIN\_SHR()**

*Available in:* DSQL, PSQL

*Syntax:*

```
BIN_SHR (number, shift)
```

**Table 8.58. BIN\_SHR Function Parameters**

Parameter	Description
number	A number of an integer type
shift	The number of bits the number value is shifted by

*Description:* 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.

*Result type:* BIGINT

*See also:* [BIN\\_SHL](#)

## BIN\_XOR()

*Available in:* DSQL, PSQL

*Possible name conflict:* YES—>[Read details](#)

*Syntax:*

```
BIN_XOR (number, number [ , number ... ])
```

**Table 8.59. BIN\_XOR Function Parameters**

Parameter	Description
number	Any integer number (literal, smallint/integer/bigint, numeric/decimal with scale 0)

*Description:* Returns the result of the bitwise XOR operation on the argument(s).

*Result type:* SMALLINT, INTEGER or BIGINT

### Note

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.

*See also:* [BIN\\_AND](#), [BIN\\_OR](#)

## Functions for Working with UUID

### CHAR\_TO\_UUID()

*Available in:* DSQL, PSQL

*Added in:* 2.5

*Syntax:*

```
CHAR_TO_UUID (ascii_uuid)
```

**Table 8.60. CHAR\_TO\_UUID Function Parameter**

Parameter	Description
ascii_uuid	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'

*Result type:* CHAR(16) CHARACTER SET OCTETS

*Description:* Converts a human-readable 36-char UUID string to the corresponding 16-byte 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\(\)](#)

## GEN\_UUID()

*Available in:* DSQL, PSQL

*Syntax:*

```
GEN_UUID ( )
```

*Result type:* CHAR(16) CHARACTER SET OCTETS

*Description:* Returns a universally unique ID as a 16-byte character string.

*Example:*

```
select gen_uuid() from rdb$database
-- returns e.g. 017347BFE212B2479C00FA4323B36320 (16-byte string)
```

*See also:* [UUID\\_TO\\_CHAR\(\)](#), [CHAR\\_TO\\_UUID\(\)](#)

## UUID\_TO\_CHAR()

*Available in:* DSQL, PSQL

*Added in:* 2.5

*Syntax:*

```
UUID_TO_CHAR (uuid)
```

```
uuid ::= a string consisting of 16 single-byte characters
```

**Table 8.61. UUID\_TO\_CHAR Function Parameters**

Parameter	Description
uuid	16-byte UUID

*Result type:* CHAR(36)

*Description:* Converts a 16-byte UUID to its 36-character, human-readable ASCII representation.

*Examples:*

```
select uuid_to_char(x'876C45F4569B320DBC4735AC3509E5F') 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-BB5711529B86'

select uuid_to_char('Firebird swings!') from rdb$database
-- returns '46697265-6269-7264-2073-77696E677321'
```

See also: [CHAR\\_TO\\_UUID\(\)](#), [GEN\\_UUID\(\)](#)

## Functions for Working with Generators (Sequences)

### GEN\_ID()

*Available in:* DSQL, ESQL, PSQL

*Description:* Increments a generator or sequence and returns its new value. From Firebird 2.0 onward, the SQL-compliant NEXT VALUE FOR syntax is preferred, except when an increment other than 1 is needed.

*Result type:* BIGINT

*Syntax:*

```
GEN_ID (generator-name, <step>)
```

**Table 8.62. GEN\_ID Function Parameters**

Parameter	Description
generator-name	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.

Parameter	Description
step	An integer expression

*Result type:* BIGINT

*Description:* 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.

*Example:*

```
new.rec_id = gen_id(gen_recnum, 1);
```

#### Warning

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.

See also: [NEXT VALUE FOR](#), [CREATE SEQUENCE \(GENERATOR\)](#)

## Conditional Functions

### COALESCE()

*Available in:* DSQL, PSQL

*Syntax:*

```
COALESCE (<exp1>, <exp2> [ , <expN> ... ])
```

**Table 8.63. COALESCE Function Parameters**

Parameter	Description
exp1, exp2 ... expN	A list of expressions of any compatible types

*Description:* 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.

*Result type:* Depends on input.

*Example:* 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.

```
select
  coalesce (Nickname, FirstName, 'Mr./Mrs.') || ' ' || LastName
as FullName
from Persons
```

See also: [IIF](#), [NULLIF](#), [CASE](#)

## DECODE()

Available in: DSQL, PSQL

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 8.64. DECODE Function Parameters**

Parameter	Description
testexpr	An expression of any compatible type that is compared to the expressions expr1, expr2 ... exprN
expr1, expr2, ... exprN	Expressions of any compatible types, to which the <testexpr> expression is compared
result1, result2, ... resultN	Returned values of any type
defaultresult	The expression to be returned if none of the conditions is met

*Result type:* Varies

*Description:* DECODE is a shortcut 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.

**Caution**

Matching is done with the “=” operator, so if `<testexpr>` is NULL, it won't match any of the `<expr>`s, not even those that are NULL.

*Example:*

```
select name,
       age,
       decode( upper(sex),
              'M', 'Male',
              'F', 'Female',
              'Unknown' ),
       religion
from people
```

*See also:* [CASE](#), [Simple CASE](#)

**IIF()**

*Available in:* DSQL, PSQL

*Syntax:*

```
IIF (<condition>, ResultT, ResultF)
```

**Table 8.65. IIF Function Parameters**

Parameter	Description
condition	A true false expression
resultT	The value returned if the condition is true
resultF	The value returned if the condition is false

*Result type:* Depends on input.

*Description:* 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.

*Example:*

```
select iif( sex = 'M', 'Sir', 'Madam' ) from Customers
```

**Note**

IIF(*Cond*, *Result1*, *Result2*) is a shortcut for “CASE WHEN *Cond* THEN *Result1* ELSE *Result2* END”.

See also: [CASE](#), [DECODE](#)

## MAXVALUE()

Available in: DSQL, PSQL

Syntax:

```
MAXVALUE (expr1 [ , ... ,exprN ])
```

**Table 8.66. MAXVALUE Function Parameters**

Parameter	Description
expr1 ... exprN	List of expressions of compatible types

*Result type:* Varies according to input—result will be of the same data type as the first expression in the list (<expr1>).

*Description:* 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.

*Example:*

```
SELECT MAXVALUE(PRICE_1, PRICE_2) AS PRICE
FROM PRICELIST
```

See also: [MINVALUE\(\)](#)

## MINVALUE()

Available in: DSQL, PSQL

Syntax:

```
MINVALUE (expr1 [ , ... , exprN ])
```

**Table 8.67. MINVALUE Function Parameters**

Parameter	Description
expr1 ... exprN	List of expressions of compatible types

*Result type:* Varies according to input—result will be of the same data type as the first expression in the list (<expr1>).



*Description:* 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.

*Example:*

```
SELECT MINVALUE(PRICE_1, PRICE_2) AS PRICE
FROM PRICELIST
```

*See also:* [MAXVALUE\(\)](#)

## NULLIF()

*Available in:* DSQL, PSQL

*Syntax:*

```
NULLIF (<exp1>, <exp2>)
```

**Table 8.68. NULLIF Function Parameters**

Parameter	Description
exp1	An expression
exp2	Another expression of a data type compatible with <exp1>

*Description:* NULLIF returns the value of the first argument, unless it is equal to the second. In that case, NULL is returned.

*Result type:* Depends on input.

*Example:*

```
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](#)

## 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.

## AVG()

Available in: DSQL, ESQL, PSQL

Syntax:

```
AVG ([ALL | DISTINCT] <expr>)
```

**Table 8.69. AVG Function Parameters**

Parameter	Description
expr	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

*Description:* 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.

*Result type:* A numeric data type, the same as the data type of the argument.

Syntax:

```
AVG (expression)
```

- If the group is empty or contains only NULLs, the result is NULL.

*Example:*

```
SELECT
  dept_no,
  AVG(salary)
FROM employee
GROUP BY dept_no
```

See also: [SELECT](#)

## COUNT()

Available in: DSQL, ESQL, PSQL

*Syntax:*

```
COUNT ([ALL | DISTINCT] <expr> | *)
```

**Table 8.70. COUNT Function Parameters**

Parameter	Description
expr	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

*Result type:* Integer

*Description:* 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.

*Example:*

```
SELECT
  dept_no,
  COUNT(*) AS cnt,
  COUNT(DISTINCT name) AS cnt_name
FROM employee
GROUP BY dept_no
```

*See also:* [SELECT](#).

## LIST()

*Available in:* DSQL, PSQL

*Changed in:* 2.5

*Syntax:*

```
LIST ([ALL | DISTINCT] expression [, separator])
```

**Table 8.71. LIST Function Parameters**

Parameter	Description
expr	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
separator	Optional alternative separator, a string expression. Comma is the default separator

*Result type:* BLOB

*Description:* 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 *expression* 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 *expression* 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 *expression* 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.

*Examples:*

1. Retrieving the list, order undefined:

```
SELECT LIST (display_name, ' ; ') FROM GR_WORK;
```

2. Retrieving the list in alphabetical order, using a derived table:

```
SELECT LIST (display_name, ' ; ')
FROM (SELECT display_name
      FROM GR_WORK
      ORDER BY display_name);
```

See also: [SELECT](#)

## MAX()

Available in: DSQL, ESQL, PSQL

Syntax:

```
MAX ([ALL | DISTINCT] <expr>)
```

**Table 8.72. MAX Function Parameters**

Parameter	Description
expr	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.

*Result type:* Returns a result of the same data type the input expression.

*Description:* 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.

### Note

The DISTINCT parameter makes no sense if used with MAX() and is implemented only for compliance with the standard.

*Example:*

```
SELECT
  dept_no,
  MAX(salary)
FROM employee
GROUP BY dept_no
```

See also: [MIN](#), [SELECT](#)

## MIN()

Available in: DSQL, ESQL, PSQL

Syntax:

```
MIN ([ALL | DISTINCT] <expr>)
```

**Table 8.73. MIN Function Parameters**

Parameter	Description
expr	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.

*Result type:* Returns a result of the same data type the input expression.

*Description:* 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.

**Note**

The DISTINCT parameter makes no sense if used with MIN() and is implemented only for compliance with the standard.

*Example:*

```
SELECT
  dept_no,
  MIN(salary)
FROM employee
GROUP BY dept_no
```

See also: [MAX](#), [SELECT](#)

## SUM()

Available in: DSQL, ESQL, PSQL

*Syntax:*

```
SUM ([ALL | DISTINCT] <expr>)
```

**Table 8.74. SUM Function Parameters**

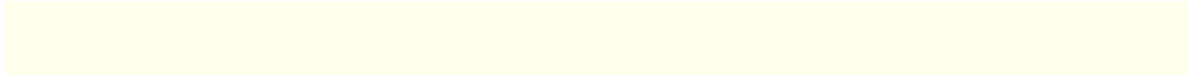
Parameter	Description
expr	Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

*Result type:* Returns a result of the same numeric data type as the input expression.

*Description:* 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.

*Example:* `SELECT dept_no, SUM (salary), FROM employee GROUP BY dept_no`



*See also:* [SELECT](#)

# Transaction Control

## REVIEW STATUS

All sections from this point forward to the end of the chapter are awaiting technical and editorial review.

Everything in Firebird happens in transactions. Units of work are isolated between a start point and an end point. Changes to data remain reversible until the moment the client application instructs the server to commit them.

## 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

## SET TRANSACTION

*Used for*: Configuring and starting a transaction

*Available*: DSQL, ESQL

*Syntax*:

```
SET TRANSACTION
  [NAME tr_name]
  [READ WRITE | READ ONLY]
  [[ISOLATION LEVEL] {
    SNAPSHOT [TABLE STABILITY]
    | READ COMMITTED [[NO] RECORD_VERSION] }]
  [WAIT | NO WAIT]
  [LOCK TIMEOUT seconds]
  [NO AUTO UNDO]
  [IGNORE LIMBO]
  [RESERVING <tables> | USING <dbhandles>]
```



```

<tables> ::= <table_spec> [, <table_spec> ...]

<table_spec> ::= tablename [, tablename ...]
               [FOR [SHARED | PROTECTED] {READ | WRITE}]

<dbhandles> ::= dbhandle [, dbhandle ...]

```

**Table 9.1. SET TRANSACTION Statement Parameters**

Parameter	Description
tr_name	Transaction name. Available only in ESQL
seconds	The time in seconds for the statement to wait in case a conflict occurs
tables	The list of tables to reserve
dbhandles	The list of databases the database can access. Available only in ESQL
table_spec	Table reservation specification
tablename	The name of the table to reserve
dbhandle	The handle of the database the database can access. Available only in ESQL

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 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  $2^{31}-1$ , or 2,147,483,647.

All clauses in the SET TRANSACTION statement are optional. If the statement starting a transaction has no clauses specified in it, it the transaction will be started with default values for access mode, lock resolution mode and isolation level, which are:

```

SET TRANSACTION
  READ WRITE
  WAIT
  ISOLATION LEVEL SNAPSHOT;

```

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.

## 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, TABLE STABILITY)
- a mechanism for reserving or releasing tables (the RESERVING clause)

### **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.

### **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, it does not apply to global temporary tables (GTT) that are allowed to be changed in READ ONLY transactions.

### **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.

### 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 process 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 this one 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.

#### Autonomous Transactions

Changes made by autonomous transactions are not seen in the context of the `SNAPSHOT` transaction that launched it.

### SNAPSHOT TABLE STABILITY Isolation Level

The `SNAPSHOT TABLE STABILITY` 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. 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 of data pending in any database table before a transaction with the `SNAPSHOT TABLE STABILITY` isolation level is started, trying to start a `SNAPSHOT TABLE STABILITY` transaction will result in an exception.

### 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.

## **RECORD\_VERSION**

One of two modifying parameters can be specified for READ COMMITTED transactions, depending on the kind of conflict resolution desired: RECORD\_VERSION and NO RECORD\_VERSION. As the names suggest, they are mutually exclusive.

- NO RECORD\_VERSION (the default value) 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.

## **NO AUTO UNDO**

The NO AUTO UNDO option affects the handling of unused record versions (garbage) in the event of rollback. With NO AUTO UNDO flagged, the ROLLBACK statement just marks the transaction as rolled back without deleting the unused 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.

## **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 Inter-Base times and 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 9.2. Compatibility of Access Options for RESERVING**

	SHARED READ	SHARED WRITE	PROTECT- ED READ	PROTECT- ED WRITE
SHARED READ	Yes	Yes	Yes	Yes
SHARED WRITE	Yes	Yes	No	No
PROTECT- ED READ	Yes	No	Yes	No
PROTECT- ED WRITE	Yes	No	No	No

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
- SHARED 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.

**Tip**

In Embedded SQL, the USING clause can be used to conserve system resources by limiting the databases the transaction can access to an enumerated list (of databases). USING is incompatible with RESERVING. A USING clause in SET TRANSACTION syntax is not supported in DSQL.

See also: [COMMIT](#), [ROLLBACK](#)

## COMMIT

*Used for:* Committing a transaction

*Available:* DSQL, ESQL

*Syntax:*

```
COMMIT [WORK] [TRANSACTION tr_name]
[RELEASE] [RETAIN [SNAPSHOT]];
```

**Table 9.3. COMMIT Statement Parameter**

Parameter	Description
tr_name	Transaction name. Available only in ESQL

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.

## 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.

**Note**

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”, 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 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 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](#)

## ROLLBACK

*Used for:* Rolling back a transaction

*Available:* DSQL, ESQL

*Syntax:*

```
ROLLBACK [WORK] [TRANSACTION tr_name]
[RETAIN [SNAPSHOT] | TO [SAVEPOINT] sp_name | RELEASE]
```

**Table 9.4. ROLLBACK Statement Parameters**

Parameter	Description
tr_name	Transaction name. Available only in ESQL

Parameter	Description
sp_name	Savepoint name. Available only in DSQL

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.

## 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, COMMIT is applied to the default transaction.

### Note

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 of the 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: [SET TRANSACTION](#), [COMMIT](#)

## ROLLBACK TO SAVEPOINT

The optional TO SAVEPOINT clause in the ROLLBACK 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 created 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](#)

## SAVEPOINT

*Used for:* Creating a savepoint

*Available:* DSQL

*Syntax:*

```
SAVEPOINT sp_name
```

**Table 9.5. SAVEPOINT Statement Parameter**

Parameter	Description
sp_name	Savepoint name. Available only in DSQL

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 deleted 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:*

```
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](#)

## RELEASE SAVEPOINT

*Used for:* Erasing a savepoint

*Available:* DSQL

*Syntax:*

```
RELEASE SAVEPOINT sp_name [ONLY]
```

**Table 9.6. RELEASE SAVEPOINT Statement Parameter**

Parameter	Description
sp_name	Savepoint name. Available only in DSQL

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](#)

## 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.

### Tip

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`.

## 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 for 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.

### Note

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.

# Security

Databases must be secure and so must the data stored in them. Firebird provides two levels of data security protection: user authentication at the server level and SQL privileges within databases. This chapter tells you how to manage security at both levels.

## User Authentication

The security of the entire database depends on identifying a user on verifying its authority, a procedure known as *authentication*. The information about users authorised to access a specific Firebird server is stored in a special security database named `security2.fdb`. Each record in `security2.fdb` is a user account for one user.

A user name, consisting of up to 31 characters, is a case-insensitive system identifier. A user must have a password, of which the first eight are significant. Whilst it is valid to enter a password longer than eight characters, any subsequent characters are ignored. Passwords are case-sensitive.

If the user specified during the connection is the SYSDBA, the database owner or a specially privileged user, that user will have unlimited access to the database.

## 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 `security2.fdb`. No user has access to the metadata of the security database.

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](#).

## POSIX Hosts

On POSIX systems, including MacOSX, Firebird will interpret a POSIX user account as though it were a Firebird user account in its own security database, provided the server sees the client machine as a trusted host and the system user accounts exist on both the client and the server. To establish a “trusted” relationship with the client

host, the corresponding entries must be included in one of the files `/etc/hosts.equiv` or `/etc/gds_hosts.equiv` on Firebird's host server.

- The file `hosts.equiv` contains trusted relationships at operating system level, encompassing all services (rlogin, rsh, rcp, and so on)
- The file `gds_hosts.equiv` contains trusted relationships between Firebird hosts only.

The format is identical for both files and looks like this:

```
hostname [username]
```

### **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 `security2.fdb`, commonly `/opt/firebird/`. The name of the password file is `SYSDBA.password`.

#### **Note**

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 POSIX host systems. Firebird interprets **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. Trusted Authentication must be enabled by setting the *Authentication* parameter to *Trusted* or *Mixed* in the configuration file, `firebird.conf`.

Even with trusted authentication enabled, Windows operating system Administrators are not automatically granted SYSDBA privileges when they connect 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*.

The embedded version of Firebird server on Windows does not use server-level authentication. However, because objects within a database are subject to SQL privileges, a valid user name and, if applicable, a role, may be required in the connection parameters.

### **The Database Owner**

The “owner” of a database is either the user who was `CURRENT_USER` at the time of creation or, if the parameters `USER` and `PASSWORD` were supplied in the `CREATE DATABASE` statement, the user cited there.

“Owner” is not a user name. The user who is the owner of a database has full [administrator rights](#) 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.

**Note**

Prior to Firebird 2.1, the owner had no automatic privileges over any database objects that were created by other users.

## RDB\$ADMIN Role

The internally-created role RDB\$ADMIN is present in every database. Assigning the RDB\$ADMIN role to a regular user in a database grants that user the privileges of the SYSDBA, in the current database only.

The elevated privileges take effect when the user is logged in to that regular database under the RDB\$ADMIN role and give full control over all objects in the 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, 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:

```
CREATE USER new_user
PASSWORD 'password'
GRANT ADMIN ROLE

ALTER USER existing_user
GRANT ADMIN ROLE

ALTER USER existing_user
REVOKE ADMIN ROLE
```

**Note**

GRANT ADMIN ROLE and REVOKE ADMIN ROLE are not statements in the GRANT and REVOKE lexicon. They are three-word parameters to the statements CREATE USER and ALTER USER.

**Table 10.1. Parameters for RDB\$ADMIN Role GRANT and REVOKE**

Parameter	Description
new_user	Using CREATE USER, name for the new user
existing_user	Using ALTER USER, Name of an existing user

Parameter	Description
password	Using CREATE USER, password for the new user. Its theoretical limit is 31 bytes but only the first 8 characters are considered.

The grantor must be already logged in as an [administrator](#).

See also: [CREATE USER](#), [ALTER USER](#)

### ***Doing the Same Task Using gsec***

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
```

#### **Note**

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. No user can connect to the security database, so the solution is that the user connects to a regular database where he also has RDB\$ADMIN rights, supplying the RDB\$ADMIN role in his login parameters. From there, he can submit any SQL user management command.

The SQL route for the user is blocked for any database in which he has not been granted the RDB\$ADMIN role.

### ***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
```

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 his RDB\$ADMIN privileges, the grantee simply includes the role in the connection attributes when connecting to the database.

## **AUTO ADMIN MAPPING**

In Firebird 2.1, Windows Administrators would automatically receive SYSDBA privileges if trusted authentication was configured for server connections. In Firebird 2.5, it is no longer automatic. The setting of the AUTO ADMIN MAPPING switch now determines whether Administrators have automatic SYSDBA 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 trusted authentication, and
- b. without specifying any role

After a successful “auto admin” connection, the current role is set to RDB\$ADMIN.

### *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](#)

In regular databases, the status of AUTO ADMIN MAPPING is checked only at connection time. If an Administrator has the RDB\$ADMIN role because auto-mapping was on when he logged in, he will keep that role for the duration of the session, even if he 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*

No SQL statements exist to switch automatic mapping on and off in the security database. Instead, *gsec* must be used:

```
gsec -mapping set
```



```
gsec -mapping drop
```

More *gsec* switches may be needed, depending on what kind of log-in you used to connect, e.g., *-user* and *-pass*, or *-trusted*.

Only SYSDBA can set the auto-mapping on if it is disabled. Any administrator can drop (disable) it.

## 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 10.2. Administrator (“Superuser”) Characteristics**

User	RDB\$ADMIN Role	Comments
SYSDBA	Auto	Exists automatically at server level. Has full privileges to all objects in all databases. Can create, alter and drop users but has no direct access to the security database
<i>root</i> user on POSIX	Auto	Exactly like SYSDBA
Superuser on POSIX	Auto	Exactly like SYSDBA
Windows Administrator	Set as <b>CURRENT_ROLE</b> if login succeeds	Exactly like SYSDBA if all of the following are true: <div> In firebird.conf file  <b>AUTO ADMIN MAPPING</b>  Login </div> <div> <i>Authentication</i> = mixed / trusted and Firebird is restarted before proceeding  Enabled in all databases in which the user needs Superuser privileges  Does not include a role </div>
Database owner	Auto	Like SYSDBA, but only in the database of which he is the owner
Regular user	Must be previously granted; must be supplied at login	Like SYSDBA, but only in the database[s] where the role is granted
POSIX OS user	Must be previously granted; must be supplied at login	Like SYSDBA, but only in the database[s] where the role is granted
Windows user	Must be previously granted; must be supplied at login	Like SYSDBA, but only in the database[s] where the role is granted. Not available if config file parameter <i>Authentication</i> = native

## SQL Statements for User Management

In Firebird 2.5 and above, user accounts are created, modified and deleted using a series of SQL statements that can be submitted by a user with full administrator rights in the security database.

### Note

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 only to edit some data in their own accounts.

## CREATE USER

*Used for:* Creating a Firebird user account

*Available in:* DSQL

*Syntax:*

```
CREATE USER username PASSWORD 'password'
[FIRSTNAME 'firstname']
[MIDDLENAME 'middlename']
[LASTNAME 'lastname']
[GRANT ADMIN ROLE];
```

**Table 10.3. CREATE USER Statement Parameters**

Parameter	Description
username	User name. The maximum length is 31 characters, following the rules for Firebird regular identifiers. It is always case-insensitive
password	User password. Its theoretical limit is 31 bytes but only the first 8 characters are considered. Case-sensitive
firstname	Optional: User's first name. Maximum length 31 characters
middlename	Optional: User's middle name. Maximum length 31 characters
lastname	Optional: User's last name. Maximum length 31 characters

Use a CREATE USER statement to create a new Firebird user account. The user must not already exist in the Firebird security database, or a primary key violation error message will be returned.

The `<username` argument must follow the rules for Firebird regular identifiers: see [Identifiers](#) in the *Structure* chapter. User names are always case-insensitive. Supplying a user name enclosed in double quotes will not cause

an exception: the quotes will be ignored. If a space is the only illegal character supplied, the user name will be truncated back to the first space character. Other illegal characters will cause an exception.

The PASSWORD clause specifies the user's password. A password of more than eight characters is accepted with a warning but any surplus characters will be ignored.

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(31) 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 (`security2.fdb`). It allows the new user to manage user accounts from any regular database he logs into, but it does not grant the user any special privileges on objects in those databases.

To create a user account, the current user must have [administrator privileges](#) in the security database. Administrator privileges only in regular databases are not sufficient.

#### Note

CREATE / ALTER / DROP USER are DDL statements. 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.

*Examples:*

1. Creating a user with the username `bigshot`:

```
CREATE USER bigshot PASSWORD 'buckshot';
```

2. Creating the user `john` with additional properties (first and last names):

```
CREATE USER john PASSWORD 'fYe_3Ksw'
FIRSTNAME 'John'
LASTNAME 'Doe';
```

3. Creating the user `superuser` with user management privileges:

```
CREATE USER superuser PASSWORD 'kMn8Kjh'
GRANT ADMIN ROLE;
```

See also: [ALTER USER](#), [DROP USER](#)

## ALTER USER

*Used for:* Modifying a Firebird user account

*Available in:* DSQL

*Syntax:*

```
ALTER USER username
{
  [SET]
  [PASSWORD 'password']
  [FIRSTNAME 'firstname']
  [MIDDLENAME 'middlename']
  [LASTNAME 'lastname']
}
[ {GRANT | REVOKE} ADMIN ROLE];
```

**Table 10.4. ALTER USER Statement Parameters**

Parameter	Description
username	User name. Cannot be changed.
password	User password. Its theoretical limit is 31 bytes but only the first 8 characters are considered. Case-sensitive
firstname	Optional: User's first name, or other optional text. Max. length is 31 characters
middlename	Optional: User's middle name, or other optional text. Max. length is 31 characters
lastname	Optional: User's last name, or other optional text. Max. length is 31 characters

Use an ALTER USER statement to edit the details in the named Firebird user account. To modify the account of another user, the current user must have [administrator privileges](#) in the security database. Administrator privileges only in regular databases are not sufficient.

Any user can alter his or her own account, except that only an administrator may use GRANT/REVOKE ADMIN ROLE.

All of the arguments are optional but at least one of them must be present:

- The PASSWORD parameter is for specifying a new password for the user
- FIRSTNAME, MIDDLENAME and LASTNAME allow updating of the optional user properties, such as the person's first name, middle name and last name respectively
- Including the clause GRANT ADMIN ROLE grants the user the privileges of the RDB\$ADMIN role in the security database (`security2.fdb`), enabling him/her to manage the accounts of other users. It does not grant the user any special privileges in regular databases.
- Including the clause 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 his or her own

**Note**

Remember to commit your work if you are working in an application that does not auto-commit DDL.

*Examples:*

1. Changing the password for the user bobby and granting him user management privileges:

```
ALTER USER bobby PASSWORD '67-UiT_G8'
GRANT ADMIN ROLE;
```

2. Editing the optional properties (the first and last names) of the user dan:

```
ALTER USER dan
FIRSTNAME 'No_Jack'
LASTNAME 'Kennedy';
```

3. Revoking user management privileges from user dumbbell:

```
ALTER USER dumbbell
DROP ADMIN ROLE;
```

See also: [CREATE USER](#), [DROP USER](#)

## DROP USER

*Used for:* Deleting a Firebird user account

*Available in:* DSQL

*Syntax:*

```
DROP USER username;
```

**Table 10.5. DROP USER Statement Parameter**

Parameter	Description
username	User name

Use the statement DROP USER to delete a Firebird user account. The current user requires [administrator privileges](#).

### Note

Remember to commit your work if you are working in an application that does not auto-commit DDL.

*Example:* Deleting the user bobby:

```
DROP USER bobby;
```

See also: [CREATE USER](#), [ALTER USER](#)

## 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 he 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 he needs 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 user (user, procedure, trigger, role) to which it is granted. Various means are available to grant multiple types of access on an object to multiple users in a single GRANT statement. Privileges may be withdrawn from a user with REVOKE statements.

Privileges are stored in the database to which they apply and are not applicable to any other database.

### The Object Owner

The user who creates 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.

#### Some Ownership Drawbacks

Any authenticated user can access any database and create any valid database object. Up to and including this release, the issue is not controlled.

Because not all database objects are associated with an owner—domains, external functions (UDFs), BLOB filters, generators (sequences) and exceptions—ownerless objects must be regarded as vulnerable on a server that is not adequately protected.

SYSDBA, 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 of the general form:

```
GRANT <privilege> ON <OBJECT-TYPE> <object-name>
  TO { <user-name> | ROLE <role-name> }
```

```
REVOKE <privilege> ON <OBJECT-TYPE> <object-name>
  FROM { <user-name> | ROLE <role-name> }
```

The <OBJECT-TYPE> is not required for every type of privilege. For some types of privilege, extra parameters are available, either as options or as requirements.

### Statements for Granting Privileges

A GRANT statement is used for granting privileges—including roles—to users and other database objects.

## GRANT

*Used for:* Granting privileges and assigning roles

*Available in:* DSQL, ESQL

*Syntax:*

```
GRANT {
    <privileges> ON [TABLE] {tablename | viewname}
    | EXECUTE ON PROCEDURE procname
}
TO <grantee_list>
    [WITH GRANT OPTION]} | [{GRANTED BY | AS} [USER] grantor];

GRANT <role_granted>
TO <role_grantee_list> [WITH ADMIN OPTION]
[{{GRANTED BY | AS} [USER] grantor]

<privileges> ::= ALL [PRIVILEGES] | <privilege_list>

<privilege_list> ::= {<privilege> [, <privilege> [, ... ] ] }

<privilege> ::=
    SELECT |
    DELETE |
    INSERT |
    UPDATE [(col [, col [, ...] ] ) ] |
    REFERENCES (col [, ...])

<grantee_list> ::= {<grantee> [, <grantee> [, ...] ]}

<grantee> ::=
    [USER] username | [ROLE] rolename | GROUP Unix_group
    | PROCEDURE procname | TRIGGER trigrname | VIEW viewname | PUBLIC

<role_granted> ::= rolename [, rolename ...]

<role_grantee_list> ::= [USER] <role_grantee> [, [USER] <role_grantee> [, ...]]

<role_grantee> ::= {username | PUBLIC }
```

**Table 10.6. GRANT Statement Parameters**

Parameter	Description
tablename	The name of the table the privilege applies to
viewname	The name of the view the privilege applies to
procname	The name of the stored procedure the EXECUTE privilege applies to; or the name of the procedure to be granted the privilege[s]

Parameter	Description
col	The table column the privilege is to apply to
Unix_group	The name of a user group in a POSIX operating system
username	The user name to which the privileges are granted to or to which the role is assigned
rolename	Role name
trigname	Trigger name
grantor	The user granting the privilege[s]

A GRANT statement grants one or more privileges on database objects to users, roles, stored procedures, triggers or views.

A regular, authenticated user has no privileges on any database object until they are explicitly granted, either to that individual user or to all users bundled as the user PUBLIC. When an object is created, only the user who has created it (the owner) and [administrators](#) have privileges for 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.

### ***The TO Clause***

The TO clause is used for listing the users, roles and database objects (procedures, triggers and views) that are to be granted the privileges enumerated in <privileges>. The clause is mandatory.

The optional USER and ROLE keywords 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 checks for a role with this name and, if there is none, the privileges are granted to the user without further checking.

### **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 that requires those privileges. A role can also be granted to a list of users.

The role must exist before privileges can be granted to it. See [CREATE ROLE](#) in the DDL chapter for the syntax and rules. The role is maintained by granting privileges to it and, when required, revoking privileges from it. If 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.

A user that is granted a role must supply that role with his login credentials in order to exercise the associated privileges. Any other privileges granted to the user are not affected by logging in with a role.

More than one role can be granted to the same user but logging in with multiple roles simultaneously is not supported.

A role can be granted only to a user.



**Please note:**

- 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, such as a procedure, trigger or view, you must specify the object type between the keyword TO and the object name.
- Although the USER and ROLE keywords are optional, it is advisable to use them, in order to avoid ambiguity.

### *The User PUBLIC*

Firebird has a predefined user named PUBLIC, that represents all users. Privileges for operations on a particular object that are granted to the user PUBLIC can be exercised by any user that has been authenticated at login.

**Important**

If privileges are granted to the user PUBLIC, they should be revoked from the user PUBLIC as well.

### *The WITH GRANT OPTION Clause*

The optional WITH GRANT OPTION clause allows the users specified in the user list to grant the privileges specified in the privilege list to other users.

**Caution**

It is possible to assign this option to the user PUBLIC. Do not do it!

### *The GRANTED BY Clause*

By default, when privileges are granted in a database, the current user is recorded as the grantor. The GRANTED BY clause enables the current user to grant those privileges as another user.

If the REVOKE statement is used, it will fail if the current user is not the user that was named in the GRANTED BY clause.

### *Alternative Syntax Using AS <username>*

The non-standard AS clause is supported as a synonym of the GRANTED BY clause to simplify migration from other database systems.

The clauses GRANTED BY and AS can be used only by the database owner and [administrators](#). The object owner cannot use it unless he also has administrator privileges.

### *Privileges on Tables and Views*

In theory, one GRANT statement grants one privilege to one user or object. In practice, the syntax allows multiple privileges to be granted to multiple users in one GRANT statement.

*Syntax extract:*

```
...
<privileges> ::= ALL [PRIVILEGES] | <privilege_list>

<privilege_list> ::= {<privilege> [, <privilege> [, ... ] ] }

<privilege> ::= {
    SELECT |
    DELETE |
    INSERT |
    UPDATE [(col [,col [, ...]])] ) ] |
    REFERENCES (col [, col [, ...] ] )
}
```

**Table 10.7. List of Privileges on Tables**

Privilege	Description
SELECT	Permits the user or object to SELECT data from the table or view
INSERT	Permits the user or object to INSERT rows into the table or view
UPDATE	Permits the user or object to UPDATE rows in the table or view, optionally restricted to specific columns
<i>col</i>	(Optional) name of a column to which the user's UPDATE privilege is restricted
DELETE	Permits the user or object to DELETE rows from the table or view
REFERENCES	Permits the user or object to reference the specified column[s] of the table via a foreign key. 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.
<i>col</i>	(Mandatory) name of one column in the referenced foreign key
ALL	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:

```
GRANT UPDATE (FIRST_NAME, LAST_NAME) ON TABLE EMPLOYEE
  TO USER IVAN;
```

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. It allows the grantee to execute the stored procedure 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.

*Example:* Granting the EXECUTE privilege on a stored procedure to a role:

```
GRANT EXECUTE ON PROCEDURE ADD_EMP_PROJ
  TO ROLE MANAGER;
```

### ***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.

**Caution**

It is possible to assign this option to PUBLIC. Do not do it!

*Examples of Role Assignment:*

1. Assigning the DIRECTOR and MANAGER roles to the user IVAN:

```
GRANT DIRECTOR, MANAGER TO USER IVAN;
```

2. Assigning the ADMIN role to the user ALEX with the authority to assign this role to other users:

```
GRANT MANAGER TO USER ALEX WITH ADMIN OPTION;
```

See also: [REVOKE](#)

## Statements for Revoking Privileges

A REVOKE statement is used for revoking privileges—including roles—from users and other database objects.

### REVOKE

*Used for:* Revoking privileges or role assignments

*Available in:* DSQL, ESQL

*Syntax:*

```
REVOKE [GRANT OPTION FOR] {  
    <privileges> ON [TABLE] {tablename | viewname} |  
    EXECUTE ON PROCEDURE procname }  
FROM <grantee_list>  
[{GRANTED BY | AS} [USER] grantor];  
  
REVOKE [ADMIN OPTION FOR] <role_granted>  
FROM {PUBLIC | <role_grantee_list>}  
[{GRANTED BY | AS} [USER] grantor];  
  
REVOKE ALL ON ALL FROM <grantee_list>  
  
<privileges> ::= ALL [PRIVILEGES] | <privilege_list>
```

```

<privilege_list> ::= {<privilege> [, <privilege> [, ... ] ] }

<privilege> ::=
    SELECT |
    DELETE |
    INSERT |
    UPDATE [(col [, col [, col [,...]] ] ) ] |
    REFERENCES (col [, col [, ...] ] )

<grantee_list> ::= {<grantee> [, <grantee> [, ...] ]}

<grantee> ::=
    [USER] username | [ROLE] rolename | GROUP Unix_group
    | PROCEDURE procname | TRIGGER trigname | VIEW viewname | PUBLIC

<role_granted> ::= rolename [, rolename ...]

<role_grantee_list> ::= [USER] <role_grantee> [, [USER] <role_grantee> [, ...]]

<role_grantee> ::= {username | PUBLIC }

```

**Table 10.8. REVOKE Statement Parameters**

Parameter	Description
tablename	The name of the table the privilege is to be revoked from
viewname	The name of the view the privilege is to be revoked from
procname	The name of the stored procedure the EXECUTE privilege is to be revoked from; or the name of the procedure that is to have the privilege[s] revoked
trigname	Trigger name
col	The table column the privilege is to be revoked from
username	The user name from which the privileges are to be revoked from or the role is to be removed from
rolename	Role name
Unix_group	The name of a user group in a POSIX operating system
grantor	The grantor user on whose behalf the the privilege[s] are being revoked

The REVOKE statement is used for revoking privileges from users, roles, stored procedures, triggers and views that were granted using the GRANT statement. See [GRANT](#) for detailed descriptions of the various types of privileges.

Only the user who granted the privilege can revoke it.

### **The FROM Clause**

The FROM clause is used to specify the list of users, roles and database objects (procedures, triggers and views) that will have the enumerated privileges revoked. The optional USER and ROLE keywords 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 checks for a role with this name and, if there is none, the privileges are revoked from the user without further checking.

**Tips**

- Although the USER and ROLE keywords are optional, it is advisable to use them in order to avoid ambiguity.
- The GRANT 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, 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 privileges on the table, view, trigger or stored procedure to other users or to roles. It does not revoke the privilege with which the grant option is associated.

***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. To revoke a privilege that was obtained by this method, the current user must be logged in either with full administrative privileges or as the user designated as <grantor> by that GRANTED BY clause.

**Note**

The same rule applies if the syntax used in the original GRANT statement used the synonymous AS form to introduce the clause, instead of the standard GRANTED BY form.

***Revoking ALL ON ALL***

If the current user is logged in with full [administrator](#) privileges in the database, the statement

```
REVOKE ALL ON ALL FROM <grantee_list>
```

can be used to revoke all privileges (including role memberships) on all objects from one or more users and/or roles. All privileges for the user will be removed, regardless of who granted them. It is a quick way to “clear” privileges when access to the database must be blocked for a particular user or role.

If the current user is not logged in as an administrator, the only privileges revoked will be those that were granted originally by that user.

The REVOKE ALL ON ALL statement cannot be used to revoke privileges that have been granted TO stored procedures, triggers or views.

**Note**

The GRANTED BY clause is not supported.

**Examples using REVOKE**

1. Revoking the privileges for reading and inserting into the SALES

```
REVOKE SELECT, INSERT ON TABLE SALES FROM USER ALEX;
```

2. Revoking the privilege for reading 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 authority 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 reading the COUNTRY table and the authority 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 reading 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 DIRECTOR and MANAGER roles from the user IVAN:

```
REVOKE DIRECTOR, MANAGER FROM USER IVAN;
```

10. Revoke from the user ALEX the authority to assign the MANAGER role to other users:

```
REVOKE ADMIN OPTION FOR MANAGER FROM USER IVAN;
```

11. Revoking all privileges (including roles) on all objects from the user IVAN:

```
REVOKE ALL ON ALL FROM IVAN;
```

After this statement is executed, the user IVAN will have no privileges whatsoever.

See also: [GRANT](#)



---

# 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.

#### **Note**

In V.2.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:

```
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. */

```

The following query will find the modules that depend on a specific table column and report the state of their RDB\$VALID\_BLR fields:

```

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$depended_on_name = 'MYTABLE'
       AND rdb$field_name = 'MYCOLUMN')

```

### Important

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 run-time, 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 <procname> and SHOW TRIGGER <trigname>, which display individual PSQL modules, do not signal invalid BLR at all.

## A Note on Equality

**Important**

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.

```
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](#)
  1. [GDSCODEs 335544366 to 335544334](#)
  2. [GDSCODEs 335544454 to 336330760](#)
  3. [GDSCODEs 335544329 to 335544613](#)
  4. [GDSCODEs 335544614 to 335544689](#)

### 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 B.1. SQLSTATE Codes and Message Texts**

SQLSTATE	Mapped Message
SQLCLASS 00 (Success)	
00000	Success
SQLCLASS 01 (Warning)	
01000	General warning
01001	Cursor operation conflict
01002	Disconnect error

<b>SQLSTATE</b>	<b>Mapped Message</b>
01003	NULL value eliminated in set function
01004	String data, right-truncated
01005	Insufficient item descriptor areas
01006	Privilege not revoked
01007	Privilege not granted
01008	Implicit zero-bit padding
01100	Statement reset to unprepared
01101	Ongoing transaction has been committed
01102	Ongoing transaction has been rolled back
SQLCLASS 02 (No Data)	
02000	No data found or no rows affected
SQLCLASS 07 (Dynamic SQL error)	
07000	Dynamic SQL error
07001	Wrong number of input parameters
07002	Wrong number of output parameters
07003	Cursor specification cannot be executed
07004	USING clause required for dynamic parameters
07005	Prepared statement not a cursor-specification
07006	Restricted data type attribute violation
07007	USING clause required for result fields
07008	Invalid descriptor count
07009	Invalid descriptor index
SQLCLASS 08 (Connection Exception)	
08001	Client unable to establish connection
08002	Connection name in use
08003	Connection does not exist
08004	Server rejected the connection
08006	Connection failure
08007	Transaction resolution unknown
SQLCLASS 0A (Feature Not Supported)	
0A000	Feature Not Supported

SQLSTATE	Mapped Message
SQLCLASS 0B (Invalid Transaction Initiation)	
0B000	Invalid transaction initiation
SQLCLASS 0L (Invalid Grantor)	
0L000	Invalid grantor
SQLCLASS 0P (Invalid Role Specification)	
0P000	Invalid role specification
SQLCLASS 0U (Attempt to Assign to Non-Updatable Column)	
0U000	Attempt to assign to non-updatable column
SQLCLASS 0V (Attempt to Assign to Ordering Column)	
0V000	Attempt to assign to Ordering column
SQLCLASS 20 (Case Not Found For Case Statement)	
20000	Case not found for case statement
SQLCLASS 21 (Cardinality Violation)	
21000	Cardinality violation
21S01	Insert value list does not match column list
21S02	Degree of derived table does not match column list
SQLCLASS 22 (Data Exception)	
22000	Data exception
22001	String data, right truncation
22002	Null value, no indicator parameter
22003	Numeric value out of range
22004	Null value not allowed
22005	Error in assignment
22006	Null value in field reference
22007	Invalid datetime format
22008	Datetime field overflow
22009	Invalid time zone displacement value
2200A	Null value in reference target
2200B	Escape character conflict
2200C	Invalid use of escape character
2200D	Invalid escape octet

<b>SQLSTATE</b>	<b>Mapped Message</b>
2200E	Null value in array target
2200F	Zero-length character string
2200G	Most specific type mismatch
22010	Invalid indicator parameter value
22011	Substring error
22012	Division by zero
22014	Invalid update value
22015	Interval field overflow
22018	Invalid character value for cast
22019	Invalid escape character
2201B	Invalid regular expression
2201C	Null row not permitted in table
22012	Division by zero
22020	Invalid limit value
22021	Character not in repertoire
22022	Indicator overflow
22023	Invalid parameter value
22024	Character string not properly terminated
22025	Invalid escape sequence
22026	String data, length mismatch
22027	Trim error
22028	Row already exists
2202D	Null instance used in mutator function
2202E	Array element error
2202F	Array data, right truncation
<b>SQLCLASS 23 (Integrity Constraint Violation)</b>	
23000	Integrity constraint violation
<b>SQLCLASS 24 (Invalid Cursor State)</b>	
24000	Invalid cursor state
24504	The cursor identified in the UPDATE, DELETE, SET, or GET statement is not positioned on a row

SQLSTATE	Mapped Message
SQLCLASS 25 (Invalid Transaction State)	
25000	Invalid transaction state
25S01	Transaction state
25S02	Transaction is still active
25S03	Transaction is rolled back
SQLCLASS 26 (Invalid SQL Statement Name)	
26000	Invalid SQL statement name
SQLCLASS 27 (Triggered Data Change Violation)	
27000	Triggered data change violation
SQLCLASS 28 (Invalid Authorization Specification)	
28000	Invalid authorization specification
SQLCLASS 2B (Dependent Privilege Descriptors Still Exist)	
2B000	Dependent privilege descriptors still exist
SQLCLASS 2C (Invalid Character Set Name)	
2C000	Invalid character set name
SQLCLASS 2D (Invalid Transaction Termination)	
2D000	Invalid transaction termination
SQLCLASS 2E (Invalid Connection Name)	
2E000	Invalid connection name
SQLCLASS 2F (SQL Routine Exception)	
2F000	SQL routine exception
2F002	Modifying SQL-data not permitted
2F003	Prohibited SQL-statement attempted
2F004	Reading SQL-data not permitted
2F005	Function executed no return statement
SQLCLASS 33 (Invalid SQL Descriptor Name)	
33000	Invalid SQL descriptor name
SQLCLASS 34 (Invalid Cursor Name)	
34000	Invalid cursor name
SQLCLASS 35 (Invalid Condition Number)	
35000	Invalid condition number



SQLSTATE	Mapped Message
SQLCLASS 36 (Cursor Sensitivity Exception)	
36001	Request rejected
36002	Request failed
SQLCLASS 37 (Invalid Identifier)	
37000	Invalid identifier
37001	Identifier too long
SQLCLASS 38 (External Routine Exception)	
38000	External routine exception
SQLCLASS 39 (External Routine Invocation Exception)	
39000	External routine invocation exception
SQLCLASS 3B (Invalid Save Point)	
3B000	Invalid save point
SQLCLASS 3C (Ambiguous Cursor Name)	
3C000	Ambiguous cursor name
SQLCLASS 3D (Invalid Catalog Name)	
3D000	Invalid catalog name
3D001	Catalog name not found
SQLCLASS 3F (Invalid Schema Name)	
3F000	Invalid schema name
SQLCLASS 40 (Transaction Rollback)	
40000	Ongoing transaction has been rolled back
40001	Serialization failure
40002	Transaction integrity constraint violation
40003	Statement completion unknown
SQLCLASS 42 (Syntax Error or Access Violation)	
42000	Syntax error or access violation
42702	Ambiguous column reference
42725	Ambiguous function reference
42818	The operands of an operator or function are not compatible
42S01	Base table or view already exists
42S02	Base table or view not found

<b>SQLSTATE</b>	<b>Mapped Message</b>
42S11	Index already exists
42S12	Index not found
42S21	Column already exists
42S22	Column not found
SQLCLASS 44 (With Check Option Violation)	
44000	WITH CHECK OPTION Violation
SQLCLASS 45 (Unhandled User-defined Exception)	
45000	Unhandled user-defined exception
SQLCLASS 54 (Program Limit Exceeded)	
54000	Program limit exceeded
54001	Statement too complex
54011	Too many columns
54023	Too many arguments
SQLCLASS HY (CLI-specific Condition)	
HY000	CLI-specific condition
HY001	Memory allocation error
HY003	Invalid data type in application descriptor
HY004	Invalid data type
HY007	Associated statement is not prepared
HY008	Operation canceled
HY009	Invalid use of null pointer
HY010	Function sequence error
HY011	Attribute cannot be set now
HY012	Invalid transaction operation code
HY013	Memory management error
HY014	Limit on the number of handles exceeded
HY015	No cursor name available
HY016	Cannot modify an implementation row descriptor
HY017	Invalid use of an automatically allocated descriptor handle
HY018	Server declined the cancellation request
HY019	Non-string data cannot be sent in pieces

<b>SQLSTATE</b>	<b>Mapped Message</b>
HY020	Attempt to concatenate a null value
HY021	Inconsistent descriptor information
HY024	Invalid attribute value
HY055	Non-string data cannot be used with string routine
HY090	Invalid string length or buffer length
HY091	Invalid descriptor field identifier
HY092	Invalid attribute identifier
HY095	Invalid Function ID specified
HY096	Invalid information type
HY097	Column type out of range
HY098	Scope out of range
HY099	Nullable type out of range
HY100	Uniqueness option type out of range
HY101	Accuracy option type out of range
HY103	Invalid retrieval code
HY104	Invalid Length/Precision value
HY105	Invalid parameter type
HY106	Invalid fetch orientation
HY107	Row value out of range
HY109	Invalid cursor position
HY110	Invalid driver completion
HY111	Invalid bookmark value
HYC00	Optional feature not implemented
HYT00	Timeout expired
HYT01	Connection timeout expired
<b>SQLCLASS XX (Internal Error)</b>	
XX000	Internal error
XX001	Data corrupted
XX002	Index corrupted

## 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.

### Note

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 B.2. SQLCODE and GDSCODE Error Codes and Message Texts (1)**

SQL-CODE	GDSCODE	Symbol	Message Text
101	335544366	Segment	Segment buffer length shorter than expected
100	335544338	from_no_match	No match for first value expression
100	335544354	no_record	Invalid database key
100	335544367	segstr_eof	Attempted retrieval of more segments than exist
100	335544374	stream_eof	Attempt to fetch past the last record in a record stream
0	335741039	gfix_opt_SQL_dialect	-sql_dialect   set database dialect n
0	335544875	bad_debug_format	Bad debug info format
-84	335544554	nonsql_security_rel	Table/procedure has non-SQL security class defined
-84	335544555	nonsql_security_fld	Column has non-SQL security class defined
-84	335544668	dsq1_procedure_use_err	Procedure @1 does not return any values
-85	335544747	username_too_long	The username entered is too long. Maximum length is 31 bytes
-85	335544748	password_too_long	The password specified is too long. Maximum length is @1 bytes
-85	335544749	username_required	A username is required for this operation
-85	335544750	password_required	A password is required for this operation
-85	335544751	bad_protocol	The network protocol specified is invalid
-85	335544752	dup_username_found	

SQL-CODE	GDSCODE	Symbol	Message Text
			A duplicate user name was found in the security database
-85	335544753	username_not_found	The user name specified was not found in the security database
-85	335544754	error_adding_sec_record	An error occurred while attempting to add the user
-85	335544755	error_modifying_sec_record	An error occurred while attempting to modify the user record
-85	335544756	error_deleting_sec_record	An error occurred while attempting to delete the user record
-85	335544757	error_updating_sec_db	An error occurred while updating the security database
-103	335544571	dsql_constant_err	Data type for constant unknown
-104	336003075	dsql_transitional_numeric	Precision 10 to 18 changed from DOUBLE PRECISION in SQL dialect 1 to 64-bit scaled integer in SQL dialect 3
-104	336003077	sql_db_dialect_dtype_unsupport	Database SQL dialect @1 does not support reference to @2 datatype
-104	336003087	dsql_invalid_label	Label @1 @2 in the current scope
-104	336003088	dsql_datatypes_not_comparable	Datatypes @1 are not comparable in expression @2
-104	335544343	invalid_blr	Invalid request BLR at offset @1
-104	335544390	syntaxerr	BLR syntax error: expected @1 at offset @2, encountered @3
-104	335544425	ctxinuse	Context already in use (BLR error)
-104	335544426	ctxnotdef	Context not defined (BLR error)
-104	335544429	badparnum	Bad parameter number
-104	335544440	bad_msg_vec	-
-104	335544456	invalid_sdl	Invalid slice description language at offset @1
-104	335544570	dsql_command_err	Invalid command
-104	335544579	dsql_internal_err	Internal error
-104	335544590	dsql_dup_option	Option specified more than once
-104	335544591	dsql_tran_err	Unknown transaction option
-104	335544592	dsql_invalid_array	Invalid array reference

SQL-CODE	GDSCODE	Symbol	Message Text
-104	335544608	command_end_err	Unexpected end of command
-104	335544612	token_err	Token unknown
-104	335544634	dsql_token_unk_err	Token unknown - line @1, column @2
-104	335544709	dsql_agg_ref_err	Invalid aggregate reference
-104	335544714	invalid_array_id	Invalid blob id
-104	335544730	cse_not_supported	Client/Server Express not supported in this release
-104	335544743	token_too_long	Token size exceeds limit
-104	335544763	invalid_string_constant	A string constant is delimited by double quotes
-104	335544764	transitional_date	DATE must be changed to TIMESTAMP
-104	335544796	sql_dialect_datatype_unsupport	Client SQL dialect @1 does not support reference to @2 datatype
-104	335544798	depend_on_uncommitted_rel	You created an indirect dependency on uncommitted metadata. You must roll back the current transaction
-104	335544821	dsql_column_pos_err	Invalid column position used in the @1 clause
-104	335544822	dsql_agg_where_err	Cannot use an aggregate function in a WHERE clause, use HAVING instead
-104	335544823	dsql_agg_group_err	Cannot use an aggregate function in a GROUP BY clause
-104	335544824	dsql_agg_column_err	Invalid expression in the @1 (not contained in either an aggregate function or the GROUP BY clause)
-104	335544825	dsql_agg_having_err	Invalid expression in the @1 (neither an aggregate function nor a part of the GROUP BY clause)
-104	335544826	dsql_agg_nested_err	Nested aggregate functions are not allowed
-104	335544849	malformed_string	Malformed string
-104	335544851	command_end_err2	Unexpected end of command- line @1, column @2
-104	336397215	dsql_max_sort_items	Cannot sort on more than 255 items
-104	336397216	dsql_max_group_items	Cannot group on more than 255 items

SQL-CODE	GDSCODE	Symbol	Message Text
-104	336397217	dsql_conflicting_sort_field	Cannot include the same field (@1.@2) twice in the ORDER BY clause with conflicting sorting options
-104	336397218	dsql_derived_table_more_columns	Column list from derived table @1 has more columns than the number of items in its SELECT statement
-104	336397219	dsql_derived_table_less_columns	Column list from derived table @1 has less columns than the number of items in its SELECT statement
-104	336397220	dsql_derived_field_unnamed	No column name specified for column number @1 in derived table @2
-104	336397221	dsql_derived_field_dup_name	Column @1 was specified multiple times for derived table @2
-104	336397222	dsql_derived_alias_select	Internal dsql error: alias type expected by pass1_expand_select_node
-104	336397223	dsql_derived_alias_field	Internal dsql error: alias type expected by pass1_field
-104	336397224	dsql_auto_field_bad_pos	Internal dsql error: column position out of range in pass1_union_auto_cast
-104	336397225	dsql_cte_wrong_reference	Recursive CTE member (@1) can refer itself only in FROM clause
-104	336397226	dsql_cte_cycle	CTE '@1' has cyclic dependencies
-104	336397227	dsql_cte_outer_join	Recursive member of CTE can't be member of an outer join
-104	336397228	dsql_cte_mult_references	Recursive member of CTE can't reference itself more than once
-104	336397229	dsql_cte_not_a_union	Recursive CTE (@1) must be an UNION
-104	336397230	dsql_cte_nonrecurs_after_recurs	CTE '@1' defined non-recursive member after recursive
-104	336397231	dsql_cte_wrong_clause	Recursive member of CTE '@1' has @2 clause
-104	336397232	dsql_cte_union_all	Recursive members of CTE (@1) must be linked with another members via UNION ALL
-104	336397233	dsql_cte_miss_nonrecursive	Non-recursive member is missing in CTE '@1'
-104	336397234	dsql_cte_nested_with	WITH clause can't be nested

<b>SQL-CODE</b>	<b>GDSCODE</b>	<b>Symbol</b>	<b>Message Text</b>
-104	336397235	dsql_col_more_than_once_using	Column @1 appears more than once in USING clause
-104	336397237	dsql_cte_not_used	CTE "@1" is not used in query
-105	335544702	like_escape_invalid	Invalid ESCAPE sequence
-105	335544789	extract_input_mismatch	Specified EXTRACT part does not exist in input datatype
-150	335544360	read_only_rel	Attempted update of read-only table
-150	335544362	read_only_view	Cannot update read-only view @1
-150	335544446	non_updatable	Not updatable
-150	335544546	constaint_on_view	Cannot define constraints on views
-151	335544359	read_only_field	Attempted update of read - only column
-155	335544658	dsql_base_table	@1 is not a valid base table of the specified view
-157	335544598	specify_field_err	Must specify column name for view select expression
-158	335544599	num_field_err	Number of columns does not match select list
-162	335544685	no_dbkey	Dbkey not available for multi - table views
-170	335544512	prcmismat	Input parameter mismatch for procedure @1
-170	335544619	extern_func_err	External functions cannot have morethan 10 parametrs
-170	335544850	prc_out_param_mismatch	Output parameter mismatch for procedure @1
-171	335544439	funmismat	Function @1 could not be matched
-171	335544458	invalid_dimension	Column not array or invalid dimensions (expected @1, encountered @2)
-171	335544618	return_mode_err	Return mode by value not allowed for this data type
-171	335544873	array_max_dimensions	Array data type can use up to @1 dimensions
-172	335544438	funnotdef	Function @1 is not defined
-203	335544708	dyn_fld_ambiguous	Ambiguous column reference



<b>SQL-CODE</b>	<b>GDSCODE</b>	<b>Symbol</b>	<b>Message Text</b>
-204	336003085	dsql_ambiguous_field_name	Ambiguous field name between @1 and @2
-204	335544463	gennotdef	Generator @1 is not defined
-204	335544502	stream_not_defined	Reference to invalid stream number
-204	335544509	charset_not_found	CHARACTER SET @1 is not defined
-204	335544511	prcnnotdef	Procedure @1 is not defined
-204	335544515	codnotdef	Status code @1 unknown
-204	335544516	xcpnotdef	Exception @1 not defined
-204	335544532	ref_cnstrnt_notfound	Name of Referential Constraint not defined in constraints table
-204	335544551	grant_obj_notfound	Could not find table/procedure for GRANT
-204	335544568	text_subtype	Implementation of text subtype @1 not located
-204	335544573	dsql_datatype_err	Data type unknown
-204	335544580	dsql_relation_err	Table unknown
-204	335544581	dsql_procedure_err	Procedure unknown
-204	335544588	collation_not_found	COLLATION @1 for CHARACTER SET @2 is not defined
-204	335544589	collation_not_for_charset	COLLATION @1 is not valid for specified CHARACTER SET
-204	335544595	dsql_trigger_err	Trigger unknown
-204	335544620	alias_conflict_err	Alias @1 conflicts with an alias in the same statement
-204	335544621	procedure_conflict_error	Alias @1 conflicts with a procedure in the same statement
-204	335544622	relation_conflict_err	Alias @1 conflicts with a table in the same statement
-204	335544635	dsql_no_relation_alias	There is no alias or table named @1 at this scope level
-204	335544636	indexname	There is no index @1 for table @2
-204	335544640	collation_requires_text	Invalid use of CHARACTER SET or COLLATE
-204	335544662	dsql_blob_type_unknown	BLOB SUB_TYPE @1 is not defined

SQL-CODE	GDSCODE	Symbol	Message Text
-204	335544759	bad_default_value	Can not define a not null column with NULL as default value
-204	335544760	invalid_clause	Invalid clause - '@1'
-204	335544800	too_many_contexts	Too many Contexts of Relation/Procedure/Views. Maximum allowed is 255
-204	335544817	bad_limit_param	Invalid parameter to FIRST. Only integers >= 0 are allowed
-204	335544818	bad_skip_param	Invalid parameter to SKIP. Only integers >= 0 are allowed
-204	335544837	bad_substring_offset	Invalid offset parameter @1 to SUBSTRING. Only positive integers are allowed
-204	335544853	bad_substring_length	Invalid length parameter @1 to SUBSTRING. Negative integers are not allowed
-204	335544854	charset_not_installed	CHARACTER SET @1 is not installed
-204	335544855	collation_not_installed	COLLATION @1 for CHARACTER SET @2 is not installed
-204	335544867	subtype_for_internal_use	Blob sub_types bigger than 1 (text) are for internal use only
-205	335544396	fldnotdef	Column @1 is not defined in table @2
-205	335544552	grant_fld_notfound	Could not find column for GRANT
-205	335544883	fldnotdef2	Column @1 is not defined in procedure @2
-206	335544578	dsql_field_err	Column unknown
-206	335544587	dsql_blob_err	Column is not a BLOB
-206	335544596	dsql_subselect_err	Subselect illegal in this context
-206	336397208	dsql_line_col_error	At line @1, column @2
-206	336397209	dsql_unknown_pos	At unknown line and column
-206	336397210	dsql_no_dup_name	Column @1 cannot be repeated in @2 statement
-208	335544617	order_by_err	Invalid ORDER BY clause
-219	335544395	relnotdef	Table @1 is not defined
-219	335544872	domnotdef	Domain @1 is not defined
-230	335544487	walw_err	WAL Writer error

SQL-CODE	GDSCODE	Symbol	Message Text
-231	335544488	logh_small	Log file header of @1 too small
-232	335544489	logh_inv_version	Invalid version of log file @1
-233	335544490	logh_open_flag	Log file @1 not latest in the chain but open flag still set
-234	335544491	logh_open_flag2	Log file @1 not closed properly; database recovery may be required
-235	335544492	logh_diff_dbname	Database name in the log file @1 is different
-236	335544493	logf_unexpected_eof	Unexpected end of log file @1 at offset @2
-237	335544494	logr_incomplete	Incomplete log record at offset @1 in log file @2
-238	335544495	logr_header_small2	Log record header too small at offset @1 in log file @
-239	335544496	logb_small	Log block too small at offset @1 in log file @2
-239	335544691	cache_too_small	Insufficient memory to allocate page buffer cache
-239	335544693	log_too_small	Log size too small
-239	335544694	partition_too_small	Log partition size too small
-243	335544500	no_wal	Database does not use Write-ahead Log
-257	335544566	start_cm_for_wal	WAL defined; Cache Manager must be started first
-260	335544690	cache_redef	Cache redefined
-260	335544692	log_redef	Log redefined
-261	335544695	partition_not_supp	Partitions not supported in series of log file specification
-261	335544696	log_length_spec	Total length of a partitioned log must be specified
-281	335544637	no_stream_plan	Table @1 is not referenced in plan
-282	335544638	stream_twice	Table @1 is referenced more than once in plan; use aliases to distinguish
-282	335544643	dsql_self_join	The table @1 is referenced twice; use aliases to differentiate

SQL-CODE	GDSCODE	Symbol	Message Text
-282	335544659	duplicate_base_table	Table @1 is referenced twice in view; use an alias to distinguish
-282	335544660	view_alias	View @1 has more than one base table; use aliases to distinguish
-282	335544710	complex_view	Navigational stream @1 references a view with more than one base table
-283	335544639	stream_not_found	Table @1 is referenced in the plan but not the from list
-284	335544642	index_unused	Index @1 cannot be used in the specified plan
-291	335544531	primary_key_notnull	Column used in a PRIMARY constraint must be NOT NULL
-292	335544534	ref_cnstrnt_update	Cannot update constraints (RDB \$REF_CONSTRAINTS)
-293	335544535	check_cnstrnt_update	Cannot update constraints (RDB \$CHECK_CONSTRAINTS)
-294	335544536	check_cnstrnt_del	Cannot delete CHECK constraint entry (RDB\$CHECK_CONSTRAINTS)
-295	335544545	rel_cnstrnt_update	Cannot update constraints (RDB \$RELATION_CONSTRAINTS)
-296	335544547	invld_cnstrnt_type	Internal gds software consistency check (invalid RDB\$CONSTRAINT_TYPE)
-297	335544558	check_constraint	Operation violates check constraint @1 on view or table @2
-313	336003099	upd_ins_doesnt_match_pk	UPDATE OR INSERT field list does not match primary key of table @1
-313	336003100	upd_ins_doesnt_match_matching	UPDATE OR INSERT field list does not match MATCHING clause
-313	335544669	dsql_count_mismatch	Count of column list and variable list do not match
-314	335544565	transliteration_failed	Cannot transliterate character between character sets
-315	336068815	dyn_dtype_invalid	Cannot change datatype for column @1. Changing datatype is not supported for BLOB or ARRAY columns
-383	336068814	dyn_dependency_exists	Column @1 from table @2 is referenced in @3

SQL-CODE	GDSCODE	Symbol	Message Text
-401	335544647	invalid_operator	Invalid comparison operator for find operation
-402	335544368	segstr_no_op	Attempted invalid operation on a BLOB
-402	335544414	blobnotsup	BLOB and array data types are not supported for @1 operation
-402	335544427	datnotsup	Data operation not supported
-406	335544457	out_of_bounds	Subscript out of bounds
-407	335544435	nullsegkey	Null segment of UNIQUE KEY
-413	335544334	convert_error	Conversion error from string "@1"

Table B.3. SQLCODE and GDSCODE Error Codes and Message Texts (2)

SQL-CODE	GDSCODE	Symbol	Message Text
-413	335544454	nofilter	Filter not found to convert type @1 to type @2
-413	335544860	blob_convert_error	Unsupported conversion to target type BLOB (subtype @1)
-413	335544861	array_convert_error	Unsupported conversion to target type ARRAY
-501	335544577	dsql_cursor_close_err	Attempt to reclose a closed cursor
-502	336003090	dsql_cursor_redefined	Statement already has a cursor @1 assigned
-502	336003091	dsql_cursor_not_found	Cursor @1 is not found in the current context
-502	336003092	dsql_cursor_exists	Cursor @1 already exists in the current context
-502	336003093	dsql_cursor_rel_ambiguous	Relation @1 is ambiguous in cursor @2
-502	336003094	dsql_cursor_rel_not_found	Relation @1 is not found in cursor @2
-502	336003095	dsql_cursor_not_open	Cursor is not open
-502	335544574	dsql_decl_err	Invalid cursor declaration
-502	335544576	dsql_cursor_open_err	Attempt to reopen an open cursor
-504	336003089	dsql_cursor_invalid	Empty cursor name is not allowed
-504	335544572	dsql_cursor_err	Invalid cursor reference
-508	335544348	no_cur_rec	No current record for fetch operation

SQL-CODE	GDSCODE	Symbol	Message Text
-510	335544575	dsql_cursor_update_err	Cursor @1 is not updatable
-518	335544582	dsql_request_err	Request unknown
-519	335544688	dsql_open_cursor_request	The prepare statement identifies a prepare statement with an open cursor
-530	335544466	foreign_key	Violation of FOREIGN KEY constraint "@1" on table "@2"
-530	335544838	foreign_key_target_doesnt_exist	Foreign key reference target does not exist
-530	335544839	foreign_key_references_present	Foreign key references are present for the record
-531	335544597	dsql_crdb_prepare_err	Cannot prepare a CREATE DATABASE/SCHEMA statement
-532	335544469	trans_invalid	Transaction marked invalid by I/O error
-551	335544352	no_priv	No permission for @1 access to @2 @3
-551	335544790	insufficient_svc_privileges	Service @1 requires SYSDBA permissions. Reattach to the Service Manager using the SYSDBA account
-552	335544550	not_rel_owner	Only the owner of a table may reassign ownership
-552	335544553	grant_nopriv	User does not have GRANT privileges for operation
-552	335544707	grant_nopriv_on_base	User does not have GRANT privileges on base table/view for operation
-553	335544529	existing_priv_mod	Cannot modify an existing user privilege
-595	335544645	stream_crack	The current position is on a crack
-596	335544644	stream_bof	Illegal operation when at beginning of stream
-597	335544632	dsql_file_length_err	Preceding file did not specify length, so @1 must include starting page number
-598	335544633	dsql_shadow_number_err	Shadow number must be a positive integer
-599	335544607	node_err	Gen.c: node not supported
-599	335544625	node_name_err	A node name is not permitted in a secondary, shadow, cache or log file name
-600	335544680	crp_data_err	Sort error: corruption in data structure

SQL-CODE	GDSCODE	Symbol	Message Text
-601	335544646	db_or_file_exists	Database or file exists
-604	335544593	dsql_max_arr_dim_exceeded	Array declared with too many dimensions
-604	335544594	dsql_arr_range_error	Illegal array dimension range
-605	335544682	dsql_field_ref	Inappropriate self-reference of column
-607	336003074	dsql_dbkey_from_non_table	Cannot SELECT RDB\$DB_KEY from a stored procedure
-607	336003086	dsql_udf_return_pos_err	External function should have return position between 1 and @1
-607	336003096	dsql_type_not_supp_ext_tab	Data type @1 is not supported for EXTERNAL TABLES. Relation '@2', field '@3'
-607	335544351	no_meta_update	Unsuccessful metadata update
-607	335544549	systrig_update	Cannot modify or erase a system trigger
-607	335544657	dsql_no_blob_array	Array/BLOB/DATE data types not allowed in arithmetic
-607	335544746	reftable_requires_pk	"REFERENCES table" without "(column)" requires PRIMARY KEY on referenced table
-607	335544815	generator_name	GENERATOR @1
-607	335544816	udf_name	UDF @1
-607	335544858	must_have_phys_field	Can't have relation with only computed fields or constraints
-607	336397206	dsql_table_not_found	Table @1 does not exist
-607	336397207	dsql_view_not_found	View @1 does not exist
-607	336397212	dsql_no_array_computed	Array and BLOB data types not allowed in computed field
-607	336397214	dsql_only_can_subscript_array	Scalar operator used on field @1 which is not an array
-612	336068812	dyn_domain_name_exists	Cannot rename domain @1 to @2. A domain with that name already exists
-612	336068813	dyn_field_name_exists	Cannot rename column @1 to @2. A column with that name already exists in table @3
-615	335544475	relation_lock	Lock on table @1 conflicts with existing lock

SQL-CODE	GDSCODE	Symbol	Message Text
-615	335544476	record_lock	Requested record lock conflicts with existing lock
-615	335544507	range_in_use	Refresh range number @1 already in use
-616	335544530	primary_key_ref	Cannot delete PRIMARY KEY being used in FOREIGN KEY definition
-616	335544539	integ_index_del	Cannot delete index used by an Integrity Constraint
-616	335544540	integ_index_mod	Cannot modify index used by an Integrity Constraint
-616	335544541	check_trig_del	Cannot delete trigger used by a CHECK Constraint
-616	335544543	cnstrnt_fld_del	Cannot delete column being used in an Integrity Constraint
-616	335544630	dependency	There are @1 dependencies
-616	335544674	del_last_field	Last column in a table cannot be deleted
-616	335544728	integ_index_deactivate	Cannot deactivate index used by an integrity constraint
-616	335544729	integ_deactivate_primary	Cannot deactivate index used by a PRIMARY/UNIQUE constraint
-617	335544542	check_trig_update	Cannot update trigger used by a CHECK Constraint
-617	335544544	cnstrnt_fld_rename	Cannot rename column being used in an Integrity Constraint
-618	335544537	integ_index_seg_del	Cannot delete index segment used by an Integrity Constraint
-618	335544538	integ_index_seg_mod	Cannot update index segment used by an Integrity Constraint
-625	335544347	not_valid	Validation error for column @1, value "@2"
-625	335544879	not_valid_for_var	Validation error for variable @1, value "@2"
-625	335544880	not_valid_for	Validation error for @1, value "@2"
-637	335544664	dsql_duplicate_spec	Duplicate specification of @1- not supported
-637	336397213	dsql_implicit_domain_name	Implicit domain name @1 not allowed in user created domain



SQL-CODE	GDSCODE	Symbol	Message Text
-660	336003098	primary_key_required	Primary key required on table @1
-660	335544533	foreign_key_notfound	Non-existent PRIMARY or UNIQUE KEY specified for FOREIGN KEY
-660	335544628	idx_create_err	Cannot create index @1
-663	335544624	idx_seg_err	Segment count of 0 defined for index @1
-663	335544631	idx_key_err	Too many keys defined for index @1
-663	335544672	key_field_err	Too few key columns found for index @1 (incorrect column name?)
-664	335544434	keytoobig	Key size exceeds implementation restriction for index "@1"
-677	335544445	ext_err	@1 extension error
-685	335544465	bad_segstr_type	Invalid BLOB type for operation
-685	335544670	blob_idx_err	Attempt to index BLOB column in index @1
-685	335544671	array_idx_err	Attempt to index array column in index @1
-689	335544403	badpagtyp	Page @1 is of wrong type (expected @2, found @3)
-689	335544650	page_type_err	Wrong page type
-690	335544679	no_segments_err	Segments not allowed in expression index @1
-691	335544681	rec_size_err	New record size of @1 bytes is too big
-692	335544477	max_idx	Maximum indexes per table (@1) exceeded
-693	335544663	req_max_clones_exceeded	Too many concurrent executions of the same request
-694	335544684	no_field_access	Cannot access column @1 in view @2
-802	335544321	arith_except	Arithmetic exception, numeric overflow, or string truncation
-802	335544836	concat_overflow	Concatenation overflow. Resulting string cannot exceed 32K in length
-803	335544349	no_dup	Attempt to store duplicate value ( visible to active transactions ) in unique index "@1"

SQL-CODE	GDSCODE	Symbol	Message Text
-803	335544665	unique_key_violation	Violation of PRIMARY or UNIQUE KEY constraint "@1" on table "@2"
-804	336003097	dsql_feature_not_supported_ods	Feature not supported on ODS version older than @1.@2
-804	335544380	wronumarg	Wrong number of arguments on call
-804	335544583	dsql_sqlda_err	SQLDA missing or incorrect version, or incorrect number/type of variables
-804	335544584	dsql_var_count_err	Count of read - write columns does not equal count of values
-804	335544586	dsql_function_err	Function unknown
-804	335544713	dsql_sqlda_value_err	Incorrect values within SQLDA structure
-804	336397205	dsql_too_old_ods	ODS versions before ODS@1 are not supported
-806	335544600	col_name_err	Only simple column names permitted for VIEW WITH CHECK OPTION
-807	335544601	where_err	No WHERE clause for VIEW WITH CHECK OPTION
-808	335544602	table_view_err	Only one table allowed for VIEW WITH CHECK OPTION
-809	335544603	distinct_err	DISTINCT, GROUP or HAVING not permitted for VIEW WITH CHECK OPTION
-810	335544605	subquery_err	No subqueries permitted for VIEW WITH CHECK OPTION
-811	335544652	sing_select_err	Multiple rows in singleton select
-816	335544651	ext_readonly_err	Cannot insert because the file is readonly or is on a read only medium
-816	335544715	extfile_uns_op	Operation not supported for EXTERNAL FILE table @1
-817	336003079	isc_sql_dialect_conflict_num	DB dialect @1 and client dialect @2 conflict with respect to numeric precision @3
-817	336003101	upd_ins_with_complex_view	UPDATE OR INSERT without MATCHING could not be used with views based on more than one table
-817	336003102	dsql_incompatible_trigger_type	Incompatible trigger type
-817	336003103	dsql_db_trigger_type_cant_change	Database trigger type can't be changed

SQL-CODE	GDSCODE	Symbol	Message Text
-817	335544361	read_only_trans	Attempted update during read - only transaction
-817	335544371	segstr_no_write	Attempted write to read-only BLOB
-817	335544444	read_only	Operation not supported
-817	335544765	read_only_database	Attempted update on read - only database
-817	335544766	must_be_dialect_2_and_up	SQL dialect @1 is not supported in this database
-817	335544793	ddl_not_allowed_by_db_sql_dial	Metadata update statement is not allowed by the current database SQL dialect @1
-820	335544356	obsolete_metadata	Metadata is obsolete
-820	335544379	wrong_ods	Unsupported on - disk structure for file @1; found @2.@3, support @4.@5
-820	335544437	wrodynver	Wrong DYN version
-820	335544467	high_minor	Minor version too high found @1 expected @2
-820	335544881	need_difference	Difference file name should be set explicitly for database on raw device
-823	335544473	invalid_bookmark	Invalid bookmark handle
-824	335544474	bad_lock_level	Invalid lock level @1
-825	335544519	bad_lock_handle	Invalid lock handle
-826	335544585	dsql_stmt_handle	Invalid statement handle
-827	335544655	invalid_direction	Invalid direction for find operation
-827	335544718	invalid_key	Invalid key for find operation
-828	335544678	inval_key_posn	Invalid key position
-829	336068816	dyn_char_fld_too_small	New size specified for column @1 must be at least @2 characters
-829	336068817	dyn_invalid_dtype_conversion	Cannot change datatype for @1. Conversion from base type @2 to @3 is not supported
-829	336068818	dyn_dtype_conv_invalid	Cannot change datatype for column @1 from a character type to a non-character type
-829	336068829	max_coll_per_charset	Maximum number of collations per character set exceeded
-829	336068830	invalid_coll_attr	Invalid collation attributes

SQL-CODE	GDSCODE	Symbol	Message Text
-829	336068852	dyn_scale_too_big	New scale specified for column @1 must be at most @2
-829	336068853	dyn_precision_too_small	New precision specified for column @1 must be at least @2
-829	335544616	field_ref_err	Invalid column reference
-830	335544615	field_aggregate_err	Column used with aggregate
-831	335544548	primary_key_exists	Attempt to define a second PRIMARY KEY for the same table
-832	335544604	key_field_count_err	FOREIGN KEY column count does not match PRIMARY KEY
-833	335544606	expression_eval_err	Expression evaluation not supported
-833	335544810	date_range_exceeded	Value exceeds the range for valid dates
-834	335544508	range_not_found	Refresh range number @1 not found
-835	335544649	bad_checksum	Bad checksum
-836	335544517	except	Exception @1
-836	335544848	except2	Exception @1
-837	335544518	cache_restart	Restart shared cache manager
-838	335544560	shutwarn	Database @1 shutdown in @2 seconds
-841	335544677	version_err	Too many versions
-842	335544697	precision_err	Precision must be from 1 to 18
-842	335544698	scale_nogt	Scale must be between zero and precision
-842	335544699	expec_short	Short integer expected
-842	335544700	expec_long	Long integer expected
-842	335544701	expec_ushort	Unsigned short integer expected
-842	335544712	expec_positive	Positive value expected
-901	335740929	gfix_db_name	Database file name (@1) already given
-901	336330753	gbak_unknown_switch	Found unknown switch
-901	336920577	gstat_unknown_switch	Found unknown switch
-901	336986113	fbsvcmgr_bad_am	Wrong value for access mode
-901	335740930	gfix_invalid_sw	Invalid switch @1
-901	335544322	bad_dbkey	Invalid database key
-901	336986114	fbsvcmgr_bad_wm	Wrong value for write mode

SQL-CODE	GDSCODE	Symbol	Message Text
-901	336330754	gbak_page_size_missing	Page size parameter missing
-901	336920578	gstat_retry	Please retry, giving a database name
-901	336986115	fbsvcmgr_bad_rs	Wrong value for reserve space
-901	336920579	gstat_wrong_ods	Wrong ODS version, expected @1, encountered @2
-901	336330755	gbak_page_size_toobig	Page size specified (@1) greater than limit (16384 bytes)
-901	335740932	gfix_incmp_sw	Incompatible switch combination
-901	336920580	gstat_unexpected_eof	Unexpected end of database file
-901	336330756	gbak_redir_output_missing	Redirect location for output is not specified
-901	336986116	fbsvcmgr_info_err	Unknown tag (@1) in info_svr_db_info block after isc_svc_query()
-901	335740933	gfix_replay_req	Replay log pathname required
-901	336330757	gbak_switches_conflict	Conflicting switches for backup/restore
-901	336986117	fbsvcmgr_query_err	Unknown tag (@1) in isc_svc_query() results
-901	335544326	bad_dpb_form	Unrecognized database parameter block
-901	335740934	gfix_pgbuf_req	Number of page buffers for cache required
-901	336986118	fbsvcmgr_switch_unknown	Unknown switch "@1"
-901	336330758	gbak_unknown_device	Device type @1 not known
-901	335544327	bad_req_handle	Invalid request handle
-901	335740935	gfix_val_req	Numeric value required
-901	336330759	gbak_no_protection	Protection is not there yet
-901	335544328	bad_segstr_handle	Invalid BLOB handle
-901	335740936	gfix_pval_req	Positive numeric value required
-901	336330760	gbak_page_size_not_allowed	Page size is allowed only on restore or create

Table B.4. SQLCODE and GDSCODE Error Codes and Message Texts (3)

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335544329	bad_segstr_id	Invalid BLOB ID

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335740937	gfix_trn_req	Number of transactions per sweep required
-901	336330761	gbak_multi_source_dest	Multiple sources or destinations specified
-901	335544330	bad_tpb_content	Invalid parameter in transaction parameter block
-901	336330762	gbak_filename_missing	Requires both input and output filenames
-901	335544331	bad_tpb_form	Invalid format for transaction parameter block
-901	336330763	gbak_dup_inout_names	Input and output have the same name. Disallowed
-901	335740940	gfix_full_req	"full" or "reserve" required
-901	335544332	bad_trans_handle	Invalid transaction handle (expecting explicit transaction start)
-901	336330764	gbak_inv_page_size	Expected page size, encountered "@1"
-901	335740941	gfix_username_req	User name required
-901	336330765	gbak_db_specified	REPLACE specified, but the first file @1 is a database
-901	335740942	gfix_pass_req	Password required
-901	336330766	gbak_db_exists	Database @1 already exists.To replace it, use the -REP switch
-901	335740943	gfix_subs_name	Subsystem name
-901	336723983	gsec_cant_open_db	Unable to open database
-901	336330767	gbak_unk_device	Device type not specified
-901	336723984	gsec_switches_error	Error in switch specifications
-901	335740945	gfix_sec_req	Number of seconds required
-901	335544337	excess_trans	Attempt to start more than @1 transactions
-901	336723985	gsec_no_op_spec	No operation specified
-901	335740946	gfix_nval_req	Numeric value between 0 and 32767 inclusive required
-901	336723986	gsec_no_usr_name	No user name specified
-901	335740947	gfix_type_shut	Must specify type of shutdown
-901	335544339	infinap	Information type inappropriate for object specified

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335544340	infona	No information of this type available for object specified
-901	336723987	gsec_err_add	Add record error
-901	336723988	gsec_err_modify	Modify record error
-901	336330772	gbak_blob_info_failed	Gds_\$blob_info failed
-901	335740948	gfix_retry	Please retry, specifying an option
-901	335544341	infunk	Unknown information item
-901	336723989	gsec_err_find_mod	Find / modify record error
-901	336330773	gbak_unk_blob_item	Do not understand BLOB INFO item @1
-901	335544342	integ_fail	Action cancelled by trigger (@1) to preserve data integrity
-901	336330774	gbak_get_seg_failed	Gds_\$get_segment failed
-901	336723990	gsec_err_rec_not_found	Record not found for user: @1
-901	336723991	gsec_err_delete	Delete record error
-901	336330775	gbak_close_blob_failed	Gds_\$close_blob failed
-901	335740951	gfix_retry_db	Please retry, giving a database name
-901	336330776	gbak_open_blob_failed	Gds_\$open_blob failed
-901	336723992	gsec_err_find_del	Find / delete record error
-901	335544345	lock_conflict	Lock conflict on no wait transaction
-901	336330777	gbak_put_blr_gen_id_failed	Failed in put_blr_gen_id
-901	336330778	gbak_unk_type	Data type @1 not understood
-901	336330779	gbak_comp_req_failed	Gds_\$compile_request failed
-901	336330780	gbak_start_req_failed	Gds_\$start_request failed
-901	336723996	gsec_err_find_disp	Find / display record error
-901	336330781	gbak_rec_failed	gds_\$receive failed
-901	336920605	gstat_open_err	Can't open database file @1
-901	336723997	gsec_inv_param	Invalid parameter, no switch defined
-901	335544350	no_finish	Program attempted to exit without finishing database
-901	336920606	gstat_read_err	Can't read a database page
-901	336330782	gbak_rel_req_failed	Gds_\$release_request failed

SQL-CODE	GDSCODE	Symbol	Message Text
-901	336723998	gsec_op_specified	Operation already specified
-901	336920607	gstat_sysmemex	System memory exhausted
-901	336330783	gbak_db_info_failed	gds_\$database_info failed
-901	336723999	gsec_pw_specified	Password already specified
-901	336724000	gsec_uid_specified	Uid already specified
-901	336330784	gbak_no_db_desc	Expected database description record
-901	335544353	no_recon	Transaction is not in limbo
-901	336724001	gsec_gid_specified	Gid already specified
-901	336330785	gbak_db_create_failed	Failed to create database @1
-901	336724002	gsec_proj_specified	Project already specified
-901	336330786	gbak_decomp_len_error	RESTORE: decompression length error
-901	335544355	no_segstr_close	BLOB was not closed
-901	336330787	gbak_tbl_missing	Cannot find table @1
-901	336724003	gsec_org_specified	Organization already specified
-901	336330788	gbak_blob_col_missing	Cannot find column for BLOB
-901	336724004	gsec_fname_specified	First name already specified
-901	335544357	open_trans	Cannot disconnect database with open transactions (@1 active)
-901	336330789	gbak_create_blob_failed	Gds_\$create_blob failed
-901	336724005	gsec_mname_specified	Middle name already specified
-901	335544358	port_len	Message length error ( encountered @1, expected @2)
-901	336330790	gbak_put_seg_failed	Gds_\$put_segment failed
-901	336724006	gsec_lname_specified	Last name already specified
-901	336330791	gbak_rec_len_exp	Expected record length
-901	336724008	gsec_inv_switch	Invalid switch specified
-901	336330792	gbak_inv_rec_len	Wrong length record, expected @1 encountered @2
-901	336330793	gbak_exp_data_type	Expected data attribute
-901	336724009	gsec_amb_switch	Ambiguous switch specified
-901	336330794	gbak_gen_id_failed	Failed in store_blr_gen_id



SQL-CODE	GDSCODE	Symbol	Message Text
-901	336724010	gsec_no_op_specified	No operation specified for parameters
-901	335544363	req_no_trans	No transaction for request
-901	336330795	gbak_unk_rec_type	Do not recognize record type @1
-901	336724011	gsec_params_not_allowed	No parameters allowed for this operation
-901	335544364	req_sync	Request synchronization error
-901	336724012	gsec_incompat_switch	Incompatible switches specified
-901	336330796	gbak_inv_bkup_ver	Expected backup version 1..8. Found @1
-901	335544365	req_wrong_db	Request referenced an unavailable database
-901	336330797	gbak_missing_bkup_desc	Expected backup description record
-901	336330798	gbak_string_trunc	String truncated
-901	336330799	gbak_cant_rest_record	warning -- record could not be restored
-901	336330800	gbak_send_failed	Gds_\$send failed
-901	335544369	segstr_no_read	Attempted read of a new, open BLOB
-901	336330801	gbak_no_tbl_name	No table name for data
-901	335544370	segstr_no_trans	Attempted action on blob outside transaction
-901	336330802	gbak_unexp_eof	Unexpected end of file on backup file
-901	336330803	gbak_db_format_too_old	Database format @1 is too old to restore to
-901	335544372	segstr_wrong_db	Attempted reference to BLOB in unavailable database
-901	336330804	gbak_inv_array_dim	Array dimension for column @1 is invalid
-901	336330807	gbak_xdr_len_expected	Expected XDR record length
-901	335544376	unres_rel	Table @1 was omitted from the transaction reserving list
-901	335544377	uns_ext	Request includes a DSRI extension not supported in this implementation
-901	335544378	wish_list	Feature is not supported
-901	335544382	random	@1
-901	335544383	fatal_conflict	Unrecoverable conflict with limbo transaction @1

<b>SQL-CODE</b>	<b>GDSCODE</b>	<b>Symbol</b>	<b>Message Text</b>
-901	335740991	gfix_exceed_max	Internal block exceeds maximum size
-901	335740992	gfix_corrupt_pool	Corrupt pool
-901	335740993	gfix_mem_exhausted	Virtual memory exhausted
-901	336330817	gbak_open_bkup_error	Cannot open backup file @1
-901	335740994	gfix_bad_pool	Bad pool id.
-901	336330818	gbak_open_error	Cannot open status and error output file @1
-901	335740995	gfix_trn_not_valid	Transaction state @1 not in valid range
-901	335544392	bdbincon	Internal error
-901	336724044	gsec_inv_username	Invalid user name (maximum 31 bytes allowed)
-901	336724045	gsec_inv_pw_length	Warning - maximum 8 significant bytes of password used
-901	336724046	gsec_db_specified	Database already specified
-901	336724047	gsec_db_admin_specified	Database administrator name already specified
-901	336724048	gsec_db_admin_pw_specified	Database administrator password already specified
-901	336724049	gsec_sql_role_specified	SQL role name already specified
-901	335741012	gfix_unexp_eoi	Unexpected end of input
-901	335544407	dbbnotzer	Database handle not zero
-901	335544408	tranotzer	Transaction handle not zero
-901	335741018	gfix_recon_fail	Failed to reconnect to a transaction in database @1
-901	335544418	trainlim	Transaction in limbo
-901	335544419	notinlim	Transaction not in limbo
-901	335544420	traoutsta	Transaction outstanding
-901	335544428	badmsgnum	Undefined message number
-901	335741036	gfix_trn_unknown	Transaction description item unknown
-901	335741038	gfix_mode_req	"read_only" or "read_write" required
-901	335544431	blocking_signal	Blocking signal has been received
-901	335741042	gfix_pzval_req	Positive or zero numeric value required

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335544442	noargacc_read	Database system cannot read argument @1
-901	335544443	noargacc_write	Database system cannot write argument @1
-901	335544450	misc_interpreted	@1
-901	335544468	tra_state	Transaction @1 is @2
-901	335544485	bad_stmt_handle	Invalid statement handle
-901	336330934	gbak_missing_block_fac	Blocking factor parameter missing
-901	336330935	gbak_inv_block_fac	Expected blocking factor, encountered "@1"
-901	336330936	gbak_block_fac_specified	A blocking factor may not be used in conjunction with device CT
-901	336068796	dyn_role_does_not_exist	SQL role @1 does not exist
-901	336330940	gbak_missing_username	User name parameter missing
-901	336330941	gbak_missing_password	Password parameter missing
-901	336068797	dyn_no_grant_admin_opt	User @1 has no grant admin option on SQL role @2
-901	335544510	lock_timeout	Lock time-out on wait transaction
-901	336068798	dyn_user_not_role_member	User @1 is not a member of SQL role @2
-901	336068799	dyn_delete_role_failed	@1 is not the owner of SQL role @2
-901	336068800	dyn_grant_role_to_user	@1 is a SQL role and not a user
-901	336068801	dyn_inv_sql_role_name	User name @1 could not be used for SQL role
-901	336068802	dyn_dup_sql_role	SQL role @1 already exists
-901	336068803	dyn_kywd_spec_for_role	Keyword @1 can not be used as a SQL role name
-901	336068804	dyn_roles_not_supported	SQL roles are not supported in on older versions of the database. A backup and restore of the database is required
-901	336330952	gbak_missing_skipped_bytes	missing parameter for the number of bytes to be skipped
-901	336330953	gbak_inv_skipped_bytes	Expected number of bytes to be skipped, encountered "@1"
-901	336068820	dyn_zero_len_id	Zero length identifiers are not allowed

SQL-CODE	GDSCODE	Symbol	Message Text
-901	336330965	gbak_err_restore_charset	Character set
-901	336330967	gbak_err_restore_collation	Collation
-901	336330972	gbak_read_error	Unexpected I/O error while reading from backup file
-901	336330973	gbak_write_error	Unexpected I/O error while writing to backup file
-901	336068840	dyn_wrong_gtt_scope	@1 cannot reference @2
-901	336330985	gbak_db_in_use	Could not drop database @1 (database might be in use)
-901	336330990	gbak_sysmemex	System memory exhausted
-901	335544559	bad_svc_handle	Invalid service handle
-901	335544561	wrospbver	Wrong version of service parameter block
-901	335544562	bad_spb_form	Unrecognized service parameter block
-901	335544563	svcnotdef	Service @1 is not defined
-901	336068856	dyn_ods_not_supp_feature	Feature '@1' is not supported in ODS @2.@3
-901	336331002	gbak_restore_role_failed	SQL role
-901	336331005	gbak_role_op_missing	SQL role parameter missing
-901	336331010	gbak_page_buffers_missing	Page buffers parameter missing
-901	336331011	gbak_page_buffers_wrong_param	Expected page buffers, encountered "@1"
-901	336331012	gbak_page_buffers_restore	Page buffers is allowed only on restore or create
-901	336331014	gbak_inv_size	Size specification either missing or incorrect for file @1
-901	336331015	gbak_file_outof_sequence	File @1 out of sequence
-901	336331016	gbak_join_file_missing	Can't join - one of the files missing
-901	336331017	gbak_stdin_not_supptd	standard input is not supported when using join operation
-901	336331018	gbak_stdout_not_supptd	Standard output is not supported when using split operation
-901	336331019	gbak_bkup_corrupt	Backup file @1 might be corrupt
-901	336331020	gbak_unk_db_file_spec	Database file specification missing
-901	336331021	gbak_hdr_write_failed	Can't write a header record to file @1

<b>SQL-CODE</b>	<b>GDSCODE</b>	<b>Symbol</b>	<b>Message Text</b>
-901	336331022	gbak_disk_space_ex	Free disk space exhausted
-901	336331023	gbak_size_lt_min	File size given (@1) is less than minimum allowed (@2)
-901	336331025	gbak_svc_name_missing	Service name parameter missing
-901	336331026	gbak_not_ownr	Cannot restore over current database, must be SYSDBA or owner of the existing database
-901	336331031	gbak_mode_req	"read_only" or "read_write" required
-901	336331033	gbak_just_data	Just data ignore all constraints etc.
-901	336331034	gbak_data_only	Restoring data only ignoring foreign key, unique, not null & other constraints
-901	335544609	index_name	INDEX @1
-901	335544610	exception_name	EXCEPTION @1
-901	335544611	field_name	COLUMN @1
-901	335544613	union_err	Union not supported

**Table B.5. SQLCODE and GDSCODE Error Codes and Message Texts (4)**

<b>SQL-CODE</b>	<b>GDSCODE</b>	<b>Symbol</b>	<b>Message Text</b>
-901	335544614	dsql_construct_err	Unsupported DSQL construct
-901	335544623	dsql_domain_err	Illegal use of keyword VALUE
-901	335544626	table_name	TABLE @1
-901	335544627	proc_name	PROCEDURE @1
-901	335544641	dsql_domain_not_found	Specified domain or source column @1 does not exist
-901	335544656	dsql_var_conflict	Variable @1 conflicts with parameter in same procedure
-901	335544666	svr_version_too_old	Server version too old to support all CREATE DATABASE options
-901	335544673	no_delete	Cannot delete
-901	335544675	sort_err	Sort error
-901	335544703	svcnoexe	Service @1 does not have an associated executable
-901	335544704	net_lookup_err	Failed to locate host machine

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335544705	service_unknown	Undefined service @1/@2
-901	335544706	host_unknown	The specified name was not found in the hosts file or Domain Name Services
-901	335544711	unprepared_stmt	Attempt to execute an unprepared dynamic SQL statement
-901	335544716	svc_in_use	Service is currently busy: @1
-901	335544731	tra_must_sweep	[no associated message]
-901	335544740	udf_exception	A fatal exception occurred during the execution of a user defined function
-901	335544741	lost_db_connection	Connection lost to database
-901	335544742	no_write_user_priv	User cannot write to RDB \$USER_PRIVILEGES
-901	335544767	blob_filter_exception	A fatal exception occurred during the execution of a blob filter
-901	335544768	exception_access_violation	Access violation.The code attempted to access a virtual address without privilege to do so
-901	335544769	exception_datatype_missalignment	Datatype misalignment.The attempted to read or write a value that was not stored on a memory boundary
-901	335544770	exception_array_bounds_exceeded	Array bounds exceeded. The code attempted to access an array element that is out of bounds.
-901	335544771	exception_float_denormal_operand	Float denormal operand.One of the floating-point operands is too small to represent a standard float value.
-901	335544772	exception_float_divide_by_zero	Floating-point divide by zero.The code attempted to divide a floating-point value by zero.
-901	335544773	exception_float_inexact_result	Floating-point inexact result.The result of a floating-point operation cannot be represented as a decimal fraction
-901	335544774	exception_float_invalid_operand	Floating-point invalid operand.An indeterminate error occurred during a floating-point operation
-901	335544775	exception_float_overflow	Floating-point overflow.The exponent of a floating-point operation is greater than the magnitude allowed

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335544776	exception_float_stack_check	Floating-point stack check.The stack overflowed or underflowed as the result of a floating-point operation
-901	335544777	exception_float_underflow	Floating-point underflow.The exponent of a floating-point operation is less than the magnitude allowed
-901	335544778	exception_integer_divide_by_zero	Integer divide by zero.The code attempted to divide an integer value by an integer divisor of zero
-901	335544779	exception_integer_overflow	Integer overflow.The result of an integer operation caused the most significant bit of the result to carry
-901	335544780	exception_unknown	An exception occurred that does not have a description.Exception number @1
-901	335544781	exception_stack_overflow	Stack overflow.The resource requirements of the runtime stack have exceeded the memory available to it
-901	335544782	exception_sigsegv	Segmentation Fault. The code attempted to access memory without privileges
-901	335544783	exception_sigill	Illegal Instruction. The Code attempted to perform an illegal operation
-901	335544784	exception_sigbus	Bus Error. The Code caused a system bus error
-901	335544785	exception_sigfpe	Floating Point Error. The Code caused an Arithmetic Exception or a floating point exception
-901	335544786	ext_file_delete	Cannot delete rows from external files
-901	335544787	ext_file_modify	Cannot update rows in external files
-901	335544788	adm_task_denied	Unable to perform operation.You must be either SYSDBA or owner of the database
-901	335544794	cancelled	Operation was cancelled
-901	335544797	svcnouser	User name and password are required while attaching to the services manager
-901	335544801	datatype_notsup	Data type not supported for arithmetic
-901	335544803	dialect_not_changed	Database dialect not changed
-901	335544804	database_create_failed	Unable to create database @1
-901	335544805	inv_dialect_specified	Database dialect @1 is not a valid dialect

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335544806	valid_db_dialects	Valid database dialects are @1
-901	335544811	inv_client_dialect_specified	Passed client dialect @1 is not a valid dialect
-901	335544812	valid_client_dialects	Valid client dialects are @1
-901	335544814	service_not_supported	Services functionality will be supported in a later version of the product
-901	335544820	invalid_savepoint	Unable to find savepoint with name @1 in transaction context
-901	335544835	bad_shutdown_mode	Target shutdown mode is invalid for database "@1"
-901	335544840	no_update	Cannot update
-901	335544842	stack_trace	@1
-901	335544843	ctx_var_not_found	Context variable @1 is not found in namespace @2
-901	335544844	ctx_namespace_invalid	Invalid namespace name @1 passed to @2
-901	335544845	ctx_too_big	Too many context variables
-901	335544846	ctx_bad_argument	Invalid argument passed to @1
-901	335544847	identifier_too_long	BLR syntax error. Identifier @1... is too long
-901	335544859	invalid_time_precision	Time precision exceeds allowed range (0-@1)
-901	335544866	met_wrong_gtt_scope	@1 cannot depend on @2
-901	335544868	illegal_prc_type	Procedure @1 is not selectable (it does not contain a SUSPEND statement)
-901	335544869	invalid_sort_datatype	Datatype @1 is not supported for sorting operation
-901	335544870	collation_name	COLLATION @1
-901	335544871	domain_name	DOMAIN @1
-901	335544874	max_db_per_trans_allowed	A multi database transaction cannot span more than @1 databases
-901	335544876	bad_proc_BLR	Error while parsing procedure @1's BLR
-901	335544877	key_too_big	Index key too big
-901	336397211	dsql_too_many_values	Too many values ( more than @1) in member list to match against



SQL-CODE	GDSCODE	Symbol	Message Text
-901	336397236	dsql_unsupp_feature_dialect	Feature is not supported in dialect @1
-902	335544333	bug_check	Internal gds software consistency check (@1)
-902	335544335	db_corrupt	Database file appears corrupt (@1)
-902	335544344	io_error	I/O error for file "@2"
-902	335544346	metadata_corrupt	Corrupt system table
-902	335544373	sys_request	Operating system directive @1 failed
-902	335544384	badblk	Internal error
-902	335544385	invpoolcl	Internal error
-902	335544387	relbadblk	Internal error
-902	335544388	blktoobig	Block size exceeds implementation restriction
-902	335544394	badodsver	Incompatible version of on-disk structure
-902	335544397	dirtypage	Internal error
-902	335544398	waitfortra	Internal error
-902	335544399	doubleloc	Internal error
-902	335544400	nodnotfnd	Internal error
-902	335544401	dupnodfnd	Internal error
-902	335544402	locnotmar	Internal error
-902	335544404	corrupt	Database corrupted
-902	335544405	badpage	Checksum error on database page @1
-902	335544406	badindex	Index is broken
-902	335544409	trareqmis	Transaction - request mismatch ( synchronization error )
-902	335544410	badhndcnt	Bad handle count
-902	335544411	wrotpbver	Wrong version of transaction parameter block
-902	335544412	wroblrver	Unsupported BLR version (expected @1, encountered @2)
-902	335544413	wrodpbver	Wrong version of database parameter block
-902	335544415	badrelation	Database corrupted

<b>SQL-CODE</b>	<b>GDSCODE</b>	<b>Symbol</b>	<b>Message Text</b>
-902	335544416	nodetach	Internal error
-902	335544417	notremote	Internal error
-902	335544422	dbfile	Internal error
-902	335544423	orphan	Internal error
-902	335544432	lockmanerr	Lock manager error
-902	335544436	sqlerr	SQL error code = @1
-902	335544448	bad_sec_info	[no associated message]
-902	335544449	invalid_sec_info	[no associated message]
-902	335544470	buf_invalid	Cache buffer for page @1 invalid
-902	335544471	indexnotdefined	There is no index in table @1 with id @2
-902	335544472	login	Your user name and password are not defined. Ask your database administrator to set up a Firebird login
-902	335544506	shutinprog	Database @1 shutdown in progress
-902	335544528	shutdown	Database @1 shutdown
-902	335544557	shutfail	Database shutdown unsuccessful
-902	335544569	dsql_error	Dynamic SQL Error
-902	335544653	psw_attach	Cannot attach to password database
-902	335544654	psw_start_trans	Cannot start transaction for password database
-902	335544717	err_stack_limit	Stack size insufficient to execute current request
-902	335544721	network_error	Unable to complete network request to host "@1"
-902	335544722	net_connect_err	Failed to establish a connection
-902	335544723	net_connect_listen_err	Error while listening for an incoming connection
-902	335544724	net_event_connect_err	Failed to establish a secondary connection for event processing
-902	335544725	net_event_listen_err	Error while listening for an incoming event connection request
-902	335544726	net_read_err	Error reading data from the connection
-902	335544727	net_write_err	Error writing data to the connection

SQL-CODE	GDSCODE	Symbol	Message Text
-902	335544732	unsupported_network_drive	Access to databases on file servers is not supported
-902	335544733	io_create_err	Error while trying to create file
-902	335544734	io_open_err	Error while trying to open file
-902	335544735	io_close_err	Error while trying to close file
-902	335544736	io_read_err	Error while trying to read from file
-902	335544737	io_write_err	Error while trying to write to file
-902	335544738	io_delete_err	Error while trying to delete file
-902	335544739	io_access_err	Error while trying to access file
-902	335544745	login_same_as_role_name	Your login @1 is same as one of the SQL role name. Ask your database administrator to set up a valid Firebird login.
-902	335544791	file_in_use	The file @1 is currently in use by another process. Try again later
-902	335544795	unexp_spb_form	Unexpected item in service parameter block, expected @1
-902	335544809	extern_func_dir_error	Function @1 is in @2, which is not in a permitted directory for external functions
-902	335544819	io_32bit_exceeded_err	File exceeded maximum size of 2GB. Add another database file or use a 64 bit I/O version of Firebird
-902	335544831	conf_access_denied	Access to @1 "@2" is denied by server administrator
-902	335544834	cursor_not_open	Cursor is not open
-902	335544841	cursor_already_open	Cursor is already open
-902	335544856	att_shutdown	Connection shutdown
-902	335544882	long_login	Login name too long (@1 characters, maximum allowed @2)
-904	335544324	bad_db_handle	Invalid database handle (no active connection)
-904	335544375	unavailable	Unavailable database
-904	335544381	imp_exc	Implementation limit exceeded
-904	335544386	nopoolids	Too many requests
-904	335544389	bufexh	Buffer exhausted

SQL-CODE	GDSCODE	Symbol	Message Text
-904	335544391	bufinuse	Buffer in use
-904	335544393	reqinuse	Request in use
-904	335544424	no_lock_mgr	No lock manager available
-904	335544430	virmemexh	Unable to allocate memory from operating system
-904	335544451	update_conflict	Update conflicts with concurrent update
-904	335544453	obj_in_use	Object @1 is in use
-904	335544455	shadow_accessed	Cannot attach active shadow file
-904	335544460	shadow_missing	A file in manual shadow @1 is unavailable
-904	335544661	index_root_page_full	Cannot add index, index root page is full
-904	335544676	sort_mem_err	Sort error: not enough memory
-904	335544683	req_depth_exceeded	Request depth exceeded. (Recursive definition?)
-904	335544758	sort_rec_size_err	Sort record size of @1 bytes is too big ????
-904	335544761	too_many_handles	Too many open handles to database
-904	335544792	service_att_err	Cannot attach to services manager
-904	335544799	svc_name_missing	The service name was not specified
-904	335544813	optimizer_between_err	Unsupported field type specified in BETWEEN predicate
-904	335544827	exec_sql_invalid_arg	Invalid argument in EXECUTE STATEMENT-cannot convert to string
-904	335544828	exec_sql_invalid_req	Wrong request type in EXECUTE STATEMENT '@1'
-904	335544829	exec_sql_invalid_var	Variable type (position @1) in EXECUTE STATEMENT '@2' INTO does not match returned column type
-904	335544830	exec_sql_max_call_exceeded	Too many recursion levels of EXECUTE STATEMENT
-904	335544832	wrong_backup_state	Cannot change difference file name while database is in backup mode
-904	335544852	partner_idx_incompat_type	Partner index segment no @1 has incompatible data type
-904	335544857	blobtoobig	Maximum BLOB size exceeded

<b>SQL-CODE</b>	<b>GDSCODE</b>	<b>Symbol</b>	<b>Message Text</b>
-904	335544862	record_lock_not_supp	Stream does not support record locking
-904	335544863	partner_idx_not_found	Cannot create foreign key constraint @1. Partner index does not exist or is inactive
-904	335544864	tra_num_exc	Transactions count exceeded. Perform backup and restore to make database operable again
-904	335544865	field_disappeared	Column has been unexpectedly deleted
-904	335544878	concurrent_transaction	Concurrent transaction number is @1
-906	335544744	max_att_exceeded	Maximum user count exceeded. Contact your database administrator
-909	335544667	drdb_completed_with_errs	Drop database completed with errors
-911	335544459	rec_in_limbo	Record from transaction @1 is stuck in limbo
-913	335544336	deadlock	Deadlock
-922	335544323	bad_db_format	File @1 is not a valid database
-923	335544421	connect_reject	Connection rejected by remote interface
-923	335544461	cant_validate	Secondary server attachments cannot validate databases
-923	335544464	cant_start_logging	Secondary server attachments cannot start logging
-924	335544325	bad_dpb_content	Bad parameters on attach or create database
-924	335544441	bad_detach	Database detach completed with errors
-924	335544648	conn_lost	Connection lost to pipe server
-926	335544447	no_rollback	No rollback performed
-999	335544689	ib_error	Firebird error

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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 2.5:

ADD	ADMIN	ALL
ALTER	AND	ANY
AS	AT	AVG
BEGIN	BETWEEN	BIGINT
BIT_LENGTH	BLOB	BOTH
BY	CASE	CAST
CHAR	CHAR_LENGTH	CHARACTER
CHARACTER_LENGTH	CHECK	CLOSE
COLLATE	COLUMN	COMMIT
CONNECT	CONSTRAINT	COUNT
CREATE	CROSS	CURRENT
CURRENT_CONNECTION	CURRENT_DATE	CURRENT_ROLE
CURRENT_TIME	CURRENT_TIMESTAMP	CURRENT_TRANSACTION
CURRENT_USER	CURSOR	DATE
DAY	DEC	DECIMAL
DECLARE	DEFAULT	DELETE
DELETING	DISCONNECT	DISTINCT
DOUBLE	DROP	ELSE
END	ESCAPE	EXECUTE
EXISTS	EXTERNAL	EXTRACT
FETCH	FILTER	FLOAT
FOR	FOREIGN	FROM
FULL	FUNCTION	GDSCODE
GLOBAL	GRANT	GROUP
HAVING	hour	IN
INDEX	INNER	INSENSITIVE
INSERT	INSERTING	INT
INTEGER	INTO	IS

JOIN	LEADING	LEFT
LIKE	LONG	LOWER
MAX	MAXIMUM_SEGMENT	MERGE
MIN	MINUTE	MONTH
NATIONAL	NATURAL	NCHAR
NO	NOT	NULL
NUMERIC	OCTET_LENGTH	OF
ON	ONLY	OPEN
OR	ORDER	OUTER
PARAMETER	PLAN	POSITION
POST_EVENT	PRECISION	PRIMARY
PROCEDURE	RDB\$DB_KEY	REAL
RECORD_VERSION	RECREATE	RECURSIVE
REFERENCES	RELEASE	RETURNING_VALUES
RETURNS	REVOKE	RIGHT
ROLLBACK	ROW_COUNT	ROWS
SAVEPOINT	SECOND	SELECT
SENSITIVE	SET	SIMILAR
SMALLINT	SOME	SQLCODE
SQLSTATE (2.5.1)	START	SUM
TABLE	THEN	TIME
TIMESTAMP	TO	TRAILING
TRIGGER	TRIM	UNION
UNIQUE	UPDATE	UPDATING
UPPER	USER	USING
VALUE	VALUES	VARCHAR
VARIABLE	VARYING	VIEW
WHEN	WHERE	WHILE
WITH	YEAR	

## Keywords

The following terms have a special meaning in Firebird 2.5 DSQL. Some of them are also reserved words, others are not.

!<	^<	^=
^>	,	: =
!=	!>	(
)	<	<=
<>	=	>
>=		~<
~=	~>	ABS
ACCENT	ACOS	ACTION
ACTIVE	ADD	ADMIN
AFTER	ALL	ALTER
ALWAYS	AND	ANY
AS	ASC	ASCENDING
ASCII_CHAR	ASCII_VAL	ASIN
AT	ATAN	ATAN2
AUTO	AUTONOMOUS	AVG

BACKUP	BEFORE	BEGIN
BETWEEN	BIGINT	BIN_AND
BIN_NOT	BIN_OR	BIN_SHL
BIN_SHR	BIN_XOR	BIT_LENGTH
BLOB	BLOCK	BOTH
BREAK	BY	CALLER
CASCADE	CASE	CAST
CEIL	CEILING	CHAR
CHAR_LENGTH	CHAR_TO_UUID	CHARACTER
CHARACTER_LENGTH	CHECK	CLOSE
COALESCE	COLLATE	COLLATION
COLUMN	COMMENT	COMMIT
COMMITTED	COMMON	COMPUTED
CONDITIONAL	CONNECT	CONSTRAINT
CONTAINING	COS	COSH
COT	COUNT	CREATE
CROSS	CSTRING	CURRENT
CURRENT_CONNECTION	CURRENT_DATE	CURRENT_ROLE
CURRENT_TIME	CURRENT_TIMESTAMP	CURRENT_TRANSACTION
CURRENT_USER	CURSOR	DATA
DATABASE	DATE	DATEADD
DATEDIFF	DAY	DEC
DECIMAL	DECLARE	DECODE
DEFAULT	DELETE	DELETING
DESC	DESCENDING	DESCRIPTOR
DIFFERENCE	DISCONNECT	DISTINCT
DO	DOMAIN	DOUBLE
DROP	ELSE	END
ENTRY_POINT	ESCAPE	EXCEPTION
EXECUTE	EXISTS	EXIT
EXP	EXTERNAL	EXTRACT
FETCH	FILE	FILTER
FIRST	FIRSTNAME	FLOAT
FLOOR	FOR	FOREIGN
FREE_IT	FROM	FULL
FUNCTION	GDSCODE	GEN_ID
GEN_UUID	GENERATED	GENERATOR
GLOBAL	GRANT	GRANTED
GROUP	HASH	HAVING
HOURL	IF	IGNORE
IIF	IN	INACTIVE
INDEX	INNER	INPUT_TYPE
INSENSITIVE	INSERT	INSERTING
INT	INTEGER	INTO
IS	ISOLATION	JOIN
KEY	LAST	LASTNAME
LEADING	LEAVE	LEFT
LENGTH	LEVEL	LIKE
LIMBO	LIST	LN
LOCK	LOG	LOG10
LONG	LOWER	LPAD
MANUAL	MAPPING	MATCHED



MATCHING	MAX	MAXIMUM_SEGMENT
MAXVALUE	MERGE	MIDDLENAME
MILLISECOND	MIN	MINUTE
MINVALUE	MOD	MODULE_NAME
MONTH	NAMES	NATIONAL
NATURAL	NCHAR	NEXT
NO	NOT	NULL
NULLIF	NULLS	NUMERIC
OCTET_LENGTH	OF	ON
ONLY	OPEN	OPTION
OR	ORDER	OS_NAME
OUTER	OUTPUT_TYPE	OVER
OVERFLOW	OVERLAY	PAD
PAGE	PAGE_SIZE	PAGES
PARAMETER	PASSWORD	PI
PLACING	PLAN	POSITION
POST_EVENT	POWER	PRECISION
PRESERVE	PRIMARY	PRIVILEGES
PROCEDURE	PROTECTED	RAND
RDB\$DB_KEY	READ	REAL
RECORD_VERSION	RECREATE	RECURSIVE
REFERENCES	RELEASE	REPLACE
REQUESTS	RESERV	RESERVING
RESTART	RESTRICT	RETAIN
RETURNING	RETURNING_VALUES	RETURNS
REVERSE	REVOKE	RIGHT
ROLE	ROLLBACK	ROUND
ROW_COUNT	ROW_NUMBER	ROWS
RPAD	SAVEPOINT	SCALAR_ARRAY
SCHEMA	SECOND	SEGMENT
SELECT	SENSITIVE	SEQUENCE
SET	SHADOW	SHARED
SIGN	SIMILAR	SIN
SINGULAR	SINH	SIZE
SKIP	SMALLINT	SNAPSHOT
SOME	SORT	SOURCE
SPACE	SQLCODE	SQLSTATE (2.5.1)
SQRT	STABILITY	START
STARTING	STARTS	STATEMENT
STATISTICS	SUB_TYPE	SUBSTRING
SUM	SUSPEND	TABLE
TAN	TANH	TEMPORARY
THEN	TIME	TIMEOUT
TIMESTAMP	TO	TRAILING
TRANSACTION	TRIGGER	TRIM
TRUNC	TWO_PHASE	TYPE
UNCOMMITTED	UNDO	UNION
UNIQUE	UPDATE	UPDATING
UPPER	USER	USING
UUID_TO_CHAR	VALUE	VALUES
VARCHAR	VARIABLE	VARYING
VIEW	WAIT	WEEK

WEEKDAY  
WHILE  
WRITE

WHEN  
WITH  
YEAR

WHERE  
WORK  
YEARDAY

# 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\$.

**Table D.1. List of System Tables**

System Table	Contents
RDB\$BACKUP_HISTORY	History of backups performed using <i>nBackup</i>
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\$DATABASE	Basic information about the 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\$PAGES	Information about database pages

System Table	Contents
RDB\$PROCEDURE_PARAMETERS	Parameters of stored procedures
RDB\$PROCEDURES	Definitions of stored procedures
RDB\$REF_CONSTRAINTS	Definitions of referential constraints (foreign keys)
RDB\$RELATION_CONSTRAINTS	Definitions of all table-level constraints
RDB\$RELATION_FIELDS	Top-level definitions of table columns
RDB\$RELATIONS	Headers of tables and views
RDB\$ROLES	Role definitions
RDB\$SECURITY_CLASSES	Access control lists
RDB\$TRANSACTIONS	State of multi-database transactions
RDB\$TRIGGER_MESSAGES	Trigger messages
RDB\$TRIGGERS	Trigger definitions
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\$BACKUP\_HISTORY

RDB\$BACKUP\_HISTORY stores the history of backups performed using the *nBackup* utility.

Column Name	Data Type	Description
RDB\$BACKUP_ID	INTEGER	The identifier assigned by the engine
RDB\$TIMESTAMP	TIMESTAMP	Backup date and time
RDB\$BACKUP_LEVEL	INTEGER	Backup level
RDB\$GUID	CHAR(38)	Unique identifier
RDB\$SCN	INTEGER	System (scan) number
RDB\$FILE_NAME	VARCHAR(255)	Full path and file name of backup file

## RDB\$CHARACTER\_SETS

RDB\$CHARACTER\_SETS names and describes the character sets available in the database.

Column Name	Data Type	Description
RDB\$CHARACTER_SET_NAME	CHAR(31)	Character set name
RDB\$FORM_OF_USE	CHAR(31)	Not used
RDB\$NUMBER_OF_CHARACTERS	INTEGER	The number of characters in the set. Not used for existing character sets
RDB\$DEFAULT_COLLATE_NAME	CHAR(31)	The name of the default collation sequence for the character set
RDB\$CHARACTER_SET_ID	SMALLINT	Unique character set identifier
RDB\$SYSTEM_FLAG	SMALLINT	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
RDB\$DESCRIPTION	BLOB TEXT	Could store text description of the character set
RDB\$FUNCTION_NAME	CHAR(31)	For a user-defined character set that is accessed via an external function, the name of the external function
RDB\$BYTES_PER_CHARACTER	SMALLINT	The maximum number of bytes representing one character

## 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).

Column Name	Data Type	Description
RDB\$CONSTRAINT_NAME	CHAR(31)	Constraint name, defined by the user or automatically generated by the system
RDB\$TRIGGER_NAME	CHAR(31)	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

## RDB\$COLLATIONS

RDB\$COLLATIONS stores collation sequences for all character sets.

Column Name	Data Type	Description
RDB\$COLLATION_NAME	CHAR(31)	Collation sequence name
RDB\$COLLATION_ID	SMALLINT	Collation sequence identifier. Together with the character set identifier, it is a unique collation sequence identifier
RDB\$CHARACTER_SET_ID	SMALLINT	Character set identifier. Together with the collection sequence identifier, it is a unique identifier
RDB\$COLLATION_ATTRIBUTES	SMALLINT	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 INSENSITIVE). Thus, the value of 5 means that the collation does not take into account trailing spaces and is accent-insensitive
RDB\$SYSTEM_FLAG	SMALLINT	Flag: the value of 0 means it is user-defined; the value of 1 means it is system-defined
RDB\$DESCRIPTION	BLOB TEXT	Could store text description of the collation sequence
RDB\$FUNCTION_NAME	CHAR(31)	Not currently used
RDB\$BASE_COLLATION_NAME	CHAR(31)	The name of the base collation sequence for this collation sequence
RDB\$SPECIFIC_ATTRIBUTES	BLOB TEXT	Describes specific attributes

## RDB\$DATABASE

RDB\$DATABASE stores basic information about the database. It contains only one record.

Column Name	Data Type	Description
RDB\$DESCRIPTION	BLOB TEXT	Database comment text
RDB\$RELATION_ID	SMALLINT	A number that steps up by one each time a table or view is added to the database
RDB\$SECURITY_CLASS	CHAR(31)	The security class defined in RDB \$SECURITY_CLASSES in order to apply access control limits common to the entire database
RDB\$CHARACTER_SET_NAME	CHAR(31)	The name of the default character set for the database set in the DEFAULT CHARACTER SET clause when the database is created. NULL for character set NONE.

## RDB\$DEPENDENCIES

RDB\$DEPENDENCIES stores the dependencies between database objects.

Column Name	Data Type	Description
RDB\$DEPENDENT_NAME	CHAR(31)	The name of the view, procedure, trigger, CHECK constraint or computed column the dependency is defined for, i.e., the <i>dependent</i> object
RDB\$DEPEDED_ON_NAME	CHAR(31)	The name of the object that the defined object—the table, view, procedure, trigger, CHECK constraint or computed column—depends on
RDB\$FIELD_NAME	CHAR(31)	The column name in the depended-on object that is referred to by the dependent view, procedure, trigger, CHECK constraint or computed column
RDB\$DEPENDENT_TYPE	SMALLINT	Identifies the type of the dependent object: 0 - table 1 - view 2 - trigger 3 - computed column 4 - CHECK constraint 5 - procedure 6 - index expression 7 - exception 8 - user

Column Name	Data Type	Description
		9 - column 10 - index
RDB\$DEPENDED_ON_TYPE	SMALLINT	Identifies the type of the object depended on:  0 - table (or a column in it) 1 - view 2 - trigger 3 - computed column 4 - CHECK constraint 5 - procedure (or its parameter[s]) 6 - index expression 7 - exception 8 - user 9 - column 10 - index 14 - generator (sequence) 15 - UDF 17 - collation

## RDB\$EXCEPTIONS

RDB\$EXCEPTIONS stores custom database exceptions.

Column Name	Data Type	Description
RDB\$EXCEPTION_NAME	CHAR(31)	Custom exception name
RDB\$EXCEPTION_NUMBER	INTEGER	The unique number of the exception assigned by the system
RDB\$MESSAGE	VARCHAR(1021)	Exception message text
RDB\$DESCRIPTION	BLOB TEXT	Could store text description of the exception
RDB\$SYSTEM_FLAG	SMALLINT	Flag: user-defined = 0 system-defined = 1 or higher

## 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.



**Note**

The column `RDB$FIELDS.RDB$FIELD_NAME` links to `RDB$RELATION_FIELDS.RDB$FIELD_SOURCE`, not to `RDB$RELATION_FIELDS.RDB$FIELD_NAME`.

Column Name	Data Type	Description
<code>RDB\$FIELD_NAME</code>	<code>CHAR(31)</code>	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
<code>RDB\$QUERY_NAME</code>	<code>CHAR(31)</code>	Not used
<code>RDB\$VALIDATION_BLR</code>	<code>BLOB BLR</code>	The binary language representation (BLR) of the SQL expression specifying the check of the CHECK value in the domain
<code>RDB\$VALIDATION_SOURCE</code>	<code>BLOB TEXT</code>	The original source text in the SQL language specifying the check of the CHECK value
<code>RDB\$COMPUTED_BLR</code>	<code>BLOB BLR</code>	The binary language representation (BLR) of the SQL expression the database server uses for evaluation when accessing a COMPUTED BY column
<code>RDB\$COMPUTED_SOURCE</code>	<code>BLOB TEXT</code>	The original source text of the expression that defines a COMPUTED BY column
<code>RDB\$DEFAULT_VALUE</code>	<code>BLOB BLR</code>	The default value, if any, for the field or domain, in binary language representation (BLR)
<code>RDB\$DEFAULT_SOURCE</code>	<code>BLOB TEXT</code>	The default value in the source code, as an SQL constant or expression
<code>RDB\$FIELD_LENGTH</code>	<code>SMALLINT</code>	Column size in bytes. FLOAT, DATE, TIME, INTEGER occupy 4 bytes. DOUBLE PRECISION, BIGINT, TIMESTAMP and BLOB identifier occupy 8 bytes. For the CHAR and VARCHAR data types, the column stores the maximum number of bytes specified when a string domain (column) is defined
<code>RDB\$FIELD_SCALE</code>	<code>SMALLINT</code>	The negative number that specifies the scale for DECIMAL and NUMERIC columns—the number of digits after the decimal point
<code>RDB\$FIELD_TYPE</code>	<code>SMALLINT</code>	Data type code for the column: 7 = SMALLINT 8 = INTEGER 10 = FLOAT

Column Name	Data Type	Description
		12 = DATE 13 = TIME 14 = CHAR 16 = BIGINT 27 = DOUBLE PRECISION 35 = TIMESTAMP 37 = VARCHAR 261 = BLOB Codes for DECIMAL and NUMERIC are the same as for the integer types used to store them
RDB\$FIELD_SUB_TYPE	SMALLINT	<p>Specifies the subtype for the BLOB data type:</p> 0 - untyped 1 - text 2 - BLR 3 - access control list 4 - reserved for future use 5 - encoded table metadata description 6 - for storing the details of a cross-database transaction that ends abnormally
		<p>Specifies for the CHAR data type:</p> 0 - untyped data 1 - fixed binary data
		<p>Specifies the particular data type for the integer data types (SMALLINT, INTEGER, BIGINT) and for fixed-point numbers (NUMERIC, DECIMAL):</p> 0 or NULL - the data type matches the value in the RDB\$FIELD_TYPE field 1 - NUMERIC 2 - DECIMAL
RDB\$MISSING_VALUE	BLOB BLR	Not used
RDB\$MISSING_SOURCE	BLOB TEXT	Not used
RDB\$DESCRIPTION	BLOB TEXT	Any domain (table column) comment text
RDB\$SYSTEM_FLAG	SMALLINT	Flag: the value of 1 means the domain is automatically created by the system, the value of 0 means that the domain is defined by the user
RDB\$QUERY_HEADER	BLOB TEXT	Not used

Column Name	Data Type	Description
RDB\$SEGMENT_LENGTH	SMALLINT	Specifies the length of the BLOB buffer in bytes for BLOB columns. Stores NULL for all other data types
RDB\$EDIT_STRING	VARCHAR(127)	Not used
RDB\$EXTERNAL_LENGTH	SMALLINT	The length of the column in bytes if it belongs to an external table. Always NULL for regular tables
RDB\$EXTERNAL_SCALE	SMALLINT	The scale factor of an integer-type field in an external table; represents the power of 10 by which the integer is multiplied
RDB\$EXTERNAL_TYPE	SMALLINT	The data type of the field as it is represented in an external table:  7 = SMALLINT 8 = INTEGER 10 = FLOAT 12 = DATE 13 = TIME 14 = CHAR 16 = BIGINT 27 = DOUBLE PRECISION 35 = TIMESTAMP 37 = VARCHAR 261 = BLOB
RDB\$DIMENSIONS	SMALLINT	Defines the number of dimensions in an array if the column is defined as an array. Always NULL for columns that are not arrays
RDB\$NULL_FLAG	SMALLINT	Specifies whether the column can take an empty value (the field will contain NULL) or not (the field will contain the value of 1)
RDB\$CHARACTER_LENGTH	SMALLINT	The length of CHAR or VARCHAR columns in characters (not in bytes)
RDB\$COLLATION_ID	SMALLINT	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
RDB\$CHARACTER_SET_ID	SMALLINT	The identifier of the character set for a character column, BLOB TEXT column or domain
RDB\$FIELD_PRECISION	SMALLINT	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

## RDB\$FIELD\_DIMENSIONS

RDB\$FIELD\_DIMENSIONS stores the dimensions of array columns.

Column Name	Data Type	Description
RDB\$FIELD_NAME	CHAR(31)	The name of the array column. It must be present in the RDB\$FIELD_NAME field of the RDB\$FIELDS table
RDB\$DIMENSION	SMALLINT	Identifies one dimension in the array column. The numbering of dimensions starts with 0
RDB\$LOWER_BOUND	INTEGER	The lower bound of this dimension
RDB\$UPPER_BOUND	INTEGER	The upper bound of this dimension

## RDB\$FILES

RDB\$FILES stores information about secondary files and shadow files.

Column Name	Data Type	Description
RDB\$FILE_NAME	VARCHAR(255)	The full path to the file and the name of either <ul style="list-style-type: none"><li>the database secondary file in a multi-file database, or</li><li>the shadow file</li></ul>
RDB\$FILE_SEQUENCE	SMALLINT	The sequential number of the secondary file in a sequence or of the shadow file in a shadow file set
RDB\$FILE_START	INTEGER	The initial page number in the secondary file or shadow file
RDB\$FILE_LENGTH	INTEGER	File length in database pages
RDB\$FILE_FLAGS	SMALLINT	For internal use
RDB\$SHADOW_NUMBER	SMALLINT	Shadow set number. If the row describes a database secondary file, the field will be NULL or its value will be 0

## RDB\$FILTERS

RDB\$FILTERS stores information about BLOB filters.

Column Name	Data Type	Description
RDB\$FUNCTION_NAME	CHAR(31)	The unique identifier of the BLOB filter
RDB\$DESCRIPTION	BLOB TEXT	Documentation about the BLOB filter and the two subtypes it is used with, written by the user
RDB\$MODULE_NAME	VARCHAR(255)	The name of the dynamic library or shared object where the code of the BLOB filter is located
RDB\$ENTRYPOINT	CHAR(31)	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
RDB\$INPUT_SUB_TYPE	SMALLINT	The BLOB subtype of the data to be converted by the function
RDB\$OUTPUT_SUB_TYPE	SMALLINT	The BLOB subtype of the converted data
RDB\$SYSTEM_FLAG	SMALLINT	Flag indicating whether the filter is user-defined or internally defined: <ul style="list-style-type: none"> <li>0 = user-defined</li> <li>1 or greater = internally defined</li> </ul>

## 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, 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.

Column Name	Data Type	Description
RDB\$RELATION_ID	SMALLINT	Table or view identifier

Column Name	Data Type	Description
RDB\$FORMAT	SMALLINT	Table format identifier—maximum 255. The critical time comes when this number approaches 255 for <i>any</i> table or view
RDB\$DESCRIPTOR	BLOB FORMAT	Stores column names and data attributes as BLOB, as they were at the time the format record was created

## RDB\$FUNCTIONS

RDB\$FUNCTIONS stores the information needed by the engine about external functions (user-defined functions, UDFs).

### Note

In future major releases (Firebird 3.0 +) RDB\$FUNCTIONS will also store the information about stored functions: user-defined functions written in PSQL.

Column Name	Data Type	Description
RDB\$FUNCTION_NAME	CHAR(31)	The unique (declared) name of the external function
RDB\$FUNCTION_TYPE	SMALLINT	Not currently used
RDB\$QUERY_NAME	CHAR(31)	Not currently used
RDB\$DESCRIPTION	BLOB TEXT	Any text with comments related to the external function
RDB\$MODULE_NAME	VARCHAR(255)	The name of the dynamic library or shared object where the code of the external function is located
RDB\$ENTRYPOINT	CHAR(31)	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
RDB\$RETURN_ARGUMENT	SMALLINT	The position number of the returned argument in the list of parameters corresponding to input arguments
RDB\$SYSTEM_FLAG	SMALLINT	Flag indicating whether the filter is user-defined or internally defined:

Column Name	Data Type	Description
		<ul style="list-style-type: none"> <li>0 = user-defined</li> <li>1 = internally defined</li> </ul>

## RDB\$FUNCTION\_ARGUMENTS

RDB\$FUNCTION\_ARGUMENTS stores the parameters of external functions and their attributes.

Column Name	Data Type	Description
RDB\$FUNCTION_NAME	CHAR(31)	The unique name (declared identifier) of the external function
RDB\$ARGUMENT_POSITION	SMALLINT	The position of the argument in the list of arguments
RDB\$MECHANISM	SMALLINT	Flag: how this argument is passed: <ul style="list-style-type: none"> <li>0 = by value</li> <li>1 = by reference</li> <li>2 = by descriptor</li> <li>3 = by BLOB descriptor</li> </ul>
RDB\$FIELD_TYPE	SMALLINT	Data type code defined for the column: 7 = SMALLINT 8 = INTEGER 12 = DATE 13 = TIME 14 = CHAR 16 = BIGINT 27 = DOUBLE PRECISION 35 = TIMESTAMP 37 = VARCHAR 261 = BLOB 40 = CSTRING (null-terminated text) 45 = BLOB_ID 261 = BLOB
RDB\$FIELD_SCALE	SMALLINT	The scale of an integer or a fixed-point argument. It is an exponent of 10
RDB\$FIELD_LENGTH	SMALLINT	Argument length in bytes: SMALLINT = 2 INTEGER = 4 DATE = 4

Column Name	Data Type	Description
		TIME = 4 BIGINT = 8 DOUBLE PRECISION = 8 TIMESTAMP = 8 BLOB_ID = 8
RDB\$FIELD_SUB_TYPE	SMALLINT	Stores the BLOB subtype for an argument of a BLOB data type
RDB\$CHARACTER_SET_ID	SMALLINT	The identifier of the character set for a character argument
RDB\$FIELD_PRECISION	SMALLINT	The number of digits of precision available for the data type of the argument
RDB\$CHARACTER_LENGTH	SMALLINT	The length of a CHAR or VARCHAR argument in characters (not in bytes)

## RDB\$GENERATORS

RDB\$GENERATORS stores generators (sequences) and keeps them up-to-date.

Column Name	Data Type	Description
RDB\$GENERATOR_NAME	CHAR(31)	The unique name of the generator
RDB\$GENERATOR_ID	SMALLINT	The unique identifier assigned to the generator by the system
RDB\$SYSTEM_FLAG	SMALLINT	Flag: 0 = user-defined 1 or greater = system-defined
RDB\$DESCRIPTION	BLOB TEXT	Could store comments related to the generator

## RDB\$INDICES

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.



Column Name	Data Type	Description
RDB\$INDEX_NAME	CHAR(31)	The unique name of the index specified by the user or automatically generated by the system
RDB\$RELATION_NAME	CHAR(31)	The name of the table to which the index belongs. It corresponds to an identifier in RDB\$RELATION_NAME.RDB\$RELATIONS
RDB\$INDEX_ID	SMALLINT	The internal (system) identifier of the index
RDB\$UNIQUE_FLAG	SMALLINT	Specifies whether the index is unique: 1 - unique 0 - not unique
RDB\$DESCRIPTION	BLOB TEXT	Could store comments concerning the index
RDB\$SEGMENT_COUNT	SMALLINT	The number of segments (columns) in the index
RDB\$INDEX_INACTIVE	SMALLINT	Indicates whether the index is currently active: 1 - inactive 0 - active
RDB\$INDEX_TYPE	SMALLINT	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
RDB\$FOREIGN_KEY	CHAR(31)	The name of the associated Foreign Key constraint, if any
RDB\$SYSTEM_FLAG	SMALLINT	Indicates whether the index is system-defined or user-defined: 1 or greater - system-defined 0 - user-defined
RDB\$EXPRESSION_BLR	BLOB BLR	Expression for an expression index, written in the binary language representation (BLR), used for calculating the values for the index at runtime.
RDB\$EXPRESSION_SOURCE	BLOB TEXT	The source code of the expression for an expression index
RDB\$STATISTICS	DOUBLE PRECISION	Stores the last known selectivity of the entire index, calculated by execution of a SET STATISTICS statement over the index. It is

Column Name	Data Type	Description
		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.

## 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.

Column Name	Data Type	Description
RDB\$INDEX_NAME	CHAR(31)	The name of the index this segment is related to. The master record is RDB\$INDICES.RDB\$INDEX_NAME.
RDB\$FIELD_NAME	CHAR(31)	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
RDB\$FIELD_POSITION	SMALLINT	The column position in the index. Positions are numbered left-to-right, starting at zero
RDB\$STATISTICS	DOUBLE PRECISION	The last known (calculated) selectivity of this column in the index. The higher the number, the lower the selectivity.

## RDB\$LOG\_FILES

RDB\$LOG\_FILES is not currently used.

## RDB\$PAGES

RDB\$PAGES stores and maintains information about database pages and their usage.

Column Name	Data Type	Description
RDB\$PAGE_NUMBER	INTEGER	The unique number of a physically created database page
RDB\$RELATION_ID	SMALLINT	The identifier of the table to which the page is allocated
RDB\$PAGE_SEQUENCE	INTEGER	The number of the page in the sequence of all pages allocated to this table
RDB\$PAGE_TYPE	SMALLINT	Indicates the page type (data, index, BLOB, etc.). For system use

## RDB\$PROCEDURES

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.

Column Name	Data Type	Description
RDB\$PROCEDURE_NAME	CHAR(31)	Stored procedure name (identifier)
RDB\$PROCEDURE_ID	SMALLINT	The procedure's unique, system-generated identifier
RDB\$PROCEDURE_INPUTS	SMALLINT	Indicates the number of input parameters. NULL if there are none
RDB\$PROCEDURE_OUTPUTS	SMALLINT	Indicates the number of output parameters. NULL if there are none
RDB\$DESCRIPTION	BLOB TEXT	Any text comments related to the procedure
RDB\$PROCEDURE_SOURCE	BLOB TEXT	The PSQL source code of the procedure
RDB\$PROCEDURE_BLR	BLOB BLR	The binary language representation (BLR) of the procedure code
RDB\$SECURITY_CLASS	CHAR(31)	May point to the security class defined in the system table RDB\$SECURITY_CLASSES in order to apply access control limits
RDB\$OWNER_NAME	CHAR(31)	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
RDB\$RUNTIME	BLOB	A metadata description of the procedure, used internally for optimization

Column Name	Data Type	Description
RDB\$SYSTEM_FLAG	SMALLINT	Indicates whether the procedure is defined by a user (value 0) or by the system (a value of 1 or greater)
RDB\$PROCEDURE_TYPE	SMALLINT	Procedure type:  1 - selectable stored procedure (contains a SUSPEND statement) 2 - executable stored procedure NULL - not known *  * for procedures created before Firebird 1.5
RDB\$VALID_BLR	SMALLINT	Indicates whether the source PSQL of the stored procedure remains valid after the latest ALTER PROCEDURE modification
RDB\$DEBUG_INFO	BLOB	Contains debugging information about variables used in the stored procedure

## RDB\$PROCEDURE\_PARAMETERS

RDB\$PROCEDURE\_PARAMETERS stores the parameters of stored procedures and their attributes. It holds one row for each parameter.

Column Name	Data Type	Description
RDB\$PARAMETER_NAME	CHAR(31)	Parameter name
RDB\$PROCEDURE_NAME	CHAR(31)	The name of the procedure where the parameter is defined
RDB\$PARAMETER_NUMBER	SMALLINT	The sequential number of the parameter
RDB\$PARAMETER_TYPE	SMALLINT	Indicates whether the parameter is for input (value 0) or output (value 1)
RDB\$FIELD_SOURCE	CHAR(31)	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.
RDB\$DESCRIPTION	BLOB TEXT	Could store comments related to the parameter
RDB\$SYSTEM_FLAG	SMALLINT	Indicates whether the parameter was defined by the system (value or greater) or by a user (value 0)

Column Name	Data Type	Description
RDB\$DEFAULT_VALUE	BLOB BLR	The default value for the parameter, in the binary language representation (BLR)
RDB\$DEFAULT_SOURCE	BLOB TEXT	The default value for the parameter, in PSQL code
RDB\$COLLATION_ID	SMALLINT	The identifier of the collation sequence used for a character parameter
RDB\$NULL_FLAG	SMALLINT	The flag indicating whether NULL is allowable
RDB\$PARAMETER_MECHANISM	SMALLINT	Flag: indicates how this parameter is passed: <ul style="list-style-type: none"> <li>• 0 = by value</li> <li>• 1 = by reference</li> <li>• 2 = by descriptor</li> <li>• 3 = by BLOB descriptor</li> </ul>
RDB\$FIELD_NAME	CHAR(31)	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(31)	The name of the table the parameter references, if it was declared using TYPE OF COLUMN instead of a regular data type

## RDB\$REF\_CONSTRAINTS

RDB\$REF\_CONSTRAINTS stores the attributes of the referential constraints—Foreign Key relationships and referential actions.

Column Name	Data Type	Description
RDB\$CONSTRAINT_NAME	CHAR(31)	Foreign key constraint name, defined by the user or automatically generated by the system
RDB\$CONST_NAME_UQ	CHAR(31)	The name of the primary or unique key constraint linked by the REFERENCES clause in the constraint definition
RDB\$MATCH_OPTION	CHAR(7)	Not used. The current value is FULL in all cases

Column Name	Data Type	Description
RDB\$UPDATE_RULE	CHAR(11)	Referential integrity actions applied to the foreign key record[s] when the primary (unique) key of the parent table is updated: RESTRICT, NO ACTION, CASCADE, SET NULL, SET DEFAULT
RDB\$DELETE_RULE	CHAR(11)	Referential integrity actions applied to the foreign key record[s] when the primary (unique) key of the parent table is deleted: RESTRICT, NO ACTION, CASCADE, SET NULL, SET DEFAULT

## RDB\$RELATIONS

RDB\$RELATIONS stores the top-level definitions and attributes of all tables and views in the system.

Column Name	Data Type	Description
RDB\$VIEW_BLR	BLOB BLR	Stores the query specification for a view, in the binary language representation (BLR). The field stores NULL for a table
RDB\$VIEW_SOURCE	BLOB TEXT	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
RDB\$DESCRIPTION	BLOB TEXT	Could store comments related to the table or view
RDB\$RELATION_ID	SMALLINT	Internal identifier of the table or view
RDB\$SYSTEM_FLAG	SMALLINT	indicates whether the table or view is user-defined (value 0) or system-defined (value 1 or greater)
RDB\$DBKEY_LENGTH	SMALLINT	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
RDB\$FORMAT	SMALLINT	Internal use, points to the relation's record in RDB\$FORMATS—do not modify
RDB\$FIELD_ID	SMALLINT	The field ID for the next column to be added. The number is not decremented when a column is dropped.

Column Name	Data Type	Description
RDB\$RELATION_NAME	CHAR(31)	Table or view name
RDB\$SECURITY_CLASS	CHAR(31)	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
RDB\$EXTERNAL_FILE	VARCHAR(255)	The full path to the external data file if the table is defined with the EXTERNAL FILE clause
RDB\$RUNTIME	BLOB	Table metadata description, used internally for optimization
RDB\$EXTERNAL_DESCRIPTION	BLOB	Could store comments related to the external file of an external table
RDB\$OWNER_NAME	CHAR(31)	The user name of the user who created the table or view originally
RDB\$DEFAULT_CLASS	CHAR(31)	Default security class, used when a new column is added to the table
RDB\$FLAGS	SMALLINT	Internal flags
RDB\$RELATION_TYPE	SMALLINT	The type of the relation object being described:  0 - system or user-defined table 1 - view 2 - external table 3 - monitoring table 4 - connection-level GTT (PRESERVE ROWS) 5 - transaction-level GTT (DELETE ROWS)

## RDB\$RELATION\_CONSTRAINTS

RDB\$RELATION\_CONSTRAINTS stores the definitions of all table-level constraints: primary, unique, foreign key, CHECK, NOT NULL constraints.

Column Name	Data Type	Description
RDB\$CONSTRAINT_NAME	CHAR(31)	The name of the table-level constraint defined by the user, or otherwise automatically generated by the system

Column Name	Data Type	Description
RDB\$CONSTRAINT_TYPE	CHAR(11)	The name of the constraint type: PRIMARY KEY, UNIQUE, FOREIGN KEY, CHECK or NOT NULL
RDB\$RELATION_NAME	CHAR(31)	The name of the table this constraint applies to
RDB\$DEFERRABLE	CHAR(3)	Currently NO in all cases: Firebird does not yet support deferrable constraints
RDB\$INITIALLY_DEFERRED	CHAR(3)	Currently NO in all cases
RDB\$INDEX_NAME	CHAR(31)	The name of the index that supports this constraint. For a CHECK or a NOT NULL constraint, it is NULL.

## RDB\$RELATION\_FIELDS

RDB\$RELATION\_FIELDS stores the definitions of table and view columns.

Column Name	Data Type	Description
RDB\$FIELD_NAME	CHAR(31)	Column name
RDB\$RELATION_NAME	CHAR(31)	The name of the table or view that the column belongs to
RDB\$FIELD_SOURCE	CHAR(31)	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.
RDB\$QUERY_NAME	CHAR(31)	Not currently used
RDB\$BASE_FIELD	CHAR(31)	Only populated for a view, it is the name of the column from the base table
RDB\$EDIT_STRING	VARCHAR(127)	Not used
RDB\$FIELD_POSITION	SMALLINT	The zero-based ordinal position of the column in the table or view, numbering from left to right
RDB\$QUERY_HEADER	BLOB TEXT	Not used
RDB\$UPDATE_FLAG	SMALLINT	Indicates whether the column is a regular one (value 1) or a computed one (value 0)



Column Name	Data Type	Description
RDB\$FIELD_ID	SMALLINT	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
RDB\$VIEW_CONTEXT	SMALLINT	For a view column, the internal identifier of the base table from which this field derives
RDB\$DESCRIPTION	BLOB TEXT	Comments related to the table or view column
RDB\$DEFAULT_VALUE	BLOB BLR	The value stored for the DEFAULT clause for this column, if there is one, written in binary language representation (BLR)
RDB\$SYSTEM_FLAG	SMALLINT	Indicates whether the column is user-defined (value 0) or system-defined (value 1 or greater)
RDB\$SECURITY_CLASS	CHAR(31)	May reference a security class defined in RDB\$SECURITY_CLASSES, in order to apply access control limits to all users of this column
RDB\$COMPLEX_NAME	CHAR(31)	Not used
RDB\$NULL_FLAG	SMALLINT	Indicates whether the column is nullable (NULL) non-nullable (value 1)
RDB\$DEFAULT_SOURCE	BLOB TEXT	The source text of the DEFAULT clause, if any
RDB\$COLLATION_ID	SMALLINT	The identifier of the collation sequence in the character set for the column, if it is not the default collation

## RDB\$ROLES

RDB\$ROLES stores the roles that have been defined in this database.

Column Name	Data Type	Description
RDB\$ROLE_NAME	CHAR(31)	Role name
RDB\$OWNER_NAME	CHAR(31)	The user name of the role owner
RDB\$DESCRIPTION	BLOB TEXT	Could store comments related to the role
RDB\$SYSTEM_FLAG	SMALLINT	System flag

## RDB\$SECURITY\_CLASSES

RDB\$SECURITY\_CLASSES stores the access control lists

Column Name	Data Type	Description
RDB\$SECURITY_CLASS	CHAR(31)	Security class name
RDB\$ACL	BLOB ACL	The access control list related to the security class. It enumerates users and their privileges
RDB\$DESCRIPTION	BLOB TEXT	Could store comments related to the security class

## 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

Column Name	Data Type	Description
RDB\$TRANSACTION_ID	INTEGER	The unique identifier of the transaction being tracked
RDB\$TRANSACTION_STATE	SMALLINT	Transaction state: 0 - in limbo 1 - committed 2 - rolled back
RDB\$TIMESTAMP	TIMESTAMP	Not used
RDB\$TRANSACTION_DESCRIPTION	BLOB	Describes the prepared transaction and could be a custom message supplied to <code>isc_prepare_transaction2</code> , even if it is not a distributed transaction. It may be used when a lost connection cannot be re-stored

## RDB\$TRIGGERS

RDB\$TRIGGERS stores the trigger definitions for all tables and views.

Column Name	Data Type	Description
RDB\$TRIGGER_NAME	CHAR(31)	Trigger name
RDB\$RELATION_NAME	CHAR(31)	The name of the table or view the trigger applies to. NULL if the trigger is applicable to a database event (“database trigger”)
RDB\$TRIGGER_SEQUENCE	SMALLINT	Position of this trigger in the sequence. Zero usually means that no sequence position is specified
RDB\$TRIGGER_TYPE	SMALLINT	<p>The event the trigger fires on:</p> <ul style="list-style-type: none"> <li>1 - before insert</li> <li>2 - after insert</li> <li>3 - before update</li> <li>4 - after update</li> <li>5 - before delete</li> <li>6 - after delete</li> <li>17 - before insert or update</li> <li>18 - after insert or update</li> <li>25 - before insert or delete</li> <li>26 - after insert or delete</li> <li>27 - before update or delete</li> <li>28 - after update or delete</li> <li>113 - before insert or update or delete</li> <li>114 - after insert or update or delete</li> <li>8192 - on connect</li> <li>8193 - on disconnect</li> <li>8194 - on transaction start</li> <li>8195 - on transaction commit</li> <li>8196 - on transaction rollback</li> </ul>
<p>Identification of the exact RDB\$TRIGGER_TYPE code is a little more complicated, since it is a bitmap, calculated according to which phase and events are covered and the order in which they are defined. For the curious, the calculation is explained in <a href="#">this blog by Mark Rotteveel</a>.</p>		
RDB\$TRIGGER_SOURCE	BLOB TEXT	Stores the source code of the trigger in PSQL

Column Name	Data Type	Description
RDB\$TRIGGER_BLR	BLOB BLR	Stores the trigger in the binary language representation (BLR)
RDB\$DESCRIPTION	BLOB TEXT	Trigger comment text
RDB\$TRIGGER_INACTIVE	SMALLINT	Indicates whether the trigger is currently inactive (1) or active (0)
RDB\$SYSTEM_FLAG	SMALLINT	Flag: indicates whether the trigger is user-defined (value 0) or system-defined (value 1 or greater)
RDB\$FLAGS	SMALLINT	Internal use
RDB\$VALID_BLR	SMALLINT	Indicates whether the text of the trigger remains valid after the latest modification by the ALTER TRIGGER statement
RDB\$DEBUG_INFO	BLOB	Contains debugging information about variables used in the trigger

## RDB\$TRIGGER\_MESSAGES

RDB\$TRIGGER\_MESSAGES stores the trigger messages.

Column Name	Data Type	Description
RDB\$TRIGGER_NAME	CHAR(31)	The name of the trigger the message is associated with
RDB\$MESSAGE_NUMBER	SMALLINT	The number of the message within this trigger (from 1 to 32,767)
RDB\$MESSAGE	VARCHAR(1023)	Text of the trigger message

## RDB\$TYPES

RDB\$TYPES stores the defining sets of enumerated types used throughout the system.

Column Name	Data Type	Description
RDB\$FIELD_NAME	CHAR(31)	Enumerated type name. Each type name masters its own set of types, e.g., object

Column Name	Data Type	Description
		types, data types, character sets, trigger types, blob subtypes, etc.
RDB\$TYPE	SMALLINT	<p>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:</p> <p>0 - TABLE  1 - VIEW  2 - TRIGGER  3 - COMPUTED_FIELD  4 - VALIDATION  5 - PROCEDURE  ...</p>
RDB\$TYPE_NAME	CHAR(31)	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.

Column Name	Data Type	Description
RDB\$USER	CHAR(31)	The user or object that is granted this privilege
RDB\$GRANTOR	CHAR(31)	The user who grants the privilege
RDB\$PRIVILEGE	CHAR(6)	<p>The privilege granted hereby:</p> <p>A - all (all privileges)  S - select (selecting data)  I - insert (inserting rows)</p>

Column Name	Data Type	Description
		D - delete (deleting rows) R - references (foreign key) U - update (updating data) E - executing (procedure)
RDB\$GRANT_OPTION	SMALLINT	Whether the WITH GRANT OPTION authority is included with the privilege:  1 - included 0 - not included
RDB\$RELATION_NAME	CHAR(31)	The name of the object (table, view, procedure or role) the privilege is granted ON
RDB\$FIELD_NAME	CHAR(31)	The name of the column the privilege is applicable to, for a column-level privilege (an UPDATE or REFERENCES privilege)
RDB\$USER_TYPE	SMALLINT	Identifies the type of user the privilege is granted TO (a user, a procedure, a view, etc.)
RDB\$OBJECT_TYPE	SMALLINT	Identifies the type of the object the privilege is granted ON

## 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.

Column Name	Data Type	Description
RDB\$VIEW_NAME	CHAR(31)	View name
RDB\$RELATION_NAME	CHAR(31)	The name of the table the view references
RDB\$VIEW_CONTEXT	SMALLINT	The alias used to reference the view column in the BLR code of the query definition
RDB\$CONTEXT_NAME	CHAR(255)	The text associated with the alias reported in the RDB\$VIEW_CONTEXT column

# 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

#### Warning

In a highly loaded environment, collecting information via the monitoring tables could have a negative impact on system performance.

**Table E.1. List of Monitoring Tables**

System Table	Contents
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\$MEMORY_USAGE	Memory usage statistics
MON\$RECORD_STATS	Record-level statistics

System Table	Contents
MON\$STATEMENTS	Statements prepared for execution
MON\$TRANSACTIONS	Started transactions

## MON\$ATTACHMENTS

MON\$ATTACHMENTS displays information about active attachments to the database.

Column Name	Data Type	Description
MON\$ATTACHMENT_ID	INTEGER	Connection identifier
MON\$SERVER_PID	INTEGER	Server process identifier
MON\$STATE	SMALLINT	Connection state: 0 - idle 1 - active
MON\$ATTACHMENT_NAME	VARCHAR(255)	Connection string—the file name and full path to the primary database file
MON\$USER	CHAR(31)	The name of the user who is using this connection
MON\$ROLE	CHAR(31)	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
MON\$GARBAGE_COLLECTION	SMALLINT	Garbage collection flag (as specified in the attachment's DPB): 1=allowed, 0=not allowed
MON\$REMOTE_PROCESS	VARCHAR(255)	The full file name and path to the executable file that established this connection



Column Name	Data Type	Description
MON\$STAT_ID	INTEGER	Statistics identifier

## 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
- Later attempts to use this connection (i.e., use its handle in API calls) will return errors

*Example:* 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.

Column Name	Data Type	Description
MON\$CALL_ID	INTEGER	Call identifier
MON\$STATEMENT_ID	INTEGER	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
MON\$CALLER_ID	INTEGER	The identifier of the calling trigger or stored procedure
MON\$OBJECT_NAME	CHAR(31)	PSQL object (module) name
MON\$OBJECT_TYPE	SMALLINT	PSQL object type (trigger or stored procedure): 2 - trigger

Column Name	Data Type	Description
		5 - stored procedure
MON\$TIMESTAMP	TIMESTAMP	The date and time when the call was started
MON\$SOURCE_LINE	INTEGER	The number of the source line in the SQL statement being executed at the moment of the snapshot
MON\$SOURCE_COLUMN	INTEGER	The number of the source column in the SQL statement being executed at the moment of the snapshot
MON\$STAT_ID	INTEGER	Statistics identifier

*EXECUTE STATEMENT Calls:* Information about calls during the execution of the EXECUTE STATEMENT statement does not get into the call stack.

*Example using MON\$CALL\_STACK:* Getting the call stack for all connections except own:

```
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
```

## MON\$CONTEXT\_VARIABLES

MON\$CONTEXT\_VARIABLES displays information about custom context variables.

Column Name	Data Type	Description
MON\$ATTACHMENT_ID	INTEGER	Connection identifier. It contains a valid value only for a connection-level context variable. For transaction-level variables it is NULL.

Column Name	Data Type	Description
MON\$TRANSACTION_ID	INTEGER	Transaction identifier. It contains a valid value only for transaction-level context variables. For connection-level variables it is NULL.
MON\$VARIABLE_NAME	VARCHAR(80)	Context variable name
MON\$VARIABLE_VALUE	VARCHAR(255)	Context variable value

## MON\$DATABASE

MON\$DATABASE displays the header information from the database the current user is connected to.

Column Name	Data Type	Description
MON\$DATABASE_NAME	VARCHAR(255)	The file name and full path of the primary database file, or the database alias
MON\$PAGE_SIZE	SMALLINT	Database page size in bytes
MON\$ODS_MAJOR	SMALLINT	Major ODS version, e.g., 11
MON\$ODS_MINOR	SMALLINT	Minor ODS version, e.g., 2
MON\$OLDEST_TRANSACTION	INTEGER	The number of the oldest [interesting] transaction (OIT)
MON\$OLDEST_ACTIVE	INTEGER	The number of the oldest active transaction (OAT)
MON\$OLDEST_SNAPSHOT	INTEGER	The number of the transaction that was active at the moment when the OAT was started - oldest snapshot transaction (OST)
MON\$NEXT_TRANSACTION	INTEGER	The number of the next transaction, as it stood when the monitoring snapshot was taken
MON\$PAGE_BUFFERS	INTEGER	The number of pages allocated in RAM for the database page cache
MON\$SQL_DIALECT	SMALLINT	Database SQL Dialect: 1 or 3
MON\$SHUTDOWN_MODE	SMALLINT	The current shutdown state of the database: 0 - the database is online 1 - multi-user shutdown 2 - single-user shutdown 3 - full shutdown

Column Name	Data Type	Description
MON\$SWEEP_INTERVAL	INTEGER	Sweep interval
MON\$READ_ONLY	SMALLINT	Flag indicating whether the database is read-only (value 1) or read-write (value 0)
MON\$FORCED_WRITES	SMALLINT	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)
MON\$RESERVE_SPACE	SMALLINT	The flag indicating reserve_space (value 1) or use_all_space (value 0) for filling database pages
MON\$CREATION_DATE	TIMESTAMP	The date and time when the database was created or was last restored
MON\$PAGES	BIGINT	The number of pages allocated for the database on an external device
MON\$STAT_ID	INTEGER	Statistics identifier
MON\$BACKUP_STATE	SMALLINT	Current physical backup (nBackup) state: 0 - normal 1 - stalled 2 - merge

## MON\$IO\_STATS

MON\$IO\_STATS displays input/output statistics. The counters are cumulative, by group, for each group of statistics.

Column Name	Data Type	Description
MON\$STAT_ID	INTEGER	Statistics identifier
MON\$STAT_GROUP	SMALLINT	Statistics group: 0 - database 1 - connection 2 - transaction 3 - statement 4 - call
MON\$PAGE_READS	BIGINT	Count of database pages read
MON\$PAGE_WRITES	BIGINT	Count of database pages written to

Column Name	Data Type	Description
MON\$PAGE_FETCHES	BIGINT	Count of database pages fetched
MON\$PAGE_MARKS	BIGINT	Count of database pages marked

## MON\$MEMORY\_USAGE

MON\$MEMORY\_USAGE displays memory usage statistics.

Column Name	Data Type	Description
MON\$STAT_ID	INTEGER	Statistics identifier
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

### Note

Not all records in this table have non-zero values. MON\$DATABASE and objects related to memory allocation have non-zero values. Minor memory allocations are not accrued here but are added to the database memory pool instead.

## MON\$RECORD\_STATS

MON\$RECORD\_STATS displays record-level statistics. The counters are cumulative, by group, for each group of statistics.

Column Name	Data Type	Description
MON\$STAT_ID	INTEGER	Statistics identifier
MON\$STAT_GROUP	SMALLINT	Statistics group: 0 - database 1 - connection 2 - transaction 3 - statement 4 - call
MON\$RECORD_SEQ_READS	BIGINT	Count of records read sequentially
MON\$RECORD_IDX_READS	BIGINT	Count of records read via an index
MON\$RECORD_INSERTS	BIGINT	Count of inserted records
MON\$RECORD_UPDATES	BIGINT	Count of updated records
MON\$RECORD_DELETES	BIGINT	Count of deleted records
MON\$RECORD_BACKOUTS	BIGINT	Count of records backed out
MON\$RECORD_PURGES	BIGINT	Count of records purged
MON\$RECORD_EXPUNGES	BIGINT	Count of records expunged

## MON\$STATEMENTS

MON\$STATEMENTS displays statements prepared for execution.

Column Name	Data Type	Description
MON\$STATEMENT_ID	INTEGER	Statement identifier
MON\$ATTACHMENT_ID	INTEGER	Connection identifier
MON\$TRANSACTION_ID	INTEGER	Transaction identifier
MON\$STATE	SMALLINT	Statement state:

Column Name	Data Type	Description
		0 - idle 1 - active 2 - stalled
MON\$TIMESTAMP	TIMESTAMP	The date and time when the statement was prepared
MON\$SQL_TEXT	BLOB TEXT	Statement text in SQL
MON\$STAT_ID	INTEGER	Statistics identifier

The STALLED state indicates that, at the time of the snapshot, the statement had an open cursor and was waiting for the client to resume fetching rows.

## 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

*Example:* Cancelling all active queries for the specified connection:

```
DELETE FROM MON$STATEMENTS
WHERE MON$ATTACHMENT_ID = 32
```

## MON\$TRANSACTIONS

MON\$TRANSACTIONS reports started transactions.

Column Name	Data Type	Description
MON\$TRANSACTION_ID	INTEGER	Transaction identifier (number)
MON\$ATTACHMENT_ID	INTEGER	Connection identifier
MON\$STATE	SMALLINT	Transaction state:

Column Name	Data Type	Description
		0 - idle 1 - active
MON\$TIMESTAMP	TIMESTAMP	The date and time when the transaction was started
MON\$TOP_TRANSACTION	INTEGER	Top-level transaction identifier (number)
MON\$OLDEST_TRANSACTION	INTEGER	Transaction ID of the oldest [interesting] transaction (OIT)
MON\$OLDEST_ACTIVE	INTEGER	Transaction ID of the oldest active transaction (OAT)
MON\$ISOLATION_MODE	SMALLINT	Isolation mode (level): 0 - consistency (snapshot table stability) 1 - concurrency (snapshot) 2 - read committed record version 3 - read committed no record version
MON\$LOCK_TIMEOUT	SMALLINT	Lock timeout: -1 - wait forever 0 - no waiting 1 or greater - lock timeout in seconds
MON\$READ_ONLY	SMALLINT	Flag indicating whether the transaction is read-only (value 1) or read-write (value 0)
MON\$AUTO_COMMIT	SMALLINT	Flag indicating whether automatic commit is used for the transaction (value 1) or not (value 0)
MON\$AUTO_UNDO	SMALLINT	Flag indicating whether the logging mechanism <i>automatic undo</i> is used for the transaction (value 1) or not (value 0)
MON\$STAT_ID	INTEGER	Statistics identifier



# Appendix F:

## Character Sets and Collation Sequences

**Table F.1. Character Sets and Collation Sequences**

Character Set	ID	Bytes per Char	Collation	Language
ASCII	2	1	ASCII	English
BIG_5	56	2	BIG_5	Chinese, Vietnamese, Korean
CP943C	68	2	CP943C	Japanese
"	"	"	CP943C_UNICODE	Japanese
CYRL	50	1	CYRL	Russian
"	"	"	DB_RUS	Russian dBase
"	"	"	PDOX_CYRL	Russian Paradox
DOS437	10	1	DOS437	U.S. English
"	"	"	DB_DEU437	German dBase
"	"	"	DB_ESP437	Spanish dBase
"	"	"	DB_FIN437	Finnish dBase
"	"	"	DB_FRA437	French dBase
"	"	"	DB_ITA437	Italian dBase
"	"	"	DB_NLD437	Dutch dBase
"	"	"	DB_SVE437	Swedish dBase
"	"	"	DB_UK437	English (Great Britain) dBase
"	"	"	DB_US437	U.S. English dBase
"	"	"	PDOX_ASCII	Code page Paradox—ASCII
"	"	"	PDOX_SWEDFIN	Swedish / Finnish Paradox
"	"	"	PDOX_INTL	International English Paradox
DOS737	9	1	DOS737	Greek
DOS775	15	1	DOS775	Baltic

Character Set	ID	Bytes per Char	Collation	Language
DOS850	11	1	DOS850	Latin I (no Euro symbol)
"	"	"	DB_DEU850	German
"	"	"	DB_ESP850	Spanish
"	"	"	DB_FRA850	French
"	"	"	DB_FRC850	French—Canada
"	"	"	DB_ITA850	Italian
"	"	"	DB_NLD850	Dutch
"	"	"	DB_PTB850	Portuguese—Brazil
"	"	"	DB_SVE850	Swedish
"	"	"	DB_UK850	English—Great Britain
"	"	"	DB_US850	U.S. English
DOS852	45	1	DOS852	Latin II
"	"	"	DB_CSY	Czech dBase
"	"	"	DB_PLK	Polish dBase
"	"	"	DB_SLO	Slovak dBase
"	"	"	PDOX_CSY	Czech Paradox
"	"	"	PDOX_HUN	Hungarian Paradox
"	"	"	PDOX_PLK	Polish Paradox
"	"	"	PDOX_SLO	Slovak Paradox
DOS857	46	1	DOS857	Turkish
"	"	"	DB_TRK	Turkish dBase
DOS858	16	1	DOS858	Latin I (with Euro symbol)
DOS860	13	1	DOS860	Portuguese
"	"	"	DB_PTG860	Portuguese dBase
DOS861	47	1	DOS861	Icelandic
"	"	"	PDOX_ISL	Icelandic Paradox
DOS862	17	1	DOS862	Hebrew
DOS863	14	1	DOS863	French—Canada
"	"	"	DB_FRC863	French dBase—Canada

Character Set	ID	Bytes per Char	Collation	Language
DOS864	18	1	DOS864	Arabic
DOS865	12	1	DOS865	Scandinavian
"	"	"	DB_DAN865	Danish dBase
"	"	"	DB_NOR865	Norwegian dBase
"	"	"	PDOX_NORDAN4	Paradox Norway and Denmark
DOS866	48	1	DOS866	Russian
DOS869	49	1	DOS869	Modern Greek
EUCJ_0208	6	2	EUCJ_0208	Japanese EUC
GB_2312	57	2	GB_2312	Simplified Chinese (Hong Kong, Korea)
GB18030	69	4	GB18030	Chinese
"	"	"	GB18030_UNICODE	Chinese
GBK	67	2	GBK	Chinese
"	"	"	GBK_UNICODE	Chinese
ISO8859_1	21	1	ISO8859_1	Latin I
"	"	"	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_FR	French
"	"	"	FR_FR_CI_AI	French—case insensitive + accent insensitive
"	"	"	IS_IS	Icelandic
"	"	"	IT_IT	Italian
"	"	"	NO_NO	Norwegian

Character Set	ID	Bytes per Char	Collation	Language
ISO8859_1	"	"	PT_PT	Portuguese
"	"	"	PT_BR	Portuguese—Brazil
"	"	"	SV_SV	Swedish
ISO8859_2	22	1	ISO8859_2	Latin 2—Central Europe (Croatian, Czech, Hungarian, Polish, Romanian, Serbian, Slovak, Slovenian)
"	"	"	CS_CZ	Czech
"	"	"	ISO_HUN	Hungarian—case insensitive, accent sensitive
"	"	"	ISO_PLK	Polish
ISO8859_3	23	1	ISO8859_3	Latin 3—Southern Europe (Malta, Esperanto)
ISO8859_4	34	1	ISO8859_4	Latin 4—Northern Europe (Estonian, Latvian, Lithuanian, Greenlandic, Lappish)
ISO8859_5	35	1	ISO8859_5	Cyrillic (Russian)
ISO8859_6	36	1	ISO8859_6	Arabic
ISO8859_7	37	1	ISO8859_7	Greek
ISO8859_8	38	1	ISO8859_8	Hebrew
ISO8859_9	39	1	ISO8859_9	Latin 5
ISO8859_13	40	1	ISO8859_13	Latin 7—Baltic
"	"	"	LT_LT	Lithuanian
KOI8R	63	1	KOI8R	Russian—dictionary ordering
"	"	"	KOI8R_RU	Russian
KOI8U	64	1	KOI8U	Ukrainian—dictionary ordering
"	"	"	KOI8U_UA	Ukrainian
KSC_5601	44	2	KSC_5601	Korean
"	"	"	KSC_DICTIONARY	Korean—dictionary sort order
NEXT	19	1	NEXT	Coding NeXTSTEP
"	"	"	NXT_DEU	German
"	"	"	NXT_ESP	Spanish
"	"	"	NXT_FRA	French

Character Set	ID	Bytes per Char	Collation	Language
"	"	"	NXT_ITA	Italian
NEXT	19	1	NXT_US	U.S. English
NONE	0	1	NONE	Neutral code page. Translation to upper case is performed only for code ASCII 97-122. Recommendation: avoid this character set
OCTETS	1	1	OCTETS	Binary character encoding
SJIS_0208	5	2	SJIS_0208	Japanese
TIS620	66	1	TIS620	Thai
"	"	"	TIS620_UNICODE	Thai
UNICODE_FSS	3	3	UNICODE_FSS	All English
UTF8	4	4	UTF8	Any language that is supported in Unicode 4.0
"	"	"	USC_BASIC	Any language that is supported in Unicode 4.0
"	"	"	UNICODE	Any language that is supported in Unicode 4.0
"	"	"	UNICODE_CI	Any language that is supported in Unicode 4.0—Case insensitive
"	"	"	UNICODE_CI_AI	Any language that is supported in Unicode 4.0—Case insensitive and accent insensitive
WIN1250	51	1	WIN1250	ANSI—Central Europe
"	"	"	BS_BA	Bosnian
"	"	"	PXW_CSY	Czech
"	"	"	PXW_HUN	Hungarian—case insensitive, accent sensitive
"	"	"	PXW_HUNDC	Hungarian—dictionary ordering
"	"	"	PXW_HUNDC	Polish
"	"	"	PXW_PLK	Slovak
"	"	"	PXW_SLOV	Slovenian
"	"	"	WIN_CZ	Czech
"	"	"	WIN_CZ_CI	Czech—Case insensitive

Character Set	ID	Bytes per Char	Collation	Language
"	"	"	WIN_CZ_CI_AI	Czech—Case insensitive and accent insensitive
WIN1251	52	1	WIN1251	ANSI Cyrillic
"	"	"	WIN1251-UA	Ukrainian
"	"	"	PXW_CYRL	Paradox Cyrillic (Russian)
WIN1252	53	1	WIN1252	ANSI—Latin I
"	"	"	PXW_INTL	English International
"	"	"	PXW_INTL850	Paradox multilingual Latin I
"	"	"	PXW_NORDAN4	Norwegian and Danish
"	"	"	PXW_SPAN	Paradox Spanish
"	"	"	PXW_SWEDFIN	Swedish and Finnish
"	"	"	WIN_PTBR	Portuguese—Brazil
WIN1253	54	1	WIN1253	ANSI Greek
"	"	"	PXW_GREEK	Paradox Greek
WIN1254	55	1	WIN1254	ANSI Turkish
"	"	"	PXW_TURK	Paradox Turkish
WIN1255	58	1	WIN1255	ANSI Hebrew
WIN1256	59	1	WIN1256	ANSI Arabic
WIN1257	60	1	WIN1257	ANSI Baltic
"	"	"	WIN1257_EE	Estonian—Dictionary ordering
"	"	"	WIN1257_LT	Lithuanian—Dictionary ordering
"	"	"	WIN1257_LV	Latvian—Dictionary ordering
WIN1258	65	1	WIN1258	Vietnamese

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# Appendix G:

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# Appendix H:

## Document History

The exact file history is recorded in the manual module in our CVS tree; see [http://sourceforge.net/cvs/?group\\_id=9028](http://sourceforge.net/cvs/?group_id=9028)

### Revision History

1.1	1 September 2015	H.E.M.B.	<p>Original was in Russian, translated by Dmitry Borodin (MegaTranslations). Raw translation edited and converted to DocBook, as this revision (1.1), by Helen Borrie.</p> <p>This revision distributed as a PDF build only, for review by Dmitry Yemanov, et al.</p> <p>Reviewers, please pay attention to the comments like this: <i>Editor's note :: The sky is falling, take cover!</i></p>
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