Informix Product Family
Informix
Version 12.10

IBM Informix Spatial Data User's Guide

SC27-4534-01

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Informix
Version 12.10

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IBM

SC27-4534-01

Note

Before using this information and the product it supports, read the information in "Notices" on page H-1.

This edition replaces SC27-4534-00.

Contents

Introduction

This introduction provides an overview of the information in this publication and describes the conventions it uses.

About this publication

This publication contains information to assist you in using the IBM® Informix® spatial extension with IBM Informix.

The IBM Informix spatial extension adds custom data types and supporting routines to the server.

This section discusses the organization of the publication, the intended audience, and the associated software products that you must have to develop and use the IBM Informix spatial extension. General information about the Informix spatial extension is available at http://www.ibm.com/software/data/informix/blades/spatial/.

Types of users

This publication is written for the following audience:

- Developers who design the tables to hold spatial information in IBM Informix databases
- Developers who write applications to access spatial information stored in IBM Informix databases

Assumptions about your locale

IBM Informix products can support many languages, cultures, and code sets. All the information related to character set, collation and representation of numeric data, currency, date, and time that is used by a language within a given territory and encoding is brought together in a single environment, called a Global Language Support (GLS) locale.

The IBM Informix OLE DB Provider follows the ISO string formats for date, time, and money, as defined by the Microsoft OLE DB standards. You can override that default by setting an Informix environment variable or registry entry, such as **DBDATE**.

If you use Simple Network Management Protocol (SNMP) in your Informix environment, note that the protocols (SNMPv1 and SNMPv2) recognize only English code sets. For more information, see the topic about GLS and SNMP in the *IBM Informix SNMP Subagent Guide*.

The examples in this publication are written with the assumption that you are using one of these locales: en_us.8859-1 (ISO 8859-1) on UNIX platforms or en_us.1252 (Microsoft 1252) in Windows environments. These locales support U.S. English format conventions for displaying and entering date, time, number, and currency values. They also support the ISO 8859-1 code set (on UNIX and Linux) or the Microsoft 1252 code set (on Windows), which includes the ASCII code set plus many 8-bit characters such as é, è, and ñ.

You can specify another locale if you plan to use characters from other locales in your data or your SQL identifiers, or if you want to conform to other collation rules for character data.

For instructions about how to specify locales, additional syntax, and other considerations related to GLS locales, see the *IBM Informix GLS User's Guide*.

What's new in spatial data for IBM Informix, Version 12.10

This publication includes information about new features and changes in existing functionality.

The following changes and enhancements are relevant to this publication. For a complete list of what's new in this release, go to http://pic.dhe.ibm.com/infocenter/informix/v121/topic/com.ibm.po.doc/new_features_ce.htm.

Table 1. What's new for the IBM Informix Spatial Data User's Guide for 12.10.xC3

Overview	Reference
Enhancements for handling spatial data You can transform spatial data between spatial reference systems that are in different geographic coordinate systems. Previously, you could transform data only within the same geographic coordinate system. You can choose from many more predefined spatial reference systems instead of defining most of the systems that you need. You can calculate the distance and area for data that is based on the round-Earth model. If your geometries have a spatial reference system that is based on angular units, you can calculate distance and area in meaningful linear units. Specify the appropriate unit of measure to convert angular units to linear units in the **ST_Area**, **ST_Buffer**, **ST_Distance**, **ST_Length**, and **ST_Perimeter** functions. You can specify predefined units of measure or define your own units of measure. The **SE_Nearest** function calculates distance between geometries that are in geographic coordinate systems by applying the linear unit of measure of meters. Informix spatial data types now conform to the OpenGIS Simple Features Specification for SQL Revision 1.1 and the ISO/IEC 13249-3 SQL/MM Part 3: Spatial. The Informix spatial solution is based on the ESRI SDE 10.2 Shape and PE libraries.	"The ST_Transform() function" on page 7-136 "The spatial_references table" on page 1-12 "Units of measure" on page 1-16 "The SE_Nearest() and SE_NearestBbox() functions" on page 7-106

Example code conventions

Examples of SQL code occur throughout this publication. Except as noted, the code is not specific to any single IBM Informix application development tool.

If only SQL statements are listed in the example, they are not delimited by semicolons. For instance, you might see the code in the following example:

```
CONNECT TO stores_demo
...

DELETE FROM customer
   WHERE customer_num = 121
...

COMMIT WORK
DISCONNECT CURRENT
```

To use this SQL code for a specific product, you must apply the syntax rules for that product. For example, if you are using an SQL API, you must use EXEC SQL at the start of each statement and a semicolon (or other appropriate delimiter) at the end of the statement. If you are using DB–Access, you must delimit multiple statements with semicolons.

Tip: Ellipsis points in a code example indicate that more code would be added in a full application, but it is not necessary to show it to describe the concept that is being discussed.

For detailed directions on using SQL statements for a particular application development tool or SQL API, see the documentation for your product.

Additional documentation

Documentation about this release of IBM Informix products is available in various formats.

You can access Informix technical information such as information centers, technotes, white papers, and IBM Redbooks® publications online at http://www.ibm.com/software/data/sw-library/.

Compliance with industry standards

IBM Informix products are compliant with various standards.

IBM Informix SQL-based products are fully compliant with SQL-92 Entry Level (published as ANSI X3.135-1992), which is identical to ISO 9075:1992. In addition, many features of IBM Informix database servers comply with the SQL-92 Intermediate and Full Level and X/Open SQL Common Applications Environment (CAE) standards.

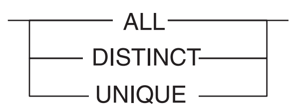
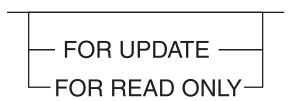
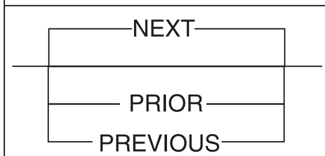
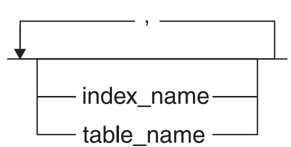
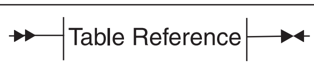
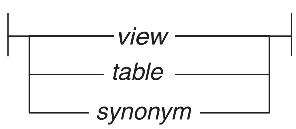
Syntax diagrams

Syntax diagrams use special components to describe the syntax for statements and commands.

Table 2. Syntax Diagram Components

Component represented in PDF	Component represented in HTML	Meaning
	>>----------------------	Statement begins.
	----------------------->	Statement continues on next line.

Table 2. Syntax Diagram Components (continued)

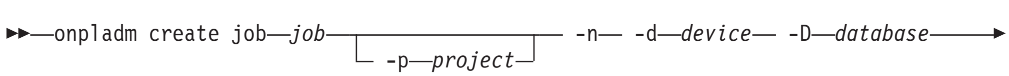
<table>
<tr><th>Component represented in PDF</th><th>Component represented in HTML</th><th>Meaning</th></tr>
<tr><td></td><td><pre>>-----------------------</pre></td><td>Statement continues from previous line.</td></tr>
<tr><td></td><td><pre>-----------------------><</pre></td><td>Statement ends.</td></tr>
<tr><td></td><td><pre>--------SELECT----------</pre></td><td>Required item.</td></tr>
<tr><td></td><td><pre>--+------------------+---
  '------LOCAL-------'</pre></td><td>Optional item.</td></tr>
<tr><td></td><td><pre>---+-----ALL-------+---
   +--DISTINCT-----+
   '---UNIQUE------'</pre></td><td>Required item with choice. Only one item must be present.</td></tr>
<tr><td></td><td><pre>---+-------------------+---
    +--FOR UPDATE-----+
    '--FOR READ ONLY--'</pre></td><td>Optional items with choice are shown below the main line, one of which you might specify.</td></tr>
<tr><td></td><td><pre>   .---NEXT---------.
----+----------------+---
    +---PRIOR--------+
    '---PREVIOUS-----'</pre></td><td>The values below the main line are optional, one of which you might specify. If you do not specify an item, the value above the line is used by default.</td></tr>
<tr><td></td><td><pre> .-------,-----------.
 V |
---+-----------------+---
    +---index_name---+
    '---table_name---'</pre></td><td>Optional items. Several items are allowed; a comma must precede each repetition.</td></tr>
<tr><td></td><td><pre>>>-| Table Reference |-><</pre></td><td>Reference to a syntax segment.</td></tr>
<tr><td>Table Reference
</td><td><pre>Table Reference
|--+-----view--------+--|
   +------table------+
   '----synonym------'</pre></td><td>Syntax segment.</td></tr>
</table>

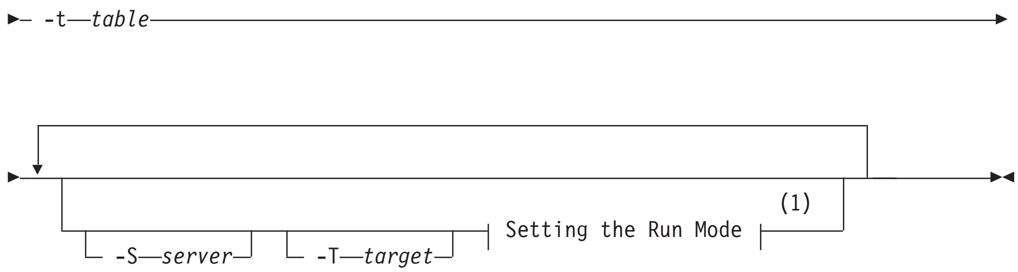
How to read a command-line syntax diagram

Command-line syntax diagrams use similar elements to those of other syntax diagrams.

Some of the elements are listed in the table in Syntax Diagrams.

Creating a no-conversion job



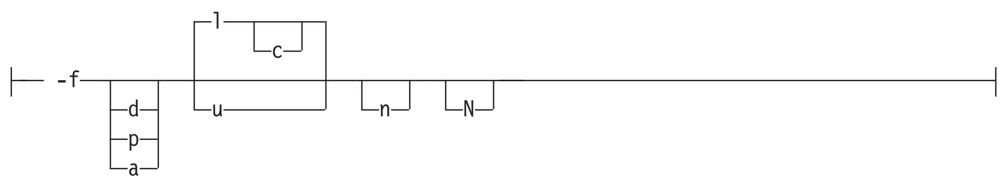


Notes:

1 See page Z-1

This diagram has a segment that is named “Setting the Run Mode,” which according to the diagram footnote is on page Z-1. If this was an actual cross-reference, you would find this segment on the first page of Appendix Z. Instead, this segment is shown in the following segment diagram. Notice that the diagram uses segment start and end components.

Setting the run mode:



To see how to construct a command correctly, start at the upper left of the main diagram. Follow the diagram to the right, including the elements that you want. The elements in this diagram are case-sensitive because they illustrate utility syntax. Other types of syntax, such as SQL, are not case-sensitive.

The Creating a No-Conversion Job diagram illustrates the following steps:

1. Include **onpladm create job** and then the name of the job.
2. Optionally, include **-p** and then the name of the project.
3. Include the following required elements:
   - **-n**
   - **-d** and the name of the device
   - **-D** and the name of the database
   - **-t** and the name of the table
4. Optionally, you can include one or more of the following elements and repeat them an arbitrary number of times:
   - **-S** and the server name
   - **-T** and the target server name
   - The run mode. To set the run mode, follow the Setting the Run Mode segment diagram to include **-f**, optionally include **d**, **p**, or **a**, and then optionally include **l** or **u**.
5. Follow the diagram to the terminator.

Keywords and punctuation

Keywords are words that are reserved for statements and all commands except system-level commands.

A keyword in a syntax diagram is shown in uppercase letters. When you use a keyword in a command, you can write it in uppercase or lowercase letters, but you must spell the keyword exactly as it appears in the syntax diagram.

You must also use any punctuation in your statements and commands exactly as shown in the syntax diagrams.

Identifiers and names

Variables serve as placeholders for identifiers and names in the syntax diagrams and examples.

You can replace a variable with an arbitrary name, identifier, or literal, depending on the context. Variables are also used to represent complex syntax elements that are expanded in other syntax diagrams. A variable in a syntax diagram, an example, or text, is shown in *lowercase italic*.

The following syntax diagram uses variables to illustrate the general form of a simple SELECT statement.

```
►►──SELECT──column_name──FROM──table_name──────────────────────────────────►◄
```

When you write a SELECT statement of this form, you replace the variables *column_name* and *table_name* with the name of a specific column and table.

How to provide documentation feedback

You are encouraged to send your comments about IBM Informix user documentation.

Use one of the following methods:

- Send email to docinf@us.ibm.com.
- In the Informix information center, which is available online at http://www.ibm.com/software/data/sw-library/, open the topic that you want to comment on. Click the feedback link at the bottom of the page, complete the form, and submit your feedback.
- Add comments to topics directly in the information center and read comments that were added by other users. Share information about the product documentation, participate in discussions with other users, rate topics, and more!

Feedback from all methods is monitored by the team that maintains the user documentation. The feedback methods are reserved for reporting errors and omissions in the documentation. For immediate help with a technical problem, contact IBM Technical Support at http://www.ibm.com/planetwide/.

We appreciate your suggestions.

Chapter 1. Getting started with spatial data

The IBM Informix spatial solution embeds a geographic information system (GIS) within the IBM Informix database server. The IBM Informix spatial data types integrate spatial and non-spatial data, providing a seamless point of access using SQL (Structured Query Language).

IBM Informix spatial data types implement the OpenGIS Consortium, Inc. (OpenGIS, or OGC) SQL3 specification of abstract data types (ADTs). These data types can store spatial data such as the location of a landmark, a street, or a parcel of land. IBM Informix spatial data types also conform to the OpenGIS Simple Features Specification for SQL Revision 1.1 and the ISO/IEC 13249-3 SQL/MM Part 3: Spatial. The Informix Spatial solution is based on the ESRI SDE 10.2 Shape and PE libraries.

You use specialized spatial data type functions to compare the values in spatial columns to determine whether the values intersect, overlap, or are related in different ways. These functions can answer questions like, “Is this school within 5 miles of a hazardous waste site?” An application programmer can use an SQL query to join a table that stores sensitive sites such as schools, playgrounds, and hospitals to another table that contains the locations of hazardous sites and return a list of sensitive areas at risk. For example, the following figure shows that a school and hospital lie within the 5-mile radius of two hazardous site locations and the nursing home lies safely outside both radii.

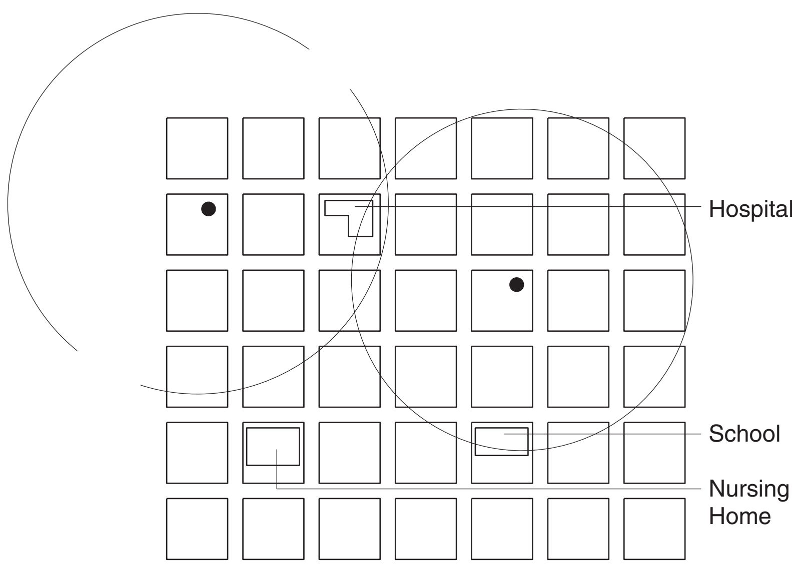


Figure 1-1. Determining whether sensitive sites are within dangerous areas

You use the **ST_Overlaps()** function to evaluate whether the polygon that represents the building footprint of the school overlaps the circular polygon that represents the 5-mile radius of a hazardous waste site. The building footprints of the school, hospital, and nursing home are stored in the ST_Polygon data type and the location of each hazardous waste site is stored in an ST_Point data type.

Overview of spatial data

The properties of spatial data include the type of spatial object, or geometry, the geographic area where the object is located, and whether the location of the object is measured in angular or linear units.

A *geometry* is a model of a geographic feature. The coordinates of a geographic feature that a geometry represents are regarded as properties of the geometry. Several kinds of geometries have other properties as well; for example, area, length, and boundary. The types of geometries include points, lines, and polygons. Each geometry is represented by a spatial data type. When you create a table for spatial data, you choose the spatial data type that corresponds to the structure of your spatial data.

When you insert spatial data into the database, you specify a spatial reference system. A *spatial reference system* is a set of parameters that represents the following characteristics of the location of a geometry:

- The numeric identifier that uniquely identifies the spatial reference system.
- Coordinates that define the maximum extent of space that is referenced by a specified range of coordinates.
- Values for a false origin and system units to store coordinate values at an acceptable scale.
- A text representation of the spatial reference system that describes what type of units the coordinates have.

Whether the coordinates for a geometry are angular or linear units depends on the type of coordinate system to which the geometry conforms. A *coordinate system* is a framework for defining the relative locations of geometries in a specific area; for example, an area on the Earth's surface or the Earth's surface as a whole. Informix supports the following types of coordinate systems: geographic coordinate system and projected coordinate systems.

You can convert data between coordinate systems and calculate the distance and area for data that is in either type of system.

Geographic coordinate system

A *geographic coordinate system* is a system that uses a three-dimensional spherical surface to determine locations on the Earth. Any location on Earth can be referenced by a point with longitude and latitude coordinates. The geographic coordinate system is appropriate for global data sets and applications, such as satellite imagery repositories.

For example, the following illustration shows a geographic coordinate system where a location is represented by the coordinates longitude 80 degree east and latitude 55 degrees north.

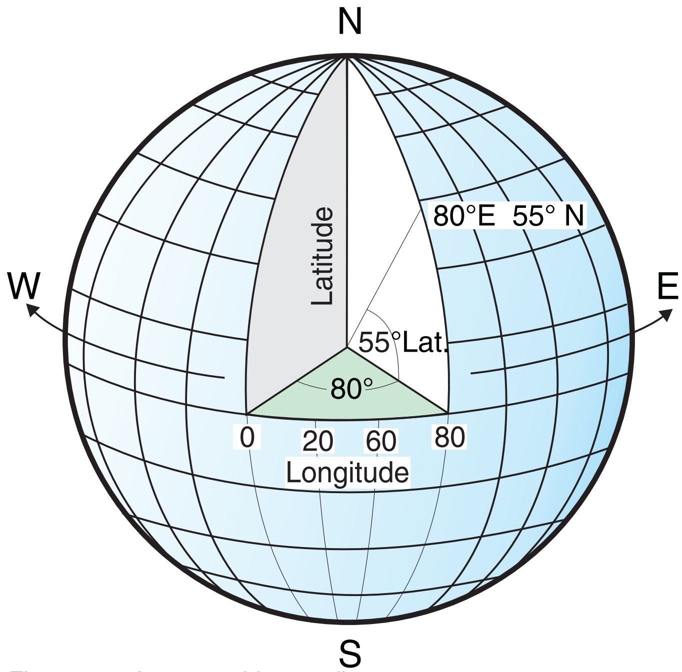


Figure 1-2. A geographic coordinate system

The lines that run east and west each have a constant latitude value and are called *parallels*. They are equidistant and parallel to one another, and form concentric circles around the Earth. The *equator* is the largest circle and divides the Earth in half. It is equal in distance from each of the poles, and the value of this latitude line is zero. Locations north of the equator have positive latitudes that range from 0 to +90 degrees, while locations south of the equator have negative latitudes that range from 0 to -90 degrees.

The following illustration shows latitude lines.

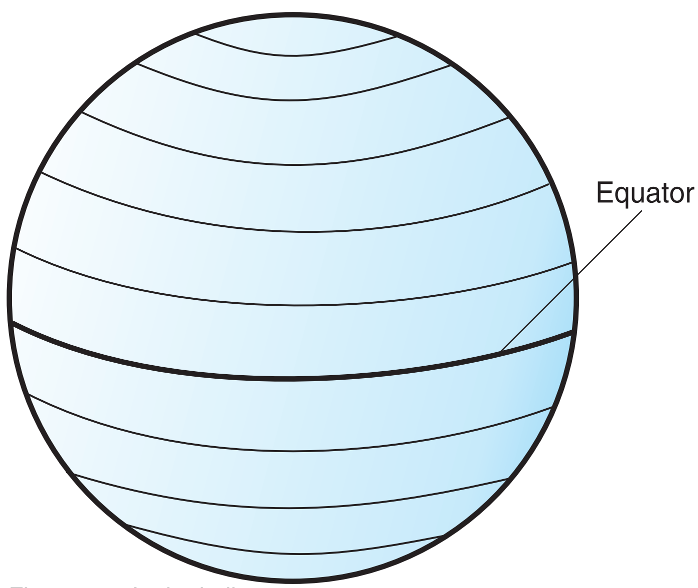


Figure 1-3. Latitude lines

The lines that run north and south each have a constant longitude value and are called *meridians*. They form circles of the same size around the Earth, and intersect at the poles. The *prime meridian* is the line of longitude that defines the origin (zero degrees) for longitude coordinates. One of the most commonly used prime meridian locations is the line that passes through Greenwich, England. However, other longitude lines, such as those that pass through Bern, Bogota, and Paris, were also as the prime meridian. Locations east of the prime meridian up to its *antipodal* meridian (the continuation of the prime meridian on the other side of the globe) have positive longitudes that range from 0 to +180 degrees. Locations west of the prime meridian have negative longitudes that range from 0 to -180 degrees.

The following illustration shows longitude lines.

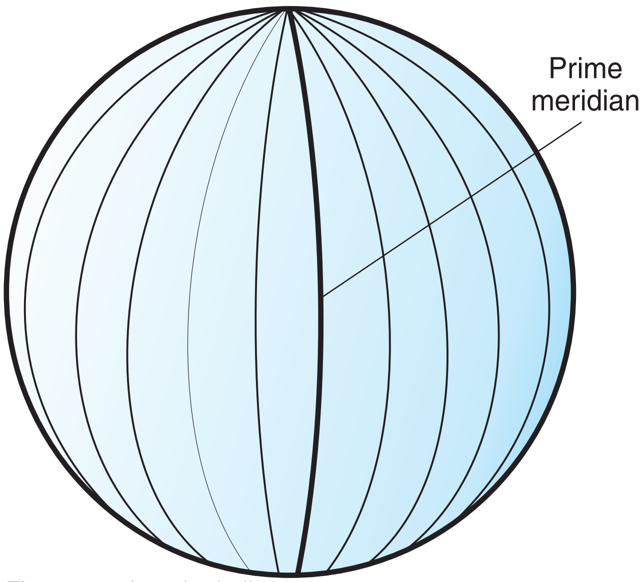


Figure 1-4. Longitude lines

The latitude and longitude lines can cover the globe to form a grid, called a *graticule*. The point of origin of the graticule is (0,0), where the equator and the prime meridian intersect. The equator is the only place on the graticule where the linear distance corresponding to one degree latitude is approximately equal the distance corresponding to one degree longitude. Because the longitude lines converge at the poles, the distance between two meridians is different at every parallel. Therefore, as you move closer to the poles, the distance corresponding to one degree latitude is much greater than the distance corresponding to one degree longitude.

It is difficult to determine the lengths of the latitude lines using the graticule. The latitude lines are concentric circles that become smaller near the poles. They form a single point at the poles where the meridians begin. At the equator, one degree of longitude is approximately 111.321 kilometers, while at 60 degrees of latitude, one degree of longitude is only 55.802 km (this approximation is based on the Clarke 1866 spheroid). Therefore, because there is no uniform length of degrees of latitude and longitude, the distance between points cannot be measured accurately by using angular units of measure.

The following illustration shows the different dimensions between locations on the graticule.

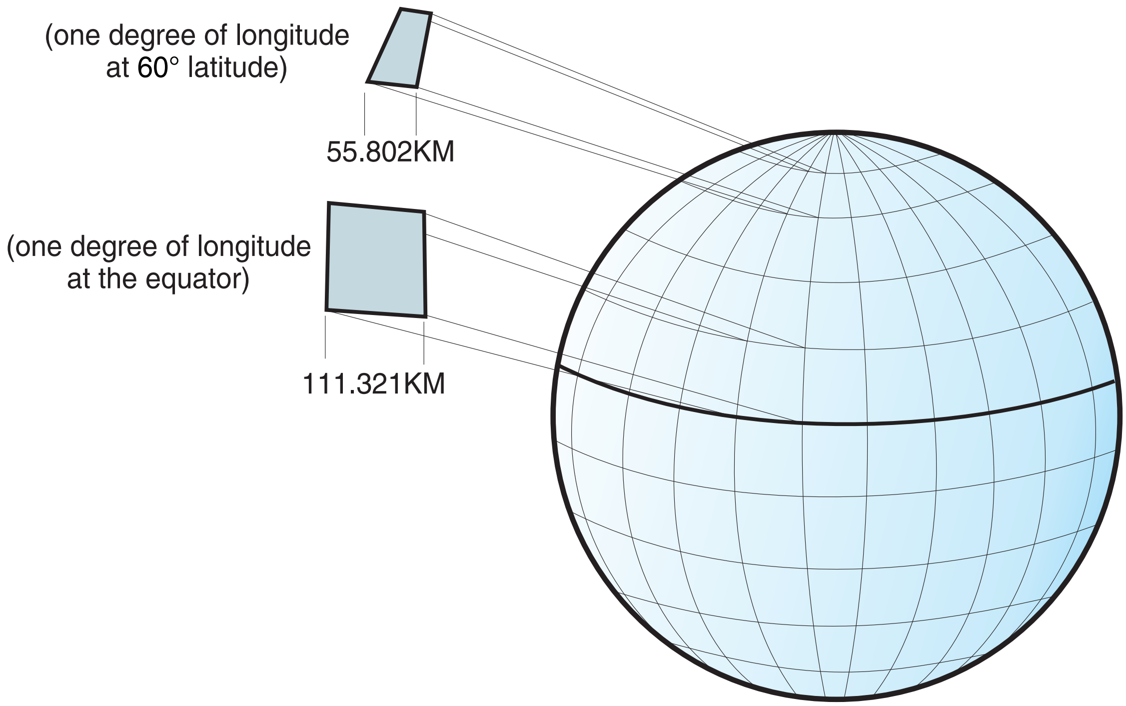


Figure 1-5. Different dimensions between locations on the graticule

A coordinate system can be defined by either a sphere or a spheroid approximation of the Earth's shape. Because the Earth is not perfectly round, a spheroid can help maintain accuracy for a map, depending on the location on the Earth. A *spheroid* is an ellipsoid that is based on an ellipse, whereas a sphere is based on a circle.

The shape of the ellipse is determined by two radii. The longer radius is called the semimajor axis, and the shorter radius is called the semiminor axis. An ellipsoid is a three-dimensional shape that is formed by rotating an ellipse around one of its axes.

The following illustration shows the sphere and spheroid approximations of the Earth and the major and minor axes of an ellipse.

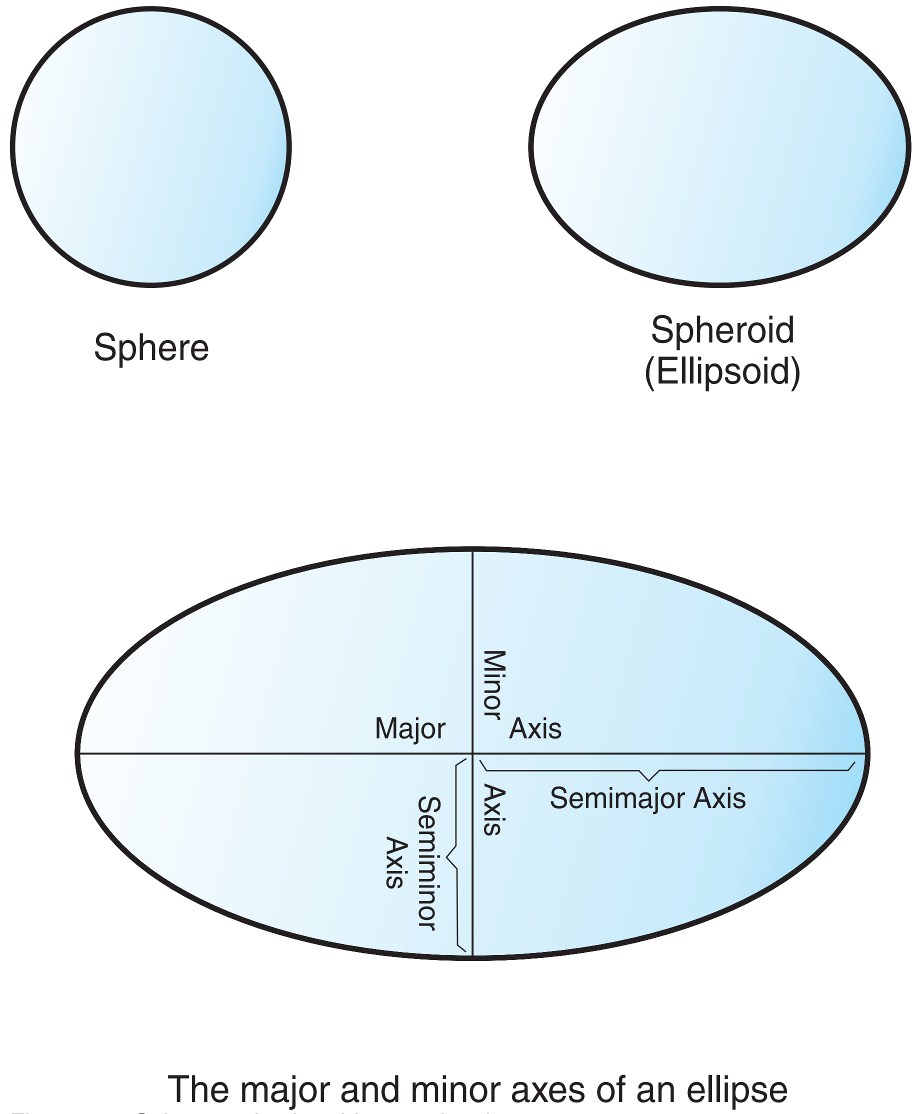


Figure 1-6. Sphere and spheroid approximations

A *datum* is a set of values that defines the position of the spheroid relative to the center of the Earth. The datum provides a frame of reference for measuring locations and defines the origin and orientation of latitude and longitude lines. Some datums are global and intend to provide good average accuracy around the world. A local datum aligns its spheroid to closely fit the Earth's surface in a particular area. Therefore, the coordinate system's measurements are not accurate if they are used with an area other than the one that they were designed.

The following illustration shows how different datums align with the Earth's surface. The local datum, NAD27, more closely aligns with Earth's surface than the Earth-centered datum, WGS84, at this particular location.

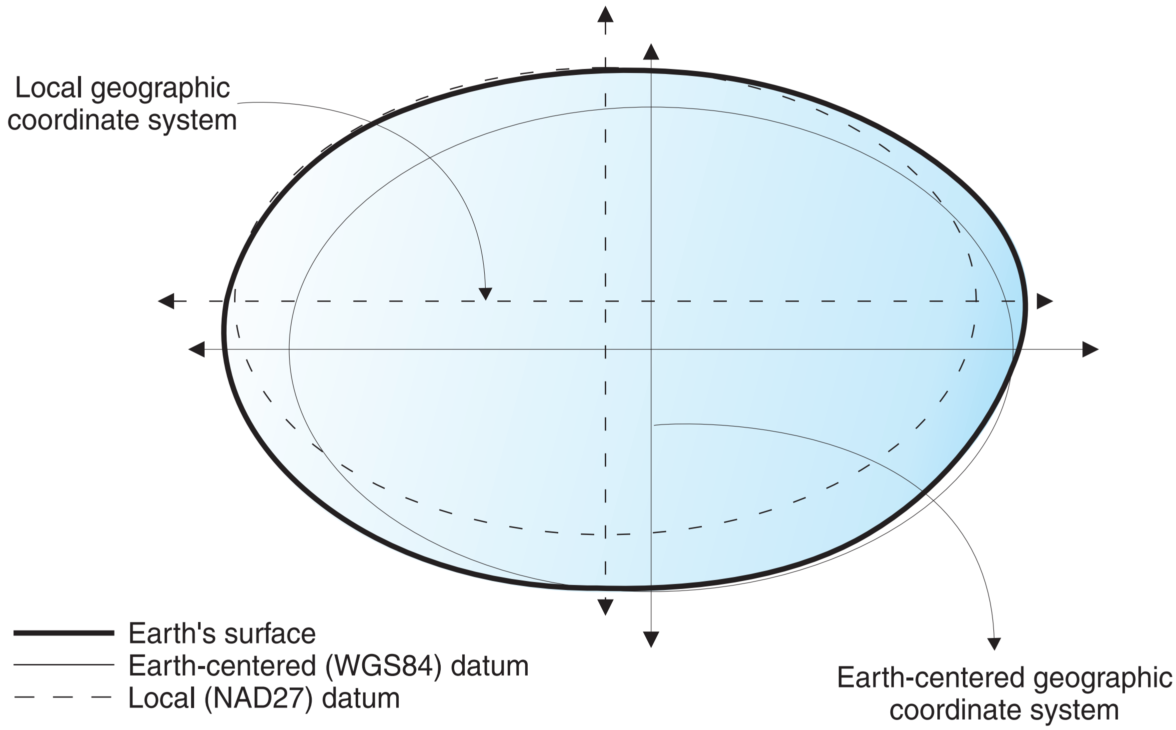


Figure 1-7. Datum alignments

Whenever you change the datum, the geographic coordinate system is altered and the coordinate values change. For example, the coordinates in DMS of a control point in Redlands, California using the North American Datum of 1983 (NAD 1983) are: "-117 12 57.75961 34 01 43.77884" The coordinates of the same point on the North American Datum of 1927 (NAD 1927) are: "-117 12 54.61539 34 01 43.72995".

Projected coordinate system

A *projected coordinate system* is a flat, two-dimensional representation of the Earth. It is based on a sphere or spheroid geographic coordinate system, but it uses linear units of measure for coordinates, so that calculations of distance and area are easily done in terms of those same units. The projected coordinate system is appropriate for regional data sets and applications.

The latitude and longitude coordinates are converted to x, y coordinates on the flat projection. The x coordinate is usually the eastward direction of a point, and the y coordinate is usually the northward direction of a point. The center line that runs east and west is referred to as the x axis, and the center line that runs north and south is referred to as the y axis.

The intersection of the x and y axes is the origin and usually has a coordinate of (0,0). The values above the x axis are positive, and the values below the x axis are negative. The lines parallel to the x axis are equidistant from each other. The values to the right of the y axis are positive, and the values to the left of the y axis are negative. The lines parallel to the y axis are equidistant.

Mathematical formulas are used to convert a three-dimensional geographic coordinate system to a two-dimensional flat projected coordinate system. The transformation is referred to as a *map projection*. Map projections usually are classified by the projection surface that is used, such as conic, cylindrical, and planar surfaces. Depending on the projection that is used, different spatial properties appear distorted. Projections are designed to minimize the distortion of one or two of the data's characteristics, yet the distance, area, shape, direction, or a combination of these properties might not be accurate representations of the data that is being modeled. There are several types of projections available. While most map projections attempt to preserve some accuracy of the spatial properties, others attempt to minimize overall distortion instead, such as the *Robinson* projection. The most common types of map projections include:

Equal area projections
: These projections preserve the area of specific features. These projections distort shape, angle, and scale. The *Albers Equal Area Conic* projection is an example of an equal area projection.

Conformal projections
: These projections preserve local shape for small areas. These projections preserve individual angles to describe spatial relationships by showing perpendicular graticule lines that intersect at 90 degree angles on the map. All of the angles are preserved; however, the area of the map is distorted. The *Mercator* and *Lambert Conformal Conic* projections are examples of conformal projections.

Equidistant projections
: These projections preserve the distances between certain points by maintaining the scale of a specific data set. Some of the distances are true distances, which are the same distances at the same scale as the globe. If you go outside the data set, the scale becomes more distorted. The *Sinusoidal* projection and the *Equidistant Conic* projection are examples of equidistant projections.

True-direction or azimuthal projections
: These projections preserve the direction from one point to all other points by maintaining some of the great circle arcs. These projections give the directions or azimuths of all points on the map correctly with respect to the center. Azimuthal maps can be combined with equal area, conformal, and equidistant projections. The *Lambert Equal Area Azimuthal* projection and the *Azimuthal Equidistant* projection are examples of azimuthal projections.

Informix spatial solution architecture

You can create tables that contain Informix spatial data type columns. You can insert and store geographic features in the spatial columns.

The following figure shows the architecture for IBM Informix and spatial applications. The IBM Informix server can communicate to Java™ applications through the Informix JDBC Driver, C applications through the IBM Informix ODBC Driver, directly with ESQL/C applications and DB-Access, and to ESRI application servers through the IBM Informix ODBC Driver. ESRI application servers communicate to license managers and ESRI clients.

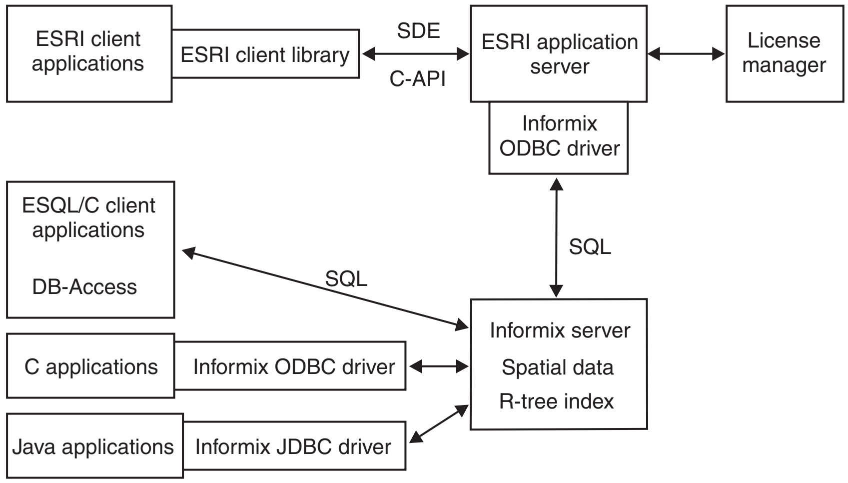


Figure 1-8. Architecture for IBM Informix and spatial applications

For each spatial data type, there is a text file import and a text file export routine. Whenever you run a load or unload statement in the DB-Access utility, import and export routines are automatically called (the **dbimport** and **dbexport** utilities also use these routines).

The ESRI ArcSDE service provides immediate access to the spatial data stored in your IBM Informix database for the ESRI GIS software programs: ArcView GIS, MapObjects, and ArcInfo software. The ArcSDE service automatically converts spatial column data into ESRI shape representation, making it available to all ESRI-supported applications and other applications capable of reading this format. When you access spatially enabled tables through the ArcSDE service, you can write applications with the existing tools that are offered by ESRI GIS software or create applications with the SDE C application programming interface (API). An experienced open database connectivity (ODBC) programmer can also make calls to Spatial SQL functions.

You can use DB-Access to run SQL queries against your spatial data. You can also write applications that access the database:
- ESQL/C applications. Use the IBM Informix Client Software Development Kit (Client SDK) to connect to the IBM Informix server.
- C applications. Use the IBM Informix ODBC Driver to connect to the IBM Informix server.
- Java applications. Use the IBM Informix JDBC Driver to connect to the IBM Informix server.

Querying the spatial columns directly requires converting the data to one of the three supported external formats. The **ST_AsText()** function converts a spatial column value to the OGC Well-Known Text (WKT) representation. The **ST_AsBinary()** and **SE_AsShape()** functions convert the spatial column values to OGC Well-Known Binary (WKB) and ESRI shape formats, respectively. After the data is converted, applications can display or manipulate the data.

You use an R-tree index to allow indexing of spatial data. R-tree indexes are designed to provide fast, efficient access to spatial data.

The Spatial Data CD contains worldwide location-based data that you can visualize and manipulate. The Spatial Data CD is included with IBM Informix software. The CD has the following contents:

- Sample spatial data
- ArcExplorer Java Edition, a lightweight visualization tool for spatial data. Enables the panning, zooming, and querying of colorful maps that are automatically generated from the data.

Related tasks:

"Preparing for spatial data" on page 1-11

Related reference:

Chapter 3, "Data exchange formats," on page 3-1

Spatial data replication

You can use spatial data types with Enterprise Replication and high-availability clusters.

The following conditions must be met to replicate spatial data:

- You must ensure that all copies of the **spatial_references** table are synchronized at all times.
- Spatial data type columns in tables that you include in your data replication system must be nullable.

Related concepts:

High availability and scalability (Administrator's Guide)

Related information:

About Enterprise Replication (Enterprise Replication Guide)

The IBM Informix Web Feature Service

The IBM Informix Web Feature Service (WFS) is a transaction service that acts as a presentation layer for spatial data.

WFS supports the following operations:

- Creating new feature instances
- Deleting feature instances
- Updating feature instances
- Querying features that are based on spatial and non-spatial constraints

The IBM Informix WFS includes a CGI client program and an IBM Informix server-side function for web programs to send requests to IBM Informix for geographical features. These geographical features are encoded in the platform-independent, XML-based geography markup language (GML). You can use WFS with the IBM Informix spatial data types to enable IBM Informix database servers to manage geographical features. WFS is written to the Open Geospatial Consortium (OGC) standard in document 04-094, Web Feature Service Implementation Specification Version 1.1.0. For more information, see the OGC website at http://www.opengeospatial.org.

Related reference:

Informix web feature service for Geospatial Data (Database Extensions Guide)

Preparing for spatial data

Before you load spatial data, you must prepare the database server for spatial data.

The database that contains the spatial data must meet the following requirements or the message `DataBlade registration failed` is printed in the online log:

- The database must be logged.
- The database must not be defined as an ANSI database.

The Scheduler must be running in the database server. If the Scheduler is not running when you create a spatial data type or run a spatial routine, a message that the data type is not found or the routine cannot be resolved is returned.

To prepare for spatial data:

1. Set the STACKSIZE configuration parameter in the `onconfig` file to at least 64. Increasing the stack size prevents stack overflow errors.
2. Optional: Create the system sbspace by setting the SYSSBSPACENAME configuration parameter in the `onconfig` file. When the UPDATE STATISTICS MEDIUM or HIGH statements are run on spatial tables, the database server stores the statistics in the system sbspace, which is specified by the SYSSBSPACENAME configuration parameter in the `onconfig` file. If you do not set the SYSSBSPACENAME configuration parameter, the database server creates the system sbspace when you create a spatial table or run a spatial routine. The system sbspace is created from the storage pool, if the storage pool is set up. Otherwise, the system sbspace is created in the same directory as the root dbspace.
3. Optional: Create an sbspace for spatial metadata and move the metadata into it. If you do not move the spatial metadata, spatial metadata is stored in the default sbspace, which is specified by the SBSPACENAME configuration parameter. If you do not set the SBSPACENAME configuration parameter in the `onconfig` file, the database server creates the default sbspace when you create a spatial table or run a spatial routine. The default sbspace is created from the storage pool, if the storage pool is set up. Otherwise, the default sbspace is created in the same directory as the root dbspace.
   a. Create an sbspace by running the **onspaces -c -S** command.
   b. Move the spatial metadata into the sbspace by running the following command:
   ```
   ALTER TABLE SE_MetadataTable PUT smd IN (mysbspace);
   ```
   c. Initialize the spatial metadata infrastructure by running the following command:
   ```
   EXECUTE FUNCTION SE_MetadataInit();
   ```
4. Optional: Create an sbspace to store spatial data by running the **onspaces -c -S** command. Include the **-DF "LOGGING=ON"** option to create the spatial data sbspace with logging, so that you can back up and restore both the user data and the metadata. If you do not create an sbspace for spatial data and reference the sbspace in the PUT clause in the CREATE TABLE statement, spatial data is stored in the default sbspace. Spatial data is stored in the sbspace when a geometry exceeds 930 bytes, for example, a line or polygon with more than 50 vertices.
5. Choose a predefined spatial reference system in the **spatial_references** table or create your own spatial reference system and add it to the **spatial_references** table. To add a spatial reference system into the **spatial_references** table:
   - Insert a row into the **spatial_references** table with an INSERT statement.

- Run the **SE_CreateSRID()** function. Specify the limits of the X and Y extents or specify an existing system on which to base the new system. The database server calculates the false origin and system units.

6. Optional: Choose or create the unit of measure for the coordinate system. If you want to calculate the distance or area for geometries that have angular units, choose a predefined unit of measure in the **st_units_of_measure** table or create your own unit of measure and add it to the **st_units_of_measure** table with an INSERT statement.
7. Create a table for the spatial data by running the CREATE TABLE statement with a spatial column in the column clause. If you created an sbspace for spatial data, include the PUT clause in the CREATE TABLE statement. You can create the table as part of loading data if you use the **loadshp** utility to load ESRI shapefiles.

Related concepts:

"Informix spatial solution architecture" on page 1-8

Related reference:

"Loading spatial data" on page 1-19

scheduler argument: Stop or start the scheduler (SQL administration API) (Administrator's Reference)

SYSSBSPACENAME configuration parameter (Administrator's Reference)

SBSPACENAME configuration parameter (Administrator's Reference)

STACKSIZE configuration parameter (Administrator's Reference)

Creating an Sbspace with the -Df option (Administrator's Reference)

The spatial_references table

The **spatial_references** table contains a spatial reference ID (SRID) for each spatial reference system.

The **spatial_references** table stores data about each map projection that you use to store the spherical geometry of the Earth, for example, your data might use the Mercator projection. The spatial reference ID (SRID) is the unique key for the record in the **spatial_references** table that describes a particular spatial reference system. All spatial reference systems that you use in your database must have a record in the **spatial_references** table. All geometries in a spatial column must use the same spatial reference system.

The IBM Informix spatial functions use the parameters of a spatial reference system to translate and scale each floating point coordinate of the geometry into 54-bit positive integers before storage. When retrieved, the coordinates are restored to their external floating point format.

The columns of the **spatial_references** table are described in the following table.

Table 1-1. The spatial_references table

Column name	Type	Example value	Description
srid	INTEGER NOT NULL	`12345`	Primary key: the unique key for the record that describes a particular spatial reference system
description	VARCHAR(64)	`WGS 1984`	A text description of the spatial reference system

Table 1-1. The spatial_references table (continued)

Column name	Type	Example value	Description
auth_name	VARCHAR(255)	`EPSG`	The name of the standard or standards body cited for the reference system
auth_srid	INTEGER	`4326`	The ID of the spatial reference system as defined by the authority cited in **auth_name** column.
falsex	FLOAT NOT NULL	`-180`	The external floating point X coordinates are converted to integers for storage in the database by subtracting the **falsex** values.
falsey	FLOAT NOT NULL	`-90`	The external floating point Y coordinates are converted to integers for storage in the database by subtracting the **falsey** values.
xyunits	FLOAT NOT NULL	`1000000`	Before the external floating point X and Y coordinates are inserted into the database, the coordinates are scaled by the value in **xyunits**. The scaling process adds a half unit and truncates the remainder.
falsez	FLOAT NOT NULL	`-1000`	The external floating point Z coordinates are converted to integers for storage in the database by subtracting the **falsez** values.
zunits	FLOAT NOT NULL	`1000`	A factor that is used to scale the Z-coordinate
falsem	FLOAT NOT NULL	`-1000`	The external floating point M coordinates are converted to integers for storage in the database by subtracting the **falsem** values.
munits	FLOAT NOT NULL	`1000`	A factor that is used to scale the measure values
srtext	CHAR(2048)	`GEOGCS["GCS_WGS_1984", DATUM["D_WGS_1984", SPHEROID["WGS_1984", 6378137, 298.257223563]], PRIMEM["Greenwich",0], UNIT["Degree", 0.0174532925199433]]`	The **srtext** column contains the well known text representation of the spatial reference system.

Example: Create a spatial reference system with an INSERT statement

The following example shows how to insert a spatial reference system into the **spatial_references** table:

```
INSERT INTO spatial_references
     (srid, description, auth_name, auth_srid, falsex, falsey,
      xyunits, falsez, zunits, falsem, munits, srtext)
   VALUES (1, NULL, NULL, NULL, 0, 0, 100, 0, 1, 0, 1, 'UNKNOWN');
```

In this example, the spatial reference system has an SRID value of `1`, a false X, Y of (`0`,`0`), and its system units are `100`. The Z coordinate and measure offsets are `0`, while the Z coordinate and measure units are 1.

Example: Create a spatial reference system with the SE_CreateSRID() function

For the hazardous sites and sensitive areas example, the coordinates are in a local countywide XY coordinate system. The X and Y coordinates range from 0 - 250 000. The **SE_CreateSRID()** function creates the new spatial reference system with the SRID of 5:

```
EXECUTE FUNCTION SE_CreateSRID(0, 0, 250000, 250000,
                              "Springfield county XY coord system");

(expression)

          5
```

Related concepts:

"The CoordRefManager Class" on page 8-3

Related reference:

"The ST_SRID() function" on page 7-128

Appendix B, "OGC well-known text representation of spatial reference systems," on page B-1

"The SE_CreateSRID() function" on page 7-33

Predefined spatial reference systems

The **spatial_references** table contains over 1000 predefined spatial reference systems.

The following table lists the predefined spatial reference systems.

Table 1-2. Predefined spatial reference systems

Authority	Authority IDs (SRIDs)	Description
EPSG	2000 - 2999	Projection systems defined by the EPSG
EPSG	46008	GEOGCS NAD 1927
EPSG	4759	GEOGCS NAD 1983_NSRS2007
EPSG	4322	GEOGCS WGS 1972
EPSG	4326	GEOGCS WGS 1984
EPSG	4760	GEOGCS WGS 1966
EPSG	32601 - 23760	WGS 1984 UTM Zones
ESRI	54001 - 54004 54008 - 54019 54021 - 54032 54034 54042 - 54046 54048 - 54053	Various world projection systems

The false origin and scale values for the system are derived from the Projected Bounds of the underlying Coordinate System. For example, EPSG 2193

(NZGD_2000_New_Zealand_Transverse_Mercator) derives the falsex, falsey and xyunits values based on the extent of the projection system:

- **falsex** = -6020520.00000
- **falsey** = -1997720.00000
- **xyunits** = 375371289.4930

The z and m coordinates for all predefined spatial reference systems have the following values in the following columns:

- **falsez** = -50000.0
- **zunits** = 1000.0
- **falsem** = -1000.0
- **munits** = 1000.0

False origin and system units

When you add a spatial reference system to the **spatial_references** table, you include a false origin and system unit to store all of your coordinate values at an acceptable scale.

Restriction: Do not change a spatial reference system's false origin and system units after you inserted spatial data into a table with the corresponding SRID. The false origin and system units translate and scale your data before storage. If you change these values, you cannot retrieve your original floating point coordinate data.

You must know the range of your data and the scale to maintain. Because coordinates are stored as positive 54-bit integers, the maximum range of values that are allowed is 0 - 9 007 199 254 740 991, but the actual range is dependent on the false origin and system units of the spatial reference system.

A negative false origin shifts the range of values in the negative direction. A positive false origin shifts the range of values in the positive direction. For example, a false origin of –1000, with a system unit of one, stores a range of values from –1000 through 2^{53} –1000.

The system unit scales the data and cannot be less than one. The larger the system unit the greater the scale that can be stored, but the smaller the range of values. For example, given a system unit of 1000 and a false origin of zero, data with 3 digits to the right of the decimal point are supported; the range of possible values is reduced to 0.001 to 2^{50}.

If you want to maintain a scale of 3 digits to the right of the decimal point, set your system units to 1000. Set the false origin to less than the minimum coordinate value in your data set. The false origin must be small enough to account for any buffering of the data. If the minimum coordinate value is –10 000 and your application includes functions that buffer the data by 5000, the false origin must be at least –15 000. Finally, make sure that the maximum ordinate value is not greater than 2^{53} by applying the following formula to the maximum value. This formula converts floating point coordinates into system units:

```
stored value = truncate(((ordinate - false origin) * system unit) + 0.5)
```

The **SE_CreateSRID()** function computes the false origin and system units for the specified X and Y extents of a spatial data set.

Related reference:

"The SE_CreateSRID() function" on page 7-33

Units of measure

Units of measure define the conversion factor between meters and other units.

You include the unit of measure information when you calculate distance or area for geometries that have angular units with the following functions:
- **ST_Area()**
- **ST_Buffer()**
- **ST_Distance()**
- **ST_Length()**
- **ST_Perimeter()**

Include the appropriate value from the **unit_name** column of the **st_units_of_measure** table when you run the function.

You can also use units of measure in your applications when you need to convert between units.

To create a new unit of measure, insert a row into the **st_units_of_measure** table. Specify values for the following columns:
- **unit_name**: The name of the unit of measure. Must be unique and cannot exceed 128 characters.
- **unit_type**: The measurement type. Can be `linear` or `angular`.
- **conversion_factor**: The conversion factor between the unit of measure and 1 meter. A double precision number that is > 0.0.
- **description**: Optional. The description of the unit of measure. Cannot exceed 255 characters.

Example

The following statement creates a linear unit of measure that is named **half_meter** and has a conversion factor of .5:

```
INSERT INTO sde.st_units_of_measure
       VALUES('half_meter','linear',.5,'test uom');
```

Compare the results of the following two queries. The following query returns the length of a linestring in meters:

```
EXECUTE FUNCTION round(st_length
              ('32605 linestring(503208 43653, 503210 43653)'::st_linestring,
               'meter'),2);

    (expression)

2.00000000000000

1 row(s) retrieved.
```

The following query returns the length of the same linestring in half-meter units:

```
EXECUTE FUNCTION round(st_length
              ('32605 linestring(503208 43653, 503210 43653)'::st_linestring,
               'half_meter'),2);

    (expression)

4.00000000000000

1 row(s) retrieved.
```

The st_units_of_measure table

The **st_units_of_measure** table stores data about units of measure. The definitions of units of measure are used to convert measurements to different units of measure.

Include the appropriate value from the **unit_name** column when you calculate distance or area for geometries that have angular units.

Table 1-3. Predefined units of measure in the st_units_of_measure table

unit_name	unit_type	conversion_factor	description
meter	linear	1	9001 - International meter
foot	linear	0.3048	9002 - International foot
foot_us	linear	0.3048006096012192	9003 - US survey foot
foot_clarke	linear	0.3047972650	9005 - Clarke's foot
fathom	linear	1.8288	9014 - Fathom
nautical_mile	linear	1852	9030 - International nautical mile
meter_german	linear	1.000001359650	9031 - German legal meter
chain_us	linear	20.11684023368047	9033 - US survey chain
link_us	linear	20.11684023368047	9034 - US survey link
mile_us	linear	20.11684023368047	9035 - US survey mile
kilometer	linear	1000	9036 - Kilometer
yard_clarke	linear	0.914391795	9037 - Yard (Clarke)
chain_clarke	linear	20.11661949	9038 - Chain (Clarke)
link_clarke	linear	0.2011661949	9039 - Link (Clarke's ratio)
yard_sears	linear	0.2011661949	9040 - Yard (Sears)
foot_sears	linear	0.3047994715386762	9041 - Sear's foot
chain_sears	linear	20.11676512155263	9042 - Chain (Sears)
link_sears	linear	0.2011676512155263	9043 - Link (Sears)
yard_benoit_1895_a	linear	0.9143992	9050 - Yard (Benoit 1895 A)
foot_benoit_1895_a	linear	0.3047997333333333	9051 - Foot (Benoit 1895 A)
chain_benoit_1895_a	linear	20.1167824	9052 - Chain (Benoit 1895 A)
link_benoit_1895_a	linear	0.201167824	9043 - Link (Sears)
yard_benoit_1895_a	linear	0.9143992	9050 - Yard (Benoit 1895 A)
foot_benoit_1895_a	linear	0.3047997333333333	9051 - Foot (Benoit 1895 A)
chain_benoit_1895_a	linear	20.1167824	9052 - Chain (Benoit 1895 A)
link_benoit_1895_a	linear	0.201167824	9053 - Link (Benoit 1895 A)
yard_benoit_1895_b	linear	0.9143992042898124	9060 - Yard (Benoit 1895 B)
foot_benoit_1895_b	linear	0.3047997347632708	9061 - Foot (Benoit 1895 B)
chain_benoit_1895_b	linear	20.11678249437587	9062 - Chain (Benoit 1895 B)
link_benoit_1895_b	linear	0.2011678249437587	9063 - Link (Benoit 1895 B)
foot_1865	linear	0.3048008333333334	9070 - Foot (1865)

Table 1-3. Predefined units of measure in the st_units_of_measure table (continued)

unit_name	unit_type	conversion_factor	description
foot_indian	linear	0.3047995102481469	9080 - Indian geodetic foot
foot_indian_1937	linear	0.30479841	9081 - Indian foot (1937)
foot_indian_1962	linear	0.3047996	9082 - Indian foot (1962)
foot_indian_1975	linear	0.3047995	9083 - Indian foot (1975)
yard_indian	linear	0.9143985307444408	9084 - Indian yard
yard_indian_1937	linear	0.91439523	9085 - Indian yard (1937)
yard_indian_1962	linear	0.9143988	9086 - Indian yard (1962)
yard_indian_1975	linear	0.9143985	9087 - Indian yard (1975)
radian	angular	1	9101 - Radian
degree	angular	0.0174532925199433	9102 - Degree
minute	angular	0.0002908882086657216	9103 - Arc-minute
second	angular	4.84813681109536E-06	9104 - Arc-second
grad	angular	0.01570796326794897	9105 - Grad (angle subtended by 1/400 circle)
gon	angular	0.01570796326794897	9106 - Gon (angle subtended by 1/400 circle)
microradian	angular	1E-06	9109 - Microradian (1e-6 radian)
minute_centesimal	angular	0.0001570796326794897	9112 - Centesimal minute (1/100th Gon (Grad))
second_centesimal	angular	1.570796326794897E-06	9113 - Centesimal second(1/10000th Gon (Grad))
mil_6400	angular	0.0009817477042468104	9114 - Mil (angle subtended by 1/6400 circle)

Related reference:
"The ST_Length() function" on page 7-83
"The ST_Perimeter() function" on page 7-113
"The ST_Area() function" on page 7-10
"The ST_Distance() function" on page 7-48
"The ST_Buffer() function" on page 7-22

Spatial tables

A *spatial table* is a table that includes one or more spatial columns.

When you create a spatial table, you specify the following information:
- The name of the table.
- The first column must be named **se_row_id** and have a type of INTEGER. The **se_row_id** column is required by the ESRI client software to be the unique key of the spatial table. The **se_row_id** column stores the SRID that you want to use for the spatial data.
- One column must have a spatial data type. A spatial column can accept only data of the type required by the spatial column. For example, a column of ST_Polygon type rejects integers, characters, and even other types of geometry.

- You can have any other columns that you need.
- You can specify an sbspace in which to store spatial data. Use the PUT clause to specify spatial column and the sbspace.

Examples

The sensitive areas and hazardous waste sites example illustrates two spatial tables.

Stored in the **sensitive_areas** table are schools, hospitals, and playgrounds. The ST_Polygon data type is used to store the sensitive areas:

```
CREATE TABLE sensitive_areas (se_row_id integer NOT NULL,
                              area_id   integer,
                              name      varchar(128),
                              size      float,
                              type      varchar(10),
                              zone      ST_Polygon);
```

The **hazardous_sites** table holds locations of hazardous waste sites. The hazardous sites are stored as points using the ST_Point type. The ST_Point data is stored in the sbspace that is named **mysbspace**:

```
CREATE TABLE hazardous_sites (se_row_id integer NOT NULL,
                              site_id   integer,
                              name      varchar(40),
                              location  ST_Point)
       PUT location in mysbspace;
```

Related reference:

Chapter 2, “Spatial data types,” on page 2-1

CREATE TABLE statement (SQL Syntax)

Loading spatial data

After you prepare for spatial data, you can load data into the spatial table. The method for loading depends on the type and amount of data. Some loading methods automatically create an between the spatial table and a spatial reference system in the **geometry_columns** table and create a spatial index. Otherwise, you must create the association and the index manually.

You can use the following data exchange formats for your spatial data:

- OGC well-known text representation (WKT)
- OGC well-known binary representation (WKB)
- ESRI shapefile format
- Geography Markup Language (GML)
- Keyhole Markup Language (KML)

These data exchange formats require input and output conversion functions to insert spatial data into, and retrieve data from, a database. Each data exchange format has a set of functions to convert data into its stored data types.

You can also use the IBM Informix load format, which does not require conversion functions.

The actual amount of data that is loaded into a GIS system usually ranges between 10 000 records for smaller systems and 100 000 000 records for larger systems. You have several options for loading large amounts of data. If you are loading data in bulk, you can avoid large numbers of log records by temporarily turning off logging for the database until the data is loaded.

Loading ESRI shapefiles for ESRI clients

To load ESRI shapefiles that can be accessed by ESRI SDE clients, acquire data from a vendor and load the data through the ESRI SDE server by running the ESRI **shp2sde** command. Accessing spatial tables through SDE software provides immediate access to SDE client software such as ArcView GIS, MapObjects, ARC/INFO, and ArcExplorer. MicroStation and AutoCAD are also accessible through SDE CAD client software.

The **shp2sde** command automatically updates the **geometry_columns** table and creates the spatial index.

Loading ESRI shapefiles for non-ESRI clients

To load ESRI shapefiles for clients other than ESRI clients, run the **loadshp** utility. A companion utility, **unloadshp**, unloads data from a database to shapefiles. Data that is loaded by the **loadshp** utility is also accessible to client programs that do not depend on ESRI system tables other than the OGC-standard **geometry_columns** and **spatial_references** tables. Data that you load with the **loadshp** utility is not accessible to ArcSDE and other ESRI client tools. You can optionally create the spatial table when you run the **loadshp** utility.

The **loadshp** utility automatically updates the **geometry_columns** table and creates the spatial index.

Loading any type of geometry format

To load any type of geometry format:

1. Load the spatial data with one of the following methods:
   - INSERT statements that load rows individually.
   - Develop your own loader application. The source code for two sample programs, **load_wkb** and **load_shapes**, is supplied with the IBM Informix software. These programs illustrate how to convert data into OGC well-known binary and ESRI shapefile formats. The programs can be modified and linked into existing applications. They are located under the `$INFORMIXDIR/extend/spatial.`*`version`*`/examples` directory. ESQL/C and ODBC versions of both programs are provided.
2. Create an association between the spatial table and a spatial reference system by updating the **geometry_columns** table.
3. Create a spatial index on the spatial table by running the CREATE INDEX statement with the USING RTREE clause.

Examples: Load individual rows

You can load individual records into the spatial table with an INSERT statement.

You can convert the well-known text representation of a polygon into an ST_Polygon type by running the **ST_PolyFromText()** function. You can convert the well-known text representation of a point into an ST_Point type by running the **ST_PointFromText()** function.

For example, in the following SQL statements, records are inserted into the **sensitive_areas** and **hazardous_sites** table:

```
INSERT INTO sensitive_areas VALUES (
    1, 408, 'Summerhill Elementary School', 67920.64, 'school',
    ST_PolyFromText('polygon ((52000 28000,58000 28000,58000 23000,
52000 23000,52000 28000))',5)
);

INSERT INTO hazardous_sites VALUES (
    1, 102, 'W. H. Kleenare Chemical Repository',
    ST_PointFromText('point (17000 57000)',5)
);
```

You can use the IBM Informix load format, which does not require a conversion function. The following example inserts a row in the **sensitive_areas** table and the **hazardous_sites** table:

```
INSERT INTO sensitive_areas VALUES (
    2, 129, 'Johnson County Hospital', 102281.91, 'hospital',
    '5 polygon ((32000 55000,32000 68000,38000 68000,38000 52000,
35000 52000,35000 55000,32000 55000))'
);

INSERT INTO hazardous_sites VALUES (
    2, 59, 'Landmark Industrial',
    '5 point (58000 49000)'
);
```

Related tasks:

"Preparing for spatial data" on page 1-11

Related reference:

INSERT statement (SQL Syntax)

Appendix A, "Load and unload shapefile data," on page A-1

Chapter 3, "Data exchange formats," on page 3-1

The geometry_columns table

When you create a table with a spatial column, or add a spatial column to an existing table, ESRI client software also requires an entry to the **geometry_columns** table. The **geometry_columns** table is a metadata table that stores the association between the spatial table and a spatial reference system.

The **loadshp** utility and the ESRI **shp2sde** command automatically create the entries in the **geometry_columns** table when you load data.

To update the **geometry_columns** table manually, insert a new row. The row must contain values for the following columns:

- **f_table_catalog**: The database name
- **f_table_schema**: The database owner name
- **f_table_name**: The table name
- **f_geometry_column**: The name of the spatial column
- **geometry_type**: The ID of the geometry type
- **srid**: The ID of the spatial reference system

The following table shows valid entries for the **geometry_type** column and the shapes they represent.

Table 1-4. Geometry type ID to spatial data type mapping

Geometry type ID	Spatial data type
0	ST_Geometry
1	ST_Point
2	ST_Curve
3	ST_LineString
4	ST_Surface
5	ST_Polygon
6	ST_GeomCollection
7	ST_MultiPoint
8	ST_MultiCurve
9	ST_MultiLineString
10	ST_MultiSurface
11	ST_MultiPolygon

Example

For the hazardous sites and sensitive areas example, the INSERT statements for the **zone** and **location** columns are:

```
INSERT INTO geometry_columns
          (f_table_catalog, f_table_schema, f_table_name,
           f_geometry_column, geometry_type, srid)
   VALUES ("mydatabase",         -- database name
           "ralph",              -- user name
           "sensitive_areas",    -- table name
           "zone",               -- spatial column name
            5,                   -- column type (5 = polygon)
            5);                  -- srid

INSERT INTO geometry_columns
          (f_table_catalog, f_table_schema, f_table_name,
           f_geometry_column, geometry_type, srid)
   VALUES ("mydatabase",         -- database name
           "ralph",              -- user name
           "hazardous_sites",    -- table name
           "location",           -- spatial column name
            1,                   -- column type (1 = point)
            5);                  -- srid
```

The **zone** column has a spatial data type of ST_Polygon. The **location** column has a spatial data type of ST_Point.

Related reference:

Appendix A, "Load and unload shapefile data," on page A-1

The spatial index

Because spatial columns contain multidimensional geographic data, applications that query spatial columns require an index strategy that quickly identifies all geometries that satisfy a specified spatial relationship. To index spatial data, you create a spatial index, called the *R-tree index*.

The two-dimensional R-tree index differs from the traditional hierarchical (one-dimensional) B-tree index. Spatial data is two-dimensional, so you cannot use the B-tree index for spatial data. Similarly, you cannot use an R-tree index with non-spatial data.

Tip: The **loadshp** utility automatically creates an R-tree index after you load the data. The ESRI **shp2sde** command can also create an R-tree index.

To create an R-tree index on the **location** column of the **hazardous_sites** table, run the CREATE INDEX statement:

```
CREATE INDEX location_ix
   ON hazardous_sites (location ST_Geometry_ops)
   USING RTREE;
```

The query optimizer does not use the R-tree index unless the statistics on the table are up-to-date. If the R-tree index is created after the data is loaded, the statistics are current and the optimizer uses the index. However, if the index is created before the data is loaded, the optimizer does not use the R-tree index because the statistics are out of date.

If you create the index before you load the data, run the UPDATE STATISTICS SQL statement:

```
UPDATE STATISTICS FOR TABLE hazardous_sites;
```

Restriction: You cannot rename a database if the database contains a table that has an R-tree index that is defined on it because R-tree indexes are implemented with secondary access method. Databases that use primary access method (also called virtual table interface) or secondary access method (also called virtual index interface) cannot be renamed.

Related reference:

"Syntax for creating an R-tree index" on page 4-1

Appendix A, "Load and unload shapefile data," on page A-1

Query spatial data

A common task in a GIS application is to retrieve the visible subset of spatial data for display in a window.

You can define a polygon that represents the boundary of the window and then run the **SE_EnvelopesIntersect()** function to find all spatial objects that overlap this window. The following statement returns the objects that overlap the polygon that is defined by the **ST_PolyFromText()** function:

```
SELECT name, type, zone FROM sensitive_areas
   WHERE SE_EnvelopesIntersect(zone,
      ST_PolyFromText('polygon((20000 20000,60000 20000,
60000 60000,20000 60000,20000 20000))', 5));
```

You can include spatial columns in the WHERE clause of queries to qualify the result set. The spatial column does not need to be in the result set. For example, the following SQL statement retrieves each sensitive area with its nearby hazardous waste site if the sensitive area is within five miles of a hazardous site. The **ST_Buffer()** function generates a circular polygon that represents the 5-mile radius around each hazardous location. The ST_Polygon geometry that is returned by the **ST_Buffer()** function becomes the argument of the **ST_Overlaps()** function, which returns t (TRUE) if the **zone** ST_Polygon of the **sensitive_areas** table overlaps the ST_Polygon generated by the **ST_Buffer()** function:

```
SELECT sa.name sensitive_area, hs.name hazardous_site
   FROM sensitive_areas sa, hazardous_sites hs
   WHERE ST_Overlaps(sa.zone, ST_Buffer(hs.location, 26400));


sensitive_area  Summerhill Elementary School
hazardous_site  Landmark Industrial

sensitive_area  Johnson County Hospital
hazardous_site  Landmark Industrial
```

Related reference:

SELECT statement (SQL Syntax)
Chapter 5, "Run parallel queries," on page 5-1

Optimize spatial queries

You can set environment variables in your database server environment to optimize your spatial queries.

You can set the following spatial environment variables in your database server environment before you start the database server.

ST_MAXLEVELS environment variable

Running the UPDATE STATISTICS HIGH statement on a large table might require large amounts of shared memory (tens of MB). If sufficient shared memory is unavailable, the UPDATE STATISTICS statement fails. You can set the **ST_MAXLEVELS** environment variable to reduce the memory requirements for updating statistics on spatial tables. Spatial tables have histograms of the spatial data to determine the cost of retrieving the data. The histogram describes how the spatial data is distributed.

The range of values for the **ST_MAXLEVELS** environment variable is 1 - 16. The default value is 16. A smaller value reduces the amount of memory that is needed to build a histogram, but might result in a less accurate histogram. The minimum recommended value is 12.

ST_COSTMULTIPLER environment variable

To adjust the cost for each row that is computed by the database server, set the **ST_COSTMULTIPLER** environment variable to a floating point value that is greater than 0. The default value is 1.0 (no effect). The database server multiplies the cost estimate by the value of the **ST_COSTMULTIPLER** environment variable to compute the cost of spatial predicates that include the following spatial functions:

- **ST_Overlaps()**
- **Equal()**
- **ST_Contains()**
- **ST_Within()**
- **SE_EnvelopeIntersect()**
- **SE_Intersects()**
- **ST_Touches()**
- **ST_Crosses()**

- **ST_Equals()**
- **ST_Disjoint()**

To increase the cost of a spatial predicate, set the value of the **ST_COSTMULTIPLER** environment variable to greater than 1.0. To decrease the cost of a spatial predicate, set the value of the **ST_COSTMULTIPLER** environment variable to less than 1.0.

The cost can be used to compute the cost of a full table scan or the cost of the refinement step in an index scan.

ST_MEMMODE environment variable

To improve performance, the database server uses a pool of temporary memory buffers for processing spatial data. You can change the behavior of this memory management system, if necessary, in two ways:
- Set the **ST_MEMMODE** environment variable.
- Set the value of the MemMode parameter while the database server is running by running the **SE_ParamSet()** function.

The **ST_MEMMODE** environment variable and the MemMode parameter can have the following values:

0
Disables memory buffer reuse. Temporary buffers, which are used for processing spatial data, are allocated from the per_routine memory pool and are not reused between UDR invocations. Several memory buffers are typically allocated and freed for every row in a table that is being processed. This setting can result in slower query performance.

1
Default. Enables memory buffer reuse. Temporary buffers are allocated from the per_command memory pool. As they are freed, they are returned to a pool and are reused for subsequent memory requests. This pool is drained when the UDR sequence completes after all rows in a table are processed. This setting can result in memory fragmentation.

2
Disables memory buffer reuse, but allocates all temporary buffers from the server per_command memory pool. This mode, with the **DONTDRAINPOOLS** server environment variable, is similar to mode 1, but allows the server to manage the memory.

Buffers that hold UDR return values are allocated from the per_command memory pool and are reused between UDR invocations.

The value of the MemMode parameter takes precedence over the value of the **ST_MEMMODE** environment variable. The MemMode parameter remains set until the server is shut down. When the server is restarted, the value of the **ST_MEMMODE** environment variable takes effect.

To view the value of the MemMode parameter, run the **SE_ParamGet()** function.

Related concepts:

Selectivity and cost functions (Performance Guide)

Related reference:

"The SE_ParamGet() function" on page 7-112
"The SE_ParamSet() function" on page 7-112

Update values in a spatial column

You run the SQL UPDATE statement to alter the values in a spatial column in the same way that you update any other type of column. Typically, you must retrieve spatial column data from the table, alter the data in a client application, and then return the data to the database.

The following pair of SQL statements illustrates how to fetch the spatial data from one row in the **hazardous_sites** table and then update the same item:

```
SELECT ST_AsText(location) FROM hazardous_sites
   WHERE site_id = 102;

UPDATE hazardous_sites
   SET location = ST_PointFromText('point(18000 57000)', 5)
   WHERE site_id = 102;
```

Related reference:

Chapter 5, “Run parallel queries,” on page 5-1

UPDATE statement (SQL Syntax)

SELECT statement (SQL Syntax)

Chapter 2. Spatial data types

IBM Informix spatial data types are divided into two categories: the base geometry subclasses and the homogeneous collection subclasses.

- The base geometries are:
  - ST_Point
  - ST_LineString
  - ST_Polygon
- The homogeneous collections are:
  - ST_MultiPoint
  - ST_MultiLineString
  - ST_MultiPolygon

Homogeneous collections are collections of base geometries; in addition to sharing base geometry properties, homogeneous collections also have some properties of their own.

The **ST_GeometryType()** function takes an ST_Geometry and returns the instantiable subclass in the form of a character string. The **ST_NumGeometries()** function takes a homogeneous collection and returns the number of base geometry elements it contains. The **ST_GeometryN()** function takes a homogeneous collection and an index and returns the *n*th base geometry.

Related reference:

"Spatial tables" on page 1-18

Properties of spatial data types

Typically, points represent an object at a single location, linestrings represent a linear characteristic, and polygons represent a spatial extent.

The OGC, in its publication of *OpenGIS Features for ODBC (SQL) Implementation Specification*, selected the term *geometry* to represent spatial features such as point locations and polygons. An abstract definition of the OpenGIS noun *geometry* might be, "a point or aggregate of points symbolizing a feature on the ground."

The ST_Geometry data type is an abstract noninstantiable superclass. Its subclasses provide instantiable data types. As such, you can define table columns to be of such types. The following figure shows the class hierarchy for the IBM Informix spatial data types.

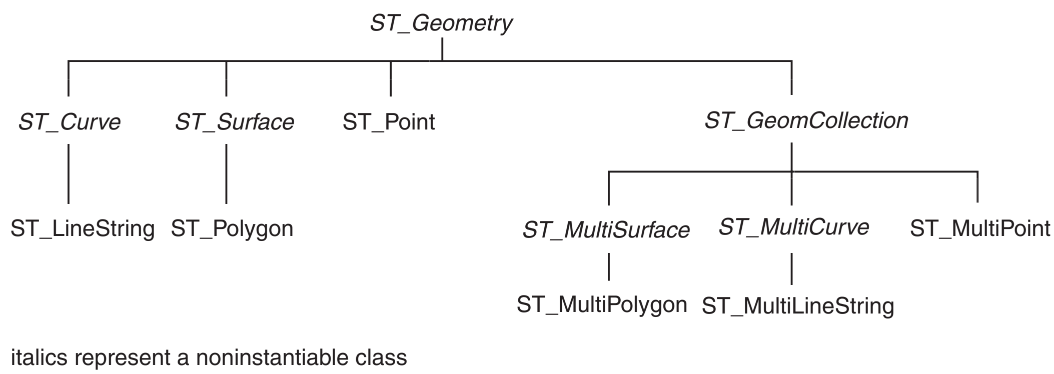


Figure 2-1. Data types class diagram

Throughout the remainder of this publication, the terms *geometry* or *geometries* collectively refer to the superclass ST_Geometry data type and all of its subclass data types. When it is necessary to specify the geometry superclass directly, it is referred to as the ST_Geometry superclass or the ST_Geometry data type.

Tip: You can define a column as type ST_Geometry, but ST_Geometry values cannot be inserted into it since they cannot be instantiated. However, any of the ST_Geometry subclass data type values can be inserted into this column.

Descriptions of the properties of the spatial data types follow. Each subclass data type inherits the properties of the ST_Geometry superclass and adds properties of its own. Functions that operate on the ST_Geometry data type also operate on any of the subclass data types. However, functions that are defined at the subclass level operate only on that data type and its subclasses data types.

Interior, boundary, and exterior

All geometries occupy a position in space that is defined by their interior, boundary, and exterior.

Exterior
All space that is not occupied by the geometry.

Boundary
Serves as the interface between its interior and exterior.

Interior
The space that is occupied by the geometry.

The subclass inherits the interior and exterior properties from ST_Geometry; the boundary property differs for each data type.

The **ST_Boundary()** function takes an ST_Geometry type and returns an ST_Geometry that represents the source ST_Geometry boundary.

Simple or nonsimple

Some subclasses of ST_Geometry (ST_LineStrings, ST_MultiPoints, and ST_MultiLineStrings) are either simple or nonsimple. They are simple if they obey all topological rules that are imposed on the subclass and nonsimple if they bend a few rules.

- ST_LineString is simple if it does not intersect its interior.
- ST_MultiPoint is simple if none of its elements occupy the same coordinate space.
- ST_MultiLineString is simple if none of its element's interiors intersect.

The **ST_IsSimple()** function takes an ST_Geometry and returns t (TRUE) if the ST_Geometry is simple and f (FALSE), otherwise.

Empty or not empty
A geometry is empty if it does not have any points.

An empty geometry has a NULL envelope, boundary, interior, and exterior. An empty geometry is always simple and can have Z coordinates or measures. Empty linestrings and multilinestrings have a 0 length. Empty polygons and multipolygons have 0 area.

The **ST_IsEmpty()** function takes an ST_Geometry and returns t (TRUE) if the ST_Geometry is empty and f (FALSE) otherwise.

Number of points
A geometry can have zero or more points.

A geometry is considered empty if it has zero points. The ST_Point subclass is the only geometry that is restricted to zero or one point; all other subclasses can have zero or more.

Envelope
The envelope of a geometry is the bounding geometry that is formed by the minimum and maximum (X,Y) coordinates.

The envelopes of most geometries form a boundary rectangle. However, the envelope of a point is the point itself, since its minimum and maximum coordinates are the same. The envelope of a horizontal or vertical linestring is a linestring that is represented by the endpoints of the source linestring.

The **ST_Envelope()** function takes an ST_Geometry and returns a ST_Geometry that represents the source ST_Geometry envelope.

Dimension
A geometry can have a dimension of 0, 1, or 2.

0 The geometry has neither length or area.

1 The geometry has a length.

2 The geometry contains area.

The point and multipoint subclasses have a dimension of 0. Points represent zero-dimensional features that can be modeled with a single coordinate, while multipoints represent data that must be modeled as a cluster of unconnected coordinates.

The subclasses linestring and multilinestring have a dimension of 1. They store road segments, branching river systems, and any other features that are linear in nature.

Polygon and multipolygon subclasses have a dimension of 2. Forest stands, parcels, water bodies, and other features whose perimeter encloses a definable area can be rendered by either the polygon or multipolygon data type.

Dimension is important not only as a property of the subclass, but also plays a part in determining the spatial relationship of two features. The dimension of the resulting feature or features determines whether the operation was successful. The dimension of the features is examined to determine how they are compared.

The **ST_Dimension()** function takes an ST_Geometry and returns its dimension as an integer.

Z coordinates
Some geometries have an associated altitude or depth.

Each of the points that form the geometry of a feature can include an optional Z coordinate that represents an altitude or depth normal to the earth's surface.

The **SE_Is3D()** predicate function takes an ST_Geometry and returns `t` (TRUE) if the function has Z coordinates and `f` (FALSE), otherwise.

Measures
Measures are values that are assigned to each coordinate.

The value represents anything that can be stored as a double-precision number.

The **SE_IsMeasured()** function takes an ST_Geometry and returns `t` (TRUE) if it contains measures and `f` (FALSE), otherwise.

Spatial reference system
The spatial reference system identifies the coordinate transformation matrix for each geometry.

All spatial reference systems that are known to the database are stored in the **spatial_references** table.

The **ST_SRID()** function takes an ST_Geometry and returns its spatial reference identifier as an integer.

ST_Point data type

The ST_Point data type is a zero-dimensional geometry that occupies a single location in coordinate space. ST_Point is used to define features such as oil wells, landmarks, and elevations.

Properties

An ST_Point has a single X,Y coordinate value, is always simple, and has a NULL boundary. An ST_Point may include a Z coordinate and an M value.

Functions

The following functions operate solely on the ST_Point data type:

ST_X()
The function returns a point data type's X coordinate value as a double-precision number.

ST_Y()
The function returns a point data type's Y coordinate value as a double-precision number.

SE_Z()
The function returns a point data type's Z coordinate value as a double-precision number.

SE_M()
The function returns a point data type's M coordinate value as a double-precision number.

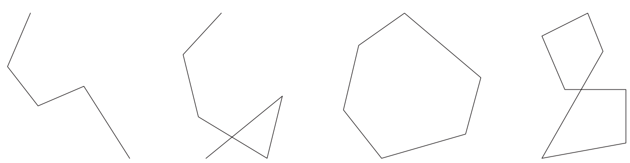
ST_LineString data type

The ST_LineString data type is a one-dimensional object stored as a sequence of points defining a linear interpolated path. ST_LineString types are often used to define linear features such as roads, rivers, and power lines.

Properties

An ST_LineString is simple if it does not intersect its interior. The endpoints (the boundary) of a closed ST_LineString occupy the same point in space. An ST_LineString is a ring if it is both closed and simple. In addition to properties inherited from the superclass ST_Geometry, ST_LineString values have length.

The endpoints normally form the boundary of a ST_LineString unless the ST_LineString is closed, in which case the boundary is NULL. The interior of a ST_LineString is the connected path that lies between the endpoints, unless it is closed, in which case the interior is continuous. The following figure shows examples of ST_LineString objects: (1) is a simple nonclosed ST_LineString; (2) is a nonsimple nonclosed ST_LineString; (3) is a closed simple ST_LineString and therefore is a ring; (4) is a closed nonsimple ST_LineString—it is not a ring.



(1) (2) (3) (4)

Figure 2-2. Examples of ST_LineString objects

Functions

The following functions operate on ST_LineString:

ST_StartPoint()
: The function returns the linestring's first point.

ST_EndPoint()
: The function returns the linestring's last point.

ST_PointN()
: The function takes an ST_LineString and an index to *n*th point and returns that point.

ST_Length()
: The function returns the linestring's length as a double-precision number.

ST_NumPoints()
: The function returns the number of points in the linestring's sequence as an integer.

ST_IsRing()
: The function returns `t` (TRUE) if the ST_LineString is a ring and `f` (FALSE) otherwise.

ST_IsClosed()
: The function returns `t` (TRUE) if the ST_LineString is closed and `f` (FALSE) otherwise.

ST_Polygon()
: The function creates a polygon from an ST_LineString that is a ring.

ST_Polygon data type

The ST_Polygon data type is a two-dimensional surface stored as a sequence of points defining its exterior bounding ring and 0 or more interior rings. Most often, ST_Polygon defines parcels of land, water bodies, and other features having spatial extent.

Properties

The ST_Polygon is always simple. The exterior and any interior rings define the boundary of an ST_Polygon, and the space enclosed between the rings defines the interior of ST_Polygon. The rings of an ST_Polygon can intersect at a tangent point, but never cross. In addition to the other properties inherited from the superclass, ST_Geometry, ST_Polygon has area.

The following figure shows examples of ST_Polygon objects: (1) is an ST_Polygon whose boundary is defined by an exterior ring; (2) is an ST_Polygon whose boundary is defined by an exterior ring and two interior rings. The area inside the interior rings is part of the ST_Polygon's exterior; (3) is a legal ST_Polygon because the rings intersect at a single tangent point.

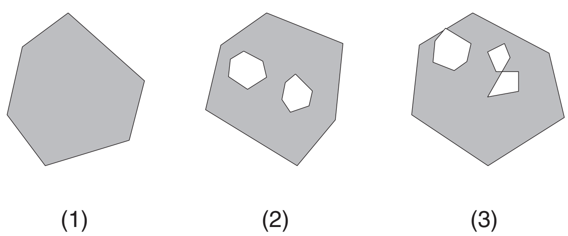


Figure 2-3. Examples of ST_Polygon objects

Functions

The following functions operate on ST_Polygon:

ST_Area()
: The function returns the polygon's area as a double-precision number.

ST_ExteriorRing()
: The function returns the polygon's exterior ring as an ST_LineString.

ST_NumInteriorRing()
: The function returns the number of interior rings that the polygon contains.

ST_InteriorRingN()
: The function takes an ST_Polygon and an index and returns the *n*th interior ring as an ST_LineString.

ST_Centroid()
: The function returns an ST_Point that is the center of the ST_Polygon's envelope.

ST_PointOnSurface()
: The function returns an ST_Point that is guaranteed to be on the surface of the ST_Polygon.

ST_Perimeter()
The function returns the perimeter of an ST_Polygon or ST_MultiPolygon.

ST_MultiPoint data type

The ST_MultiPoint data type is a collection of ST_Points. ST_MultiPoint can define aerial broadcast patterns and incidents of a disease outbreak.

An ST_MultiPoint is simple if none of its elements occupy the same coordinate space. Just like its elements, it has a dimension of 0. The boundary of a ST_MultiPoint is NULL.

ST_MultiLineString data type

The ST_MultiLineString data type is a collection of ST_LineStrings. ST_MultiLineStrings are used to define streams or road networks.

Properties

ST_MultiLineStrings are simple if they only intersect at the endpoints of the ST_LineString elements. ST_MultiLineStrings are nonsimple if the interiors of the ST_LineString elements intersect.

The boundary of an ST_MultiLineString is the non-intersected endpoints of the ST_LineString elements. The ST_MultiLineString is closed if all its ST_LineString elements are closed. The boundary of a ST_MultiLineString is NULL if all the endpoints of all the elements are intersected. In addition to the other properties inherited from the superclass ST_Geometry, ST_MultiLineStrings have length.

The following figure shows examples of ST_MultiLineStrings:

- (1) is a simple ST_MultiLineString whose boundary is the four endpoints of its two ST_LineString elements.
- (2) is a simple ST_MultiLineString because only the endpoints of the ST_LineString elements intersect. The boundary is two non-intersected endpoints.
- (3) is a non-simple ST_MultiLineString because the interior of one of its ST_LineString elements is intersected. The boundary of this ST_MultiLineString is the three non-intersected endpoints.
- (4) is a simple non-closed ST_MultiLineString. It is not closed because its element ST_LineStrings are not closed. It is simple because none of the interiors of any of the element ST_LineStrings intersect.
- (5) is a simple closed ST_MultiLineString. It is closed because all its elements are closed. It is simple because none of its elements intersect at the interiors.

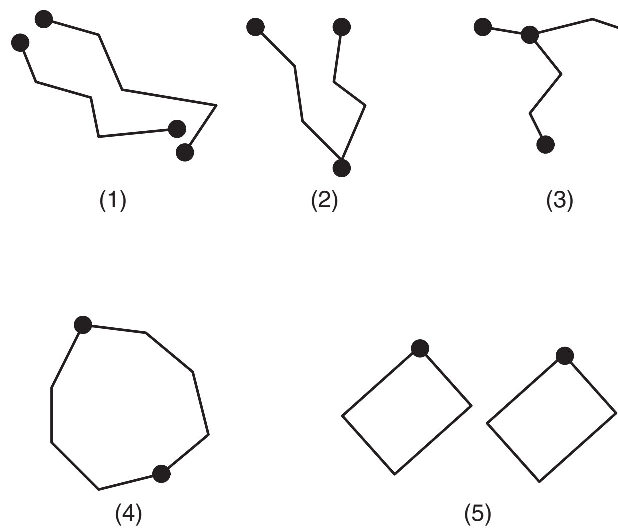


Figure 2-4. Examples of ST_MultiLineString objects

Functions

The following functions operate on ST_MultiLineStrings:

ST_Length()
: The function returns the cumulative length of all its ST_LineString elements as a double-precision number.

ST_IsClosed()
: The function returns `t` (TRUE) if the ST_MultiLineString is closed and `f` (FALSE), otherwise.

ST_MultiPolygon data type

The ST_MultiPolygon data type defines features such as a forest stratum or a non-contiguous parcel of land such as an island chain.

Properties

The boundary of an ST_MultiPolygon is the cumulative length of its elements' exterior and interior rings. The interior of an ST_MultiPolygon is defined as the cumulative interiors of its element ST_Polygons. The boundary of an ST_MultiPolygon's elements can only intersect at a tangent point. In addition to the other properties inherited from the superclass ST_Geometry, ST_MultiPolygons have area.

The following figure shows examples of ST_MultiPolygon: (1) is ST_MultiPolygon with two ST_Polygon elements. The boundary is defined by the two exterior rings and the three interior rings; (2) is an ST_MultiPolygon with two ST_Polygon elements. The boundary is defined by the two exterior rings and the two interior rings. The two ST_Polygon elements intersect at a tangent point.

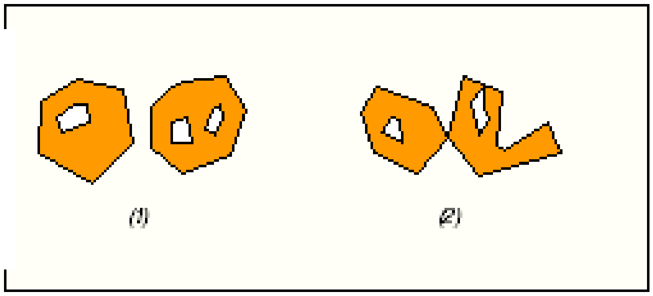


Figure 2-5. Examples of ST_MultiPolygon objects

Functions

The following functions that operate on ST_MultiPolygons:

ST_Area()
: The function returns the cumulative area of its ST_Polygon elements as a double-precision number.

ST_Centroid()
: The function returns an ST_Point that is the center of an ST_MultiPolygon's envelope.

ST_PointOnSurface()
: The function returns an ST_Point that is guaranteed to be on the surface of one of its ST_Polygon elements.

Locale override

The external text representation of double-precision numbers in spatial data types follows the U.S. English locale (**en_us.8859-1**). In this standard, all text input must use dots (.) as decimal separators and must be single-byte ASCII, regardless of the locale. (Internally, the database server overrides the current locale with the U.S. English locale.)

For example, in many European locales, the decimal separator is a comma. You can keep using a non-English locale, but you must use dots in all text input, as follows:

```
ST_PointFromText('point zm (10.01 20.04 3.2 9.5)', 1)
```

This is true even if in your locale you normally use `3,2` instead of `3.2`. External text always contains dots, regardless of the locale.

Spatial data types with SPL

You can use stored procedure language (SPL) with spatial data types.

SPL has two restrictions that might be relevant to working with spatial data:

- LVARCHAR variables in an SPL routine are restricted to 2K.
- SPL does not support a global variable defined on a UDT or complex type.

Casts between spatial data types

You can cast between spatial data types from subtype to supertype.

If you attempt to cast from a supertype to a subtype, or another combination of types that is not compatible, the function returns NULL.

The following example casts to a ST_LineString and filters out any NULL values:

```
SELECT ST_StartPoint(my_geometry_col::ST_LineString) from mytab
      WHERE ST_GeometryType(my_geometry_col) = 'st_linestring';
```

Chapter 3. Data exchange formats

You can use several different GIS data exchange formats for spatial data.

Related concepts:

"Informix spatial solution architecture" on page 1-8

Related reference:

"Loading spatial data" on page 1-19

Well-known text representation

You can generate a geometry from the OGC well-known text (WKT) representation. The WKT is an ASCII text-formatted string that allows geometry to be exchanged in ASCII text form.

You can use the following functions in a third- or fourth-generation language (3GL or 4GL) program because they do not require the definition of any special program structures.

ST_GeomFromText()
: The function creates an ST_Geometry from a text representation of any geometry type.

ST_PointFromText()
: The function creates an ST_Point from a point text representation.

ST_LineFromText()
: The function creates an ST_LineString from a linestring text representation.

ST_PolyFromText()
: The function creates an ST_Polygon from a polygon text representation.

ST_MPointFromText()
: The function creates an ST_MultiPoint from a multipoint representation.

ST_MLineFromText()
: The function creates an ST_MultiLineString from a multilinestring representation.

ST_MPolyFromText()
: The function creates an ST_MultiPolygon from a multipolygon representation.

ST_AsText()
: The function converts an existing geometry into a text representation.

Related reference:

Appendix C, "OGC well-known text representation of geometry," on page C-1

Well-known binary representation

You can generate a geometry from the OGC well-known binary (WKB) representation. The WKB representation is a contiguous stream of bytes. It permits geometry to be exchanged between a client application and an SQL database in binary form.

ST_GeomFromWKB()
The function creates an ST_Geometry from a WKB representation of any geometry type.

ST_PointFromWKB()
The function creates an ST_Point from a point WKB representation.

ST_LineFromWKB()
The function creates an ST_LineString from a linestring WKB representation.

ST_PolyFromWKB()
The function creates an ST_Polygon from a polygon WKB representation.

ST_MPointFromWKB()
The function creates an ST_MultiPoint from a multipoint WKB representation.

ST_MLineFromWKB()
The function creates an ST_MultiLineString from a multilinestring WKB representation.

ST_MPolyFromWKB()
The function creates an ST_MultiPolygon from a multipolygon WKB representation.

ST_AsBinary()
The function converts an existing geometry value into well-known binary representation.

Related reference:

Appendix C, "OGC well-known text representation of geometry," on page C-1

ESRI shape representation

You can generate a geometry from an *ESRI shape representation*. In addition to the two-dimensional representation supported by the Open GIS well-known binary representation, the ESRI shape representation also supports optional Z coordinates and measures.

The following functions generate geometry from an ESRI shape.

SE_GeomFromShape()
The function creates an ST_Geometry from a shape of any geometry type.

SE_PointFromShape()
The function creates an ST_Point from a point shape.

SE_LineFromShape()
The function creates an ST_LineString from a polyline shape.

SE_PolyFromShape()
The function creates an ST_Polygon from a polygon shape.

SE_MPointFromShape()
The function creates an ST_MultiPoint from a multipoint shape.

SE_MLineFromShape()
The function creates an ST_MultiLineString from a multipart polyline shape.

SE_MPolyFromShape()

The function creates an ST_MultiPolygon from a multipart polygon shape.

For all of these functions, the first argument is the shape representation and the second argument is the spatial reference identifier to assign to the **ST_Geometry**. For example, the **SE_GeomFromShape()** function has the following syntax:

```
SE_GeomFromShape(shapegeometry, SRID)
```

The **SE_AsShape()** function converts the geometry value into an ESRI shape representation.

Related reference:

Appendix E, "ESRI shape representation," on page E-1

Geography Markup Language representation

You can generate a geometry from a Geography Markup Language (GML) representation. The GML can be represented as either GML2 (OGC GML standard 2.1.2) or GML3 (OGC GML standard 3.1.1). In addition to the two-dimensional representation supported by the Open GIS well-known binary representation, the GML representation also supports optional Z coordinates and measures.

The following functions generate a geometry from a GML string.

ST_GeomFromGML()
: The function creates an ST_Geometry from a string of any geometry type.

ST_PointFromGML()
: The function creates an ST_Point from a point string.

ST_LineFromGML()
: The function creates an ST_LineString from a polyline string.

ST_PolyFromShape()
: The function creates an ST_Polygon from a polygon string.

ST_MPointFromGML()
: The function creates an ST_MultiPoint from a multipoint string.

ST_MLineFromGML()
: The function creates an ST_MultiLineString from a multipart polyline string.

ST_MPolyFromGML()
: The function creates an ST_MultiPolygon from a multipart polygon string.

For all of these functions, the first argument is the GML representation and the second optional argument is the spatial reference identifier to assign to the ST_Geometry. For example, the **ST_GeomFromGML()** function has the following syntax:

```
ST_GeomFromGML(gml_string, [SRID])
```

```
 ST_GeomFromGML('<gml:Point srsName="ESPG:1234" srsDimension="2">
     <gml:pos>10.02 20.01</gml:pos></gml:Point>', 1000)
```

The **SE_AsGML()** and **ST_AsGML()** functions convert the geometry value into a GML representation.

The **ST_EnvelopeAsGML()** function converts an ST_Polygon into a GML3 Envelope element.

Keyhole Markup Language representation

You can generate a geometry from a Keyhole Markup Language (KML) representation. KML is an XML-based schema for expressing geographic annotation and visualization on online maps and earth browsers.

The following functions generate a geometry from a KML string.

SE_EnvelopeFromKML()
: The function creates an ST_Polygon from a KML LatLonBox string.

ST_GeomFromKML()
: The function creates an ST_Geometry from a KML fragment.

ST_LineFromKML()
: The function creates an ST_LineString from a KML LineString string.

ST_MLineFromKML()
: The function creates an ST_MultiLineString from a KML MultiGeometry string.

ST_MPointFromKML()
: The function creates an ST_MultiPoint from a KML MultiGeometry and Point combination string.

ST_MPolyFromKML()
: The function creates an ST_MultiPolygon from a KML MultiGeometry and Polygon combination string.

ST_PointFromKML()
: The function creates an ST_Point from a KML Point string.

ST_PolyFromKML()
: The function creates an ST_Polygon from a KML Polygon string.

For most of these functions, the first argument is the KML representation and the second optional argument is the spatial reference identifier to assign to the ST_Geometry. For example, the **ST_LineFromKML()** function has the following syntax:

```
ST_LineFromKML(kmlstring lvarchar, SRID integer)
```

The **SE_AsKML()** and **ST_AsKML()** functions convert the geometry value into a GML representation.

The **ST_EnvelopeAsKML()** function converts an ST_Envelope bounding box into a KML LatLonBox string.

Chapter 4. R-tree indexes

An index organizes access to data so that entries can be found quickly, without searching every row. The R-tree access method enables you to index multidimensional objects.

Queries that use an index execute more quickly and provide a significant performance improvement. The R-tree access method speeds access to multidimensional data. It organizes data in a tree-shaped structure, with bounding boxes at the nodes. Bounding boxes indicate the farthest extent of the data that is connected to the subtree below.

A search using an R-tree index can quickly descend the tree to find objects in the general area of interest and then perform more exact tests on the objects themselves. An R-tree index can improve performance because it eliminates the need to examine objects outside the area of interest. Without an R-tree index, a query would need to evaluate every object to find those that match the query criteria.

When you create an index, you can specify an *access method* and an *operator class* (if you do not specify an access method, the default B-tree access method is used). The access method organizes the data in a way that speeds up access. The operator class is used by the optimizer to determine whether to use an index in a query.

To create an R-tree index, you must specify an operator class that supports an R-tree index on the data type you want to index. The operator class you use for IBM Informix spatial data types is **ST_Geometry_Ops**.

The B-tree access method creates a one dimensional ordering that speeds access to traditional numeric or character data. You can use B-tree to index a column of non-spatial data or to create a functional index on the results of a spatial function that returns numeric or character data. For example, you could create a functional B-tree index on the results of the **ST_NumPoints()** function because **ST_NumPoints()** returns an integer value.

Restriction: The B-tree access method indexes numeric and character data only. You cannot use the B-tree access method to index spatial data.

The syntax for creating an index is described in detail in the CREATE INDEX statement in *IBM Informix Guide to SQL: Syntax*.

For a detailed description of R-tree indexes, refer to the *IBM Informix R-Tree Index User's Guide*.

Syntax for creating an R-tree index

To use the R-tree access method, you create an index on a column of a spatial type.

Syntax

```
►►──CREATE INDEX──index_name──ON──table_name──────────────────────────►
```



```
►─(─column_name─ST_Geometry_Ops─)────────────────────────────────►

►─USING RTREE─┬──────────────────┬─┬───────────────┬─;──────────►◄
              └─(─parameters─)─┘ └─index_options─┘
```

Element	Description
column_name	The name of the spatial column.
index_name	The name to give your index.
index_options	The index options are FRAGMENT BY and IN.
parameters	The parameters available for R-tree indexes are bottom_up_build, BOUNDING_BOX_INDEX, NO_SORT, sort_memory, and fill_factor.
table_name	The name of the table that contains the spatial column to index.

Restriction: You cannot rename databases that contain R-tree indexes.

The BOTTOM_UP_BUILD, BOUNDING_BOX_INDEX, and NO_SORT parameters affect the size of the index and the speed at which it is built. The following table shows the valid combinations of these parameters.

Table 4-1. Parameters of the CREATE INDEX statement for spatial data

Parameters clause of CREATE INDEX statement	Description
BOTTOM_UP_BUILD='no', BOUNDING_BOX_INDEX='no', NO_SORT='no'	Creates an index by inserting spatial objects into the R-tree one at a time A copy of each object's in-row data is stored at the leaf level of the R-tree. This is the default if the DBSPACETEMP parameter in your `onconfig` file is not defined.
BOTTOM_UP_BUILD='no', BOUNDING_BOX_INDEX='yes', NO_SORT='no'	Creates a more compact index from the top down Only the bounding boxes of each object are stored at the leaf level of the R-tree. No temporary dbspace is required.
BOTTOM_UP_BUILD='yes', BOUNDING_BOX_INDEX='no', NO_SORT='no'	Creates an index by sorting the spatial data and then building the R-tree from the bottom up This is generally faster than building an index from the top down. This is the default if you have a temporary dbspace and it is specified by the DBSPACETEMP parameter in your `onconfig` file.
BOTTOM_UP_BUILD='yes', BOUNDING_BOX_INDEX='no', NO_SORT='yes'	Creates an index in less time • Does not require a temporary dbspace • Spatial data must be presorted, either by loading the data in a predetermined order or by creating a clustered functional B-tree index by using the **SE_SpatialKey()** function.

Table 4-1. Parameters of the CREATE INDEX statement for spatial data (continued)

Parameters clause of CREATE INDEX statement	Description
BOTTOM_UP_BUILD='yes', BOUNDING_BOX_INDEX='yes', NO_SORT='no'	Creates a more compact index from the bottom up, which is faster than building from the top down • This is the default if you have a temporary dbspace *and* it is specified by the DBSPACETEMP parameter in your `onconfig` file. • Spatial data need not be presorted.
BOTTOM_UP_BUILD='yes', BOUNDING_BOX_INDEX='yes', NO_SORT='yes'	Creates a more compact index in less time • Does not require a temporary dbspace • Spatial data must be presorted.

Related reference:

"The spatial index" on page 1-22

"The SE_SpatialKey() function" on page 7-128

Bottom-up versus top-down index builds

R-tree indexes are created using one of two options: *top-down build* or *bottom-up build*. When an index is built from the top down, spatial objects are inserted into the R-tree one at a time. Objects are grouped together in the R-tree according to their spatial proximity to one another.

When an index is built from the bottom up, objects are first sorted according to a numeric value which is generated by the **SE_SpatialKey()** function. Then the R-tree is built by inserting all objects into the leaf pages (the bottom level) of the tree in sorted order and then building a hierarchy of bounding boxes above the leaf pages.

An R-tree index can be built much more quickly from the bottom up than from the top down, typically 10 to 20 times faster. This increased speed comes at a price: you must create a temporary dbspace of sufficient size to sort all the spatial data in the table. To determine the size, use the following formula:

```
Size (in bytes) = Number of rows in table * 1000
```

Refer to your *IBM Informix Administrator's Guide* for more information about dbspaces.

The NO_SORT option eliminates the need for a temporary dbspace, but your spatial data *must* be presorted in the table. This means that it must be inserted into the table in sorted order, or sorted by means of a clustered B-tree index after it is loaded.

You should also note that the bottom-up build option only makes sense if you load all of your spatial data into a table before you create an R-tree index. There is no performance advantage to either build option if you create an index on an empty table and then insert data.

Depending on certain characteristics of your spatial data, an index built from the top down may be more effective than one built from the bottom up. Properties that can adversely affect a bottom-up built index include many objects that overlap each other, or many objects that are very close together, such that the sort key produced by the **SE_SpatialKey()** function is the same value for a large number of objects.

Related reference:

"The SE_SpatialKey() function" on page 7-128

Functional R-tree indexes

Under certain conditions, you can create a functional R-tree index, using one of the several spatial data type functions. A functional index is built using the value returned by a function rather than the value of a column in a table.

For example, you can create an R-tree index on the centroids of the objects in a table, rather than on the objects themselves:

```
CREATE TABLE poly_tab (poly_col ST_Geometry);

CREATE INDEX centroid_idx ON poly_tab
   (ST_Centroid(poly_col) ST_Geometry_ops) USING RTREE;
```

You can use the following spatial data type functions in a functional index:

- **ST_Centroid()**
- **ST_EndPoint()**
- **ST_Envelope()**
- **SE_Midpoint()**
- **ST_Point()**
- **ST_PointN()**
- **ST_PointOnSurface()**
- **ST_StartPoint()**

Verify that the index is correctly built

To verify whether an index was successfully built, use the **oncheck** utility.

The output from **oncheck** for a successfully built index starts as shown:

```
WARNING: index check requires a s-lock on tables whose lock level is page.
Information for Partition num: 1049006
Node: Level 0, Pagenum 32, Usage 55.7%, No. of Children 11, right -1
```

Refer to your *IBM Informix Administrator's Guide* for information about using the **oncheck** utility.

The spatial operator class ST_Geometry_Ops

An operator class defines operators, called *strategy functions*, that can use an index. The operator class that the IBM Informix spatial data types require **ST_Geometry_Ops**.

Restriction: Do not use **rtree_ops**, the default R-tree operator class for the secondary access method.

The strategy functions for the **ST_Geometry_Ops** operator classes are:

- **ST_Contains()**
- **ST_Crosses()**
- **ST_Equals()**

- **SE_EnvelopesIntersect()**
- **ST_Intersects()**
- **SE_Nearest()**
- **SE_NearestBbox()**
- **ST_Overlaps()**
- **ST_Touches()**
- **ST_Within()**

How spatial operators use R-tree indexes

After you have created an index, it is considered by the query optimizer for any supported combination of argument types.

The index can be used regardless of whether the indexed column is the first or second argument. An operator with two parameters—also known as a *binary operator*—can take advantage of an index defined on a column that serves as one of its arguments.

Chapter 5. Run parallel queries

Running queries in parallel distributes the work for one aspect of a query among several processors and can dramatically improve performance.

You can use any of the spatial data type functions in a parallel query, except the **SE_BoundingBox()**, **SE_CreateSRID()**, **SE_MetadataInit()**, and **SE_Trace()** functions.

Related reference:

"Update values in a spatial column" on page 1-26

"Query spatial data" on page 1-23

Parallel query execution infrastructure

The database server creates and maintains various database objects to manage the execution of spatial queries in parallel.

Do not alter or delete any of the following items of infrastructure:

- The **SE_MetadataTable** table.
- The SE_Metadata opaque type.
- The metadata smart large object, which is stored in the default sbspace.
- The metadata `lohandle` file.
- The metadata memory cache.
- Triggers on the **spatial_references** table

You can use the **SE_MetadataInit()** function to re-initialize this infrastructure in case of difficulty.

Resolve problems with SE_MetadataInit()

In some rare circumstances, you might need to run the **SE_MetadataInit()** function to resolve problems.

Run the **SE_MetadataInit()** function to resolve the following problems:

- The metadata `lohandle` file is corrupted or missing, or cannot be created.
- The metadata smart large object is corrupted or missing.
- The metadata memory cache is corrupted or locked.

The **SE_MetadataInit()** function cannot be run in parallel.

Related reference:

"The SE_MetadataInit() function" on page 7-94

Execute parallel queries

To run queries in parallel, you must use the IBM Informix parallel database query (PDQ) feature.

To take full advantage of the performance enhancement PDQ provides, you need to use fragmented tables; table fragmentation allows you to store parts of a table on different disks.

See the *IBM Informix Performance Guide* for information about these topics. The *IBM Informix Performance Guide* contains topics that describe how the database server executes queries in parallel and how you can manage running queries in parallel; it also includes topics that describe how to work with fragmented tables.

Chapter 6. Estimate your spatial data

The total amount of space you need for spatial data is equal to the size of spatial tables plus the size of the spatial indexes.

The table size approximations discussed here should be within 100 MB accuracy for large tables; to make estimates of greater precision, refer to the *IBM Informix Performance Guide*.

Further tuning information is available at http://www.ibm.com/software/data/informix/blades/spatial/.

To estimate the amount of space you need for spatial data, add the results of the following calculations:

Estimating the storage space for the table

The total size of a spatial table is equal to the column sizes plus the dbspace overhead size multiplied by the number of rows.

To make a rough estimate of the storage space required by the spatial table:
1. Estimate the number of rows in the table.
2. Add the spatial column size, the non-spatial column size, and the dbspace overhead size together.
3. Multiply the sum by the estimated number of rows.

Estimate the size of the spatial column

The size of a spatial column depends on the points per feature, and coordinate factor, and the annotation size.

Estimate the size of the spatial column using the formula:

```
spatial column size = (average points per feature * coordinate factor)
+ annotation size
```

The *average points per feature* is the sum of all coordinate points required to render the features stored in a spatial table divided by the number of rows in the table. If the sum of all coordinates is difficult to obtain, use the approximations of the average number of points per feature for each data type in the table.

The collection data types (MultiPoints, MultiLineStrings, and MultiPolygons) are difficult to estimate. The numbers shown in the table are based on the types of data sets that these data types are most often applied to: broadcast patterns for MultiPoints, stream networks for MultiLineStrings, and island topology for MultiPolygons.

Data type	Average points per feature
Point	1
LineString (urban)	5
LineString (rural)	50
Polygon (urban)	7

Data type	Average points per feature
Polygon (rural)	150
MultiPoint	50
MultiLineString	250
MultiPolygon	1000

The *coordinate factor* is based on the dimensions of the coordinates stored by the spatial column. Select the coordinate factor from the table below.

Coordinate type	Coordinate factor
XY	4.8
XYZ	7.2
XY and measures	7.2
XYZ and measures	9.6

If your layer includes annotation, set the *annotation size* to 300 bytes (this is the average space required to store most annotation). This includes the space required to store text, placement geometry, lead line geometry, and various attributes describing the annotation's size and font.

Estimate the size of non-spatial columns

You can estimate the row size of fixed-sized columns by querying the **systables** system catalog table. You must estimate the average size of variable length columns.

To determine the size of the remaining columns of a spatial table, create the table without the spatial column and query the **rowsize** column of the **systables** table. In this example, a table called **lots** is created with three columns:

```
create table lots (lot_id integer,
                   owner_name varchar(128),
                   owner_address varchar(128))
```

Selecting the row size for the **lots** table from **systables** returns a value of 262 bytes:

```
select rowsize from systables where tabname = 'lots';

262
```

Tables containing variable length columns of type VARCHAR or NVARCHAR require the row size to be reduced to reflect the actual length of the data stored. In this example, the **owner_name** and **owner_address** columns are variable length VARCHAR columns and can occupy up to 129 bytes each (128 bytes for data plus an extra byte for the null terminator). The average size of the owner name is actually 68 bytes, and the average size of the address is 102 bytes. Therefore, the estimated row size should be reduced to 174 bytes.

Estimate dbspace overhead requirements

The amount of dbspace overhead that spatial tables require depends on the number of rows.

Spatial tables with more than 10,000 rows require about 200 bytes of overhead per row.

Spatial tables with fewer than 10,000 rows but more than 1,000 rows require 300 bytes per row.

Spatial tables with fewer than 1,000 rows require 400 bytes per row.

Estimating the smart large object storage space

A spatial data value is stored in row if the value is less than or equal to 930 bytes. However, if the value is greater than 930 bytes, only a pointer of 64 bytes is stored in row. This pointer refers to the smart large object in which the actual data is stored.

Important: Store sbspaces on a disk separate from both the table and the indexes.

To estimate the amount of smart large object storage space:

1. Determine the smart large object ratio using the following formula:
   ```
   smart large object ratio = (spatial column size / 1920)
   ```
   The smart large object ratio cannot be greater than 1. So if the smart large object ratio you calculate is greater than one, set it to 1.
2. Multiply your smart large object ratio by the number of rows in your table to obtain the amount of smart large object space used by your table:
   ```
   smart large object space = ( ( smart large object ratio ) *
         number of rows)
   ```
3. Determine the amount of in-line table space required using the following formula:
   ```
   in-line space = (size of spatial table) - (smart large object space)
   ```

Estimating the size of spatial indexes

You can calculate the size of your spatial indexes based on the size of your spatial columns and dbspace overhead space size.

The ArcSDE service creates and maintains two indexes whenever you add a spatial column to one of your tables. The ArcSDE service creates an R-tree index on the spatial column and a B-tree index on the SE_ROW_ID INTEGER column. The R-tree index is named `a`*n*`_ix1` and the B-tree index is named `a_`*n*`_ix2`, where *n* is the spatial column's layer number assigned by the ArcSDE service.

The indexes are three percent greater than the dbspace overhead space and spatial column size of the table.

To calculate the index space requirements:

1. Combine the spatial column size and the dbspace overhead space size.
2. Multiply this sum by the number of rows in the table.
3. Multiply the result of step 2 by 1.03.

Chapter 7. Spatial functions

Use specific spatial data type functions to perform operations on spatial data.

Spatial data type functions can perform the following types of operations on spatial data:

- Determine spatial relationships: You can determine whether a specific relationship exists between a pair of geometries.

  The distance that separates a hazardous waste disposal site and a school is an example of a spatial relationship.
- Produce a new geometry: You can compare two existing geometries and return a new geometry that is based on how the two geometries are related.

  For example, the **ST_Difference()** function returns that portion of the first geometry that is not intersected or overlapped by the second.
- Transform geometries: You can generate a new geometry from an existing geometry and a formula.

Functions can compare two geometries if the SRIDs of the arguments are the same. To compare two geometries that have different SRIDs, use the **ST_Transform()** function to transform one of the geometries.

The Dimensionally Extended 9 Intersection Model (DE-9IM) is a mathematical approach that defines the pair-wise spatial relationship between geometries of different types and dimensions.

Most spatial data functions are compliant with OpenGIS and ISO/SQLMM standards and have the prefix `ST_`. Some spatial data functions extend the OpenGIS and ISO/SQLMM standards and have the prefix `SE_`.

The following OpenGIS and ISO/SQLMM-compliant functions replace deprecated functions that extend the standards:

Table 7-1. Compliant functions that replace extension functions

Compliant function	Extension function
ST_Is3D()	SE_Is3D()
ST_IsMeasured()	SE_IsMeasured()
ST_LocateAlong()	SE_LocateAlong()
ST_LocateBetween()	SE_LocateBetween()
ST_M()	SE_M()
ST_Z()	SE_Z()
ST_MaxM()	SE_MMax()
ST_MinM()	SE_MMin()
ST_MaxX()	SE_XMax()
ST_MinX()	SE_XMin()
ST_MaxY()	SE_YMax()
ST_MinY()	SE_YMin()
ST_MaxZ()	SE_ZMax()

Table 7-1. Compliant functions that replace extension functions (continued)

Compliant function	Extension function
ST_MaxZ()	SE_ZMin()

The Dimensionally Extended 9 Intersection Model

The Dimensionally Extended 9 Intersection Model (DE-9IM) developed by Clementini and others, dimensionally extends the 9 Intersection Model of Egenhofer and Herring. DE-9IM is a mathematical approach that defines the pair-wise spatial relationship between geometries of different types and dimensions. This model expresses spatial relationships among all types of geometry as pair-wise intersections of their interior, boundary, and exterior with consideration for the dimension of the resulting intersections.

Given geometries *a* and *b*, I(*a*), B(*a*), and E(*a*) represent the interior, boundary, and exterior of *a*, and I(*b*), B(*b*), and E(*b*) represent the interior, boundary, and exterior of *b*. The intersections of I(*a*), B(*a*), and E(*a*) with I(*b*), B(*b*), and E(*b*) produce a 3-by-3 matrix. Each intersection can result in geometries of different dimensions. For example, the intersection of the boundaries of two polygons could consist of a point and a linestring, in which case the **dim()** function would return the maximum dimension of 1.

The dim function returns a value of -1, 0, 1, or 2. The -1 corresponds to the null set that is returned when no intersection was found or **dim()**.

Table 7-2. Results of intersections

	Interior	Boundary	Exterior
Interior	dim(I(a)I(b))	dim(I(a)B(b))	dim(I(a)E(b))
Boundary	dim(B(a)I(b))	dim(B(a)B(b))	dim(B(a)E(b))
Exterior	dim(E(a)I(b))	dim(E(a)B(b))	dim(E(a)E(b))

The results of the spatial relationship for the functions can be understood or verified by comparing the results with a pattern matrix that represents the acceptable values for the DE-9IM.

The pattern matrix contains the acceptable values for each of the intersection matrix cells. The possible pattern values are:

T An intersection must exist; dim = 0, 1, or 2.

F An intersection must not exist; dim = -1.

***** It does not matter if an intersection exists or not; dim = -1, 0, 1, or 2.

0 An intersection must exist and its maximum dimension must be 0; dim = 0.

1 An intersection must exist and its maximum dimension must be 1; dim = 1.

2 An intersection must exist and its maximum dimension must be 2; dim = 2. For example, the pattern matrix of the **ST_Within()** function for geometry combinations has the following form:

Table 7-3. Pattern matrix of the ST_Within() function

			b	
		Interior	**Boundary**	**Exterior**
	Interior	T	*	F
a	Boundary	*	*	F
	Exterior	*	*	*

Simply put, the **ST_Within()** function returns TRUE when the interiors of both geometries intersect, and the interior and boundary of geometry *a* does not intersect the exterior of geometry *b*. All other conditions do not matter.

Related reference:

"The ST_Equals() function" on page 7-57

"The ST_Disjoint() function" on page 7-44

"The ST_Intersects() function" on page 7-74

"The ST_Touches() function" on page 7-133

"The ST_Overlaps() function" on page 7-109

"The ST_Crosses() function" on page 7-39

"The ST_Within() function" on page 7-142

"The ST_Contains() function" on page 7-28

Summary of spatial functions by task type

The spatial data type functions do different types of tasks, such as generating different formats, manipulating or comparing data, and obtaining information about data.

The following table shows the spatial data type functions arranged by task type.

Table 7-4. Spatial functions by task type

Function task type	Description	Function name
Generate a geometry from a well-known text representation.	Takes a well-known text representation and returns an ST_Geometry using SRID 0	"The ST_WKTToSQL() function" on page 7-145
	Takes a well-known text representation and returns an ST_Geometry	"The ST_GeomFromText() function" on page 7-67
	Takes a well-known text representation and returns an ST_Point	"The ST_PointFromText() function" on page 7-119
	Takes a well-known text representation and returns an ST_LineString	"The ST_LineFromText() function" on page 7-88
	Takes a well-known text representation and returns an ST_Polygon	"The ST_PolyFromText() function" on page 7-124
	Takes a well-known text representation and returns an ST_MultiLine	"The ST_MLineFromText() function" on page 7-97
	Takes a well-known text representation and returns an ST_MultiPoint	"The ST_MPointFromText() function" on page 7-101
	Takes a well-known text representation and returns an ST_MultiPolygon	"The ST_MPolyFromText() function" on page 7-105

Table 7-4. Spatial functions by task type (continued)

Function task type	Description	Function name
Generate a geometry from a well-known binary representation.	Takes a well-known binary representation and returns an ST_Geometry using SRID 0	"The ST_WKBToSQL() function" on page 7-144
	Takes a well-known binary representation and returns an ST_Geometry	"The ST_GeomFromWKB() function" on page 7-68
	Takes a well-known binary representation and returns an ST_Point	"The ST_PointFromWKB() function" on page 7-119
	Takes a well-known binary representation and returns an ST_LineString	"The ST_LineFromWKB() function" on page 7-88
	Takes a well-known binary representation and returns an ST_Polygon	"The ST_PolyFromWKB() function" on page 7-124
	Takes a well-known binary representation and returns an ST_MultiLine	"The ST_MLineFromWKB() function" on page 7-98
	Takes a well-known binary representation and returns an ST_MultiPoint	"The ST_MPointFromWKB() function" on page 7-101
	Takes a well-known binary representation and returns an ST_MultiPolygon	"The ST_MPolyFromWKB() function" on page 7-105
Generate a geometry from an ESRI shape representation.	Takes an ESRI shape representation and returns an ST_Geometry using SRID 0	"The SE_ShapeToSQL() function" on page 7-127
	Takes an ESRI shape representation and returns an ST_Geometry	"The SE_GeomFromShape() function" on page 7-66
	Takes an ESRI shape representation and returns an ST_Point	"The SE_PointFromShape() function" on page 7-118
	Takes an ESRI shape representation and returns an ST_LineString	"The SE_LineFromShape() function" on page 7-87
	Takes an ESRI shape representation and returns an ST_Polygon	"The SE_PolyFromShape() function" on page 7-123
	Takes an ESRI shape representation and returns an ST_MultiLine	"The SE_MLineFromShape() function" on page 7-96
	Takes an ESRI shape representation and returns an ST_MultiPoint	"The SE_MPointFromShape() function" on page 7-100
	Takes an ESRI shape representation and returns an ST_MultiPolygon	"The SE_MPolyFromShape() function" on page 7-104

Table 7-4. Spatial functions by task type (continued)

Function task type	Description	Function name
Generate a geometry from a GML representation.	Takes a GML2 or GML3 string representation of an envelope and returns an ST_Polygon	"The ST_EnvelopeFromGML() function" on page 7-55
	Takes a GML2 or GML3 string representation and returns an ST_Geometry	"The ST_GeomFromGML() function" on page 7-63
	Takes a GML2 or GML3 string representation and returns an ST_LineString	"The ST_LineFromGML() function" on page 7-85
	Takes a GML2 or GML3 string representation and returns an ST_MultiLineString	"The ST_MLineFromGML() function" on page 7-94
	Takes a GML2 or GML3 string representation and returns an ST_MultiPoint	"The ST_MPointFromGML() function" on page 7-99
	Takes a GML2 or GML3 string representation and returns an ST_MultiPolygon	"The ST_MPolyFromGML() function" on page 7-102
	Takes a GML2 or GML3 string representation and returns an ST_Point	"The ST_PointFromGML() function" on page 7-116
	Takes a GML2 or GML3 string representation and returns an ST_Polygon	"The ST_PolyFromGML() function" on page 7-121
Generate a geometry from a KML representation.	Takes a KML LatLonBox string representation and returns an ST_Polygon	"The SE_EnvelopeFromKML() function" on page 7-55
	Takes a KML fragment string representation and returns an ST_Geometry	"The ST_GeomFromKML() function" on page 7-66
	Takes a KML LineString string representation and returns an ST_LineString	"The ST_LineFromKML() function" on page 7-86
	Takes a KML MultiGeometry string representation and returns an ST_MultiLineString	"The ST_MLineFromKML() function" on page 7-96
	Takes a KML MultiGeometry and Point combination string representation and returns an ST_MultiPoint	"The ST_MPointFromKML() function" on page 7-100
	Takes a KML MultiGeometry and Polygon combination string representation and returns an ST_MultiPolygon	"The ST_MPolyFromKML() function" on page 7-103
	Takes a KML Point string representation and returns an ST_Point	"The ST_PointFromKML() function" on page 7-117
	Takes a KML Polygon string representation and returns an ST_Polygon	"The ST_PolyFromKML() function" on page 7-122

Table 7-4. Spatial functions by task type (continued)

Function task type	Description	Function name
Convert a geometry to an external format.	Returns the well-known text representation of a geometry object	"The ST_AsText() function" on page 7-19
	Returns the well-known binary representation of a geometry object	"The ST_AsBinary() function" on page 7-13
	Returns the ESRI shape representation of a geometry object	"The SE_AsShape() function" on page 7-18
	Returns the GML representation of a geometry object	"The SE_AsGML() function" on page 7-14 or "The ST_AsGML() function" on page 7-15
	Returns the GML3 Envelope element of an ST_Envelope object	"The ST_EnvelopeAsGML() function" on page 7-54
	Returns the KML representation of a geometry object	"The ST_AsKML() function" on page 7-16 or "The SE_AsKML() function" on page 7-15
	Returns the KML LatLonBox of an ST_Envelope object	"The SE_EnvelopeAsKML() function" on page 7-54
Manipulate the ST_Point data type.	Creates an ST_Point data type from an X and Y coordinate	"The ST_Point() function" on page 7-115
	Returns the X coordinate of a point	"The ST_X() function" on page 7-146
	Returns the Y coordinate of a point	"The ST_Y() function" on page 7-147
	Returns the Z coordinate of a point	"The ST_Z function" on page 7-148
	Returns the measure value of a point	"The ST_M() function" on page 7-92
Manipulate the ST_LineString and ST_MultiLineString data types.	Returns the first point	"The ST_StartPoint() function" on page 7-130
	Returns the midpoint	"The SE_Midpoint() function" on page 7-94
	Returns the last point	"The ST_EndPoint() function" on page 7-51
	Returns the *n*th point	"The ST_PointN() function" on page 7-120
	Returns the length	"The ST_Length() function" on page 7-83
	Creates an ST_Polygon from a ring (closed linestring)	"The ST_Polygon() function" on page 7-125

Table 7-4. Spatial functions by task type (continued)

Function task type	Description	Function name
Manipulate the ST_Polygon and ST_MultiPolygon data types.	Calculates the area	"The ST_Area() function" on page 7-10
	Calculates the geometric center	"The ST_Centroid() function" on page 7-27
	Returns the exterior ring	"The ST_ExteriorRing() function" on page 7-59
	Counts the number of interior rings	"The ST_NumInteriorRing() function" on page 7-108
	Returns the *n*th interior ring	"The ST_InteriorRingN() function" on page 7-69
	Returns a point on the surface	"The ST_PointOnSurface() function" on page 7-121
	Returns the perimeter	"The ST_Perimeter() function" on page 7-113
Obtain parameters of a geometry.	Returns the dimensions of the coordinates	"The ST_CoordDim() function" on page 7-31
	Returns the dimension of the geometry	"The ST_Dimension() function" on page 7-43
	Returns the shortest distance to another geometry	"The ST_Distance() function" on page 7-48
	Returns the distance to a point	"The ST_DistanceToPoint() function" on page 7-50
	Returns the point at a specific distance	"The ST_PointAtDistance() function" on page 7-116
	Returns the data type	"The ST_GeometryType() function" on page 7-62
	Returns the number of points	"The ST_NumPoints() function" on page 7-108
	Returns the spatial reference ID	"The ST_SRID() function" on page 7-128
	Returns the maximum and minimum X coordinate	"The ST_MaxX() and ST_MinX() functions" on page 7-93
	Returns the maximum and minimum Y coordinate	"The ST_MaxY() and ST_MinY() functions" on page 7-93
	Returns the maximum and minimum Z coordinate	"The ST_MaxZ() and ST_MinZ() functions" on page 7-93
	Returns the maximum and minimum measure value	"The ST_MaxM() and ST_MinM() functions" on page 7-93

Table 7-4. Spatial functions by task type (continued)

Function task type	Description	Function name
Determine the properties of a geometry.	Determines whether a linestring or multilinestring is closed	"The ST_IsClosed() function" on page 7-77
	Determines whether a geometry is empty (it has no points)	"The ST_IsEmpty() function" on page 7-79
	Determines whether a geometry has measures	"The ST_IsMeasured() function" on page 7-80
	Determines whether a linestring is a ring (it is closed and simple)	"The ST_IsRing() function" on page 7-81
	Determines whether a geometry is simple	"The ST_IsSimple() function" on page 7-82
	Determines whether a geometry is topologically valid	"The ST_IsValid() function" on page 7-82
	Determines whether an object has Z coordinates	"The ST_Is3D() function" on page 7-77
	Tests whether two geometries meet the conditions specified by a specified DE-91M pattern matrix	"The ST_Relate() function" on page 7-126
Determine whether a certain relationship exists between two geometries.	Determines whether one geometry completely contains another	"The ST_Contains() function" on page 7-28
	Determines whether a geometry crosses another	"The ST_Crosses() function" on page 7-39
	Determines whether two geometries are non-intersecting	"The ST_Disjoint() function" on page 7-44
	Determines whether the envelopes of two geometries intersect	"The SE_EnvelopesIntersect() function" on page 7-56
	Determines whether two geometries are spatially equal	"The ST_Equals() function" on page 7-57
	Determines whether two geometries intersect	"The ST_Intersects() function" on page 7-74
	Determines whether two geometries overlap	"The ST_Overlaps() function" on page 7-109
	Determines whether two geometries touch	"The ST_Touches() function" on page 7-133
	Determines whether one object is completely inside another	"The ST_Within() function" on page 7-142

Table 7-4. Spatial functions by task type (continued)

Function task type	Description	Function name
Compare geometries and return a new geometry based on how the geometries are related.	An aggregate function that computes the union of geometries of the same dimension	"The SE_Dissolve() function" on page 7-47
	Returns the portion of the primary geometry that is not intersected by the secondary geometry	"The ST_Difference() function" on page 7-41
	Computes the intersection of two geometries	"The ST_Intersection() function" on page 7-72
	Returns the perpendicular projection of a point on the nearest segment of a linestring	"The SE_PerpendicularPoint() function" on page 7-114
	Returns an ST_Geometry object that is composed of the parts of the two source geometries that are not common to both	"The ST_SymDifference() function" on page 7-131
	Computes the union of two geometries	"The ST_Union() function" on page 7-140
Generate a new geometry from an existing geometry.	Generates a geometry that is the buffer that surrounds the source object	"The ST_Buffer() function" on page 7-22
	Generates the combined boundary of the geometry	"The ST_Boundary() function" on page 7-20
	Calculates the spatial extent of all geometries in a table column	"The SE_BoundingBox() function" on page 7-21
	Generates the convex hull of a geometry	"The ST_ConvexHull() function" on page 7-30
	Generates the bounding box of a geometry	"The ST_Envelope() function" on page 7-52
	Generates a geometry with fewer vertices but of the same general shape	"The SE_Generalize() function" on page 7-60
	Generates an ST_MultiPoint representing points that have the specified measure value	"The ST_LocateAlong() function" on page 7-89
	Generates an ST_MultiPoint or ST_MultiLineString representing points or paths that have measures in the specified range	"The ST_LocateBetween() function" on page 7-90
	Appends a vertex to a linestring	"The SE_VertexAppend() function" on page 7-142
	Deletes a vertex from a geometry	"The SE_VertexDelete() function" on page 7-142
	Updates a vertex in a geometry	"The SE_VertexUpdate() function" on page 7-142
Manage collections.	Returns the *n*th geometry	"The ST_GeometryN() function" on page 7-62
	Returns the number of geometries in the collection	"The ST_NumGeometries() function" on page 7-107
Nearest-neighbor queries.	Retrieves nearby geometries in increasing distance order. **SE_NearestBbox()** is similar to **SE_Nearest()**, but measures distances between bounding boxes of geometries.	"The SE_Nearest() and SE_NearestBbox() functions" on page 7-106

Table 7-4. Spatial functions by task type (continued)

Function task type	Description	Function name
Assist in managing spatial reference systems.	Computes the false origin and system units for a data set and creates an entry in the **spatial_references** table	"The SE_CreateSRID() function" on page 7-33
	Returns the OGC well-known text representation of a spatial reference system	"The SE_CreateSrtext() function" on page 7-36
	Returns the text for all types of spatial reference systems that use the specified ID	"The SE_CreateSrtextList() function" on page 7-38
	Returns the number of spatial reference system types for a specified ID	"The SE_CreateSrtextCount() function" on page 7-38
	Returns the spatial reference ID for a geometry	"The ST_SRID() function" on page 7-128
	Returns the Authority Name and Authority SRID of a spatial reference ID	"The SE_SRID_Authority() function" on page 7-130
	Transforms a geometry from one spatial reference system to another	"The ST_Transform() function" on page 7-136
Administration	Returns the in-row, out-of-row, and total size of a geometry in bytes	"The SE_InRowSize() function" on page 7-69 "The SE_OutOfRowSize() function" on page 7-109 "The SE_TotalSize() function" on page 7-133
	Reinitializes the spatial reference system memory cache	"The SE_MetadataInit() function" on page 7-94
	Returns the value of a specified parameter or all parameters if called with no parameters	"The SE_ParamGet() function" on page 7-112
	Sets the specified parameter to a new value	"The SE_ParamSet() function" on page 7-112
	Returns usage information (if called with no parameters)	"The SE_ParamSet() function" on page 7-112
	Returns the version and release date of the spatial data extension	"The SE_Release() function" on page 7-127
	Generates a sort key for geometries	"The SE_SpatialKey() function" on page 7-128
	Controls tracing to assist in debugging	"The SE_Trace() function" on page 7-135

The ST_Area() function

The **ST_Area()** function returns the area of a polygon or multipolygon.

Syntax

```
ST_Area(pl1 ST_Polygon)
ST_Area(pl1 ST_Polygon, linear_uom varchar(128))

ST_Area(mpl1 ST_MultiPolygon)
ST_Area(mpl1 ST_MultiPolygon, linear_uom varchar(128))
```

The *linear_uom* parameter converts the result to the specified unit of measure. To calculate the area if the polygon is in a geographic coordinate system where the coordinates are in an angular unit of measure, you must specify a linear unit of measure with the *linear_uom* parameter. Angular units of measure are converted to linear units of measure by great-circle calculations. If the polygon is in a projected coordinate system that has a unit of measure that is different from the unit of measure that is specified by the *linear_uom* parameter, then the returned value is converted to the unit of measure that is specified by the *linear_uom* parameter. The *linear_uom* parameter must be the name of a linear unit of measure from the **unit_name** column of the **st_units_of_measure** table.

Return type

DOUBLE PRECISION

Example: Find the area of buildings

The city engineer needs a list of building areas. To create the list, a GIS technician selects the building ID and area of each building footprint.

The building footprints are stored in the **buildingfootprints** table that is created with the following CREATE TABLE statement:

```
CREATE TABLE buildingfootprints (building_id  integer,
                                 lot_id       integer,
                                 footprint    ST_MultiPolygon);
```

To satisfy the city engineer's request, the technician selects the unique key, the **building_id**, and the **area** of each building footprint from the **buildingfootprints** table:

```
SELECT building_id, ST_Area(footprint) area
   FROM buildingfootprints;

building_id           area

        506 78.00000000000
        543 68.00000000000
       1208 123.0000000000
        178 87.00000000000
```

The following figure shows the four building footprints that are labeled with their building ID numbers and displayed alongside their adjacent street.

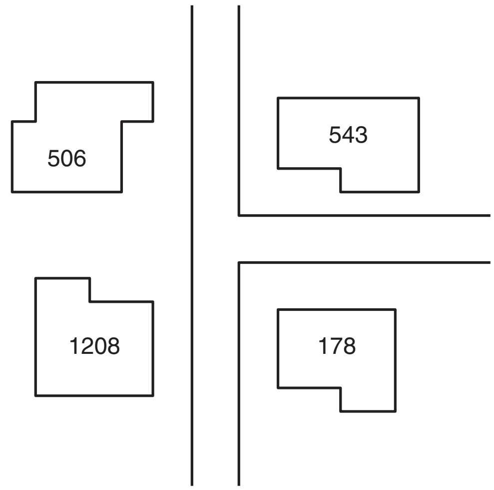


Figure 7-1. Building footprints

Examples: Find the areas of polygons

The following statement returns the area of a polygon in square meters:

```
EXECUTE FUNCTION round(
        st_area(
                '32608 polygon((576100 15230, 576100 15232, 576102 15232,
                 576102 15230, 576100 15230))'::st_polygon,
                'meter'),
        2);

    (expression)

4.00000000000000

1 row(s) retrieved.
```

The following statement returns the area of a multipolygon in square meters:

```
EXECUTE FUNCTION round(
        st_area(
                '32608 multipolygon(((576100 15230, 576100 15232, 576102 15232,
                 576102 15230, 576100 15230)),((576104 4, 576104 6, 576106 6,
                 576106 4, 576104 4)))'::st_multipolygon,
                'meter'),
        2);

    (expression)

8.00000000000000

1 row(s) retrieved.
```

Example: Find the area of a polygon that has angular coordinates

The following statement returns the area in square meters of a 10 kilometer buffer around the coordinates from the angular coordinate system WGS 84 - 4326 that represent the latitude and longitude of New York (40.67000 N, 73.94000 W):

```
EXECUTE FUNCTION ST_Area(ST_Buffer('4326 point(-73.94000 40.67000)'
                ::st_point, 10, 'kilometer')::st_polygon, 'meter');

  (expression)

313934956.2857
```

Related reference:

"The st_units_of_measure table" on page 1-17

The ST_AsBinary() function

The **ST_AsBinary()** function takes a geometry object and returns its well-known binary representation.

The return type of **ST_AsBinary()** is defined as ST_Geometry to allow spatial objects greater than 2 kilobytes to be retrieved by a client application. Typically, you use **ST_AsBinary()** to retrieve spatial data from the server and send it to a client, as in:

```
SELECT ST_AsBinary(geomcol) FROM mytable
```

IBM Informix automatically casts the output of the **ST_AsBinary()** function to the proper data type for transmission to the client.

You can write user-defined routines (UDRs) in C or SPL to extend the functionality of the existing spatial data type functions. You can use **ST_AsBinary()** to convert an ST_Geometry to its well-known binary representation. If you pass the output of **ST_AsBinary()** to another UDR whose function signature requires an LVARCHAR input, you should explicitly cast the return type of **ST_AsBinary()** to LVARCHAR, as in:

```
EXECUTE FUNCTION MySpatialFunc(ST_AsBinary(geomcol)::lvarchar);
```

Syntax

```
ST_AsBinary(g1 ST_Geometry)
```

Return type

ST_Geometry

Example

The code fragment below converts the footprint multipolygons of the **buildingfootprints** table into WKB multipolygons using the **ST_AsBinary()** function. The multipolygons are passed to the application's **draw_polygon()** function for display:

```
/* Create the SQL expression. */
    sprintf(sql_stmt,
            "SELECT ST_AsBinary(zone) "
            "FROM sensitive_areas WHERE "
            "SE_EnvelopesIntersect(zone,ST_PolyFromWKB(?,%d))", srid);

    /* Prepare the SQL statement. */
    SQLPrepare(hstmt, (UCHAR *) sql_stmt, SQL_NTS);

    /* Bind the query shape parameter. */
    pcbvalue1 = query_wkb_len;
    SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_BINARY,
                      SQL_INFX_UDT_LVARCHAR, query_wkb_len, 0,
                      query_wkb_buf, query_wkb_len, &pcbvalue1);
```

```
/* Execute the query. */
rc = SQLExecute(hstmt);

/* Assign the results of the query (the buildingfootprint polygons)
 * to the fetched_binary variable. */
SQLBindCol (hstmt, 1, SQL_C_BINARY,
            fetched_wkb_buf, 10000, &fetched_wkb_len);

/* Fetch each polygon within the display window and display it. */
while (1)
{
    rc = SQLFetch(hstmt);
    if (rc == SQL_NO_DATA_FOUND)
        break;
    else
        returncode_check(NULL, hstmt, rc, "SQLFetch");

    draw_polygon(fetched_wkb_buf);
}

/* Close the result set cursor */
SQLCloseCursor(hstmt);
```

The SE_AsGML() function

The **SE_AsGML()** function returns the Geography Markup Language (GML) representation of an ST_Geometry spatial type.

Typically, you use the **SE_AsGML()** function to retrieve the GML representation of a spatial primitive from the server and send it to a client, as in:

```
SELECT SE_AsGML(geomcol) FROM mytable
```

The return type of the **SE_AsGML()** function is defined as LVARCHAR. You can write user-defined routines (UDRs) in C or SPL to extend the functionality of the existing spatial data type functions. You can use the **SE_AsGML()** function to convert an ST_Geometry type to its GML representation.

Syntax

```
SE_AsGML(p ST_Geometry)
```

Return type

ST_Geometry

Example

In this example, the **SE_AsGML()** function converts the **location** column of the table **mytable** into its GML description.

```
CREATE TABLE mytable (id integer, location ST_Point);

INSERT INTO mytable VALUES(
   1,
   ST_PointFromText('point (10.02 20.01)', 1000)
);

SELECT SE_AsGML(location) FROM mytable WHERE id = 1;

<gml:Point srsName="UNKNOWN">
<gml:coord><gml:X>10.02</gml:X><gml:Y>20.01</gml:Y></gml:coord>
</gml:Point>
```

The $INFORMIXDIR/extend/spatial.*version*/examples/gml directory contains more information about how to use an XML parser to validate the results of this function.

The ST_AsGML() function

The **ST_AsGML()** function returns the Geography Markup Language (GML) representation of an ST_Geometry spatial type that conforms to either the GML2 or GML3 standard.

Typically, you use the **ST_AsGML()** function to retrieve the GML representation of a spatial primitive from the server and send it to a client, specifying the GML version to use. For example:

```
SELECT ST_AsGML(geomcol, 3) FROM mytable
```

Syntax

```
ST_AsGML(p ST_Geometry, int Version)
```

Version is the GML version that is used to encode the returned geometry. Specify 2 for GML2 and 3 for GML3. The default is 2.

Return type

ST_Geometry

Example

The first example returns a geometry from the **mypoints** table as a GML2 representation. The second example returns the geometry as a GML3 representation.

```
SELECT id, ST_AsGML(pt,2) FROM mypoints WHERE id=1

id 1
<gml:Point> <gml:coord><gml:X>-95.7</gml:X>
<gml:Y>38.1</gml:Y></gml:coord></gml:Point>

SELECT id, ST_AsGML(pt,3) AS gml_v32arg, ST_AsGML(pt)
  AS gml_v31arg FROM mypoints WHERE id=1

id 1
gml_v32arg <gml:Point><gml:pos>-95.7 38.1</gml:pos></gml:Point>
gml_v31arg <gml:Point><gml:pos>-95.7 38.1</gml:pos></gml:Point>
```

The $INFORMIXDIR/extend/spatial.*version*/examples/gml directory contains more information about how to use an XML parser to validate the results of this function.

The SE_AsKML() function

The **SE_AsKML()** function returns the Keyhole Markup Language (KML) representation of an ST_Geometry spatial type.

Typically, you use the **SE_AsKML()** function to retrieve the KML representation of a spatial primitive from the server and send it to a client, as in:

```
SELECT SE_AsKML(geomcol) FROM mytable
```

The return type of the **SE_AsKML()** function is defined as LVARCHAR. You can write user-defined routines (UDRs) in C or SPL to extend the functionality of the existing spatial data type functions.

Syntax

```
SE_AsKML(p ST_Geometry)
```

Return type

ST_Geometry

Example

In this example, the **SE_AsKML()** function converts the **location** column of the table **mytable** into its KML description.

```
CREATE TABLE mytable (id integer, location ST_Point);

INSERT INTO mytable VALUES(
   1, ST_PointFromText('point (10.02 20.01)', 1000)
);

SELECT id, SE_AsKML(p1) FROM point_t ORDER BY id asc;
id            100_xy
<Point><coordinates>10.02,20.01</coordinates></Point>

CREATE TABLE line_t (id integer, p1 ST_LineString);

INSERT INTO line_t VALUES(
  1,
  ST_LineFromText('linestring (0.0 0.0,0.0 1.0,1.0 0.0,1.0 1.0)',1000)
);
1 row(s) inserted.


INSERT INTO line_t VALUES(
  2,
  ST_LineFromText('linestring z (0.0 0.0 0,0.0 1.0 1,1.0 0.0 1,1.0 1.0 1)',1000)
);
1 row(s) inserted.

INSERT INTO line_t VALUES(
  3,
  ST_LineFromText('linestring m (0.0 0.0 0,0.0 1.0 1,1.0 0.0 1,1.0 1.0 1)',1000)
);
1 row(s) inserted.


SELECT id, SE_AsKML(p1) FROM line_t ORDER BY id ASC;
id            1
<LineString><coordinates>0,0 0,1 1,0 1,1</coordinates></LineString>
id            2
<LineString>
  <coordinates>0,0,0 0,1,1 1,0,1 1,1,1</coordinates>
</LineString>
id            3
<LineString><coordinates>0,0 0,1 1,0 1,1</coordinates></LineString>
```

The ST_AsKML() function

The **ST_AsKML()** function returns the Keyhole Markup Language (KML) representation of an ST_Geometry spatial type.

ST_AsKML() can also take an optional parameter that describes KML shape attributes.

Syntax

```
ST_AsKML(p ST_Geometry)
ST_AsKML(p ST_Geometry, attributes lvarchar)
```

The attributes parameter can contain one or more KML shape attributes, in XML format. The following table describes common KML shape attributes.

Table 7-5. KML shape attributes

Attribute	Description
<extrude>	A Boolean value that specifies if the geometry is connected to the ground (1) or not (0). To extrude a geometry, the value of the <altitudeMode> attribute must be either **relativeToGround** or **absolute** and the Z coordinate within the <coordinates> element must be greater than zero (0). If this attribute is not specified, it is false (0).
<tessellate>	A Boolean value that specifies if the geometry should follow the terrain (1) or not (0). To enable tessellation for the geometry, the value for the <altitudeMode> attribute must be **clampToGround**. If this attribute is not specified, it is false (0).
<altitudeMode>	Specifies how Z coordinates in the <coordinates> element are interpreted. Possible values are: **clampToGround (default)** Indicates to ignore the altitude specification in the geometry and place it at ground level. **relativeToGround** Interprets the altitude specification in the geometry and places it at that altitude above the ground. **absolute** Interprets the altitude specification in the geometry and places it at that altitude above sea level.

The Spatial DataBlade® module does not check whether the attributes are valid. If any of the attributes are not valid, the resulting KML fragment might not be valid when it is received by the application.

Return type

LVARCHAR

Example

```
EXECUTE FUNCTION ST_AsKML(ST_PointFromText('POINT(-83.54354 34.23425)',4))
```

Output:

```
<Point>
        <coordinates>-83.5435399663,34.2342500677</coordinates>
</Point>
```

In this example, **ST_AsKML()** contains KML shape attributes to specify that the geometry is connected to the ground:

```
EXECUTE FUNCTION ST_AsKML(ST_PointFromText('POINT Z
                         (-83.54523 34.214312 100)',4),
                         '<extrude>1</extrude><altitudeMode>
                         clampToGround</altitudeMode>');
```

Output:

```
<Point>
       <extrude>1</extrude>
       <altitudeMode>clampToGround</altitudeMode>
       <coordinates>-83.545522957,34.2143120335,100</coordinates>
</Point>
```

The SE_AsShape() function

The **SE_AsShape()** function takes a geometry object and returns it in ESRI shapefile format.

The return type of **SE_AsShape()** is defined as ST_Geometry to allow spatial objects greater than 2 kilobytes in size to be retrieved by a client application.

Typically, you use **ST_AsShape()** to retrieve spatial data from the server and send it to a client, as in:

```
SELECT SE_AsShape(geomcol) FROM mytable
```

IBM Informix automatically casts the output of the **SE_AsShape()** function to the proper data type for transmission to the client.

You can write user-defined routines (UDRs) in C or SPL to extend the functionality of the existing spatial data type functions. You can use **SE_AsShape()** to convert an ST_Geometry to ESRI shapefile format. If you pass the output of **SE_AsShape()** to another UDR whose function signature requires an LVARCHAR input, you should explicitly cast the return type of **SE_AsShape()** to LVARCHAR, as in:

```
EXECUTE FUNCTION MySpatialFunc(SE_AsShape(geomcol)::lvarchar);
```

Syntax

```
SE_AsShape(g1 ST_Geometry)
```

Return type

ST_Geometry

Example

The code fragment below illustrates how the **SE_AsShape()** function converts the **zone** polygons of the **sensitive_areas** table into shape polygons. These shape polygons are passed to the application's **draw_polygon()** function for display:

```
/* Create the SQL expression. */
    sprintf(sql_stmt,
            "SELECT SE_AsShape(zone) "
            "FROM sensitive_areas WHERE "
            "SE_EnvelopesIntersect(zone,SE_PolyFromShape(?,%d))", srid);

    /* Prepare the SQL statement. */
    SQLPrepare(hstmt, (UCHAR *)sql_stmt, SQL_NTS);

    /* Bind the query geometry parameter. */
    pcbvalue1 = query_shape_len;
    SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_BINARY,
```

```
                        SQL_INFX_UDT_LVARCHAR, query_shape_len, 0,
                        query_shape_buf, query_shape_len, &pcbvalue1);

    /* Execute the query. */
    rc = SQLExecute(hstmt);

    /* Assign the results of the query (the Zone polygons) to the
       fetched_shape_buf variable. */
    SQLBindCol (hstmt, 1, SQL_C_BINARY,
                fetched_shape_buf, 10000, &fetched_shape_len);

    /* Fetch each polygon within the display window and display it. */
    while (SQL_SUCCESS == (rc = SQLFetch(hstmt)))
        draw_polygon(fetched_shape_buf);
```

The ST_AsText() function

The **ST_AsText()** function takes an ST_Geometry object and returns its well-known text representation.

The return type of **ST_AsText()** is defined as ST_Geometry to allow spatial objects greater than 2 kilobytes to be retrieved by a client application.

Typically, you use **ST_AsText()** to retrieve spatial data from the server and send it to a client, as in:

```
SELECT ST_AsText(geomcol) FROM mytable
```

IBM Informix automatically casts the output of the **ST_AsText()** function to the proper data type for transmission to the client.

You can write user-defined routines (UDRs) in C or SPL to extend the functionality of the existing spatial data type functions. You can use **ST_AsText()** to convert an ST_Geometry to its well-known text representation. If you pass the output of **ST_AsText()** to another UDR whose function signature requires an LVARCHAR input, you should explicitly cast the return type of **ST_AsText()** to LVARCHAR, as in:

```
EXECUTE FUNCTION MySpatialFunc(ST_AsText(geomcol)::lvarchar)
```

Syntax

```
ST_AsText(g1 ST_Geometry)
```

Return type

ST_Geometry

Example

The **ST_AsText()** function converts the **hazardous_sites** location point into its text description:

```
CREATE TABLE hazardous_sites (site_id   integer,
                              name      varchar(40),
                              location  ST_Point);



INSERT INTO hazardous_sites VALUES(
     102, 'W. H. Kleenare Chemical Repository',
     ST_PointFromText('point (1020.12 324.02)',1000)
);
```

```
SELECT site_id, name, ST_AsText(location) Location
   FROM hazardous_sites;


site_id   102
name      W. H. Kleenare Chemical Repository
location  POINT (1020.12 324.02)
```

The ST_Boundary() function

The **ST_Boundary()** function takes a geometry object and returns its combined boundary as a geometry object.

Syntax

```
ST_Boundary(g1 ST_Geometry)
```

Return type

ST_Geometry

Example

In this example the **boundary_test** table is created with two columns: **geotype** defined as a VARCHAR, and **g1** defined as the superclass ST_Geometry. The INSERT statements that follow insert each one of the subclass geometries. The **ST_Boundary()** function retrieves the boundary of each subclass stored in the **g1** geometry column. Note that the dimension of the resulting geometry is always one less than the input geometry. Points and multipoints always result in a boundary that is an empty geometry, dimension -1. Linestrings and multilinestrings return a multipoint boundary, dimension 0. A polygon or multipolygon always returns a multilinestring boundary, dimension 1:

```
CREATE TABLE boundary_test (geotype varchar(20),
                            g1      ST_Geometry);

INSERT INTO boundary_test VALUES(
   'Point', ST_PointFromText('point (10.02 20.01)',1000)
);

INSERT INTO boundary_test VALUES(
   'Linestring',
   ST_LineFromText('linestring (10.02 20.01,10.32 23.98,11.92 25.64)',1000)
);

INSERT INTO boundary_test VALUES(
   'Polygon',
   ST_PolyFromText('polygon ((10.02 20.01,11.92 35.64,25.02 34.15,19.15
   33.94, 10.02 20.01))',1000)
);

INSERT INTO boundary_test VALUES(
   'Multipoint',
   ST_MPointFromText('multipoint (10.02 20.01,10.32 23.98,11.92 25.64)',1000)
);

INSERT INTO boundary_test VALUES(
   'Multilinestring',
   ST_MLineFromText('multilinestring ((10.02 20.01,10.32 23.98,11.92 25.64),
   (9.55 23.75,15.36 30.11))',1000)
);

INSERT INTO boundary_test VALUES(
   'Multipolygon',
```

```
   ST_MPolyFromText('multipolygon (((10.02 20.01,11.92 35.64,25.02
   34.15,19.15 33.94,10.02 20.01)),((51.71 21.73,73.36 27.04,71.52 32.87,52.43
   31.90,51.71 21.73)))',1000)
);

SELECT geotype, ST_Boundary(g1)
   FROM boundary_test;


geotype       Point
(expression)  1000 POINT EMPTY

geotype       Linestring
(expression)  1000 MULTIPOINT (10.02 20.01, 11.92 25.64)

geotype       Polygon
(expression)  1000 MULTILINESTRING ((10.02 20.01, 19.15 33.94, 25.02
   34.15, 11.92 35.64, 10.02 20.01))

geotype       Multipoint
(expression)  1000 POINT EMPTY

geotype       Multilinestring
(expression)  1000 MULTIPOINT (9.55 23.75, 10.02 20.01, 11.92 25.64, 15.36 30.1
              1)

geotype       Multipolygon
(expression)  1000 MULTILINESTRING ((10.02 20.01, 19.15 33.94, 25.02 34.15,
   11.92 35.64, 10.02 20.01),(51.71 21.73, 73.36 27.04, 71.52 32.87, 52.43
   31.9, 51.71 21.73))
```

The SE_BoundingBox() function

The **SE_BoundingBox()** function returns a polygon which represents the spatial extent (the minimum and maximum X and Y values) of all the geometries in a spatial column of a table.

Important: You must have an R-tree index on the spatial column.

Syntax

```
SE_BoundingBox (tablename varchar(128),
                columnname varchar(128))
```

Return type

ST_Polygon

Example

The **buildingfootprints** table is created with the following statement. The **building_id** column uniquely identifies the buildings, the **lot_id** identifies the building's lot, and the footprint multipolygon stores the building's geometry:

```
CREATE TABLE buildingfootprints (building_id  integer,
                                 lot_id       integer,
                                 footprint    ST_MultiPolygon);
```

After the table is populated, create an R-tree index on the **footprint** column:

```
CREATE INDEX footprint_ix
   ON buildingfootprints (footprint ST_Geometry_ops)
   USING RTREE;
```

Use the **SE_BoundingBox()** function to obtain a polygon that defines the spatial extent of all the polygons in the table:

```
EXECUTE FUNCTION SE_BoundingBox ('buildingfootprints', 'footprint');


(expression)  1000 POLYGON ((7 22, 38 22, 38 55, 7 55, 7 22))
```

Obtaining the Spatial Extent of a Functional Index

You cannot use the **SE_BoundingBox()** function on a functional R-tree index. Instead, you must use the **rtreeRootBB()** function. The **rtreeRootBB()** function takes the index name and type name as arguments and returns the well-known text representation of an ST_Polygon, as shown in the following example:

```
CREATE TABLE xytab (x float, y float, srid int);

INSERT INTO xytab VALUES (1, 2, 0);
INSERT INTO xytab VALUES (3, 4, 0);

CREATE INDEX point_idx ON xytab
   (ST_Point(x,y,srid) ST_Geometry_ops) USING RTREE;

EXECUTE FUNCTION rtreeRootBB('point_idx', 'st_point');

(expression)  0 POLYGON ((1 2, 3 2, 3 4, 1 4, 1 2))
```

See also

"The ST_Envelope() function" on page 7-52

The ST_Buffer() function

The **ST_Buffer()** function encircles a geometry object at a specified distance and returns a geometry object that is the buffer that surrounds the source object.

Syntax

```
ST_Buffer(g1 ST_Geometry, distance double_precision)
ST_Buffer(g1 ST_Geometry, distance double_precision, linear_uom varchar(128))
```

Return type

ST_Geometry

Usage

As shown in the following figure, **ST_Buffer()** generates a polygon or a multipolygon that surrounds a geometry at a specified radius.

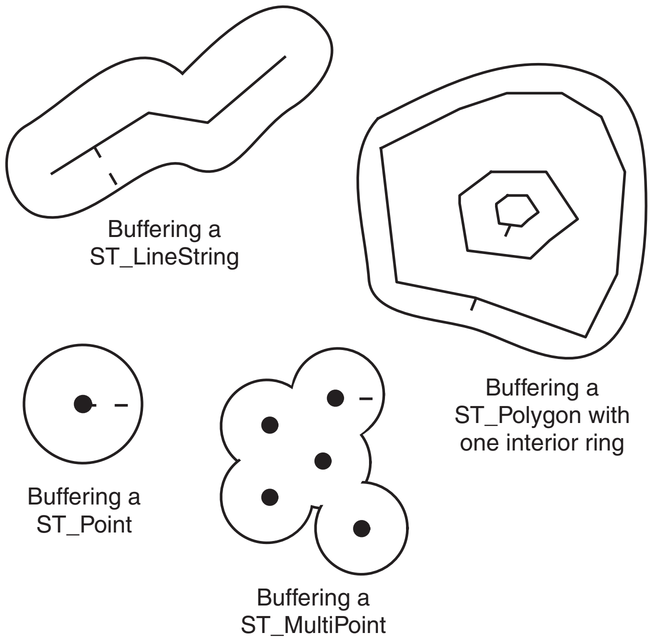


Figure 7-2. Buffers generated by the ST_Buffer() function

A single polygon results when a primary geometry is buffered or when the buffer polygons of a collection are close enough to overlap. When enough separation exists between the elements of a buffered collection, individual buffer ST_Polygons result in an ST_MultiPolygon.

The **ST_Buffer()** function accepts both positive and negative distances, but only geometries with a dimension of 2 (ST_Polygon and ST_MultiPolygon) can apply a negative buffer. The absolute value of the buffer distance is used when the dimension of the source geometry is less than 2. Generally, positive buffer distances generate polygon rings away from the center of the source geometry and, for the exterior ring of a ST_Polygon or ST_MultiPolygon, toward the center when the distance is negative. For interior rings of an ST_Polygon or ST_MultiPolygon, the buffer ring is toward the center when the buffer distance is positive and away when it is negative.

The buffering process merges buffer polygons that overlap. Negative distances greater than one-half the maximum interior width of a polygon result in an empty geometry.

The *linear_uom* parameter converts the result to the specified unit of measure. To calculate the buffer if the geometries are in a geographic coordinate system where the coordinates are in an angular unit of measure, you must specify a linear unit of measure with the *linear_uom* parameter. Angular units of measure are converted to linear units of measure by great-circle calculations. If the geometry is in a projected coordinate system that has a unit of measure that is different from the unit of measure that is specified by the *linear_uom* parameter, then the returned value is converted to the unit of measure that is specified by the *linear_uom* parameter. The *linear_uom* parameter must be the name of a linear unit of measure from the **unit_name** column of the **st_units_of_measure** table.

Example: Find 5-mile radii of hazardous sites

The county supervisor needs a list of hazardous sites whose 5-mile radius overlaps sensitive areas such as schools, hospitals, and nursing homes. The sensitive areas are stored in the table **sensitive_areas** that is created with the following CREATE TABLE statement. The **zone** column, which is defined as a **ST_Polygon**, stores the outline of each of the sensitive areas:

```
CREATE TABLE sensitive_areas (id     integer,
                              name   varchar(128),
                              size   float,
                              type   varchar(10),
                              zone   ST_Polygon);
```

The hazardous sites are stored in the following **hazardous_sites** table. The **location** column, which is defined as a point, stores the geographic center of each hazardous site:

```
CREATE TABLE hazardous_sites (site_id   integer,
                              name      varchar(40),
                              location  ST_Point);
```

The **sensitive_areas** and **hazardous_sites** tables are joined by the **ST_Overlaps()** function. This function returns `t` (TRUE) for all **sensitive_areas** rows whose **zone** polygons overlap the buffered 5-mile radius of the **hazardous_sites** location point.

```
SELECT sa.name, hs.name
   FROM sensitive_areas sa, hazardous_sites hs
   WHERE ST_Overlaps(sa.zone, ST_Buffer(hs.location,26400));


name  Johnson County Hospital
name  Landmark Industrial

name  Summerhill Elementary School
name  Landmark Industrial
```

The following figure shows that some of the sensitive areas in this administrative district lie within the 5-mile buffer radius of the hazardous site locations. It is clear that both buffers intersect the hospital and one intersects the school. The nursing home lies safely outside both radii.

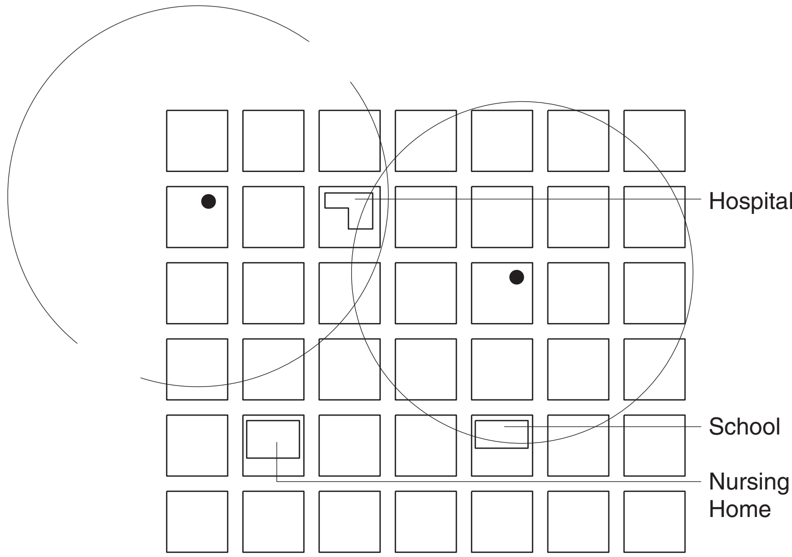


Figure 7-3. Sensitive areas

Example: Find a 3-meter buffer around a multipoint

The following statement returns a polygon that surrounds a multipoint by a buffer of 3 meters:

```
EXECUTE FUNCTION st_buffer(
       '32608 multipoint(576100 15230, 576100 15232, 576102 15232,
                        576102 15230, 576100 15230)'::st_multipoint,
       3, 'meter');


(expression)  32608 POLYGON ((576097 15230, 576097.006423 15229.8037906, 576097
              .025665 15229.6084214, 576097.057644 15229.414729, 576097.102223
              15229.2235429, 576097.15921 15229.0356816, 576097.228361 15228.85
              19497, 576097.309382 15228.6731339, 576097.401924 15228.5, 576097
              .505591 15228.3332893, 576097.61994 15228.1737157, 576097.744481
              15228.0219626, 576097.87868 15227.8786797, 576098.021963 15227.74
              44806, 576098.173716 15227.61994, 576098.333289 15227.5055912, 57
              6098.5 15227.4019238, 576098.673134 15227.3093818, 576098.85195 1
              5227.2283614, 576099.035682 15227.1592096, 576099.223543 15227.10
              22225, 576099.414729 15227.0576442, 576099.608421 15227.0256654,
              576099.803791 15227.0064232, 576100 15227, 576100.196209 15227.00
              64232, 576100.391579 15227.0256654, 576100.585271 15227.0576442,
              576100.776457 15227.1022225, 576100.964318 15227.1592096, 576101
              15227.1726392, 576101.035682 15227.1592096, 576101.223543 15227.1
              022225, 576101.414729 15227.0576442, 576101.608421 15227.0256654,
               576101.803791 15227.0064232, 576102 15227, 576102.196209 15227.0
              064232, 576102.391579 15227.0256654, 576102.585271 15227.0576442,
               576102.776457 15227.1022225, 576102.964318 15227.1592096, 576103
              .14805 15227.2283614, 576103.326866 15227.3093818, 576103.5 15227
              .4019238, 576103.666711 15227.5055912, 576103.826284 15227.61994,
               576103.978037 15227.7444806, 576104.12132 15227.8786797, 576104.
              255519 15228.0219626, 576104.38006 15228.1737157, 576104.494409 1
              5228.3332893, 576104.598076 15228.5, 576104.690618 15228.6731339,
               576104.771639 15228.8519497, 576104.84079 15229.0356816, 576104.
              897777 15229.2235429, 576104.942356 15229.414729, 576104.974335 1
              5229.6084214, 576104.993577 15229.8037906, 576105 15230, 576104.9
              93577 15230.1962094, 576104.974335 15230.3915786, 576104.942356 1
              5230.585271, 576104.897777 15230.7764571, 576104.84079 15230.9643
              184, 576104.827361 15231, 576104.84079 15231.0356816, 576104.8977
              77 15231.2235429, 576104.942356 15231.414729, 576104.974335 15231
              .6084214, 576104.993577 15231.8037906, 576105 15232, 576104.99357
              7 15232.1962094, 576104.974335 15232.3915786, 576104.942356 15232
```

```
                .585271, 576104.897777 15232.7764571, 576104.84079 15232.9643184,
                 576104.771639 15233.1480503, 576104.690618 15233.3268661, 576104
                .598076 15233.5, 576104.494409 15233.6667107, 576104.38006 15233.
                8262843, 576104.255519 15233.9780374, 576104.12132 15234.1213203,
                 576103.978037 15234.2555194, 576103.826284 15234.38006, 576103.6
                66711 15234.4944088, 576103.5 15234.5980762, 576103.326866 15234.
                6906182, 576103.14805 15234.7716386, 576102.964318 15234.8407904,
                 576102.776457 15234.8977775, 576102.585271 15234.9423558, 576102
                .391579 15234.9743346, 576102.196209 15234.9935768, 576102 15235,
                 576101.803791 15234.9935768, 576101.608421 15234.9743346, 576101
                .414729 15234.9423558, 576101.223543 15234.8977775, 576101.035682
                 15234.8407904, 576101 15234.8273608, 576100.964318 15234.8407904
                , 576100.776457 15234.8977775, 576100.585271 15234.9423558, 57610
                0.391579 15234.9743346, 576100.196209 15234.9935768, 576100 15235
                , 576099.803791 15234.9935768, 576099.608421 15234.9743346, 57609
                9.414729 15234.9423558, 576099.223543 15234.8977775, 576099.03568
                2 15234.8407904, 576098.85195 15234.7716386, 576098.673134 15234.
                6906182, 576098.5 15234.5980762, 576098.333289 15234.4944088, 576
                098.173716 15234.38006, 576098.021963 15234.2555194, 576097.87868
                 15234.1213203, 576097.744481 15233.9780374, 576097.61994 15233.8
                262843, 576097.505591 15233.6667107, 576097.401924 15233.5, 57609
                7.309382 15233.3268661, 576097.228361 15233.1480503, 576097.15921
                 15232.9643184, 576097.102223 15232.7764571, 576097.057644 15232.
                585271, 576097.025665 15232.3915786, 576097.006423 15232.1962094,
                 576097 15232, 576097.006423 15231.8037906, 576097.025665 15231.6
                084214, 576097.057644 15231.414729, 576097.102223 15231.2235429,
                576097.15921 15231.0356816, 576097.172639 15231, 576097.15921 152
                30.9643184, 576097.102223 15230.7764571, 576097.057644 15230.5852
                71, 576097.025665 15230.3915786, 576097.006423 15230.1962094, 576
                097 15230))

1 row(s) retrieved.
```

Example: Find a buffer around a point that has angular coordinates

The following statement returns a 20-mile buffer around the latitude and longitude of New York (40.67000 N, 73.94000 W). The distance is linear, but the result is a polygon in the WGS 84 geographic coordinate system:

```
EXECUTE FUNCTION ST_Buffer('4326 point(-73.94000 40.67000)'::st_point,
                           20, 'mile_us');

(expression)  4326 POLYGON ((-73.94 40.9598410446, -73.9650052554 40.9592177873
              , -73.9899020331 40.9573507189, -74.0145823443 40.9542479379, -74
              .0389391756 40.9499229014, -74.0628669705 40.9443943641, -74.0862
              62103 40.9376862943, -74.1090233418 40.9298277658, -74.1310523018
               40.9208528277, -74.1522538813 40.9108003512, -74.1725366824 40.8
              997138558, -74.191813413 40.8876413147, -74.2100012676 40.8746349
              404, -74.2270222864 40.8607509525, -74.2428036898 40.8460493278,
              -74.2572781883 40.8305935344, -74.270384265 40.8144502508, -74.28
              20664306 40.7976890725, -74.2922754499 40.7803822052, -74.3009685
              386 40.762604149, -74.3081095301 40.7444313721, -74.3136690117 40
              .725941978, -74.3176244305 40.7072153662, -74.3199601683 40.68833
              18884, -74.3206675854 40.6693725018, -74.3197450343 40.6504184208
              , -74.3171978431 40.6315507692, -74.3130382692 40.6128502335, -74
              .3072854238 40.5943967192, -74.2999651681 40.5762690118, -74.2911
              099818 40.558544444, -74.2807588051 40.5412985687, -74.2689568546
               40.5246048426, -74.2557554153 40.5085343173, -74.2412116083 40.4
              931553434, -74.2253881367 40.4785332853, -74.2083530102 40.464730
              2495, -74.1901792499 40.4518048277, -74.170944575 40.4398118544,
              -74.1507310716 40.4288021807, -74.1296248465 40.4188224653, -74.1
              077156662 40.4099149825, -74.085096583 40.4021174495, -74.0618635
              499 40.3954628715, -74.0381150244 40.389979407, -74.0139515651 40
              .3856902529, -73.9894754197 40.3826135501, -73.9647901079 40.3807
              623093, -73.94 40.3801443581, -73.9152098921 40.3807623093, -73.8
```

```
905245803 40.3826135501, -73.8660484349 40.3856902529, -73.841884
9756 40.389979407, -73.8181364501 40.3954628715, -73.794903417 40
.4021174495, -73.7722843338 40.4099149825, -73.7503751535 40.4188
224653, -73.7292689284 40.4288021807, -73.709055425 40.4398118544
, -73.6898207501 40.4518048277, -73.6716469898 40.4647302495, -73
.6546118633 40.4785332853, -73.6387883917 40.4931553434, -73.6242
445847 40.5085343173, -73.6110431454 40.5246048426, -73.599241194
9 40.5412985687, -73.5888900182 40.558544444, -73.5800348319 40.5
762690118, -73.5727145762 40.5943967192, -73.5669617308 40.612850
2335, -73.5628021569 40.6315507692, -73.5602549657 40.6504184208,
 -73.5593324146 40.6693725018, -73.5600398317 40.6883318884, -73.
5623755695 40.7072153662, -73.5663309883 40.725941978, -73.571890
4699 40.7444313721, -73.5790314614 40.762604149, -73.5877245501 4
0.7803822052, -73.5979335694 40.7976890725, -73.609615735 40.8144
502508, -73.6227218117 40.8305935344, -73.6371963102 40.846049327
8, -73.6529777136 40.8607509525, -73.6699987324 40.8746349404, -7
3.688186587 40.8876413147, -73.7074633176 40.8997138558, -73.7277
461187 40.9108003512, -73.7489476982 40.9208528277, -73.770976658
2 40.9298277658, -73.793737897 40.9376862943, -73.8171330295 40.9
443943641, -73.8410608244 40.9499229014, -73.8654176557 40.954247
9379, -73.8900979669 40.9573507189, -73.9149947446 40.9592177873,
 -73.94 40.9598410446))

1 row(s) retrieved.
```

Related reference:

"The st_units_of_measure table" on page 1-17

The ST_Centroid() function

The **ST_Centroid()** function takes a polygon or multipolygon and returns the geometric center of the bounding box of the polygon or multipolygon as a point.

Syntax

```
ST_Centroid(pl1 ST_Polygon)
ST_Centroid(mpl1 ST_MultiPolygon)
```

Return type

ST_Point

Example

The city GIS technician wants to display the building footprint multipolygons as single points in a building density graphic.

The building footprints are stored in the **buildingfootprints** table that was created with the following CREATE TABLE statement:

```
CREATE TABLE buildingfootprints (building_id  integer,
                                 lot_id       integer,
                                 footprint    ST_MultiPolygon);
```

The **ST_Centroid()** function returns the centroid of each building footprint multipolygon:

```
SELECT building_id, ST_Centroid(footprint) Centroid
   FROM buildingfootprints;


building_id  506
centroid     1000 POINT (12.5 49.5)
```

```
building_id  543
centroid     1000 POINT (32 51.5)

building_id  1208
centroid     1000 POINT (12.5 30.5)

building_id  178
centroid     1000 POINT (32 28.5)
```

The ST_Contains() function

The **ST_Contains()** function takes two geometry objects and returns t (TRUE) if the first object completely contains the second; otherwise, it returns f (FALSE).

Syntax

```
ST_Contains(g1 geometry, g2 geometry)
```

Usage

To return TRUE, the boundary and interior of the second geometry cannot intersect the exterior of the first geometry. **ST_Contains()** returns the opposite result of **ST_Within()**.

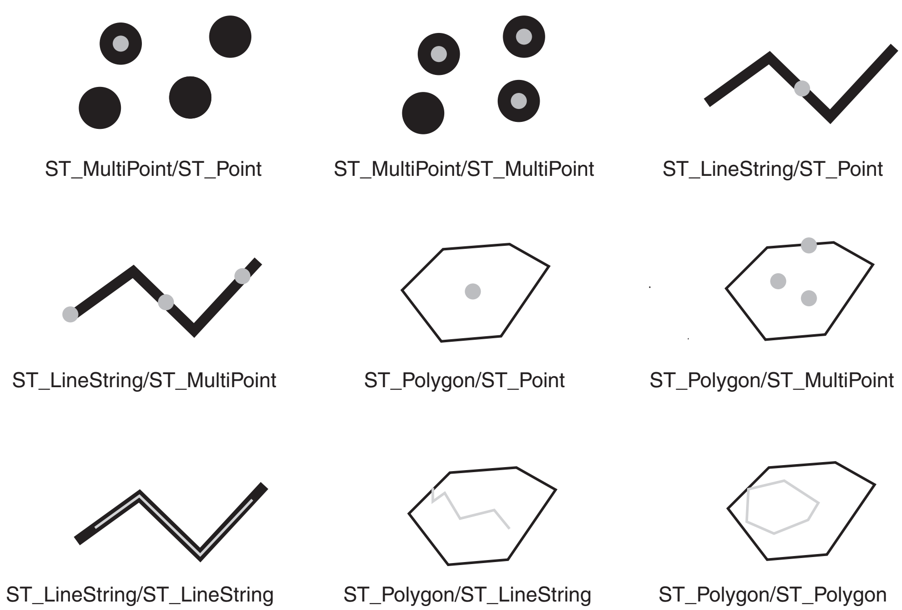


Figure 7-4. Contained geometries

The results of the spatial relationship of the **ST_Contains()** function can be understood or verified by comparing the results with a pattern matrix that represents the acceptable values for the DE-9IM. The pattern matrix of the **ST_Contains()** function states that the interiors of both geometries must intersect. It also states that the interior and boundary of the secondary (geometry *b*) must not intersect the exterior of the primary (geometry *a*).

Table 7-6. Pattern matrix for the ST_Contains() function.

		b	
	Interior	**Boundary**	**Exterior**
Interior	T	*	*

Table 7-6. Pattern matrix for the ST_Contains() function (continued).

		b		
		Interior	**Boundary**	**Exterior**
a	Boundary	*	*	*
	Exterior	F	F	*

Return type

BOOLEAN

Example

In the example below, two tables are created: **buildingfootprints** contains a city's building footprints, and **lots** contains its lots. The city engineer wants to ensure that all building footprints are completely inside their lots.

In both tables, the ST_MultiPolygon data type stores the geometry of the building footprints and the lots. The database designer selected multipolygons for both features because lots can be separated by natural features such as rivers, and building footprints can comprise several buildings:

```
CREATE TABLE buildingfootprints (building_id  integer,
                                 lot_id       integer,
                                 footprint    ST_MultiPolygon);

CREATE TABLE lots (lot_id  integer,
                   lot     ST_MultiPolygon);
```

The city engineer first selects the buildings that are not contained within one lot:

```
SELECT building_id
   FROM buildingfootprints, lots
   WHERE NOT ST_Contains(lot,footprint);
```

Although the first query provides a list of all building IDs that have footprints outside a lot polygon, it does not determine whether the rest are assigned the correct **lot_id**. The city engineer runs a second query to check the data integrity on the **lot_id** column of the **buildingfootprints** table:

```
SELECT bf.building_id, bf.lot_id, lots.lot_id
   FROM buildingfootprints bf, lots
   WHERE NOT ST_Contains(lot,footprint)
   AND lots.lot_id <> bf.lot_id;
```

In the following figure, the building footprints are labeled with their building IDs and lie inside their lot lines. The lot lines are illustrated with dotted lines. Although not shown, they extend to the street centerline to completely encompass the lot lines and the building footprints within them.

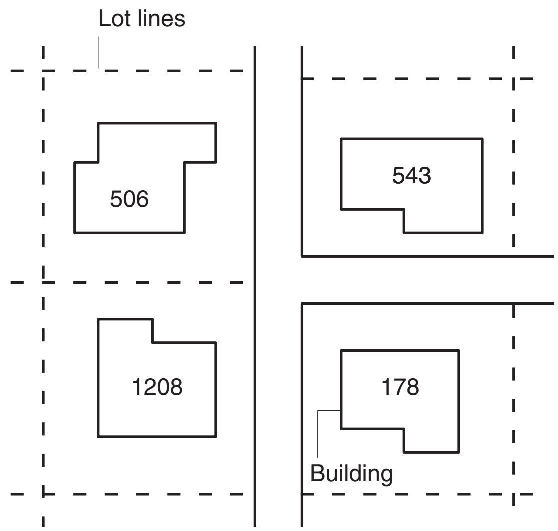


Figure 7-5. Building footprints and lot lines.

Related reference:
"The Dimensionally Extended 9 Intersection Model" on page 7-2

The ST_ConvexHull() function

The **ST_ConvexHull()** function returns the convex hull of any geometry object that has at least three vertices forming a convex.

Syntax

```
ST_ConvexHull (g1 ST_ Geometry)
```

Usage

Creating a convex hull is often the first step when tessellating a set of points to create a triangulated irregular network (TIN). If vertices of the geometry do not form a convex, **ST_ConvexHull()** returns a null.

ST_ConvexHull() generates an ST_Polygon value from the convex hull of three of the geometries that are pictured in the following figure. **ST_ConvexHull()** returns a null for the two-point ST_LineString because it does not form a convex hull.

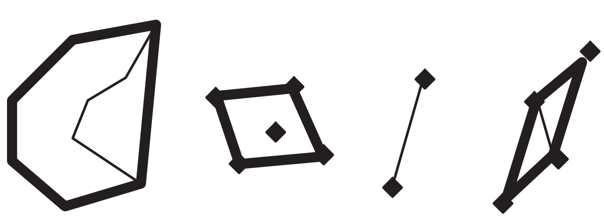


Figure 7-6. The ST_ConvexHull() function.

Return type

ST_Geometry

Example

The example creates the **convexhull_test** table that has two columns: **geotype** and **g1**. The **geotype** column is of VARCHAR(20) type and holds the name of the geometry subclass that is stored in **g1**, an ST_Geometry column:

```
CREATE TABLE convexhull_test (geotype varchar(20),
                              g1      ST_Geometry);
```

The following INSERT statements insert several geometry subclasses into the **convexhull_test** table:

```
INSERT INTO convexhull_test VALUES(
   'Point',
   ST_PointFromText('point (10.02 20.01)',1000)
);

INSERT INTO convexhull_test VALUES(
   'Linestring',
   ST_LineFromText('linestring (10.02 20.01,10.32 23.98,11.92 25.64)',1000)
);

INSERT INTO convexhull_test VALUES(
   'Polygon',
   ST_PolyFromText('polygon ((10.02 20.01,11.92 35.64,25.02 34.15,
19.15 33.94,10.02 20.01))',1000)
);

INSERT INTO convexhull_test VALUES(
   'MultiPoint',
   ST_MPointFromText('multipoint (10.02 20.01,10.32 23.98,11.92 25.64)',1000)
);

INSERT INTO convexhull_test VALUES(
   'MultiLineString',
   ST_MLineFromText('multilinestring ((10.02 20.01,10.32 23.98,11.92
25.64),(9.55 23.75,15.36 30.11))',1000)
);

INSERT INTO convexhull_test VALUES(
   'Multipolygon',
   ST_MPolyFromText('multipolygon (((10.02 20.01,11.92 35.64,25.02
34.15,19.15 33.94,10.02 20.01)),((51.71 21.73,73.36 27.04,71.52
32.87,52.43 31.90,51.71 21.73)))',1000)
);
```

The SELECT statement lists the subclass name that is stored in the **geotype** column and the convex hull:

```
SELECT geotype, ST_ConvexHull(g1) convexhull
   FROM convexhull_test;
```

The ST_CoordDim() function

The **ST_CoordDim()** function returns the coordinate dimensions of the ST_Geometry value.

For example, a point with a Z coordinate has three dimensions and a point with a Z coordinate and measures has four dimensions.

Syntax

```
ST_CoordDim(g ST_Geometry)
```

Return type

INTEGER

Example

The **coorddim_test** table is created with the columns **geotype** and **g1**. The **geotype** column stores the name of the geometry subclass stored in the **g1** ST_Geometry column:

```
CREATE TABLE coorddim_test (geotype varchar(20),
                            g1      ST_Geometry);
```

The INSERT statements insert a sample subclass into the **coorddim_test** table:

```
INSERT INTO coorddim_test VALUES(
   'Point',
   ST_PointFromText('point (10.02 20.01)',1000)
);

INSERT INTO coorddim_test VALUES(
   'Point',
   ST_PointFromText('point z (10.02 20.01 3.21)',1000)
);

INSERT INTO coorddim_test VALUES(
   'LineString',
   ST_LineFromText('linestring (10.02 20.01, 10.32 23.98, 11.92 25.64)',1000)
);

INSERT INTO coorddim_test VALUES(
   'LineString',
   ST_LineFromText('linestring m (10.02 20.01 1.23, 10.32 23.98 4.56, 11.92
25.64 7.89)',1000)
);

INSERT INTO coorddim_test VALUES(
   'Polygon',
   ST_PolyFromText('polygon ((10.02 20.01,11.92 35.64,25.02
34.15,19.15 33.94, 10.02 20.01))',1000)
);

INSERT INTO coorddim_test VALUES(
   'Polygon',
   ST_PolyFromText('polygon zm ((10.02 20.01 9.87 1.23, 11.92
35.64 7.65 2.34, 25.02 34.15 6.54 3.45, 19.15 33.94 5.43 4.56,
10.02 20.01 9.87 1.23))',1000)
);
```

The SELECT statement lists the subclass name stored in the **geotype** column with the dimension of that geometry:

```
SELECT geotype, ST_CoordDim(g1) coord_dimension
   FROM coorddim_test;

geotype              coord_dimension

Point                              2
Point                              3
LineString                         2
LineString                         3
Polygon                            2
Polygon                            4

6 row(s) retrieved.
```

The SE_CreateSRID() function

The **SE_CreateSRID()** function is a utility function that, given the X and Y extents of a spatial data set, computes the false origin and system units and creates a new entry in the **spatial_references** table. Appropriate offsets and scale factors for typical Z values and M values are also provided.

Syntax

Use the following syntax to create a spatial reference system that is based on an existing spatial reference system that is not listed in the **spatial_references** table:

```
SE_CreateSRID (factory_id integer,
               type varchar(64) default NULL,
               description varchar(64) default NULL,
               SRID integer default NULL)
```

Table 7-7. Options for the SE_CreateSRID() function

Parameter	Description
factory_id	The ESRI Projection Engine ID number of an existing spatial reference system that is not listed in the **spatial_references** table on which to base the new spatial reference system. If the *factory_id* is the same as an SRID in the **spatial_references** table, an error is returned.
type	The type of coordinate system: • **projcs**: Default. Projected coordinate system. • **geogcs**: Geographic coordinate system.
description	Your description of the spatial reference system. Default is '*auth_name auth_srid auth_version*', where *auth_name* is the authority name, *auth_srid* is the factory ID, and *auth_version* is the version number that is associated with the factory ID.
SRID	The new SRID. Default is the same value as the *factory_id* parameter.

Use the following syntax to create a spatial reference system by specifying X and Y extents:

```
SE_CreateSRID (xmin float, ymin float,
               xmax float, ymax float,
               description varchar(64))
```

Table 7-8. Options for the SE_CreateSRID() function

Parameter	Description
xmin	The minimum value of the x-coordinate
ymin	The minimum value of the y-coordinate
xmax	The maximum value of the x-coordinate

Table 7-8. Options for the SE_CreateSRID() function (continued)

Parameter	Description
ymax	The maximum value of the y-coordinate
description	Your description of the spatial reference system

Usage

The **spatial_references** table holds data about spatial reference systems. A spatial reference system is a description of a coordinate system for a set of geometric objects; it gives meaning to the X and Y values that are stored in the database.

You need to specify an SRID of a spatial reference system when you load spatial data into a database because the database server translates and scales each floating point coordinate of the geometry into a 53-bit positive integer before storage.

The **spatial_references** table contains many predefined spatial reference systems. If the predefined spatial reference systems are not suitable for your data, you can run the **SE_CreateSRID()** function to create a more appropriate **spatial_references** table entry. You can base your system on an existing spatial reference system that is not already in the **spatial_references** table or you can specify the X and Y extents of your data. If you specify the X and Y extent data, the database server calculates the value for the false origin and system units. Therefore, the **SE_CreateSRID()** function might not create sufficiently refined parameters to describe the spatial reference system that you need. You can use an INSERT statement to specify false origin and system units.

Return type

Returns the SRID of a newly created **spatial_references** table entry as an integer.

Example: Create an SRID by specifying X and Y extents

The following example creates an entry in the **spatial_references** table that is suitable for spatial data in New Zealand and returns the assigned SRID of 1001:

```
EXECUTE FUNCTION SE_CreateSRID (166, -48, 180, -34,
                                "New Zealand: lat/lon coords");

(expression)

        1001
```

The following query shows the resulting **spatial_references** table entry:

```
SELECT * FROM spatial_references WHERE srid = 1001;


srid         1001
description  New Zealand: lat/lon coords
auth_name
auth_srid
falsex       164.6000000000
falsey       -49.4000000000
xyunits      127826407.5600
falsez       -1000.00000000
```

```
zunits       1000.000000000
falsem       -1000.00000000
munits       1000.000000000
srtext       UNKNOWN
```

Example: Create a spatial reference system that is a copy of an existing system

The following statement creates a spatial reference system with an SRID of 1002 that is based on the EPSG coordinate system that has a factory ID of 4326:

```
EXECUTE FUNCTION SE_CreateSrid(4326, 'projcs', 'WGS 1984', 1002);

(expression)

        1002
```

The following statement shows the properties of SRID 1002:

```
SELECT * FROM spatial_references WHERE srid = 1002;


srid         1002
description  WGS 1984
auth_name    EPSG
auth_srid    4326
falsex       -216.000000000
falsey       -126.000000000
xyunits      20849998274900
falsez       -1000.00000000
zunits       1000.000000000
falsem       -1000.00000000
munits       1000.000000000
srtext       GEOGCS["GCS_WGS_1984",DATUM["D_WGS_1984",SPHEROID["WGS_1984",63781
             37.0,298.257223563]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.01745
             32925199433]]

1 row(s) retrieved.
```

Example: Add an existing spatial reference system

The following statement shows the OGC well-known text representation of an existing spatial reference system that has a factory ID of 3000. This factory ID is not listed in the **spatial_reference** table by default.

```
EXECUTE FUNCTION SE_CreateSrtext(3000);


(expression)  PROJCS["Gunung_Segara_NEIEZ",GEOGCS["GCS_Gunung_Segara",DATUM["D_
             Gunung_Segara",SPHEROID["Bessel_1841",6377397.155,299.1528128]],P
             RIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECT
             ION["Mercator"],PARAMETER["False_Easting",3900000.0],PARAMETER["F
             alse_Northing",900000.0],PARAMETER["Central_Meridian",110.0],PARA
             METER["Standard_Parallel_1",4.45405154589751],UNIT["Meter",1.0]]

1 row(s) retrieved.)
```

The following statement adds the factory ID 3000 to the **spatial_reference** table. Because an SRID is not specified, by default, the SRID is the same as the factory ID:

```
EXECUTE FUNCTION SE_CreateSrid(3000);

(expression)
```

```
      3000

1 row(s) retrieved.
```

The following statement shows the properties of SRID 3000:

```
SELECT * FROM spatial_references WHERE srid = 3000;


srid         3000
description  EPSG 3000, version 8.1.1
auth_name    EPSG
auth_srid    3000
falsex       -22096080.0000
falsey       -35225280.0000
xyunits      124666151.4420
falsez       -1000.00000000
zunits       1000.000000000
falsem       -1000.00000000
munits       1000.000000000
srtext       PROJCS

1 row(s) retrieved.
```

Related concepts:

"False origin and system units" on page 1-15

Related reference:

"The spatial_references table" on page 1-12

"The SE_CreateSrtext() function"

The SE_CreateSrtext() function

The **SE_CreateSrtext()** function returns the OGC well-known text representation of a spatial reference system, given the ESRI Projection Engine ID number for a coordinate system.

The ID numbers are in the file `pedef.h`, in the directory `$INFORMIXDIR/extend/spatial.`*`version`*`/include`.

Syntax

```
SE_CreateSrtext (factory_id integer)
SE_CreateSrtext (factory_id integer, type varchar(64) default NULL)
```

The *type* parameter indicates the type of spatial reference system when different types of systems have overlapping IDs. The following table lists the values of the *type* parameter. You can use either the long type value or the corresponding short type value.

Table 7-9. Object types

Long type value	Short type value	Spatial reference system name
geogcs	gcs	Geographic Coordinate System
projcs	pcs	Projected Coordinate System
coordsys	crs	Either the Geographic Coordinate System or the Project Coordinate System

Table 7-9. Object types (continued)

Long type value	Short type value	Spatial reference system name
vertcs	vcs	Vertical Coordinate System
geoxyzcs	xyz	Geographic Coordinate System with XYZ coordinates
hvcoordsys	hvc	Horizontal-vertical Coordinate System
datum	dat	Datum
vdatum	vdt	Vertical datum
hvdatum	hvd	Either datum or vertical datum
geogtran	gtf	Geographic Transform
verttran	vtf	Vertical Transform
linunit	lin	Linear units
angunit	ang	Angular units
unit	uni	Either linear or angular units
areaunit	are	Area units
primem	pri	Prime Meridian
spheriod	sph	Spheroid
method	mth	Method
htmethod	htm	Horizontal method
vtmethod	vtm	Vertical method
projection	prj	Projection method
parameter	par	Parameter

Return type

LVARCHAR

Example

To obtain the spatial reference system text for the 1983 North American Datum:

```
EXECUTE FUNCTION SE_CreateSrtext(4269);


(expression)  GEOGCS["GCS_North_American_1983",DATUM["D_North_American_1983",SP
              HEROID["GRS_1980",6378137,298.257222101]],PRIMEM["Greenwich",0],U
              NIT["Degree",0.0174532925199432955]]
```

Tip: You can transfer the output of **SE_CreateSrtext()** directly into the **spatial_references** table with the following SQL statement:

```
UPDATE spatial_references
   SET srtext = SE_CreateSrtext(4269) WHERE srid = 1000;
```

Related reference:

"The SE_CreateSRID() function" on page 7-33

"The text representation of a spatial system" on page B-1

The SE_CreateSrtextCount() function

The **SE_CreateSrtextCount()** function returns the number of spatial reference systems that use the specified ESRI Projection Engine ID number.

Syntax

```
SE_CreateSrtextCount (factory_id int)
```

Return type

INTEGER

Example

To return the number of spatial reference systems that use the ID 5109:

```
EXECUTE FUNCTION SE_SrtextCount(5109);

(expression)

           2

1 row(s) retrieved.
```

The ID 5109 has two spatial reference system types.

The SE_CreateSrtextList() function

The **SE_CreateSrtextList()** function returns the OGC well-known text representation of every spatial reference system that uses the specified ESRI Projection Engine ID number. The text for each spatial reference system is separated by a new line character.

If the specified ID number is used by a single spatial reference system, the **SE_CreateSrtextList()** function returns the same text as the **SE_CreateSrtext()** function. The ID numbers are in the file `pedef.h`, in the directory `$INFORMIXDIR/extend/spatial.`*`version`*`/include`.

Syntax

```
SE_CreateSrtextList (factory_id int)
```

Return type

LVARCHAR

Example

To return the spatial reference system text for the ID 5109:

```
EXECUTE FUNCTION SE_CreateSrtextList(5109);


(expression)  PROJCS["ETRS_1989_NTM_Zone_9",GEOGCS["GCS_ETRS_1989",DATUM["D_ETR
              S_1989",SPHEROID["GRS_1980",6378137.0,298.257222101]],PRIMEM["Gre
              enwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECTION["Trans
              verse_Mercator"],PARAMETER["False_Easting",100000.0],PARAMETER["F
              alse_Northing",1000000.0],PARAMETER["Central_Meridian",9.5],PARAM
              ETER["Scale_Factor",1.0],PARAMETER["Latitude_Of_Origin",58.0],UNI
```

```
            T["Meter",1.0]]
            VDATUM["Normaal_Amsterdams_Peil"]

1 row(s) retrieved.
```

The ID 5109 has two spatial reference system types: a Projected Coordinate System and a vertical datum.

The ST_Crosses() function

The **ST_Crosses()** function returns t (TRUE) if the intersection of two geometry objects results in an ST_Geometry object whose dimension is one less than the maximum dimension of the source objects.

Syntax

```
ST_Crosses(g1 ST_Geometry, g2 ST_Geometry)
```

Usage

The intersection object must contain points that are interior to both source geometries and it must not be equal to either of the source objects. Otherwise, it returns f (FALSE).

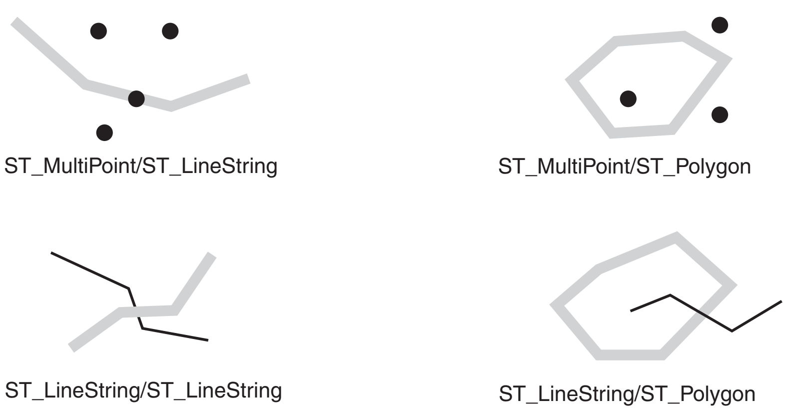


Figure 7-7. Crossing geometries

The results of the spatial relationship of the **ST_Crosses()** function can be understood or verified by comparing the results with a pattern matrix that represents the acceptable values for the DE-9IM. The **ST_Crosses()** function returns TRUE if the intersection object contains points that are interior to both source geometries, but is not equal to either of the source objects.

This **ST_Crosses()** function pattern matrix applies to ST_MultiPoint and ST_LineString; ST_MultiPoint and ST_MultiLineString; ST_MultiPoint and ST_Polygon; ST_MultiPoint and ST_MultiPolygon; ST_LineString and ST_Polygon; and ST_LineString and ST_MultiPolygon. The matrix states that the interiors must intersect and at least the interior of the primary (geometry *a*) must intersect the exterior of the secondary (geometry *b*).

Table 7-10. Pattern matrix for the ST_Crosses() function.

	Interior (b)	**Boundary (b)**	**Exterior (b)**
Interior (a)	T	*	T
Boundary (a)	*	*	*

Table 7-10. Pattern matrix for the ST_Crosses() function (continued).

	Interior (b)	Boundary (b)	Exterior (b)
Exterior (a)	*	*	*

This **ST_Crosses()** function matrix applies to ST_LineString and ST_LineString; ST_LineString and ST_MultiLineString; and ST_MultiLineString and ST_MultiLineString. The matrix states that the dimension of the intersection of the interiors must be 0 (intersect at a point). If the dimension of this intersection was 1 (intersect at a linestring), the **ST_Crosses()** function would return FALSE but the **ST_Overlaps()** function would return TRUE.

	Interior (b)	Boundary (b)	Exterior (b)
Interior (a)	0	*	*
Boundary (a)	*	*	*
Exterior (a)	*	*	*

Return type

BOOLEAN

Example

The county government is considering a new regulation that states all hazardous waste storage facilities must not be within 5 miles of any waterway. The county GIS manager has an accurate representation of rivers and streams, which are stored as multilinestrings in the **waterways** table. However, the GIS manager has only a single point location for each of the hazardous waste storage facilities:

```
CREATE TABLE waterways (id     integer,
                        name   varchar(128),
                        water  ST_MultiLineString);

CREATE TABLE hazardous_sites (site_id   integer,
                              name      varchar(40),
                              location  ST_Point);
```

The GIS manager needs to alert the county supervisor to any existing facilities that would violate the proposed regulation. To determine whether such notification is necessary, the GIS manager must buffer the **hazardous_sites** locations to see whether any rivers or streams cross the buffer polygons. The **ST_Crosses()** function compares the buffered **hazardous_sites** with **waterways**, returning only those records where the waterway crosses over the county's proposed regulated radius:

```
SELECT ww.name waterway, hs.name hazardous_site
   FROM waterways ww, hazardous_sites hs
   WHERE ST_Crosses(ST_Buffer(hs.location,(5 * 5280)),ww.water);


waterway        Fedders creek
hazardous_site  Landmark Industrial
```

The following figure shows that the 5-mile buffered radius of the hazardous waste sites crosses the stream network that runs through the county's administrative district. Because the stream network is defined as an ST_MultiLineString, all linestring segments that are part of the segments that cross the radius are included in the result set.

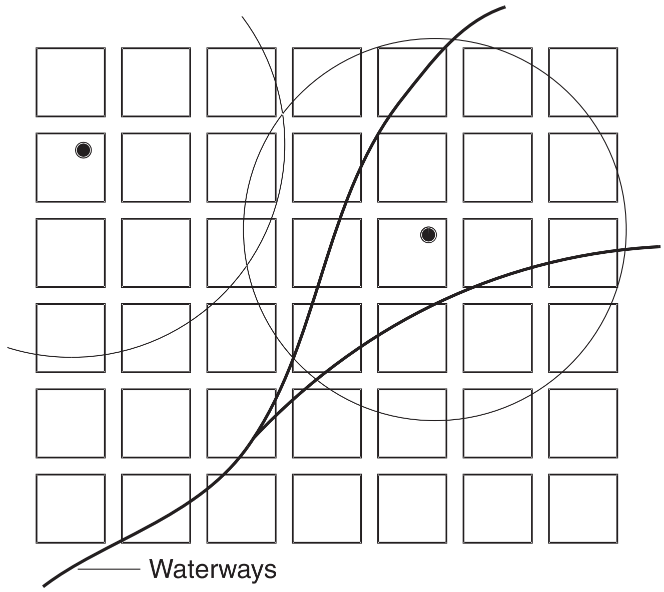


Figure 7-8. Hazardous waste sites and the stream network.

Related reference:

"The Dimensionally Extended 9 Intersection Model" on page 7-2

The ST_Difference() function

The **ST_Difference()** function takes two geometry objects and returns a geometry object that is the difference of the source objects. In other words, it returns the portion of the primary geometry that is not intersected by the secondary geometry, the logical AND NOT of space.

Syntax

```
ST_Difference(g1 ST_Geometry, g2 ST_Geometry)
```

Usage

The **ST_Difference()** function operates only on geometries of like dimension and returns an ST_GeomCollection (ST_MultiPoint, ST_MultiLineString, or ST_MultiPolygon) that has the same dimension as the source geometries. If the source geometries are equal, an empty geometry is returned.

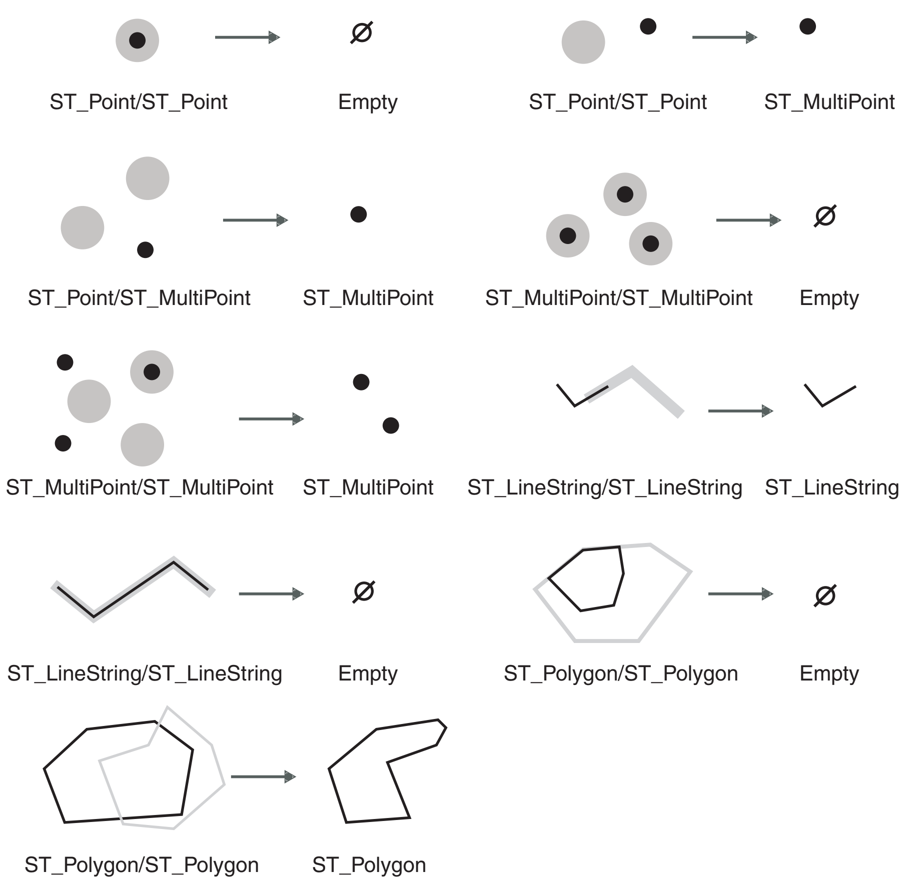


Figure 7-9. The ST_Difference() function

Return type

ST_Geometry

Example

The city engineer needs to know the total city lot area that is not covered by buildings. In fact, the engineer wants the sum of the lot area after the building area is removed:

```
CREATE TABLE buildingfootprints (building_id  integer,
                                 lot_id       integer,
                                 footprint    ST_MultiPolygon);

CREATE TABLE lots (lot_id  integer,
                   lot     ST_MultiPolygon);
```

The city engineer equijoins the **buildingfootprints** and **lots** tables on the **lot_id** column and takes the sum of the area of the difference of the lots less the building footprints:

```
SELECT SUM(ST_Area(ST_Difference(lot,footprint)::ST_MultiPolygon))
   FROM buildingfootprints bf, lots
   WHERE bf.lot_id = lots.lot_id;
```

The ST_Dimension() function

The **ST_Dimension()** function returns the dimension of a geometry object.

A geometry can have one of three dimensions:

0 The geometry has neither length nor area.

1 The geometry has length.

2 The geometry has area.

Syntax

```
ST_Dimension(g1 ST_Geometry)
```

Return type

INTEGER

Example

The **dimension_test** table is created with the columns **geotype** and **g1**. The **geotype** column stores the name of the subclass stored in the **g1** ST_Geometry column:

```
CREATE TABLE dimension_test (geotype varchar(20),
                             g1      ST_Geometry);
```

The following INSERT statements insert a sample subclass into the **dimension_test** table:

```
INSERT INTO dimension_test VALUES(
   'Point',
   ST_PointFromText('point (10.02 20.01)',1000)
);

INSERT INTO dimension_test VALUES(
   'Linestring',
   ST_LineFromText('linestring (10.02 20.01,10.32 23.98,11.92 25.64)',1000)
);

INSERT INTO dimension_test VALUES(
   'Polygon',
   ST_PolyFromText('polygon ((10.02 20.01,11.92 35.64,25.02 34.15,
19.15 33.94,10.02 20.01))',1000)
);

INSERT INTO dimension_test VALUES(
   'Multipoint',
   ST_MPointFromText('multipoint (10.02 20.01,10.32 23.98,11.92 25.64)',1000)
);

INSERT INTO dimension_test VALUES(
   'Multilinestring',
   ST_MLineFromText('multilinestring ((10.02 20.01,10.32
23.98,11.92 25.64),(9.55 23.75,15.36 30.11))',1000)
);

INSERT INTO dimension_test VALUES(
   'Multipolygon',
   ST_MPolyFromText('multipolygon (((10.02 20.01,11.92 35.64,25.02
34.15,19.15 33.94,10.02 20.01)),((51.71 21.73,73.36 27.04,71.52
32.87,52.43 31.90,51.71 21.73)))',1000)
);
```

The SELECT statement lists the subclass name stored in the **geotype** column with the dimension of that geotype:

```
SELECT geotype, ST_Dimension(g1) Dimension
   FROM dimension_test;

geotype                dimension

Point                          0
Linestring                     1
Polygon                        2
Multipoint                     0
Multilinestring                1
Multipolygon                   2
```

The ST_Disjoint() function

The **ST_Disjoint()** function takes two geometries and returns `t` (TRUE) if the two geometries are completely non-intersecting; otherwise, it returns `f` (FALSE).

Syntax

```
ST_Disjoint(g1 ST_Geometry, g2 ST_Geometry)
```

Usage

The following figure shows various geometric objects that do not touch each other.

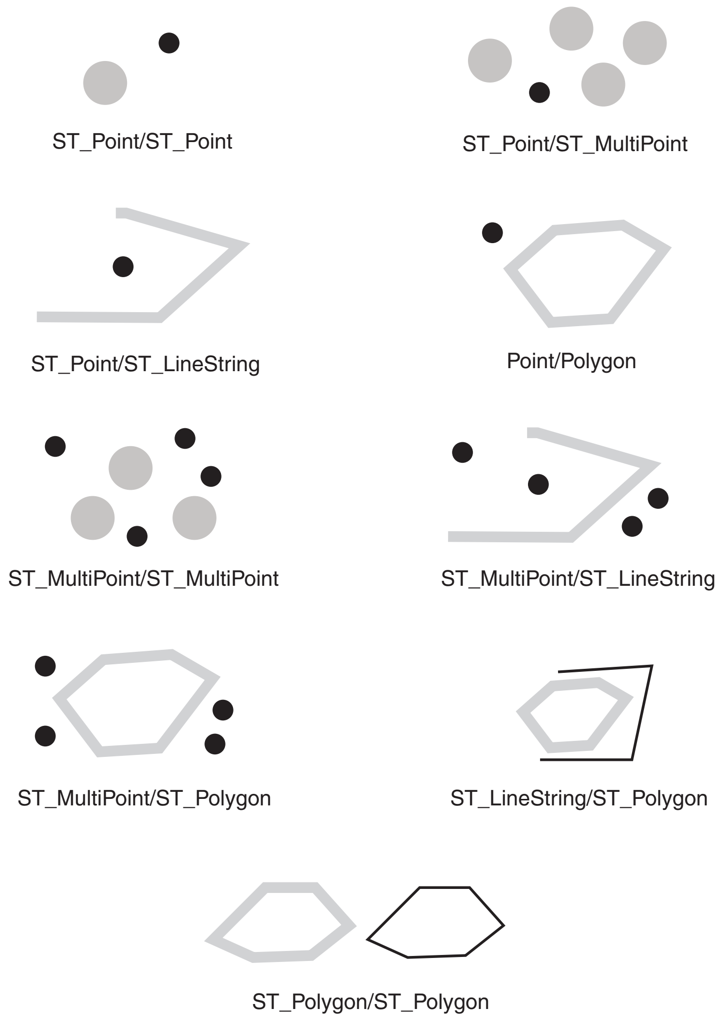


Figure 7-10. Disjoint geometries

The results of the spatial relationship of the **ST_Disjoint()** function can be understood or verified by comparing the results with a pattern matrix that represents the acceptable values for the DE-9IM. The **ST_Disjoint()** function pattern matrix states that neither the interiors nor the boundaries of either geometry intersect.

Table 7-11. Pattern matrix for the ST_Disjoint() function.

		b		
		Interior	**Boundary**	**Exterior**
	Interior	F	F	*
a	Boundary	F	F	*
	Exterior	*	*	*

Return type

BOOLEAN

Example

An insurance company wants to assess the insurance coverage for the town's hospital, nursing homes, and schools. Part of this process includes determining the threat that the hazardous waste sites pose to each institution. Currently, the insurance company wants to consider only those institutions that are not at risk of contamination. The insurance company commissions a GIS consultant to locate all institutions that are outside a 5-mile radius of a hazardous waste storage facility.

The **sensitive_areas** table contains several columns that describe the threatened institutions in addition to the **zone** column, which stores the institutions' polygon geometries:

```
CREATE TABLE sensitive_areas (id     integer,
                              name   varchar(128),
                              size   float,
                              type   varchar(10),
                              zone   ST_Polygon);
```

The **hazardous_sites** table stores the identity of the sites in the **site_id** and **name** columns, The actual geographic location of each site is stored in the **location** point column:

```
CREATE TABLE hazardous_sites (site_id   integer,
                              name      varchar(40),
                              location  ST_Point);
```

The SELECT statement lists the names of all sensitive areas that are outside the 5-mile radius of a hazardous waste site:

```
SELECT sa.name
   FROM sensitive_areas sa, hazardous_sites hs
   WHERE ST_Disjoint(ST_Buffer(hs.location,(5 * 5280)), sa.zone);
```

You can also use the **ST_Intersects()** function to perform this query because **ST_Intersects()** and **ST_Disjoint()** return the opposite results:

```
SELECT sa.name
   FROM sensitive_areas sa, hazardous_sites hs
   WHERE NOT ST_Intersects(ST_Buffer(hs.location,(5 * 5280)), sa.zone);
```

The following figure shows that the nursing home is the only sensitive area for which the **ST_Disjoint()** function returns `t` (TRUE) when comparing sensitive sites to the 5-mile radius of the hazardous waste sites. The **ST_Disjoint()** function returns `t` whenever two geometries do not intersect in any way.

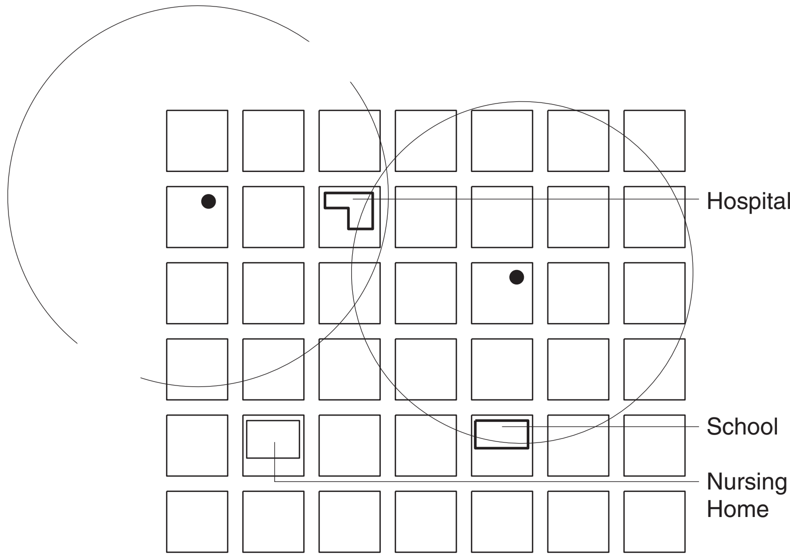


Figure 7-11. Sensitive Sites and Hazardous Waste Sites

Related reference:
"The Dimensionally Extended 9 Intersection Model" on page 7-2

The SE_Dissolve() function

The **SE_Dissolve()** function is an aggregate function that computes the union of geometries of the same dimension. If just one geometry satisfies your query, it is returned unaltered.

Syntax

```
SE_Dissolve (g1 ST_Geometry)
```

Usage

The following figure shows the union of various geometric objects.

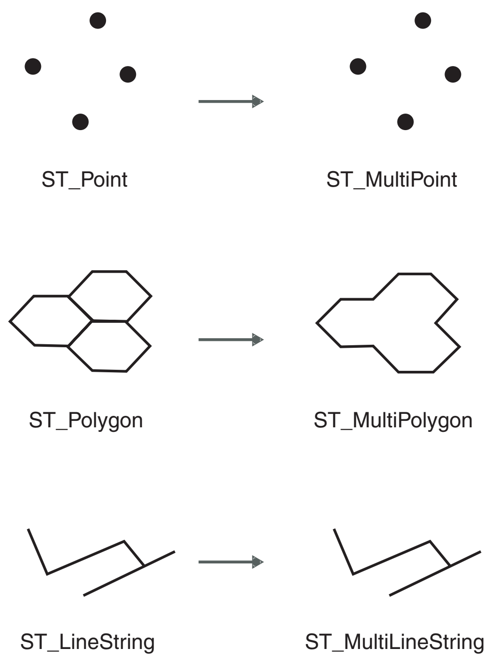


Figure 7-12. Geometries resulting from use of SE_Dissolve()

Return type

ST_Geometry

Example

The following example creates a single multipolygon from the individual hexagons that are inserted into the **honeycomb** table:

```
CREATE TABLE honeycomb (cell_id int, hex_cell ST_Polygon);

INSERT INTO honeycomb
   VALUES (1, '0 polygon((5 10,7 7,10 7,12 10,10 13,7 13,5 10))');
INSERT INTO honeycomb
   VALUES (2, '0 polygon((12 4,15 4,17 7,15 10,12 10,10 7,12 4))');
INSERT INTO honeycomb
   VALUES (3, '0 polygon((17 7,20 7,22 10,20 13,17 13,15 10,17 7))');
INSERT INTO honeycomb
   VALUES (4, '0 polygon((15 10,17 13,15 16,12 16,10 13,12 10,15 10))');


SELECT SE_Dissolve(hex_cell) FROM honeycomb;

se_dissolve  0 MULTIPOLYGON (((5 10, 7 7, 10 7, 12 4, 15 4, 17 7, 20 7, 22
10, 20 13, 17 13, 15 16, 12 16, 10 13, 7 13, 5 10)))
```

Related reference:

"The ST_Union() function" on page 7-140

The ST_Distance() function

The **ST_Distance()** function returns the shortest distance that separates two geometries.

Syntax

```
ST_Distance(g1 ST_Geometry, g2 ST_Geometry)
ST_Distance(g1 ST_Geometry, g2 ST_Geometry, linear_uom varchar(128))
```

The *linear_uom* parameter converts the result to the specified unit of measure. To calculate the distance if the geometries are in a geographic coordinate system where the coordinates are in an angular unit of measure, you must specify a linear unit of measure with the *linear_uom* parameter. Angular units of measure are converted to linear units of measure by great-circle calculations. If the geometries are in a projected coordinate system that has a unit of measure that is different from the unit of measure that is specified by the *linear_uom* parameter, then the returned value is converted to the unit of measure that is specified by the *linear_uom* parameter. The *linear_uom* parameter must be the name of a linear unit of measure from the **unit_name** column of the **st_units_of_measure** table.

Return type

DOUBLE PRECISION

Example: List buildings within a foot of a lot line

The city engineer needs a list of all buildings within one foot of any lot line.

The **building_id** column of the **buildingfootprints** table uniquely identifies each building. The **lot_id** column identifies the lot each building belongs to. The **footprints** multipolygon stores the geometry of each building's footprint:

```
CREATE TABLE buildingfootprints (building_id  integer,
                                 lot_id       integer,
                                 footprint    ST_MultiPolygon);
```

The **lots** table stores the **lot_id** that uniquely identifies each lot and the **lot** ST_MultiPolygon that contains the lot geometry:

```
CREATE TABLE lots (lot_id  integer,
                   lot     ST_MultiPolygon);
```

The following query returns a list of building IDs that are within one foot of their lot lines. The **ST_Distance()** function performs a spatial join on the **footprints** and **lot** ST_MultiPolygon columns. However, the equijoin between **bf.lot_id** and **lots.lot_id** ensures that only the ST_MultiPolygons belonging to the same lot are compared by the **ST_Distance()** function:

```
SELECT bf.building_id
   FROM buildingfootprints bf, lots
   WHERE bf.lot_id = lots.lot_id
   AND ST_Distance(footprint,lot) <= 1.0;
```

Examples: Distance between two points

The following query returns the distance between two points in meters:

```
EXECUTE FUNCTION round(
        ST_Distance(
                '32608 point(576100 15230)'::st_point,
                '32608 point(576102 15230)'::st_point,
                'meter'),
        2);

    (expression)
```

```
2.00000000000000

1 row(s) retrieved.
```

The following query returns the distance between two points in feet:

```
EXECUTE FUNCTION round(
        ST_Distance(
                '32608 point(576100 15230)'::st_point,
                '32608 point(576102 15230)'::st_point,
                'foot'),
        2);

    (expression)

6.56000000000000

1 row(s) retrieved.
```

Examples: Find the distance between two points that have angular units

These examples are based on the angular coordinate system WGS 84, which has SRID 4326. They calculate the distance between the following latitude and longitude values for New York and Los Angeles:

- Latitude and longitude of New York: 73.94000 W, 40.67000 N
- Latitude and longitude of Los Angles: 118.25000 W, 34.05000 N

The following statement returns the distance between New York and Los Angeles in US miles:

```
EXECUTE FUNCTION ST_Distance('4326 point(-73.94000 40.67000)',
               '4326 point(-118.25000 34.05000)', 'mile_us');

  (expression)

2454.991002988

1 row(s) retrieved.
```

The following statement returns the distance between New York and Los Angeles in kilometers:

```
EXECUTE FUNCTION ST_Distance('4326 point(-73.94000 40.67000)',
              '4326 point(-118.25000 34.05000)', 'kilometer');

  (expression)

3950.932942578

1 row(s) retrieved.
```

Related reference:

"The st_units_of_measure table" on page 1-17

The ST_DistanceToPoint() function

The **ST_DistanceToPoint()** function returns the distance from the start of the line to the specified point. Z coordinates and measures are ignored.

Syntax

```
ST_DistanceToPoint (ST_LineString, ST_Point)
ST_DistanceToPoint (ST_MultiLineString, ST_Point)
```

Return type

DOUBLE

Example

The following SQL statement creates the **sample_geometries** table with two columns. The ID column uniquely identifies each row. The **geometry** ST_LineString column stores sample geometries.

```
CREATE TABLE sample_geometries(id INTEGER, geometry ST_LINESTRING);
```

The following SQL statement inserts two rows into the **sample_geometries** table:

```
INSERT INTO sample_geometries(id, geometry)
VALUES
 (1,ST_LineString('LINESTRING ZM(0 0 0 0, 10 100 1000 10000)',1)),
 (2,ST_LineString('LINESTRING ZM(10 100 1000 10000, 0 0 0 0)',1));
```

The following SELECT statement and the corresponding result set show how to use the **ST_DistanceToPoint()** function to find the distance to the point at the location (1.5, 15.0):

```
SELECT ID, DECIMAL(ST_DistanceToPoint(geometry,ST_Point(1.5,15.0,1)),10,5)
AS DISTANCE FROM sample_geometries;

ID          DISTANCE
----------- ------------
          1     15.07481
          2     85.42394

  2 record(s) selected.
```

The ST_EndPoint() function

The **ST_EndPoint()** function returns the last point of a linestring.

Syntax

```
ST_EndPoint(ln1 ST_LineString)
```

Return type

ST_Point

Example

The **endpoint_test** table stores the **gid** INTEGER column, which uniquely identifies each row and the **ln1** ST_LineString column that stores linestrings:

```
CREATE TABLE endpoint_test (gid integer,
                            ln1 ST_LineString);
```

The following INSERT statements insert linestrings into the **endpoint_test** table. The first linestring does not have Z coordinates or measures, while the second one does:

```
INSERT INTO endpoint_test VALUES(
   1,
   ST_LineFromText('linestring (10.02 20.01,23.73 21.92,30.10 40.23)',1000)
);

INSERT INTO endpoint_test VALUES(
   2,
   ST_LineFromText('linestring zm (10.02 20.01 5.0 7.0,23.73 21.92
6.5 7.1,30.10 40.23 6.9 7.2)',1000)
);
```

The following query lists the **gid** column with the output of the **ST_EndPoint()** function. The **ST_EndPoint()** function generates an ST_Point geometry:

```
SELECT gid, ST_EndPoint(ln1) Endpoint
   FROM endpoint_test;


gid       1
endpoint  1000 POINT (30.1 40.23)

gid       2
endpoint  1000 POINT ZM (30.1 40.23 6.9 7.2)
```

See also

"The ST_StartPoint() function" on page 7-130

The ST_Envelope() function

The **ST_Envelope()** function returns the bounding box of a geometry object.

This is usually a rectangle, but the envelope of a point is the point itself, and the envelope of a horizontal or vertical linestring is a linestring represented by the endpoints of the source geometry.

Syntax

```
ST_Envelope(g1 ST_Geometry)
```

Return type

ST_Geometry

Example

The **geotype** column of the **envelope_test** table stores the name of the geometry subclass stored in the **g1 ST_Geometry** column:

```
CREATE TABLE envelope_test (geotype varchar(20),
                            g1      ST_Geometry);
```

The following INSERT statements insert each geometry subclass into the **envelope_test** table:

```
INSERT INTO envelope_test VALUES(
   'Point',
   ST_PointFromText('point (10.02 20.01)',1000)
);

INSERT INTO envelope_test VALUES(
   'Linestring',
   ST_LineFromText('linestring (10.01 20.01, 10.01 30.01, 10.01 40.01)', 1000)
);
```

```
INSERT INTO envelope_test VALUES(
   'Linestring',
   ST_LineFromText('linestring (10.02 20.01,10.32 23.98,11.92 25.64)', 1000)
);

INSERT INTO envelope_test VALUES(
   'Polygon',
   ST_PolyFromText('polygon ((10.02 20.01,11.92 35.64,25.02
34.15,19.15 33.94, 10.02 20.01))',1000)
);

INSERT INTO envelope_test VALUES(
   'Multipoint',
   ST_MPointFromText('multipoint (10.02 20.01,10.32 23.98,11.92 25.64)', 1000)
);

INSERT INTO envelope_test VALUES(
   'Multilinestring',
   ST_MLineFromText('multilinestring ((10.01 20.01,20.01
20.01,30.01 20.01), (30.01 20.01,40.01 20.01,50.01 20.01))',1000)
);

INSERT INTO envelope_test VALUES(
   'Multilinestring',
   ST_MLineFromText('multilinestring ((10.02 20.01,10.32
23.98,11.92 25.64),(9.55 23.75,15.36 30.11))',1000)
);

INSERT INTO envelope_test VALUES(
   'Multipolygon',
   ST_MPolyFromText('multipolygon (((10.02 20.01,11.92 35.64,25.02
34.15,19.15 33.94,10.02 20.01)),((51.71 21.73,73.36 27.04,71.52
32.87,52.43 31.90,51.71 21.73)))',1000)
);
```

The following query lists the subclass name and its envelope. The **ST_Envelope()** function returns a point, a linestring, or a polygon:

```
SELECT geotype, ST_Envelope(g1) Envelope
   FROM envelope_test;


geotype   Point
envelope  1000 POINT (10.02 20.01)

geotype   Linestring
envelope  1000 LINESTRING (10.01 20.01, 10.01 40.01)

geotype   Linestring
envelope  1000 POLYGON ((10.02 20.01, 11.92 20.01, 11.92 25.64, 10.02 25.64, 10.02 20.01))

geotype   Polygon
envelope  1000 POLYGON ((10.02 20.01, 25.02 20.01, 25.02 35.64, 10.02 35.64, 10.02 20.01))

geotype   Multipoint
envelope  1000 POLYGON ((10.02 20.01, 11.92 20.01, 11.92 25.64, 10.02 25.64, 10.02 20.01))

geotype   Multilinestring
envelope  1000 LINESTRING (10.01 20.01, 50.01 20.01)

geotype   Multilinestring
envelope  1000 POLYGON ((9.55 20.01, 15.36 20.01, 15.36 30.11, 9.55 30.11, 9.55 20.01))

geotype   Multipolygon
envelope  1000 POLYGON ((10.02 20.01, 73.36 20.01, 73.36 35.64, 10.02 35.64, 10.02 20.01))
```

See also

"The SE_BoundingBox() function" on page 7-21

The ST_EnvelopeAsGML() function

The **ST_EnvelopeAsGML()** function takes a geometry value returned by ST_Envelope and generates a GML3 Envelope element.

Syntax

```
ST_EnvelopeAsGML(p ST_Geometry)
```

Return type

ST_Geometry

Example

```
ST_EnvelopeFromGML(ST_Envelope(ST_LineFromText('LINESTRING(1 2, 3 4)', 1003)))
```

Output:

```
<gml:Envelope srsName="EPSG:1234">
    <gml:lowerCorner> 1 2</gml:lowerCorner>
    <gml:upperCorner> 3 4 </gml:upperCorner>
</gml:Envelope>
```

The SE_EnvelopeAsKML() function

The **SE_EnvelopeAsKML()** function takes a geometry value returned by ST_Envelope and returns it as a KML LatLonBox.

Syntax

```
SE_EnvelopeAsKML(p ST_Geometry)
```

Return type

ST_Geometry

Example

```
EXECUTE FUNCTION SE_EnvelopeAsKML(ST_PolyFromText('POLYGON
                  ((-124.21160602 25.8373769872,
                  -67.1589579416 25.8373769872,
                  -67.1589579416 49.384359066,
                  -124.21160602 49.384359066,
                  -124.21160602 25.8373769872))',3));
```

Output:

```
<LatLonBox>
           <north>49.384359066</north>
           <south>25.8373769872</south>
           <east>-67.1589579416</east>
           <west>-124.21160602</west>
</LatLonBox>
```

The ST_EnvelopeFromGML() function

The **ST_EnvelopeFromGML()** function takes a GML2 or GML3 string representation of an envelope and an optional spatial reference ID and returns a geometry object.

If the **srsName** attribute is specified in the GML string, then a corresponding entry in the **spatial_references** table must exist unless it is specified as UNKNOWN or DEFAULT.

Syntax

```
ST_EnvelopeFromGML(gml_string lvarchar)
ST_EnvelopeFromGML(gml_string lvarchar, SRID integer)
```

Return type

A four sided ST_Polygon representing the envelope.

Example

```
ST_EnvelopeFromGML('<gml:Envelope>
    <gml:lowerCorner> -180.0 -90.0</gml:lowerCorner>
    <gml:upperCorner> 180.0 90.0 </gml:upperCorner>
</gml:Envelope>', 1003)
```

The SE_EnvelopeFromKML() function

The **SE_EnvelopeFromKML()** function takes a KML LatLonBox or LatLonAltBox and an optional spatial reference ID and returns a polygon.

The LatLonBox and LatLonAltBox contain four coordinates: north, south, east, and west, that are used to form the traditional pair of SW, NE coordinates usually found with bounding boxes. LatLonAltBox also contains the elements minAltitude and maxAltitude, and while those will be accepted as valid tags in the KML fragment, they are not used to form a Z-polygon. Only 2-D polygons are returned.

Syntax

```
SE_EnvelopeFromKML(kml_string lvarchar)
SE_EnvelopeFromKML(kml_string lvarchar, SRID integer)
```

Return type

A four sided ST_Polygon representing the envelope.

Example

In this example, the KML LatLonBox includes four coordinates:

```
EXECUTE FUNCTION SE_EnvelopeFromKML('<LatLonBox><north>34.54356</north>
                                    <south>33.543634</south>
                                    <east>-83.21454</east>
                                    <west>-86.432536</west>',4);
```

Output:

```
4 POLYGON ((-86.3253600195 33.5436340112, -83.2145400212 33.543630112,
            -83.2145400212 34.5435600828, -86.3253600195 34.5435600828,
            -86.3253600195 33.5436340112))
```

In this example, the KML LatLonAltBox includes the four coordinates as well as the minAltitude, maxAltitude, and altitudeMode attributes:

```
EXECUTE FUNCTION SE_EnvelopeFromKML('<LatLonAltBox><north>45.0</north>
                 <south>42.0</south><east>-80.0</east><west>-82.0</west>
                 <minAltitude>0</minAltitude><maxAltitude>0</maxAltitude>
                 <altitudeMode>clampToGround</altitudeMode>',4);
```

However, the output only includes the four coordinates:

```
4 POLYGON((-82.0 42.0, -80.0 42.0, -80.0 45.0, -82.0 45.0, -82.0 42.0))
```

The SE_EnvelopesIntersect() function

The **SE_EnvelopesIntersect()** function returns t (TRUE) if the envelopes of two geometries intersect; otherwise, it returns f (FALSE).

Syntax

```
SE_EnvelopesIntersect(g1 ST_Geometry, g2 ST_Geometry)
```

Return type

BOOLEAN

Example

The **get_window()** function retrieves the display window coordinates from the application. The window parameter is actually a polygon shape structure containing a string of coordinates that represents the display polygon. The **SE_PolygonFromShape()** function converts the display window shape into a polygon that the **SE_EnvelopesIntersect()** function uses as its intersection envelope. All **sensitive_areas zone** polygons that intersect the interior or boundary of the display window are returned. Each polygon is fetched from the result set and passed to the **draw_polygon()** function:

```
/* Get the display window coordinates as a polygon shape. */
    get_window(&query_shape_buf, &query_shape_len);

    /* Create the SQL expression. The envelopesintersect function limits
     * the result set to only those zone polygons that intersect the
     * envelope of the display window. */
    sprintf(sql_stmt,
            "select SE_AsShape(zone) ",
            "from sensitive_areas where ",
            "SE_EnvelopesIntersect(zone,SE_PolyFromShape(?,1))");

    /* Prepare the SQL statement. */
    SQLPrepare(hstmt, (UCHAR *)sql_stmt, SQL_NTS);

    /* Bind the query geometry parameter. */
    pcbvalue1 = query_shape_len;
    SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_BINARY,
                      SQL_INFX_UDT_LVARCHAR, query_shape_len, 0,
                      query_shape_buf, query_shape_len, &pcbvalue1);

    /* Execute the query. */
    rc = SQLExecute(hstmt);

    /* Assign the results of the query (the Zone polygons) to the
       fetched_shape_buf variable. */
    SQLBindCol (hstmt, 1, SQL_C_BINARY, fetched_shape_buf, 100000,
                &fetched_shape_len);
```

```
/* Fetch each polygon within the display window and display it. */
while (SQL_SUCCESS == (rc = SQLFetch(hstmt)))
    draw_polygon(fetched_shape_buf);
```

The ST_Equals() function

The **ST_Equals()** function compares two geometries and returns t (TRUE) if the geometries are spatially equal; otherwise, it returns f (FALSE).

Syntax

```
ST_Equals(g1 ST_Geometry, g2 ST_Geometry)
```

Return type

BOOLEAN

Usage

The following figure shows sets of various geometric objects that are spatially equivalent.

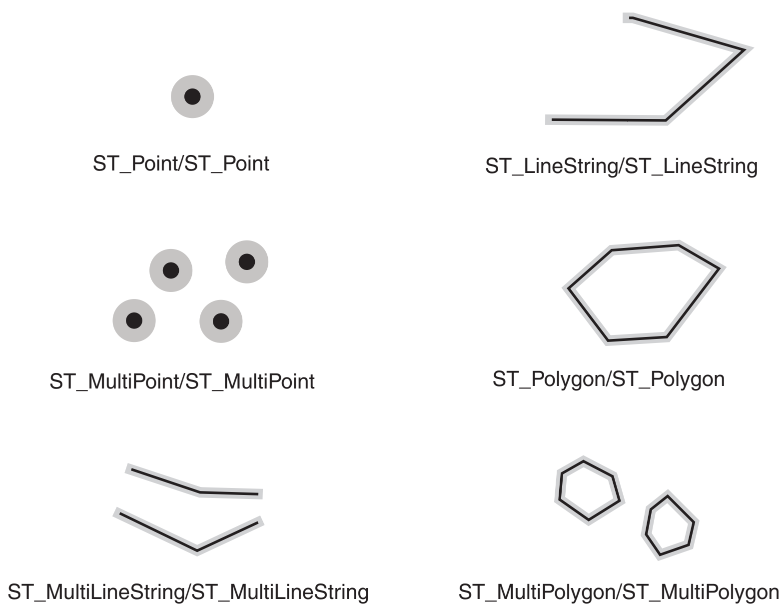


Figure 7-13. Equal geometries

Using the **ST_Equals()** function is functionally equivalent to using **ST_IsEmpty**(**ST_SymDifference**(*a*,*b*)).

Since the **ST_Equals()** function is computationally intensive, consider whether you can use the **Equals()** function instead, which does a byte-by-byte comparison of two objects. The **Equals()** function is a system function. It is called in SQL statements when you use the = operator, as shown in the second SELECT statement in the following example.

To illustrate the difference between **ST_Equals()** and **Equals()**, consider the following example:

```
CREATE TABLE equal_test (id   integer,
                         line ST_LineString);

INSERT INTO equal_test VALUES
   (1, ST_LineFromText('linestring(10 10, 20 20)', 1000));

INSERT INTO equal_test VALUES
   (2, ST_LineFromText('linestring(20 20, 10 10)', 1000));
```

The following query returns both rows because **ST_Equals()** determines that both linestrings are spatially equivalent:

```
SELECT id FROM equal_test
   WHERE ST_Equals (line, ST_LineFromText('linestring(10 10, 20 20)', 1000));

         id

          1
          2
```

The following query returns only the first row because **Equals()** performs only a memory comparison of the linestrings:

```
SELECT id FROM equal_test
   WHERE line = ST_LineFromText('linestring(10 10, 20 20)', 1000);

         id

          1
```

The results of the spatial relationship of the **ST_Equals()** function can be understood or verified by comparing the results with a pattern matrix that represents the acceptable values for the DE-9IM. The DE-9IM pattern matrix for the **ST_Equals()** function ensures that the interiors intersect and that no interior or boundary of either geometry intersects the exterior of the other.

Table 7-12. The DE-9IM pattern matrix for the ST_Equals() function.

			b	
		Interior	**Boundary**	**Exterior**
	Interior	T	*	F
a	Boundary	*	*	F
	Exterior	F	F	*

Example

The city GIS technician suspects that some of the data in the **buildingfootprints** table was somehow duplicated. To alleviate concern, the technician queries the table to determine whether any of the footprints multipolygons are equal.

The **buildingfootprints** table is created with the following statement. The **building_id** column uniquely identifies the buildings. The **lot_id** identifies the building's lot, and the **footprint** multipolygon stores the building's geometry:

```
CREATE TABLE buildingfootprints (building_id  integer,
                                 lot_id       integer,
                                 footprint    ST_MultiPolygon);
```

The **buildingfootprints** table is spatially joined to itself by the **ST_Equals()** function, which returns 1 whenever it finds two multipolygons that are equal. The **bf1.building_id <> bf2.building_id** condition eliminates the comparison of a geometry to itself:

```
SELECT bf1.building_id, bf2.building_id
   FROM buildingfootprints bf1, buildingfootprints bf2
   WHERE ST_Equals(bf1.footprint,bf2.footprint)
   AND bf1.building_id <> bf2.building_id;
```

Related reference:

"The Dimensionally Extended 9 Intersection Model" on page 7-2

The ST_ExteriorRing() function

The **ST_ExteriorRing()** function returns the exterior ring of a polygon as a linestring.

Syntax

```
ST_ExteriorRing(pl1 ST_Polygon)
```

Return type

ST_LineString

Example

An ornithologist studying the bird population on several South Sea islands knows that the feeding zone of the bird species of interest is restricted to the shoreline. As part of the calculation of the island's carrying capacity, the ornithologist requires the islands' perimeters. Some of the islands are so large, they have several ponds on them. However, the shorelines of the ponds are inhabited exclusively by another more aggressive bird species. Therefore, the ornithologist requires the perimeter of the exterior ring only of the islands.

The **ID** and **name** columns of the **islands** table identifies each island, while the **land** polygon column stores the island's geometry:

```
CREATE TABLE islands (id    integer,
                      name  varchar(32),
                      land  ST_Polygon);
```

The **ST_ExteriorRing()** function extracts the exterior ring of each island polygon as a linestring. The length of the linestring is calculated by the **ST_Length()** function. The linestring lengths are summarized by the SUM operator:

```
SELECT SUM(ST_Length(ST_ExteriorRing(land)))
  FROM islands;
```

As shown in the following figure, the exterior rings of the islands represent the ecological interface each island shares with the sea. Some of the islands have lakes, which are represented by the interior rings of the polygons.

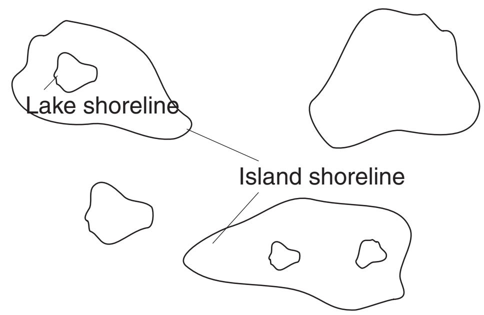


Figure 7-14. Islands and lakes

The SE_Generalize() function

The **SE_Generalize()** function reduces the number of vertices in an ST_LineString, ST_MultiLineString, ST_Polygon, or ST_MultiPolygon while preserving the general character of the geometric shape.

Syntax

```
SE_Generalize (g1 ST_Geometry, threshold float)
```

The value of the *threshold* argument must be small enough compared to the size of the object that the function can return a generalized shape.

Usage

This function uses the Douglas-Peucker line-simplification algorithm. The vertex sequence of the input geometry is recursively subdivided until a run of vertices can be replaced by a straight-line segment. No vertex in that iteration can deviate from the straight line by more than the threshold.

Z values, if present, are not considered when a set of vertices are simplified.

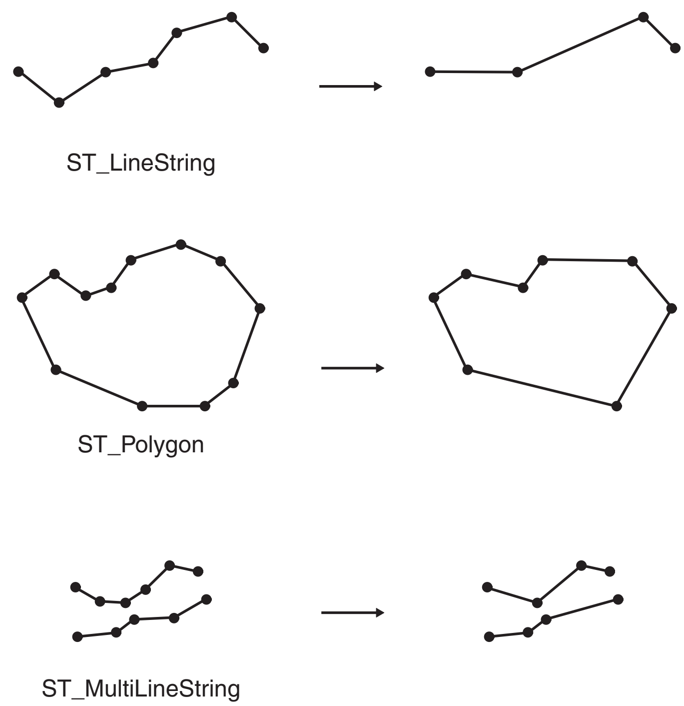


Figure 7-15. Geometries resulting from use of SE_Generalize()

Return type

ST_Geometry, unless the input geometry is an ST_Point, ST_MultiPoint, or an empty geometry of any subtype, in which case this function returns NULL.

If the function returns error USE21, the value of the *threshold* argument is too large.

Example

The following statements create a table and a linestring that has multiple vertices:

```
CREATE TABLE jagged_lines(line ST_LineString);

INSERT INTO jagged_lines VALUES(
   "0 linestring(10 10, 20 20, 20 18, 30 30, 30 28, 40 40)"
);
```

The following example includes a small threshold value and results in no vertices being removed:

```
SELECT SE_Generalize(line, 0.5) FROM jagged_lines;

(expression)  0 LINESTRING (10 10, 20 20, 20 18, 30 30, 30 28, 40 40)
```

The following example includes a larger threshold value and results in some vertices being removed:

```
SELECT SE_Generalize(line, 2) FROM jagged_lines;

(expression)  0 LINESTRING (10 10, 40 40)
```

The ST_GeometryN() function

The **ST_GeometryN()** function takes a takes an ST_GeomCollection (ST_MultiPoint, ST_MultiLineString, or ST_MultiPolygon) and an INTEGER index and returns the *n*th **ST_Geometry** object in the collection.

Syntax

```
ST_GeometryN(mpt1 ST_MultiPoint, index integer)
ST_GeometryN(mln1 ST_MultiLineString, index integer)
ST_GeometryN(mpl1 ST_MultiPolygon, index integer)
```

Return type

ST_Geometry

Example

The city engineer wants to know which building footprints are all inside the first polygon of the **lots** ST_MultiPolygon.

The **building_id** column uniquely identifies each row of the **buildingfootprints** table. The **lot_id** column identifies the building's lot. The **footprint** column stores the building geometries:

```
CREATE TABLE buildingfootprints (building_id  integer,
                                 lot_id       integer,
                                 footprint    ST_MultiPolygon);

CREATE TABLE lots (lot_id  integer,
                   lot     ST_MultiPolygon);
```

The query lists the **buildingfootprints** table values of **building_id** and **lot_id** for all building footprints that are all within the first lot polygon. The **ST_GeometryN()** function returns a first lot polygon element in the ST_MultiPolygon:

```
SELECT bf.building_id,bf.lot_id
   FROM buildingfootprints bf,lots
   WHERE ST_Within(footprint,ST_GeometryN(lot,1))
   AND bf.lot_id = lots.lot_id;
```

The ST_GeometryType() function

The **ST_GeometryType()** function takes an ST_Geometry object and returns its geometry type as a string.

Syntax

```
ST_GeometryType (g1 ST_Geometry)
```

Return type

VARCHAR(32) containing one of the following text strings:
- st_point
- st_linestring
- st_polygon
- st_multipoint
- st_multilinestring

- st_multipolygon

Example

The **geometrytype_test** table contains the **g1** ST_Geometry column:

```
CREATE TABLE geometrytype_test(g1 ST_Geometry);
```

The following INSERT statements insert each geometry subclass into the **g1** column:

```
INSERT INTO geometrytype_test VALUES(
   ST_GeomFromText('point (10.02 20.01)',1000)
);

INSERT INTO geometryType_test VALUES(
   ST_GeomFromText('linestring (10.01 20.01, 10.01 30.01, 10.01 40.01)', 1000)
);

INSERT INTO geometrytype_test VALUES(
   ST_GeomFromText('polygon ((10.02 20.01,11.92 35.64,25.02
34.15,19.15 33.94, 10.02 20.01))',1000)
);

INSERT INTO geometrytype_test VALUES(
   ST_GeomFromText('multipoint (10.02 20.01,10.32 23.98,11.92 25.64)', 1000)
);

INSERT INTO geometrytype_test VALUES(
   ST_GeomFromText('multilinestring ((10.02 20.01,10.32
23.98,11.92 25.64),(9.55 23.75,15.36 30.11))',1000)
);

INSERT INTO geometrytype_test VALUES(
   ST_GeomFromText('multipolygon (((10.02 20.01,11.92 35.64,25.02
34.15,19.15 33.94 ,10.02 20.01)),((51.71 21.73,73.36 27.04,71.52
32.87,52.43 31.90,51.71 21.73)))'
,1000)
);
```

The following query lists the geometry type of each subclass stored in the **g1** geometry column:

```
SELECT ST_GeometryType(g1) Geometry_type
   FROM geometrytype_test;


geometry_type  st_point

geometry_type  st_linestring

geometry_type  st_polygon

geometry_type  st_multipoint

geometry_type  st_multilinestring

geometry_type  st_multipolygon
```

The ST_GeomFromGML() function

The **ST_GeomFromGML()** function takes a GML2 or GML version 3 string representation and an optional spatial reference ID and returns a geometry object.

If the **srsName** attribute is specified in the GML string, a corresponding entry must exist in the **spatial_references** table, or it must be specified as UNKNOWN or DEFAULT. The GML representation can include Z and M measures, but must include the appropriate **srsDimension** attribute. The following table describes the corresponding geometry values for each **srsDimension** value.

Table 7-13. Geometry values for srsDimension values

srsDimension value	Geometry value
2	A geometry value with only X and Y coordinate values.
3	A geometry value with X, Y, and Z coordinate values in GML version 3 or using the <coordinates> tag in GML 2. A geometry value with X, Y and measure values if the <X>, <Y>, and <M> tags are used in the <coord> elements of the GML representation.
4	A geometry value with X, Y, Z, and measure coordinate values.

Syntax

```
ST_GeomFromGML(gml_string lvarchar)
ST_GeomFromGML(gml_string lvarchar, SRID integer)
```

For `SRID`, specify `2` if the GML conforms to GML version 2, or specify `3` for GML3. The default is `3`.

Return type

ST_Geometry

Example

The **geometry_test** table contains the INTEGER **gid** column, which uniquely identifies each row, and the **g1** column, which stores the geometry:

```
CREATE TABLE geometry_test (gid smallint, g1 ST_Geometry);
```

The following INSERT statements insert the data into the **gid** and **g1** columns of the **geometry_test** table. The **ST_GeomFromGML()** function converts the GML text representation of each geometry into its corresponding instantiable subclass:

```
INSERT INTO geometry_test VALUES (
1,
ST_GeomFromGML('<gml:Point srsName="DEFAULT" srsDimension="2">
  <gml:pos>10.02 20.01</gml:pos></gml:Point>',1000)) ;

INSERT INTO geometry_test VALUES (
2,
ST_GeomFromGML('<gml:LineString srsName="DEFAULT" srsDimension="2">
  <gml:posList dimension="2">10.01 20.01 10.01 30.01 10.01 40.01
  </gml:posList>
  </gml:LineString>',1000)) ;

INSERT INTO geometry_test VALUES (
3,
ST_GeomFromGML('<gml:Polygon srsName="DEFAULT" srsDimension="2">
  <gml:exterior>
  <gml:LinearRing>
  <gml:posList dimension="2">
    10.02 20.01 19.15 33.94 25.02 34.15 11.92 35.64 10.02 20.01
  </gml:posList>
  </gml:LinearRing>
```

```
  </gml:exterior>
  </gml:Polygon>',1000)) ;

INSERT INTO geometry_test VALUES (
4,
ST_GeomFromGML('<gml:MultiPoint srsName="DEFAULT" srsDimension="2">
  <gml:PointMember>
  <gml:Point srsName="DEFAULT" srsDimension="2">
  <gml:pos>10.02 20.01</gml:pos>
  </gml:Point>
  </gml:PointMember><gml:PointMember>
  <gml:Point srsName="DEFAULT" srsDimension="2">
  <gml:pos>10.32 23.98</gml:pos>
  </gml:Point>
  </gml:PointMember>
  <gml:PointMember>
  <gml:Point srsName="DEFAULT" srsDimension="2">
  <gml:pos>11.92 25.64</gml:pos>
  </gml:Point>
  </gml:PointMember>
  </gml:MultiPoint>',1000)) ;

INSERT INTO geometry_test VALUES (
5,
ST_GeomFromGML('<gml:MultiLineString srsName="DEFAULT" srsDimension="2">
  <gml:LineStringMember>
  <gml:LineString srsName="DEFAULT" srsDimension="2">
  <gml:posList dimension="2">10.02 20.01 10.32 23.98 11.92 25.64
  </gml:posList>
  </gml:LineString>
  </gml:LineStringMember>
  <gml:LineStringMember>
  <gml:LineString srsName="DEFAULT" srsDimension="2">
  <gml:posList dimension="2">9.55 23.75 15.36 30.11</gml:posList>
  </gml:LineString>
  </gml:LineStringMember>
  </gml:MultiLineString>',1000)) ;

INSERT INTO geometry_test VALUES(
6,
ST_GeomFromGML('<gml:MultiPolygon srsName="DEFAULT" srsDimension="2">
  <gml:PolygonMember><gml:Polygon srsName="DEFAULT" srsDimension="2">
  <gml:exterior>
  <gml:LinearRing>
  <gml:posList dimension="2">
    10.02 20.01 19.15 33.94 25.02 34.15 11.92 35.64 10.02 20.01
  </gml:posList>
  </gml:LinearRing>
  </gml:exterior>
  </gml:Polygon>
  </gml:PolygonMember>
  <gml:PolygonMember>
  <gml:Polygon srsName="DEFAULT" srsDimension="2">
  <gml:exterior><gml:LinearRing>
  <gml:posList dimension="2">
    51.71 21.73 73.36 27.04 71.52 32.87 52.43 31.9 51.71 21.73
  </gml:posList>
  </gml:LinearRing>
  </gml:exterior>
  </gml:Polygon>
  </gml:PolygonMember>
  </gml:MultiPolygon>',1000)) ;
```

The ST_GeomFromKML() function

The **ST_GeomFromKML()** function takes a KML fragment and returns an ST_Geometry corresponding to the fragment.

Syntax

```
ST_GeomFromKML(kml_string lvarchar)
```

Return type

Depends on the KML fragment type, as shown in the following table.

Table 7-14. KML fragment to return type mapping

KML fragment	Return type
Point	ST_Point
LineString	ST_LineString
Polygon	ST_Polygon
MultiGeometry plus Point	ST_MultiPoint
MultiGeometry plus LineString	ST_MultiLineString
MultiGeometry plus Polygon	ST_MultiPolygon

Example

The **geometry_test** table contains the INTEGER **gid** column, which uniquely identifies each row, and the **geom** column, which stores the geometry:

```
CREATE TABLE geometry_test (gid INTEGER, geom ST_Geometry);
```

The following INSERT statements insert the data into the **gid** and **geom** columns of the **geometry_test** table. The **ST_GeomFromKML()** function converts the KML text representation of each geometry into its corresponding instantiable subclass:

```
INSERT INTO geometry_test VALUES(1,ST_GeomFromKML('<Point><coordinates>
                                 10.02,20.01</coordinates></Point>',4))

INSERT INTO geometry_test VALUES(2,ST_GeomFromKML('<LineString><coordinates>
                                 10.01,20.01 20.01,30.01 30.01,40.01
                                 </coordinates></LineString>',4));
```

The SE_GeomFromShape() function

The **SE_GeomFromShape()** function takes a shape and a spatial reference ID and returns a geometry object.

Syntax

```
SE_GeomFromShape(s1 lvarchar, SRID integer)
```

Return type

ST_Geometry

Example

The following C code fragment contains ODBC functions included with the spatial data type functions that insert data into the **lots** table.

The **lots** table was created with two columns: the **lot_id**, which uniquely identifies each lot, and the **lot** polygon column, which contains the geometry of each lot:

```
CREATE TABLE lots (lot_id  integer,
                   lot     ST_MultiPolygon);
```

The **SE_GeomFromShape()** function converts shapes into an IBM Informix spatial geometry. The entire INSERT statement is copied into **shp_sql**. The INSERT statement contains parameter markers to accept the **lot_id** and **lot** data, dynamically:

```
/* Create the SQL insert statement to populate the lots
     * table. The question marks are parameter markers that indicate
     * the column values that will be inserted at run time. */
    sprintf(sql_stmt,
            "INSERT INTO lots (lot_id, lot) "
            "VALUES(?, SE_GeomFromShape(?, %d))", srid);

    /* Prepare the SQL statement for execution. */
    rc = SQLPrepare (hstmt, (unsigned char *)sql_stmt, SQL_NTS);

    /* Bind the lot_id to the first parameter. */
    pcbvalue1 = 0;
    rc = SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_SLONG,
                           SQL_INTEGER, 0, 0,
                           &lot_id, 0, &pcbvalue1);

    /* Bind the lot geometry to the second parameter. */
    pcbvalue2 = lot_shape_len;
    rc = SQLBindParameter (hstmt, 2, SQL_PARAM_INPUT, SQL_C_BINARY,
                           SQL_INFX_UDT_LVARCHAR, lot_shape_len, 0,
                           lot_shape_buf, lot_shape_len, &pcbvalue2);

    /* Execute the insert statement. */
    rc = SQLExecute (hstmt);
```

The ST_GeomFromText() function

The **ST_GeomFromText()** function takes a well-known text representation and a spatial reference ID and returns a geometry object.

Syntax

```
ST_GeomFromText(wkt lvarchar, SRID integer)
```

Return type

ST_Geometry

Example

The **geometry_test** table contains the INTEGER **gid** column, which uniquely identifies each row, and the **g1** column, which stores the geometry:

```
CREATE TABLE geometry_test (gid smallint,
                            g1  ST_Geometry);
```

The following INSERT statements insert the data into the **gid** and **g1** columns of the **geometry_test** table. The **ST_GeomFromText()** function converts the text representation of each geometry into its corresponding instantiable subclass:

```
INSERT INTO geometry_test VALUES(
   1,
   ST_GeomFromText('point (10.02 20.01)',1000)
);
```

```
INSERT INTO geometry_test VALUES(
   2,
   ST_GeomFromText('linestring (10.01 20.01, 10.01 30.01, 10.01 40.01)',1000)
);

INSERT INTO geometry_test VALUES(
   3,
   ST_GeomFromText('polygon ((10.02 20.01, 11.92 35.64, 25.02
34.15, 19.15 33.94, 10.02 20.01))',1000)
);

INSERT INTO geometry_test VALUES(
   4,
   ST_GeomFromText('multipoint (10.02 20.01,10.32 23.98,11.92 25.64)',1000)
);

INSERT INTO geometry_test VALUES(
   5,
   ST_GeomFromText('multilinestring ((10.02 20.01, 10.32 23.98,
11.92 25.64),(9.55 23.75,15.36 30.11))',1000)
);

INSERT INTO geometry_test VALUES(
   6,
   ST_GeomFromText('multipolygon (((10.02 20.01, 11.92 35.64,
25.02 34.15, 19.15 33.94, 10.02 20.01)),((51.71 21.73, 73.36
27.04, 71.52 32.87, 52.43 31.90, 51.71 21.73)))',1000)
);
```

The ST_GeomFromWKB() function

The **ST_GeomFromWKB()** function takes a well-known binary representation and a spatial reference ID to return a geometry object.

The **ST_GeomFromWKB()** function does not support the ST_GeomCollection.

Syntax

```
ST_GeomFromWKB(WKB lvarchar, SRID integer)
```

Return type

ST_Geometry

Example

The following C code fragment contains ODBC functions included with the IBM Informix spatial data type functions that insert data into the **lots** table.

The lots table was created with two columns: the **lot_id**, which uniquely identifies each lot, and the **lot** polygon column, which contains the geometry of each lot:

```
CREATE TABLE lots (lot_id  integer,
                   lot     ST_MultiPolygon);
```

The **ST_GeomFromWKB()** function converts WKB representations into Informix spatial geometry. The entire INSERT statement is copied into a **wkb_sql** CHAR string. The INSERT statement contains parameter markers to accept the **lot_id** and **lot** data, dynamically:

```
/* Create the SQL insert statement to populate the lots
     * table. The question marks are parameter markers that indicate
     * the column values that will be inserted at run time. */
```

```
sprintf(sql_stmt,
        "INSERT INTO lots (lot_id, lot) "
        "VALUES(?, ST_GeomFromWKB(?, %d))", srid);

/* Prepare the SQL statement for execution. */
rc = SQLPrepare (hstmt, (unsigned char *)sql_stmt, SQL_NTS);

/* Bind the lot_id to the first parameter. */
pcbvalue1 = 0;
rc = SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_SLONG,
                       SQL_INTEGER, 0, 0,
                       &lot_id, 0, &pcbvalue1);

/* Bind the lot geometry to the second parameter. */
pcbvalue2 = lot_wkb_len;
rc = SQLBindParameter (hstmt, 2, SQL_PARAM_INPUT, SQL_C_BINARY,
                       SQL_INFX_UDT_LVARCHAR, lot_wkb_len, 0,
                       lot_wkb_buf, lot_wkb_len, &pcbvalue2);

/* Execute the insert statement. */
rc = SQLExecute (hstmt);
```

The SE_InRowSize() function

The **SE_InRowSize()** function returns the size of the in-row portion of a geometry. Geometries which are less than 930 bytes are stored entirely in-row: that is, the entire value is stored in a table's dbspace.

The **SE_InRowSize()** function returns the size of the in-row portion of a geometry. Geometries which are less than 930 bytes are stored entirely in-row: that is, the entire value is stored in a table's dbspace.

You can use this function to obtain an estimate of the amount of disk space consumed by one or more geometries. However, this function does not account for dbspace and sbspace overhead, so cannot be used to obtain an exact total.

Syntax

```
SE_InRowSize(ST_Geometry)
```

Return type

INTEGER

See also

"The SE_OutOfRowSize() function" on page 7-109

"The SE_TotalSize() function" on page 7-133

The ST_InteriorRingN() function

The **ST_InteriorRingN()** function returns the *n*th interior ring of a polygon as an ST_LineString.

The order of the rings cannot be predefined since the rings are organized according to the rules defined by the internal geometry verification routines and not by geometric orientation.

Syntax

```
ST_InteriorRingN(pl1 ST_Polygon, index integer)
```

Return type

ST_LineString

Example

An ornithologist studying the bird population on several South Sea islands knows that the feeding zone of this passive species is restricted to the seashore. Some of the islands are so large they have several lakes on them. The shorelines of the lakes are inhabited exclusively by another more aggressive species. The ornithologist knows that if the perimeter of the ponds on each island exceeds a certain threshold, the aggressive species will become so numerous that it will threaten the passive seashore species. Therefore, the ornithologist requires the aggregated perimeter of the interior rings of the islands.

The following figure shows the exterior rings of the islands that represent the ecological interface each island shares with the sea. Some of the islands have lakes, which are represented by the interior rings of the polygons.

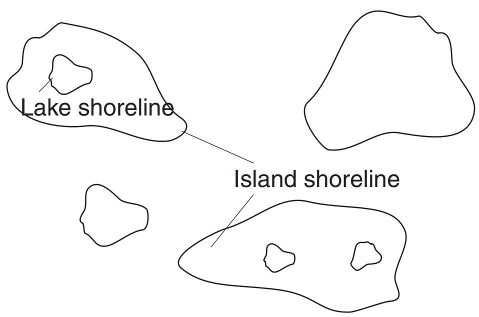


Figure 7-16. Islands and lakes.

The **ID** and **name** columns of the **islands** table identifies each island, while the **land** ST_Polygon column stores the island geometry:

```
CREATE TABLE islands (id    integer,
                      name  varchar(32),
                      land  ST_Polygon);
```

This ODBC code fragment uses the **ST_InteriorRingN()** function to extract the interior ring (lake) from each island polygon as a linestring. The perimeter of the linestring returned by the **ST_Length()** function is totaled and displayed along with the island ID:

```
/* Prepare and execute the query to get the island IDs and number
       of lakes (interior rings); */
    sprintf(sql_stmt,
            "SELECT id, ST_NumInteriorRing(land) FROM islands");

    /* Allocate memory for the island cursor */
    rc = SQLAllocHandle (SQL_HANDLE_STMT, hdbc, &island_cursor);

    rc = SQLExecDirect (island_cursor, (UCHAR *)sql_stmt, SQL_NTS);

    /* Bind the island table's id column to island_id. */
    rc = SQLBindCol (island_cursor, 1, SQL_C_SLONG,
                     &island_id, 0, &id_ind);
```

```
/* Bind the result of ST_NumInteriorRing(land) to num_lakes. */
rc = SQLBindCol (island_cursor, 2, SQL_C_SLONG,
                 &num_lakes, 0, &lake_ind);

/* Allocate memory to the SQL statement handle lake_cursor. */
rc = SQLAllocHandle (SQL_HANDLE_STMT, hdbc, &lake_cursor);

/* Prepare the query to get the length of an interior ring. For
 * efficiency, we only prepare this query once. */
sprintf (sql_stmt,
         "SELECT ST_Length(ST_InteriorRingN(land, ?))"
         "FROM islands WHERE id = ?");
rc = SQLPrepare (lake_cursor, (UCHAR *)sql_stmt, SQL_NTS);

/* Bind the lake_number to the first parameter. */
pcbvalue1 = 0;
rc = SQLBindParameter (lake_cursor, 1, SQL_PARAM_INPUT, SQL_C_LONG,
                       SQL_INTEGER, 0, 0,
                       &lake_number, 0, &pcbvalue1);

/* Bind the island_id to the second parameter. */
pcbvalue2 = 0;
rc = SQLBindParameter (lake_cursor, 2, SQL_PARAM_INPUT, SQL_C_LONG,
                       SQL_INTEGER, 0, 0,
                       &island_id, 0, &pcbvalue2);

/* Bind the result of the ST_Length function to lake_perimeter. */
rc = SQLBindCol (lake_cursor, 1, SQL_C_SLONG,
                 &lake_perimeter, 0, &length_ind);

/* Outer loop:
 * get the island ids and the number of lakes (interior rings).*/
while (1)
{
    /* Fetch an island.*/
    rc = SQLFetch (island_cursor);
    if (rc == SQL_NO_DATA)
        break;
    else
        returncode_check(NULL, hstmt, rc, "SQLFetch");

    /* Inner loop: for this island,
     * get the perimeter of all its lakes (interior rings). */
    for (total_perimeter = 0,lake_number = 1;
         lake_number <= num_lakes;
         lake_number++)
    {
        rc = SQLExecute (lake_cursor);
        rc = SQLFetch (lake_cursor);
        total_perimeter += lake_perimeter;
        SQLFreeStmt (lake_cursor, SQL_CLOSE);
    }

    /* Display the island ID and the total perimeter of its lakes.*/
    printf ("Island ID = %d, Total lake perimeter = %d\n",
            island_id,total_perimeter);
}

SQLFreeStmt (lake_cursor, SQL_DROP);
SQLFreeStmt (island_cursor, SQL_DROP);
```

The ST_Intersection() function

The **ST_Intersection()** function takes two ST_Geometry objects and returns the intersection set as an ST_Geometry object. If the two objects do not intersect, the return value is an empty geometry.

Syntax

```
ST_Intersection(g1 ST_Geometry, g2 ST_Geometry)
```

Usage

If an ST_LineString intersects an ST_Polygon, the **ST_Intersection()** function returns the portion of the ST_LineString common to the interior and boundary of the ST_Polygon as an ST_MultiLineString. The ST_MultiLineString contains more than one ST_LineString if the source ST_LineString intersects the ST_Polygon with two or more discontinuous segments.

The following figure illustrates examples of the **ST_Intersection()** function.

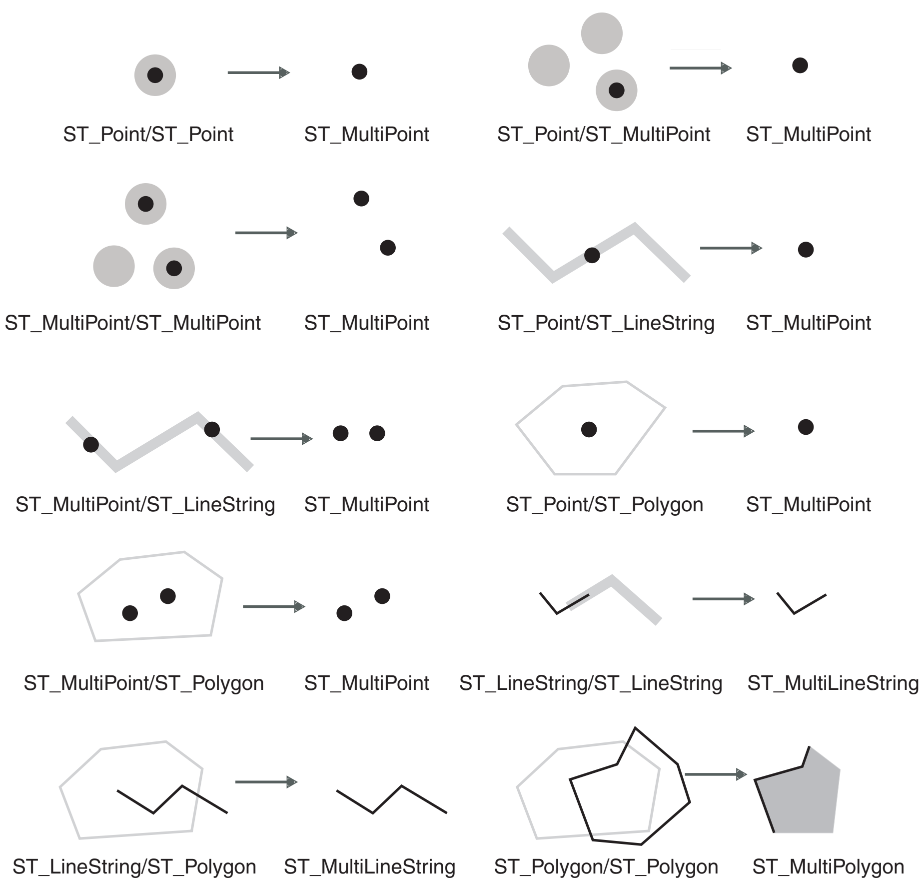


Figure 7-17. Intersection sets of geometries

Return type

ST_Geometry

Example

The fire marshal must obtain the areas of the hospitals, schools, and nursing homes that are intersected by the radius of a possible hazardous waste contamination.

The sensitive areas are stored in the **sensitive_areas** table that is created with the CREATE TABLE statement that follows. The **zone** column, which is defined as an ST_Polygon type, stores the outline of each of the sensitive areas:

```
CREATE TABLE sensitive_areas (id     integer,
                              name   varchar(128),
                              size   float,
                              type   varchar(10),
                              zone   ST_Polygon);
```

The hazardous sites are stored in the **hazardous_sites** table that is created with the CREATE TABLE statement that follows. The **location** column, which is defined as an ST_Point type, stores a location that is the geographic center of each hazardous site:

```
CREATE TABLE hazardous_sites (site_id   integer,
                              name      varchar(40),
                              location  ST_Point);
```

The **ST_Buffer()** function generates a 5-mile buffer that surrounds the hazardous waste site locations. The **ST_Intersection()** function generates polygons from the intersection of the buffered hazardous waste sites and the sensitive areas. The **ST_Area()** function returns the intersection polygons' area, which is summarized for all hazardous sites by the SUM operator. The GROUP BY clause directs the query to aggregate the intersection areas by hazardous waste site ID:

```
SELECT hs.site_id, SUM(ST_Area(ST_Intersection(sa.zone,
       ST_Buffer(hs.location,(5 * 5280)))::ST_MultiPolygon))
   FROM sensitive_areas sa, hazardous_sites hs
   GROUP BY hs.site_id;

    site_id          (sum)

        102 87000000.00000
         59 77158581.63280
```

In the following figure, the circles represent the 5-mile buffer polygons that surround the hazardous waste sites. The intersection of these buffer polygons with the sensitive area polygons produces three polygons: the hospital in the upper left corner is intersected twice, while the school in the lower right corner is intersected only once.

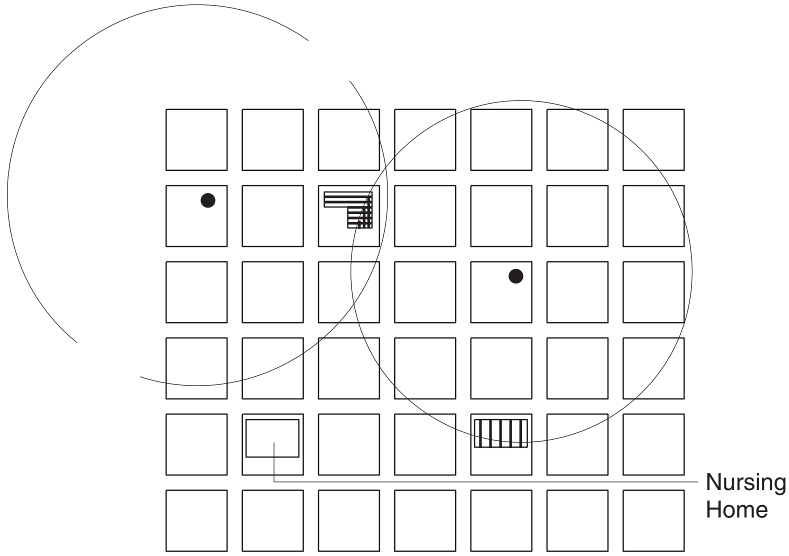


Figure 7-18. Using the **ST_Intersection()** *function*

The ST_Intersects() function

The **ST_Intersects()** function returns `t` (TRUE) if the intersection of two geometries does not result in an empty set; otherwise, returns `f` (FALSE).

Syntax

```
ST_Intersects (g1 ST_Geometry, g2 ST_Geometry)
```

Usage

The following figure shows various geometric objects that intersect.

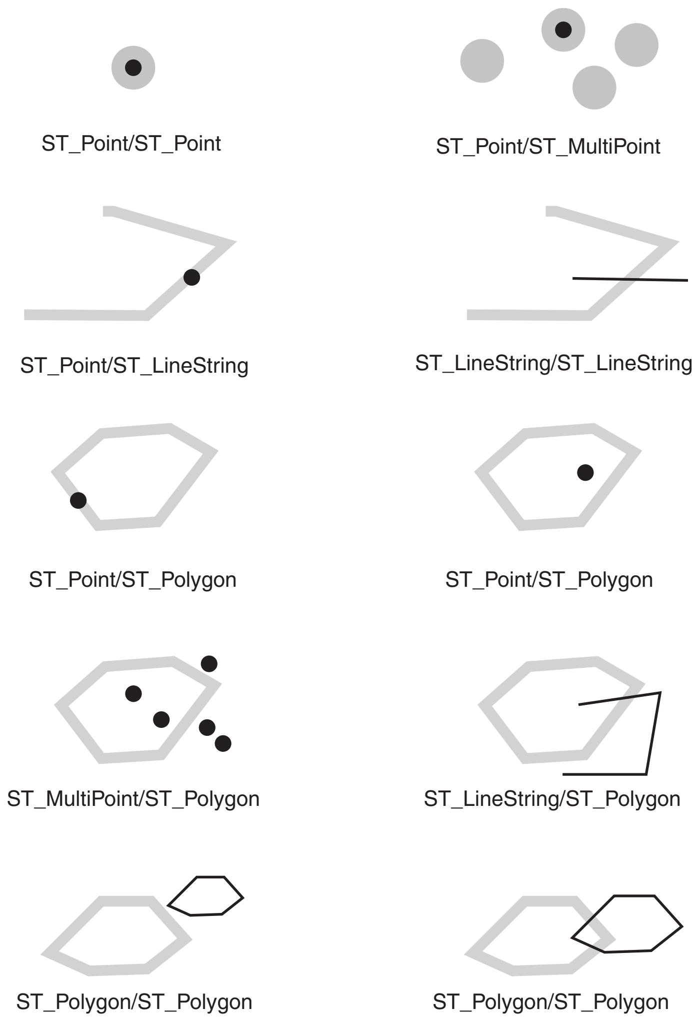


Figure 7-19. A selection of geometries that intersect

The results of the spatial relationship of the **ST_Intersects()** function can be understood or verified by comparing the results with a pattern matrix that represents the acceptable values for the DE-9IM. The **ST_Intersects()** function returns TRUE if the conditions of any of the following pattern matrices returns TRUE.

The **ST_Intersects()** function returns TRUE if the interiors of both geometries intersect.

Table 7-15. Pattern matrix for the ST_Intersects() function.

	Interior (b)	**Boundary (b)**	**Exterior (b)**
Interior (a)	T	*	*
Boundary (a)	*	*	*
Exterior (a)	*	*	*

The **ST_Intersects()** function returns TRUE if the boundary of the first geometry intersects the boundary of the second geometry.

	Interior (b)	Boundary (b)	Exterior (b)
Interior (a)	*	T	*
Boundary (a)	*	*	*
Exterior (a)	*	*	*

The **ST_Intersects()** function returns TRUE if the boundary of the first geometry intersects the interior of the second.

	Interior (b)	Boundary (b)	Exterior (b)
Interior (a)	*	*	*
Boundary (a)	T	*	*
Exterior (a)	*	*	*

The **ST_Intersects()** function returns TRUE if the boundaries of either geometry intersect.

	Interior (b)	Boundary (b)	Exterior (b)
Interior (a)	*	*	*
Boundary (a)	*	T	*
Exterior (a)	*	*	*

Return type

BOOLEAN

Example

The fire marshal wants a list of sensitive areas within a 5-mile radius of a hazardous waste site.

The sensitive areas are stored in the following **sensitive_areas** table. The **zone** column is defined as an ST_Polygon type and stores the outline of the sensitive areas:

```
CREATE TABLE sensitive_areas (id     integer,
                              name   varchar(128),
                              size   float,
                              type   varchar(10),
                              zone   ST_Polygon);
```

The hazardous sites are stored in the **hazardous_sites** table that is created with the CREATE TABLE statement that follows. The **location** column, which is defined as an ST_Point type, stores the geographic center of each hazardous site:

```
CREATE TABLE hazardous_sites (site_id   integer,
                              name      varchar(40),
                              location  ST_Point);
```

The query returns a list of sensitive-area and hazardous-site names for sensitive areas that intersect the 5-mile buffer radius of the hazardous sites:

```
SELECT sa.name, hs.name
   FROM sensitive_areas sa, hazardous_sites hs
   WHERE ST_Intersects(ST_Buffer(hs.location,(5 * 5280)),sa.zone);
```

```
name  Johnson County Hospital
name  W. H. Kleenare Chemical Repository

name  Johnson County Hospital
name  Landmark Industrial

name  Summerhill Elementary School
name  Landmark Industrial
```

Related reference:

"The Dimensionally Extended 9 Intersection Model" on page 7-2

The ST_Is3D() function

The **SE_Is3d()** function returns t (TRUE) if the ST_Geometry object has three-dimensional coordinates; otherwise, returns f (FALSE).

Properties of geometries are described in "Properties of spatial data types" on page 2-1.

Syntax

```
ST_Is3D(g1 ST_Geometry)
```

Return type

BOOLEAN

Example

The **threed_test** table is created with INTEGER **gid** and **g1** ST_Geometry columns:

```
CREATE TABLE threed_test (gid   smallint,
                          g1    ST_Geometry);
```

The following INSERT statements insert two points into the **threed_test** table. The first point does not contain Z coordinates, while the second does:

```
INSERT INTO threed_test VALUES(
   1, ST_PointFromText('point (10 10)',1000)
);

INSERT INTO threed_test VALUES(
   1, ST_PointFromText('point z(10.92 10.12 5)',1000)
);
```

The query lists the contents of the **gid** column with the results of the **SE_Is3d** function. The function returns a 0 for the first row, which does not have a Z coordinate, and a 1 for the second row, which does:

```
SELECT gid, ST_Is3D (g1) is_it_3d from threed_test;

   gid is_it_3d

     1        f
     1        t
```

The ST_IsClosed() function

The **ST_IsClosed()** function takes an ST_LineString or ST_MultiLineString and returns t (TRUE) if it is closed; otherwise, it returns f (FALSE).

Properties of geometries are described in "Properties of spatial data types" on page 2-1.

Syntax

```
ST_IsClosed(ln1 ST_LineString)
ST_IsClosed(mln1 ST_MultiLineString)
```

Return type

BOOLEAN

Example

The **closed_linestring** table is created with a single ST_LineString column:

```
CREATE TABLE closed_linestring (ln1 ST_LineString);
```

The following INSERT statements insert two records into the **closed_linestring** table. The first record is not a closed linestring, while the second is:

```
INSERT INTO closed_linestring VALUES(
   ST_LineFromText('linestring (10.02 20.01,10.32 23.98,11.92 25.64)', 1000)
);

INSERT INTO closed_linestring VALUES(
   ST_LineFromText('linestring (10.02 20.01,11.92 35.64,25.02 34.15,
   19.15 33.94,10.02 20.01)',1000)
);
```

The query returns the results of the **ST_IsClosed()** function. The first row returns a `0` because the linestring is not closed, while the second row returns a 1 because the linestring is closed.

```
SELECT ST_IsClosed(ln1) Is_it_closed
   FROM closed_linestring;

is_it_closed

           f
           t
```

The **closed_mlinestring** table is created with a single ST_MultiLineString column:

```
CREATE TABLE closed_mlinestring (mln1 ST_MultiLineString);
```

The following INSERT statements insert an ST_MultiLineString record that is not closed and another that is:

```
INSERT INTO closed_mlinestring VALUES(
   ST_MLineFromText('multilinestring ((10.02 20.01,10.32 23.98,
   11.92 25.64),(9.55 23.75,15.36 30.11))',1000)
);

INSERT INTO closed_mlinestring VALUES(
   ST_MLineFromText('multilinestring ((10.02 20.01,11.92 35.64,
   25.02 34.15,19.15 33.94,10.02 20.01),(51.71 21.73,73.36 27.04,
   71.52 32.87,52.43 31.90,51.71 21.73))',1000)
);
```

The query lists the results of the **ST_IsClosed()** function. The first row returns `0` because the multilinestring is not closed. The second row returns 1 because the multilinestring stored in the **mln1** column is closed. A multilinestring is closed if all of its linestring elements are closed:

```
SELECT ST_IsClosed(mln1) Is_it_closed
   FROM closed_mlinestring;

is_it_closed

           f
           t
```

The ST_IsEmpty() function

The **ST_IsEmpty()** function returns t (TRUE) if the geometry is empty; otherwise, returns f (FALSE).

See a description of properties of geometries in "Properties of spatial data types" on page 2-1.

Syntax

```
ST_IsEmpty(g1 ST_Geometry)
```

Return type

BOOLEAN

Example

The CREATE TABLE statement below creates the **empty_test** table with geotype, which stores the data type of the subclasses that are stored in the **g1** ST_Geometry column:

```
CREATE TABLE empty_test (geotype varchar(20),
                         g1      ST_Geometry);
```

The following INSERT statements insert two records each for the geometry subclasses: point, linestring, and polygon; one record is empty and one is not:

```
INSERT INTO empty_test VALUES(
    'Point', ST_PointFromText('point (10.02 20.01)',1000)
);

INSERT INTO empty_test VALUES(
    'Point', ST_PointFromText('point empty',1000)
);

INSERT INTO empty_test VALUES(
    'Linestring',
    ST_LineFromText('linestring (10.02 20.01,10.32 23.98,11.92 25.64)',1000)
);

INSERT INTO empty_test VALUES(
   'Linestring',
   ST_LineFromText('linestring empty',1000)
);

INSERT INTO empty_test VALUES(
    'Polygon',
    ST_PolyFromText('polygon ((10.02 20.01,11.92 35.64,25.02
34.15,19.15 33.94,10.02 20.01))',1000)
);

INSERT INTO empty_test VALUES(
    'Polygon',
    ST_PolyFromText('polygon empty',1000)
);
```

The query returns the geometry type from the **geotype** column and the results of the **ST_IsEmpty()** function:

```
SELECT geotype, ST_IsEmpty(g1) Is_it_empty
   FROM empty_test


geotype              is_it_empty

Point                         f
Point                         t
Linestring                    f
Linestring                    t
Polygon                       f
Polygon                       t
```

The ST_IsMeasured() function

The **ST_IsMeasured()** function returns `t` (TRUE) if the ST_Geometry object has measures; otherwise, returns `f` (FALSE).

Properties of geometries are described in "Properties of spatial data types" on page 2-1.

Syntax

```
ST_IsMeasured(g1 ST_Geometry)
```

Return type

BOOLEAN

Example

The **measure_test** table is created with two columns: a SMALLINT column, **gid**, which uniquely identifies rows, and **g1**, an ST_Geometry column, which stores the ST_Point geometries:

```
CREATE TABLE measure_test (gid smallint,
                           g1  ST_Geometry);
```

The following INSERT statements insert two records into the **measure_test** table. The first record stores a point that does not have a measure, while the second record does have a measure value:

```
INSERT INTO measure_test VALUES(
    1,
    ST_PointFromText('point (10 10)',1000)
);

INSERT INTO measure_test VALUES(
    2,
    ST_PointFromText('point m (10.92 10.12 5)',1000)
);
```

The query lists the **gid** column and the results of the **ST_IsMeasured()** function. The **ST_IsMeasured()** function returns a `0` for the first row because the point does not have a measure; it returns a `1` for the second row because the point does have measures:

```
SELECT gid,ST_IsMeasured(g1) Has_measures
   FROM measure_test;
```

```
gid has_measures

  1          f
  2          t
```

The ST_IsRing() function

The **ST_IsRing()** function takes an ST_LineString and returns `t` (TRUE) if it is a ring (that is, the ST_LineString is closed and simple); otherwise, it returns `f` (FALSE).

Properties of geometries are described in "Properties of spatial data types" on page 2-1.

Syntax

```
ST_IsRing(ln1 ST_LineString)
```

Return type

BOOLEAN

Example

The **ring_linestring** table is created with the SMALLINT column **gid** and the ST_LineString column **ln1**:

```
CREATE TABLE ring_linestring (gid smallint,
                              ln1 ST_LineString);
```

The following INSERT statements insert three linestrings into the **ln1** column. The first row contains a linestring that is not closed and is not a ring. The second row contains a closed and simple linestring that is a ring. The third row contains a linestring that is closed, but not simple, because it intersects its own interior. It is also not a ring:

```
INSERT INTO ring_linestring VALUES(
   1,
   ST_LineFromText('linestring (10.02 20.01,10.32 23.98,11.92 25.64)', 1000)
);

INSERT INTO ring_linestring VALUES(
   2,
   ST_LineFromText('linestring (10.02 20.01,11.92 35.64,25.02
34.15,19.15 33.94, 10.02 20.01)', 1000)
);

INSERT INTO ring_linestring VALUES(
   3,
   ST_LineFromText('linestring (15.47 30.12,20.73 22.12,10.83
14.13,16.45 17.24,21.56 13.37,11.23 22.56,19.11 26.78,15.47 30.12)', 1000)
);
```

The query returns the results of the **ST_IsRing()** function. The first and third rows return `0` because the linestrings are not rings, while the second row returns `1` because it is a ring:

```
SELECT gid, ST_IsRing(ln1) Is_it_a_ring
   FROM ring_linestring;

   gid is_it_a_ring
```

```
  1          f
  2          t
  3          f
```

The ST_IsSimple() function

The **ST_IsSimple()** function returns t (TRUE) if the geometry object is simple; otherwise, it returns f (FALSE). Properties of geometries are described in "Properties of spatial data types" on page 2-1.

Syntax

```
ST_IsSimple (g1 ST_Geometry)
```

Return type

BOOLEAN

Example

The table **issimple_test** is created with two columns. The **pid** column is a SMALLINT containing the unique identifier for each row. The **g1** ST_Geometry column stores the simple and nonsimple geometry samples:

```
CREATE TABLE issimple_test (pid smallint,
                            g1  ST_Geometry);
```

The following INSERT statements insert two records into the **issimple_test** table. The first is a simple linestring because it does not intersect its interior. The second is non-simple because it does intersect its interior:

```
INSERT INTO issimple_test VALUES(
   1,
   ST_LineFromText('linestring (10 10, 20 20, 30 30)',1000)
);

INSERT INTO issimple_test VALUES(
   2,
   ST_LineFromText('linestring (10 10,20 20,20 30,10 30,10 20,20 10)',1000)
);
```

The query returns the results of the **ST_IsSimple()** function. The first record returns t because the linestring is simple, while the second record returns f because the linestring is not simple:

```
SELECT pid, ST_IsSimple(g1) Is_it_simple
   FROM issimple_test;

   pid is_it_simple

     1          t
     2          f
```

The ST_IsValid() function

The **ST_IsValid()** function takes an ST_Geometry and returns t (TRUE) if it is topologically correct; otherwise it returns f (FALSE). Properties of geometries are described in "Properties of spatial data types" on page 2-1.

The IBM Informix Spatial DataBlade Module validates spatial data before accepting it, so **ST_IsValid()** always returns TRUE. This function may be used to validate spatial data supplied by other implementations of the OpenGIS spatial data specification.

Syntax

```
ST_IsValid(g ST_Geometry)
```

Return type

BOOLEAN

The ST_Length() function

The **ST_Length()** function returns the length of an ST_LineString or ST_MultiLineString.

Syntax

```
ST_Length(ln1 ST_LineString)
ST_Length(ln1 ST_LineString, linear_uom varchar(128))

ST_Length(mln1 ST_MultiLineString)
ST_Length(mln1 ST_MultiLineString, linear_uom varchar(128))
```

The *linear_uom* parameter converts the result to the specified unit of measure. To calculate the length if the line is in a geographic coordinate system where the coordinates are in an angular unit of measure, you must specify a linear unit of measure with the *linear_uom* parameter. Angular units of measure are converted to linear units of measure by great-circle calculations. If the line is in a projected coordinate system that has a unit of measure that is different from the unit of measure that is specified by the *linear_uom* parameter, then the returned value is converted to the unit of measure that is specified by the *linear_uom* parameter. The *linear_uom* parameter must be the name of a linear unit of measure from the **unit_name** column of the **st_units_of_measure** table.

Return type

DOUBLE PRECISION

Example: Find the length of steams and rivers

A local ecologist who is studying the migratory patterns of the salmon population in the county's waterways wants the length of all stream and river systems within the county.

The **waterways** table is created with the **ID** and **name** columns that identify each stream and river system that is stored in the table. The **water** column is a multilinestring, because the river and stream systems are often an aggregate of several linestrings:

```
CREATE TABLE waterways (id     integer,
                        name   varchar(128),
                        water  ST_MultiLineString);
```

The query returns the name of each system along with the length of the system that is generated by the length function:

```
SELECT name, ST_Length(water) Length
   FROM waterways;


name    Fedders creek
length  175853.9869703
```

The following figure shows the river and stream systems that lie within the county boundary.

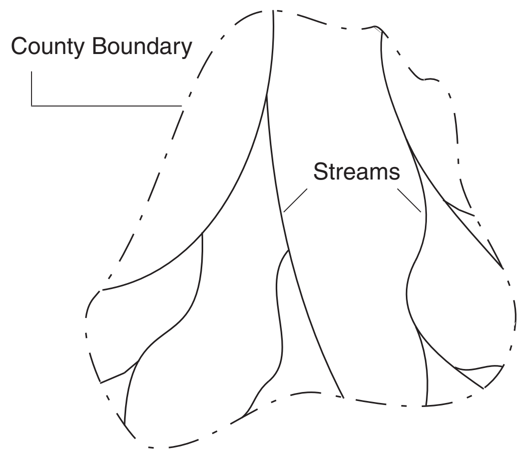


Figure 7-20. Stream and river systems

Examples: Find the length lines in meters

The following statement returns the length of a linestring in meters:

```
EXECUTE FUNCTION round(
        st_length(
                '32608 linestring(576100 15230, 576102 15230)'::st_linestring,
                'meter'),
        2);

    (expression)

2.00000000000000

1 row(s) retrieved.
```

The following statement returns the length of a multilinestring in meters:

```
EXECUTE FUNCTION round(
        st_length(
                '32608 multilinestring((576100 15230, 576100 15232,
                 576102 15232, 576102 15230, 576100 15230),(576104 4,
                 576104 6, 576106 6, 576106 4, 576104 4))'::st_multilinestring,
                'meter'),
        2);

    (expression)

16.0000000000000

1 row(s) retrieved.
```

Examples: Find the length of a line that has angular coordinates

These examples are based on the angular coordinate system WGS 84, which has SRID 4326. They calculate the length of a line between New York and Los Angeles, which is based on the following coordinates:

- Latitude and longitude of New York: 40.67000 N, 73.94000 W
- Latitude and longitude of Los Angles: 34.05000 N, 118.25000 W

The following statement returns the length between New York and Los Angeles in US miles:

```
EXECUTE FUNCTION ST_Length('4326 linestring(-73.94000 40.67000,
                 -118.25000 34.05000)'::st_linestring, 'mile_us');

  (expression)

2454.991002988

1 row(s) retrieved.
```

The following statement returns the length between New York and Los Angeles in kilometers:

```
EXECUTE FUNCTION ST_Length('4326 linestring(-73.94000 40.67000,
                 -118.25000 34.05000)'::st_linestring, 'kilometer');

  (expression)

3950.932942578

1 row(s) retrieved.
```

Related reference:

"The st_units_of_measure table" on page 1-17

The ST_LineFromGML() function

The **ST_LineFromGML()** function takes a GML2 or GML3 string representation of an ST_LineString and an optional spatial reference ID and returns a polyline object.

Syntax

```
ST_LineFromGML(gmlstring lvarchar)
ST_LineFromGML(gmlstring lvarchar, SRID integer)
```

Return type

ST_LineString

Example

The **gml_linetest** table is created with the SMALLINT column **gid** and the ST_LineString column **ln1**:

```
CREATE TABLE gml_linetest (gid smallint, ln1 ST_LineString);

INSERT INTO gml_linetest VALUES (1, ST_LineFromGML('<gml:LineString>
                <gml:posList> -110.45 45.256 -109.48 46.46 -109.86 43.84
                </gml:posList></gml:LineString>',4));
INSERT INTO gml_linetest VALUES (2, ST_LineFromGML('<gml:LineString
                srsName="EPSG:4326" srsDimension="3"><gml:posList
                dimension="3">-110.449999933 45.2559999343 10
                -109.47999994 46.4600005499 10 -109.86000008
```

```
                43.8400000201 20</gml:posList></gml:LineString>'));
INSERT INTO gml_linetest VALUES(3,ST_LineFromGML('<gml:LineString
                srsName="EPSG:4326" srsDimension="4"><gml:posList
                dimension="4">-110.449999933 45.2559999343 10  54
                -109.47999994 46.4600005499 10  58
                -109.86000008 43.8400000201 20 64 </gml:posList>
                </gml:LineString>'));
```

The first record specifies a spatial reference ID of 4 (WGS84) and a default dimension of 2. The second and third records contain Z and M measures and pass the spatial reference ID through the srsName attribute.

Output:

```
SELECT * FROM gml_linetest;

gid  1
ln1  4 LINESTRING (-110.449999933 45.2559999343,
                   -109.47999994 46.4600000469,
                   -109.86000008 43.8400000201)

gid  2
ln1  4 LINESTRING Z (-110.449999933 45.2559999343 10,
                     -109.47999994 46.4600005499 10,
                     -109.86000008 43.8400000201 20)

gid  3
ln1  4 LINESTRING ZM (-110.449999933 45.2559999343 10 54,
                      -109.47999994 46.4600005499 10 58,
                      -109.86000008 43.8400000201 20 64)
```

The ST_LineFromKML() function

The **ST_LineFromKML()** function takes a KML LineString string and an optional spatial reference ID and returns a linestring object. A KML LineString string can contain the KML shape attributes <extrude>, <tessellate>, and <altitudeMode>, but they are ignored in the ST_LineString representation.

Syntax

```
ST_LineFromKML(kmlstring lvarchar)
ST_LineFromKML(kmlstring lvarchar, SRID integer)
```

Return type

ST_LineString

Example

```
EXECUTE FUNCTION ST_LineFromKML('<LineString><coordinates>-130.597293,50.678292,
                          0 -129.733457,50.190606,0 -130.509877,49.387208,
                          0 -128.801553,48.669761,0 -129.156745,47.858658,
                         0 -128.717835,47.739997,0</coordinates></LineString>',4);
```

Output:

```
(expression)  4 LINESTRING Z (-130.597292947 50.6782919759 0, -129.733456972
50.1906059982 0, -130.509877068 49.3872080751 0, -128.801553066 48.669761042 0,
-129.156744951 47.8586579701 0, -128.717834948 47.7399970362 0)
```

The SE_LineFromShape() function

The **SE_LineFromShape()** function takes a shape of type polyline and a spatial reference ID to return an ST_LineString. A polyline with only one part is appropriate as an ST_LineString, and a polyline with multiple parts is appropriate as an ST_MultiLineString (see “The SE_MLineFromShape() function” on page 7-96).

Syntax

```
SE_LineFromShape(s1 lvarchar, SRID integer)
```

Return type

ST_LineString

Example

The **sewerlines** table is created with three columns: **sewer_id**, which uniquely identifies each sewer line; the INTEGER **class** column, which identifies the type of sewer line (generally associated with the line's capacity); and the **sewer** ST_LineString column, which stores the sewer line geometry:

```
CREATE TABLE sewerlines (sewer_id  integer,
                         class     integer,
                         sewer     ST_LineString);
```

This code fragment populates the **sewerlines** table with the unique ID, class, and geometry of each sewer line:

```
/* Create the SQL insert statement to populate the sewerlines
     * table. The question marks are parameter markers that indicate
     * the column values that will be inserted at run time. */
    sprintf(sql_stmt,
            "INSERT INTO sewerlines (sewer_id,class,sewer) "
            "VALUES(?, ?, SE_LineFromShape(?, %d))", srid);

    /* Prepare the SQL statement for execution. */
    rc = SQLPrepare (hstmt, (unsigned char *)sql_stmt, SQL_NTS);

    /* Bind the sewer_id to the first parameter. */
    pcbvalue1 = 0;
    rc = SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_SLONG,
                           SQL_INTEGER, 0, 0,
                           &sewer_id, 0, &pcbvalue1);

    /* Bind the sewer_class to the second parameter. */
    pcbvalue2 = 0;
    rc = SQLBindParameter (hstmt, 2, SQL_PARAM_INPUT, SQL_C_SLONG,
                           SQL_INTEGER, 0, 0,
                           &sewer_class, 0, &pcbvalue2);

    /* Bind the sewer geometry to the third parameter. */
    pcbvalue3 = sewer_shape_len;
    rc = SQLBindParameter (hstmt, 3, SQL_PARAM_INPUT, SQL_C_BINARY,
                           SQL_INFX_UDT_LVARCHAR, sewer_shape_len, 0,
                           sewer_shape_buf, sewer_shape_len, &pcbvalue3);

    /* Execute the insert statement. */
    rc = SQLExecute (hstmt);
```

The ST_LineFromText() function

The **ST_LineFromText()** function takes a well-known text representation of type ST_LineString and a spatial reference ID and returns an ST_LineString.

Syntax

```
ST_LineFromText(WKT lvarchar, SRID integer)
```

Return type

ST_LineString

Example

The **linestring_test** table is created with a single **ln1** ST_LineString column:

```
CREATE TABLE linestring_test (ln1 ST_LineString);
```

The following INSERT statement inserts an ST_LineString into the **ln1** column using the **ST_LineFromText()** function:

```
INSERT INTO linestring_test VALUES(
   ST_LineFromText('linestring(10.01 20.03,20.94 21.34,35.93 19.04)',1000)
);
```

The ST_LineFromWKB() function

The **ST_LineFromWKB()** function takes a well-known binary representation of type ST_LineString and a spatial reference ID, returning an ST_LineString.

Syntax

```
ST_LineFromWKB(wkb lvarchar, SRID integer)
```

Return type

ST_LineString

Example

The **sewerlines** table is created with three columns. The first column, **sewer_id**, uniquely identifies each sewer line. The INTEGER **class** column identifies the type of sewer line, generally associated with the line capacity. The **sewer ST_LineString** column stores the sewer line geometries:

```
CREATE TABLE sewerlines (sewer_id  integer,
                         class     integer,
                         sewer     ST_LineString);
```

This code fragment populates the **sewerlines** table with the unique ID, class, and geometry of each sewer line:

```
/* Create the SQL insert statement to populate the sewerlines
 * table. The question marks are parameter markers that indicate
 * the column values that will be inserted at run time. */
sprintf(sql_stmt,
        "INSERT INTO sewerlines (sewer_id,class,sewer) "
        "VALUES(?, ?, ST_LineFromWKB(?, %d))", srid);

/* Prepare the SQL statement for execution. */
rc = SQLPrepare (hstmt, (unsigned char *)sql_stmt, SQL_NTS);
```

```
/* Bind the sewer_id to the first parameter. */
pcbvalue1 = 0;
rc = SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_SLONG,
                       SQL_INTEGER, 0, 0,
                       &sewer_id, 0, &pcbvalue1);

/* Bind the sewer_class to the second parameter. */
pcbvalue2 = 0;
rc = SQLBindParameter (hstmt, 2, SQL_PARAM_INPUT, SQL_C_SLONG,
                       SQL_INTEGER, 0, 0,
                       &sewer_class, 0, &pcbvalue2);

/* Bind the sewer geometry to the third parameter. */
pcbvalue3 = sewer_wkb_len;
rc = SQLBindParameter (hstmt, 3, SQL_PARAM_INPUT, SQL_C_BINARY,
                       SQL_INFX_UDT_LVARCHAR, sewer_wkb_len, 0,
                       sewer_wkb_buf, sewer_wkb_len, &pcbvalue3);

/* Execute the insert statement. */
rc = SQLExecute (hstmt);
```

The ST_LocateAlong() function

The **ST_LocateAlong()** function takes a geometry object and a measure to return as an ST_MultiPoint the set of points found having that measure.

Syntax

```
ST_LocateAlong(g1 ST_Geometry, m1 double precision)
```

Usage

SE_LocateAlong() returns the location as an ST_MultiPoint.

If the source geometry's dimension is 0 (for ST_Point and ST_MultiPoint), only points with a matching measure value are returned as an ST_MultiPoint. However, for source geometries whose dimension is greater than 0, the location is interpolated. For example, if the requested measure value is 5.5 and the ST_LineString vertices have measures of 3, 4, 5, 6, and 7, an interpolated point that falls exactly halfway between the vertices with measure values 5 and 6 is returned.

SE_LocateAlong() locates a point on a linestring by interpolating the given measure value, if necessary. The following figure shows a case where a point with measure 5.5 is interpolated halfway between the vertices of the ST_LineString with measures 5 and 6. For ST_MultiPoints, an exact match is required. In the case of the above ST_MultiPoint, **SE_LocateAlong()** returns the point that has measure 5.5.

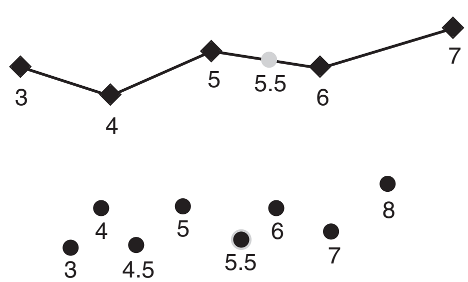


Figure 7-21. The SE_LocateAlong function

Return type

ST_Geometry

Example

The **locatealong_test** table is created with two columns: the **gid** column uniquely identifies each row, and the **g1** ST_Geometry column stores sample geometry:

```
CREATE TABLE locatealong_test (gid integer,
                               g1  ST_Geometry);
```

The following INSERT statements insert two rows. The first is a multilinestring, while the second is a multipoint:

```
INSERT INTO locatealong_test VALUES(
   1,
   ST_MLineFromText('multilinestring m ((10.29 19.23 5,23.82 20.29
6,30.19 18.47 7,45.98 20.74 8),(23.82 20.29 6,30.98 23.98 7,42.92
25.98 8))', 1000)
);

INSERT INTO locatealong_test VALUES(
   2,
   ST_MPointFromText('multipoint m (10.29 19.23 5,23.82 20.29
6,30.19 18.47 7,45.98 20.74 8,23.82 20.29 6,30.98 23.98 7,42.92
25.98 8)', 1000)
);
```

In this query, the **ST_LocateAlong()** function finds points whose measure is 6.5. The first row returns an ST_MultiPoint containing two points. However, the second row returns an empty point. For linear features (geometry with a dimension greater than 0), **ST_LocateAlong()** can interpolate the point, but for multipoints the target measure must match exactly:

```
SELECT gid, SE_locatealong(g1,6.5) Geometry
   FROM locatealong_test;


gid       1
geometry  1000 MULTIPOINT M (27.005 19.38 6.5, 27.4 22.135 6.5)

gid       2
geometry  1000 POINT M EMPTY
```

In this query, the **ST_LocateAlong()** function returns a multipoint for both rows. The target measure of 7 matches measures in the multilinestring and multipoint source data:

```
SELECT gid, SE_locatealong(g1,7) Geometry
   FROM locatealong_test;


gid       1
geometry  1000 MULTIPOINT M (30.19 18.47 7, 30.98 23.98 7)

gid       2
geometry  1000 MULTIPOINT M (30.19 18.47 7, 30.98 23.98 7)
```

The ST_LocateBetween() function

The **ST_LocateBetween()** function takes an ST_Geometry object and two measure locations and returns an ST_Geometry that represents the set of disconnected paths between the two measure locations.

Syntax

```
ST_LocateBetween(g1 ST_Geometry, fm double precision, tm double precision)
```

Usage

If the source geometry dimension is 0, **SE_LocateBetween()** returns an ST_MultiPoint consisting of all points whose measures lie between the two source measures.

For source geometries whose dimension is greater than 0, **SE_LocateBetween()** returns an ST_MultiLineString if a path can be interpolated; otherwise, **SE_LocateBetween()** returns an ST_MultiPoint containing the point locations.

An empty point is returned whenever **SE_LocateBetween()** cannot interpolate a path or find a location between the measures.

SE_LocateBetween() performs an inclusive search of the geometries; therefore, the geometry measures must be greater than or equal to the *from* measure and less than or equal to the *to* measure.

In the following figure, **SE_LocateBetween()** returns an ST_MultiLineString that is between measures 4.3 and 6.9.

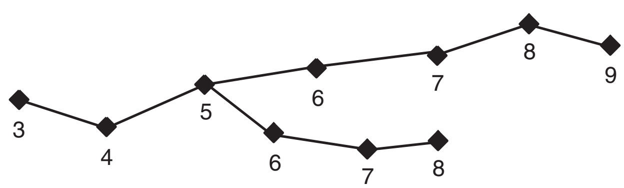


Figure 7-22. The SE_LocateBetween function

Return type

ST_Geometry

Example

The **locatebetween_test** table is created with two columns: the **gid** INTEGER column uniquely identifies each row, while the **g1** ST_MultiLineString stores the sample geometry:

```
CREATE TABLE locatebetween_test (gid integer, g1 ST_Geometry);
```

The following INSERT statements insert two rows into the **locatebetween_test** table. The first row is an ST_MultiLineString and the second is an ST_MultiPoint:

```
INSERT INTO locatebetween_test VALUES(
   1,
   ST_MLineFromText('multilinestring m ((10.29 19.23 5,23.82 20.29
6, 30.19 18.47 7,45.98 20.74 8),(23.82 20.29 6,30.98 23.98 7,42.92
25.98 8))',1000)
);

INSERT INTO locatebetween_test VALUES(
   2,
   ST_MPointFromText('multipoint m (10.29 19.23 5,23.82 20.29
6,30.19 18.47 7,45.98 20.74 8,23.82 20.29 6,30.98 23.98 7,42.92
25.98 8)', 1000)
);
```

In the query, the **ST_LocateBetween** function locates measures that lie between 6.5 and 7.5, inclusively. The first row returns an ST_MultiLineString containing several linestrings. The second row returns an ST_MultiPoint because the source data was ST_MultiPoint. When the source data has a dimension of 0 (point or multipoint), an exact match is required:

```
SELECT gid, ST_LocateBetween(g1,6.5,7.5) Geometry
   FROM locatebetween_test;


gid       1
geometry  1000 MULTILINESTRING M ((27.005 19.38 6.5, 30.19 18.47
7, 38.085 19.6
          05 7.5),(27.4 22.135 6.5, 30.98 23.98 7, 36.95 24.98 7.5))

gid       2
geometry  1000 MULTIPOINT M (30.19 18.47 7, 30.98 23.98 7)
```

The ST_M() function

The **ST_M()** function returns the measure value of a point.

Syntax

```
ST_M(p1 ST_Point)
```

Return type

DOUBLE PRECISION

Example

The **m_test** table is created with the **gid** INTEGER column, which uniquely identifies the row, and the **pt1** ST_Point column that stores the sample geometry:

```
CREATE TABLE m_test (gid integer,
                     pt1 ST_Point);
```

The following INSERT statements insert a point with measures and a point without measures:

```
INSERT INTO m_test VALUES(
   1,
   ST_PointFromText('point (10.02 20.01)', 1000)
);

INSERT INTO m_test VALUES(
   2,
   ST_PointFromText('point zm (10.02 20.01 5.0 7.0)', 1000)
);
```

In this query, the **ST_M()** function lists the measure values of the points. Because the first point does not have measures, the **ST_M()** function returns NULL:

```
SELECT gid, ST_M(pt1) The_measure
   FROM m_test;

        gid    the_measure

          1
          2 7.000000000000
```

The ST_MaxM() and ST_MinM() functions

The **ST_MaxM()** and **ST_MinM()** functions return the maximum and minimum measure values of a geometry.

Syntax

```
ST_MaxM(ST_Geometry)
```

```
ST_MinM(ST_Geometry)
```

Return type

DOUBLE PRECISION

The ST_MaxX() and ST_MinX() functions

The **ST_MaxX()** and **ST_MinX()** functions return the maximum and minimum X coordinates of a geometry.

Syntax

```
ST_MaxX(ST_Geometry)
```

```
ST_MinX(ST_Geometry)
```

Return type

DOUBLE PRECISION

The ST_MaxY() and ST_MinY() functions

The **ST_MaxY()** and **ST_MinY()** functions return the maximum and minimum Y coordinates of a geometry.

Syntax

```
ST_MaxY(ST_Geometry)
```

```
ST_MinY(ST_Geometry)
```

Return type

DOUBLE PRECISION

The ST_MaxZ() and ST_MinZ() functions

The **ST_MaxZ()** and **ST_MinZ()** functions return the maximum and minimum Z coordinates of a geometry.

Syntax

```
ST_MaxZ(ST_Geometry)
```

```
ST_MinZ(ST_Geometry)
```

Return type

DOUBLE PRECISION

The SE_MetadataInit() function

The **SE_MetadataInit()** function reinitializes the spatial reference system large object and memory cache.

For computational efficiency and to allow spatial data type functions to be executed in parallel, the contents of the **spatial_references** table are kept in both a smart large object and a memory cache. If these copies become corrupt or unreadable, one of the following errors is raised:

- `USE48 SE_Metadata lohandle file not found, unreadable, or corrupt.`
- `USE51 SE_Metadata smart blob is corrupt or unreadable.`
- `USE52 SE_Metadata memory cache is locked.`

Execute the **SE_MetadataInit()** function to reinitialize the spatial reference system smart large object and memory cache.

Syntax

```
SE_MetadataInit()
```

Return type

The text string OK, if the function was successfully executed

Example

```
execute function SE_MetadataInit();
```

Related reference:

"Resolve problems with SE_MetadataInit()" on page 5-1

The SE_Midpoint() function

The **SE_Midpoint()** function determines the midpoint of a linestring. The midpoint is defined as that point which is equidistant from both endpoints of a linestring, measuring distance along the linestring.

If the input linestring has Z values or measures, the Z value or measure of the midpoint are computed by linear interpolation between the adjacent vertices.

Syntax

```
SE_Midpoint (ln1 ST_LineString)
```

Return type

ST_Point

The ST_MLineFromGML() function

The **ST_MLineFromGML()** function takes a GML2 or GML3 string representation of an ST_MultiLineString and an optional spatial reference ID and returns a multipart polyline object.

Syntax

```
ST_MLineFromGML(gmlstring lvarchar)
ST_MLineFromGML(gmlstring lvarchar, SRID integer)
```

Return type

ST_MultiLineString

Example

The **gml_linetest** table is created with the SMALLINT column **gid** and the ST_MultiLineString column **ln1**:

```
CREATE TABLE gml_linetest(gid smallint, ln1 ST_MultiLineString);

INSERT INTO gml_linetest VALUES (1, ST_MLineFromGML('<gml:MultiLineString>
            <gml:LineStringMember><gml:LineString><gml:posList>-110.45 45.256
            -109.48 46.46 -109.86 43.84</gml:posList></gml:LineString>
            </gml:LineStringMember><gml:LineStringMember><gml:LineString>
            <gml:posList>-99.45 33.256 -99.48 36.46 -99.86 33.84</gml:posList>
            </gml:LineString></gml:LineStringMember></gml:MultiLineString>',4));

INSERT INTO gml_linetest VALUES (2, ST_MLineFromGML('<gml:MultiLineString
            srsName="EPSG:4326" srsDimension="3"><gml:LineStringMember>
            <gml:LineString srsName="EPSG:4326" srsDimension="3"><gml:posList
            dimension="3">-110.449999933 45.2559999343 10 -109.47999994
            46.4600005499 10 -109.86000008 43.8400000201 20</gml:posList>
            </gml:LineString></gml:LineStringMember><gml:LineStringMember>
            <gml:LineString srsName="EPSG:4326" srsDimension="3"><gml:posList
            dimension="3">-99.45 33.256 10 -99.48 36.46 10 -99.86 33.84 20
            </gml:posList></gml:LineString></gml:LineStringMember>
            </gml:MultiLineString>'));

INSERT INTO gml_linetest VALUES (3, ST_MLineFromGML('<gml:MultiLineString
            srsName="EPSG:4326" srsDimension="4"><gml:LineStringMember>
            <gml:LineString srsName="EPSG:4326" srsDimension="4"><gml:posList
            dimension="4">-110.449999933 45.2559999343 10 54 -109.47999994
            46.4600005499 10 58 -109.86000008 43.8400000201 20 64</gml:posList>
            </gml:LineString></gml:LineStringMember><gml:LineStringMember>
            <gml:LineString srsName="EPSG:4326" srsDimension="4"><gml:posList
            dimension="4">-99.45 33.256 10 54 -99.48 36.46 10 58 -99.86 33.84 20 64
            </gml:posList></gml:LineString></gml:LineStringMember>
            </gml:MultiLineString>'));
```

The first record specifies a spatial reference ID of 4 (WGS84) and a default dimension of 2. The second and third records contain Z and M measures and pass the spatial reference ID through the srsName attribute.

Output:

```
SELECT * FROM gml_linetest;

gid  1
ln1  4 MULTILINESTRING ((-110.449999933 45.2559999343, -109.47999994 46.4600000
     469, -109.86000008 43.8400000201),(-99.4499999329 33.2559999343, -99.47999
     99397 36.4600000469, -99.8600000805 33.8400000201))

gid  2
ln1  4 MULTILINESTRING Z ((-110.449999933 45.2559999343 10, -109.47999994 46.46
     00005499 10, -109.86000008 43.8400000201 20),(-99.4499999329 33.2559999343
      10, -99.4799999397 36.4600000469 10, -99.8600000805 33.8400000201 20))

gid  3
ln1  4 MULTILINESTRING ZM ((-110.449999933 45.2559999343 10 54, -109.47999994 4
     6.4600005499 10 58, -109.86000008 43.8400000201 20 64),(-99.4499999329 33.
     2559999343 10 54, -99.4799999397 36.4600000469 10 58, -99.8600000805 33.84
     00000201 20 64))

3 row(s) retrieved.
```

The ST_MLineFromKML() function

The **ST_MLineFromKML()** function takes a KML MultiLineString string and an optional spatial reference ID and returns a multipart polyline object. A KML MultiLineString string can contain the KML shape attributes <extrude>, <tessellate>, and <altitudeMode>, but they are ignored in the ST_MultiLineString representation.

Syntax

```
ST_MLineFromKML(kmlstring lvarchar)
ST_MLineFromKML(kmlstring lvarchar, SRID integer)
```

Return type

ST_MultiLineString

Example

```
EXECUTE FUNCTION ST_MLineFromKML(<MultiGeometry>
    <LineString>
      <coordinates>
        -122.4425587930444,37.80666418607323,0
        -122.4428379594768,37.80663578323093,0
      </coordinates>
    </LineString>
    <LineString>
      <coordinates>
        -122.4425509770566,37.80662588061205,0
        -122.4428340530617,37.8065999493009,0
      </coordinates>
    </LineString>
  </MultiGeometry>,4);
```

The SE_MLineFromShape() function

The **SE_MLineFromShape()** function creates an ST_MultiLineString from a shape of type polyline and a spatial reference ID. A polyline with only one part is appropriate as an ST_LineString (see "The SE_LineFromShape() function" on page 7-87) and a polyline with multiple parts is appropriate as an ST_MultiLineString.

Syntax

```
SE_MLineFromShape(s1 lvarchar, SRID integer)
```

Return type

ST_MultiLineString

Example

The **waterways** table is created with the **ID** and **name** columns that identify each stream and river system stored in the table. The **water** column is an ST_MultiLineString because the river and stream systems are often an aggregate of several linestrings:

```
CREATE TABLE waterways (id     integer,
                        name   varchar(128),
                        water  ST_MultiLineString);
```

This code fragment populates the **waterways** table with a unique ID, a name, and a **water** multilinestring:

```
/* Create the SQL insert statement to populate the waterways
     * table. The question marks are parameter markers that indicate
     * the column values that will be inserted at run time. */
    sprintf(sql_stmt,
            "INSERT INTO waterways (id,name,water) "
            "VALUES(?, ?, ST_MlineFromShape(?, %d))", srid);

    /* Prepare the SQL statement for execution. */
    rc = SQLPrepare (hstmt, (unsigned char *)sql_stmt, SQL_NTS);

    /* Bind the id to the first parameter. */
    pcbvalue1 = 0;
    rc = SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_SLONG,
                           SQL_INTEGER, 0, 0,
                           &id, 0, &pcbvalue1);

    /* Bind the name to the second parameter. */
    pcbvalue2 = name_len;
    rc = SQLBindParameter (hstmt, 2, SQL_PARAM_INPUT, SQL_C_CHAR,
                           SQL_CHAR, name_len, 0,
                           name, name_len, &pcbvalue2);

    /* Bind the water geometry to the third parameter. */
    pcbvalue3 = water_shape_len;
    rc = SQLBindParameter (hstmt, 3, SQL_PARAM_INPUT, SQL_C_BINARY,
                           SQL_INFX_UDT_LVARCHAR, water_shape_len, 0,
                           water_shape_buf, water_shape_len, &pcbvalue3);
    /* Execute the insert statement. */
    rc = SQLExecute (hstmt);
```

The ST_MLineFromText() function

The **ST_MLineFromText()** function takes a well-known text representation of type ST_MultiLineString and a spatial reference ID and returns an ST_MultiLineString.

Syntax

```
ST_MLineFromText(wkt lvarchar, SRID integer)
```

Return type

ST_MultiLineString

Example

The **mlinestring_test** is created with the **gid** SMALLINT column that uniquely identifies the row and the **ml1** ST_MultiLineString column:

```
CREATE TABLE mlinestring_test (gid smallint,
                               ml1 ST_MultiLineString);
```

The following INSERT statement inserts the ST_MultiLineString with the **ST_MLineFromText()** function:

```
INSERT INTO mlinestring_test VALUES(
   1,
   ST_MLineFromText('multilinestring((10.01 20.03,10.52
40.11,30.29 41.56,31.78 10.74),(20.93 20.81, 21.52 40.10))', 1000)
)
```

The ST_MLineFromWKB() function

The **ST_MLineFromWKB()** function creates an ST_MultiLineString from a well-known binary representation of type ST_MultiLineString and a spatial reference ID.

Syntax

```
ST_MLineFromWKB(WKB lvarchar, SRID integer)
```

Return type

ST_MultiLineString

Example

The **waterways** table is created with the **ID** and **name** columns that identify each stream and river system stored in the table. The **water** column is an ST_MultiLineString because the river and stream systems are often an aggregate of several linestrings:

```
CREATE TABLE waterways (id     integer,
                        name   varchar(128),
                        water  ST_MultiLineString);
```

This code fragment populates the **waterways** table with a unique ID, a name, and a **water** ST_MultiLineString:

```
/* Create the SQL insert statement to populate the waterways
     * table. The question marks are parameter markers that indicate
     * the column values that will be inserted at run time. */
    sprintf(sql_stmt,
            "INSERT INTO waterways (id,name,water) "
            "VALUES(?, ?, ST_MlineFromWKB(?, %d))", srid);

    /* Prepare the SQL statement for execution. */
    rc = SQLPrepare (hstmt, (unsigned char *)sql_stmt, SQL_NTS);

    /* Bind the id to the first parameter. */
    pcbvalue1 = 0;
    rc = SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_SLONG,
                           SQL_INTEGER, 0, 0,
                           &id, 0, &pcbvalue1);

    /* Bind the name to the second parameter. */
    pcbvalue2 = name_len;
    rc = SQLBindParameter (hstmt, 2, SQL_PARAM_INPUT, SQL_C_CHAR,
                           SQL_CHAR, name_len, 0,
                           name, name_len, &pcbvalue2);

    /* Bind the water geometry to the third parameter. */
    pcbvalue3 = water_wkb_len;
    rc = SQLBindParameter (hstmt, 3, SQL_PARAM_INPUT, SQL_C_BINARY,
                           SQL_INFX_UDT_LVARCHAR, water_wkb_len, 0,
                           water_wkb_buf, water_wkb_len, &pcbvalue3);

    /* Execute the insert statement. */
    rc = SQLExecute (hstmt);
```

The ST_MPointFromGML() function

The **ST_MPointFromGML()** function takes a GML2 or GML3 string representation of an ST_MultiPoint and an optional spatial reference ID and returns a polygon object.

Syntax

```
ST_MPointFromGML(gmlstring lvarchar)
ST_MPointFromGML(gmlstring lvarchar, SRID integer)
```

Return type

ST_MultiPoint

Example

The **gml_pointtest** table is created with the SMALLINT column **gid** and the ST_MultiPoint column **mpt1**:

```
CREATE TABLE gml_pointtest(gid smallint, mpt1 ST_MultiPoint);

INSERT INTO gml_pointtest VALUES (1, ST_MPointFromGML('<gml:MultiPoint>
            <gml:PointMember><gml:Point><gml:pos>-110.45 45.256</gml:pos>
            </gml:Point></gml:PointMember><gml:PointMember><gml:Point>
            <gml:pos>-99.45 33.256</gml:pos></gml:Point></gml:PointMember>
            </gml:MultiPoint>',4));

INSERT INTO gml_pointtest VALUES (2, ST_MPointFromGML('<gml:MultiPoint
           srsName="EPSG:4326" srsDimension="3"><gml:PointMember><gml:Point
           srsName="EPSG:4326" srsDimension="3"><gml:pos>-110.449999933
           45.2559999343 10</gml:pos></gml:Point></gml:PointMember>
           <gml:PointMember><gml:Point srsName="EPSG:4326" srsDimension="3">
           <gml:pos>-99.86 33.84 20</gml:pos></gml:Point></gml:PointMember>
           </gml:MultiPoint>'));

INSERT INTO gml_pointtest VALUES (3, ST_MPointFromGML('<gml:MultiPoint
          srsName="EPSG:4326" srsDimension="4"><gml:PointMember><gml:Point
          srsName="EPSG:4326" srsDimension="4"><gml:pos>-109.47999994
          46.4600005499 10 58</gml:pos></gml:Point></gml:PointMember>
          <gml:PointMember><gml:Point srsName="EPSG:4326" srsDimension="4">
          <gml:pos>-99.45 33.256 10 54</gml:pos></gml:Point></gml:PointMember>
          </gml:MultiPoint>'));
```

The first record specifies a spatial reference ID of 4 (WGS84) and a default dimension of 2. The second and third records contain Z and M measures and pass the spatial reference ID through the srsName attribute.

Output:

```
SELECT * FROM gml_pointtest;

gid   1
mpt1  4 MULTIPOINT (-110.449999933 45.2559999343, -99.4499999329 33.2559999343)


gid   2
mpt1  4 MULTIPOINT Z (-110.449999933 45.2559999343 10, -99.8600000805 33.840000
      0201 20)

gid   3
mpt1  4 MULTIPOINT ZM (-109.47999994 46.4600005499 10 58, -99.4499999329 33.255
      9999343 10 54)

3 row(s) retrieved.
```

The ST_MPointFromKML() function

The **ST_MPointFromKML()** function takes a KML MultiGeometry and Point combination and an optional spatial reference ID and returns a multipoint object. A Point string can contain the elements of <coordinates>, <extrude>, <tessellate>, and <altitudeMode>, but they are ignored.

Syntax

```
ST_MPointFromKML(kmlstring lvarchar)
ST_MPointFromKML(kmlstring lvarchar, SRID integer)
```

Return type

ST_MultiPoint

Example

```
EXECUTE FUNCTION ST_MPointFromKML('<MultiGeometry><Point><coordinates>
            -122.365662,37.826988, 0</coordinates></Point><Point>
            <coordinates>-122.365038,37.82655,0</coordinates>
            </Point></MultiGeometry>',4);
```

Output:

```
4 MULTIPOINT Z (-122.365662056 37.8269879529 0, -122.36503794
               37.8265500822 0)
```

The SE_MPointFromShape() function

The **SE_MPointFromShape()** function takes a shape of type multipoint and a spatial reference ID to return an ST_MultiPoint.

Syntax

```
SE_MPointFromShape(s1 lvarchar, SRID integer)
```

Return type

ST_MultiPoint

Example

The **species_sitings** table is created with three columns. The **species** and **genus** columns uniquely identify each row, while the **sitings** ST_MultiPoint stores the locations of the species sitings:

```
CREATE TABLE species_sitings (species  varchar(32),
                              genus    varchar(32),
                              sitings  ST_MultiPoint);
```

This code fragment populates the **species_sitings** table:

```
/* Create the SQL insert statement to populate the species_sitings
     * table. The question marks are parameter markers that indicate
     * the column values that will be inserted at run time. */
    sprintf(sql_stmt,
            "INSERT INTO species_sitings (species,genus,sitings) "
            "VALUES(?, ?, SE_MpointFromShape(?, %d))", srid);

    /* Prepare the SQL statement for execution. */
    rc = SQLPrepare (hstmt, (unsigned char *)sql_stmt, SQL_NTS);

    /* Bind the species to the first parameter. */
```

```
    pcbvalue1 = species_len;
    rc = SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_CHAR,
                           SQL_CHAR, species_len, 0,
                           species, species_len, &pcbvalue1);

    /* Bind the genus to the second parameter. */
    pcbvalue2 = genus_len;
    rc = SQLBindParameter (hstmt, 2, SQL_PARAM_INPUT, SQL_C_CHAR,
                           SQL_CHAR, genus_len, 0,
                           genus, genus_len, &pcbvalue2);

    /* Bind the sitings geometry to the third parameter. */
    pcbvalue3 = sitings_shape_len;
    rc = SQLBindParameter (hstmt, 3, SQL_PARAM_INPUT, SQL_C_BINARY,
                           SQL_INFX_UDT_LVARCHAR, sitings_shape_len, 0,
                           sitings_shape_buf, sitings_shape_len, &pcbvalue3);

    /* Execute the insert statement. */
    rc = SQLExecute (hstmt);
```

The ST_MPointFromText() function

The **ST_MPointFromText()** function creates an ST_MultiPoint from a well-known text representation of type ST_MultiPoint and a spatial reference ID.

Syntax

```
ST_MPointFromText(WKT lvarchar, SRID integer)
```

Return type

ST_MultiPoint

Example

The **multipoint_test** table is created with the single ST_MultiPoint **mpt1** column:

```
CREATE TABLE multipoint_test (gid  smallint,
                              mpt1 ST_MultiPoint);
```

The following INSERT statement inserts a multipoint into the **mpt1** column using the **ST_MPointFromText()** function:

```
INSERT INTO multipoint_test VALUES(
    1,
    ST_MPointFromText('multipoint(10.01 20.03,10.52 40.11,30.29
41.56,31.78 10.74)',1000)
);
```

The ST_MPointFromWKB() function

The **ST_MPointFromWKB()** function creates an ST_MultiPoint from a well-known binary representation of type ST_MultiPoint and a spatial reference ID.

Syntax

```
ST_MPointFromWKB (WKB lvarchar, SRID integer)
```

Return type

ST_MultiPoint

Example

The **species_sitings** table is created with three columns. The **species** and **genus** columns uniquely identify each row, while the **sitings** ST_MultiPoint stores the locations of the species sightings:

```
CREATE TABLE species_sitings (species  varchar(32),
                              genus    varchar(32),
                              sitings  ST_MultiPoint);
```

This code fragment populates the **species_sitings** table:

```
/* Create the SQL insert statement to populate the species_sitings
     * table. The question marks are parameter markers that indicate
     * the column values that will be inserted at run time. */
    sprintf(sql_stmt,
            "INSERT INTO species_sitings (species,genus,sitings) "
            "VALUES(?, ?, ST_MpointFromWKB(?, %d))", srid);

    /* Prepare the SQL statement for execution. */
    rc = SQLPrepare (hstmt, (unsigned char *)sql_stmt, SQL_NTS);

    /* Bind the species to the first parameter. */
    pcbvalue1 = species_len;
    rc = SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_CHAR,
                           SQL_CHAR, species_len, 0,
                           species, species_len, &pcbvalue1);

    /* Bind the genus to the second parameter. */
    pcbvalue2 = genus_len;
    rc = SQLBindParameter (hstmt, 2, SQL_PARAM_INPUT, SQL_C_CHAR,
                           SQL_CHAR, genus_len, 0,
                           genus, genus_len, &pcbvalue2);

    /* Bind the sitings geometry to the third parameter. */
    pcbvalue3 = sitings_wkb_len;
    rc = SQLBindParameter (hstmt, 3, SQL_PARAM_INPUT, SQL_C_BINARY,
                           SQL_INFX_UDT_LVARCHAR, sitings_wkb_len, 0,
                           sitings_wkb_buf, sitings_wkb_len, &pcbvalue3);

    /* Execute the insert statement. */
    rc = SQLExecute (hstmt);
```

The ST_MPolyFromGML() function

The **ST_MPolyFromGML()** function takes a GML2 or GML3 string representation of an ST_MultiPoly and an optional spatial reference ID and returns a multipart polygon object.

Syntax

```
ST_MPolyFromGML(gmlstring lvarchar)
ST_MPolyFromGML(gmlstring lvarchar, SRID integer)
```

Return type

ST_MultiPolygon

Example

The **test_multipoly** table is created with the INTEGER column **id** and the ST_MultiPolygon column **geom**:

```
CREATE TABLE test_multipoly (id INTEGER, geom ST_MultiPolygon);

INSERT INTO test_multipoly VALUES(1,ST_MPolyFromGML
     ('<gml:MultiPolygon srsName="EPSG:4326" srsDimension="2">
     <gml:PolygonMember><gml:Polygon srsName="EPSG:4326" srsDimension="2">
     <gml:exterior><gml:LinearRing><gml:posList dimension="2">
     -94.36  32.49 -92.66 32.69 -92.15 32.46 -93.09 33.08 -93.37 33.19
     -94.36 32.49</gml:posList></gml:LinearRing>
     </gml:exterior></gml:Polygon></gml:PolygonMember>
     <gml:PolygonMember><gml:Polygon srsName="EPSG:4326" srsDimension="2">
     <gml:exterior><gml:LinearRing><gml:posList dimension="2">
     -84.36 32.49 -82.66 32.69 -82.15 32.46 -83.09 33.08 -83.37 33.19
     -84.36 32.49</gml:posList></gml:LinearRing></gml:exterior>
     < /gml:Polygon></gml:PolygonMember></gml:MultiPolygon>',4));
```

This record specifies a spatial reference ID of 4 (WGS84) and both member polygons have a dimension of 2 and six sides.

Output:

```
SELECT * FROM test_multipoly;

id    1
geom  4 MULTIPOLYGON (((-94.3600000805 32.4900000536, -92.6599999799
                      32.6899999866, -92.1500000335 32.4600000469,
                      -93.0900000201 33.0800000738, -93.3700000268
                      33.1899999866, -94.3600000805 32.4900000536)),
                      ((-84.3600000805 32.4900000536, -82.6599999799
                      32.6899999866, -82.1500000335 32.4600000469,
                      -83.0900000201 33.0800000738, -83.3700000268
                      33.1899999866, -84.3600000805 32.4900000536)))
```

The ST_MPolyFromKML() function

The **ST_MPolyFromKML()** function takes a MultiGeometry and Polygon combination and an optional spatial reference ID and returns a polygon object.

Syntax

```
ST_MPolyFromKML(kmlstring lvarchar)
ST_MPolyFromKML(kmlstring lvarchar, SRID integer)
```

Return type

ST_MultiPolygon

Example

The **test_multipoly** table is created with the INTEGER column **id** and the ST_MultiPolygon column **geom**:

```
CREATE TABLE test_multipoly (id INTEGER, geom ST_MultiPolygon);

INSERT INTO test_multipoly VALUES(1,ST_MPolyFromKML('<MultiGeometry>
              <Polygon><outerBoundaryIs><LinearRing><coordinates>
              -94.36,32.49 -92.65,32.68 -92.15,32.46 -93.09,33.08
              -93.37,33.18 -94.36,32.49</coordinates>
             </LinearRing></outerBoundaryIs></Polygon><Polygon>
             <outerBoundaryIs><LinearRing><coordinates>-84.36,32.49
             -82.65,32.68 -82.15,32.46 -83.09,33.08 -83.37,33.18
             -84.3600000805,32.4900000536</coordinates>
             </LinearRing></outerBoundaryIs></Polygon><
             /MultiGeometry>',4));
```

This record specifies a spatial reference ID of 4 (WGS84) and both member polygons have two dimensions and six sides.

Output:

```
SELECT * FROM test_multipoly;

id    1
geom  4 MULTIPOLYGON (((-94.3600000805 32.4900000536, -92.6599999799
        32.6899999866, -92.1500000335 32.4600000469, -93.0900000201
        33.0800000738, -93.3700000268 33.1899999866, -94.3600000805
        32.4900000536)),((-84.3600000805 32.4900000536, -82.6599999799
        32.6899999866, -82.1500000335 32.4600000469, -83.0900000201
        33.0800000738, -83.3700000268 33.1899999866, -84.3600000805
        32.4900000536)))
```

The SE_MPolyFromShape() function

The **SE_MPolyFromShape()** function takes a shape of type polygon and a spatial reference ID to return an ST_MultiPolygon.

Syntax

```
SE_MPolyFromShape(s1 lvarchar, SRID integer)
```

Return type

ST_MultiPolygon

Example

The **lots** table stores the **lot_id**, which uniquely identifies each lot, and the **lot** multipolygon that contains the lot line geometry:

```
CREATE TABLE lots (lot_id  integer,
                   lot     ST_MultiPolygon);
```

This code fragment populates the **lots** table:

```
/* Create the SQL insert statement to populate the lots table.
     * The question marks are parameter markers that indicate the
     * column values that will be inserted at run time. */
    sprintf(sql_stmt,
            "INSERT INTO lots (lot_id,lot)"
            "VALUES(?, SE_MpolyFromShape(?, %d))", srid);

    /* Prepare the SQL statement for execution. */
    rc = SQLPrepare (hstmt, (unsigned char *)sql_stmt, SQL_NTS);

    /* Bind the lot_id to the first parameter. */
    pcbvalue1 = 0;
    rc = SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_SLONG,
                           SQL_INTEGER, 0, 0,
                           &lot_id, 0, &pcbvalue1);

    /* Bind the lot geometry to the second parameter. */
    pcbvalue2 = lot_shape_len;
    rc = SQLBindParameter (hstmt, 2, SQL_PARAM_INPUT, SQL_C_BINARY,
                           SQL_INFX_UDT_LVARCHAR, lot_shape_len, 0,
                           lot_shape_buf, lot_shape_len, &pcbvalue2);

    /* Execute the insert statement. */
    rc = SQLExecute (hstmt);
```

The ST_MPolyFromText() function

The **ST_MPolyFromText()** function takes a well-known text representation of type ST_MultiPolygon and a spatial reference ID and returns an ST_MultiPolygon.

Syntax

```
ST_MPolyFromText(WKT lvarchar, SRID integer)
```

Return type

ST_MultiPolygon

Example

The **multipolygon_test** table is created with the single ST_MultiPolygon **mpl1** column:

```
CREATE TABLE multipolygon_test (mpl1 ST_MultiPolygon);
```

The following INSERT statement inserts an ST_MultiPolygon into the **mp11** column using the **ST_MPolyFromText()** function:

```
INSERT INTO multipolygon_test VALUES(
   ST_MPolyFromText('multipolygon(((10.01 20.03,10.52 40.11,30.29
41.56,31.78 10.74,10.01 20.03),(21.23 15.74,21.34 35.21,28.94
35.35,29.02 16.83,21.23 15.74)),((40.91 10.92,40.56 20.19,50.01
21.12,51.34 9.81,40.91 10.92)))',1000)
);
```

The ST_MPolyFromWKB() function

The **ST_MPolyFromWKB()** function takes a well-known binary representation of type ST_MultiPolygon and a spatial reference ID to return an ST_MultiPolygon.

Syntax

```
ST_MPolyFromWKB (WKB lvarchar, SRID integer)
```

Return type

ST_MultiPolygon

Example

The **lots** table stores the **lot_id**, which uniquely identifies each lot, and the lot multipolygon that contains the lot line geometry:

```
CREATE TABLE lots (lot_id  integer,
                   lot     ST_MultiPolygon);
```

This code fragment populates the **lots** table:

```
/* Create the SQL insert statement to populate the lots table.
     * The question marks are parameter markers that indicate the
     * column values that will be inserted at run time. */
    sprintf(sql_stmt,
            "INSERT INTO lots (lot_id, lot) "
            "VALUES(?, ST_MpolyFromWKB(?, %d))", srid);

    /* Prepare the SQL statement for execution. */
    rc = SQLPrepare (hstmt, (unsigned char *)sql_stmt, SQL_NTS);
```

```
/* Bind the lot_id to the first parameter. */
pcbvalue1 = 0;
rc = SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_SLONG,
                       SQL_INTEGER, 0, 0,
                       &lot_id, 0, &pcbvalue1);

/* Bind the lot geometry to the second parameter. */
pcbvalue2 = lot_wkb_len;
rc = SQLBindParameter (hstmt, 2, SQL_PARAM_INPUT, SQL_C_BINARY,
                       SQL_INFX_UDT_LVARCHAR, lot_wkb_len, 0,
                       lot_wkb_buf, lot_wkb_len, &pcbvalue2);

/* Execute the insert statement. */
rc = SQLExecute (hstmt);
```

The SE_Nearest() and SE_NearestBbox() functions

The **SE_Nearest()** function returns the nearest-neighbors to a specified geometry. The **SE_NearestBBox()** function returns the nearest-neighbors that are based on the distance between bounding boxes.

The **SE_Nearest()** function uses an R-tree index, which you must create if it does not exist. Query results are returned in order of increasing distance from the query object. The distance is measured by applying the same algorithm as used by the **ST_Distance()** function. For geometry values that are in a geographic coordinate system, the distance is calculated by applying the linear unit of measure of meters.

The **SE_NearestBBox()** function runs more quickly than the **SE_Nearest()** function, but might return objects in a different order, depending on the shape of the objects.

These functions can be used only in the WHERE clause of a query.

Required: You must create an R-tree index on the geometry column on which you want to perform nearest-neighbor queries.

Syntax

```
SE_Nearest (g1 ST_Geometry, g2 ST_Geometry)
```

```
SE_NearestBbox (g1 ST_Geometry, g2 ST_Geometry)
```

Return type

BOOLEAN

Example

The **cities** table contains the names and locations of world cities:

```
CREATE TABLE cities (name varchar(255),
                     locn ST_Point);
```

Populate this table with data from a DB-Access load file, `cities.load` (this data file contains the names and locations of approximately 300 world cities), as the example shows:

```
LOAD FROM cities.load INSERT INTO cities;
```

Create an R-tree index on the **locn** column:

```
CREATE INDEX cities_idx ON cities (locn ST_Geometry_ops) USING RTREE;

UPDATE STATISTICS FOR TABLE cities (locn);
```

Now search for the five cities nearest London:

```
SELECT FIRST 5 name FROM cities
  WHERE SE_Nearest(locn, '0 point(0 51)');


name  London

name  Birmingham

name  Paris

name  Nantes

name  Amsterdam
```

Warning: Using a fragmented R-tree index for nearest-neighbor queries raises an error. Results are not returned in nearest distance order because the query is run on each separate index fragment, and results from each fragment are combined in an unspecified order.

The ST_NumGeometries() function

The **ST_NumGeometries()** function takes a ST_GeomCollection (ST_MultiPoint, ST_MultiLineString, or ST_MultiPolygon) and returns the number of geometries in the collection.

Syntax

```
ST_NumGeometries(mpt1 ST_MultiPoint)
ST_NumGeometries(mln1 ST_MultiLineString)
ST_NumGeometries(mpl1 ST_MultiPolygon)
```

Return type

INTEGER

Example

The city engineer needs to know the number of distinct buildings associated with each building footprint.

The building footprints are stored in the **buildingfootprints** table that was created with the following CREATE TABLE statement:

```
CREATE TABLE buildingfootprints (building_id  integer,
                                 lot_id       integer,
                                 footprint    ST_MultiPolygon);
```

The query lists the **building_id** that uniquely identifies each building and the number of buildings in each footprint with the **ST_NumGeometries()** function:

```
SELECT building_id, ST_NumGeometries(footprint) no_of_buildings
   FROM buildingfootprints;

building_id no_of_buildings
```

```
        506              1
        543              1
       1208              1
        178              1
```

The ST_NumInteriorRing() function

The **ST_NumInteriorRing()** function takes an ST_Polygon and returns the number of its interior rings.

Syntax

```
ST_NumInteriorRing(pl1 ST_Polygon)
```

Return type

INTEGER

Example

An ornithologist studying a bird population on several South Sea islands wants to identify which islands contain one or more lakes, because the bird species of interest feeds only in freshwater lakes.

The **ID** and **name** columns of the **islands** table identifies each island, while the **land** ST_Polygon column stores the island geometry:

```
CREATE TABLE islands (id    integer,
                      name  varchar(32),
                      land  ST_Polygon);
```

Because interior rings represent the lakes, the **ST_NumInteriorRing()** function lists only those islands that have at least one interior ring:

```
SELECT name
   FROM islands
   WHERE ST_NumInteriorRing(land) > 0;
```

The ST_NumPoints() function

The **ST_NumPoints()** function returns the number of points in an ST_Geometry.

Syntax

```
ST_NumPoints(g1 ST_Geometry)
```

Return type

INTEGER

Example

The **numpoints_test** table has two columns: **geotype**, a VARCHAR column that contains a description of the type of geometry; and **g1**, an ST_Geometry type that contains the geometry itself:

```
CREATE TABLE numpoints_test (geotype varchar(12),
                             g1      ST_Geometry);
```

The following INSERT statements insert a point, a linestring, and a polygon:

```
INSERT INTO numpoints_test VALUES(
   'point',
   ST_PointFromText('point (10.02 20.01)',1000)
);

INSERT INTO numpoints_test VALUES(
   'linestring',
   ST_LineFromText('linestring (10.02 20.01, 23.73 21.92)',1000)
);

INSERT INTO numpoints_test VALUES(
   'polygon',
   ST_PolyFromText('polygon ((10.02 20.01, 23.73 21.92, 24.51
12.98,  11.64 13.42, 10.02 20.01))',1000)
);
```

The query lists the geometry type and the number of points in each:

```
SELECT geotype, ST_NumPoints(g1) Number_of_points
   FROM numpoints_test;

geotype      number_of_points

point                       1
linestring                  2
polygon                     5
```

The SE_OutOfRowSize() function

The **SE_OutOfRowSize()** function returns the size of the out-of-row portion of a geometry. Geometries which are larger than 930 bytes (for example, polygons with many vertices) have an in-row component and an out-of-row component; the out-of-row component is stored in an sbspace.

If a geometry has no out-of-row component, **SE_OutOfRowSize()** returns `0`.

You can use this function to obtain an estimate of the amount of diskspace consumed by one or more geometries. However, this function does not account for dbspace and sbspace overhead, so cannot be used to obtain an exact total.

Syntax

```
SE_OutOfRowSize(ST_Geometry)
```

Return type

INTEGER

See also

"The SE_InRowSize() function" on page 7-69

"The SE_TotalSize() function" on page 7-133

The ST_Overlaps() function

The **ST_Overlaps()** function returns `t` (TRUE) if the intersection of two ST_Geometry objects results in an ST_Geometry object of the same dimension but not equal to either source object. Otherwise, it returns `f` (FALSE).

Syntax

```
ST_Overlaps(g1 ST_Geometry, g2 ST_Geometry)
```

Usage

The following figure shows various geometric objects that overlap.

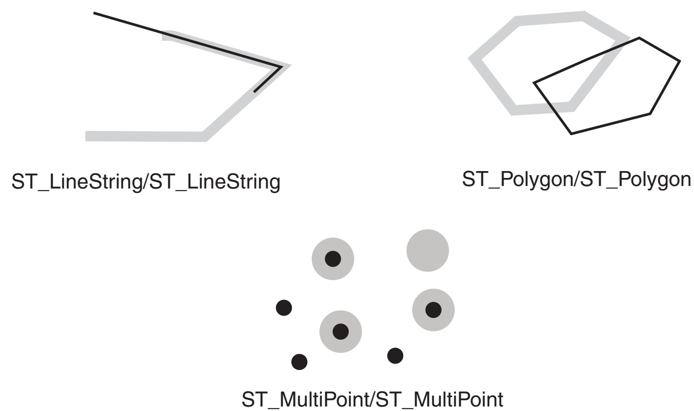


Figure 7-23. Overlapping geometries

The results of the spatial relationship of the **ST_Operlaps()** function can be understood or verified by comparing the results with a pattern matrix that represents the acceptable values for the DE-9IM. The **ST_Operlaps()** function returns TRUE if the intersection of the objects results in an object of the same dimension but not equal to either source object.

This pattern matrix applies to ST_Polygon and ST_Polygon; ST_MultiPoint and ST_MultiPoint; and ST_MultiPolygon and ST_MultiPolygon overlaps. For these combinations, the **ST_Overlaps()** function returns TRUE if the interior of both geometries intersects the other's interior and exterior.

Table 7-16. Pattern matrix for the ST_Overlaps() function.

	Interior (b)	**Boundary (b)**	**Exterior (b)**
Interior (a)	T	*	T
Boundary (a)	*	*	*
Exterior (a)	T	*	*

This pattern matrix applies to ST_LineString and ST_LineString; and to ST_MultiLineString and ST_MultiLineString overlaps. In this case, the intersection of the geometries must result in a geometry that has a dimension of 1 (another ST_LineString or ST_MultiLineString). If the dimension of the intersection of the interiors resulted in 0 (a point), the **ST_Overlaps()** function would return FALSE; however, the **ST_Crosses()** function would return TRUE.

	Interior (b)	**Boundary (b)**	**Exterior (b)**
Interior (a)	1	*	T
Boundary (a)	*	*	*
Exterior (a)	T	*	*

Return type

BOOLEAN

Example

The county supervisor needs a list of hazardous waste sites whose 5-mile radius overlaps sensitive areas.

The **sensitive_areas** table contains several columns that describe the threatened institutions in addition to the **zone** column, which stores the institution ST_Polygon geometries:

```
CREATE TABLE sensitive_areas (id     integer,
                              name   varchar(128),
                              size   float,
                              type   varchar(10),
                              zone   ST_Polygon);
```

The **hazardous_sites** table stores the identity of the sites in the **site_id** and **name** columns. The actual geographic location of each site is stored in the **location** point column:

```
CREATE TABLE hazardous_sites (site_id   integer,
                              name      varchar(40),
                              location  ST_Point);
```

The **sensitive_areas** and **hazardous_sites** tables are joined by the **ST_Overlaps()** function. It returns `t` (TRUE) for all **sensitive_areas** rows whose **zone** polygons overlap the buffered 5-mile radius of the **hazardous_sites** location points:

```
SELECT hs.name hazardous_site, sa.name sensitive_area
   FROM hazardous_sites hs, sensitive_areas sa
   WHERE ST_Overlaps(ST_Buffer(hs.location,(26400)),sa.zone);


hazardous_site  Landmark Industrial
sensitive_area  Johnson County Hospital

hazardous_site  Landmark Industrial
sensitive_area  Summerhill Elementary School
```

The following figure shows that the hospital and the school overlap the 5-mile radius of the county's two hazardous waste sites. The nursing home does not.

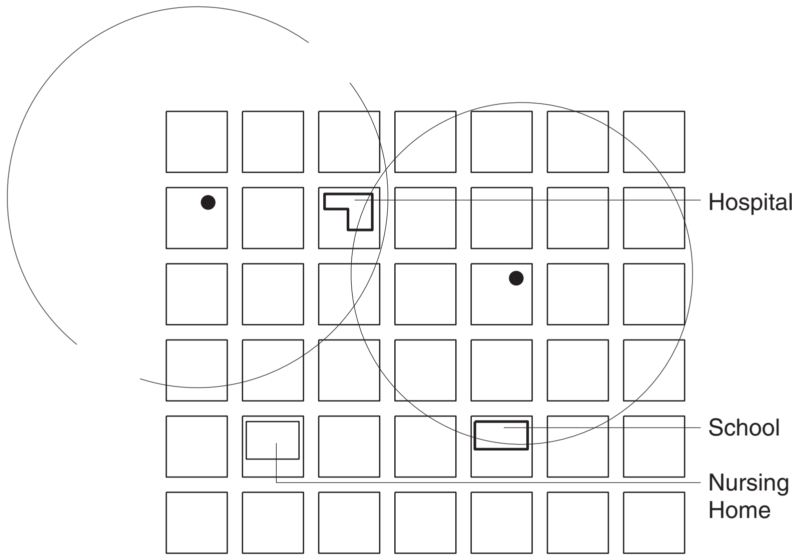


Figure 7-24. Using the ST_Overlaps() function

Related reference:

"The Dimensionally Extended 9 Intersection Model" on page 7-2

The SE_ParamGet() function

The **SE_ParamGet()** function with no arguments returns the values of all parameters. Calling **SE_ParamGet()** with a parameter name in quotation marks returns the current value of the named parameter.

Syntax

```
SE_ParamSet(name lvarchar) returns lvarchar
SE_ParamSet() returns lvarchar
```

Return type

LVARCHAR

Example

```
execute function SE_ParamGet();
execute function SE_ParamGet('MemMode');
```

Related reference:

"Optimize spatial queries" on page 1-24

The SE_ParamSet() function

The **SE_ParamSet()** function with no arguments returns usage information. Calling **SE_ParamSet()** with a parameter name in quotation marks and a value sets the parameter to the specified value. The new value is returned. Parameter names are not case-sensitive. Quotation marks are not required for numeric values.

Syntax

```
SE_ParamSet(name lvarchar, value lvarchar) returns lvarchar
SE_ParamSet() returns lvarchar
```

Return type

LVARCHAR

Example

```
execute function SE_ParamSet();
execute function SE_ParamSet('memmode', '0');
execute function SE_ParamSet('MemMode', 1);
```

Related reference:

"Optimize spatial queries" on page 1-24

The ST_Perimeter() function

The **ST_Perimeter()** function returns the perimeter of a polygon or multipolygon.

Syntax

```
ST_Perimeter(s ST_Polygon)
ST_Perimeter(s ST_Polygon, linear_uom varchar(128))

ST_Perimeter(ms ST_MultiPolygon)
ST_Perimeter(ms ST_MultiPolygon, linear_uom varchar(128))
```

The *linear_uom* parameter converts the result to the specified unit of measure. To calculate the perimeter if the polygon is in a geographic coordinate system where the coordinates are in an angular unit of measure, you must specify a linear unit of measure with the *linear_uom* parameter. Angular units of measure are converted to linear units of measure by great-circle calculations. If the polygon is in a projected coordinate system that has a unit of measure that is different from the unit of measure that is specified by the *linear_uom* parameter, then the returned value is converted to the unit of measure that is specified by the *linear_uom* parameter. The *linear_uom* parameter must be the name of a linear unit of measure from the **unit_name** column of the **st_units_of_measure** table.

Return type

DOUBLE PRECISION

Example: Find the perimeter of lakes

An ecologist who studies shoreline birds needs to determine the shoreline for the lakes within a particular area. The lakes are stored as ST_MultiPolygon type in the **waterbodies** table, created with the following CREATE TABLE statement:

```
CREATE TABLE WATERBODIES (wbid integer, waterbody ST_MultiPolygon);
```

In the following SELECT statement, the **ST_Perimeter()** function returns the perimeter that surrounds each body of water, while the SUM operator aggregates the perimeters to return their total:

```
SELECT SUM(ST_Perimeter(waterbody)) FROM waterbodies;
```

Examples: Find the perimeter polygons

The following statement returns the perimeter of a polygon in meters:

```
execute function round(
        st_perimeter(
                '32608 polygon((576100 15230, 576100 15232, 576102 15232,
                                576102 15230, 576100 15230))'::st_polygon,
```

```
                'meter'),
        2);

    (expression)

8.00000000000000

1 row(s) retrieved.
```

The following statement returns the perimeter of a multipolygon in meters:

```
EXECUTE FUNCTION round(
        st_perimeter(
                '32608 multipolygon(((576100 15230, 576100 15232, 576102 15232,
                 576102 15230, 576100 15230)),((576104 4, 576104 6, 576106 6,
                 576106 4, 576104 4)))'::st_multipolygon,
                'meter'),
        2);

    (expression)

16.0000000000000

1 row(s) retrieved.
```

Example: Find the perimeter of a polygon that is based on angular coordinates

The following statement returns the perimeter distance in meters of a 10 kilometer buffer around the coordinates from the angular coordinate system WGS 84, which has SRID 4326, that represent the latitude and longitude of New York (73.94000 W, 40.67000 N):

```
EXECUTE FUNCTION ST_perimeter(ST_Buffer('4326 point(-73.94000 40.67000)'
                    ::st_point, 10, 'kilometer')::st_polygon, 'meter');

  (expression)

62820.61328130

1 row(s) retrieved.
```

Related reference:

"The st_units_of_measure table" on page 1-17

The SE_PerpendicularPoint() function

The **SE_PerpendicularPoint()** function finds the perpendicular projection of a point on to the nearest segment of a linestring or multilinestring. If two or more such perpendicular projected points are equidistant from the input point, they are all returned. If no perpendicular point can be constructed, an empty point is returned.

If the input linestring has Z values or measures, the Z value or measure of the perpendicular point are computed by linear interpolation between the adjacent vertices.

Syntax

```
SE_PerpendicularPoint(ST_LineString, ST_Point)

SE_PerpendicularPoint(ST_MultiLineString, ST_Point)
```

Return type

ST_MultiPoint

Example

```
CREATE TABLE linestring_test (line ST_LineString);

-- Create a U-shaped linestring:
INSERT INTO linestring_test VALUES (
   ST_LineFromText('linestring z (0 10 1, 0 0 3, 10 0 5, 10 10 7)', 0)
);


-- Perpendicular point is coincident with the input point,
-- on the base of the U:
SELECT SE_PerpendicularPoint(line, ST_PointFromText('point(5 0)', 0))
  FROM linestring_test;

(expression)  0 MULTIPOINT Z (5 0 4)


-- Perpendicular points are located on all three segments of the U:
SELECT SE_PerpendicularPoint(line, ST_PointFromText('point(5 5)', 0))
  FROM linestring_test;

(expression)  0 MULTIPOINT Z (0 5 2, 5 0 4, 10 5 6)


-- Perpendicular points are located at the endpoints of the U:
SELECT SE_PerpendicularPoint(line, ST_PointFromText('point(5 10)', 0))
  FROM linestring_test;

(expression)  0 MULTIPOINT Z (0 10 1, 10 10 7)


-- Perpendicular point is on the base of the U:
SELECT SE_PerpendicularPoint(line, ST_PointFromText('point(5 15)', 0))
  FROM linestring_test;

(expression)  0 MULTIPOINT Z (5 0 4)


-- No perpendicular point can be constructed:
SELECT SE_PerpendicularPoint(line, ST_PointFromText('point(15 15)', 0))
  FROM linestring_test;

(expression)  0 POINT EMPTY
```

The ST_Point() function

The **ST_Point()** function returns an ST_Point, given an X-coordinate, Y-coordinate, and spatial reference ID.

Syntax

```
ST_Point(X double precision, Y double precision, SRID integer)
```

Return type

ST_Point

Example

The following CREATE TABLE statement creates the **point_test** table, which has a single point column, **pt1**:

```
CREATE TABLE point_test (pt1 ST_Point);
```

The **ST_Point()** function converts the point coordinates into an ST_Point geometry before the INSERT statement inserts it into the **pt1** column:

```
INSERT INTO point_test VALUES(
   ST_Point(10.01,20.03,1000)
);
```

The ST_PointAtDistance() function

The **ST_PointAtDistance()** function returns the point the specified distance from the start of the line. Z coordinates and measures are ignored.

Syntax

```
ST_PointAtDistance (ST_LineString, float)
ST_PointAtDistance (ST_MultiLineString, float)
```

Return type

ST_Point

Example

The following SQL statement creates the **sample_geometries** table with two columns. The ID column uniquely identifies each row. The **geometry** ST_LineString column stores sample geometries.

```
CREATE TABLE sample_geometries(id INTEGER, geometry ST_LINESTRING);
```

The following SQL statement inserts two rows into the **sample_geometries** table:

```
INSERT INTO sample_geometries(id, geometry)
VALUES
 (1,ST_LineString('LINESTRING ZM(0 0 0 0, 10 100 1000 10000)',1)),
 (2,ST_LineString('LINESTRING ZM(10 100 1000 10000, 0 0 0 0)',1));
```

The following SELECT statement and the corresponding result set show how to use the **ST_PointAtDistance()** function to find points at a distance of 15 coordinate units from the start of the linestring.

```
SELECT ID, VARCHAR(ST_AsText(ST_PointAtDistance(geometry, 15)), 50) AS POINTAT
FROM  sample_geometries;

ID          POINTAT
----------- --------------------------------------------------
          1 POINT ZM(1.492556 14.925558 149 1493)
          2 POINT ZM(8.507444 85.074442 851 8507)

  2 record(s) selected.
```

The ST_PointFromGML() function

The **ST_PointFromGML()** function takes a GML2 or GML3 string representation of an ST_Point and an optional spatial reference ID and returns a point object.

Syntax

```
ST_PointFromGML(gmlstring lvarchar)
ST_PointFromGML(gmlstring lvarchar, SRID integer)
```

Return type

ST_Point

Example

The **point_t** table contains the gid INTEGER column, which uniquely identifies each row, the pdesc column which describes the point, and the p1 column which stores the point. In this example, GML3 is shown.

```
CREATE TABLE point_t (gid INTEGER, pdesc VARCHAR(30), p1 ST_Point);

INSERT INTO point_t VALUES(
1,
'This point is a simple XY point',
ST_PointFromGML('<gml:Point srsName="DEFAULT" srsDimension="2">
<gml:pos>10.02 20.01</gml:pos></gml:Point>',1000)) ;

INSERT INTO point_t VALUES(
2,
'This point is a XYZ point',
ST_PointFromGML('<gml:Point srsName="DEFAULT" srsDimension="3">
<gml:pos>10.02 20.01 5</gml:pos></gml:Point>',1000)) ;

INSERT INTO point_t VALUES(
3,
'This point is a XYM point',
ST_PointFromGML('<gml:Point srsName="DEFAULT" srsDimension="3">
<gml:pos>10.02 20.01 7</gml:pos></gml:Point>',1000));

INSERT INTO point_t VALUES(
4,
'This point is a XYZM point',
ST_PointFromGML('<gml:Point srsName="DEFAULT" srsDimension="4">
<gml:pos>10.02 20.01 5 7</gml:pos></gml:Point>',1000)) ;

INSERT INTO point_t VALUES(
5,
'This point is an empty point',
ST_PointFromGML('<gml:Point xsi:nil="true" srsName="UNKNOWN:0"
srsDimension="2"/>',1000));
```

The ST_PointFromKML() function

The **ST_PointFromKML()** function takes a KML Point string and an optional spatial reference ID and returns a point object. A Point string can contain the elements of <coordinates>, <extrude>, <tessellate>, and <altitudeMode>.

Syntax

```
ST_PointFromKML(kmlstring lvarchar)
ST_PointFromKML(kmlstring lvarchar, SRID integer)
```

Return type

ST_Point

Example

```
EXECUTE FUNCTION ST_PointFromKML('<Point><coordinates>-122.44255879,37.80666418
                </coordinates></Point>',3);
```

Output:

```
   3 POINT (-122.44255879 37.80666418)
```

The SE_PointFromShape() function

The **SE_PointFromShape()** function creates an ST_Point from a shape of type point and a spatial reference ID.

Syntax

```
SE_PointFromShape(s1 lvarchar, SRID integer)
```

Return type

ST_Point

Example

The hazardous sites are stored in the **hazardous_sites** table created with the CREATE TABLE statement that follows. The **location** column, defined as a point, stores a location that is the geographic center of each hazardous site:

```
CREATE TABLE hazardous_sites (site_id   integer,
                              name      varchar(40),
                              location  ST_Point);
```

The program fragment populates the **hazardous_sites** table:

```
/* Create the SQL insert statement to populate the hazardous_sites
     * table. The question marks are parameter markers that indicate
     * the column values that will be inserted at run time. */
    sprintf(sql_stmt,
           "INSERT INTO hazardous_sites (site_id, name, location) "
           "VALUES(?, ?, SE_PointFromShape(?, %d))", srid);

    /* Prepare the SQL statement for execution. */
    rc = SQLPrepare (hstmt, (unsigned char *)sql_stmt, SQL_NTS);

    /* Bind the site_id to the first parameter. */
    pcbvalue1 = 0;
    rc = SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_SLONG,
                           SQL_INTEGER, 0, 0,
                           &site_id, 0, &pcbvalue1);

    /* Bind the name to the second parameter. */
    pcbvalue2 = name_len;
    rc = SQLBindParameter (hstmt, 2, SQL_PARAM_INPUT, SQL_C_CHAR,
                           SQL_CHAR, 0, 0,
                           name, 0, &pcbvalue2);

    /* Bind the location geometry to the third parameter. */
    pcbvalue3 = location_shape_len;
    rc = SQLBindParameter (hstmt, 3, SQL_PARAM_INPUT, SQL_C_BINARY,
                           SQL_INFX_UDT_LVARCHAR, location_shape_len, 0,
                           location_shape_buf, location_shape_len, &pcbvalue3);

    /* Execute the insert statement. */
    rc = SQLExecute (hstmt);
```

The ST_PointFromText() function

The **ST_PointFromText()** function takes a well-known text representation of type point and a spatial reference ID and returns a point.

Syntax

```
ST_PointFromText(WKT lvarchar, SRID integer)
```

Return type

ST_Point

Example

The **point_test** table is created with the single ST_Point column **pt1**:

```
CREATE TABLE point_test (gid  smallint,
                              pt1 ST_Point);
```

The **ST_PointFromText()** function converts the point text coordinates to the ST_Point format before the INSERT statement inserts the point into the **pt1** column:

```
INSERT INTO point_test VALUES(
    1,
    ST_PointFromText('point(10.01 20.03)',1000)
);
```

The ST_PointFromWKB() function

The **ST_PointFromWKB()** function takes a well-known binary representation of type ST_Point and a spatial reference ID to return an ST_Point.

Syntax

```
ST_PointFromWKB (WKB lvarchar, SRID integer)
```

Return type

ST_Point

Example

The hazardous sites are stored in the **hazardous_sites** table created with the CREATE TABLE statement that follows. The **location** column, defined as an ST_Point, stores a location that is the geographic center of each hazardous site:

```
CREATE TABLE hazardous_sites (site_id   integer,
                              name      varchar(40),
                              location  ST_Point);
```

The program fragment populates the **hazardous_sites** table:

```
    /* Create the SQL insert statement to populate the hazardous_sites
     * table. The question marks are parameter markers that indicate
     * the column values that will be inserted at run time. */
    sprintf(sql_stmt,
            "INSERT INTO hazardous_sites (site_id, name, location) "
            "VALUES(?, ?, ST_PointFromWKB(?, %d))", srid);

    /* Prepare the SQL statement for execution. */
    rc = SQLPrepare (hstmt, (unsigned char *)sql_stmt, SQL_NTS);
```

```
/* Bind the site_id to the first parameter. */
pcbvalue1 = 0;
rc = SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_SLONG,
                       SQL_INTEGER, 0, 0,
                       &site_id, 0, &pcbvalue1);

/* Bind the name to the second parameter. */
pcbvalue2 = name_len;
rc = SQLBindParameter (hstmt, 2, SQL_PARAM_INPUT, SQL_C_CHAR,
                       SQL_CHAR, 0, 0,
                       name, 0, &pcbvalue2);

/* Bind the location geometry to the third parameter. */
pcbvalue3 = location_wkb_len;
rc = SQLBindParameter (hstmt, 3, SQL_PARAM_INPUT, SQL_C_BINARY,
                       SQL_INFX_UDT_LVARCHAR, location_wkb_len, 0,
                       location_wkb_buf, location_wkb_len, &pcbvalue3);

/* Execute the insert statement. */
rc = SQLExecute (hstmt);
```

The ST_PointN() function

The **ST_PointN()** function takes an ST_LineString and an INTEGER index and returns a point that is the *n*th vertex in the ST_LineString's path. (The numbering of the vertices in the linestring starts with 1.)

Syntax

```
ST_PointN (ln1 ST_LineString, index integer)
```

Return type

ST_Point

Example

The **pointn_test** table is created with the **gid** column, which uniquely identifies each row, and the **ln1** ST_LineString column:

```
CREATE TABLE pointn_test (gid integer,
                          ln1 ST_LineString);
```

The following INSERT statements insert two linestring values. The first linestring does not have Z coordinates or measures, while the second linestring has both:

```
INSERT INTO pointn_test VALUES(
   1,
   ST_LineFromText('linestring (10.02 20.01,23.73 21.92,30.10 40.23)',1000)
);

INSERT INTO pointn_test VALUES(
   2,
   ST_LineFromText('linestring zm (10.02 20.01 5.0 7.0,23.73 21.92
6.5 7.1,30.10 40.23 6.9 7.2)',1000)
);
```

The query lists the **gid** column and the second vertex of each linestring. The first row results in an ST_Point without a Z coordinate or measure, while the second row results in an ST_Point with a Z coordinate and a measure. The **ST_PointN()** function will also include a Z coordinate or measure value if they exist in the source linestring:

```
SELECT gid, ST_PointN(ln1,2) the_2nd_vertex
   FROM pointn_test;


gid             1
the_2nd_vertex  1000 POINT (23.73 21.92)

gid             2
the_2nd_vertex  1000 POINT ZM (23.73 21.92 6.5 7.1)
```

The ST_PointOnSurface() function

The **ST_PointOnSurface()** function takes an ST_Polygon or ST_MultiPolygon and returns an ST_Point guaranteed to lie on its surface.

Syntax

```
ST_PointOnSurface (pl1 ST_Polygon)
ST_PointOnSurface (mpl1 ST_MultiPolygon)
```

Return type

ST_Point

Example

The city engineer wants to create a label point for each building footprint.

The **buildingfootprints** table that was created with the following CREATE TABLE statement stores the building footprints:

```
CREATE TABLE buildingfootprints (building_id  integer,
                                 lot_id       integer,
                                 footprint    ST_MultiPolygon);
```

The **ST_PointOnSurface()** function generates a point that is guaranteed to be on the surface of the building footprints:

```
SELECT building_id, ST_PointOnSurface(footprint)
  FROM buildingfootprints;


building_id   506
(expression)  1000 POINT (12.5 49.5)

building_id   543
(expression)  1000 POINT (32 52.5)

building_id   1208
(expression)  1000 POINT (12.5 27.5)

building_id   178
(expression)  1000 POINT (32 30)
```

The ST_PolyFromGML() function

The **ST_PolyFromGML()** function takes a GML2 or GML3 string representation of an ST_Polygon and an optional spatial reference ID and returns a polygon object.

Syntax

```
ST_PolyFromGML(gmlstring lvarchar)
ST_PolyFromGML(gmlstring lvarchar, SRID integer)
```

Return type

ST_Polygon

Example

The **test_poly** table is created with the INTEGER column **id** and the ST_Polygon column **geom**:

```
CREATE TABLE test_poly(id INTEGER, geom ST_Polygon);

INSERT INTO test_poly VALUES(1,ST_PolyFromGML('<gml:Polygon
             srsName="EPSG:4326" srsDimension="2">
             <gml:exterior><gml:LinearRing><gml:posList dimension="2">
             -84.36 32.49 -82.66 32.69 -82.15 32.46 -83.09 33.08 -83.37
             33.19 -84.36 32.49</gml:posList></gml:LinearRing>
             </gml:exterior>< /gml:Polygon>',4));
```

This record specifies a spatial reference id of 4 (WGS84) and represents a two-dimensional six-sided polygon.

Output:

```
SELECT * FROM test_poly;

id    1
geom  4 POLYGON ((-84.3600000805 32.4900000536, -82.6599999799
                  32.6899999866, -82.1500000335 32.4600000469,
                  -83.0900000201 33.0800000738, -83.3700000268
                  33.1899999866, -84.3600000805 32.4900000536))
```

The ST_PolyFromKML() function

The **ST_PolyFromKML()** function takes a KML Polygon string representation and an optional spatial reference ID and returns a polygon object.

Syntax

```
ST_PolyFromKML(kmlstring lvarchar)
ST_PolyFromKML(kmlstring lvarchar, SRID integer)
```

Return type

ST_Polygon

Example

```
EXECUTE FUNCTION ST_PolyFromKML('<Polygon><outerBoundaryIs>
                 <LinearRing>
                 <coordinates>-122.365662,37.826988,0
                 -122.365202,37.826302,0 -122.364581,37.82655,0
                 -122.365038,37.827237,0 -122.365662,37.826988,0
                 </coordinates></LinearRing></outerBoundaryIs>
                 </Polygon>',4);
```

Output:

```
4 POLYGON Z ((-122.365662056 37.8269879529 0, -122.365202058
              37.8263019779 0, -122.364580958 37.8265500822 0,
              -122.36503794 37.827237063 0, -122.365662056
              37.8269879529 0))
```

The SE_PolyFromShape() function

The **SE_PolyFromShape()** function returns an ST_Polygon from a shape of type polygon and a spatial reference ID.

Syntax

```
SE_PolyFromShape(s1 lvarchar, SRID integer)
```

Return type

ST_Polygon

Example

The **sensitive_areas** table contains several columns that describe the threatened institutions in addition to the **zone** column, which stores the institution polygon geometries:

```
CREATE TABLE sensitive_areas (id     integer,
                              name   varchar(128),
                              size   float,
                              type   varchar(10),
                              zone   ST_Polygon);
```

The program fragment populates the **sensitive_areas** table. The question marks represent parameter markers for the **ID**, **name**, **size**, **type**, and **zone** values that will be retrieved at run time:

```
/* Create the SQL insert statement to populate the sensitive_areas
 * table. The question marks are parameter markers that indicate
 * the column values that will be inserted at run time. */
sprintf(sql_stmt,
        "INSERT INTO sensitive_areas (id, name, size, type, zone) "
        "VALUES(?, ?, ?, ?, SE_PolyFromShape(?, %d))", srid);

/* Prepare the SQL statement for execution. */
rc = SQLPrepare (hstmt, (unsigned char *)sql_stmt, SQL_NTS);

/* Bind the id to the first parameter. */
pcbvalue1 = 0;
rc = SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_SLONG,
                       SQL_INTEGER, 0, 0,
                       &id, 0, &pcbvalue1);

/* Bind the name to the second parameter. */
pcbvalue2 = name_len;
rc = SQLBindParameter (hstmt, 2, SQL_PARAM_INPUT, SQL_C_CHAR,
                       SQL_CHAR, 0, 0,
                       name, 0, &pcbvalue2);

/* Bind the size to the third parameter. */
pcbvalue3 = 0;
rc = SQLBindParameter (hstmt, 3, SQL_PARAM_INPUT, SQL_C_FLOAT,
                       SQL_REAL, 0, 0,
                       &size, 0, &pcbvalue3);

/* Bind the type to the fourth parameter. */
pcbvalue4 = type_len;
rc = SQLBindParameter (hstmt, 4, SQL_PARAM_INPUT, SQL_C_CHAR,
                       SQL_VARCHAR, type_len, 0,
                       type, type_len, &pcbvalue4);

/* Bind the zone geometry to the fifth parameter. */
pcbvalue5 = zone_shape_len;
```

```
    rc = SQLBindParameter (hstmt, 5, SQL_PARAM_INPUT, SQL_C_BINARY,
                           SQL_INFX_UDT_LVARCHAR, zone_shape_len, 0,
                           zone_shape_buf, zone_shape_len, &pcbvalue5);

    /* Execute the insert statement. */
    rc = SQLExecute (hstmt);
```

The ST_PolyFromText() function

The **ST_PolyFromText()** function takes a well-known text representation of type ST_Polygon and a spatial reference ID and returns an ST_Polygon.

Syntax

```
ST_PolyFromText(wkt lvarchar, SRID integer)
```

Return type

ST_Polygon

Example

The **polygon_test** table is created with the single polygon column:

```
CREATE TABLE polygon_test (pl1 ST_Polygon);
```

The following INSERT statement inserts a polygon into the **pl1** polygon column using the **ST_PolyFromText()** function:

```
INSERT INTO polygon_test VALUES(
    ST_PolyFromText('polygon((10.01 20.03,10.52 40.11,30.29
41.56,31.78 10.74,10.01 20.03))',1000)
);
```

The ST_PolyFromWKB() function

The **ST_PolyFromWKB()** function takes a well-known binary representation of type ST_Polygon and a spatial reference ID to return an ST_Polygon.

Syntax

```
ST_PolyFromWKB(wkb lvarchar, SRID integer)
```

Return type

ST_Polygon

Example

The **sensitive_areas** table contains several columns that describe the threatened institutions in addition to the **zone** column, which stores the institution ST_Polygon geometries:

```
CREATE TABLE sensitive_areas (id     integer,
                              name   varchar(128),
                              size   float,
                              type   varchar(10),
                              zone   ST_Polygon);
```

The program fragment populates the **sensitive_areas** table:

```
/* Create the SQL insert statement to populate the sensitive_areas
 * table. The question marks are parameter markers that indicate
 * the column values that will be inserted at run time. */
sprintf(sql_stmt,
        "INSERT INTO sensitive_areas (id, name, size, type, zone) "
        "VALUES(?, ?, ?, ?, ST_PolyFromWKB(?, %d))", srid);

/* Prepare the SQL statement for execution. */
rc = SQLPrepare (hstmt, (unsigned char *)sql_stmt, SQL_NTS);

/* Bind the id to the first parameter. */
pcbvalue1 = 0;
rc = SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_SLONG,
                       SQL_INTEGER, 0, 0,
                       &id, 0, &pcbvalue1);

/* Bind the name to the second parameter. */
pcbvalue2 = name_len;
rc = SQLBindParameter (hstmt, 2, SQL_PARAM_INPUT, SQL_C_CHAR,
                       SQL_CHAR, 0, 0,
                       name, 0, &pcbvalue2);

/* Bind the size to the third parameter. */
pcbvalue3 = 0;
rc = SQLBindParameter (hstmt, 3, SQL_PARAM_INPUT, SQL_C_FLOAT,
                       SQL_REAL, 0, 0,
                       &size, 0, &pcbvalue3);

/* Bind the type to the fourth parameter. */
pcbvalue4 = type_len;
rc = SQLBindParameter (hstmt, 4, SQL_PARAM_INPUT, SQL_C_CHAR,
                       SQL_VARCHAR, type_len, 0,
                       type, type_len, &pcbvalue4);

/* Bind the zone geometry to the fifth parameter. */
pcbvalue5 = zone_wkb_len;
rc = SQLBindParameter (hstmt, 5, SQL_PARAM_INPUT, SQL_C_BINARY,
                       SQL_INFX_UDT_LVARCHAR, zone_wkb_len, 0,
                       zone_wkb_buf, zone_wkb_len, &pcbvalue5);

/* Execute the insert statement. */
rc = SQLExecute (hstmt);
```

The ST_Polygon() function

The **ST_Polygon()** function generates an ST_Polygon from a ring (an ST_LineString that is both simple and closed).

Syntax

```
ST_Polygon (ln ST_LineString)
```

Return type

ST_Polygon

Example

The following CREATE TABLE statement creates the **polygon_test** table, which has a single column, **p1**:

```
CREATE TABLE polygon_test (p1 ST_polygon);
```

The INSERT statement converts a ring (an ST_LineString that is both closed and simple) into an ST_Polygon and inserts it into the **p1** column using the **ST_LineFromText()** function within the **ST_Polygon()** function:

```
INSERT INTO polygon_test VALUES(
   ST_Polygon(ST_LineFromText('linestring (10.01 20.03, 20.94
21.34, 35.93 10.04, 10.01 20.03)',1000))
);
```

The ST_Relate() function

The **ST_Relate()** function compares two geometries and returns 1 (TRUE) if the geometries meet the conditions specified by the DE-9IM pattern matrix string; otherwise, 0 (FALSE) is returned.

Syntax

```
ST_Relate(g1 ST_Geometry, g2 ST_Geometry, patternMatrix lvarchar)
```

Return type

BOOLEAN

Example

A DE-9IM pattern matrix is a device for comparing geometries. There are several types of such matrices. For example, the *equals* pattern matrix will tell you if any two geometries are equal.

In this example, an equals pattern matrix, shown below, is read left to right, and top to bottom into the string ("T*F**FFF*"):

Table 7-17. Pattern matrix for equals

	Interior (b)	Boundary (b)	Exterior (b)
Interior (a)	T	*	F
Boundary (a)	*	*	F
Exterior (a)	F	F	*

Next, the table **relate_test** is created with the following CREATE TABLE statement:

```
CREATE TABLE relate_test (g1 ST_Geometry,
                          g2 ST_Geometry,
                          g3 ST_Geometry);
```

The following INSERT statements insert a sample subclass into the **relate_test** table:

```
INSERT INTO relate_test VALUES(
   ST_PointFromText('point (10.02 20.01)',1000),
   ST_PointFromText('point (10.02 20.01)',1000),
   ST_PointFromText('point (30.01 20.01)',1000)
);
```

The following SELECT statement and the corresponding result set lists the subclass name stored in the **geotype** column with the dimension of that geotype:

```
SELECT ST_Relate(g1,g2,"T*F**FFF*") equals,
       ST_Relate(g1,g3,"T*F**FFF*") not_equals
   FROM relate_test;
```

```
equals not_equals

     t          f
```

The SE_Release() function

The **SE_Release()** function returns a text string containing the installed version and release date of the IBM Informix spatial extension.

Syntax

```
SE_Release()
```

Return type

A text string containing the installed version and release date.

The SE_ShapeToSQL() function

The **SE_ShapeToSQL()** function constructs an ST_Geometry given its ESRI shape representation. The SRID of the St_Geometry is 0.

Syntax

```
SE_ShapeToSQL(ShapeGeometry lvarchar)
```

Return type

ST_Geometry

Example

The following C code fragment contains ODBC functions that insert data into the **lots** table. The **lots** table was created with two columns: **lot_id**, which uniquely identifies each lot, and the **lot** polygon column, which contains the geometry of each lot:

```
CREATE TABLE lots (lot_id  integer,
                   lot     ST_MultiPolygon);
```

The **SE_ShapeToSQL()** function converts shapes into ST_Geometry values. The INSERT statement contains parameter markers to accept the **lot_id** and the lot data, dynamically:

```
/* Create the SQL insert statement to populate the lots table.
     * The question marks are parameter markers that indicate the
     * column values that will be inserted at run time. */
    sprintf(sql_stmt,
            "INSERT INTO lots (lot_id, lot) "
            "VALUES(?, SE_ShapeToSQL(?))");

    /* Prepare the SQL statement for execution. */
    rc = SQLPrepare (hstmt, (unsigned char *)sql_stmt, SQL_NTS);

    /* Bind the lot_id to the first parameter. */
    pcbvalue1 = 0;
    rc = SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_SLONG,
                           SQL_INTEGER, 0, 0,
                           &lot_id, 0, &pcbvalue1);

    /* Bind the lot geometry the second parameter. */
    pcbvalue2 = lot_shape_len;
```

```
rc = SQLBindParameter (hstmt, 2, SQL_PARAM_INPUT, SQL_C_BINARY,
                       SQL_INFX_UDT_LVARCHAR, lot_shape_len, 0,
                       lot_shape_buf, lot_shape_len, &pcbvalue2);

/* Execute the insert statement. */
rc = SQLExecute (hstmt);
```

The SE_SpatialKey() function

The **SE_SpatialKey()** function generates a *sort key* for an ST_Geometry. A sort key is a numeric value that can be used to sort spatial objects according to their proximity to one another.

The sort key is computed by applying the Hilbert space-filling curve algorithm to the center point of an object's bounding box.

Syntax

```
SE_SpatialKey(g1 ST_Geometry)
```

Return type

A numeric sort key, as an INT8

Example

Create and populate a **cities** table containing the names and locations of world cities:

```
CREATE TABLE cities (name varchar(255),
                     locn ST_Point);

LOAD FROM cities.load INSERT INTO cities;
```

Create a clustered functional B-tree index. This rearranges the table data, placing it in spatial key sort order. Chapter 4, "R-tree indexes," on page 4-1, provides information about using indexes, in particular, R-tree indexes. For example:

```
CREATE CLUSTER INDEX cbt_idx ON cities (SE_SpatialKey(locn));
```

Create an R-tree index with the NO_SORT option:

```
CREATE INDEX locn_idx ON cities (locn ST_Geometry_ops)
  USING RTREE (BOTTOM_UP_BUILD='yes', NO_SORT='yes');
```

Drop the B-tree index; it is no longer needed:

```
DROP INDEX cbt_idx;
```

Related concepts:

"Bottom-up versus top-down index builds" on page 4-3

Related reference:

"Syntax for creating an R-tree index" on page 4-1

The ST_SRID() function

The **ST_SRID()** function takes an ST_Geometry object and returns its spatial reference ID.

Syntax

```
ST_SRID(g1 ST_Geometry)
```

Return type

INTEGER

Example

During the installation of the IBM Informix Spatial DataBlade Module, the **spatial_references** table is created by this CREATE TABLE statement:

```
CREATE TABLE sde.spatial_references
(
    srid              integer      NOT NULL,
    description       varchar(64),
    auth_name         varchar(255),
    auth_srid         integer,
    falsex            float        NOT NULL,
    falsey            float        NOT NULL,
    xyunits           float        NOT NULL,
    falsez            float        NOT NULL,
    zunits            float        NOT NULL,
    falsem            float        NOT NULL,
    munits            float        NOT NULL,
    srtext            char(2048)   NOT NULL,
  PRIMARY KEY (srid)
      CONSTRAINT sde.sp_ref_pk
);
```

Before you can create geometry and insert it into a table, you must enter the SRID of that geometry into the **spatial_references** table. This is a sample insert of a spatial reference system. The spatial reference system has an SRID value of 1, a false X, Y of (0,0), and its system units are 100. The Z coordinate and measure offsets are 0, while the Z coordinate and measure units are 1.

```
INSERT INTO spatial_references
     (srid, description, auth_name, auth_srid, falsex, falsey,
      xyunits, falsez, zunits, falsem, munits, srtext)
   VALUES (1, NULL, NULL, NULL, 0, 0, 100, 0, 1, 0, 1, 'UNKNOWN');
```

Important: Choose the parameters of a **spatial_references** table entry with care.

The following table is created for this example:

```
CREATE TABLE srid_test(g1 ST_Geometry);
```

In the next statement, an ST_Point geometry located at coordinate (10.01,50.76) is inserted into the geometry column **g1**. When the ST_Point geometry is created by the **ST_PointFromText()** function, it is assigned the SRID value of 1:

```
INSERT INTO srid_test VALUES(
   ST_PointFromText('point(10.01 50.76)',1000)
);
```

The **ST_SRID()** function returns the spatial reference ID of the geometry just entered:

```
SELECT ST_SRID(g1)
   FROM srid_test;

(expression)

        1000
```

Related reference:

"The spatial_references table" on page 1-12

The SE_SRID_Authority() function

The **SE_SRID_Authority()** function takes a spatial reference ID and returns the Authority Name and Authority SRID as an LVARCHAR string in the form AuthName:SRID. If the AuthName is null in the sde.spatial_references table for a given spatial reference ID, the srtext is returned.

Syntax

```
SE_SRID_Authority(SRID integer)
```

Return type

LVARCHAR

Example

```
select SE_SRID_Authority(srid) from sde.spatial_references;

(expression)  UNKNOWN:0
(expression)  EPSG:4135
(expression)  EPSG:4267
(expression)  EPSG:4269
(expression)  EPSG:4326
(expression)  UNKNOWN:0
(expression)  UNKNOWN:0
(expression)  UNKNOWN:0
(expression)  AUTH_NAME:1234
(expression)  GEOGCS["GCS_Old_Hawaiian",
              DATUM["D_OldHawaiian",
              SPHEROID["Clarke_1866",6378206.4,294.9786982]],
              PRIMEM["Greenwich",0],UNIT["Degree",0.01745329 25199433]]

10 row(s) retrieved.
```

The ST_StartPoint() function

The **ST_StartPoint()** function returns the first point of a linestring.

Syntax

```
ST_StartPoint(ln1 ST_LineString)
```

Return type

ST_Point

Example

The **startpoint_test** table is created with the **gid** INTEGER column, which uniquely identifies the rows of the table, and the **ln1** ST_LineString column:

```
CREATE TABLE startpoint_test (gid integer,
                              ln1 ST_LineString);
```

The following INSERT statements insert the ST_LineStrings into the **ln1** column. The first ST_LineString does not have Z coordinates or measures, while the second ST_LineString has both:

```
INSERT INTO startpoint_test VALUES(
   1,
   ST_LineFromText('linestring (10.02 20.01,23.73 21.92,30.10 40.23)', 1000)
);
```

```
INSERT INTO startpoint_test VALUES(
   2,
   ST_LineFromText('linestring zm (10.02 20.01 5.0 7.0,23.73 21.92
6.5 7.1,30.10 40.23 6.9 7.2)', 1000)
);
```

The **ST_StartPoint()** function extracts the first point of each ST_LineString. The first point in the list does not have a Z coordinate or a measure, while the second point has both because the source linestring does:

```
SELECT gid, ST_StartPoint(ln1) Startpoint
   FROM startpoint_test;


gid         1
startpoint  1000 POINT (10.02 20.01)

gid         2
startpoint  1000 POINT ZM (10.02 20.01 5 7)
```

See also

"The ST_EndPoint() function" on page 7-51

The ST_SymDifference() function

The **ST_SymDifference()** function takes two ST_Geometry objects and returns an ST_Geometry object that is the logical XOR of space. In other words, it returns an object that is composed of the portions of the source objects that are not part of the intersection set.

Syntax

```
ST_SymDifference (g1 ST_Geometry, g2 ST_Geometry)
```

Usage

The source geometries must have the same dimension. If the geometries are equal, the **ST_StartPoint()** function returns an empty geometry; otherwise, the function returns the result as an ST_GeomCollection (ST_MultiPoint, ST_MultiLineString, or ST_MultiPolygon).

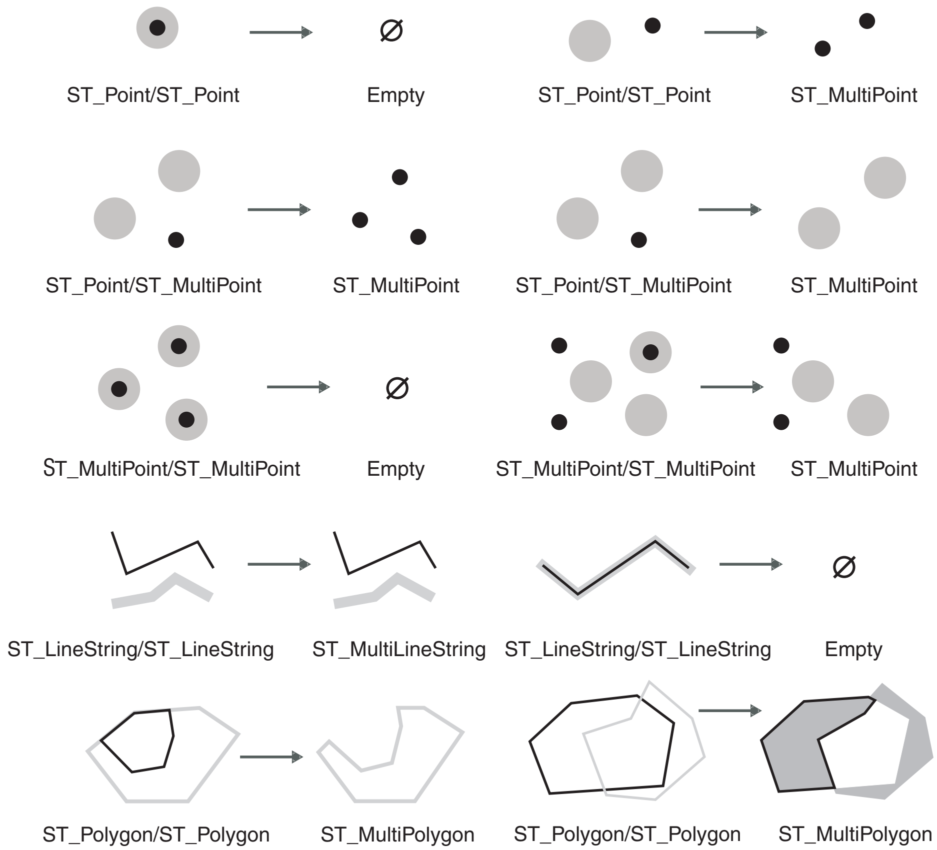


Figure 7-25. The symmetric difference of geometries

Return type

ST_Geometry

Example

For a special report, the county supervisor must determine the area of sensitive areas and 5-mile hazardous site radii that do not intersect.

The **sensitive_areas** table contains several columns that describe the threatened institutions, in addition to the **zone** column, which stores the institutions' ST_Polygon geometries:

```
CREATE TABLE sensitive_areas (id     integer,
                              name   varchar(128),
                              size   float,
                              type   varchar(10),
                              zone   ST_Polygon);
```

The **hazardous_sites** table stores the identity of the sites in the **site_id** and **name** columns. The actual geographic location of each site is stored in the **location** point column:

```
CREATE TABLE hazardous_sites (site_id   integer,
                              name      varchar(40),
                              location  ST_Point);
```

The **ST_Buffer()** function generates a 5-mile buffer that surrounds the hazardous waste site locations. The **ST_StartPoint()** function returns the polygons of the buffered hazardous waste site polygons and the sensitive areas that do not intersect:

```
SELECT sa.name sensitive_area, hs.name hazardous_site,
       ST_Area(ST_SymDifference(ST_buffer(hs.location,(5 * 5280)),sa.zone)::
   ST_MultiPolygon) area
   FROM hazardous_sites hs, sensitive_areas sa;
```

The following figure shows that the symmetric difference of the hazardous waste sites and the sensitive areas results in the subtraction of the intersected areas.

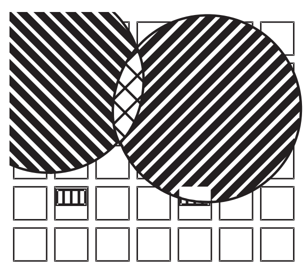


Figure 7-26. Using the ST_SymDifference function

The SE_TotalSize() function

The **SE_TotalSize()** function returns the sum of the in-row and out-of-row components of a geometry.

You can use this function to obtain an estimate of the amount of disk space consumed by one or more geometries. However, this function does not account for dbspace and sbspace overhead, so cannot be used to obtain an exact total.

Syntax

```
SE_TotalSize(ST_Geometry)
```

Return type

INTEGER

See also

"The SE_InRowSize() function" on page 7-69

"The SE_OutOfRowSize() function" on page 7-109

The ST_Touches() function

The **ST_Touches()** function returns t (TRUE) if none of the points common to both geometries intersect the interiors of both geometries; otherwise, it returns f (FALSE). At least one geometry must be an ST_LineString, ST_Polygon, ST_MultiLineString, or ST_MultiPolygon.

Syntax

```
ST_Touches(g1 ST_Geometry, g2 ST_Geometry)
```

Usage

The following figure shows various geometric objects that touch but do not intersect with each other.

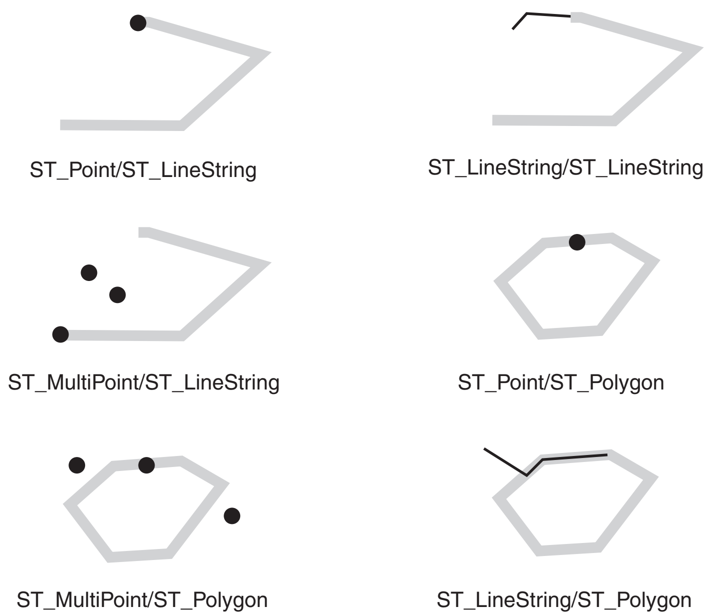


Figure 7-27. Touching geometries

The results of the spatial relationship of the **ST_Touches()** function can be understood or verified by comparing the results with a pattern matrix that represents the acceptable values for the DE-9IM. The pattern matrices state that the **ST_Touches()** function returns TRUE when the interiors of the geometry do not intersect, and the boundary of either geometry intersects the other's interior or boundary.

The **ST_Touches()** function returns TRUE if the boundary of one geometry intersects the interior of the other but the interiors do not intersect.

Table 7-18. Pattern matrix for the ST_Touches() function.

	Interior (b)	**Boundary (b)**	**Exterior (b)**
Interior (a)	F	T	*
Boundary (a)	*	*	*
Exterior (a)	*	*	*

The **ST_Touches()** function returns TRUE if the boundary of one geometry intersects the interior of the other but the interiors do not intersect.

	Interior (b)	**Boundary (b)**	**Exterior (b)**
Interior (a)	F	*	*
Boundary (a)	T	*	*
Exterior (a)	*	*	*

The **ST_Touches()** function returns TRUE if the boundaries of both geometries intersect but the interiors do not.

	Interior (b)	Boundary (b)	Exterior (b)
Interior (a)	F	*	*
Boundary (a)	*	T	*
Exterior (a)	*	*	*

Return type

BOOLEAN

Example

The GIS technician is asked to provide a list of all sewer lines whose endpoints intersect another sewer line.

The **sewerlines** table is created with three columns. The first column, **sewer_id**, uniquely identifies each sewer line. The INTEGER **class** column identifies the type of sewer line, generally associated with the line's capacity. The **sewer** ST_LineString column stores the sewer line's geometry:

```
CREATE TABLE sewerlines (sewer_id  integer,
                         class     integer,
                         sewer     ST_LineString);
```

The query returns a list of **sewer_ids** that touch one another:

```
SELECT s1.sewer_id, s2.sewer_id
   FROM sewerlines s1, sewerlines s2
   WHERE ST_Touches(s1.sewer, s2.sewer);
```

Related reference:

"The Dimensionally Extended 9 Intersection Model" on page 7-2

The SE_Trace() function

The **SE_Trace()** function provides tracing for spatial data type functions.

The **SE_Trace()** function provides the following levels of tracing:

Level 1
: SQL function entry and exit

Level 2
: Secondary function entry and exit

Level 3
: Miscellaneous additional tracing

Important: You should turn off tracing during normal use, because it can generate tremendous amounts of trace output data. It is intended for use byIBM Software Support in isolating problems.

Syntax

```
SE_Trace(pathname lvarchar, level integer)
```

Where *pathname* is a file name and full path on the server machine and *level* is 1, 2 or 3.

Return type

The text string OK, if the function was successfully executed

Example

This example shows the file separator for UNIX: a forward slash (/). If you are using a Windows platform, substitute the UNIX file separator with a backslash (\) in the path name.

```
execute function SE_Trace ('/tmp/spatial.trc', 1);
```

The ST_Transform() function

The **ST_Transform()** function transforms an ST_Geometry into the specified spatial reference system.

The following transformations are valid:

- Between two UNKNOWN coordinate systems (that is, the **srtext** column in the **spatial_references** table for both SRIDs contains UNKNOWN)
- Between a projected coordinate system and an unprojected coordinate system
- Between two projected coordinate systems
- Between two coordinate systems that have different false origins or system units

The geographical coordinate systems of the source and target spatial reference systems do not need to be the same. A spatial reference system in one geographical coordinate system can be transformed into a spatial reference system in a different geographical coordinate system if the transform is supported by the ESRI libraries.

Syntax

```
ST_Transform(g ST_Geometry, SRID integer)
```

Return type

ST_Geometry

Example: Change the false origin of a spatial reference system

Suppose you create a **spatial_references** table entry suitable for Australia with the **SE_CreateSrid()** function:

```
EXECUTE FUNCTION SE_CreateSrid (110, -45, 156, -10,
                                "Australia: lat/lon coords");

(expression)

        1002
```

Now load all of your data for Australia:

```
CREATE TABLE aus_locns (name varchar(128), locn ST_Point);

INSERT INTO aus_locns VALUES ("Adelaide",    '1002 point(139.14 -34.87)');
INSERT INTO aus_locns VALUES ("Brisbane",    '1002 point(153.36 -27.86)');
INSERT INTO aus_locns VALUES ("Canberra",    '1002 point(148.84 -35.56)');
INSERT INTO aus_locns VALUES ("Melbourne",   '1002 point(145.01 -37.94)');
INSERT INTO aus_locns VALUES ("Perth",       '1002 point(116.04 -32.12)');
INSERT INTO aus_locns VALUES ("Sydney",      '1002 point(151.37 -33.77)');
```

After you load all of your data for the Australian mainland, you realize you must include data for a few outlying islands, such as Norfolk Island and the Cocos Islands. However, the false origin and scale factor that you chose for SRID 1002 does not work for these islands as well:

```
INSERT INTO aus_locns VALUES ("Norfolk Is.", '1002 point(167.83 -29.24)');
(USE19) - Coordinates out of bounds in ST_PointIn.

INSERT INTO aus_locns VALUES ("Cocos Is.",   '1002 point( 96.52 -12.08)');
(USE19) - Coordinates out of bounds in ST_PointIn.
```

The solution is to create a **spatial_references** table entry with a false origin and scale factor that accommodates both the old data and new data, and then update the old data:

```
EXECUTE FUNCTION SE_CreateSrid (95, -55, 170, -10,
                                "Australia + outer islands: lat/lon coords");

(expression)

        1003


INSERT INTO aus_locns VALUES ("Norfolk Is.", '1003 point(167.83 -29.24)');
INSERT INTO aus_locns VALUES ("Cocos Is.",   '1003 point( 96.52 -12.08)');

UPDATE aus_locns
   SET locn = ST_Transform(locn, 1003)::ST_Point
   WHERE ST_Srid(locn) = 1002;
```

Example: Project data dynamically

In a typical application, spatial data is stored in unprojected latitude and longitude format. Then, when you draw a map, you retrieve the data in a particular projection.

First, create a **spatial_references** table entry that is suitable for your unprojected data. For this example, use the 1983 North American datum. Because this datum is a well-known, standard datum you can use the **SE_CreateSrtext()** function to create the **srtext** field:

```
INSERT INTO spatial_references
  (srid, description, falsex, falsey, xyunits,
   falsez, zunits, falsem, munits, srtext)
VALUES (1004, "Unprojected lat/lon, NAD 83 datum",
        -180, -90, 5000000, 0, 1000, 0, 1000,
        SE_CreateSrtext(4269));
```

Now create a table and load your data:

```
CREATE TABLE airports (id    char(4),
                       name  varchar(128),
                       locn  ST_Point);

INSERT INTO airports VALUES(
   'BTM', 'Bert Mooney',          '1004 point(-112.4975 45.9548)');
INSERT INTO airports VALUES(
   'BZN', 'Gallatin Field',       '1004 point(-111.1530 45.7769)');
INSERT INTO airports VALUES(
   'COD', 'Yellowstone Regional', '1004 point(-109.0238 44.5202)');
INSERT INTO airports VALUES(
   'JAC', 'Jackson Hole',         '1004 point(-110.7377 43.6073)');
INSERT INTO airports VALUES(
   'IDA', 'Fanning Field',        '1004 point(-112.0702 43.5146)');
```

Create one or more **spatial_references** table entries for any projections that you need. Be sure that the underlying geographic coordinate system (in this case, NAD 83) is the same:

```
INSERT INTO spatial_references
  (srid, description, falsex, falsey, xyunits,
   falsez, zunits, falsem, munits, srtext)
VALUES (1005, "UTM zone 12N, NAD 83 datum",
        336000, 4760000, 1000, 0, 1000, 0, 1000,
        SE_CreateSrtext(26912));
```

Transform the data to a projected coordinate system on an as needed basis:

```
SELECT id, ST_Transform(locn, 1005) as utm FROM airports;


id   BTM
utm  1005 POINT (383951.152 5090115.666)

id   BZN
utm  1005 POINT (488105.331 5069271.419)

id   COD
utm  1005 POINT (657049.762 4931552.365)

id   JAC
utm  1005 POINT (521167.881 4828291.447)

id   IDA
utm  1005 POINT (413500.979 4818519.081)
```

Example: Compare geometries that have different SRIDs

You can use the **ST_Transform()** function to transform a geometry when you compare two geometries that have different SRIDs:

```
SELECT * FROM tab1 a, tab2 b WHERE
   ST_Intersects(a.shape, ST_Transform(b.shape, ST_SRID(a.shape)));
```

Example: Transform between geographic spatial reference systems

The following statements create a table and insert data for the geographic spatial reference system 4326:

```
CREATE TABLE geogcs_to_geogs_xform (pid smallint, geom ST_Geometry) ;

INSERT INTO geogcs_to_geogs_xform
       VALUES (5, ST_GeomFromText ('point (10.05 10.28)', 4326)) ;

INSERT INTO geogcs_to_geogs_xform
       VALUES (6, ST_GeomFromText ('point z (10.05 10.28 2.51)', 4326)) ;

INSERT INTO geogcs_to_geogs_xform
       VALUES (7, ST_GeomFromText ('point m (10.05 10.28 4.72)', 4326)) ;

INSERT INTO geogcs_to_geogs_xform
       VALUES (8, ST_GeomFromText ('point zm (10.05 10.28 2.51 4.72)', 4326)) ;
```

The following query transforms the rows from the geographic spatial reference system 4326 to the geographic spatial reference system 4269:

```
SELECT pid, ST_Transform (geom, 4269) FROM geogcs_to_geogs_xform;

pid          5
(expression)  4269 POINT (10.0499794612 10.2799956451)
```

```
pid           6
(expression)  4269 POINT Z (10.0499794612 10.2799956451 2.51)

pid           7
(expression)  4269 POINT M (10.0499794612 10.2799956451 4.72)

pid           8
(expression)  4269 POINT ZM (10.0499794612 10.2799956451 2.51 4.72)

4 row(s) retrieved.
```

Example: Transform between projected spatial reference systems

This example transforms data between projected spatial reference systems that are in different geographic coordinate systems.

The following statements create a table and insert data for the projected spatial reference system 2153:

```
CREATE TABLE projcs_to_projcs_xform (pid smallint, geom ST_Geometry) ;

INSERT INTO projcs_to_projcs_xform
       VALUES (11, ST_GeomFromText ('point(573900 9350)', 2153)) ;

INSERT INTO projcs_to_projcs_xform
       VALUES (12, ST_GeomFromText ('multipoint(573900 9350, 573900 9351,
               573901 9351, 573901 9350, 573900 9350)', 2153)) ;

INSERT INTO projcs_to_projcs_xform
       VALUES (13, ST_GeomFromText ('linestring(573900 9350, 573901 9350)',
               2153)) ;

INSERT INTO projcs_to_projcs_xform
       VALUES (14, ST_GeomFromText ('linestring(573900 9350, 573900 9351,
               573901 9351, 573901 9350, 573900 9350)', 2153)) ;

INSERT INTO projcs_to_projcs_xform
       VALUES (15, ST_GeomFromText ('multilinestring((573900 9350, 573900 9351,
               573901 9351, 573901 9350, 573900 9350),(573902 2, 573902 3,
               573903 3, 573903 2, 573902 2))', 2153)) ;

INSERT INTO projcs_to_projcs_xform
       VALUES (16, ST_GeomFromText ('polygon((573900 9350, 573900 9351,
               573901 9351, 573901 9350, 573900 9350))', 2153)) ;

INSERT INTO projcs_to_projcs_xform
       VALUES (17, ST_GeomFromText ('multipolygon(((573900 9350, 573900 9351,
               573901 9351, 573901 9350, 573900 9350)),((573902 2, 573902 3,
               573903 3, 573903 2, 573902 2)))', 2153)) ;
```

The following query transforms the rows from the projected spatial reference system 2153 to the projected spatial reference system 32611:

```
SELECT pid, ST_Transform (geom, 32611) FROM projcs_to_projcs_xform;

pid           11
(expression)  32611 POINT (573898.627678 9349.9324469)

pid           12
(expression)  32611 MULTIPOINT (573898.627678 9349.9324469, 573898.627678 9350.
              9324471, 573899.627679 9350.93244701, 573899.627679 9349.93244681
              , 573898.627678 9349.9324469)

pid           13
```

```
(expression)  32611 LINESTRING (573898.627678 9349.9324469, 573899.627679 9349.
              93244681)

pid           14
(expression)  32611 LINESTRING (573898.627678 9349.9324469, 573898.627678 9350.
              9324471, 573899.627679 9350.93244701, 573899.627679 9349.93244681
              , 573898.627678 9349.9324469)

pid           15
(expression)  32611 MULTILINESTRING ((573898.627678 9349.9324469, 573898.627678
               9350.9324471, 573899.627679 9350.93244701, 573899.627679 9349.93
              244681, 573898.627678 9349.9324469),(573900.626767 1.93059742451,
               573900.626768 2.93059762195, 573901.626768 2.93059752136, 573901
              .626768 1.93059733883, 573900.626767 1.93059742451))

pid           16
(expression)  32611 POLYGON ((573898.627678 9349.9324469, 573899.627679 9349.93
              244681, 573899.627679 9350.93244701, 573898.627678 9350.9324471,
              573898.627678 9349.9324469))

pid           17
(expression)  32611 MULTIPOLYGON (((573898.627678 9349.9324469, 573899.627679 9
              349.93244681, 573899.627679 9350.93244701, 573898.627678 9350.932
              4471, 573898.627678 9349.9324469)),((573900.626767 1.93059742451,
               573901.626768 1.93059733883, 573901.626768 2.93059752136, 573900
              .626768 2.93059762195, 573900.626767 1.93059742451)))

7 row(s) retrieved.
```

Related reference:

Appendix B, “OGC well-known text representation of spatial reference systems,” on page B-1

The ST_Union() function

The **ST_Union()** function returns an ST_Geometry object that is the union of two source objects, the Boolean logical OR of space.

Syntax

```
ST_Union(g1 ST_Geometry, g2 ST_Geometry)
```

Usage

The source geometries must have the same dimension. **ST_Union()** returns the result as an ST_GeomCollection (ST_MultiPoint, ST_MultiLineString, or ST_MultiPolygon).

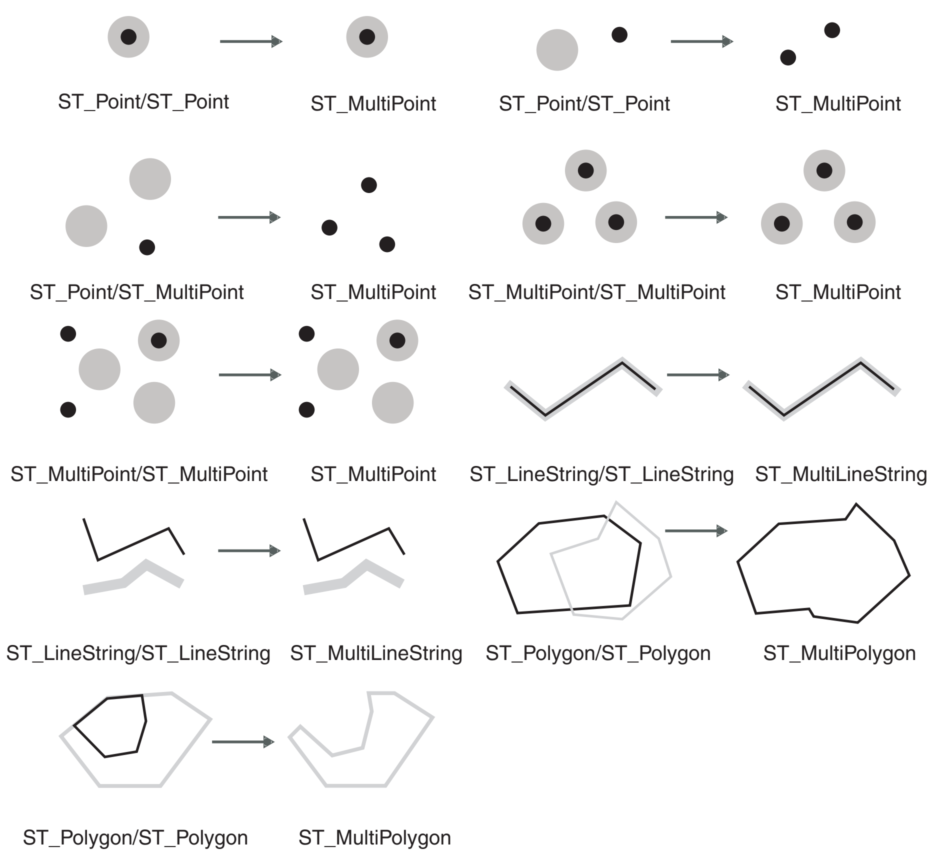


Figure 7-28. The union set of two geometries

Return type

ST_Geometry

Example

The **sensitive_areas** table contains several columns that describe the threatened institutions in addition to the **zone** column, which stores the institutions' ST_Polygon geometries:

```
CREATE TABLE sensitive_areas (id     integer,
                              name   varchar(128),
                              size   float,
                              type   varchar(10),
                              zone   ST_Polygon);
```

The **hazardous_sites** table stores the identity of the sites in the **site_id** and **name** columns. The actual geographic location of each site is stored in the **location** point column:

```
CREATE TABLE hazardous_sites (site_id   integer,
                              name      varchar(40),
                              location  ST_Point);
```

The **ST_Buffer()** function generates a 5-mile buffer that surrounds the hazardous waste site locations. The **ST_Union()** function generates polygons from the union of the buffered hazardous waste site polygons and the sensitive areas. The **ST_Area()** function returns the unioned polygon area:

```
SELECT sa.name sensitive_area, hs.name hazardous_site,
       ST_Area(ST_Union(ST_Buffer(hs.location,(5 * 5280)),sa.zone)::
   ST_MultiPolygon) area
   FROM hazardous_sites hs, sensitive_areas sa;
```

Related reference:

"The SE_Dissolve() function" on page 7-47

The SE_VertexAppend() function

The **SE_VertexAppend()** function appends a vertex to the end of an ST_LineString. If the linestring has Z values or measures, the vertex to be appended must also have Z values or measures.

Syntax

```
SE_VertexAppend (ST_LineString, ST_Point)
```

Return type

ST_LineString

The SE_VertexDelete() function

The **SE_VertexDelete()** function deletes a vertex from a geometry. You must supply the exact vertex to be deleted, including Z value and measure if applicable. All vertices in the geometry which match this value will be deleted.

Syntax

```
SE_VertexDelete (ST_Geometry, ST_Point)
```

Return type

ST_Geometry

The SE_VertexUpdate() function

The **SE_VertexUpdate()** function changes the value of a vertex in a geometry. You must supply both the exact old value and the new value of the vertex to be altered. If the input geometry has Z values or measures, you must supply them as well. All vertices in the geometry which match the old value will be updated.

Syntax

```
SE_VertexUpdate (ST_Geometry, old ST_Point, new ST_Point)
```

Return type

ST_Geometry

The ST_Within() function

The **ST_Within()** function returns `t` (TRUE) if the first object is completely within the second; otherwise, it returns `f` (FALSE).

Syntax

```
ST_Within(g1 ST_Geometry, g2 ST_Geometry)
```

Usage

To return TRUE, the boundary and interior of the first geometry cannot intersect the exterior of the second geometry. **ST_Within()** tests for the exact opposite result of **ST_Contains()**.

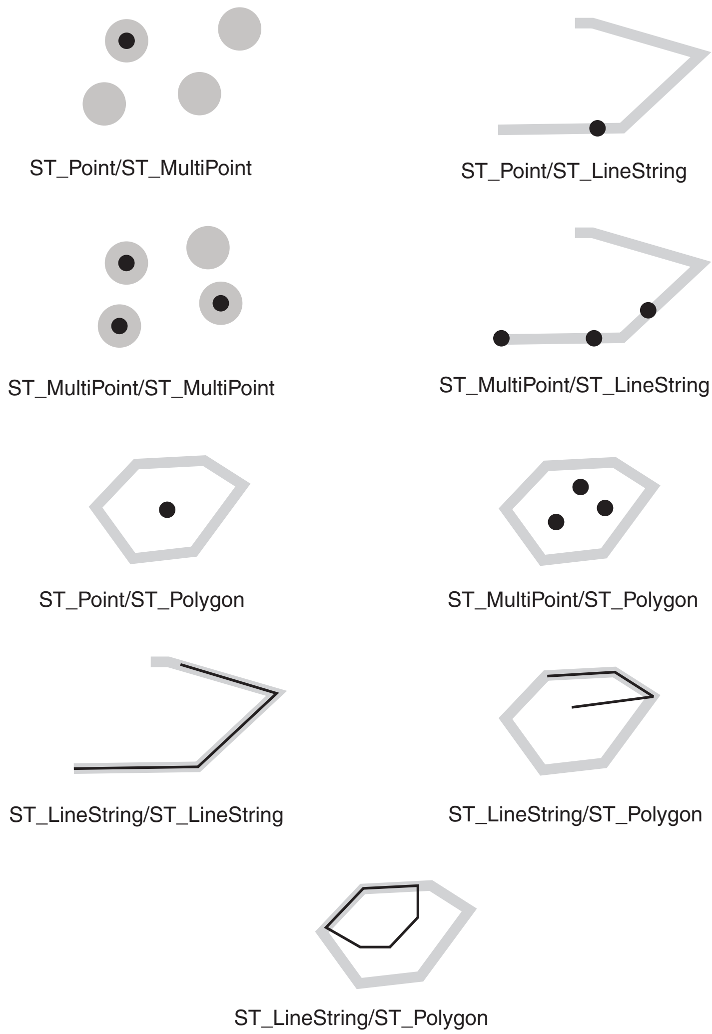


Figure 7-29. Geometries within other geometries

The results of the spatial relationship of the **ST_Within()** function can be understood or verified by comparing the results with a pattern matrix that represents the acceptable values for the DE-9IM. The **ST_Within()** function pattern matrix states that the interiors of both geometries must intersect and that the interior and boundary of the primary geometry (geometry *a*) must not intersect the exterior of the secondary (geometry *b*).

Table 7-19. Pattern matrix for the ST_Within() function.

			b	
		Interior	**Boundary**	**Exterior**
	Interior	T	*	F
a	Boundary	*	*	F
	Exterior	*	*	*

Return type

BOOLEAN

Example

In the example, two tables are created: **buildingfootprints** contains a city's building footprints, while the other, **lots**, contains its lots. The city engineer wants to make sure that all the building footprints are completely inside their lots.

In both tables, the ST_MultiPolygon data type stores the ST_Geometry of the building footprints and the lots. The database designer selected multipolygons for both features because lots can be separated by natural features such as a river, and building footprints comprise several buildings:

```
CREATE TABLE buildingfootprints (building_id  integer,
                                 lot_id       integer,
                                 footprint    ST_MultiPolygon);


CREATE TABLE lots (lot_id  integer,
                   lot     ST_MultiPolygon);
```

The city engineer first retrieves the buildings that are not completely within a lot:

```
SELECT building_id
   FROM buildingfootprints, lots
   WHERE ST_Within(footprint,lot);

building_id

        506
        543
        178
```

The city engineer realizes that although the first query produces a list of all building IDs that have footprints outside a lot polygon, it does not ascertain whether the rest have the correct **lot_id** assigned to them. This second query performs a data integrity check on the **lot_id** column of the **buildingfootprints** table:

```
SELECT bf.building_id, bf.lot_id bldg_lot_id, lots.lot_id lots_lot_id
   FROM buildingfootprints bf, lots
   WHERE ST_Within(footprint,lot)
   AND lots.lot_id <> bf.lot_id;

building_id bldg_lot_id lots_lot_id

        178       5192         203
```

Related reference:

"The Dimensionally Extended 9 Intersection Model" on page 7-2

The ST_WKBToSQL() function

The **ST_WKBToSQL()** function constructs an ST_Geometry given its well-known binary representation. The SRID of the ST_Geometry is 0.

Syntax

```
ST_WKBToSQL(WKBGeometry lvarchar)
```

Return type

ST_Geometry

Example

The following CREATE TABLE statement creates the **lots** table, which has two columns: **lot_id**, which uniquely identifies each lot, and the **lot** polygon column, which contains the geometry of each lot:

```
CREATE TABLE lots (lot_id  integer,
                   lot     ST_MultiPolygon);
```

The following C code fragment contains ODBC functions included with the spatial data type functions that insert data into the **lots** table.

The **ST_WKBToSQL()** function converts WKB representations intoIBM Informix spatial geometry. The entire INSERT statement is copied into the *sql_stmt* string. The INSERT statement contains parameter markers to accept the **lot_id** data and the **lot** data, dynamically:

```
/* Create the SQL insert statement to populate the lots table.
     * The question marks are parameter markers that indicate the
     * column values that will be inserted at run time. */
    sprintf(sql_stmt,
            "INSERT INTO lots (lot_id, lot) "
            "VALUES (?, ST_WKBToSQL(?))");

    /* Prepare the SQL statement for execution */
    rc = SQLPrepare (hstmt, (unsigned char *)sql_stmt, SQL_NTS);

    /* Bind the lot_id to the first parameter. */
    pcbvalue1 = 0;
    rc = SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_SLONG,
                           SQL_INTEGER, 0, 0,
                           &lot_id, 0, &pcbvalue1);

    /* Bind the lot geometry to the second parameter. */
    pcbvalue2 = lot_wkb_len;
    rc = SQLBindParameter (hstmt, 2, SQL_PARAM_INPUT, SQL_C_BINARY,
                           SQL_INFX_UDT_LVARCHAR, lot_wkb_len, 0,
                           lot_wkb_buf, lot_wkb_len, &pcbvalue2);

    /* Execute the insert statement. */
    rc = SQLExecute (hstmt);
```

The ST_WKTToSQL() function

The **ST_WKTToSQL()** function constructs an ST_Geometry given its well-known text representation. The SRID of the ST_Geometry is `0`.

Syntax

```
ST_WKTToSQL (WKT lvarchar)
```

Return type

ST_Geometry

Example

The following CREATE TABLE statement creates the **geometry_test** table, which contains two columns: **gid**, of type INTEGER, which uniquely identifies each row, and the **g1** column, which stores the geometry:

```
CREATE TABLE geometry_test (gid integer,
                            g1  ST_Geometry);
```

The following INSERT statements insert the data into the **gid** and **g1** columns of the **geometry_test** table. The **ST_WKTToSQL()** function converts the text representation of each geometry into its corresponding IBM Informix Spatial DataBlade Module instantiable subclass:

```
INSERT INTO geometry_test VALUES(
   1,
   ST_WKTToSQL('point (10.02 20.01)')
);

INSERT INTO geometry_test VALUES(
   2,
   ST_WKTToSQL('linestring (10.02 20.01,10.01 30.01,10.01 40.01)')
);

INSERT INTO geometry_test VALUES(
   3,
   ST_WKTToSQL('polygon ((10.02 20.01,11.92 35.64,25.02
34.15,19.15 33.94,10.02 20.01))')
);

INSERT INTO geometry_test VALUES(
   4,
   ST_WKTToSQL('multipoint (10.02 20.01,10.32 23.98,11.92 35.64)')
);

INSERT INTO geometry_test VALUES(
   5,
   ST_WKTToSQL('multilinestring ((10.02 20.01,10.32 23.98,11.92
25.64),(9.55 23.75,15.36 30.11))')
);

INSERT INTO geometry_test VALUES(
   6,
   ST_WKTToSQL('multipolygon (((10.02 20.01,11.92 35.64,25.02
34.15,19.15 33.94,10.02 20.01)),((51.71 21.73,73.36 27.04,71.52
32.87,52.43 31.90,51.71 21.73)))')
);
```

The ST_X() function

The **ST_X()** function returns the X coordinate of a point.

Syntax

```
ST_X(pt1 ST_Point)
```

Return type

DOUBLE PRECISION

Example

The **x_test** table is created with two columns: **gid**, which uniquely identifies the row, and the **pt1** point column:

```
CREATE TABLE x_test (gid integer,
                     pt1 ST_Point);
```

The following INSERT statements insert two rows. One is a point without a Z coordinate or a measure. The other column has both a Z coordinate and a measure:

```
INSERT INTO x_test VALUES(
   1,
   ST_PointFromText('point (10.02 20.01)', 1000)
);

INSERT INTO x_test VALUES(
   2,
   ST_PointFromText('point zm (10.02 20.01 5.0 7.0)', 1000)
);
```

The query retrieves the values in the **gid** column and the DOUBLE PRECISION X coordinate of the points:

```
SELECT gid, ST_X(pt1) x_coord
   FROM x_test;

        gid       x_coord

          1 10.02000000000
          2 10.02000000000
```

The ST_Y() function

The **ST_Y()** function returns the Y coordinate of a point.

Syntax

```
ST_Y(p1 ST_Point)
```

Return type

DOUBLE PRECISION

Example

The **y_test** table is created with two columns: **gid**, which uniquely identifies the row, and the **pt1** point column:

```
CREATE TABLE y_test (gid integer,
                     pt1 ST_Point);
```

The following INSERT statements insert two rows. One is a point without a Z coordinate or a measure. The other has both a Z coordinate and a measure:

```
INSERT INTO y_test VALUES(
    1,
    ST_PointFromText('point (10.02 20.01)', 1000)
);

INSERT INTO y_test VALUES(
    2,
    ST_PointFromText('point zm (10.02 20.01 5.0 7.0)',1000)
);
```

The query retrieves the values in the **gid** column and the DOUBLE PRECISION Y coordinate of the points:

```
SELECT gid, ST_Y(pt1) y_coord
   FROM y_test;

        gid       y_coord

          1 20.01000000000
          2 20.01000000000
```

The ST_Z function

The **ST_Z()** function returns the Z coordinate of a point.

Syntax

```
ST_Z(p1 ST_Point)
```

Return type

DOUBLE PRECISION

Example

The **z_test** table is created with two columns: **gid**, which uniquely identifies the row, and the **pt1** point column:

```
CREATE TABLE z_test (gid integer,
                     pt1 ST_Point);
```

The following INSERT statements insert two rows. One is a point without a Z coordinate or a measure. The other has both a Z coordinate and a measure:

```
INSERT INTO z_test VALUES(
   1,
   ST_PointFromText('point (10.02 20.01)', 1000)
);

INSERT INTO z_test VALUES(
   2,
   ST_PointFromText('point zm (10.02 20.01 5.0 7.0)', 1000)
);
```

The query retrieves the values in the **gid** column and the DOUBLE PRECISION Z coordinate of the points. The first row is NULL because the point does not have a Z coordinate:

```
SELECT gid, ST_Z(pt1) z_coord
  FROM z_test;

        gid       z_coord

          1
          2 5.000000000000
```

Chapter 8. Spatial Java API

The spatial Java API enables Java applications to access geometry features that are stored in databases that contain spatial data. The spatial Java API provides classes to work with spatial objects from Java client-side programs. The client-side objects are called *value objects*. Spatial value objects can also be created and examined by Java methods that parallel some of the spatial data functions.

Important: The Java API can read from the database, but cannot write to it.

The accompanying Javadoc provides detailed information about all packages, classes, and methods. Some methods are not yet implemented; they are noted as such in the Javadoc. The Javadoc is installed in `extend/spatial.8.21.`*x*`C`*n*`/doc/java/docs.jar`, where *x* represents the operating system bit size and *n* represents the fix pack level. To view it, you must first use the following command:

```
jar xf docs.jar
```

Compatibility with the ESRI ArcSDE Java API

The spatial Java API is compatible with the ESRI ArcSDE Java API. It provides a partial implementation of the same set of OGC (Open GISConsortium) interfaces.

Depending on the needs of your application, you can develop a program by using the spatial Java API and later install ArcSDE. You can then use its Java API to take advantage of its enhanced spatial functionality. The ESRI Java API is integrated with the ESRI ArcSDE software, whereas the spatial Java API does not implement that functionality.

Overview of the Java API

The Java API library is implemented in a package called com.ibm.spatial.

Within the main package, **SpatialManager** is a class that contains static convenience methods to facilitate error reporting and logging.

Within the srs subpackage, the **CoordRefManager** class provides methods to create and handle **CoordRef** objects, which hold definitions of *spatial reference systems*. For more information about the **SpatialManager** and **CoordRefManager** classes, see "The SpatialManager Class" on page 8-4 and "The CoordRefManager Class" on page 8-3.

The subpackages of com.ibm.spatial are:

geom (geometry objects)
: The geometry package implements the OGC Geometry Model.

io (geometry input/output)
: The geometry input/output package provides a reader/writer framework and implements readers and writers for the spatial data.

msg (localizable messages)
: The localizable messages package contains localizable error messages in ListResourceBundle format.

srs (coordinate reference classes)
The coordinate reference package provides classes necessary to manage coordinate reference objects.

util (utility classes)
The utility package contains utility classes, for error and warning message generation, logging, and so on. A logging API similar to that specified by J2SDK 1.4 is implemented, allowing for an easy transition to using the JDK logging classes.

Geometries

The geometries supported by the IBM Informix spatial extension form a hierarchy, which is shown in the following diagram.

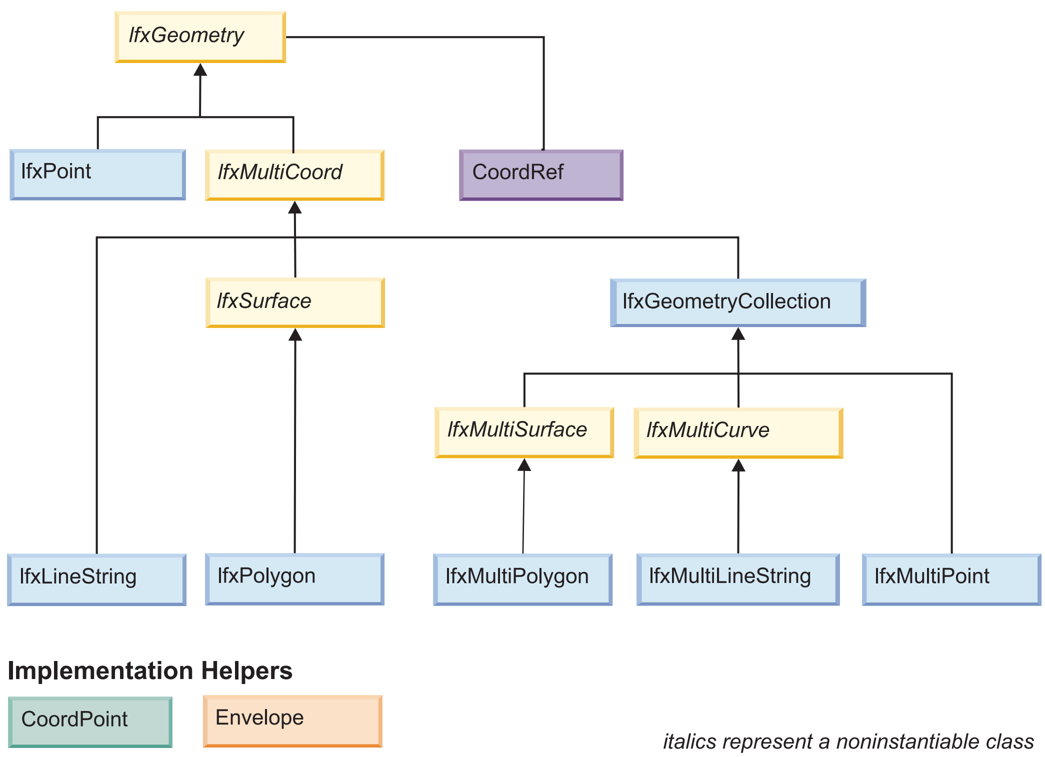


Figure 8-1. Spatial Java API geometry class hierarchy

To create geometries, you can:

- Use the **GeometryFactory** class, which generates geometry objects from their components.
- Read geometries from the database by using spatial functions.

Uses for the Java API

There are many ways you can use the Java API to manipulate your spatial data.

For example, an application might use the IBM Informix JDBC Driver to connect to a spatial database, extract data from a geometry column, and use that binary stream to construct a geometry object. That shape could then be rendered on screen or interrogated for shape subparts.

As another example, an application could run stored procedures on the database server to determine spatial relationships or to generate new geometries, then retrieve the results to render on the client.

For more information about using the Java API, see “Example 1: Retrieving a Point From a Table” on page 8-7 and “Examples 2, 3, and 4: How to Use the Java API” on page 8-7.

The CoordRefManager Class

The **CoordRefManager** class provides methods that create and handle **CoordRef** objects, which hold definitions of *spatial reference systems*.

A **CoordRef** object represents a coordinate reference that defines a spatial reference system. This includes the coordinate system plus a set of offset and scale values that convert floating point real-world values into integers for compatibility with the ESRI SDE layer.

A **CoordRefManager** object is usually associated with a particular database that contains spatial data. In this database, the **spatial_references** table stores data about each map projection that you use to store the spherical geometry of the Earth. This data enables the spatial extension to translate the data into a flat, X-Y coordinate system.

The spatial reference ID (SRID) is the unique key for records in the **spatial_references** table. All spatial reference systems that are used in this database must have a record in the **spatial_references** table. Also, all geometries in a spatial column must use the same spatial reference system.

A **CoordRefManager** object can retrieve a spatial reference system from the database using the SRID. **CoordRefManager** can also create and store user-defined spatial reference systems in the database.

CoordRefManager creates a local cache of objects that are in use, that is, **CoordRef** objects that are referenced by existing geometry instances. The following methods operate with this cache:

- **get(int)** Reads a coordinate reference with the given SRID into the cache and returns it to the user

  This is the only method that should be used by geometry factories when associating new geometries to a coordinate reference.
- **put(CoordRef)** Saves a given **CoordRef** object in the cache and writes it into the database
- **getAll()**, **getAllSrids()** Return all the elements that are stored in the cache
- **refresh()** If other database clients directly modify the **spatial_references** table, the database and the cache may get out of synchronization. This method refreshes elements that are in the *inuse cache* with data from the underlying database.
- **remove()**, **removeFromCache()** Remove a **CoordRef** object from both the cache and database, or only from the cache. **CoordRef** objects must not be removed from the cache unless there are no geometries associated with them.
- **findXXX()** Query the database directly for coordinate references that are not in use (for example, to list all the coordinate references with a specified authoritative name and ID).

The enumerations returned by the **findXXX()** methods are not failsafe in the sense iterators are when used by the java.util package. The enumerations contain a snapshot of the **CoordRefManager** object and the database at the moment the **findXXX()** method is called and do not reflect later changes in the cache or database.

CoordRefManager is safe for concurrent access by multiple threads.

Important: You must ensure that the local cache stays synchronized with the underlying database; for example, do not directly delete rows from the **spatial_references** table.

Related reference:

"The spatial_references table" on page 1-12

The SpatialManager Class

The **SpatialManager** class provides methods that support error reporting and logging.

The following classes are used by the **SpatialManager** class to report errors and log messages:

- **ErrorHandler**
- **ErrorReporter**
- **Logger**
- **LogHandler**
- **LogRecord**
- **MessageProvider**
- **SpatialException**

The **ErrorHandler** class defines an interface for error notification. If you want to implement customized error handling in your spatial application, you must implement this interface and register an instance with the **SpatialManager**. The Java API will then notify the application through this interface before reporting different types of errors.

Overview of a Spatial Java API Application

Most spatial Java API applications need to perform the steps described in this section.

Using Logging

Using the **SpatialManager** class, you can turn on logging, for example to a file `/tmp/spatial.log`. You can alternatively send formatted log records to an existing writer object.

To turn logging on

```
SpatialManager.setLogWriter("/tmp/spatial.log");
SpatialManager.setLogLevel(Logger.WARNING);
```

To turn logging off

```
SpatialManager.setLogLevel(Logger.OFF);
```

Assigning a Connection to CoordRefManager

Applications must assign an open database connection to the **CoordRef- Manager** object. This enables the **CoordRefManager** object to query the **spatial_references** table and cache its contents locally. If you forget to do this, a SpatialException with the message `Invalid argument: CoordRef=null` is usually thrown whenever you try to instantiate a geometry object.

To assign an open database connection to a CoordRefManager object

```
java.sql.Connection conn;
// Open the connection...
...
// Assign the connection to a CoordRefManager object
CoordRefManager crm = CoordRefManager.getInstance();
crm.setConnection(conn);
```

Querying and Displaying Geometries

The following code fragment demonstrates how to query geometries and display geometry data.

```
Connection conn;
Map typeMap;
// Acquire a database connection
...
// Set up the typemap
typeMap = IfxSQLData.enableTypes(conn);
// Set the CoordRefManager connection
CoordRefManager.getInstance().setConnection(conn);
// Running the query
Statement stmt = conn.createStatement();
ResultSet rs = stmt.executeQuery(
"SELECT id, geom FROM geomtab where id >= 0");
while (rs.next()) {
Integer id = (Integer)rs.getObject(1);
Geometry geo = (Geometry) rs.getObject(2, typeMap);
if (geo == null) {
System.out.println("NULL");
continue;
}
// Print out the well-known text representation
System.out.println(geo.asText());
}
stmt.close();
```

Reading Coordinate Data

Many applications need to read coordinate data from a geometry object. This example uses for loops to read the coordinates of an existing geometry object, to temporarily hold the coordinates in a buffer, and then to pass the coordinates to a drawing function.

```
IfxGeometry geo;
...
double buf[] = new double[1000];
for(int part = 0; part < geo.numParts(); part++) {
for(int subpart = 0; subpart < geo.numSubParts(part); subpart++) {
int position = 0, read = 0;
for (int points = geo.numPoints(part, subpart);
points > 0;
points -= read) {
read = geo.toCoordArray(buf, 0, IfxGeometry.COORD_XY,
position, part, subpart);
if (read == 0) break;
```

```
// do something with the coordinate buffer
...
// update position of the next point to read
position += read;
}
}
}
```

Preparing to Run a Program

Before you run a spatial Java API program, set your CLASSPATH environment variable and compile the program.

Setting your CLASSPATH Environment Variable

When compiling or running the programs in this chapter, set your CLASSPATH environment variable to include:

- The IBM Informix JDBC Driver, **ifxjdbc.jar**, in the directory where you installed the driver.
- The Spatial DataBlade Java API, **spatial.jar**, in the directory where you installed the DataBlade module, `$INFORMIXDIR/extend/spatial.`*`version`*.
- The `examples/java` directory (where these example programs are located) in the directory where you installed the DataBlade module, `$INFORMIXDIR/extend/spatial.`*`version`*.

Compiling the Programs

Use the **javac** command to compile the programs in this chapter (be sure that your CLASSPATH is set correctly, as described above). For example, to compile all the programs, go to the `examples/java` directory and enter the following command:

```
javac *.java
```

Running the Programs

After you set your CLASSPATH environment variable and compile the program, you can run a spatial Java API program.

Use the following command to run the programs:

```
java program "classname
host:portnumber/database:informixserver=servername;user=username;
password=yourpassword;"
```

Where the following values are:

`classname`
: The name of the class you want to execute.

`portnumber`
: The port number that Informix server is listening on.

`servername`
: The name of the server defined as INFORMIXSERVER.

`username`
: Your user name.

`yourpassword`
: Your password.

Here is an example of a command to run the programs:

```
java program "jdbc:informixsqli://
host:port/database:informixserver=server;user=user;
password=pass;"
```

Example 1: Retrieving a Point From a Table

The commented code fragment below shows how to retrieve a Point shape from a database table using a SELECT statement.

The **points_t** table was created using the following SQL statement:

```
CREATE TABLE points_t (id integer, pt st_point);
```

The database connection URL is passed as an argument to the example.

```
void example(String url) {
// load the Informix JDBC driver
Class.forName("com.informix.jdbc.IfxDriver");
// get the connection
Connection conn = DriverManager.getConnection(url);
// get the custom type map associated with the spatial data types
Map typeMap = IfxSQLData.enableTypes(conn);
// set the CoordRefManager connection
CoordRefManager.getInstance().setConnection(conn);
// run a query and fetch the spatial data
Statement stmt = conn.createStatement();
ResultSet rs = stmt.executeQuery("SELECT id, pt FROM points_t");
while (rs.next()) {
Integer id = (Integer) rs.getObject(1);
IfxPoint pt = (IfxPoint) rs.getObject(2, typeMap);
// print out x and y coordinates
System.out.println("X=" + pt.getX() + " Y=" + pt.getY());
}
}
```

Examples 2, 3, and 4: How to Use the Java API

These examples are located in the `INFORMIXDIR/extend/spatial`*`version`*`/examples/java` directory in the directory where you installed the DataBlade module. The examples are fully commented to demonstrate how to use the Java API.

The examples all have a similar structure and contain three routines:

- **init()**
  Performs initialization tasks
- **doRun()**
  Contains the main functioning of the program
- **cleanup()**
  Performs cleanup

GeometryToWKT

The example program **GeometryToWKT** reads geometry objects from an IBM Informix spatial table and converts them into WKT (well-known text format) strings.

The program first creates a table, inserts geometry data into it, and then queries the table. The output of the program shows the well-known text representation of sample geometries.

GeometryToArray

The **GeometryToArray** program creates new geometries using a geometry factory, then reads coordinate data out of these geometry objects.

The program first creates several geometry objects and stores them in a Java vector object. Then it uses two techniques to read coordinate data out of the geometry objects, using one of the following methods

- **IfxGeometry.toCoordArray()**
- **IfxGeometry.toPointArray()**

CoordRefCreate

The **CoordRefCreate** program creates new coordinate reference objects and inserts them into the **spatial_references** table.

The program first demonstrates how to search the database for a specific coordinate reference, then creates a new **CoordRef** object and serializes it as a new spatial reference system row in the **spatial_references** table. The output of this program shows the result of a query for retrieving the new spatial reference system from the database.

Appendix A. Load and unload shapefile data

Use the **infoshp**, **loadshp**, and **unloadshp** utilities for working with spatial data contained in ESRI shapefiles.

The executable files for the utilities are located in the `$INFORMIXDIR/extend/spatial.`*`version`*`/bin` directory:

- The **infoshp** utility is useful for gathering information from ESRI shapefiles when you are preparing to load the shapefiles into a database.
- The **loadshp** utility loads spatial data from an ESRI shapefile into the database.
- The **unloadshp** utility copies data from the database to an ESRI shapefile.

You can leave them in this directory, or you can copy them to `$INFORMIXDIR/bin`. If you leave them here, you may want to add `$INFORMIXDIR/extend/spatial.`*`version`*`/bin` to your **`$PATH`** environment variable. If you copy the files to `$INFORMIXDIR/bin`, you may not need to change your **`$PATH`** environment variable, if `$INFORMIXDIR/bin` is already included in the variable definition.

Important: The **loadshp** utility does not add information to ESRI system tables, such as the **layers** table. Therefore, data loaded with the **loadshp** utility is not accessible to ArcSDE and other ESRI client tools. Use the ESRI **shp2sde** command to load data if you want to access it using ESRI client tools. Data loaded using the **loadshp** utility is accessible to client programs that do not depend on ESRI system tables other than the OGC-standard **geometry_columns** and **spatial_references** tables.

Related reference:

"The geometry_columns table" on page 1-21
"Loading spatial data" on page 1-19
"The spatial index" on page 1-22

The infoshp utility

The **infoshp** utility reports information extracted from headers of the `.shp`, `.shx`, and `.dbf` files that make up ESRI shapefiles. It also detects the presence of optional `.prj` files that may be associated with ESRI shapefiles and reports the coordinate system information. The **infoshp** utility can check for **spatial_references** table entries that are qualified to load one or more shapefiles. If no spatial reference exists that can be used to load the specified shapefiles, the **infoshp** utility can create a new entry in the **spatial_references** table for loading the shapefiles.

Syntax

```
                                         ┌──────────┐
                                         ▼          │
►►──infoshp──┬─ -o─┤ Info Info ├── -f────filename──┴─┬──────────────────────────────►◄
             └─ -V─────────────────────────────────────┘
```


Info Info::

```
├──┬─info──────────────────────────────────────────────────────────────────────┬──────────┤
   ├─check──┬── -D─database──┬──────────────┬──┬───────────────────────────────┬┘
   └─create─┘                └─ -s─server───┘  └─ -u─username── -p─password──┘
```

Operation modes

You use the **-o** flag to set the operation mode for the **infoshp** command. Set the **-o** flag to one of the following options:

check Checks for **spatial_references** table entries that are qualified to load the specified shapefiles.

create Creates a new entry in the **spatial_references** table for loading the specified shapefiles.

info Reports information extracted from the headers of the `.shp`, `.shx`, `.dbf`, and optional `.prj` files associated with the specified shapefiles.

Command-line switches

You can use the **infoshp** command flags to specify the following options.

-D The database name

-f The path and name of one or more ESRI shapefiles to process

-p (optional) The IBM Informix password

If you specify the **-p** option, you must also specify the **-u** option.

-s (optional)
The IBM Informix server

Defaults to the value of the INFORMIXSERVER environment variable

-u (optional)
The IBM Informix user name

If you specify the **-u** option, you must also specify the **-p** option.

-V Prints version information for this utility

The loadshp utility

The **loadshp** utility loads spatial features and associated attributes from an ESRI shapefile into a table in an IBM Informix database.

When **loadshp** creates a table, it inserts a row into the **geometry_columns** system table. When you want to drop a table created by **loadshp**, you should also delete the corresponding row from the **geometry_columns** table.

Tip: The **loadshp** utility creates a primary key constraint on the **se_row_id** column of the table that you are loading.

Syntax

```
>>──loadshp──┬─ -o──┤ Append Mode ├──────────┬──────────────────────────────────><
             │      ├ Init and Create Mode ├─┤
             │      └ SQL Mode ├─────────────┘
             └─ -V───────────────────────────┘
```

Append mode:

```
├──append── -l──tablename──,──colname── -f──filename── -D──database──┬──────────────┬──►
                                                                     └─ -s──server──┘

►──┬──────────────────────────────────┬──┬──────────────────┬──┬────────────────┬──┬────────────────────────┬──►
   └─ -u──username── -p──password─────┘  └─ -b──begin_row───┘  └─ -e──end_row───┘  └─ -c──commit_interval───┘

►──┬───────┬──┬────────────────────────┬────────────────────────────────────┤
   └─ -ic──┘  └─ -log──┬─────────────┬─┘
                       └─directory───┘
```

Init and create mode:

```
├──┬─create─┬── -l──tablename──,──colname── -f──filename──────────────────────►
   └─init───┘

►── -D──database──┬──────────────┬──┬─────────────────────────────────┬──────►
                  └─ -s──server──┘  └─ -u──username── -p──password────┘

►──┬──────────────────┬──┬────────────────┬──┬─────────────────┬──┬──────────────────────┬──►
   └─ -b──begin_row───┘  └─ -e──end_row───┘  └─ -in──dbspace───┘  └─ -put──sbspace_list──┘

►──┬──────────────────────────────┬──┬────────────────────────────────┬──┬────────────────────────┬──►
   └─ -ext──initial_extent_size───┘  └─ -next──next_extent_size───────┘  └─ -c──commit_interval───┘

►──┬───────┬──┬──────────┬──┬───────────────┬──┬────────────────────────┬───────────┤
   └─ -ic──┘  └─ -noidx──┘  └─ -srid──srid──┘  └─ -log──┬─────────────┬─┘
                                                        └─directory───┘
```

SQL mode:

```
├──sql── -l──tablename──,──colname── -f──filename──┬─────────────────┬──┬──────────────────────┬──►
                                                   └─ -in──dbspace───┘  └─ -put──sbspace_list──┘

►──┬──────────────────────────────┬──┬────────────────────────────────┬──┬────────────────────────┬──┤
   └─ -ext──initial_extent_size───┘  └─ -next──next_extent_size───────┘  └─ -log──┬─────────────┬─┘
                                                                                  └─directory───┘
```

Operation modes

You use the **-o** flag to set the operation mode for the **loadshp** command. Set the **-o** flag to one of the following options:

append

Spatial features are added to the table specified by the **-l** flag. The structure of the existing database table must match the structure of a table derived from information specified by the **-l** command-line option and from metadata stored in the shapefile's associated `.dbf` file.

create Spatial features are loaded into a newly created database table. An error is returned if a table with the name specified by the **-l** flag already exists. The structure of the new table is derived from the table name and column name specified by the **-l** command-line option as well as from metadata stored in the shapefile's associated `.dbf` file.

init The table specified by the **-l** flag is first dropped and then spatial features are loaded into a newly created table of the same name.

sql The following SQL statements are displayed on the console (and can be logged to a file):

- DROP TABLE ...
- DELETE FROM **geometry_columns** ...
- CREATE TABLE ...
- INSERT INTO **geometry_columns** ...
- CREATE UNIQUE INDEX ... USING btree;
- ALTER TABLE ... ADD CONSTRAINT PRIMARY KEY (se_row_id) ...
- CREATE INDEX ... USING rtree;
- UPDATE STATISTICS ...

The structure of the table to be loaded is derived from information specified by the **-l** command-line option and from metadata stored in the shapefile's associated `.dbf` file containing feature attributes.

Command-line switches

You can use the **loadshp** command-line switches to specify the following options.

-b (optional)
The first row in the shapefile to load

-c (optional)
The number of rows to load before committing work and beginning a new transaction

Defaults to 1000 rows

If you are loading data into a database that does not have transaction logging enabled, the commit interval determines how frequently information messages are displayed on the console.

-D The database name

-e (optional)
The last row in the shapefile to load

-ext (optional)
Specifies the initial extent size for the table to be loaded

This option is not valid in the **append** option of the **-o** flag.

-f The path and name of the ESRI shapefile to be loaded

-ic (optional)
Specifies use of an INSERT CURSOR

Using an INSERT CURSOR to load data significantly reduces load time, but limits the client program's ability to handle errors. INSERT CURSORs buffer rows before writing them to the database to improve performance. If an error is encountered during the load, all buffered rows following the last successfully inserted row are discarded.

-in (optional)
Specifies the dbspace in which to create the table to be loaded

This option is not valid in the **append** option of the **-o** flag.

-l The table and geometry column to load data into

-log (optional)
Specifies whether to write information about the status of data loading to a log file

The log file has the same name as the shapefile you are loading from with the extension `.log`.

If you do not specify a directory, the log file is created in the same directory as the shapefile you are loading from.

-next Specifies the next extent size for the table to be loaded

This option is not valid in the **append** option of the **-o** flag.

-noidx (optional)
Specifies that indexes should not be built and statistics should not be updated after the shapefile data has been loaded

Unless this option is specified when executing **loadshp -o create** or **loadshp -o init**, a unique B-tree index is built on the **se_row_id** column, an R-tree index is built on the **geometry** column, and statistics are updated for the table after the shapefile data has been loaded.

-p (optional)
The IBM Informix password

If you specify the **-p** option, you must also specify the **-u** option.

-put (optional)
Specifies the sbspaces in which large shapes inserted into the load table's geometry column will be stored

Multiple sbspace names must be separated by commas and no white space must appear in the list of sbspace names. This option is not valid with the **append** option of the **-o** flag.

-s (optional)
The IBM Informix server

Defaults to the value of the INFORMIXSERVER environment variable.

-srid (optional)
The spatial reference ID for the data you are loading

The integer you specify must exist as a spatial reference ID in the **spatial_references** table. If you do not specify the **-srid** command-line option, the spatial reference ID defaults to 0.

-u (optional)
The IBM Informix user name

If you specify the **-u** option, you must also specify the **-p** option.

-V Prints version information for this utility

The unloadshp utility

The **unloadshp** utility copies spatial features and associated attributes from a table in an IBM Informix database into an ESRI shapefile.

Syntax

```
>>--unloadshp--+- -o--+-| Init Mode |---+-+----------------------------------><
               |      '-| Append Mode |-' |
               '- -V----------------------'
```

Init mode:

```
|--init-- -l--tablename--,--colname-- -f--filename-- -D--database--+-------------+-->
                                                                   '- -s--server-'

>--+-----------------------------------+--+-----------------+--+-------------------+-->
   '- -u--username-- -p--password-'     '- -t--shape_type-'  '- -w--where_clause-'

>--+----------------------+-----------------------------------------------------|
   '- -log--+-----------+-'
            '-directory-'
```

Append mode:

```
|--append-- -l--tablename--,--colname-- -f--filename-- -D--database--+-------------+-->
                                                                     '- -s--server-'

>--+-------------------------------+--+-------------------+--+----------------------+---|
   '- -u--username-- -p--password-'  '- -w--where_clause-'  '- -log--+-----------+-'
                                                                      '-directory-'
```

Operation modes

You use the **-o** flag to set the operation mode for the **unloadshp** command. Set the **-o** flag to one of the following options:

append
: Spatial features are appended to the existing ESRI shapefile specified by the **-f** option.

init
: Spatial features are unloaded into a newly created ESRI shapefile.

Command-line switches

You can use the **unloadshp** command flags to specify the following options.

-D
: The database name

-f
: The path and name of the shapefile

-l
: The table and geometry column from which to extract data

  The table and column must exist, and the executing user must either own the table or have access to it.

-log (optional)
: Specifies whether to write information about the status of data loading to a log file

  The log file has the same name as the shapefile you are loading into with the extension .log.

  If you do not specify a directory, the log file is created in the same directory as the shapefile you are loading.

-p (optional)
: The IBM Informix password

  If you specify the **-p** option, you must also specify the **-u** option.

-s (optional)
: The IBM Informix server

  Defaults to the value of the INFORMIXSERVER environment variable.

-t (optional)
: An integer indicating the type of shape to extract and write to the ESRI shapefile

  The possible values are:

  1 Point

  2 PolyLine

  5 Polygon

  8 Multipoint

  9 PointZ

  10 PolyLineZ

  11 PointZM

  13 PolyLineZM

  15 PolygonZM

  18 MultiPointZM

  19 PolygonZ

  20 MultiPointZ

  21 PointM

  23 PolyLineM

  25 PolygonM

  28 MultiPointM

  If you do not specify the **-t** option, the type defaults to the type of the first shape retrieved from the database table.

-u (optional)
: The IBM Informix user name

  If you specify the **-u** option, you must also specify the **-p** option.

-V Prints version information for this utility

-w (optional)

(optional) The SQL WHERE clause to qualify the data extracted from the table

Enclose the WHERE clause in double quotation marks and enclose any string literals within the clause in single quotation marks. Omit the keyword WHERE.

Appendix B. OGC well-known text representation of spatial reference systems

These topics explain how to represent a spatial reference system using a text string and provides information about supported units of measure, spheroids, datums, prime meridians, and projections.

The information provided in these topics is primarily intended for use with the **ST_Transform()** function.

Related reference:

"The spatial_references table" on page 1-12

"The ST_Transform() function" on page 7-136

The text representation of a spatial system

The well-known text representation of spatial reference systems provides a standard textual representation for spatial reference system information.

The definitions of the well-known text representation are modeled after the POSC/EPSG coordinate system data model.

A spatial reference system, also referred to as a coordinate system, is a geographic (latitude, longitude), a projected (X,Y), or a geocentric (X, Y, Z) coordinate system.

A coordinate system is composed of several objects. Each object is defined by an uppercase keyword (for example, DATUM or UNIT) followed by the defining, comma-delimited parameters of the object in brackets. Some objects are composed of other objects.

Implementations are free to substitute standard brackets ( ) for square brackets [ ] and should be prepared to read both forms of brackets.

The Extended Backus Naur Form (EBNF) definition for the string representation of a coordinate system is as follows, using square brackets:

```
<coordinate system> = <projected cs> | <geographic cs>
   | <geocentric cs>
<projected cs> = PROJCS["<name>", <geographic cs>,
   <projection>, {<parameter>,}* <linear unit>]
<projection> = PROJECTION["<name>"]
<parameter> = PARAMETER["<name>", <value>]
<value> = <number>
```

A coordinate system of a data set is identified by one of the following three keywords:

PROJCS
: if the data is in projected coordinates

GEOGCS
: if in geographic coordinates

GEOCCS
: if in geocentric coordinates

The PROJCS keyword is followed by all of the pieces that define the projected coordinate system. The first piece of any object is always the name. Several objects follow the name: the geographic coordinate system, the map projection, one or more parameters, and the linear unit of measure.

As an example, UTM zone 10N on the NAD83 datum is defined as:

```
PROJCS["NAD_1983_UTM_Zone_10N",
    <geographic cs>,
    PROJECTION["Transverse_Mercator"],
    PARAMETER["False_Easting",500000.0],
    PARAMETER["False_Northing",0.0],
    PARAMETER["Central_Meridian",-123.0],
    PARAMETER["Scale_Factor",0.9996],
    PARAMETER["Latitude_of_Origin",0.0],
    UNIT["Meter",1.0]]
```

The name and several objects define the geographic coordinate system object: the datum, the prime meridian, and the angular unit of measure:

```
<geographic cs> = GEOGCS["<name>", <datum>, <prime meridian>,     <angular unit>]

<datum> = DATUM["<name>", <spheroid>]

<spheroid> = SPHEROID["<name>", <semi-major axis>,
    <inverse flattening>]

<semi-major axis> = <number>
NOTE: semi-major axis is measured in meters and must be > 0.

<inverse flattening> = <number>

<prime meridian> = PRIMEM["<name>", <longitude>]

<longitude> = <number>
```

The geographic coordinate system string for UTM zone 10N on NAD83 is:

```
GEOGCS["GCS_North_American_1983",
    DATUM["D_North_American_1983",
    SPHEROID["GRS_1980",6378137,298.257222101]],
    PRIMEM["Greenwich",0],
    UNIT["Degree",0.0174532925199433]]
```

The UNIT object can represent angular or linear units of measure:

```
<angular unit> = <unit>
<linear unit> = <unit>
<unit> = UNIT["<name>", <conversion factor>]
<conversion factor> = <number>
```

The conversion factor specifies the number of meters (for a linear unit) or the number of radians (for an angular unit) per unit and must be greater than zero.

Therefore, the full string representation of UTM zone 10N is:

```
PROJCS["NAD_1983_UTM_Zone_10N",
GEOGCS["GCS_North_American_1983",
  DATUM["D_North_American_1983",SPHEROID["GRS_1980",6378137,298.257222101]],
PRIMEM["Greenwich",0],UNIT["Degree",0.0174532925199433]],
PROJECTION["Transverse_Mercator"],PARAMETER["False_Easting",500000.0],
PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",-123.0],
PARAMETER["Scale_Factor",0.9996],PARAMETER["Latitude_of_Origin",0.0],
UNIT["Meter",1.0]]
```

A geocentric coordinate system is quite similar to a geographic coordinate system. It is represented by:

```
<geocentric cs> = GEOCCS["<name>", <datum>, <prime meridian>, <linear unit>]
```

You can use the **SE_CreateSrtext()** function to assist you in constructing these spatial reference system text strings.

The remainder of this appendix shows the OGC well-known text "building blocks" of spatial reference systems that are supported by the IBM Informix spatial data types.

These text strings can be generated by the **SE_CreateSrtext()** function; you use the factory ID number in the first column of the table as the input argument to **SE_CreateSrtext()**.

Related reference:

"The SE_CreateSrtext() function" on page 7-36

Linear units

IBM Informix spatial data types support many linear units.

The following table shows a representative sample of the linear units of measure supported by the IBM Informix spatial data types. For a complete list of supported linear units of measure, see the file `INFORMIXDIR/extend/spatial.`*`version`*`/include/pedef.h`.

Table B-1. Linear units of measure

Factory ID	Description	OGC well-known text string
9001	International meter	UNIT["Meter",1]
9002	International foot	UNIT["Foot",0.3048]
9003	US survey foot	UNIT["Foot_US",0.3048006096012192]
9005	Clarke's foot	UNIT["Foot_Clarke",0.3047972650]
9014	Fathom	UNIT["Fathom",1.8288]
9030	International nautical mile	UNIT["Nautical_Mile",1852]
9031	German legal meter	UNIT["Meter_German",1.000001359650]
9033	US survey chain	UNIT["Chain_US",20.11684023368047]
9034	US survey link	UNIT["Link_US",0.2011684023368047]
9035	US survey mile	UNIT["Mile_US",1609.347218694438]
9036	Kilometer	UNIT["Kilometer",1000]
9037	Yard (Clarke)	UNIT["Yard_Clarke",0.914391795]
9038	Chain (Clarke)	UNIT["Chain_Clarke",20.11661949]
9039	Link (Clarke's ratio)	UNIT["Link_Clarke",0.2011661949]
9040	Yard (Sears)	UNIT["Yard_Sears",0.9143984146160287]
9041	Sear's foot	UNIT["Foot_Sears",0.3047994715386762]
9042	Chain (Sears)	UNIT["Chain_Sears",20.11676512155263]
9043	Link (Sears)	UNIT["Link_Sears",0.2011676512155263]
9050	Yard (Benoit 1895 A)	UNIT["Yard_Benoit_1895_A",0.9143992]
9051	Foot (Benoit 1895 A)	UNIT["Foot_Benoit_1895_A",0.3047997333333333]

Table B-1. Linear units of measure (continued)

Factory ID	Description	OGC well-known text string
9052	Chain (Benoit 1895 A)	UNIT["Chain_Benoit_1895_A",20.1167824]
9053	Link (Benoit 1895 A)	UNIT["Link_Benoit_1895_A",0.201167824]
9060	Yard (Benoit 1895 B)	UNIT["Yard_Benoit_1895_B",0.9143992042898124]
9061	Foot (Benoit 1895 B)	UNIT["Foot_Benoit_1895_B",0.3047997347632708]
9062	Chain (Benoit 1895 B)	UNIT["Chain_Benoit_1895_B",20.11678249437587]
9063	Link (Benoit 1895 B)	UNIT["Link_Benoit_1895_B",0.2011678249437587]
9070	Foot (1865)	UNIT["Foot_1865",0.3048008333333334]
9080	Indian geodetic foot	UNIT["Foot_Indian",0.3047995102481469]
9081	Indian foot (1937)	UNIT["Foot_Indian_1937",0.30479841]
9082	Indian foot (1962)	UNIT["Foot_Indian_1962",0.3047996]
9083	Indian foot (1975)	UNIT["Foot_Indian_1975",0.3047995]
9084	Indian yard	UNIT["Yard_Indian",0.9143985307444408]
9085	Indian yard (1937)	UNIT["Yard_Indian_1937",0.91439523]
9086	Indian yard (1962)	UNIT["Yard_Indian_1962",0.9143988]
9087	Indian yard (1975)	UNIT["Yard_Indian_1975",0.9143985]

Angular units

IBM Informix spatial data types support many angular units.

The following table shows a representative sample of the angular units of measure supported by the IBM Informix spatial data types. For a complete list of supported angular units of measure, see the file `INFORMIXDIR/extend/spatial.`*`version`*`/include/pedef.h`.

Table B-2. Angular units

Factory ID	Description	OGC well-known text string
9101	Radian	UNIT["Radian",1]
9102	Degree	UNIT["Degree",0.0174532925199433]
9103	Arc-minute	UNIT["Minute",0.0002908882086657216]
9104	Arc-second	UNIT["Second",4.84813681109536E-06]
9105	Grad (angle subtended by 1/400 circle)	UNIT["Grad",0.01570796326794897]
9106	Gon (angle subtended by 1/400 circle)	UNIT["Gon",0.01570796326794897]
9109	Microradian (1e-6 radian)	UNIT["Microradian",1E-06]
9112	Centesimal minute (1/100th Gon (Grad))	UNIT["Minute_Centesimal",0.0001570796326794897]
9113	Centesimal second(1/10000th Gon (Grad))	UNIT["Second_Centesimal",1.570796326794897E-06]
9114	Mil (angle subtended by 1/6400 circle)	UNIT["Mil_6400",0.0009817477042468104]

Geodetic spheroids

IBM Informix spatial data types support many geodetic spheriods.

The following table lists a representative sample of the geodetic spheroids supported by the IBM Informix spatial data types. For a complete list of supported geodetic spheroids, see the file `INFORMIXDIR/extend/spatial.`*`version`*`/include/pedef.h`.

Table B-3. Geodetic spheriods

Factory ID	Description	OGC well-known text string
7001	Airy 1830	SPHEROID["Airy_1830",6377563.396,299.3249646]
7002	Airy modified	SPHEROID["Airy_Modified",6377340.189,299.3249646]
7041	Average Terrestrial System 1977	SPHEROID["ATS_1977",6378135,298.257]
7003	Australian National	SPHEROID["Australian",6378160,298.25]
7004	Bessel 1841	SPHEROID["Bessel_1841",6377397.155,299.1528128]
7005	Bessel modified	SPHEROID["Bessel_Modified",6377492.018,299.1528128]
7006	Bessel Namibia	SPHEROID["Bessel_Namibia",6377483.865,299.1528128]
7007	Clarke 1858	SPHEROID["Clarke_1858",6378293.639,294.260676369]
7008	Clarke 1866	SPHEROID["Clarke_1866",6378206.4,294.9786982]
7009	Clarke 1866 Michigan	SPHEROID["Clarke_1866_Michigan",6378450.047,294.978684677]
7034	Clarke 1880	SPHEROID["Clarke_1880",6378249.138,293.466307656]
7013	Clarke 1880 (Arc)	SPHEROID["Clarke_1880_Arc",6378249.145,293.466307656]
7010	Clarke 1880 (Benoit)	SPHEROID["Clarke_1880_Benoit",6378300.79,293.466234571]
7011	Clarke 1880 (IGN)	SPHEROID["Clarke_1880_IGN",6378249.2,293.46602]
7012	Clarke 1880 (RGS)	SPHEROID["Clarke_1880_RGS",6378249.145,293.465]
7014	Clarke 1880 (SGA)	SPHEROID["Clarke_1880_SGA",6378249.2,293.46598]
7042	Everest 1830 (definition)	SPHEROID["Everest_1830",6377299.36,300.8017]
7018	Everest 1830 (modified)	SPHEROID["Everest_1830_Modified",6377304.063,300.8017]
7015	Everest (adjustment 1937)	SPHEROID["Everest_Adjustment_1937",6377276.345,300.8017]
7044	Everest (definition 1962)	SPHEROID["Everest_Definition_1962",6377301.243,300.8017255]
7016	Everest (definition 1967)	SPHEROID["Everest_Definition_1967",6377298.556,300.8017]
7045	Everest (definition 1975)	SPHEROID["Everest_Definition_1975",6377299.151,300.8017255]
7031	GEM gravity potential model	SPHEROID["GEM_10C",6378137,298.257222101]
7036	GRS 1967 = International 1967	SPHEROID["GRS_1967",6378160,298.247167427]
7019	GRS 1980	SPHEROID["GRS_1980",6378137,298.257222101]
7020	Helmert 1906	SPHEROID["Helmert_1906",6378200,298.3]
7021	Indonesian National	SPHEROID["Indonesian",6378160,298.247]
7022	International 1924	SPHEROID["International_1924",6378388,297]
7023	International 1967	SPHEROID["International_1967",6378160,298.25]
7024	Krasovsky 1940	SPHEROID["Krasovsky_1940",6378245,298.3]
7025	Transit precise ephemeris	SPHEROID["NWL_9D",6378145,298.25]

Table B-3. Geodetic spheriods (continued)

Factory ID	Description	OGC well-known text string
7032	OSU 1986 geoidal model	SPHEROID["OSU_86F",6378136.2,298.25722]
7033	OSU 1991 geoidal model	SPHEROID["OSU_91A",6378136.3,298.25722]
7027	Plessis 1817	SPHEROID["Plessis_1817",6376523,308.64]
7035	Authalic sphere	SPHEROID["Sphere",6371000,0]
7028	Struve 1860	SPHEROID["Struve_1860",6378298.3,294.73]
7029	War Office	SPHEROID["War_Office",6378300.583,296]
7026	NWL-10D == WGS 1972	SPHEROID["NWL_10D",6378135,298.26]
7043	WGS 1972	SPHEROID["WGS_1972",6378135,298.26]
7030	WGS 1984	SPHEROID["WGS_1984",6378137,298.257223563]
107001	WGS 1966	SPHEROID["WGS_1966",6378145,298.25]
107002	Fischer 1960	SPHEROID["Fischer_1960",6378166,298.3]
107003	Fischer 1968	SPHEROID["Fischer_1968",6378150,298.3]
107004	Fischer modified	SPHEROID["Fischer_Modified",6378155,298.3]
107005	Hough 1960	SPHEROID["Hough_1960",6378270,297]
107006	Everest modified 1969	SPHEROID["Everest_Modified_1969",6377295.664,300.8017]
107007	Walbeck	SPHEROID["Walbeck",6376896,302.78]
107008	Authalic sphere (ARC/INFO)	SPHEROID["Sphere_ARC_INFO",6370997,0]
107036	GRS 1967 Truncated	SPHEROID["GRS_1967_Truncated",6378160,298.25]

Horizontal datums (spheroid only)

IBM Informix spatial data types support many spheriod horizontal datums.

The following table lists a representative sample of the horizontal datums (spheroid only) supported by the IBM Informix spatial data types. For a complete list of supported horizontal datums (spheroid only), see the file `INFORMIXDIR/extend/spatial.`*`version`*`/include/pedef.h`.

Table B-4. Spheroid horizontal datums

Factory ID	Description	OGC well-known text string
6001	Airy 1830	DATUM["D_Airy_1830",SPHEROID["Airy_1830",6377563.396,299.3249646]]
6002	Airy modified	DATUM["D_Airy_Modified",SPHEROID["Airy_Modified",6377340.189, 299.3249646]]
6003	Australian National	DATUM["D_Australian",SPHEROID["Australian",6378160,298.25]]
6004	Bessel 1841	DATUM["D_Bessel_1841",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
6005	Bessel modified	DATUM["D_Bessel_Modified",SPHEROID["Bessel_Modified", 6377492.018,299.1528128]]
6006	Bessel Namibia	DATUM["D_Bessel_Namibia",SPHEROID["Bessel_Namibia",6377483.865, 299.1528128]]
6007	Clarke 1858	DATUM["D_Clarke_1858",SPHEROID["Clarke_1858",6378293.639, 294.260676369]]
6008	Clarke 1866	DATUM["D_Clarke_1866",SPHEROID["Clarke_1866",6378206.4, 294.9786982]]

Table B-4. Spheroid horizontal datums (continued)

Factory ID	Description	OGC well-known text string
6009	Clarke 1866 Michigan	DATUM["D_Clarke_1866_Michigan",SPHEROID["Clarke_1866_Michigan", 6378450.047,294.978684677]]
6034	Clarke 1880	DATUM["D_Clarke_1880",SPHEROID["Clarke_1880",6378249.138, 293.466307656]]
6013	Clarke 1880 (Arc)	DATUM["D_Clarke_1880_Arc",SPHEROID["Clarke_1880_Arc", 6378249.145,293.466307656]]
6010	Clarke 1880 (Benoit)	DATUM["D_Clarke_1880_Benoit",SPHEROID["Clarke_1880_Benoit", 6378300.79,293.466234571]]
6011	Clarke 1880 (IGN)	DATUM["D_Clarke_1880_IGN",SPHEROID["Clarke_1880_IGN", 6378249.2,293.46602]]
6012	Clarke 1880 (RGS)	DATUM["D_Clarke_1880_RGS",SPHEROID["Clarke_1880_RGS", 6378249.145,293.465]]
6014	Clarke 1880 (SGA)	DATUM["D_Clarke_1880_SGA",SPHEROID["Clarke_1880_SGA", 6378249.2,293.46598]]
6042	Everest 1830	DATUM["D_Everest_1830",SPHEROID["Everest_1830",6377299.36, 300.8017]]
6015	Everest (adjustment 1937)	DATUM["D_Everest_Adj_1937",SPHEROID["Everest_Adjustment_1937", 6377276.345,300.8017]]
6044	Everest (definition 1962)	DATUM["D_Everest_Def_1962",SPHEROID["Everest_Definition_1962", 6377301.243,300.8017255]]
6016	Everest (definition 1967)	DATUM["D_Everest_Def_1967",SPHEROID["Everest_Definition_1967", 6377298.556,300.8017]]
6045	Everest (definition 1975)	DATUM["D_Everest_Def_1975",SPHEROID["Everest_Definition_1975", 6377299.151,300.8017255]]
6018	Everest modified	DATUM["D_Everest_Modified",SPHEROID["Everest_1830_Modified", 6377304.063,300.8017]]
6031	GEM gravity potential model	DATUM["D_GEM_10C",SPHEROID["GEM_10C",6378137,298.257222101]]
6036	GRS 1967	DATUM["D_GRS_1967",SPHEROID["GRS_1967",6378160,298.247167427]]
6019	GRS 1980	DATUM["D_GRS_1980",SPHEROID["GRS_1980",6378137,298.257222101]]
6020	Helmert 1906	DATUM["D_Helmert_1906",SPHEROID["Helmert_1906",6378200,298.3]]
6021	Indonesian National	DATUM["D_Indonesian",SPHEROID["Indonesian",6378160,298.247]]
6022	International 1927	DATUM["D_International_1924",SPHEROID["International_1924",6378388,297]]
6023	International 1967	DATUM["D_International_1967",SPHEROID["International_1967",6378160,298.25]]
6024	Krasovsky 1940	DATUM["D_Krasovsky_1940",SPHEROID["Krasovsky_1940",6378245, 298.3]]
6025	Transit precise ephemeris	DATUM["D_NWL_9D",SPHEROID["NWL_9D",6378145,298.25]]
6032	OSU 1986 geoidal model	DATUM["D_OSU_86F",SPHEROID["OSU_86F",6378136.2,298.25722]]
6033	OSU 1991 geoidal model	DATUM["D_OSU_91A",SPHEROID["OSU_91A",6378136.3,298.25722]]
6027	Plessis 1817	DATUM["D_Plessis_1817",SPHEROID["Plessis_1817",6376523,308.64]]
6035	Authalic sphere	DATUM["D_Sphere",SPHEROID["Sphere",6371000,0]]
6028	Struve 1860	DATUM["D_Struve_1860",SPHEROID["Struve_1860",6378298.3,294.73]]
6029	War Office	DATUM["D_War_Office",SPHEROID["War_Office",6378300.583,296]]
106001	WGS 1966	DATUM["D_WGS_1966",SPHEROID["WGS_1966",6378145,298.25]]

Table B-4. Spheroid horizontal datums (continued)

Factory ID	Description	OGC well-known text string
106002	Fischer 1960	DATUM["D_Fischer_1960",SPHEROID["Fischer_1960",6378166,298.3]]
106003	Fischer 1968	DATUM["D_Fischer_1968",SPHEROID["Fischer_1968",6378150,298.3]]
106004	Fischer modified	DATUM["D_Fischer_Modified",SPHEROID["Fischer_Modified",6378155, 298.3]]
106005	Hough 1960	DATUM["D_Hough_1960",SPHEROID["Hough_1960",6378270,297]]
106006	Everest modified 1969	DATUM["D_Everest_Modified_1969", SPHEROID["Everest_Modified_1969",6377295.664,300.8017]]
106007	Walbeck	DATUM["D_Walbeck",SPHEROID["Walbeck",6376896,302.78]]
106008	Authalic sphere (ARC/INFO)	DATUM["D_Sphere_ARC_INFO",SPHEROID["Sphere_ARC_INFO", 6370997,0]]

Horizontal datums

IBM Informix spatial data types support many horizontal datums.

The following table lists a representative sample of the horizontal datums supported by the IBM Informix spatial data types. For a complete list of supported horizontal datums, see the file `INFORMIXDIR/extend/spatial.`*`version`*`/include/pedef.h`.

Table B-5. Horizontal datums

Factory ID	Description	OGC well-known text string
6201	Adindan	DATUM["D_Adindan",SPHEROID["Clarke_1880_RGS",6378249.145, 293.465]]
6205	Afgooye	DATUM["D_Afgooye",SPHEROID["Krasovsky_1940",6378245,298.3]]
6206	Agadez	DATUM["D_Agadez",SPHEROID["Clarke_1880_IGN",6378249.2, 293.46602]]
6202	Australian Geodetic Datum 1966	DATUM["D_Australian_1966",SPHEROID["Australian",6378160,298.25]]
6203	Australian Geodetic Datum 1984	DATUM["D_Australian_1984",SPHEROID["Australian",6378160,298.25]]
6204	Ain el Abd 1970	DATUM["D_Ain_el_Abd_1970",SPHEROID["International_1924", 6378388,297]]
6289	Amersfoort	DATUM["D_Amersfoort",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
6208	Aratu	DATUM["D_Aratu",SPHEROID["International_1924",6378388,297]]
6209	Arc 1950	DATUM["D_Arc_1950",SPHEROID["Clarke_1880_Arc",6378249.145, 293.466307656]]
6210	Arc 1960	DATUM["D_Arc_1960",SPHEROID["Clarke_1880_RGS",6378249.145, 293.465]]
6901	Ancienne Triangulation Francaise	DATUM["D_ATF",SPHEROID["Plessis_1817",6376523,308.64]]
6122	Average Terrestrial System 1977	DATUM["D_ATS_1977",SPHEROID["ATS_1977",6378135,298.257]]
6212	Barbados 1938	DATUM["D_Barbados_1938",SPHEROID["Clarke_1880_RGS", 6378249.145,293.465]]
6211	Batavia	DATUM["D_Batavia",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
6213	Beduaram	DATUM["D_Beduaram",SPHEROID["Clarke_1880_IGN",6378249.2, 293.46602]]
6214	Beijing 1954	DATUM["D_Beijing_1954",SPHEROID["Krasovsky_1940",6378245,298.3]]

Table B-5. Horizontal datums (continued)

Factory ID	Description	OGC well-known text string
6215	Reseau National Belge 1950	DATUM["D_Belge_1950",SPHEROID["International_1924",6378388,297]]
6313	Reseau National Belge 1972	DATUM["D_Belge_1972",SPHEROID["International_1924",6378388,297]]
6216	Bermuda 1957	DATUM["D_Bermuda_1957",SPHEROID["Clarke_1866",6378206.4, 294.9786982]]
6217	Bern 1898	DATUM["D_Bern_1898",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
6306	Bern 1938	DATUM["D_Bern_1938",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
6218	Bogota	DATUM["D_Bogota",SPHEROID["International_1924",6378388,297]]
6219	Bukit Rimpah	DATUM["D_Bukit_Rimpah",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
6220	Camacupa	DATUM["D_Camacupa",SPHEROID["Clarke_1880_RGS",6378249.145, 293.465]]
6221	Campo Inchauspe	DATUM["D_Campo_Inchauspe",SPHEROID["International_1924", 6378388,297]]
6222	Cape	DATUM["D_Cape",SPHEROID["Clarke_1880_Arc",6378249.145, 293.466307656]]
6223	Carthage	DATUM["D_Carthage",SPHEROID["Clarke_1880_IGN",6378249.2, 293.46602]]
6224	Chua	DATUM["D_Chua",SPHEROID["International_1924",6378388,297]]
6315	Conakry 1905	DATUM["D_Conakry_1905",SPHEROID["Clarke_1880_IGN",6378249.2, 293.46602]]
6225	Corrego Alegre	DATUM["D_Corrego_Alegre",SPHEROID["International_1924",6378388,297]]
6226	Cote d'Ivoire	DATUM["D_Cote_d_Ivoire",SPHEROID["Clarke_1880_IGN",6378249.2, 293.46602]]
6274	Datum 73	DATUM["D_Datum_73",SPHEROID["International_1924",6378388,297]]
6227	Deir ez Zor	DATUM["D_Deir_ez_Zor",SPHEROID["Clarke_1880_IGN",6378249.2, 293.46602]]
6316	Dealul Piscului 1933	DATUM["D_Dealul_Piscului_1933",SPHEROID["International_1924", 6378388,297]]
6317	Dealul Piscului 1970	DATUM["D_Dealul_Piscului_1970",SPHEROID["Krasovsky_1940", 6378245,298.3]]
6314	Deutsche Hauptdreiecksnetz	DATUM["D_Deutsche_Hauptdreiecksnetz",SPHEROID["Bessel_1841", 6377397.155,299.1528128]]
6228	Douala	DATUM["D_Douala",SPHEROID["Clarke_1880_IGN",6378249.2, 293.46602]]
6230	European Datum 1950	DATUM["D_European_1950",SPHEROID["International_1924",6378388, 297]]
6231	European Datum 1987	DATUM["D_European_1987",SPHEROID["International_1924",6378388, 297]]
6229	Egypt 1907	DATUM["D_Egypt_1907",SPHEROID["Helmert_1906",6378200,298.3]]
6258	European Terrestrial Reference Frame 1989	DATUM["D_ETRF_1989",SPHEROID["WGS_1984",6378137, 298.257223563]]
6232	Fahud	DATUM["D_Fahud",SPHEROID["Clarke_1880_RGS",6378249.145, 293.465]]
6132	Final Datum 1958	DATUM["D_FD_1958",SPHEROID["Clarke_1880_RGS",6378249.145, 293.465]]
6233	Gandajika 1970	DATUM["D_Gandajika_1970",SPHEROID["International_1924",6378388, 297]]
6234	Garoua	DATUM["D_Garoua",SPHEROID["Clarke_1880_IGN",6378249.2, 293.46602]]
6283	Geocentric Datum of Australia 1994	DATUM["D_GDA_1994",SPHEROID["GRS_1980",6378137, 298.257222101]]
6121	Greek Geodetic Reference System 1987	DATUM["D_GGRS_1987",SPHEROID["GRS_1980",6378137, 298.257222101]]

Table B-5. Horizontal datums (continued)

Factory ID	Description	OGC well-known text string
6120	Greek	DATUM["D_Greek",SPHEROID["Bessel_1841",6377397.155,299.1528128]]
6235	Guyane Francaise	DATUM["D_Guyane_Francaise",SPHEROID["International_1924", 6378388,297]]
6255	Herat North	DATUM["D_Herat_North",SPHEROID["International_1924",6378388, 297]]
6254	Hito XVIII 1963	DATUM["D_Hito_XVIII_1963",SPHEROID["International_1924",6378388,297]]
6236	Hu Tzu Shan	DATUM["D_Hu_Tzu_Shan",SPHEROID["International_1924",6378388, 297]]
6237	Hungarian Datum 1972	DATUM["D_Hungarian_1972",SPHEROID["GRS_1967",6378160, 298.247167427]]
6239	Indian 1954	DATUM["D_Indian_1954",SPHEROID["Everest_Adjustment_1937", 6377276.345,300.8017]]
6240	Indian 1975	DATUM["D_Indian_1975",SPHEROID["Everest_Adjustment_1937", 6377276.345,300.8017]]
6238	Indonesian Datum 1974	DATUM["D_Indonesian_1974",SPHEROID["Indonesian",6378160, 298.247]]
6241	Jamaica 1875	DATUM["D_Jamaica_1875",SPHEROID["Clarke_1880",6378249.138, 293.466307656]]
6242	Jamaica 1969	DATUM["D_Jamaica_1969",SPHEROID["Clarke_1866",6378206.4, 294.9786982]]
6243	Kalianpur 1880	DATUM["D_Kalianpur_1880",SPHEROID["Everest_1830",6377299.36, 300.8017]]
6244	Kandawala	DATUM["D_Kandawala",SPHEROID["Everest_Adjustment_1937", 6377276.345,300.8017]]
6245	Kertau	DATUM["D_Kertau",SPHEROID["Everest_1830_Modified",6377304.063, 300.8017]]
6123	Kartastokoordinaatti-jarjestelma	DATUM["D_KKJ",SPHEROID["International_1924",6378388,297]]
6246	Kuwait Oil Company	DATUM["D_Kuwait_Oil_Company",SPHEROID["Clarke_1880_RGS", 6378249.145,293.465]]
6319	Kuwait Utility	DATUM["D_Kuwait_Utility",SPHEROID["GRS_1980",6378137, 298.257222101]]
6247	La Canoa	DATUM["D_La_Canoa",SPHEROID["International_1924",6378388,297]]
6249	Lake	DATUM["D_Lake",SPHEROID["International_1924",6378388,297]]
6250	Leigon	DATUM["D_Leigon",SPHEROID["Clarke_1880_RGS",6378249.145, 293.465]]
6251	Liberia 1964	DATUM["D_Liberia_1964",SPHEROID["Clarke_1880_RGS",6378249.145, 293.465]]
6207	Lisbon	DATUM["D_Lisbon",SPHEROID["International_1924",6378388,297]]
6126	Lithuania 1994	DATUM["D_Lithuania_1994",SPHEROID["GRS_1980",6378137, 298.257222101]]
6288	Loma Quintana	DATUM["D_Loma_Quintana",SPHEROID["International_1924",6378388,297]]
6252	Lome	DATUM["D_Lome",SPHEROID["Clarke_1880_IGN",6378249.2, 293.46602]]
6253	Luzon 1911	DATUM["D_Luzon_1911",SPHEROID["Clarke_1866",6378206.4, 294.9786982]]
6903	Madrid 1870	DATUM["D_Madrid_1870",SPHEROID["Struve_1860",6378298.3,294.73]]
6128	Madzansua —superseded by Tete	DATUM["D_Madzansua",SPHEROID["Clarke_1866",6378206.4, 294.9786982]]
6256	Mahe 1971	DATUM["D_Mahe_1971",SPHEROID["Clarke_1880_RGS",6378249.145, 293.465]]
6257	Makassar	DATUM["D_Makassar",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
6259	Malongo 1987	DATUM["D_Malongo_1987",SPHEROID["International_1924",6378388, 297]]
6260	Manoca	DATUM["D_Manoca",SPHEROID["Clarke_1880_RGS",6378249.145, 293.465]]
6262	Massawa	DATUM["D_Massawa",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]

Table B-5. Horizontal datums (continued)

Factory ID	Description	OGC well-known text string
6261	Merchich	DATUM["D_Merchich",SPHEROID["Clarke_1880_IGN",6378249.2, 293.46602]]
6312	Militar-Geographische Institut	DATUM["D_MGI",SPHEROID["Bessel_1841",6377397.155,299.1528128]]
6264	Mhast	DATUM["D_Mhast",SPHEROID["International_1924",6378388,297]]
6263	Minna	DATUM["D_Minna",SPHEROID["Clarke_1880_RGS",6378249.145, 293.465]]
6265	Monte Mario	DATUM["D_Monte_Mario",SPHEROID["International_1924",6378388, 297]]
6130	Moznet	DATUM["D_Moznet",SPHEROID["WGS_1984",6378137,298.257223563]]
6266	M'poraloko	DATUM["D_Mporaloko",SPHEROID["Clarke_1880_IGN",6378249.2, 293.46602]]
6268	NAD Michigan	DATUM["D_North_American_Michigan", SPHEROID["Clarke_1866_Michigan",6378450.047,294.978684677]]
6267	North American Datum 1927	DATUM["D_North_American_1927",SPHEROID["Clarke_1866", 6378206.4,294.9786982]]
6269	North American Datum 1983	DATUM["D_North_American_1983",SPHEROID["GRS_1980",6378137, 298.257222101]]
6270	Nahrwan 1967	DATUM["D_Nahrwan_1967",SPHEROID["Clarke_1880_RGS", 6378249.145,293.465]]
6271	Naparima 1972	DATUM["D_Naparima_1972",SPHEROID["International_1924", 6378388,297]]
6902	Nord de Guerre	DATUM["D_Nord_de_Guerre",SPHEROID["Plessis_1817",6376523, 308.64]]
6318	National Geodetic Network (Kuwait)	DATUM["D_NGN",SPHEROID["WGS_1984",6378137,298.257223563]]
6273	NGO 1948	DATUM["D_NGO_1948",SPHEROID["Bessel_Modified",6377492.018, 299.1528128]]
6307	Nord Sahara 1959	DATUM["D_Nord_Sahara_1959",SPHEROID["Clarke_1880_RGS", 6378249.145,293.465]]
6276	NSWC 9Z-2	DATUM["D_NSWC_9Z_2",SPHEROID["NWL_9D",6378145,298.25]]
6275	Nouvelle Triangulation Francaise	DATUM["D_NTF",SPHEROID["Clarke_1880_IGN",6378249.2,293.46602]]
6272	New Zealand Geodetic Datum 1949	DATUM["D_New_Zealand_1949",SPHEROID["International_1924", 6378388,297]]
6129	Observatario —superseded by Tete	DATUM["D_Observatario",SPHEROID["Clarke_1866",6378206.4, 294.9786982]]
6279	OS (SN) 1980	DATUM["D_OS_SN_1980",SPHEROID["Airy_1830",6377563.396, 299.3249646]]
6277	OSGB 1936	DATUM["D_OSGB_1936",SPHEROID["Airy_1830",6377563.396, 299.3249646]]
6278	OSGB 1970 (SN)	DATUM["D_OSGB_1970_SN",SPHEROID["Airy_1830",6377563.396, 299.3249646]]
6280	Padang 1884	DATUM["D_Padang_1884",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
6281	Palestine 1923	DATUM["D_Palestine_1923",SPHEROID["Clarke_1880_Benoit", 6378300.79,293.466234571]]
6282	Pointe Noire	DATUM["D_Pointe_Noire",SPHEROID["Clarke_1880_IGN",6378249.2, 293.46602]]
6248	Provisional South American Datum 1956	DATUM["D_Provisional_S_American_1956", SPHEROID["International_1924",6378388,297]]
6284	Pulkovo 1942	DATUM["D_Pulkovo_1942",SPHEROID["Krasovsky_1940",6378245, 298.3]]
6200	Pulkovo 1995	DATUM["D_Pulkovo_1995",SPHEROID["Krasovsky_1940",6378245, 298.3]]

Table B-5. Horizontal datums (continued)

Factory ID	Description	OGC well-known text string
6285	Qatar	DATUM["D_Qatar",SPHEROID["International_1924",6378388,297]]
6286	Qatar 1948	DATUM["D_Qatar_1948",SPHEROID["Helmert_1906",6378200,298.3]]
6287	Qornoq	DATUM["D_Qornoq",SPHEROID["International_1924",6378388,297]]
6124	RT 1990	DATUM["D_RT_1990",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
6291	South American Datum 1969	DATUM["D_South_American_1969", SPHEROID["GRS_1967_Truncated",6378160,298.25]]
6125	Samboja	DATUM["D_Samboja",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
6292	Sapper Hill 1943	DATUM["D_Sapper_Hill_1943",SPHEROID["International_1924", 6378388,297]]
6293	Schwarzeck	DATUM["D_Schwarzeck",SPHEROID["Bessel_Namibia",6377483.865, 299.1528128]]
6294	Segora	DATUM["D_Segora",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
6295	Serindung	DATUM["D_Serindung",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
6308	Stockholm 1938	DATUM["D_Stockholm_1938",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
6138	Alaska, St. George Island	DATUM["D_St_George_Island",SPHEROID["Clarke_1866",6378206.4, 294.9786982]]
6136	Alaska, St. Lawrence Island	DATUM["D_St_Lawrence_Island",SPHEROID["Clarke_1866",6378206.4, 294.9786982]]
6137	Alaska, St. Paul Island	DATUM["D_St_Paul_Island",SPHEROID["Clarke_1866",6378206.4, 294.9786982]]
6296	Sudan	DATUM["D_Sudan",SPHEROID["Clarke_1880_IGN",6378249.2, 293.46602]]
6297	Tananarive 1925	DATUM["D_Tananarive_1925",SPHEROID["International_1924",6378388,297]]
6127	Tete	DATUM["D_Tete",SPHEROID["Clarke_1866",6378206.4,294.9786982]]
6298	Timbalai 1948	DATUM["D_Timbalai_1948",SPHEROID["Everest_Definition_1967", 6377298.556,300.8017]]
6299	TM65	DATUM["D_TM65",SPHEROID["Airy_Modified",6377340.189, 299.3249646]]
6300	TM75	DATUM["D_TM75",SPHEROID["Airy_Modified",6377340.189, 299.3249646]]
6301	Tokyo	DATUM["D_Tokyo",SPHEROID["Bessel_1841",6377397.155,299.1528128]]
6302	Trinidad 1903	DATUM["D_Trinidad_1903",SPHEROID["Clarke_1858",6378293.639, 294.260676369]]
6303	Trucial Coast 1948	DATUM["D_Trucial_Coast_1948",SPHEROID["Helmert_1906",6378200, 298.3]]
6304	Voirol 1875	DATUM["D_Voirol_1875",SPHEROID["Clarke_1880_IGN",6378249.2, 293.46602]]
6305	Voirol Unifie 1960	DATUM["D_Voirol_Unifie_1960",SPHEROID["Clarke_1880_RGS", 6378249.145,293.465]]
6322	WGS 1972	DATUM["D_WGS_1972",SPHEROID["WGS_1972",6378135,298.26]]
6324	WGS 1972 Transit Broadcast Ephemeris	DATUM["D_WGS_1972_BE",SPHEROID["WGS_1972",6378135,298.26]]
6326	WGS 1984	DATUM["D_WGS_1984",SPHEROID["WGS_1984",6378137, 298.257223563]]
6309	Yacare	DATUM["D_Yacare",SPHEROID["International_1924",6378388,297]]
6310	Yoff	DATUM["D_Yoff",SPHEROID["Clarke_1880_IGN",6378249.2,293.46602]]
6311	Zanderij	DATUM["D_Zanderij",SPHEROID["International_1924",6378388,297]]
6600	Anguilla 1957	DATUM["D_Anguilla_1957",SPHEROID["Clarke_1880_RGS", 6378249.145,293.465]]

Table B-5. Horizontal datums (continued)

Factory ID	Description	OGC well-known text string
6133	Estonia 1992	DATUM["D_Estonia_1992",SPHEROID["GRS_1980",6378137, 298.257222101]]
6602	Dominica 1945	DATUM["D_Dominica_1945",SPHEROID["Clarke_1880_RGS", 6378249.145,293.465]]
6603	Grenada 1953	DATUM["D_Grenada_1953",SPHEROID["Clarke_1880_RGS", 6378249.145,293.465]]
6609	NAD_1927 (CGQ77)	DATUM["D_NAD_1927_CGQ77",SPHEROID["Clarke_1866", 6378206.4,294.9786982]]
6608	NAD 1927 (1976)	DATUM["D_NAD_1927_Definition_1976",SPHEROID["Clarke_1866", 6378206.4,294.9786982]]
6134	PDO Survey Datum 1993	DATUM["D_PDO_1993",SPHEROID["Clarke_1880_RGS",6378249.145, 293.465]]
6605	St. Kitts 1955	DATUM["D_St_Kitts_1955",SPHEROID["Clarke_1880_RGS",6378249.145,293.465]]
6606	St. Lucia 1955	DATUM["D_St_Lucia_1955",SPHEROID["Clarke_1880_RGS", 6378249.145,293.465]]
6607	St. Vincent 1945	DATUM["D_St_Vincent_1945",SPHEROID["Clarke_1880_RGS", 6378249.145,293.465]]
6140	NAD 1983 (Canadian Spatial Reference System)	DATUM["D_North_American_1983_CSRS98",SPHEROID["GRS_1980", 6378137,298.257222101]]
6141	Israel	DATUM["D_Israel",SPHEROID["GRS_1980",6378137,298.257222101]]
6142	Locodjo 1965	DATUM["D_Locodjo_1965",SPHEROID["Clarke_1880_RGS",6378249.145,293.465]]
6143	Abidjan 1987	DATUM["D_Abidjan_1987",SPHEROID["Clarke_1880_RGS",6378249.145,293.465]]
6144	Kalianpur 1937	DATUM["D_Kalianpur_1937",SPHEROID["Everest_Adjustment_1937", 6377276.345,300.8017]]
6145	Kalianpur 1962	DATUM["D_Kalianpur_1962",SPHEROID["Everest_Definition_1962", 6377301.243,300.8017255]]
6146	Kalianpur 1975	DATUM["D_Kalianpur_1975",SPHEROID["Everest_Definition_1975", 6377299.151,300.8017255]]
6147	Hanoi 1972	DATUM["D_Hanoi_1972",SPHEROID["Krasovsky_1940",6378245,298.3]]
6148	Hartebeesthoek 1994	DATUM["D_Hartebeesthoek_1994",SPHEROID["WGS_1984",6378137, 298.257223563]]
6149	CH 1903	DATUM["D_CH1903",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
6150	CH 1903+	DATUM["D_CH1903+",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
6151	Swiss Terrestrial Reference Frame 1995	DATUM["D_Swiss_TRF_1995",SPHEROID["GRS_1980",6378137, 298.257222101]]
6152	NAD 1983 (HARN)	DATUM["D_North_American_1983_HARN",SPHEROID["GRS_1980", 6378137,298.257222101]]
6153	Rassadiran	DATUM["D_Rassadiran",SPHEROID["International_1924",6378388,297]]
6154	ED 1950 (ED77)	DATUM["D_European_1950_ED77",SPHEROID["International_1924", 6378388,297]]
6135	Old Hawaiian	DATUM["D_Old_Hawaiian",SPHEROID["Clarke_1866",6378206.4, 294.9786982]]
6601	Antigua Astro 1943	DATUM["D_Antigua_1943",SPHEROID["Clarke_1880_RGS",6378249.145,293.465]]
6604	Montserrat Astro 1958	DATUM["D_Montserrat_1958",SPHEROID["Clarke_1880_RGS", 6378249.145,293.465]]
6139	Puerto Rico	DATUM["D_Puerto_Rico",SPHEROID["Clarke_1866",6378206.4, 294.9786982]]

Table B-5. Horizontal datums (continued)

Factory ID	Description	OGC well-known text string
6131	Indian 1960	DATUM["D_Indian_1960",SPHEROID["Everest_Adjustment_1937", 6377276.345,300.8017]]
6155	Dabola	DATUM["D_Dabola",SPHEROID["Clarke_1880_RGS",6378249.145, 293.465]]
6156	S-JTSK	DATUM["D_S_JTSK",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
6165	Bissau	DATUM["D_Bissau",SPHEROID["International_1924",6378388,297]]
106101	Estonia 1937	DATUM["D_Estonia_1937",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
106102	Hermannskogel	DATUM["D_Hermannskogel",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
106103	Sierra Leone 1960	DATUM["D_Sierra_Leone_1960",SPHEROID["Clarke_1880_RGS", 6378249.145,293.465]]
106201	European 1979	DATUM["D_European_1979",SPHEROID["International_1924",6378388, 297]]
106202	Everest, Bangladesh	DATUM["D_Everest_Bangladesh", SPHEROID["Everest_Adjustment_1937",6377276.345,300.8017]]
106203	Everest, India and Nepal	DATUM["D_Everest_India_Nepal", SPHEROID["Everest_Definition_1962",6377301.243,300.8017255]]
106204	Hjorsey 1955	DATUM["D_Hjorsey_1955",SPHEROID["International_1924",6378388, 297]]
106205	Hong Kong 1963	DATUM["D_Hong_Kong_1963",SPHEROID["International_1924", 6378388,297]]
106206	Oman	DATUM["D_Oman",SPHEROID["Clarke_1880_RGS",6378249.145, 293.465]]
106207	South Asia Singapore	DATUM["D_South_Asia_Singapore",SPHEROID["Fischer_Modified", 6378155,298.3]]
106208	Ayabelle Lighthouse	DATUM["D_Ayabelle",SPHEROID["Clarke_1880_RGS",6378249.145, 293.465]]
106211	Point 58	DATUM["D_Point_58",SPHEROID["Clarke_1880_RGS",6378249.145, 293.465]]
106212	Astro Beacon E 1945	DATUM["D_Beacon_E_1945",SPHEROID["International_1924",6378388, 297]]
106213	Tern Island Astro 1961	DATUM["D_Tern_Island_1961",SPHEROID["International_1924", 6378388,297]]
106214	Astronomical Station 1952	DATUM["D_Astro_1952",SPHEROID["International_1924",6378388,297]]
106215	Bellevue IGN	DATUM["D_Bellevue_IGN",SPHEROID["International_1924",6378388, 297]]
106216	Canton Astro 1966	DATUM["D_Canton_1966",SPHEROID["International_1924",6378388, 297]]
106217	Chatham Island Astro 1971	DATUM["D_Chatham_Island_1971",SPHEROID["International_1924", 6378388,297]]
106218	DOS 1968	DATUM["D_DOS_1968",SPHEROID["International_1924",6378388,297]]
106219	Easter Island 1967	DATUM["D_Easter_Island_1967",SPHEROID["International_1924", 6378388,297]]
106220	Guam 1963	DATUM["D_Guam_1963",SPHEROID["Clarke_1866",6378206.4, 294.9786982]]
106221	GUX 1 Astro	DATUM["D_GUX_1",SPHEROID["International_1924",6378388,297]]
106222	Johnston Island 1961	DATUM["D_Johnston_Island_1961",SPHEROID["International_1924", 6378388,297]]
106259	Kusaie Astro 1951	DATUM["D_Kusaie_1951",SPHEROID["International_1924",6378388, 297]]
106224	Midway Astro 1961	DATUM["D_Midway_1961",SPHEROID["International_1924",6378388, 297]]
106226	Pitcairn Astro 1967	DATUM["D_Pitcairn_1967",SPHEROID["International_1924",6378388, 297]]
106227	Santo DOS 1965	DATUM["D_Santo_DOS_1965",SPHEROID["International_1924", 6378388,297]]
106228	Viti Levu 1916	DATUM["D_Viti_Levu_1916",SPHEROID["Clarke_1880_RGS", 6378249.145,293.465]]

Table B-5. Horizontal datums (continued)

Factory ID	Description	OGC well-known text string
106229	Wake-Eniwetok 1960	DATUM["D_Wake_Eniwetok_1960",SPHEROID["Hough_1960",6378270, 297]]
106230	Wake Island Astro 1952	DATUM["D_Wake_Island_1952",SPHEROID["International_1924", 6378388,297]]
106231	Anna 1 Astro 1965	DATUM["D_Anna_1_1965",SPHEROID["Australian",6378160,298.25]]
106232	Gan 1970	DATUM["D_Gan_1970",SPHEROID["International_1924",6378388,297]]
106233	ISTS 073 Astro 1969	DATUM["D_ISTS_073_1969",SPHEROID["International_1924",6378388, 297]]
106234	Kerguelen Island 1949	DATUM["D_Kerguelen_Island_1949",SPHEROID["International_1924", 6378388,297]]
106235	Reunion	DATUM["D_Reunion",SPHEROID["International_1924",6378388,297]]
106237	Ascension Island 1958	DATUM["D_Ascension_Island_1958",SPHEROID["International_1924", 6378388,297]]
106238	Astro DOS 71/4	DATUM["D_DOS_71_4",SPHEROID["International_1924",6378388,297]]
106239	Cape Canaveral	DATUM["D_Cape_Canaveral",SPHEROID["Clarke_1866", 6378206.4, 294.9786982]]
106240	Fort Thomas 1955	DATUM["D_Fort_Thomas_1955",SPHEROID["Clarke_1880_RGS", 6378249.145,293.465]]
106241	Graciosa Base SW 1948	DATUM["D_Graciosa_Base_SW_1948",SPHEROID["International_1924", 6378388,297]]
106242	ISTS 061 Astro 1968	DATUM["D_ISTS_061_1968",SPHEROID["International_1924",6378388, 297]]
106243	L.C. 5 Astro 1961	DATUM["D_LC5_1961",SPHEROID["Clarke_1866",6378206.4, 294.9786982]]
106245	Observ Meteorologico 1939	DATUM["D_Observ_Meteorologico_1939", SPHEROID["International_1924",6378388,297]]
106246	Pico de Las Nieves	DATUM["D_Pico_de_Las_Nieves",SPHEROID["International_1924", 6378388,297]]
106247	Porto Santo 1936	DATUM["D_Porto_Santo_1936",SPHEROID["International_1924", 6378388,297]]
106249	Sao Braz	DATUM["D_Sao_Braz",SPHEROID["International_1924",6378388,297]]
106250	Selvagem Grande 1938	DATUM["D_Selvagem_Grande_1938",SPHEROID["International_1924", 6378388,297]]
106251	Tristan Astro 1968	DATUM["D_Tristan_1968",SPHEROID["International_1924",6378388, 297]]
106252	American Samoa 1962	DATUM["D_Samoa_1962",SPHEROID["Clarke_1866",6378206.4, 294.9786982]]
106253	Camp Area Astro	DATUM["D_Camp_Area",SPHEROID["International_1924",6378388,297]]
106254	Deception Island	DATUM["D_Deception_Island",SPHEROID["Clarke_1880_RGS", 6378249.145,293.465]]
106255	Gunung Segara	DATUM["D_Gunung_Segara",SPHEROID["Bessel_1841",6377397.155, 299.1528128]]
106257	S-42 Hungary	DATUM["D_S42_Hungary",SPHEROID["Krasovsky_1940",6378245, 298.3]]
106260	Alaskan Islands	DATUM["D_Alaskan_Islands",SPHEROID["Clarke_1866",6378206.4, 294.9786982]]
106261	Hong Kong 1980	DATUM["D_Hong_Kong_1980", SPHEROID["International_1924", 6378388,297]
106262	Datum Lisboa Bessel	DATUM["D_Datum_Lisboa_Bessel", SPHEROID["Bessel_1841", 6377397.155,299.1528128]]
106263	Datum Lisboa Hayford	DATUM["D_Datum_Lisboa_Hayford", SPHEROID["International_1924", 6378388,297]]

Table B-5. Horizontal datums (continued)

Factory ID	Description	OGC well-known text string
106264	Reseau Geodesique Francais 1993	DATUM["D_RGF_1993", SPHEROID["GRS_1980", 6378137,298.257222101]]
106265	New Zealand Geodetic Datum 2000	DATUM["D_NZGD_2000", SPHEROID["GRS_1980",6378137, 298.257222101]]

Prime meridians

IBM Informix spatial data types support many prime meridians.

The following table lists a representative sample of the prime meridians supported by the IBM Informix spatial data types. For a complete list of supported prime meridians, see the file `INFORMIXDIR/extend/spatial.`*`version`*`/include/pedef.h`.

Table B-6. Prime meridians

Factory ID	Description	OGC well-known text string
8901	Greenwich 0°00'00"	PRIMEM["Greenwich",0]
8912	Athens 23°42'58".815 E	PRIMEM["Athens",23.7163375]
8907	Bern 7°26'22".5 E	PRIMEM["Bern",7.439583333333333]
8904	Bogota 74°04'51".3 W	PRIMEM["Bogota",-74.08091666666667]
8910	Brussels 4°22'04".71 E	PRIMEM["Brussels",4.367975]
8909	Ferro 17°40'00" W	PRIMEM["Ferro",-17.66666666666667]
8908	Jakarta 106°48'27".79 E	PRIMEM["Jakarta",106.8077194444444]
8902	Lisbon 9°07'54".862 W	PRIMEM["Lisbon",-9.131906111111112]
8905	Madrid 3°41'16".58 W	PRIMEM["Madrid",-3.687938888888889]
8913	Oslo 10°43'22".5 E	PRIMEM["Oslo",10.72291666666667]
8903	Paris 2°20'14".025 E	PRIMEM["Paris",2.337229166666667]
8906	Rome 12°27'08".4 E	PRIMEM["Rome",12.45233333333333]
8911	Stockholm 18°03'29".8 E	PRIMEM["Stockholm",18.05827777777778]

Projection parameters

IBM Informix spatial data types support many projection parameters.

The following table lists a representative sample of the projection parameters supported by the IBM Informix spatial data types. For a complete list of supported projection parameters, see the file `INFORMIXDIR/extend/spatial.`*`version`*`/include/pedef.h`.

Table B-7. Projection parameters

Factory ID	Description	OGC well-known text string
100001	False Easting	PARAMETER["False_Easting",0]
100002	False Northing	PARAMETER["False_Northing",0]
100003	Scale Factor	PARAMETER["Scale_Factor",1]
100004	Azimuth	PARAMETER["Azimuth",45]
100010	Central Meridian	PARAMETER["Central_Meridian",0]

Table B-7. Projection parameters (continued)

Factory ID	Description	OGC well-known text string
100011	Longitude Of Origin	PARAMETER["Longitude_Of_Origin",0]
100012	Longitude Of Center	PARAMETER["Longitude_Of_Center",-75]
100013	Longitude Of 1st Point	PARAMETER["Longitude_Of_1st_Point",0]
100014	Longitude Of 2nd Point	PARAMETER["Longitude_Of_2nd_Point",60]
100020	Central Parallel	PARAMETER["Central_Parallel",0]
100021	Latitude Of Origin	PARAMETER["Latitude_Of_Origin",0]
100022	Latitude Of Center	PARAMETER["Latitude_Of_Center",40]
100023	Latitude Of 1st Point	PARAMETER["Latitude_Of_1st_Point",0]
100024	Latitude Of 2nd Point	PARAMETER["Latitude_Of_2nd_Point",60]
100025	Standard Parallel 1	PARAMETER["Standard_Parallel_1",60]
100026	Standard Parallel 2	PARAMETER["Standard_Parallel_2",60]
100027	Pseudo Standard Parallel 1	PARAMETER["Pseudo_Standard_Parallel_1",60]
100037	X Scale	PARAMETER["X_Scale",1]
100038	Y Scale	PARAMETER["Y_Scale",1]
100039	XY Plane Rotation	PARAMETER["XY_Plane_Rotation",0]
100040	X Axis Translation	PARAMETER["X_Axis_Translation",0]
100041	Y Axis Translation	PARAMETER["Y_Axis_Translation",0]
100042	Z Axis Translation	PARAMETER["Z_Axis_Translation",0]
100043	X Axis Rotation	PARAMETER["X_Axis_Rotation",0]
100044	Y Axis Rotation	PARAMETER["Y_Axis_Rotation",0]
100045	Z Axis Rotation	PARAMETER["Z_Axis_Rotation",0]
100046	Scale Difference	PARAMETER["Scale_Difference",0]
100047	Dataset Name	PARAMETER["Dataset_",0]

Map projections

IBM Informix spatial data types support many map projections.

The following table lists a representative sample of the map projections supported by the IBM Informix spatial data types. For a complete list of supported map projections, see the file `INFORMIXDIR/extend/spatial.`*`version`*`/include/pedef.h`.

Table B-8. Map projections

Factory ID	Description	OGC well-known text string
43001	Plate Carree	PROJECTION["Plate_Carree"]
43002	Equidistant Cylindrical	PROJECTION["Equidistant_Cylindrical"]
43003	Miller Cylindrical	PROJECTION["Miller_Cylindrical"]
43004	Mercator	PROJECTION["Mercator"]
43005	Gauss-Kruger	PROJECTION["Gauss_Kruger"]
43006	Transverse Mercator	PROJECTION["Transverse_Mercator"]
43007	Albers	PROJECTION["Albers"]
43008	Sinusoidal	PROJECTION["Sinusoidal"]

Table B-8. Map projections (continued)

Factory ID	Description	OGC well-known text string
43009	Mollweide	PROJECTION["Mollweide"]
43010	Eckert VI	PROJECTION["Eckert_VI"]
43011	Eckert V	PROJECTION["Eckert_V"]
43012	Eckert IV	PROJECTION["Eckert_IV"]
43013	Eckert III	PROJECTION["Eckert_III"]
43014	Eckert II	PROJECTION["Eckert_II"]
43015	Eckert I	PROJECTION["Eckert_I"]
43016	Gall Stereographic	PROJECTION["Gall_Stereographic"]
43017	Behrmann	PROJECTION["Behrmann"]
43018	Winkel I	PROJECTION["Winkel_I"]
43019	Winkel II	PROJECTION["Winkel_II"]
43020	Lambert Conformal Conic	PROJECTION["Lambert_Conformal_Conic"]
43021	Polyconic	PROJECTION["Polyconic"]
43022	Quartic Authalic	PROJECTION["Quartic_Authalic"]
43023	Loximuthal	PROJECTION["Loximuthal"]
43024	Bonne	PROJECTION["Bonne"]
43025	Hotine 2 Pt Natural Origin	PROJECTION["Hotine_Oblique_Mercator_Two_ Point_Natural_Origin"]
43026	Stereographic	PROJECTION["Stereographic"]
43027	Equidistant Conic	PROJECTION["Equidistant_Conic"]
43028	Cassini	PROJECTION["Cassini"]
43029	Van der Grinten I	PROJECTION["Van_der_Grinten_I"]
43030	Robinson	PROJECTION["Robinson"]
43031	Two-Point Equidistant	PROJECTION["Two_Point_Equidistant"]
43032	Azimuthal Equidistant	PROJECTION["Azimuthal_Equidistant"]
43033	Lambert Azimuthal Equal Area	PROJECTION["Lambert_Azimuthal_Equal_Area"]
43034	Cylindrical Equal Area	PROJECTION["Cylindrical_Equal_Area"]
43035	Hotine 2 Point Center	PROJECTION["Hotine_Oblique_Mercator_Two_ Point_Center"]
43036	Hotine Azimuth Natural Origin	PROJECTION["Hotine_Oblique_Mercator_Azimuth _Natural_Origin"]
43037	Hotine Azimuth Center	PROJECTION["Hotine_Oblique_Mercator_Azimuth _Center"]
43038	Double Stereographic	PROJECTION["Double_Stereographic"]
43039	Krovak Oblique Lambert	PROJECTION["Krovak"]
43040	New Zealand Map Grid	PROJECTION["New_Zealand_Map_Grid"]
43041	Orthographic	PROJECTION["Orthographic"]
43042	Winkel Tripel	PROJECTION["Winkel_Tripel"]
43043	Aitoff	PROJECTION["Aitoff"]
43044	Hammer Aitoff	PROJECTION["Hammer_Aitoff"]
43045	Flat Polar Quartic	PROJECTION["Flat_Polar_Quartic"]

Table B-8. Map projections (continued)

Factory ID	Description	OGC well-known text string
43046	Craster Parabolic	PROJECTION["Craster_Parabolic"]
43047	Gnomonic	PROJECTION["Gnomonic"]
43048	Bartholomew Times	PROJECTION["Times"]
43049	Vertical Near-Side Perspective	PROJECTION["Vertical_Near_Side_Perspective"]

Appendix C. OGC well-known text representation of geometry

Each geometry type has a well-known text representation from which new instances can be constructed or existing instances can be converted to textual form for alphanumeric display.

Related reference:

"Well-known text representation" on page 3-1

"Well-known binary representation" on page 3-1

Well-known text representation in a C program

The well-known text representation of geometry can be incorporated into a C program. The structure for such an implementation is defined below. The notation {}* denotes zero or more repetitions of the tokens within the braces. The braces do not appear in the output token list.

```
<Geometry Tagged Text> :=
       | <Point Tagged Text>
       | <LineString Tagged Text>
       | <Polygon Tagged Text>
       | <MultiPoint Tagged  Text>
       | <MultiLineString Tagged Text>
       | <MultiPolygon Tagged Text>

<Point Tagged Text> :=
      POINT <Point Text>
<LineString Tagged Text> :=
      LINESTRING <LineString Text>
<Polygon Tagged Text> :=
      POLYGON <Polygon Text>
<MultiPoint Tagged Text> :=
      MULTIPOINT <Multipoint Text>
<MultiLineString Tagged Text> :=
      MULTILINESTRING <MultiLineString Text>
<MultiPolygon Tagged Text> :=
      MULTIPOLYGON <MultiPolygon Text>

<Point Text> := EMPTY
       |    <Point>
       | Z  <PointZ>
       | M  <PointM>
       | ZM <PointZM>


<Point> :=  <x>  <y>
       <x> := double precision literal
       <y> := double precision literal

<PointZ> :=  <x>  <y>  <z>
       <x> := double precision literal
       <y> := double precision literal
       <z> := double precision literal

<PointM> :=  <x>  <y>  <m>
        <x> := double precision literal
        <y> := double precision literal
        <m> := double precision literal


<PointZM> :=  <x>  <y>  <z>  <m>
```

```
<x> := double precision literal
<y> := double precision literal
<z> := double precision literal
<m> := double precision literal


<LineString Text> := EMPTY
         |     ( <Point Text >   {,  <Point Text> }*  )
         |  Z  ( <PointZ Text >  {,  <PointZ Text> }*  )
         |  M  ( <PointM Text >  {,  <PointM Text> }*  )
         |  ZM ( <PointZM Text > {,  <PointZM Text> }* )


<Polygon Text> := EMPTY
       | ( <LineString Text > {,< LineString Text > }*)

<Multipoint Text> := EMPTY
       | ( <Point Text >   {,  <Point Text > }*  )

<MultiLineString Text> := EMPTY
       | ( <LineString Text > {,< LineString Text>}*  )

<MultiPolygon Text> := EMPTY
       | ( < Polygon Text > {,  < Polygon Text > }*  )
```

Well-known text representation in an SQL editor

Since the well-known text representation is text, it can be typed into an SQL script or directly into an SQL editor. The text is converted to and from a geometry by a function. Functions that convert text to geometry have the following syntax:

```
function ('text description',SRID)
```

Example:

```
ST_PointFromText('point zm (10.01 20.04 3.2 9.5)', 1)
```

The spatial reference identifier, SRID—the primary key to the **spatial_references** table—identifies the possible spatial reference systems within an IBM Informix instance. An SRID is assigned to a spatial column when it is created. Before a geometry can be inserted into a spatial column, its SRID must match the SRID of the spatial column.

The *text description* is made up of three basic components enclosed in single quotation marks:

```
'geometry type [coordinate type] [coordinate list]'
```

The *geometry type* is defined as one of the following: point, linestring, polygon, multipoint, multilinestring, or multipolygon.

The *coordinate type* specifies whether the geometry has Z coordinates or measures. Leave this argument blank if the geometry has neither; otherwise, set the coordinate type to Z for geometries containing Z coordinates, M for geometries with measures, and ZM for geometries that have both.

The *coordinate list* defines the double-precision vertices of the geometry. Coordinate lists are comma-delimited and enclosed by parentheses. Geometries having multiple components require sets of parentheses to enclose each component part. If the geometry is empty, the EMPTY keyword replaces the coordinates.

The following examples provide a complete list of all possible permutations of the text description portion of the text representation.

Geometry type	Text description	Comment
ST_Point	‘point empty'	Empty point
ST_Point	‘point z empty'	Empty point with Z coordinate
ST_Point	‘point m empty'	Empty point with measure
ST_Point	‘point zm empty'	Empty point with Z coordinate and measure
ST_Point	‘point (10.05 10.28)'	Point
ST_Point	‘point z (10.05 10.28 2.51)'	Point with Z coordinate
ST_Point	‘point m (10.05 10.28 4.72)'	Point with measure
ST_Point	‘point zm (10.05 10.28 2.51 4.72)'	Point with Z coordinate and measure
ST_LineString	‘linestring empty'	Empty linestring
ST_LineString	‘linestring z empty'	Empty linestring with Z coordinates
ST_LineString	‘linestring m empty'	Empty linestring with measures
ST_LineString	‘linestring zm empty'	Empty linestring with Z coordinates and measures
ST_LineString	‘linestring (10.05 10.28 , 20.95 20.89)'	Linestring
ST_LineString	‘linestring z (10.05 10.28 3.09, 20.95 31.98 4.72, 21.98 29.80 3.51)'	Linestring with Z coordinates
ST_LineString	‘linestring m (10.05 10.28 5.84, 20.95 31.98 9.01, 21.98 29.80 12.84)'	Linestring with measures
ST_LineString	‘linestring zm (10.05 10.28 3.09 5.84, 20.95 31.98 4.72 9.01, 21.98 29.80 3.51 12.84)'	Linestring with Z coordinates and measures
ST_Polygon	‘polygon empty'	Empty polygon
ST_Polygon	‘polygon z empty'	Empty polygon with Z coordinates
ST_Polygon	‘polygon m empty	Empty polygon with measures
ST_Polygon	‘polygon zm empty'	Empty polygon with Z coordinates and measures
ST_Polygon	‘polygon ((10 10, 10 20, 20 20, 20 15, 10 10))'	Polygon
ST_Polygon	‘polygon z ((10 10 3, 10 20 3, 20 20 3, 20 15 4, 10 10 3))'	Polygon with Z coordinates
ST_Polygon	‘polygon m ((10 10 8, 10 20 9, 20 20 9, 20 15 9, 10 10 8))'	Polygon with measures
ST_Polygon	‘polygon zm ((10 10 3 8, 10 20 3 9, 20 20 3 9, 20 15 4 9, 10 10 3 8))'	Polygon with Z coordinates and measures
ST_MultiPoint	‘multipoint empty'	Empty multipoint
ST_MultiPoint	‘multipoint z empty'	Empty multipoint with Z coordinates
ST_MultiPoint	‘multipoint m empty'	Empty multipoint with measures
ST_MultiPoint	‘multipoint zm empty'	Empty multipoint with Z coordinates and measures
ST_MultiPoint	‘multipoint (10 10, 20 20)'	Multipoint with two points
ST_MultiPoint	‘multipoint z (10 10 2, 20 20 3)'	Multipoint with Z coordinates
ST_MultiPoint	‘multipoint m (10 10 4, 20 20 5)'	Multipoint with measures
ST_MultiPoint	‘multipoint zm (10 10 2 4, 20 20 3 5)'	Multipoint with Z coordinates and measures
ST_MultiLineString	‘multilinestring empty'	Empty multilinestring
ST_MultiLineString	‘multilinestring z empty'	Empty multilinestring with Z coordinates
ST_MultiLineString	‘multilinestring m empty'	Empty multilinestring with measures
ST_MultiLineString	‘multilinestring zm empty'	Empty multilinestring with Z coordinates and measures

Geometry type	Text description	Comment
ST_MultiLineString	‘multilinestring ((10.05 10.28 , 20.95 20.89),(20.95 20.89, 31.92 21.45))'	Multilinestring
ST_MultiLineString	‘multilinestring z ((10.05 10.28 3.4, 20.95 20.89 4.5),(20.95 20.89 4.5, 31.92 21.45 3.6))'	Multilinestring with Z coordinates
ST_MultiLineString	‘multilinestring m ((10.05 10.28 8.4, 20.95 20.89 9.5),(20.95 20.89 9.5, 31.92 21.45 8.6))'	Multilinestring with measures
ST_MultiLineString	‘multilinestring zm ((10.05 10.28 3.4 8.4, 20.95 20.89 4.5 9.5), (20.95 20.89 4.5 9.5, 31.92 21.45 3.6 8.6))'	Multilinestring with Z coordinates and measures
ST_MultiPolygon	‘multipolygon empty'	Empty multipolygon
ST_MultiPolygon	‘multipolygon z empty'	Empty multipolygon with Z coordinates
ST_MultiPolygon	‘multipolygon m empty'	Empty multipolygon with measures
ST_MultiPolygon	‘multipolygon zm empty'	Empty multipolygon with Z coordinates and measures
ST_MultiPolygon	‘multipolygon (((10 10, 10 20, 20 20, 20 15 , 10 10), (50 40, 50 50, 60 50, 60 40, 50 40)))'	Multipolygon
ST_MultiPolygon	‘multipolygon z (((10 10 7, 10 20 8, 20 20 7, 20 15 5, 10 10 7), (50 40 6, 50 50 6, 60 50 5, 60 40 6, 50 40 7)))'	Multipolygon with Z coordinates
ST_MultiPolygon	‘multipolygon m (((10 10 2, 10 20 3, 20 20 4, 20 15 5, 10 10 2), (50 40 7, 50 50 3, 60 50 4, 60 40 5, 50 40 7)))'	Multipolygon with measures
ST_MultiPolygon	‘multipolygon zm (((10 10 7 2, 10 20 8 3, 20 20 7 4, 20 15 5 5, 10 10 7 2), (50 40 6 7, 50 50 6 3, 60 50 5 4, 60 40 6 5, 50 40 7 7)))'	Multipolygon with Z coordinates and measures

Modified well-known text representation

The IBM Informix software provides an additional modified well-known text representation for loading text strings directly into geometry columns without filtering the string through one of the Spatial DataBlade text functions. By placing the SRID in front of the text description, you can insert the resulting text string directly into a spatial column. The load statement in the DB-Access utility reads text files generated with this format and inserts the modified well-known text representation into the geometry columns.

To create a modified well-known text representation, remove the quotations and precede the text description with the SRID separated by a space.

For example, the well-known text representation of a point in the **ST_PointFromText()** function:

```
ST_PointFromText('Point zm (10.98  29.91 10.2 9.1)',1)
```

converts to:

```
1 ST_Point zm(10.98  29.91 10.2 9.1)
```

You can write the modified text string into a file and separate it from other column values by the standard delimiter.

Appendix D. OGC well-known binary representation of geometry

The well-known binary representation for OGC geometry (WKBGeometry), provides a portable representation of a geometry value as a contiguous stream of bytes. It permits geometry values to be exchanged between a client application and an SQL database in binary form.

The well-known binary representation for geometry is obtained by serializing a geometry instance as a sequence of numeric types drawn from the set {Unsigned Integer, Double} and then serializing each numeric type as a sequence of bytes using one of two well-defined, standard binary representations for numeric types (NDR, XDR). The specific binary encoding used for a geometry byte stream is described by a one-byte tag that precedes the serialized bytes. The only difference between the two encodings of geometry is byte order. The XDR encoding is big endian, while the NDR encoding is little endian.

Numeric type definitions

An ‘unsigned integer' is a 32-bit (4 byte) data type that encodes a nonnegative integer in the range [0, 4294967295].

A ‘double' is a 64-bit (8 byte) double-precision data type that encodes a double-precision number using the IEEE 754 double-precision format.

The above definitions are common to both XDR and NDR.

XDR (big endian) encoding of numeric types

The XDR representation of an unsigned integer is big endian (most significant byte first).

The XDR representation of a double is big endian (sign bit is first byte).

NDR (little endian) encoding of numeric types

The NDR representation of an unsigned integer is little endian (least significant byte first).

The NDR representation of a double is little endian (sign bit is last byte).

Conversion between the NDR and XDR representations of WKB geometry

Conversion between the NDR and XDR data types for unsigned integers and doubles is a simple operation involving reversing the order of bytes within each unsigned integer or double in the byte stream.

Description of WKBGeometry byte streams

The well-known binary representation for geometry is described below. The basic building block is the byte stream for a point that consists of two doubles. The byte streams for other geometries are built using the byte streams for geometries that have already been defined.

Important: These structures are only intended to define the stream of bytes that is transmitted between the client and server. They should not be used as C-language data structures. See the following figure for an example of such a byte stream.

```
// Basic Type definitions
// byte : 1 byte
// uint32 : 32 bit unsigned integer  (4 bytes)
// double : double precision number (8 bytes)

// Building Blocks : Point, LinearRing
Point {
    double x;
    double y;
    double z;
    double m;
};

LinearRing   {
    uint32    numPoints;
    Point     points[numPoints];
}

enum wkbGeometryType {
 wkbPoint                  = 1,
  wkbLineString            = 2,
  wkbPolygon               = 3,
  wkbMultiPoint            = 4,
  wkbMultiLineString       = 5,
  wkbMultiPolygon          = 6,
  wkbGeometryCollection    = 7,
  wkbPointZ                = 1001,
  wkbLineStringZ           = 1002,
  wkbPolygonZ              = 1003,
  wkbMultiPointZ           = 1004,
  wkbMultiLineStringZ      = 1005,
  wkbMultiPolygonZ         = 1006,
  wkbGeometryCollectionZ   = 1007,
  wkbPointM                = 2001,
  wkbLineStringM           = 2002,
  wkbPolygonM              = 2003,
  wkbMultiPointM           = 2004,
  wkbMultiLineStringM      = 2005,
  wkbMultiPolygonM         = 2006,
  wkbGeometryCollectionM   = 2007,
  wkbPointZM               = 3001,
  wkbLineStringZM          = 3002,
  wkbPolygonZM             = 3003,
  wkbMultiPointZM          = 3004,
  wkbMultiLineStringZM     = 3005,
  wkbMultiPolygonZM        = 3006,
  wkbGeometryCollectionZM  = 3007
};

enum wkbByteOrder {
    wkbXDR = 0,    // Big Endian
    wkbNDR = 1     // Little Endian
};

WKBPoint {
```

```
    byte      byteOrder;
    uint32    wkbType;                                       // 1
    Point     point;
}



WKBLineString {
    byte     byteOrder;
    uint32   wkbType;                                        // 2
    uint32   numPoints;
    Point    points[numPoints];
}

WKBPolygon            {
    byte       byteOrder;
    uint32     wkbType;                                        // 3
    uint32     numRings;
    LinearRing  rings[numRings];
}

WKBMultiPoint            {
byte      byteOrder;
uint32    wkbType;                                             // 4
uint32    num_wkbPoints;
WKBPoint  WKBPoints[num_wkbPoints];
}

WKBMultiLineString                {
    byte          byteOrder;
    uint32        wkbType;                                       // 5
    uint32        num_wkbLineStrings;
    WKBLineString  WKBLineStrings[num_wkbLineStrings];
}

wkbMultiPolygon {
    byte       byteOrder;
    uint32     wkbType;                                        // 6
    uint32     num_wkbPolygons;
    WKBPolygon  wkbPolygons[num_wkbPolygons];
}

WKBGeometry  {
    union {
    WKBPoint             point;
    WKBLineString        linestring;
    WKBPolygon           polygon;
    WKBGeometryCollection collection;
    WKBMultiPoint        mpoint;
    WKBMultiLineString   mlinestring;
    WKBMultiPolygon      mpolygon;
}
};


WKBGeometryCollection {
byte       byte_order;
uint32     wkbType;                                   // 7
uint32     num_wkbGeometries;
WKBGeometry              wkbGeometries[num_wkbGeometries]
}
```

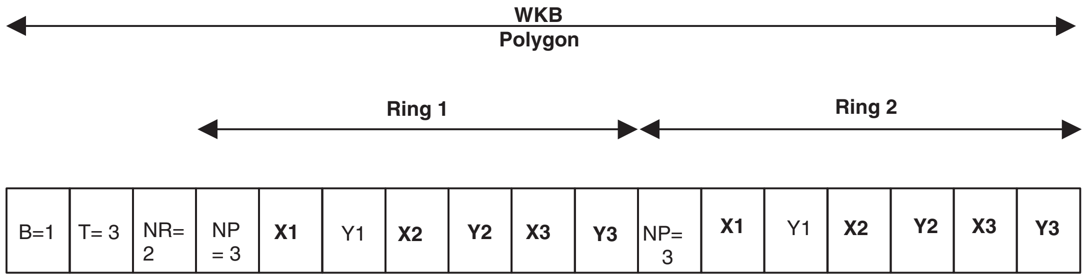


Figure D-1. Well-known binary representation for a geometry object in NDR format(B=1) of type polygon (T=3) with two rings (NR = 2) and each ring having three points (NP = 3)

The number of bytes in each box is shown in the following table.

Table D-1. Bytes in boxes

Ring	Box	Bytes
	B=1	1
	T=3	4
	NR=2	4
1	NP=3	4
1	X1	8
1	Y1	8
1	X2	8
1	Y2	8
1	X3	8
1	Y3	8
2	NP=3	4
2	X1	8
2	Y1	8
2	X2	8
2	Y2	8
2	X3	8
2	Y3	8

Assertions for well-known binary representation for geometry

The well-known binary representation for geometry is designed to represent instances of the geometry types described in the geometry object model and in the *OpenGIS Abstract Specification*.

These assertions imply the following:

Linear rings
: Rings are simple and closed, which means that linear rings may not self intersect.

Polygons

No two linear rings in the boundary of a polygon may cross each other. The linear rings in the boundary of a polygon may intersect, at most, at a single point but only as a tangent.

Multipolygons

The interiors of two polygons that are elements of a multipolygon may not intersect. The boundaries of any two polygons that are elements of a multipolygon may touch at only a finite number of points.

Appendix E. ESRI shape representation

The ESRI shape representation is an industry standard format that is used in ESRI shape files. You can use the **SE_AsShape()** function to retrieve geometries from a table in shape format. You can insert shape format data into database tables by using the **SE_GeomFromShape()**, **SE_PointFromShape()**, **SE_PolyFromShape()**, and other similar functions. All functions are described in detail in Chapter 7, "Spatial functions," on page 7-1.

These topics provide background information about the ESRI shape representation.

Related reference:

"ESRI shape representation" on page 3-2

Shape type values

A shape type of 0 indicates a null shape with no geometric data for the shape.

Value	Shape type	Spatial data type
0	Null Shape	Empty ST_Geometry
1	Point	ST_Point
3	PolyLine	ST_MultiLineString
5	Polygon	ST_MultiPolygon
8	MultiPoint	ST_MultiPoint
9	PointZ	ST_Point with Z coordinates
10	PolyLineZ	ST_MultiLineString with Z coordinates
11	PointZM	ST_Point with Z coordinates and measures
13	PolyLineZM	ST_MultiLineString with Z coordinates and measures
15	PolygonZM	ST_MultiPolygon with Z coordinates and measures
18	MultiPointZM	ST_MultiPoint with Z coordinates and measures
19	PolygonZ	ST_MultiPolygon with Z coordinates
20	MultiPointZ	ST_MultiPoint with Z coordinates
21	PointM	ST_Point with measures
23	PolyLineM	ST_MultiLineString with measures
25	PolygonM	ST_MultiPolygon with measures
28	MultiPointM	ST_MultiPoint with measures

Shape types not specified above (2, 4, 6, and so on) are reserved for future use.

The ST_LineString and ST_Polygon Spatial data types do not have equivalent shape type values.

Shape types in XY space

These topics describe shapes with X and Y coordinates.

Point

A Point consists of a pair of double-precision coordinates in the order X, Y. The following table shows Point byte stream contents.

Position	Field	Value	Type	Number	Byte order
Byte 0	Shape Type	1	Integer	1	Little endian
Byte 4	X	X	Double	1	Little endian
Byte 12	Y	Y	Double	1	Little endian

MultiPoint

A MultiPoint consists of a collection of points. The bounding box is stored in the order Xmin, Ymin, Xmax, Ymax. The following table shows MultiPoint byte stream contents.

Position	Field	Value	Type	Number	Byte order
Byte 0	Shape Type	8	Integer	1	Little endian
Byte 4	Box	Box	Double	4	Little endian
Byte 36	NumPoints	NumPoints	Integer	1	Little endian
Byte 40	Points	Points	Point	NumPoints	Little endian

PolyLine

A PolyLine is an ordered set of vertices that consists of one or more parts. A part is a connected sequence of two or more points. Parts may be connected to and may intersect one another.

Because this specification does not forbid consecutive points with identical coordinates, shapefile readers must handle such cases. On the other hand, the degenerate zero length parts that might result are not allowed.

The following fields are for a PolyLine:

Box The bounding box for the PolyLine, stored in the order Xmin, Ymin, Xmax, Ymax

NumParts
The number of parts in the PolyLine

NumPoints
The total number of points for all parts

Parts An array of length NumParts. Stores, for each PolyLine, the index of its first point in the points array

Array indexes are numbered with respect to 0.

Points An array of length NumPoints

The points for each part in the PolyLine are stored end to end. The points for part 2 follow the points for part 1, and so on. The parts array holds the array index of the starting point for each part. There is no delimiter in the points array between parts.

The following table shows PolyLine byte stream contents.

Position	Field	Value	Type	Number	Byte order
Byte 0	Shape Type	3	Integer	1	Little endian
Byte 4	Box	Box	Double	4	Little endian
Byte 36	NumParts	NumParts	Integer	1	Little endian
Byte 40	NumPoints	NumPoints	Integer	1	Little endian

Position	Field	Value	Type	Number	Byte order
Byte 44	Parts	Parts	Integer	NumParts	Little endian
Byte X	Points	Points	Point	NumPoints	Little endian

Tip: X = 44 + (4 * NumParts)

Polygon

A polygon consists of one or more rings. A ring is a connected sequence of four or more points that form a closed, non-self-intersecting loop. A polygon may contain multiple outer rings. The order of vertices or orientation for a ring indicates which side of the ring is the interior of the polygon. The neighborhood to the right of an observer walking along the ring in vertex order is the neighborhood inside the polygon. Vertices of rings defining holes in polygons are in a counterclockwise direction. Vertices for a single, ringed polygon are, therefore, always in clockwise order. The rings of a polygon are referred to as its parts.

Because this specification does not forbid consecutive points with identical coordinates, shapefile readers must handle such cases. On the other hand, the degenerate zero length or zero area parts that might result are not allowed.

The following fields are for a polygon:

Box The bounding box for the polygon, stored in the order Xmin, Ymin, Xmax, Ymax

NumParts
The number of rings in the polygon

NumPoints
The total number of points for all rings

Parts An array of length NumParts.

Stores, for each ring, the index of its first point in the points array. Array indexes are numbered with respect to 0.

Points An array of length NumPoints

The points for each ring in the polygon are stored end to end. The points for ring 2 follow the points for ring 1, and so on. The parts array holds the array index of the starting point for each ring. There is no delimiter in the points array between rings.

The following are important notes about polygon shapes:

- The rings are closed (the first and last vertex of a ring must be the same).
- The order of rings in the points array is not significant.
- Polygons stored in a shapefile must be clean.
- A clean polygon is one that has no self-intersections. This means that a segment belonging to one ring may not intersect a segment belonging to another ring. The rings of a polygon can touch each other at vertices but not along segments. Colinear segments are considered intersecting.
- A clean polygon is one that has the inside of the polygon on the *correct* side of the line that defines it. The neighborhood to the right of an observer walking along the ring in vertex order is the inside of the polygon. Vertices for a single, ringed polygon are, therefore, always in clockwise order.

Rings defining holes in these polygons have a counterclockwise orientation. *Dirty* polygons occur when the rings that define holes in the polygon also go clockwise, which causes overlapping interiors.

A sample polygon instance

The following figure shows a polygon with one hole and a total of eight vertices.

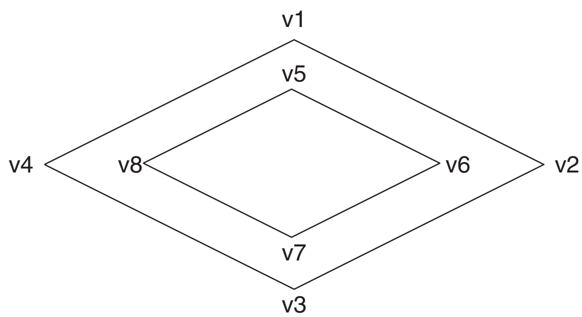
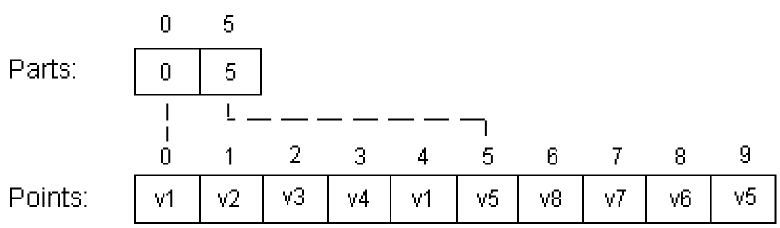


Figure E-1. A sample polygon

For this example, NumParts equals 2 and NumPoints equals 10. Note that the order of the points for the doughnut (hole) polygon is reversed below.



The following table shows Polygon byte stream contents

Position	Field	Value	Type	Number	Byte order
Byte 0	Shape Type	5	Integer	1	Little endian
Byte 4	Box	Box	Double	4	Little endian
Byte 36	NumParts	NumParts	Integer	1	Little endian
Byte 40	NumPoints	NumPoints	Integer	1	Little endian
Byte 44	Parts	Parts	Integer	NumParts	Little endian
Byte X	Points	Points	Point	NumPoints	Little endian

Tip: X = 44 + (4 * NumParts)

Measured shape types in XY space

These topics describe shapes with X and Y coordinates that also have measure values.

PointM

A PointM consists of a pair of double-precision coordinates in the order X, Y, plus a measure M. The following table shows PointM byte stream contents.

Position	Field	Value	Type	Number	Byte order
Byte 0	Shape Type	21	Integer	1	Little endian

Position	Field	Value	Type	Number	Byte order
Byte 4	X	X	Double	1	Little endian
Byte 12	Y	Y	Double	1	Little endian
Byte 20	M	M	Double	1	Little endian

MultiPointM

The following fields are for a MultiPointM:

Box The bounding box for the MultiPointM, stored in the order Xmin, Ymin, Xmax, Ymax

NumParts
The number of Points

NumPoints
An array of Points of length NumPoints

M Range
The minimum and maximum measures for the MultiPointM stored in the order Mmin, Mmax

M Array
An array of Measures of length NumPoints

The following table shows MultiPointM byte stream contents.

Position	Field	Value	Type	Number	Byte order
Byte 0	Shape Type	28	Integer	1	Little endian
Byte 4	Box	Box	Double	4	Little endian
Byte 36	NumPoints	NumPoints	Integer	1	Little endian
Byte 40	Points	Points	Point	NumPoints	Little endian
Byte X	Mmin	Mmin	Double	1	Little endian
Byte X+8	Mmax	Mmax	Double	1	Little endian
Byte X+16	M Array	M Array	Double	NumPoints	Little endian

Tip: X = 40 + (16 * NumPoints).

PolyLineM

A shapefile PolyLineM consists of one or more parts. A part is a connected sequence of two or more points. Parts may or may not be connected to one another. Parts may or may not intersect one another.

The following fields are for a PolyLineM:

Box The bounding box for the PolyLineM stored in the order Xmin, Ymin, Xmax, Ymax

NumParts
The number of parts in the PolyLineM

NumPoints
The total number of points for all parts

Parts An array of length NumParts

Stores, for each part, the index of its first point in the points array. Array indexes are numbered with respect to 0.

Points An array of length NumPoints

The points for each part in the PolyLineM are stored end to end. The points for part 2 follow the points for part 1, and so on. The parts array holds the array index of the starting point for each part. There is no delimiter in the points array between parts.

M Range
The minimum and maximum measures for the PolyLineM stored in the order Mmin, Mmax

M Array
An array of length NumPoints

The measures for each part in the PolyLineM are stored end to end. The measures for part 2 follow the measures for part 1, and so on. The parts array holds the array index of the starting point for each part. There is no delimiter in the measure array between parts.

The following table shows PolyLineM byte stream contents.

Position	Field	Value	Type	Number	Byte order
Byte 0	Shape Type	23	Integer	1	Little endian
Byte 4	Box	Box	Double	4	Little endian
Byte 36	NumParts	NumParts	Integer	1	Little endian
Byte 40	NumPoints	NumPoints	Integer	1	Little endian
Byte 44	Parts	Parts	Integer	NumParts	Little endian
Byte X	Points	Points	Point	NumPoints	Little endian
Byte Y	Mmin	Mmin	Double	1	Little endian
Byte Y+8	Mmax	Mmax	Double	1	Little endian
Byte Y+16	M Array	M Array	Double	NumPoints	Little endian

Tip: X = 44 + (4 * NumParts), Y = X + (16 * NumPoints)

PolygonM

A PolygonM consists of a number of rings. A ring is a closed, non-self-intersecting loop. Note that intersections are calculated in XY space, *not* in XYM space. A PolygonM may contain multiple outer rings. The rings of a PolygonM are referred to as its parts.

The following fields are for a PolygonM:

Box The bounding box for the PolygonM, stored in the order Xmin, Ymin, Xmax, Yma

NumParts
The number of rings in the PolygonM

NumPoints
The total number of points for all rings

Parts An array of length NumParts

Stores, for each ring, the index of its first point in the points array. Array indexes are numbered with respect to 0.

Points An array of length NumPoints

The points for each ring in the PolygonM are stored end to end. The points for Ring 2 follow the points for Ring 1, and so on. The parts array holds the array index of the starting point for each ring. There is no delimiter in the points array between rings.

M Range
The minimum and maximum measures for the PolygonM stored in the order Mmin, Mmax

M Array
An array of length NumPoints

The measures for each ring in the PolygonM are stored end to end. The measures for Ring 2 follow the measures for Ring 1, and so on. The parts array holds the array index of the starting measure for each ring. There is no delimiter in the measure array between rings.

The following are important notes about PolygonM shapes:

- The rings are closed (the first and last vertex of a ring must be the same).
- The order of rings in the points array is not significant.

The following table shows PolygonM byte stream contents.

Position	Field	Value	Type	Number	Byte order
Byte 0	Shape Type	15	Integer	1	Little endian
Byte 4	Box	Box	Double	4	Little endian
Byte 36	NumParts	NumParts	Integer	1	Little endian
Byte 40	NumPoints	NumPoints	Integer	1	Little endian
Byte 44	Parts	Parts	Integer	NumParts	Little endian
Byte X	Points	Points	Point	NumPoints	Little endian
Byte Y	Mmin	Mmin	Double	1	Little endian
Byte Y+8	Mmax	Mmax	Double	1	Little endian
Byte Y+16	M Array	M Array	Double	NumPoints	Little endian

Tip: X = 44 + (4 * NumParts), Y = X + (16 * NumPoints)

Shape types in XYZ space

These topics describe shapes with X, Y, and Z coordinates.

PointZ

A PointZ consists of a triplet of double-precision coordinates in the order X, Y, Z.

The following table shows PointZ byte stream contents.

Position	Field	Value	Type	Number	Byte order
Byte 0	Shape Type	9	Integer	1	Little endian
Byte 4	X	X	Double	1	Little endian
Byte 12	Y	Y	Double	1	Little endian
Byte 20	Z	Z	Double	1	Little endian

MultiPointZ

A MultiPointZ represents a set of PointZs, as follows:

- The bounding box is stored in the order Xmin, Ymin, Xmax, Ymax.

- The bounding Z range is stored in the order Zmin, Zmax.

The following table shows MultiPointZ byte stream contents.

Position	Field	Value	Type	Number	Byte order
Byte 0	Shape Type	20	Integer	1	Little endian
Byte 4	Box	Box	Double	4	Little endian
Byte 36	NumPoints	NumPoints	Integer	1	Little endian
Byte 40	Points	Points	Point	NumPoints	Little endian
Byte X	Zmin	Zmin	Double	1	Little endian
Byte X+8	Zmax	Zmax	Double	1	Little endian
Byte X+16	Z Array	Z Array	Double	NumPoints	Little endian

Tip: X = 40 + (16 * NumPoints)

PolyLineZ

A PolyLineZ consists of one or more parts. A part is a connected sequence of two or more points. Parts may or may not be connected to one another. Parts may or may not intersect one another.

The following fields are for a PolyLineZ:

Box The bounding box for the PolyLineZ, stored in the order Xmin, Ymin, Xmax, Ymax

NumParts
The number of parts in the PolyLineZ

NumPoints
The total number of points for all parts

Parts An array of length NumParts

Stores, for each part, the index of its first point in the points array.

Array indexes are numbered with respect to 0.

Points An array of length NumPoints

The points for each part in the PolyLineZ are stored end to end. The points for part 2 follow the points for part 1, and so on. The parts array holds the array index of the starting point for each part. There is no delimiter in the points array between parts.

Z Range
The minimum and maximum Z values for the PolyLineZ stored in the order Zmin, Zmax

Z Array
An array of length NumPoints

The Z values for each part in the PolyLineZ are stored end to end. The Z values for part 2 follow the Z values for part 1, and so on. The parts array holds the array index of the starting point for each part. There is no delimiter in the Z Array between parts.

The following table shows PolyLineZ byte stream contents

Position	Field	Value	Type	Number	Byte order
Byte 0	Shape Type	10	Integer	1	Little endian
Byte 4	Box	Box	Double	4	Little endian
Byte 36	NumParts	NumParts	Integer	1	Little endian
Byte 40	NumPoints	NumPoints	Integer	1	Little endian
Byte 44	Parts	Parts	Integer	NumParts	Little endian
Byte X	Points	Points	Point	NumPoints	Little endian
Byte Y	Zmin	Zmin	Double	1	Little endian
Byte Y+8	Zmax	Zmax	Double	1	Little endian
Byte Y+16	Z Array	Z Array	Double	NumPoints	Little endian

Tip: X = 44 + (4 * NumParts), Y = X + (16 * NumPoints)

PolygonZ

A PolygonZ consists of a number of rings. A ring is a closed, non-self-intersecting loop. A PolygonZ may contain multiple outer rings. The rings of a PolygonZ are referred to as its parts.

The following fields are for a PolygonZ:

Box
The bounding box for the PolygonZ stored in the order Xmin, Ymin, Xmax, Ymax

NumParts
The number of rings in the PolygonZ

NumPoints
The total number of points for all rings

Parts
An array of length NumParts

Stores, for each ring, the index of its first point in the points array. Array indexes are numbered with respect to 0.

Points
An array of length NumPoints

The points for each ring in the PolygonZ are stored end to end. The points for ring 2 follow the points for ring 1, and so on. The parts array holds the array index of the starting point for each ring. There is no delimiter in the points array between rings.

Z Range
The minimum and maximum Z values for the PolygonZ stored in the order Zmin, Zmax

Z Array
An array of length NumPoints

The Z values for each ring in the PolygonZ are stored end to end. The Z values for ring 2 follow the Z values for ring 1, and so on. The parts array holds the array index of the starting Z value for each ring. There is no delimiter in the Z value array between rings.

The following are important notes about PolygonZ shapes:

- The rings are closed (the first and last vertex of a ring must be the same).
- The order of rings in the points array is not significant.

The following table shows PolygonZ byte stream contents.

Position	Field	Value	Type	Number	Byte order
Byte 0	Shape Type	19	Integer	1	Little endian
Byte 4	Box	Box	Double	4	Little endian
Byte 36	NumParts	NumParts	Integer	1	Little endian
Byte 40	NumPoints	NumPoints	Integer	1	Little endian
Byte 44	Parts	Parts	Integer	NumParts	Little endian
Byte X	Points	Points	Point	NumPoints	Little endian
Byte Y	Zmin	Zmin	Double	1	Little endian
Byte Y+8	Zmax	Zmax	Double	1	Little endian
Byte Y+16	Z Array	Z Array	Double	NumPoints	Little endian

Tip: X = 44 + (4 * NumParts), Y = X + (16 * NumPoints)

Measured shape types in XYZ space

These topics describe shapes with X, Y, and Z coordinates that also have measure values.

PointZM

A PointZM consists of a quadruplet of double-precision coordinates in the order X, Y, Z, M.

The following table shows PointZM byte stream contents.

Position	Field	Value	Type	Number	Byte order
Byte 0	Shape Type	11	Integer	1	Little endian
Byte 4	X	X	Double	1	Little endian
Byte 12	Y	Y	Double	1	Little endian
Byte 20	Z	Z	Double	1	Little endian
Byte 28	M	M	Double	1	Little endian

MultiPointZM

A MultiPointZM represents a set of PointZMs, as follows:

- The bounding box is stored in the order Xmin, Ymin, Xmax, Ymax.
- The bounding Z range is stored in the order Zmin, Zmax.
- The bounding M range is stored in the order Mmin, Mmax.

The following table shows MultiPointZM byte stream contents.

Position	Field	Value	Type	Number	Byte order
Byte 0	Shape Type	18	Integer	1	Little endian
Byte 4	Box	Box	Double	4	Little endian
Byte 36	NumPoints	NumPoints	Integer	1	Little endian
Byte 40	Points	Points	Point	NumPoints	Little endian
Byte X	Zmin	Zmin	Double	1	Little endian
Byte X+8	Zmax	Zmax	Double	1	Little endian
Byte X+16	Z Array	Z Array	Double	NumPoints	Little endian
Byte Y	Mmin	Mmin	Double	1	Little endian
Byte Y+8	Mmax	Mmax	Double	1	Little endian
Byte Y+16	M Array	M Array	Double	NumPoints	Little endian

Tip: X = 40 + (16 * NumPoints), Y = X + 16 + (8 * NumPoints)

PolyLineZM

A PolyLineZM consists of one or more parts. A part is a connected sequence of two or more points. Parts may or may not be connected to one another. Parts may or may not intersect one another.

The following fields are for a PolyLineZM:

Box
The bounding box for the PolyLineZM, stored in the order Xmin, Ymin, Xmax, Ymax

NumParts
The number of parts in the PolyLineZM

NumPoints
The total number of points for all parts

Parts
An array of length NumParts

Stores, for each part, the index of its first point in the points array.

Array indexes are numbered with respect to 0

Points
An array of length NumPoints

The points for each part in the PolyLineZM are stored end to end. The points for part 2 follow the points for part 1, and so on. The parts array holds the array index of the starting point for each part. There is no delimiter in the points array between parts.

Z Range
The minimum and maximum Z values for the PolyLineZM stored in the order Zmin, Zmax

Z Array
An array of length NumPoints

The Z values for each part in the PolyLineZM are stored end to end. The Z values for part 2 follow the Z values for part 1, and so on. There is no delimiter in the Z Array between parts.

M Range
The minimum and maximum measures for the PolyLineZM stored in the order Mmin, Mmax

M Array
An array of length NumPoints

The measures for each part in the PolyLineZM are stored end to end. The measures for part 2 follow the measures for part 1, and so on. There is no delimiter in the measure array between parts.

The following table shows PolyLineZM byte stream contents.

Position	Field	Value	Type	Number	Byte order
Byte 0	Shape Type	13	Integer	1	Little endian
Byte 4	Box	Box	Double	4	Little endian
Byte 36	NumParts	NumParts	Integer	1	Little endian
Byte 40	NumPoints	NumPoints	Integer	1	Little endian
Byte 44	Parts	Parts	Integer	NumParts	Little endian
Byte X	Points	Points	Point	NumPoints	Little endian

Position	Field	Value	Type	Number	Byte order
Byte Y	Zmin	Zmin	Double	1	Little endian
Byte Y+8	Zmax	Zmax	Double	1	Little endian
Byte Y+16	Z Array	Z Array	Double	NumPoints	Little endian
Byte Z	Mmin	Mmin	Double	1	Little endian
Byte Z+8	Mmax	Mmax	Double	1	Little endian
Byte Z+16	M Array	M Array	Double	NumPoints	Little endian

Tip: X = 44 + (4 * NumParts), Y = X + (16 * NumPoints), Z=Y + 16 + (8 * NumPoints)

PolygonZM

A PolyLineZM consists of a number of rings. A ring is a closed, non-self-intersecting loop. A PolyLineZM may contain multiple outer rings. The rings of a PolyLineZM are referred to as its parts.

The following fields are for a PolyLineZM:

Box
The bounding box for the PolyLineZM, stored in the order Xmin, Ymin, Xmax, Ymax

NumParts
The number of rings in the PolyLineZM

NumPoints
The total number of points for all rings

Parts
An array of length NumParts

Stores, for each ring, the index of its first point in the points array.

Array indexes are numbered with respect to 0.

Points
An array of length NumPoints

The points for each ring in the PolyLineZM are stored end to end. The points for ring 2 follow the points for ring 1, and so on. The parts array holds the array index of the starting point for each ring. There is no delimiter in the points array between rings.

Z Range
The minimum and maximum Z values for the PolyLineZM are stored in the order Zmin, Zmax

Z Array
An array of length NumPoints

The Z values for each ring in the PolyLineZM are stored end to end. The Z values for ring 2 follow the Z values for ring 1, and so on. There is no delimiter in the Z value array between rings.

M Range
The minimum and maximum measures for the PolyLineZM stored in the order Mmin, Mmax

M Array
An array of length NumPoints

The measures for each ring in the PolyLineZM are stored end to end. The measures for ring 2 follow the measures for ring 1, and so on. There is no delimiter in the measure array between rings.

The following are important notes about PolyLineZM shapes:

- The rings are closed (the first and last vertex of a ring must be the same).
- The order of rings in the points array is not significant.

The following table shows PolyLineZM byte stream contents.

Position	Field	Value	Type	Number	Byte order
Byte 0	Shape Type	15	Integer	1	Little endian
Byte 4	Box	Box	Double	4	Little endian
Byte 36	NumParts	NumParts	Integer	1	Little endian
Byte 40	NumPoints	NumPoints	Integer	1	Little endian
Byte 44	Parts	Parts	Integer	NumParts	Little endian
Byte X	Points	Points	Point	NumPoints	Little endian
Byte Y	Zmin	Zmin	Double	1	Little endian
Byte Y+8	Zmax	Zmax	Double	1	Little endian
Byte Y+16	Z Array	Z Array	Double	NumPoints	Little endian
Byte Z	Mmin	Mmin	Double	1	Little endian
Byte Z+8	Mmax	Mmax	Double	1	Little endian
Byte Z+16	M Array	M Array	Double	NumPoints	Little endian

Tip: X = 44 + (4 * NumParts), Y = X + (16 * NumPoints), Z=Y + 16 + (8 * NumPoints)

Appendix F. Error messages

Spatial DataBlade functions that generate any of these errors will abort. Likewise, if a Spatial DataBlade function is part of a transaction, the transaction also aborts. Error message parameters marked with percent signs—for example, are replaced with appropriate values in the actual message text.

Error messages and their explanations

USE01 **Unable to establish a connection in %FUNCTION%.**

Explanation: The IBM Informix server unexpectedly returned a null value instead of a connection handle when the function attempted to connect to the server. The function was unable to determine the exact cause of the error.

User response: If this error continues to occur, contact IBM Informix Technical Support for assistance.

7USE02 **Function %FUNCTION% is unable to allocate memory.**

Explanation: The function could not allocate the memory that it requires.

User response: Ensure that your hardware meets the minimum memory requirements specified in the IBM Informix installation guide. Also make sure that you have not overallocated memory to the IBM Informix server or other applications. Consider increasing the amount of your hardware physical memory.

USE03 **Invalid geometry in %FUNCTION%.**

Explanation: The parameters entered into the function have produced an invalid geometry.

User response: Check the parameters and review Chapter 2, "Spatial data types," on page 2-1, for a description of valid geometry.

USE04 **Function %FUNCTION% not applicable to type %TYPE%.**

Explanation: An invalid geometry type was passed to the function. Valid geometry types are geometry, point, linestring, polygon, multipoint, multilinestring, and multipolygon.

User response: Resubmit the function with one of the valid geometry types.

USE05 **This function is not yet implemented.**

Explanation: The function has not been implemented for the current release. However, it may be available in a future release.

USE06 **Unknown ESRI shape library error (%ERRCODE%) in %FUNCTION%.**

Explanation: Contact IBM Informix Technical Support for assistance. Please include this error number and any other related error messages and information from the `$INFORMIXDIR/online.log` file. If you are using the Spatial DataBlade module in conjunction with ArcSDE from ESRI, please also include any related information from the `$SDEHOME/etc/sde.errlog` file.

USE07 **Internal SAPI error. %SAPIFUNC% returned %RETVAL%. Failure in %FUNCNAME%.**

Explanation: An error has occurred in the SAPI subsystem of the IBM Informix server.

User response: Contact IBM Informix Technical Support.

USE08 **Nearest-neighbor queries require an index scan.**

Explanation: An attempt was made to use a nearest-neighbor function as a filter during a sequential scan of a table. This is not supported.

USE09 **Unknown or unsupported shape file type (%TYPE%) found in %FUNCTION%.**

Explanation: An unrecognized shapefile type was encountered.

User response: For more information about shapefile types, see "Shape type values" on page E-1.

USE10 **Unknown or unsupported OpenGIS WKB type (%TYPE%) found in %FUNCTION%.**

Explanation: An unrecognized OpenGIS well-known binary type was encountered. This version of the Spatial DataBlade only supports point, linestring, polygon, multipoint, multilinestring, and multipolygon.

USE11 Invalid SRID %SRID% or NULL in %FUNCTION%.

Explanation: A spatial reference identifier must be an integer value greater than 0. Negative values, real numbers, and characters are invalid.

USE12 Unknown or unsupported geometry type (%TYPE%) found in %FUNCTION%.

Explanation: An unrecognized geometry type was encountered. If you are inserting spatial data in a binary format it may be corrupt or malformed.

USE13 Spatial DataBlade not installed correctly: the spatial_references table does not exist.

Explanation: The Spatial DataBlade was not able to access the **spatial_references** table because it could not be found.

User response: Review the installation instructions for the Spatial DataBlade module and, if necessary, recreate the **spatial_references** table.

USE14 Unknown spatial reference identifier %SRID%.

Explanation: The **sde.spatial_references** table contains a list of all valid spatial reference identifiers. The function attempted to create a geometry with an SRID that does not exist in this table.

User response: Either use an SRID that is already in the **sde.spatial_references** table or add the unknown SRID to the table.

USE15 Invalid coordinate reference system object in function %FUNCTION%.

Explanation: A programmatic error has occurred in the Spatial DataBlade.

User response: Contact IBM Informix Technical Support.

USE16 Unable to get the geometry data pointer from the server in %FUNCTION%.

Explanation: A programmatic error has occurred in the Spatial DataBlade.

User response: Contact IBM Informix Technical Support.

USE17 Geometry verification failed.

Explanation: An error has occurred while the Spatial DataBlade was verifying the topological correctness of a geometry.

User response: Contact IBM Informix Technical Support.

USE18 Buffer operation failed.

Explanation: The source geometry and buffer distance submitted to the buffer function would result in a buffer with coordinates that fall outside the coordinate system specified in the source geometry's spatial reference system.

USE19 Coordinates out of bounds in %FUNCTION%.

Explanation: The function has created a geometry with coordinates that fall outside the coordinate system.

User response: Review "The spatial_references table" on page 1-12 for information about selecting a coordinate system. Typically, this error occurs when the buffer function generates a geometry with coordinates that are beyond the source geometry's coordinate system, which the new geometry inherits.

You may need to adjust the false origin and system units for your data. Please refer to the description of the **ST_Transform()** function in Chapter 7, "Spatial functions," on page 7-1, for additional information.

USE20 Invalid parameter in function %FUNCTION%.

Explanation: One of the parameters passed to the function is invalid.

User response: Review the syntax of the function listed in Chapter 7, "Spatial functions," on page 7-1. Correct the invalid parameter and resubmit the function.

USE21 Geometry integrity error in function %FUNCTION%.

Explanation: An inconsistency has been detected in a geometry's internal data structure.

User response: If you ran the **SE_Generalize()** function, the value of the *threshold* argument might be too large compared to the size of the object. Run the function again with a smaller *threshold* value.

If this error continues to occur, contact IBM Informix Software Support for assistance.

USE22 **Too many points in feature.**

Explanation: Returned if the buffer function creates a feature that exceeds the maximum number of points specified as a parameter to the function.

User response: Increase the size of the maximum number of points parameter and resubmit the function.

USE23 **Spatial reference conflict, %SRID1% vs %SRID2%.**

Explanation: The geometries passed to the function did not share the same spatial reference system.

User response: Convert one of the geometries to have the same spatial reference system as the other and resubmit the function.

USE24 **Incompatible geometries in function %FUNCTION%.**

Explanation: The function expected two geometries of a certain type and did not receive them.

User response: Review the syntax of the function described in Chapter 7, "Spatial functions," on page 7-1, correct the geometry, and resubmit the function.

USE25 **Subscript %SUBSCRIPT% out of range in function %FUNCTION%.**

Explanation: The function has detected that the subscript entered is outside the allowable range of values. For instance, the **ST_PointN()** function returns the *n*th point identified by the index parameter. If a negative value, 0, or a number greater than the number of points in the source linestring were entered, this error message would be returned.

User response: Correct the subscript value and resubmit the function.

USE26 **Subtype mismatch: received subtype=%TYPE1%, expected subtype=%TYPE2%.**

Explanation: This error can occur when you try to insert a geometry of one subtype into a column of a different subtype, for example an ST_Point into an ST_LineString column.

User response: To insert more than one subtype into a column, make that a column of type ST_Geometry.

USE27 **Unknown or unsupported geometry data structure version (%VERSION%) found in %FUNCTION%.**

Explanation: Future versions of the Spatial DataBlade may not be able to interpret geometries stored using this version of the DataBlade module. Similarly, this version of the Spatial DataBlade may not be able to interpret geometries stored using a future version.

If an upgrade mechanism is provided with a new version of this DataBlade module, use it on your data as described in the release notes. If an upgrade mechanism is not provided, you must unload your data with the old DataBlade module version and reload it with the new version.

USE28 **Invalid text in %FUNCTION%.**

Explanation: The text string entered with the well-known text representation function is invalid.

User response: Correct the string and resubmit the function. Refer to Appendix C, "OGC well-known text representation of geometry," on page C-1, for a valid text string description.

USE29 **Unexpected system error in %FUNCTION%.**

Explanation: An internal error occurred while creating a geometry. The system was not able to determine why this error occurred.

User response: Contact IBM Informix Technical Support for assistance. Please include this error number and any other related error messages and information from the `$INFORMIXDIR/online.log` file. If you are using the Spatial DataBlade module in conjunction with ArcSDE from ESRI, please also include any related information from the `$SDEHOME/etc/sde.errlog` file.

USE30 **Overlapping polygon rings in %FUNCTION%.**

Explanation: The internal rings of a polygon may not overlap one another or the bounding external ring. Polygon rings may only intersect at a single point.

USE31 **Too few points for geometry type in %FUNCTION%.**

Explanation: The number of coordinates entered for the geometry was too few. Points and multipoints require a minimum of one point; linestrings and multilinestrings require a minimum of two points; and polygons and multipolygons require a minimum of four points.

USE32 **Polygon does not close in %FUNCTION%.**

Explanation: The first and last coordinates of a polygon ring must be the same. An exterior or interior ring did not close (did not have the same first and last coordinates).

USE33 **Interior ring not enclosed by exterior ring in %FUNCTION%.**

Explanation: The interior rings of a polygon must be inside the exterior rings. The interior ring was detected to be outside its exterior ring.

USE34 **Polygon has no area in %FUNCTION%.**

Explanation: The rings of a polygon must enclose an area. The first and last point of each polygon ring must be the same. A ring may not cross itself.

USE35 **Polygon ring contains a spike in %FUNCTION%.**

Explanation: Polygon rings contain spikes whenever coordinates other than the endpoints are the same. The boundary of a polygon must be a continuous ring or series of rings.

USE36 **Multipolygon exterior rings overlap in %FUNCTION%.**

Explanation: The exterior rings of a multipolygon must enclose independent areas. The exterior rings of each polygon of a multipolygon may not overlap. They may, however, intersect at a single point. Polygons whose intersection results in a linestring will automatically be merged after the intersecting linestring has been dissolved.

USE37 **The geometry boundary is self-intersecting in %FUNCTION%.**

USE38 **The geometry has too many parts in %FUNCTION%.**

Explanation: The string that defines the geometry has too many parts for its type. Points, linestrings, and polygons are single-part geometries. The string has defined more than one part for one of these geometries. If a multipart geometry is desired, use multipoint, multilinestring, or multipolygon.

USE39 **Mismatched text string parentheses in %FUNCTION%.**

Explanation: The parentheses of the text string defining the geometry do not match.

User response: For a description of the well-known text representation, review Appendix C, "OGC well-known text representation of geometry," on page C-1.

USE40 **Unknown or unsupported ESRI entity type (%TYPE%) found in %FUNCTION%.**

Explanation: The internal type representation is invalid.

User response: Contact ESRI Technical Support.

USE41 **The projection string for your SRID is invalid in %FUNCTION%.**

Explanation: The projection string stored in the **spatial_references** table was determined to be invalid.

User response: Compare the projection string with the valid projection strings listed in Appendix B, "OGC well-known text representation of spatial reference systems," on page B-1.

USE42 **Nearest-neighbor queries are not supported by the current version of the server.**

Explanation: Nearest-neighbor queries are supported by IBM Informix Version 9.3 and later.

USE43 **%PARAM1% value must be less than %PARAM2% value.**

Explanation: When executing the **SE_CreateSrid()** function, xmin must be less than xmax and ymin must be less than ymax.

USE44 **Unknown OGIS WKB byte-order byte encountered in %FUNCTION%.**

Explanation: An unrecognized OpenGIS well-known binary byte-order byte was encountered. This is the first byte of the geometry data input byte stream. Valid values are 0x00 (big endian) and 0x01 (little endian).

USE45 **OGIS WKB geometry collection type is not supported.**

Explanation: The OpenGIS collection type (7) is not supported by this version of the Spatial DataBlade module.

USE46 **Incompatible coordinate reference systems in function %FUNCTION%.**

Explanation: This error can occur when you attempt to transform geometries using the **ST_Transform()** function. The only allowable transformations in this version of the Spatial DataBlade module are:

- Between two UNKNOWN coordinate systems (that is, the **srtext** column in the **spatial_references** table for both SRIDs is "UNKNOWN")

- Between a projected coordinate system and an unprojected coordinate system, in which the underlying geographic coordinate systems are the same
- Between two projected coordinate systems, in which the underlying geographic coordinate systems are the same
- Between two coordinate systems with the same geographic coordinate system (that is, a difference in false origin or system unit only)

USE47 Cannot create SE_Metadata lohandle file %NAME%. Check directory permissions.

Explanation: The metadata `lohandle` file is created at the time the DataBlade module is registered in your database. This file is located in the directory `$INFORMIXDIR/extend/spatial.`*versno*`/metadata`. The user who registers the DataBlade must have write permission on this directory.

If this error occurs after you have successfully registered the Spatial DataBlade module, you should correct the permissions on the `metadata` directory and then recreate the metadata `lohandle` file by running the following SQL statement:

```
execute function SE_MetadataInit();
```

USE48 SE_Metadata lohandle file %FILE% not found, unreadable, or corrupt. Execute function SE_MetadataInit to reinitialize.

Explanation: The purpose of the **SE_Metadata** `lohandle` file is to allow access to metadata by all parallelized functions of the Spatial DataBlade module. It can be restored by running the following SQL statement:

```
execute function SE_MetadataInit();
```

This will reread the **spatial_references** table, recreate a smart large object containing metadata, and re-create a file containing the large object handle for this smart large object.

USE49 SE_MetadataTable is a read only table.

Explanation: The **SE_MetadataTable** table is created and populated when the Spatial DataBlade module is registered.

User response: Do not attempt to modify this table in any way.

USE50 Vertex not found in %FUNCTION%.

Explanation: The specified vertex cannot be found in the original geometry.

User response: Verify that the X, Y, M, and Z values (if any) of the vertex to be updated or deleted exactly match.

USE51 SE_Metadata smart blob is corrupt or unreadable.

Explanation: Execute the **SE_MetadataInit()** function to repair the smart large object. To enable parallel data queries, a copy of the **spatial_references** table contents is stored in a smart large object. This smart large object is created when the Spatial DataBlade is registered and is synchronized with the **spatial_references** table by means of triggers. If the smart large object is corrupted, it can be re-created by running the following SQL statement:

```
EXECUTE FUNCTION SE_MetadataInit();
```

USE52 SE_Metadata memory cache is locked.

Explanation: Execute the **SE_MetadataInit()** function to reinitialize the memory cache. For computational efficiency, a copy of the **spatial_references** table contents is cached in memory. This cache is shared by all sessions and access to it is controlled by a spinlock. If a session failed to release this lock, another session may not be able to obtain access.

User response: To forcibly reset the lock, run the following SQL statement:

```
EXECUTE FUNCTION SE_MetadataInit();
```

USE53 Spatial datablade assert failure. File = %FILE%, line = %LINE%.

Explanation: A programmatic error has occurred in the Spatial DataBlade module. Contact IBM Informix Technical Support.

USE54 You must create a default sbspace before you can register the Spatial DataBlade.

Explanation: When the Spatial DataBlade is registered, a small (8 KB) smart large object is created and stored in the default sbspace. Registration fails if there is no default sbspace. This smart large object can be moved to a non-default sbspace after registration is complete; instructions for moving it are provided in the release notes.

-674 Routine (%FUNCTION%) cannot be resolved.

Explanation: This error message is generally returned by the IBM Informix server whenever you try to apply the function to a non-supported type.

User response: Check the geometry type entered and resubmit the function.

Appendix G. Accessibility

IBM strives to provide products with usable access for everyone, regardless of age or ability.

Accessibility features for IBM Informix products

Accessibility features help a user who has a physical disability, such as restricted mobility or limited vision, to use information technology products successfully.

Accessibility features

The following list includes the major accessibility features in IBM Informix products. These features support:

- Keyboard-only operation.
- Interfaces that are commonly used by screen readers.
- The attachment of alternative input and output devices.

Keyboard navigation

This product uses standard Microsoft Windows navigation keys.

Related accessibility information

IBM is committed to making our documentation accessible to persons with disabilities. Our publications are available in HTML format so that they can be accessed with assistive technology such as screen reader software.

IBM and accessibility

For more information about the IBM commitment to accessibility, see the *IBM Accessibility Center* at http://www.ibm.com/able.

Dotted decimal syntax diagrams

The syntax diagrams in our publications are available in dotted decimal format, which is an accessible format that is available only if you are using a screen reader.

In dotted decimal format, each syntax element is written on a separate line. If two or more syntax elements are always present together (or always absent together), the elements can appear on the same line, because they can be considered as a single compound syntax element.

Each line starts with a dotted decimal number; for example, `3` or `3.1` or `3.1.1`. To hear these numbers correctly, make sure that your screen reader is set to read punctuation. All syntax elements that have the same dotted decimal number (for example, all syntax elements that have the number `3.1`) are mutually exclusive alternatives. If you hear the lines `3.1 USERID` and `3.1 SYSTEMID`, your syntax can include either `USERID` or `SYSTEMID`, but not both.

The dotted decimal numbering level denotes the level of nesting. For example, if a syntax element with dotted decimal number `3` is followed by a series of syntax elements with dotted decimal number `3.1`, all the syntax elements numbered `3.1` are subordinate to the syntax element numbered `3`.

Certain words and symbols are used next to the dotted decimal numbers to add information about the syntax elements. Occasionally, these words and symbols might occur at the beginning of the element itself. For ease of identification, if the word or symbol is a part of the syntax element, the word or symbol is preceded by the backslash (\) character. The * symbol can be used next to a dotted decimal number to indicate that the syntax element repeats. For example, syntax element *FILE with dotted decimal number 3 is read as 3 * FILE. Format 3* FILE indicates that syntax element FILE repeats. Format 3* * FILE indicates that syntax element * FILE repeats.

Characters such as commas, which are used to separate a string of syntax elements, are shown in the syntax just before the items they separate. These characters can appear on the same line as each item, or on a separate line with the same dotted decimal number as the relevant items. The line can also show another symbol that provides information about the syntax elements. For example, the lines 5.1*, 5.1 LASTRUN, and 5.1 DELETE mean that if you use more than one of the LASTRUN and DELETE syntax elements, the elements must be separated by a comma. If no separator is given, assume that you use a blank to separate each syntax element.

If a syntax element is preceded by the % symbol, that element is defined elsewhere. The string that follows the % symbol is the name of a syntax fragment rather than a literal. For example, the line 2.1 %OP1 refers to a separate syntax fragment OP1.

The following words and symbols are used next to the dotted decimal numbers:

? Specifies an optional syntax element. A dotted decimal number followed by the ? symbol indicates that all the syntax elements with a corresponding dotted decimal number, and any subordinate syntax elements, are optional. If there is only one syntax element with a dotted decimal number, the ? symbol is displayed on the same line as the syntax element (for example, 5? NOTIFY). If there is more than one syntax element with a dotted decimal number, the ? symbol is displayed on a line by itself, followed by the syntax elements that are optional. For example, if you hear the lines 5 ?, 5 NOTIFY, and 5 UPDATE, you know that syntax elements NOTIFY and UPDATE are optional; that is, you can choose one or none of them. The ? symbol is equivalent to a bypass line in a railroad diagram.

! Specifies a default syntax element. A dotted decimal number followed by the ! symbol and a syntax element indicates that the syntax element is the default option for all syntax elements that share the same dotted decimal number. Only one of the syntax elements that share the same dotted decimal number can specify a ! symbol. For example, if you hear the lines 2? FILE, 2.1! (KEEP), and 2.1 (DELETE), you know that (KEEP) is the default option for the FILE keyword. In this example, if you include the FILE keyword but do not specify an option, default option KEEP is applied. A default option also applies to the next higher dotted decimal number. In this example, if the FILE keyword is omitted, default FILE(KEEP) is used. However, if you hear the lines 2? FILE, 2.1, 2.1.1! (KEEP), and 2.1.1 (DELETE), the default option KEEP only applies to the next higher dotted decimal number, 2.1 (which does not have an associated keyword), and does not apply to 2? FILE. Nothing is used if the keyword FILE is omitted.

***** Specifies a syntax element that can be repeated zero or more times. A dotted decimal number followed by the * symbol indicates that this syntax element can be used zero or more times; that is, it is optional and can be repeated. For example, if you hear the line 5.1* data-area, you know that you can include more than one data area or you can include none. If you hear the lines 3*, 3 HOST, and 3 STATE, you know that you can include HOST, STATE, both together, or nothing.

Notes:

1. If a dotted decimal number has an asterisk (*) next to it and there is only one item with that dotted decimal number, you can repeat that same item more than once.
2. If a dotted decimal number has an asterisk next to it and several items have that dotted decimal number, you can use more than one item from the list, but you cannot use the items more than once each. In the previous example, you can write HOST STATE, but you cannot write HOST HOST.
3. The * symbol is equivalent to a loop-back line in a railroad syntax diagram.

\+ Specifies a syntax element that must be included one or more times. A dotted decimal number followed by the + symbol indicates that this syntax element must be included one or more times. For example, if you hear the line 6.1+ data-area, you must include at least one data area. If you hear the lines 2+, 2 HOST, and 2 STATE, you know that you must include HOST, STATE, or both. As for the * symbol, you can repeat a particular item if it is the only item with that dotted decimal number. The + symbol, like the * symbol, is equivalent to a loop-back line in a railroad syntax diagram.

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