Lightning Guide to MS Access & SQL

A practical guide to Database Design with MS Access and SQL

Prof. Arturo Azcorra
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to Databases with
Microsoft Access and SQL
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PART N. CONTENTS AND ACKNOWLEDGEMENTS .............................................. I
PREVIEW OF SECTION F.10

F.10 **What is a Transform operation and how do I write it?**

This chapter also answers the questions:

- **How do I create cross tables?**

---

57 There could be some type conversion combinations that make Union operators non-associative.
• What is a crosstab Query?

A Transform operation is an SQL operation performed with the Transform operator (click F.10.1) plus its corresponding operands. Therefore, a Transform operation is the complete SQL code associated to the Transform operator.

A Transform operation produces cross tables in a very flexible way. In its simplest form, a Transform operation generates new field names from the values of the field written in the “PIVOT” clause, and also, places the values of the expression written in the “TRANSFORM” clause in the correct places under the newly generated field names.

Transform is extremely useful to display your Query results as a cross table. Imagine you have the following record-list (in this case it is a Table, but most frequently it is a Query result or an inner SQL operation):

<table>
<thead>
<tr>
<th>T_Capital_Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
</tr>
<tr>
<td>Beijing</td>
</tr>
<tr>
<td>Beijing</td>
</tr>
<tr>
<td>Washington</td>
</tr>
<tr>
<td>Washington</td>
</tr>
<tr>
<td>Beijing</td>
</tr>
<tr>
<td>Beijing</td>
</tr>
<tr>
<td>Washington</td>
</tr>
<tr>
<td>Washington</td>
</tr>
</tbody>
</table>

Now you want to display this information as a cross table, with fields “Capital” (renamed to “Cap_City”), “2018”, “2019”, “2020” and “2021”, and the value of “Rainfall” in the corresponding cell under the fields “2018”, “2019”, “2020” and “2021”. In summary, what you want is:

<table>
<thead>
<tr>
<th>F_Transform_1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cap_City</td>
</tr>
<tr>
<td>Beijing</td>
</tr>
<tr>
<td>Washington</td>
</tr>
</tbody>
</table>

Then, this is exactly what you would get with the following Transform operation:

```
TRANSFORM First(Rainfall) AS GenVals
SELECT Capital AS Cap_City
FROM T_Capital_Rainfall
GROUP BY Capital
PIVOT Cal_Year ;
```

The “n” leftmost output fields of a Transform are called the “SELECT” fields, because they are determined by the “SELECT” clause. The output fields placed to the right of the “SELECT” fields are called the “PIVOT” fields, because they are

---

58 This is the Table “T_Capital_Rainfall” in file “Company_Database.accdb”.
59 This is the Query “F_Transform_1” from the “Company_Database.accdb” file.
generated by converting to String the returned values of the “PIVOT” expression (click F.10.11), subject to the modifications of the optional “IN” list (click F.10.12). In this example, we have one “SELECT” field (field name “Cap_City”) and four “PIVOT” fields (with field names “2018”, “2019”, “2020” and “2021”).

Transform operations cannot be nested. The Transform operation must be the first operation in a Query, and a Query cannot contain any other Transform operation. Consequently, a Transform operation cannot be used as an input record-list in any other Query or SQL operation. A Query that has a Transform operation cannot be used in any other Query. The Transform operation can therefore only be the very last operation over a record-list.

If you want to know more about a Transform operation, you may click:

• “F.10.1 What is the Transform operator?”
• “F.10.2 What is the input record-list (“FROM” clause) of a Transform?”
• “F.10.3 What are the output fields of a Transform?”
• “F.10.4 What is the output record-list of a Transform?”
• “F.10.5 Can I see an example of a Transform operation?”
• “F.10.6 What is the “TRANSFORM” clause of a Transform?”
• “F.10.7 What is the “SELECT” clause of a Transform?”
• “F.10.8 What is the “ORDER BY” clause of a Transform?”
• “F.10.9 What is the “WHERE” clause of a Transform?”
• “F.10.10 What is the “GROUP BY” clause of a Transform?”
• “F.10.11 What is the “PIVOT” clause of a Transform?”
• “F.10.12 What is the “IN” clause of a Transform?”
• “F.10.13 How do the clauses from Transform and Select compare?”
• “F.10.14 How do I write a correct (syntax) Transform?”

F.10.1 What is the Transform operation?

Transform is a consulting (click F.6) operator that works over one single input record-list, plus other operands that are not record-lists.

The Transform operator includes the clauses “SELECT”, “DISTINCT” (optional and irrelevant), “DISTINCTROW” (optional and not advisable), “FROM”, “WHERE” (optional), “GROUP BY”, “ORDER BY” (optional) and “IN” (optional).
A simplified view of writing (syntax) a Transform operation is:

```sql
TRANSFORM PIVOT-field-values-expression()
SELECT [DISTINCT] [DISTINCTROW] Output-expression() 1 to n
FROM Input-record-list
[ WHERE Where-Boolean-expression(Input-field-names) ]
GROUP BY Group_by-expression(Input-field-names) 1 to k
[ ORDER BY Order_by-expression() 1 to w ]
PIVOT PIVOT-field-names-expression(Input-field-names) ;
[ IN ( List-of-PIVOT-values ) ]
```

The clauses enclosed between square brackets “[]” are optional.

The following picture shows the output of the Transform operation:

The Transform operator creates a cross table by converting the distinct values of the “PIVOT” expression (click F.10.11) into additional generated field names (i.e., “columns”) and presenting the results of the “TRANSFORM” expression (click F.10.6) in the corresponding cells (row x column).

The Transform operator produces:

- The rows by doing record aggregation over the (mandatory) “GROUP BY” expressions.
- The fixed leftmost columns (the “SELECT” fields names and values) with the conventional “SELECT” expressions.
- The cross table column names (the “PIVOT” field names) by doing record aggregation over the (mandatory) “PIVOT” expression.
- The cross table column values by doing record aggregation of the “TRANSFORM” expression over the “GROUP BY” expressions jointly with the “PIVOT” expression.

Remind that record aggregation produces only one value from each group of records. I now explain the above bullet points in more detail.

The number of rows is determined by the 1 to k “GROUP BY” expressions (click F.10.10). There will be as many rows as groups of (retained) input records (see below). Each group contains the (retained) input records that produce the same results in all the 1 to k “GROUP BY” expressions. Notice that the resulting arrays of “k” results from the “GROUP BY” expressions are all distinct. Notice also that these result arrays are not shown in the output of the Transform operation and are just internal for its processing. The “GROUP BY” clause of a Transform works exactly the
same as the “GROUP BY” clause (click F.7.9) of a Select.

The “n” leftmost output fields of a Transform are called the “SELECT” fields, because they are determined by the “SELECT” clause. The output fields placed to the right of the “SELECT” fields are called the “PIVOT” fields, because they are generated by converting to String the returned values of the “PIVOT” expression (click F.10.11), subject to the modifications of the optional “IN” list (click F.10.12).

The number of select columns “n”, their field names, the field order and the field values are determined by the “SELECT” clause (click F.10.7) with the “GROUP BY” clause (click F.10.10). The value of field “j” from the row “i” is produced by applying the corresponding “SELECT” expression “j”, to all the records in the group “i” of (retained) input records corresponding to this row. These groups of (retained) input records are the same as the ones indicated in the previous paragraph.

The number of “PIVOT” columns and their field names are determined by the distinct values returned by the “PIVOT” expression computed over all the (retained) input records. The field order is (click F.10.3.3), left to right, ascending alphanumeric by the value returned by the “PIVOT” expression. However, if the optional “IN” clause is used, then the number of “PIVOT” columns, the field names and the field order are all determined by the “IN” list (click F.10.12).

The field value of “PIVOT” field “j” from the row “i” is produced by applying the “TRANSFORM” expression, to all the records in the group “(i, j)” of (retained) input records corresponding to row “i” and column “j”. Each group “(i, j)” contains the (retained) input records that produce the same results in all the 1 to k “GROUP BY” expressions as the values in row “i” and the same result in the “PIVOT” expression as the field name of column “j”. If there is a field name collision with a “SELECT” field, or the “IN” clause is used, this becomes slightly more complex (click F.10.4.1).

The order of records is unknown, unless the optional “ORDER BY” clause (click F.10.9) is used. The ordering works the same as the “ORDER BY” clause (click F.7.12) from the Select operator, with just one restriction: the “ORDER BY” expressions must be a list of any number of exactly the same “GROUP BY” expressions or the “PIVOT” expression.

The “Input-record-list” is stated in the “FROM” clause. The “FROM” clause in the Transform operator works exactly the same as the “FROM” clause (click F.7.4) in the Select operators.

If the optional “WHERE” clause is used, the input records that produce True in the “Where-Boolean-expression()” are retained, while the other ones are discarded. The “WHERE” clause (click F.10.9) of a Transform operator works exactly the same as the “WHERE” clause (click F.7.7) of a Select operator. If against my advice you use the optional “DISTINCTROW” clause, you may click F.7.8.

Very important to highlight that if the input record-list is a Table name, no records will be deleted from the Table, and the Table remains unmodified. This is so because all the SQL consulting operators work over an image of Table’s records, and not over the Table records themselves. Remind that the Transform operator is a consulting SQL operator (i.e., one that can only consult Tables) and it is not a data-changing SQL operator. If you want to actually modify your Table’s records, you may click
“F.6.2 What are the SQL data-changing operators?”.
If you want to know more about Transform, you may click:
• “F.10.2 What is the input record-list (“FROM” clause) of a Transform?”
• “F.10.3 What are the output fields of a Transform?”
• “F.10.4 What is the output record-list of a Transform?”
• “F.10.5 Can I see an example of a Transform operation?”
• “F.10.13 How do the clauses from Transform and Select compare?”
• “F.10.14 How do I write a correct (syntax) Transform?”
If you want to know the SQL color codes used in this Lightning Guide, you may click “F.11.2 What are the SQL color codes used in this Guide?”.

F.10.2 What is the input record-list (“FROM” clause) of a Transform?
In a Transform operation (click F.10.1), the mandatory “FROM” clause indicates its input record-list, as follows:

```
FROM { } or [ { Table-name or Query-name } ] or [ ]
```

The input record-list is indicated in its “FROM” clause, exactly the same as the one from the Select operation.

If you want to write (syntax) a correct “FROM” clause, you may click F.10.14.

F.10.3 What are the output fields of a Transform?
You may click:
• “F.10.3.1 What is the number of output fields of a Transform?”
• “F.10.3.2 What are the output field names of a Transform?”
• “F.10.3.3 What is the output field order of a Transform?”
• “F.10.3.4 What are the output data/field types of a Transform?”
• “F.10.4 What is the output record-list of a Transform?”

F.10.3.1 What is the number of output fields of a Transform?
In a Transform operation (click F.10.1), the number of output fields is indicated in the “SELECT”, “PIVOT” and “IN” clauses as follows:

```
TRANSFORM PIVOT-field-values-exp()
SELECT [DISTINCT] [TOP int [PERCENT]] [DISTINCTROW or ALL]
{ * or Output-exp_1(exp-elements) [AS Output-field-name_1] ]
[, ... , Output-exp_n(exp-elements) [AS Output-field-name_n] ] }
```

...
The “n” leftmost output fields of a Transform are called the “SELECT” fields, because they are determined by the “SELECT” clause. The output fields placed to the right of the “SELECT” fields are called the “PIVOT” fields, because they are generated by converting to String the returned values of the “PIVOT” expression (click F.10.11), subject to the modifications of the optional “IN” list (click F.10.12).

What is the number of output “SELECT” fields of a Transform?
The number “n” of “SELECT” fields is the number of “SELECT” expressions. This is exactly the same as in a Select operation (click F.7.5).

What is the number of output “PIVOT” fields of a Transform?
If the optional “IN” clause is not used, the number of “PIVOT” fields is the number of distinct values returned by the “PIVOT” expression computed over all the (retained) input records.

Else, if the optional “IN” clause is used, then the number of “PIVOT” fields is the number of values in the “IN” list.

F.10.3.2 What are the output field names of a Transform?
In a Transform operation (click F.10.1), the output field names are indicated in the “SELECT”, “PIVOT” and “IN” clauses as follows:

```sql
SELECT [DISTINCT] [TOP int [PERCENT]] [DISTINCTROW or ALL]
{ * or
  Output-exp_1(exp-elements) [AS Output-field-name_1]
  [ , ... 
  , Output-exp_n(exp-elements) [AS Output-field-name_n] ] }

... PIVOT PIVOT-field-names-exp(Input-field-names)
[ IN ( List-of-PIVOT-values ) ]
```

The “n” leftmost output fields of a Transform are called the “SELECT” fields, because they are determined by the “SELECT” clause. The output fields placed to the right of the “SELECT” fields are called the “PIVOT” fields, because they are generated by converting to String the returned values of the “PIVOT” expression (click F.10.11), subject to the modifications of the optional “IN” list (click F.10.12).

What are the names of output “SELECT” fields of a Transform?
The names of the “n” “SELECT” fields are the identifiers “Output-field-name_i” from the “SELECT” clause. This is exactly the same as in a Select operation (click F.7.5).

What are the names of output “PIVOT” fields of a Transform?
Regarding the names of the “PIVOT” fields, we have the following three cases:

- The “IN” clause is not used, and the distinct value (converted to String) returned by the “PIVOT” expression is different from all the “SELECT” field names. Then, the name of this “PIVOT” field is the distinct value (converted to String) returned by the “PIVOT” expression.
- The “IN” clause is used, and the value (converted to String) from the “IN” list is
different from all the “SELECT” field names.

Then, the name of this “PIVOT” field is the value (converted to String) from “IN” list.

- The value (converted to String), which is either a distinct value returned by the “PIVOT” expression or a value from the “IN” list, is the same as one of the “SELECT” field names.

Then, the name of this “PIVOT” field is “FieldN”, where “N” is an integer value assigned by MS-Access.

The data type of the “PIVOT” expression is usually String, but it can also be any other data type. In case the data type of the expression is not String, then MS-Access will convert its result to a String (to become a field name). The values True/Yes/On or ticked and False/No/Off or unticked are converted to the field names “-1” and “0”, respectively. An integer-like data type value is converted to the field name of the equivalent String (e.g., “-12”, “14”). A Date value is converted to the field name of the equivalent String (e.g., “04/05/2003”). A fractional data type is converted to the field name of the equivalent String, but, replacing the period “.” with underscore “_”. The reason for this is that names cannot contain a period “.” (click D.2.5). Therefore, the number “-0.45” is converted to the field name “-0_45”.

In case that one or more input records make the expression in the “PIVOT” clause produce Null, these Nulls will produce a valid “PIVOT” field name which is “<>”. I strongly recommend that you avoid using the string “<>” in the “List-of-PIVOT-values” of the “IN” clause, to avoid confusion with a “PIVOT” field arising from a Null (which is most likely not intentional).

A Null, either returned by the “PIVOT” expression or written in the “IN” list, will produce “<>” as the “PIVOT” field name. If both a Null and an explicit “<>” happen, the field corresponding to Null will be named “<>”, while the field corresponding to “<>” will be named “FieldN”, where “N” is an integer value assigned by MS-Access.

Field names cannot include the period “.” character (click D.2.5). For this reason, every period “.” character in a value from the “PIVOT” expression or in a value from the “IN” list, will be converted to the underscore “_” character in the resulting “PIVOT” field name. For example, the returned values numeric “3.4” and string “Oh.No” from the “PIVOT” expression produce the “PIVOT” field names “3_4” and “Oh_No” respectively; likewise, the values “54.6” and “Hi.there” found in the “IN” list produce the “PIVOT” field name “54_6” and “Hi.there”, respectively.

If you use the “IN” clause, the data type returned by the “PIVOT” expression must be the same as the one of all the elements in the “IN” list, either directly or through type conversion. Otherwise, the Query will crash. Curiously, a Null, either returned by the “PIVOT” expression or explicitly written in “IN” list, is always considered as having a compatible data type. I now present a few examples to clarify this paragraph:

- The following works, because “Cal_Year” is a number and all the elements in the “IN” list are numbers, or can be converted to a number, or are Null.

```
Pivot Cal_Year
IN (2016, 2020, "2018", "34", Null)
```
• The following **crashes**, because “**Cal_Year**” is a **number** and the string “**Hello**” cannot be converted to a **number**.

```sql
    PIVOT Cal_Year
```

• The following works, because “**Date_Time**” is a **Date/Time** and **all** the elements in the “**IN**” list are either **Date/Time** or can be converted to a **Date/Time**, or are **Null**.

```sql
    PIVOT Date_Time
    IN (#2018-1-1#, "3/January/2020", Null)
```

• The following **crashes**, because “**Date_Time**” is a **Date/Time** and the string “**Hello**” cannot be converted to a **number**.

```sql
    PIVOT Date_Time
    IN (#2018-1-1#, "Hello", Null)
```

### F.10.3.3 What is the output field order of a Transform?

In a **Transform** operation (click **F.10.1**), the **output field order** is indicated in the **“SELECT”**, **“PIVOT”** and **“IN”** clauses as follows:

```sql
    SELECT [DISTINCT] [TOP int [PERCENT]] [DISTINCTROW or ALL]
    { * or
      Output-exp_1(exp-elements) [AS Output-field-name_1]
      [, ...
      , Output-exp_n(exp-elements) [AS Output-field-name_n] ] } 

    PIVOT PIVOT-field-names-exp(Input-field-names)
    [IN ( List-of-PIVOT-values ) ]
```

The **“n” leftmost output fields** of a **Transform** are called the **“SELECT” fields**, because they are determined by the **“SELECT”** clause. The **output fields** placed to the right of the **“SELECT” fields** are called the **“PIVOT” fields**, because they are **generated** by converting to **String** the **returned values** of the **“PIVOT” expression** (click **F.10.11**), subject to the modifications of the optional **“IN” list** (click **F.10.12**).

**What is the order of output “SELECT” fields of a Transform?**

The **order** of the **“n” “SELECT” fields** is the same as the one of the **“SELECT” expressions**. This is exactly the same as in a **Select** operation (click **F.7.5**).

**What is the order of output “PIVOT” fields of a Transform?**

If the optional **“IN”** clause is **not** used, the **order** of the **“PIVOT” fields** is, left to right, **ascending** by the **value** produced by the **“PIVOT” expression**. Notice that if the **“PIVOT” expression** produces a **numeric value**, the **field ordering** will be **ascending numeric**, while if it produces a **String value** the field ordering will be **ascending alphabetical**, which is different. You can easily change between both by enclosing the **“PIVOT” expression** in a type conversion function (click **G.2.5**). If a **Null** is produced, it will always be the **first** (leftmost) **“PIVOT” field**, with **field name** **“<>”**.

Else, if the optional **“IN”** clause is **used**, then the **“PIVOT” field order** is the one you wrote in the **“IN” list** (click **F.10.12**).

Notice that the field order just described is **maintained** even when a **“PIVOT” field name** (either converted from the **“PIVOT” expression** or from the **“IN” list**) is the
same as a “SELECT” field name. In this case, the “PIVOT” field name is changed to “FieldN”, but its position within the “PIVOT” fields is not changed.

The “PIVOT” field name corresponding to a Null value (i.e., the field name “<>”) can also be reordered by including it in the “IN” list. I strongly recommend that you never use the string “<>” neither as a “SELECT” field name, nor as a name in the “IN” list, nor as a name produced by the “PIVOT” expression. If you use “<>” in either of these three cases, you create the risk of mistaking that field with a “PIVOT” field arising from Null (which is most likely not intentional).

F.10.3.4 What are the output data/field types of a Transform?

In a Transform operation (click F.10.1), the output data/field types are indicated in the “TRANSFORM”, “SELECT”, “PIVOT” and “IN” clauses as follows:

```sql
TRANSFORM PIVOT-field-values-exp() SELECT [DISTINCT] [TOP int [PERCENT]] [DISTINCTROW or ALL]
    {
        * or
        Output-exp_1(exp-elements) [AS Output-field-name_1]
        [, ...,
         Output-exp_n(exp-elements) [AS Output-field-name_n] ] } }

... PIVOT PIVOT-field-names-exp(Input-field-names)
[IN ( List-of-PIVOT-values ) ]
```

The “n” leftmost output fields of a Transform are called the “SELECT” fields, because they are determined by the “SELECT” clause. The output fields placed to the right of the “SELECT” fields are called the “PIVOT” fields, because they are generated by converting to String the returned values of the “PIVOT” expression (click F.10.11), subject to the modifications of the optional “IN” list (click F.10.12).

What is the data/field type of output “SELECT” fields of a Transform?

The data/field type of the “n” “SELECT” fields are the ones of the corresponding “SELECT” expressions. This is exactly the same as in a Select operation (click F.7.5).

What is the data/field type of output “PIVOT” fields of a Transform?

Regarding the data/field type of the “PIVOT” fields, we have the following three cases:

- The “IN” clause is not used, and the distinct value (converted to String) returned by the “PIVOT” expression is different from all the “SELECT” field names. Then, the data type of this “PIVOT” field is the one of the “TRANSFORM” expression “PIVOT-field-values-exp()”.

- The “IN” clause is used, and the value (converted to String) from the “IN” list is different from all the “SELECT” field names. Then, the data type of this “PIVOT” field is unknown (and all this field’s values are Null).

- The value (converted to String), which is either a distinct value returned by the “PIVOT” expression or a value from the “IN” list, is the same as one of the “SELECT” field names. Then, the data type of this “PIVOT” field is the one of the same-name “SELECT” field.
If you want to know what are the output field values and/or what is the output record-list of a Transform, you may click “F.10.4 What is the output record-list of a Transform?”.

F.10.4 What is the output record-list of a Transform?

You may click:

- “F.10.4.1 What are the output field values of a Transform?”
- “F.10.4.2 What are the output records of a Transform?”
- “F.10.4.3 How many output records does a Transform produce?”

F.10.4.1 What are the output field values of a Transform?

In a Transform, the output field values are determined by the “TRANSFORM”, “SELECT”, “PIVOT” and “IN” clauses as follows:

```sql
TRANSFORM
  PIVOT-field-values-exp
    SELECT [DISTINCT] [DISTINCTROW or ALL]
    [AS Output-field-name]
    Output-field-names
    , PIVOT-field-names-exp(Input-field-names)
    , Group_by-exp_1(Input-field-names)
    , ...;
    Group_by-exp_k(Input-field-names)
    , SQL_agg_func(exp_t11(INOUT-field-names))
    , ...;
    SQL_agg_func(exp_tld(INOUT-field-names))
) [ AS Output-field-name ]

[ , ...,
  Output-field-names
  , PIVOT-field-names-exp(Input-field-names)
  , Group_by-exp_1(Input-field-names)
  , ...;
  Group_by-exp_k(Input-field-names)
  , SQL_agg_func(exp_o11(INOUT-field-names))
  , ...;
  SQL_agg_func(exp_oly(INOUT-field-names))
) [ AS Output-field-name_1 ]

[ , ...,
  Output-field-names
  , PIVOT-field-names-exp(Input-field-names)
  , Group_by-exp_1(Input-field-names)
  , ...;
  Group_by-exp_k(Input-field-names)
  , SQL_agg_func(exp_on1(INOUT-field-names))
  , ...;
  SQL_agg_func(exp_onz(INOUT-field-names))
) [ AS Output-field-name_n ]

PIVOT PIVOT-field-names-exp(Input-field-names)
[ IN ( List-of-PIVOT-values ) ]
```

The “n” leftmost output fields of a Transform are called the “SELECT” fields, because they are determined by the “SELECT” clause. The output fields placed to the right of the “SELECT” fields are called the “PIVOT” fields, because they are generated by converting to String the returned values of the “PIVOT” expression (click F.10.11), subject to the modifications of the optional “IN” list (click F.10.12).

What are the values of output “SELECT” fields of a Transform?

The values of the “n” “SELECT” fields are the result of the “SELECT” expressions,
computed over the groups of (retained) input records produced by the “GROUP BY” expression. This is the same as in a Select-group_by_aggreg operation (click F.7.6.2), with only one difference. The one difference is that in a Transform, the “SELECT” expressions 1 to n can also use an element the “PIVOT” expression.

You may see this in the SQL code above. This is somehow surprising, because the “PIVOT” expression produces multiple values (different in the general case) when computed over the (retained) input records in the group corresponding to a given output record (remind that we are using a “GROUP BY” clause). The way this works is that when evaluating a “SELECT” expression that includes the “PIVOT” expression, it returns the result as if the “PIVOT” expression was enclosed in the “Min()” SQL aggregate function. This is, whenever you write the the “PIVOT” expression “PIVOT-field-names-expression()” within a “SELECT” expression, it works as if you had written “Min(PIVOT-field-names-expression())”.

Notice that if a “PIVOT” field is discarded because the “IN” clause is used, and the corresponding result from the “PIVOT” expression is not in the “IN” list, the result of using the “PIVOT” expression within the “SELECT” expression will remain unaffected. This is, you will still get the “Min()” value over all the values produced, even if the “Min()” value is not in the “IN” list.

Finally, as a rather strange case, if you use the “PIVOT” expression as an element of a “SELECT” expression, and you also use the “IN” clause, the corresponding “SELECT” expression will produce the exception value “#Error”. Curiously, if the “SELECT” expression is exactly the same as the “PIVOT” expression, this works fine. This may be an MS-Access bug.

What are the values of output “PIVOT” fields of a Transform?

Regarding the values of the “PIVOT” fields, we have the following three cases:

- The “IN” clause is not used, and the distinct value (converted to String) returned by the “PIVOT” expression is different from all the “SELECT” field names. Then, the value of this “PIVOT” field is the result of the “TRANSFORM” expression computed over the groups of (retained) input records produced by the “GROUP BY” expressions jointly with the “PIVOT” expression.

In more detail, the value of field “i” and row “i” is produced by applying the “TRANSFORM” expression, to all the records in the group “(i, j)” of (retained) input records corresponding to row “i” and column “j”. Each group “(i, j)” contains the (retained) input records that produce the same results in all the 1 to k “GROUP BY” expressions as the values in row “i” and the same result in the “PIVOT” expression as the field name of column “j”. Since these groups of input records depend on the result of the “PIVOT” expression, they will be different (in the general case) for each “PIVOT” field, and therefore, the “TRANSFORM” expression will produce different values (i.e., different columns of values) below each of the “PIVOT” fields.

- The “IN” clause is used, and the value (converted to String) from the “IN” list is different from all the “SELECT” field names. Then, the value of this “PIVOT” field is Null in all the output records.

- The value (converted to String), which is either a distinct value returned by the
“PIVOT” expression or a value from the “IN” list, is the same as one of the “SELECT” field names. Then, the value of this “PIVOT” field is the same as the one in the same-name “SELECT” field in each and every output record. This is, the “column” of values under this field is the same as the “column” of values under the same-name “SELECT” field.

In the first bullet above, notice that it is not surprising to be able to use the “PIVOT” expression as one of the elements of the “TRANSFORM” expression, because in this case the “PIVOT” expression produces the same value in every record of each group. However, in the explanation above in “What are the values of output “SELECT” fields of a Transform?” it was surprising that you could use the “PIVOT” expression as an element of the “SELECT” expressions, because in that case the “PIVOT” expression may produce different values in the different records of each group.

Why does the same expression produce different values within the “SELECT” and “TRANSFORM” expressions?

Because in a Transform, the “SELECT” expressions and the “TRANSFORM” expression are computed over different groups of input records. The “SELECT” expressions are computed over groups of input records that produce the same results in all the “GROUP BY” expressions. However, the “TRANSFORM” expression is computed over groups of input records that produce the same result in all the “GROUP BY” expressions and also in the “PIVOT” expression.

Let me show this with an example over the Table “T_Capital_Rainfall_District”.

<table>
<thead>
<tr>
<th>T_Capital_Rainfall_District</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
</tr>
<tr>
<td>Beijing</td>
</tr>
<tr>
<td>Beijing</td>
</tr>
<tr>
<td>Beijing</td>
</tr>
<tr>
<td>Beijing</td>
</tr>
<tr>
<td>Washington</td>
</tr>
<tr>
<td>Washington</td>
</tr>
<tr>
<td>Washington</td>
</tr>
<tr>
<td>Washington</td>
</tr>
</tbody>
</table>

If you now run the Query:

```sql
TRANSFORM Sum(Rainfall) AS GenVals
SELECT Capital AS Cap_City, Sum(Rainfall) AS Total
FROM T_Capital_Rainfall_District
GROUP BY Capital
PIVOT Cal_Year ;
```

This is the Query “F_Transform_sum” from the “Company_Database.acccb” file.
you then get the result:

<table>
<thead>
<tr>
<th>F_Transform_Sum</th>
<th>Total</th>
<th>2018</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cap_City</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beijing</td>
<td>32</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>Beijing</td>
<td>34</td>
<td>11</td>
<td>23</td>
</tr>
<tr>
<td>Washington</td>
<td>18</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Washington</td>
<td>21</td>
<td>12</td>
<td>9</td>
</tr>
</tbody>
</table>

Notice how the "TRANSFORM" expression "\text{Sum}(\text{Rainfall})" and the "SELECT" expression "\text{Sum}(\text{Rainfall})", that are exactly the same, produce different results under the field names "Total", "2018" and "2019". The reason is that the "SELECT" expression "\text{Sum}(\text{Rainfall})" is computed over the record groups produced by the "GROUP BY" expressions, while the same "TRANSFORM" expression "\text{Sum}(\text{Rainfall})" is computed over the record groups produced by the "GROUP BY" expressions jointly with the "PIVOT" expression. In other words, the "SELECT" expression "\text{Sum}(\text{Rainfall})" is the sum for each "Capital" (i.e., adding all districts and all years) while the "TRANSFORM" expression "\text{Sum}(\text{Rainfall})" is the sum for each "Capital" and each "Cal_Year" (i.e., adding all districts). Notice how the "TRANSFORM" expression produces a different column of values for each "PIVOT" field (i.e., for "2018" and "2019").

Since in this case we are using the "\text{Sum}()" aggregate function, the result under "Total" is the addition of the results under "2018" and "2019". However, notice that this does not happen with some other SQL aggregate functions (see the last bullet point of F.10.5).

**F.10.4.2 What are the output records of a Transform?**

In a Transform, the output records are determined by the optional "WHERE" clause, the "GROUP BY" clause and the optional "ORDER BY" clause as follows:

```sql
[WHERE Where-Boolean-exp(Input-field-names) ]
GROUP BY Group_by-exp_1(Input-field-names)  
[', ... , Group_by-exp_k(Input-field-names) ]

[ORDER BY Group_by-exp_x(Input-field-names) [DESC]  
[', ... , Group_by-exp_y(Input-field-names) [DESC] ] ]
```

Transform produces as many records as groups of (retained) input records from the "GROUP BY" expressions. Each group contains the (retained) input records that produce the same results in all the "GROUP BY" expressions. Notice that the resulting field value arrays from "Group_by-expression()" 1 to k are all distinct. Notice also that these resulting field value arrays are not shown in the result of the Transform operation.

For each such output record its field values will be the ones indicated in the previous subsection F.10.4.1.

The order of records is unknown, unless the optional "ORDER BY" clause
(click F.10.12) is used. The ordering works the same as the “ORDER BY” clause (click F.7.12) from the Select operator, with just one restriction: the expressions in the Transform “ORDER BY” clause must be a list of any number of exactly the same “GROUP BY” expressions.

F.10.4.3 How many output records does a Transform produce?

Knowing how many records a Transform produces is very useful when debugging your Queries.

A Transform produces as many records as groups of (retained) input records are produced by the “GROUP BY” expressions. Each group contains the (retained) input records that produce the same results in all the “GROUP BY” expressions.

Notice that the number of output records is determined only by the (retained) input records (i.e., the “WHERE” Boolean expression) and the “GROUP BY” expressions.

F.10.5 Can I see an example of a Transform operation?

A simple but quite complete example of a Transform operation⁶¹ is:

```
TRANSFORM StDev(Temp_Max) AS GenVals
SELECT Capital AS Cap_City, Cal_Year AS C_Year,
      StDev(Temp_Max) AS StDev_T_Max_Year
FROM T_Capital_temps
GROUP BY Capital, Cal_Year
PIVOT Quart
```

The Table “T_Capital_Temps” used in this example has the following structure and values:

<table>
<thead>
<tr>
<th>City</th>
<th>District</th>
<th>Cal_Year</th>
<th>Quart</th>
<th>Temp_max</th>
<th>Temp_min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>Dongcheng</td>
<td>2018</td>
<td>Q1</td>
<td>12.3</td>
<td>0</td>
</tr>
<tr>
<td>Beijing</td>
<td>Dongcheng</td>
<td>2018</td>
<td>Q2</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Beijing</td>
<td>Dongcheng</td>
<td>2018</td>
<td>Q3</td>
<td>7.8</td>
<td>6.7</td>
</tr>
<tr>
<td>Beijing</td>
<td>Dongcheng</td>
<td>2018</td>
<td>Q4</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>Beijing</td>
<td>Xicheng</td>
<td>2018</td>
<td>Q1</td>
<td>2.26</td>
<td>-3.25</td>
</tr>
<tr>
<td>Beijing</td>
<td>Xicheng</td>
<td>2018</td>
<td>Q2</td>
<td>5.6</td>
<td>-4.5</td>
</tr>
<tr>
<td>Beijing</td>
<td>Xicheng</td>
<td>2018</td>
<td>Q3</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Beijing</td>
<td>Xicheng</td>
<td>2018</td>
<td>Q4</td>
<td>18</td>
<td>13</td>
</tr>
<tr>
<td>Brasilia</td>
<td>Asa_Norte</td>
<td>2019</td>
<td>Q1</td>
<td>7.4</td>
<td>-0.96</td>
</tr>
<tr>
<td>Brasilia</td>
<td>Asa_Norte</td>
<td>2019</td>
<td>Q2</td>
<td>7.57</td>
<td>-1.05</td>
</tr>
<tr>
<td>Brasilia</td>
<td>Asa_Norte</td>
<td>2019</td>
<td>Q3</td>
<td>17.5</td>
<td>7.4</td>
</tr>
<tr>
<td>Brasilia</td>
<td>Asa_Norte</td>
<td>2019</td>
<td>Q4</td>
<td>10.04</td>
<td>2.35</td>
</tr>
<tr>
<td>Brasilia</td>
<td>Guara_I</td>
<td>2019</td>
<td>Q1</td>
<td>10.62</td>
<td>3.17</td>
</tr>
<tr>
<td>Brasilia</td>
<td>Guara_I</td>
<td>2019</td>
<td>Q2</td>
<td>11.43</td>
<td>4.21</td>
</tr>
<tr>
<td>Brasilia</td>
<td>Guara_I</td>
<td>2019</td>
<td>Q3</td>
<td>12.4</td>
<td>5.52</td>
</tr>
<tr>
<td>Brasilia</td>
<td>Guara_I</td>
<td>2019</td>
<td>Q4</td>
<td>11.12</td>
<td>3.81</td>
</tr>
</tbody>
</table>

⁶¹ This is the Query “F_Transform_examp” from the “Company_Database.accdb” file.
Then, the **Transform** operation above would produce the following **output** record-list:

<table>
<thead>
<tr>
<th>F_Transform_examp</th>
<th>Cap_City</th>
<th>C_Year</th>
<th>StDev_T_Max_Year</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>2018</td>
<td>9.28</td>
<td>7.10</td>
<td>1.13</td>
<td>15.70</td>
<td>0.71</td>
<td></td>
</tr>
<tr>
<td>Brasilia</td>
<td>2019</td>
<td>3.17</td>
<td>2.28</td>
<td>2.73</td>
<td>3.61</td>
<td>0.76</td>
<td></td>
</tr>
<tr>
<td>Washington</td>
<td>2018</td>
<td>3.98</td>
<td>4.52</td>
<td>0.99</td>
<td>3.08</td>
<td>5.40</td>
<td></td>
</tr>
</tbody>
</table>

Let me explain in more detail why are you getting this **output** record-list.

**What is the input record-list of this example?**

The **input record-list** is the Table “**T_Capital_Temps**” in the “FROM” clause. Since in this example there is no “WHERE” clause, the **retained input records** are all the records in the Table “**T_Capital_Temps**”.

**What is the output record-list of this example?**

The **output** record-list of is determined by the “**GROUP BY**” clause. The “**GROUP BY**” **expressions** are “**Capital**” and “**Cal_Year**”. Therefore, the **output** records correspond to the **distinct values** produced by the (retained) **input records** in the “**GROUP BY**” **expressions** “**Capital**” and “**Cal_Year**”. If you check the Table “**T_Capital_Temps**” you will see that there are **three distinct arrays** of values for “**Capital**” and “**Cal_Year**”:

<table>
<thead>
<tr>
<th>Capital</th>
<th>Cal_Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>2018</td>
</tr>
<tr>
<td>Brasilia</td>
<td>2019</td>
</tr>
<tr>
<td>Washington</td>
<td>2018</td>
</tr>
</tbody>
</table>

**What are the output field names of this example?**

The **names** of the “**SELECT**” **fields** are “**Cap_City**”, “**C_Year**” and
“StDev_T_Max_Year”, as indicated in the “SELECT” clause.

The names of the “PIVOT” fields are “Q1”, “Q2”, “Q3” and “Q4”, because these are the distinct results of the “PIVOT” expression “Quart”, when computed over all the (retained) input records.

**What is the output field order of this example?**

The “SELECT” fields are produced in that order because this is how they appear in the “SELECT” clause.

The “PIVOT” fields are produced in that order because the data type of the “PIVOT” expression is Strings, and Strings are ordered in alphabetical order.

**What are the output field values of this example?**

The values of the “SELECT” fields are the result of the “SELECT” expressions “Capital”, “Cal_Year” and “StDev(Temp_Max)” computed over the groups of (retained) input records produced by the “GROUP BY” expressions.

The (retained) input records in each group are the ones that produce the same values in the “GROUP BY” expressions. In this example, there are three groups, each characterized by the results “(Beijing, 2018)”, “(Brasilia, 2019)” and “(Washington, 2018)”. You may check that the values of the “SELECT” fields above correspond to the explanation I have just given.

The values of the “PIVOT” fields are the result of the “TRANSFORM” expression “StDev(Temp_max)” computed over the groups of (retained) input records produced by the “GROUP BY” expressions jointly with the “PIVOT” expression.

In more detail, the value of field “j” from the output record “i” is produced by applying the “TRANSFORM” expression “Avg(Temp_max)”, to all the records in the group “(i, j)” of (retained) input records corresponding to record “i” and field “j”. Each group “(i, j)” contains the (retained) input records that produce the same results in all the 1 to k “GROUP BY” expressions as the values in row “i” and the same result in the “PIVOT” expression as the field name of column “j”.

I want to point out two relevant aspects from this example, that apply to all Transform operations:

- Notice that the “SELECT” expression “StDev(Temp_Max)” is exactly the same as the “TRANSFORM” expression “StDev(Temp_Max)”. However, being the same expression it produces different results because it is computed over different groups of (retained) input records. The “SELECT” expression is computed over groups produced by the “GROUP BY” expressions, while the “TRANSFORM” expression is computed over groups produced the “GROUP BY” expressions jointly with the “PIVOT” expression.

- Notice that the field values of “StDev_T_Max_Year” are not the result of SQL aggregate function “StDev()” over the values of fields “Q1”, “Q2”, “Q3” and “Q4”, in each row. If they were computed like that, the result would be: “7.00”, “1.19” and “1.93”, which is different from the actual output of the Query: “9.28”, “3.17” and “3.98”.
The reason is that the field values of “StDev_T_Max_Year” are the result of the “SELECT” expression “StDev(Temp_Max)” computed over the groups of (retained) input records produced by the “GROUP BY” expressions. In this example, this means computing the function “StDev()” over all the values of “Temp_Max” for each “Capital” and each “Cal_Year”.

F.10.6 What is the “TRANSFORM” clause of a Transform?

In a Transform operation (click F.10.1), the mandatory “TRANSFORM” clause determines the “PIVOT” data/field types (click F.10.3.4) and the “PIVOT” field values (click F.10.4.1), as follows:

```
TRANSFORM PIVOT-field-values-expression()
```

If you want to write (syntax) a correct “TRANSFORM” clause, you may click F.10.14.

F.10.7 What is the “SELECT” clause of a Transform?

In a Transform operation (click F.10.1), the mandatory “SELECT” clause determines the “SELECT” fields (click F.10.3), the “SELECT” field names (click F.10.3.2), the “SELECT” field order (click F.10.3.3), the “SELECT” data/field types (click F.10.3.4) and the “SELECT” field values (click F.10.4.1), as follows:

```
SELECT Output-expression_1() [ AS Output-field-name_1 ]
[ , ... , Output-expression_n() [ AS Output-field-name_n ] ]
```

If you want to write (syntax) a correct “SELECT” clause, you may click F.10.14.

F.10.8 What is the “ORDER BY” clause of a Transform?

In a Transform operation (click F.10.1), the optional “ORDER BY” clause determines the order of the output records, as follows:

```
ORDER BY [ Group_by-exp_x(Input-field-names) [DESC] ]
, ... , Group_by-exp_y(Input-field-names) [DESC] ]
[ [ , ] PIVOT-field-names-exp(Input-field-names) [DESC]]]
```

Each “ORDER BY” expression must be exactly the same as one of the “GROUP BY” expressions or as the “PIVOT” expression, which is a very strong restriction.

Aside from this restriction on the Transform “ORDER BY” expressions, the “ORDER BY” of a Transform works exactly the same as the “ORDER BY” of a Select: you may click “F.7.12 How do I use “ORDER BY” to order the output records of a Select?”.

If you want to write (syntax) a correct “ORDER BY” clause, you may click F.10.14.

F.10.9 What is the “WHERE” clause of a Transform?

In a Transform operation (click F.10.1), the optional “WHERE” clause indicates what are the retained input records, as follows:

```
WHERE Where-Boolean-expression(Input-field-names)
```

The “WHERE” Boolean expression is built using the “Input-field-names”
combining them with functions (excluding SQL aggregate), value operators and constants.

The “WHERE” clause of a Transform works exactly the same as the “WHERE” clause of a Select. You may see “F.7.7 What is the “WHERE” clause of a Select?”.

If you want to write (syntax) a correct “WHERE” clause, you may click F.10.14.

F.10.10 What is the “GROUP BY” clause of a Transform?

In a Transform operation (click F.10.1), the mandatory “GROUP BY” clause determines the output records (click F.10.4.2), as follows:

\[
\text{GROUP BY} \quad \text{Group}_i(\text{Input-field-names})
\]

Each “GROUP BY” expression is built using the “Input-field-names” combining them with functions (excluding SQL aggregate), value operators and constants.

The “GROUP BY” of a Transform works exactly the same as the “GROUP BY” of a Select. You may click “F.7.9 What is the “GROUP BY” clause of a Select-group by aggreg?”.

There is also a very subtle, but very interesting, difference: the “GROUP BY” clause is optional in a Select, but it is mandatory in a Transform. This is because you can only do a cross table if there is only one value for each row and column. If you had several values for each row and column, there would be no criterion to choose one of them to be displayed. Therefore, the Transform operation guarantees that there is only one value for each row and column. The way to guarantee this is producing the cross table values from record aggregation of the rows and columns. Remind that record aggregation produces only one value from each group of records.

If you want to write (syntax) a correct “GROUP BY” clause, you may click F.10.14.

F.10.11 What is the “PIVOT” clause of a Transform?

In a Transform operation (click F.10.1), the mandatory “PIVOT” clause determines the “PIVOT” fields (click F.10.3), the “PIVOT” field names (click F.10.3.2) and the “PIVOT” field order (click F.10.3.3), as follows:

\[
\text{PIVOT} \quad \text{PIVOT-field-names-expression}(\text{Input-field-names})
\]

The “PIVOT” clause contains the expression that produces the “PIVOT” field names (click F.10.3.2), unless the optional “IN” clause (click F.10.12) is used. If the optional “IN” clause is used, then the “PIVOT” field names are produced by the list of values in the “IN” clause.

The “PIVOT” expression is built using the “Input-field-names” combining them with functions (excluding SQL aggregate), value operators and constants.

If you want to write (syntax) a correct “PIVOT” clause, you may click F.10.14.
F.10.12 What is the “IN” clause of a Transform?

In a Transform operation (click F.10.1), the optional “IN” clause determines the “PIVOT” fields, the “PIVOT” field names (click F.10.3.2) and the “PIVOT” field order (click F.10.3.3), as follows:

   IN ( List-of-PIVOT-values )

The “IN” keyword is followed by a list of constants. I will call this list the “IN” list. The “IN” list is enclosed between parentheses and the constants are separated with commas.

The “IN” clause is most frequently used to specify the order of the “PIVOT” fields and/or to discard some of them. The way to do this is just by writing in the “IN” list the “PIVOT” field names that you want (i.e., excluding some if you do not want them), and writing them in the specific order that you want them.

In the general case, when the “IN” clause is used, the “PIVOT” fields, their field names and their field order will be exactly the ones and with the same order as they appear in the “IN” clause (except if they are the same as a “SELECT” field name). I now explain the possible cases in more detail:

- If the “IN” list does not include a value that is produced by the “PIVOT” expression, then the “PIVOT” field corresponding to that value does not appear in the output of the Transform.
- If the “IN” list includes a value that is produced by the “PIVOT” expression, and that value (converted to String) is not one of the “SELECT” field names, then the corresponding “PIVOT” field will be in the output of the Transform, in the order indicated in the “IN” list, with the corresponding field values produced by the “TRANSFORM” expression.
- If the “IN” list includes a value that is not produced by the “PIVOT” expression, and that value (converted to String) is not one of the “SELECT” field names, then that value (converted to String) will be a “PIVOT” field, in the order indicated in the “IN” list, with all its values being Null.
- If the “IN” list includes a value that (converted to String) is one of the “SELECT” field names, then a “PIVOT” field will be produced with the name “FieldN”, where “N” is an integer value assigned by MS-Access. The order of that field is the one of the corresponding value in the “IN” list. The values of this field will be exactly the same ones as the ones of “SELECT” field whose name was the same.

The “PIVOT” field name corresponding to a Null value (i.e., “PIVOT” field name “<>”) can also be reordered by including it in the “IN” clause. I strongly recommend that you do not use a “PIVOT” expression that produces the string “<>”, to avoid confusion with a “PIVOT” field name arising from Null (which most likely will be unintentional).

The “IN” list cannot contain duplicated values: if it does, the Query will crash with a syntax error message.

As I indicated at the beginning of this section, the “IN” clause is most frequently used
to specify the order of the “PIVOT” fields and/or to discard some of them. As I have explained just above, the “IN” clause can also be used to add copies of “SELECT” fields and/or to create new “PIVOT” fields. However, the two features in the previous sentence do not seem very useful to me, because the added fields would have either replicated values or Null (respectively), in all the output records.

If you want to write (syntax) a correct “IN” clause, you may click F.10.14.

F.10.13 How do the clauses from Transform and Select compare?

To better understand Select and Transform, I think it is useful to compare the characteristics of the clauses of a Select operation and of a Transform operation:

- In the Transform (mandatory) “SELECT” clause, each “SELECT” expression may include as its elements the “PIVOT” expression, in addition to the elements in the (mandatory) “SELECT” clause of a Select-group_by_aggreg. This allows to use the “PIVOT” field names in the “SELECT” expressions. Remind that in a Select-group_by_aggreg, the “SELECT” expressions can contain other “Output-field-names” (as long as you do not create a circular reference, click F.7.14), any number of “GROUP BY” expressions, and any number of SQL aggregate functions each having as argument its specific expression over the “Input-field-names” and other “Output-field-names” (as long as you do not create a circular reference, nor a nested SQL aggregate function, click F.7.14).

- The Transform (optional) “DISTINCT” clause does not produce any effect in the results of the Transform operation, while in the Select operation the (optional) “DISTINCT” clause removes all the redundant output duplicate records.

- The Transform (optional) “ORDER BY” clause can only use as its expressions the “GROUP BY” expressions (over the Input-field-names) or the “PIVOT” expression (over the Input-field-names). Aside from this, its functionality is the same as the (optional) “GROUP BY” clause from a Select.

- Transform does not have the (optional) “HAVING” and “TOP” clauses, that the Select operator has.

- Select does not have the (mandatory) “TRANSFORM” and “PIVOT” clauses nor the (optional) “IN” clause, that the Transform operator has.

- Both Transform and Select have the (not advisable) (optional) “DISTINCTROW” clause.

F.10.14 How do I write a correct (syntax) Transform?

You may click:

- “F.10.14.1 What is a syntax-example of a Transform?”
- “F.10.14.2 What are the formal rules (syntax) to write a Transform?”
- “F.10.14.3 Can I nest Transform operations?”