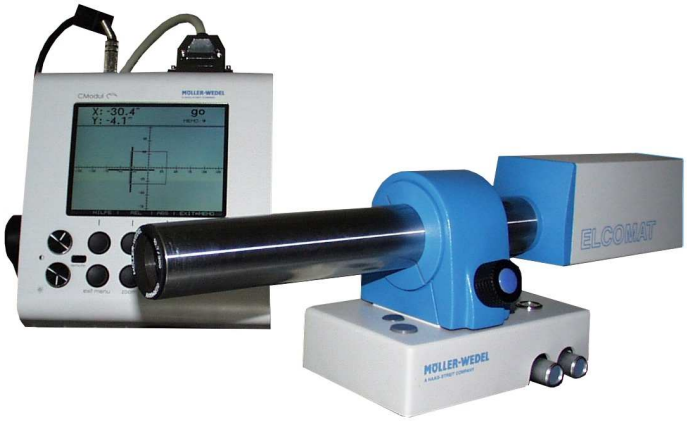
Software description

RTM V1.4x

06/2011

Universal Measurement System for Determining Positional Uncertainties and Positioning Accuracies of rotary tables



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Contents:

1.	**Program definition and installation/ General operation**	**1 - 1**
1.1	Program definition	1 - 1
1.2	Installation	1 - 1
1.3	General operation	1 - 2
1.4	Hints for de-installation	1 - 2
1.5	Software-history	1 - 3
2.	**The main window, global settings**	**2 - 1**
2.1	The main window	2 - 1
2.1.1	Basic menu commands in the RTM main menu	2 - 2
2.1.2	Settings for the program layout	2 - 2
2.2	The service mode	2 - 3
2.3	The folder structure	2 - 4
3.	**The measurement process for Determining the Positional Uncertainties and Positioning Accuracies of rotary tables with RTM**	**3 - 1**
3.1	Measurement parameters and measurement templates	3 - 1
3.1.1	Definition - measurement template	3 - 1
3.1.2	Description of the measurement parameters	3 - 1
3.1.2.1	The location of the measuring positions	3 - 2
3.1.2.2	Positioning procedures and positioning direction	3 - 2
3.1.2.3	Polygons and polygon errors	3 - 4
3.1.3	Generation and modification of measurement templates and polygons	3 - 4
3.2	The measurement status window	3 - 6
3.2.1	The measured value display	3 - 6
3.2.2	The measurement process display	3 - 8
3.3	The measurement process	3 - 9
3.3.1	Options for the measurement value logging	3 - 11
3.3.2	The measurement flow control	3 - 13
3.4	Settings for the measurement process	3 - 15
3.4.1	The index cards Measurement process and Acoustic Signals	3 - 15
3.4.2	The index card measuring sensors	3 - 16
3.4.3	The index card Measurement flow control	3 - 18
4.	**Safe and evaluation of measurement results**	**4 - 1**
4.1	Measured value files and measured value file windows	4 - 1
4.2	Evaluation of the measurement results	4 - 2
4.3	The measuring record	4 - 4
4.3.1	The report text in the measuring record, measuring record templates	4 - 5
4.3.1.1	Definition, wildcards	4 - 5
4.3.1.2	The formula editor	4 - 6
4.3.1.3	The wildcard list using in RTM measuring record templates	4 - 6
4.3.1.4	Editing a measuring record template	4 - 8
4.3.1.5	Customized data in the measuring record	4 - 10
4.3.2	The graphical presentation of the measurement results	4 - 11
4.3.2.1	General	4 - 11
4.3.2.2	The configuration of the graphics presentation	4 - 12

1. Program definition and installation/ General operation

1.1 Program definition

The program **RTM** and the belonging hardware (e.g. AKF *ELCOMAT* of the company Möller-Wedel-Optical GmbH) can measure and display *positional uncertainties* and the *positioning accuracy* of any kind of rotary tables that moves horizontally and/or vertically. The thus recorded measurement value (= deviation from the target value) for a turntable is called *pitch error* in the rotating direction and *drunkenness* if seen vertically to the rotating direction.

RTM can realize menu and dialogue controlled entries of measurement parameters and also saves the configuration data, controls the hardware and saves and graphically analyses the measurement results in measurement files and protocols.

1.2 Installation

The following preconditions are required for the installation of **RTM**:

- a IBM-compatible PC with an processor type Intel Pentium III or compatible, or higher;
- operating system Windows 98, NT (with SP 4), 2000, XP, Vista-32;
- screen resolution at least 800x600 pixel with >= 256 colors;
- hard disk memory at least 4 MB;
- an USB-port or (optionally) an LPT-port for the connection of the software protection key („dongle“);
- one serial port for the connection of the ELCOMAT (the alternatively use of USB-serial-adapters should be tested before);
- for the installation you need administrator rights on the PC (not required for the use of the software);
- the software needs read- and write-access to the using program and data folders, the windows registry is only used on the software-installation/-de-installation.

Please perform the program installation in the following order:

1. Installation of the ELCOMAT and connection with the PC via serial ports (COM1, COM2, ...), if necessary uses USB-serial adapters.
2. **RTM**-software-installation (please run the program SETUP.EXE from the installation-CD and follow the instructions on the screen). The software installation included the installation of the software protection key driver.
3. Connect the software protection key („dongle“) with the PC (via USB- or LPT-port).
4. Start of **RTM** (a PC-reboot is not necessary).

After installation your **RTM-p**rogram folder includes the following files and subfolders:

- the main program file RTM.EXE
- the configuration file RTM.INI for the storage of program specifically settings
- the file RTM.MVL for the storage of measurement templates
- the file RTM.POL for the storage of the polygon data used for the measurements
- the file MPIWIN32.DLL is a function library for the software protection key
- some measuring record template files (*.PVL) as measuring record samples for your measurements, if applicable in a separated folder
- different files (DEISL1.ISU, _DEISREG.ISR, _ISREG32.DLL ...), used for program updates or de-installation,
- folders for the storage of the measured value files and the measuring records.

Using **RTM** the following files are created:

- the configuration file RTMHIST.INI for the storage of history lists (e.g. for filenames of loaded files etc.)
- the file RTM.DAT for the storage of custom specifically measuring record parameter.

RTM only maintain and safe all program parameter and settings in configuration files (see above), the software don't use the windows registry (there only entries for the software protection key installation and an uninstall-entry for the software-de-installation will be created → *section 1.4*).
So it is simple for the user to safe and restore current program settings in case of a data backup or if you need support from the manufacturer or vendor.
Furthermore thereby it s possible to start RTM for example directly from an USB flash drive without a software installation (note that for fully functionality the software protection key must be installed and connected on the used PC).

1.3 General operation

For operating the program, you must be able to work with MS-Windows. All inquiries are menu- or dialog-controlled with the keyboard or the mouse. Wrong entries are generally not accepted by the program, i.e. you cannot enter a word into a field that expects a numeral entry. Furthermore sensible parameter limits operate in all numeral fields.
If the numeral fields have "arrow keys" to the right, the shown parameter can be increased or lowered within the allowed limits by mouse clicks. For some entry errors, mainly for text entries, there is a list available (which can be opened with the help of an arrow on the right field edge) where you can choose the required data; new entries are saved automatically. If a new entry of data is impossible (e.g. for presentation attributes of the measuring functions, to be recognized when the entry cursor is missing), you must choose an entry from the list.
Depending on the program status, some objects and menu entries cannot be activated in a window. They are displayed in gray (e.g. no data can be stored if none have been entered).

1.4 Hints for de-installation

The software de-installation happens using the belonging entry in the *Add/remove programs*-list in the *control panel*. Normally there are files left in the program installation folder (like configuration files etc.) after the software de-installation, so this folder won't delete. In this case you can manually delete the remaining files and the installation folder.
If you use any other OEG software on your PC apart from **RTM**, they might be saved with the help of the same software protection key. Therefore the software protection key is not removed automatically when de-installing **RTM** and must be de-installed separately if necessary. To do so, insert your set-up CD, switch to the folder \TOOLS on the CD and start the program CBSETUP.

1.5 Software history

02/2008 ... 07/2008 - RTM V1.0 ... V1.04 - Test versions, not delivered

08/2008 ... 09/2008 - RTM V1.10, V1.11

- Integration of the measurement flow control for the collection of measured values
- Integration of acoustic signal output for the collection of measured values

12.11.2008 - RTM V1.20

- Extension of the measurement flow control to a fully automatic for the measurement value logging
- Integration of definable user rights for standard mode user (→ *section 2.2*)

10.12.2008 - RTM V1.21

- *Changes/extensions:*
  - The maximal number of decimal places in the measured value display was increased from 4 to 5.
  - The measurement results (statistical values) in the report can be generated in wsec or degrees.
  - The program version information has been integrated into the program file RTM.EXE.
- *Error corrections:*
  - An error which occurred when calculating the positional uncertainty in acc. with VDI was eliminated.
  - The data for customer specific protocol parameters were not written into the measuring record.

10.02.2009 - RTM V1.22

- *Changes/extensions:*
  - Abridged and free adjustable ELCOMAT reading and timeout pulses - now you can measure rotary table with positioning times << 1 sec.

07/2009 - RTM V1.30 - Test version, not delivered

01.09.2009 - RTM V1.31

- *Changes/extensions:*
  - More adjustable user rights for standard mode user
  - Revision of several setting dialogs
- *Optimizations/Error corrections:*
  - ELCOMAT data transfer optimization
  - Prevention of a multiple start of the application
  - Prevention of a change and/or reset of the hardware configuration in case of connecting problems
  - Prevention of a inadvertent overwriting/deleting of measuring record templates during the modification of measured data file parameter

16.09.2009 - RTM V1.32

- *Changes/extensions:*
  - Graphical and tabular representation of the measurement in the measurement status window
  - Including of program version information into the application

06.11.2009 - RTM V1.40

- *Changes/extensions:*
  - Implementation of an algebraic sign test to get a distinct assignment of the measured value display to the positive rolling direction of the measurement object (the algebraic sign of the measured values can be tested and inverted if necessary before each measurement); therefore the request of the rolling direction is dropped.
  - Change of the text mask for the auto name function at the generation of measurement templates
- *Error correction:*
  - Little error corrections in the layout of the measurement report
  - Sometimes the request of the rolling direction wasn't made before a measurement (now this request is replaced with the new algebraic sign test - see above).

24.02.2010 - RTM V1.41

- *Changes/extensions:*
  - Enhanced tabulary input of the polygon errors (highlighted faulty text, alternative input of decimal points or decimal comma available, enhanced plausibility test)
- *Error correction:*
  - replacement of some remained German measurement unit signs with the English equivalents in the English software version
  - little layout corrections

12.07.2010 – RTM V1.42

- *Changes/extensions:*
  - The ELCOMAT type and protocol is changeable inside the software.
  - Optimization of the automatic ELCOMAT search
  - Implementation of the one-axis ELCOMAT 2000
- *Error correction:*
  - Bugfix in the measurement value display – in case of no measured values using the ELCOMAT text protocol even the measured value 0 was displayed.

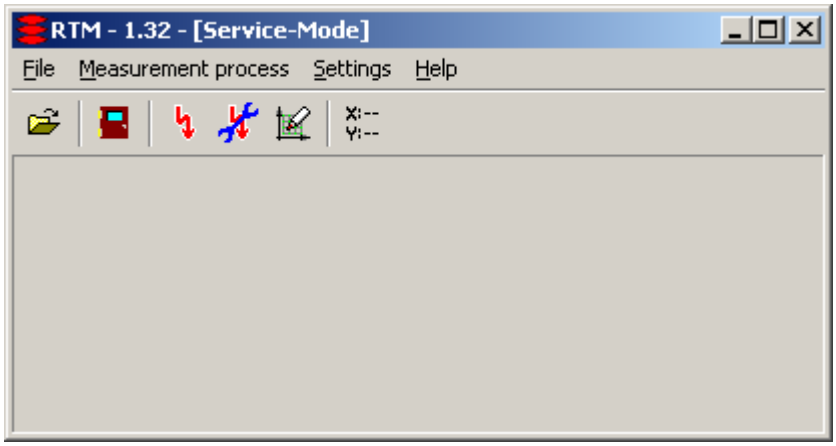
12.01.2011 – RTM V1.43

- *Changes/extensions:*
  - The measured value table in the measured value window can contained up to 60 columns (as yet up to maximal 10).
  - The number of columns in the report measured value table is variable, you can split the table in up to three sub tables.

2. The main window, global settings

2.1 The main window

The **RTM** main window is a simple window and contains only the main menu and a toolbar.



The icons in the toolbar can be used as an alternative to the respective menu commands. This manual, however, only refers to the menu commands to simplify the matter. If the pointer shortly remains on an icon, a support window is displayed that shows the menu commands corresponding to the icon.

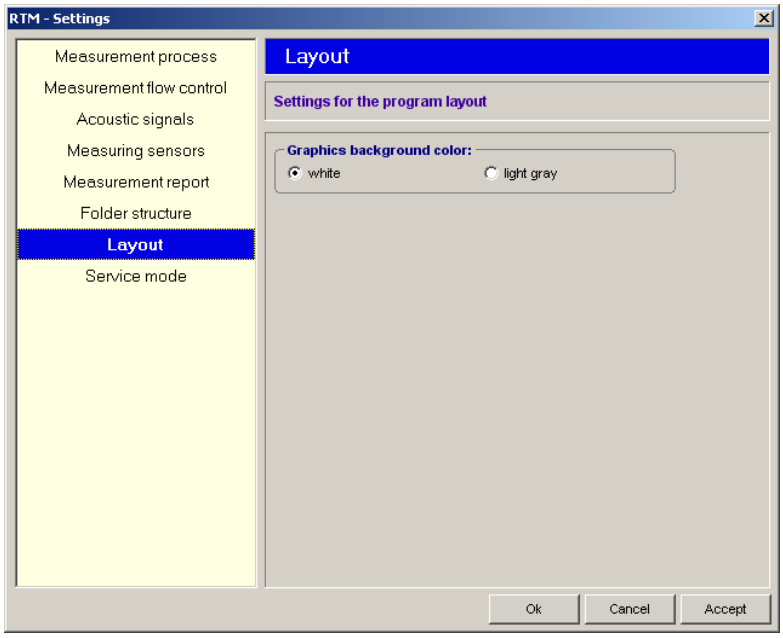
During the complete **RTM** program procedure the main window serves as the bottom layer of all the open program windows, especially the measured value file windows, dialogs etc.

2.1.1 Basic menu commands in the RTM main menu

The main window contains some basic menu commands that are mainly self-explaining and can be found in many Windows programs in a similar form. Thus their functions are only briefly explained here:

- *File → Open:*
  Use the command to load an **RTM** measured value file for editing and evaluating.
  For every loaded file a separate measured value file window with the filename in the title bar is generated. The measured data of all opened measured value files are displayed in the graphics in the main window. The last opened measured value file or the one selected from the respective window is taken as the *current* measured value file whose measured value file window gets the focus and will be moved in the foreground of the screen (→ *section 4.1*).
  You also get a list with the filenames of the last opened files in the *file* menu to re-open these files with one mouse click.
- *File → Close all:*
  This command closes all open measured value files. If unsaved alterations available in a measured value file, **RTM** will ask you to save or ignore the alterations before closing the file. Individual measured value files can be closed with the respective menu command in the belonging window displaying the measured value files.
- File → Setup printer
  Use the command to configure your printer or select another printer for printing.
- *File → Exit:*
  Use the command to exit **RTM**. Before that the measured value files are closed and security checks are made (see *File → Close all).*
- *Help → Info:*
  The number of the version and the copyright information of your **RTM** program version and data of your software protection key are displayed. If the service-mode is activated (→ *section 2.2*), it also is available to display system information about your PC and the current operating system.

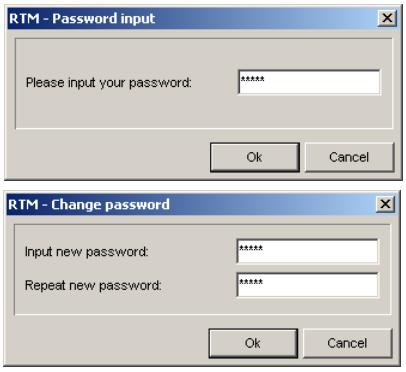
2.1.2 Settings for the program layout



Using the menu command *Settings* the opposite dialog window opened. With the settings on the index card *Layout* you can modify the graphical presentation of the **RTM** measurement results.

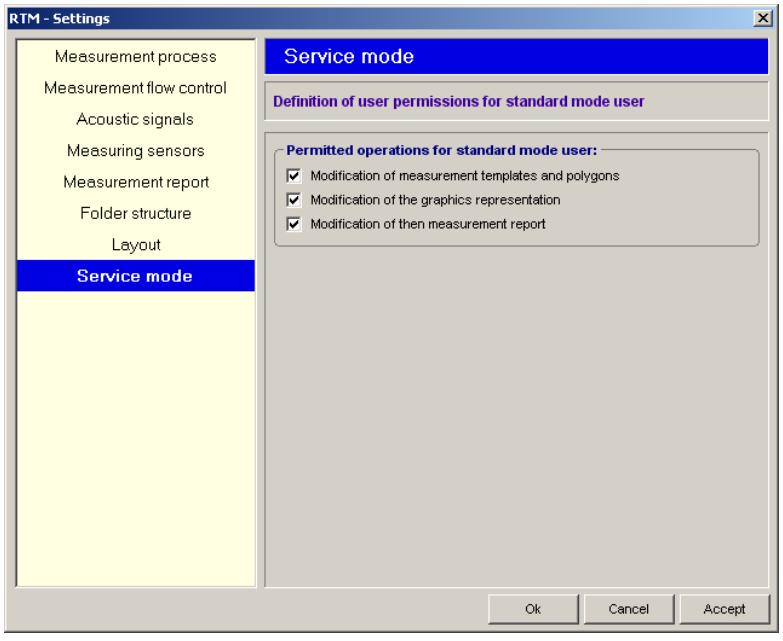
2.2 The service mode

A careless change of important settings for the measurement execution and evaluation can make the measurement more difficult and have a negative influence on the quality and reliability of the measurement results. Therefore experienced users should only operate the belonging dialogs; for **RTM** they can only be accessed in the so-called *service mode* after entering a password.
When starting the program the service mode is de-activated, you are in the *standard mode* where measurements are run, but settings can only be changed limitedly.
The respectively current status is shown in the header of the **RTM** main window.



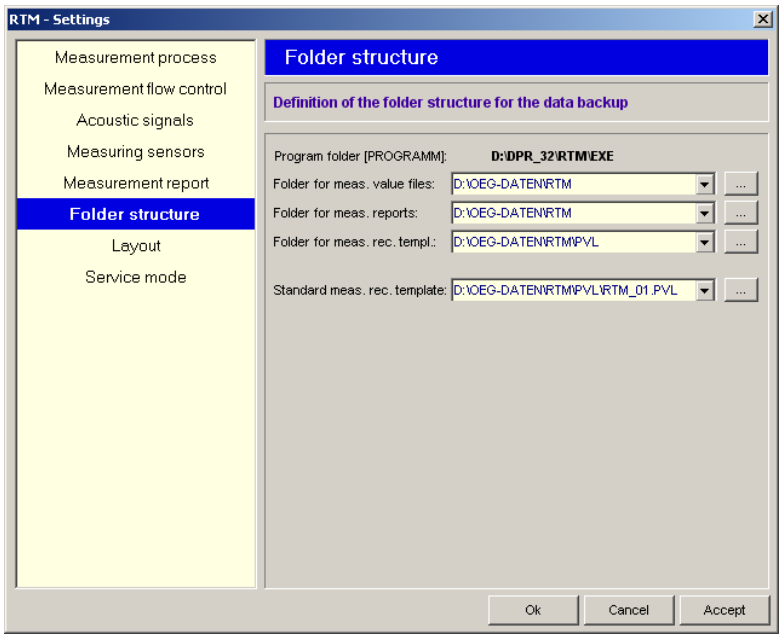
You activate the service mode with the help of the menu item *Settings - Start service mode* by entering your password.
After the first installation of **RTM** the default password is “OEG“. Please differentiate between capital and small letters when entering the password. A password can maximally be 8 characters long. All alphanumeric and special characters excepted SPACE are accepted (without using the Ctrl, Alt or function keys). To increase the security while entering the password, each individual character is displayed as ‘*’ on the screen.
With the help of the menu item *Settings - Leave service mode* the access to the above settings is blocked again.

The service mode also allows you to change your password in the menu item *Settings - Change the service mode password*. Your new password must be entered twice to check the correct spelling and is then asked for again. After that **RTM** confirms that the password was changed successfully by displaying a respective message.



For some program operations the service mode allows you to decide whether they should be available in the default mode. These settings can be found in the dialog window **RTM** settings in the menu item *Settings* on the index card *Service Mode*.

2.3 The folder structure



In order to increase the clarity, a folder structure for the storage of the created and used files is generated when installing **RTM**.

The folder names can be defined in the dialog window with the help of the menu command *Settings* on the index card *Folder structure*. When you load and save files, these directories are opened.

With the help of the buttons on the right of the entry fields you can comfortably select your folder in a dialog. For folders that have been saved into your current program folder the name of program folder in the entry fields are replaced by the wildcard character [PROGRAM].

3. The measurement process for Determining the Positional Uncertainties and Positioning Accuracies of rotary tables with RTM

3.1 Measurement parameters and measurement templates

3.1.1 Definition - measurement template

An **RTM** *measurement template* is a collection of various parameters which are required for running a measurement to determine the positional uncertainty and the positioning accuracy of a measurement object. The data of all templates are saved in the RTM.MVL file in your program folder.
In the following the individual parameters are described; further information can be found in
→ *section 3.3 The measurement process*.

3.1.2 Description of the measurement parameters

An **RTM** measurement template contains the following measurement parameters:

- the *name of the template*
  is needed for the purpose of identification and may maximally consist of 32 alphanumerical characters.
- the *number of measurement cycles*
  defines how often each measuring position is targeted in a positive (and/or positive and negative) direction during one measurement to determine the coincidental and systematic shares of the positional uncertainties with reference to the measurement results. It normally depends on the later analysis (VDI / ISO → *section ...*); usually there are between 3 and 5 runs.
- the *number of measuring positions per cycle* is the sum of measuring positions on the measurement object
- the *location of the measuring positions* on the measurement object → *section 3.1.2.1*
- the *data channels used for the measurement value logging*
  define the AKF measurement signals indirectly that are used for the measurement value logging. There are two data channels available (X,Y) for which normally (vertical AKF and the rotary table with a vertical axis as the measurement object) the following measurement signals are allocated:

  Channel X - AKF meas. signal X - horizontal meas. direction - Determining pitch error
  Channel Y - AKF meas. signal Y - vertical meas. direction - Determining the drunkenness

  This allocation can change depending on the measurement setup and the measurement object. By selecting the data channels you define whether the pitch error or the drunkenness of measurement object should be found.
- *Positioning procedure* and *positioning direction, startup way* and *Turn back way* → *section 3.1.2.2*
- optionally the *polygon* used for the measurement or, if necessary, the known *measurement and polygon error* at the individual measuring positions → *section 3.1.2.3*
- the name of a *measuring record template file* to be used for the evaluation:
  can be set optionally. If the file does not exist or no name was set, a default measuring record template file is used (→ *section 2.3*). The name is served as preset and can be changed during the evaluation.

3.1.2.1 The location of the measuring positions

The *location of the measuring positions* on the measurement object is defined by the measurement object itself (e.g. the step size of the rotary table). For the definition, there are the following options:

1. **Full circle with a constant angle difference:**

This setting is applicable for e.g. rotary tables with a full rotation and a constant angle between the neighboring measuring positions. The location of the measuring positions and the angle difference are firmly defined by the number of measuring positions per cycle distributed over a full circle.
Due to the evaluation method it is to consider that the first measuring position on the measurement object is approached twice per measurement cycle – initially as the first (0°) and finally as the last (360°) measuring position in this option.
This setting covers the majority of measurements in practical life.

2. **Selection of the position (pitch circle) with a constant angle difference:**

If the total of all measuring positions equals less (occasionally also more) than a full circle (360°), but the angle between the neighboring measuring positions is constant, select this setting. The location of the measuring positions is defined with the help of the setting parameters *First measuring position, angle difference* and *the number of measuring positions per cycle.*

3. **Selection of the position (pitch circle) with a variable angle difference:**

Here you are free to determine the angle value of each measuring position. The parameter *No. of measuring positions per cycle* defines the number of measuring positions; for changing the angle values please double-click on the respective field in the correction value / measuring position table.

3.1.2.2 Positioning procedures and positioning direction

For positioning the measurement point additional auxiliary positions must be defined on the measurement object:

- the *startup way*
  defines the distance of the auxiliary position that is located before the first measuring position from where the measuring position is approached in a positive direction.
- the *turn back way*
  defines the distance of an auxiliary position that is located behind the last measuring position from where the last measuring position is approached in a negative direction (→ linear and quasi-pilgrim-stepping positioning) and/or
  the distance between two auxiliary positions located before and behind each measuring position from where this measuring position is approached (→ pendulum-stepping positioning)

The positioning direction defines if each measuring position in each measurement cycle is approached twice (once in a positive and once in a negative direction = bi-directional) or just once (in a positive direction = unidirectional).
Approaching the measuring positions is referred to as the *positive direction* if the measuring position is approached from an upfront auxiliary position (→ *startup way*) or from an upfront measuring position; we refer to a *negative direction* if the measuring position is approached from behind an auxiliary position (→ *turn back way*) or a follow-up measuring position.

The *positioning procedure* and the *positioning direction* define the order of approaching the individual measuring positions in a measurement cycle. There are three positioning procedures available which can be used bi-directionally or uni-directionally.
In the following only the positioning procedures with a bi-directional positioning direction are referred to (for the unidirectional positioning all approach movements from a negative direction incl. the auxiliary positions occupied before are omitted).

1. Linear positioning

For the linear positioning all measuring positions are first approached in a positive and then in a negative direction. This process is repeated in accordance with the number of measurement cycles. Therefore the following positioning order is used:

1. The first auxiliary position is approached (→ startup way).
2. All measuring positions are approached in a positive direction in an ascending order.
3. The second auxiliary position is approached (→ turn back way).
4. All measuring positions are approached in a negative direction in a descending order.
5. Steps 1 - 4 are repeated in accordance with the number of measurement cycles.
6. End of the positioning process.

2. Quasi-pilgrim-stepping positioning

For the quasi-pilgrim-stepping positioning two neighboring measuring positions are approached in turns in a positive and negative direction in accordance with the number of measurement cycles. This procedure is repeated from the first to the last measuring position in an ascending order. For the measurement the following positioning order is used (n = measuring position):

1. The first auxiliary position is approached (→ startup way).
2. The first measuring position in a positive direction is approached.
3. Steps 1 - 2 are repeated in accordance with the number of measurement cycles.
4. n = 2
5. The measuring position n is approached in a positive direction.
6. The measuring position n-1 is approached in a negative direction.
7. Steps 5 - 6 are repeated in accordance with the number of measurement cycles
8. n = n + 1
9. If n <= the number of measuring positions, proceed to point 5.
10. The second auxiliary position (→ turn back way) is approached.
11. The last measuring position is approached in a negative direction.
12. Steps 10 - 11 are repeated in accordance with the number of measurement cycles.
13. End of the positioning process.

3. Pendulum-stepping positioning

For the pendulum-stepping positioning each measuring position is approached in the positive and the negative direction in turns. To do so two additional auxiliary positions are required for each measuring position (→ turn back way). This process is repeated from the first to the last measuring position in an ascending order. All measurement positions are approached in a positive direction in an ascending order. Therefore the following positioning order is used for a measurement (n = measuring position):

1. n = 1
2. The first auxiliary position before the measuring position n (→ turn back way) is approached.
3. The measuring position n is approached in a positive direction.
4. The second auxiliary position after the measuring position n (→ turn back way) is approached in a negative direction.
5. The measuring position n is approached in a negative direction.
6. Steps 2 – 5 are repeated in accordance with the number of measurement cycles.
7. n = n + 1
8. If <= number of measuring positions, proceed to point 2.
9. End of the positioning process.

3.1.2.3 Polygons and polygon errors

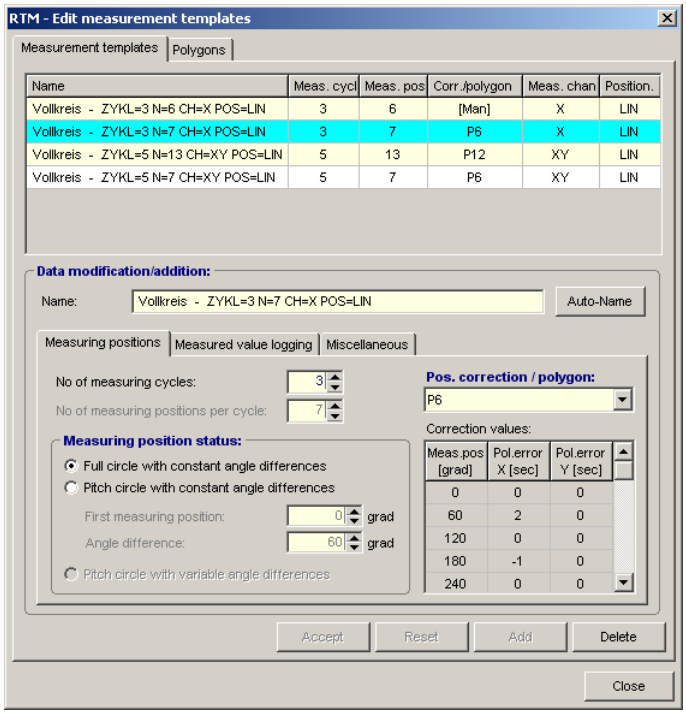
Every measurement with the auto-collimator is based on the reflection of the measuring signal at the individual measuring positions on the measurement object. Generally a polygon is applied or an existing reflecting face on the measurement object is used.
Due to the polygon or the measurement setup there can be systematic deviations of the measurement results from the nominal value. If the deviations are known and constant, they can be entered when defining the polygon or as manual correction values directly into the measurement template; thus they will be considered for every measurement with this template.
Define in the *Pos. correction / polygon* filed (→ *section 3.1.3*), how to take place the positional error correction during the measurement:

- *No correction values:*
  No correction values are considered for the measurement.
- *Manual correction values:*
  Input your positional based correction values in the correction value table directly.
- *Select a polygon:*
  For the measurement the polygon related polygon errors used as correction values (→ *section 3.1.3*), these values are displayed in the correction value table.

The data for the polygons defined for this purpose are administered in **RTM** together with the templates. As for the measurement templates any number of polygons with its belonging parameters can be defined and entered. After that the polygons are allocated to the respective measurement template. The procedure is described in *section* → *section 3.1.3*.

3.1.3 Generation and modification of measurement templates and polygons

The menu item *Measurement process* → *Edit measurement templates* allows you to access a dialog window for generating and modify **RTM** measurement templates and the parameters for the polygons required for the measurements.



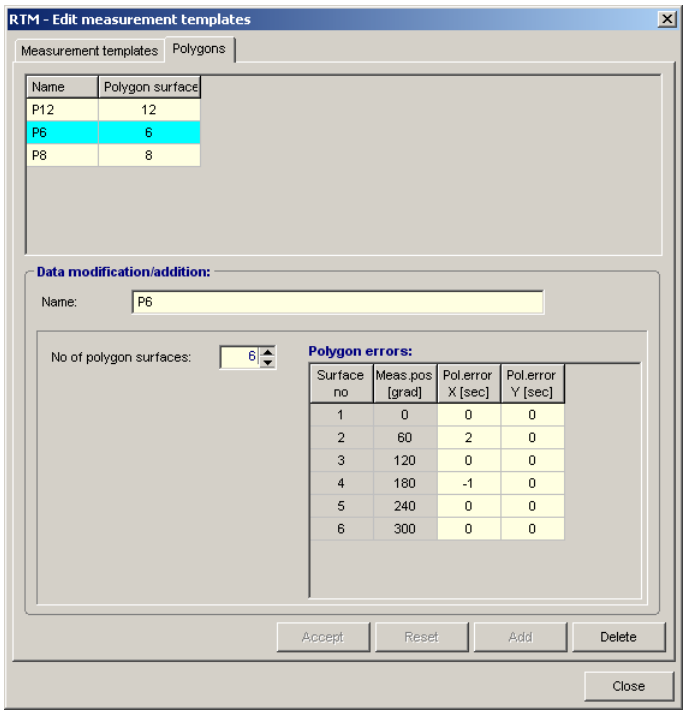
One dialog window each with horizontally divided index cards for *Measurement templates* and *Polygons* is opened on top of which an alphabetical list of all available *Measurement templates/Polygons* is displayed. At the bottom of the dialog window in the block *Data modification / addition* there are boxes and control elements for displaying and processing parameters of the chosen measurement templates/polygons and for entering new ones.

With the help of the control keys under the parameters new measurement templates can be added and existing ones can be processed or deleted. Depending on the status only those keys are available that are really needed.

Hint: Processing entries in the dialog is generally only possible in the service or the standard mode if the belonging user right (→ *section 2.2)* has been activated. Otherwise the dialog is only opened for viewing.

The following functions are available for processing measurement templates:

- *Name:*
  Please set the name of the measurement template here. If you choose *Auto Name,* a name is generated automatically on the basis of the chosen parameters and suggested in the field *Name*.
- *Parameter – Measuring positions:*
  The parameters in this index card define the number of measurement cycles, the number and locations of the measuring positions on the measurement object and the polygon to be used for your measurement (→ *section 3.1.2*).
- *Parameter – Measurement value logging:*
  Define the data channels used for the measurement value logging, the order and the way in which the measuring positions should be approached (→ *Section 3.1.2*).
- *Parameter – Others:*
  Here you can optionally generate a measuring record template for a measurement evaluation which differs from the default measuring record template.
- *Add template:*
  The key *Add* is activated if you have entered the name of a not yet existing measurement template in the *Name* field. After pushing the key a new measurement template with the currently displayed parameters is added to the list.
- *Delete template:*
  The key *Delete* deletes the highlighted measurement template in the list after a security check.



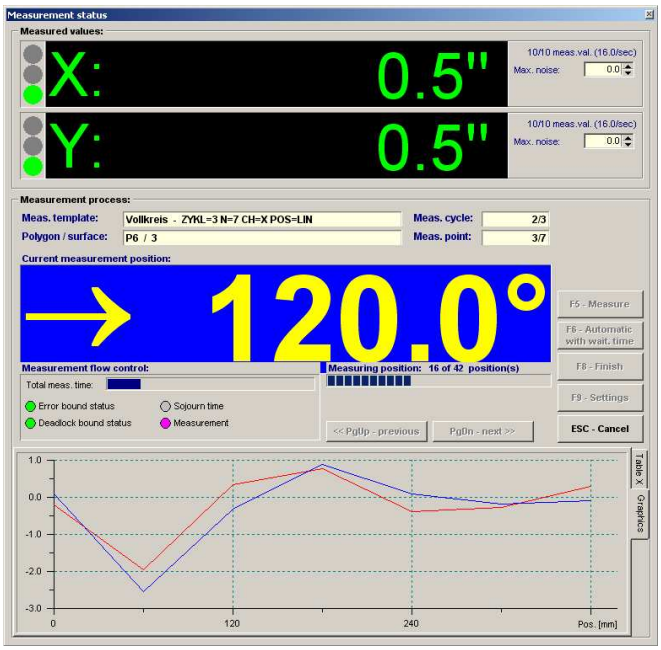
In the index card *Polygons* your used polygons can be entered and processed as described above.
The polygons are just defined by the description and the number of belonging polygon surfaces; possibly the belonging polygon errors are also available as parameters which can directly be entered into the displayed list.

Hint: When the buttons *Accept* and *Reset* (after changing parameters) or *Add* and *Reset* (after entering a new name) are activated, you need to decide for one option before exiting the edit mode of this measurement template.

The dialog window *Edit measurement templates* is also displayed before a measurement for selecting a measurement template. The parameters of the template, however, cannot be changed in this case and the index card *Polygons* is not displayed either.

The dialog window can be left with the *Close* key.

3.2 The measurement status window



The window *Measurement status* serves to display the current measured values of the active data channels and to control the measurement process.
During a measurement it is constantly visible. If no measurement is performed it can be displayed by using the menu item *Measurement process – Show measurement status window* or it can be shown or hidden via the respective icon in the toolbar. The measured values of all active data channels are always shown in the upper part *Measured values*, the lower part *Measurement process* serves to control the measurement process and is only visible during a measurement.

By changing the window height with the mouse you also change the font size of the measured value display and the measurement position display. During a measurement you change the font size of the measured value display by changing the window height on the top border of the window, and you change the font size of the measurement position display by changing the window height on the bottom border of the window.

3.2.1 The measured value display

In the measurement status window, under *Measured values*, you can see the current measured values of the measuring sensors, which are connected to one or two data channels (or the average of a certain amount of recently transmitted measured values is shown). Only the measured values of the activated data channels are shown, non-activated channels are hidden.

Hint: Only the visible measured values in the measured value display are appreciable for the RTM measurements. Contingent on algebraic sign correction and the measure value reset at the measurement start the measured value display can be differentiate to the display of the auto-collimator in the algebraic sign and/or numerically. Provided that the measurement parameter are correct these differences are contingent to the measuring configuration and no errors.

The colored markings on the left of the measured value displays mark the following states (n = the number of measured values for the dynamic averaging):

Red - No measured values are received from the measuring sensor (and also none shown).

Yellow - Measured values are received but with one of the following exceptions:
- The measured values are beyond the measurement range (range overflow – in this case the data display shows *****).
- Since the last interruption of the measured value reception or the range overflow, less than n measured values have been received.
- The PV criterion (maximum noise, see below) is not met.

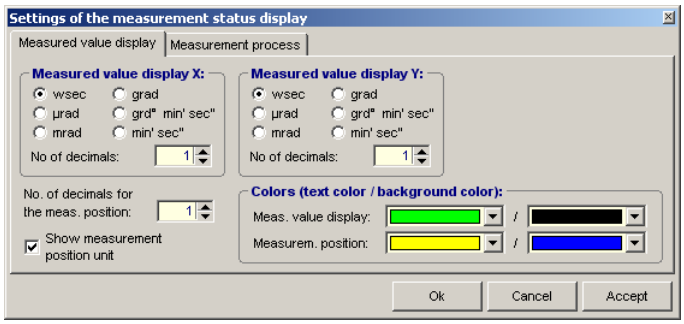
The displayed value is the average of the individual measured values received since the last interruption (or the last n measured values).

Green - At least n measured values have constantly been received since the last interruption and the PV criterion of the last n measured values is met. The displayed value is the average of the last n individual measured values.

The following parameters are shown/set on the right of the measured value display for each data channel with connected measuring sensors:

- *k / n measured values (x/sec):*
  k = number of recently received measured values from which the shown average is calculated
  n = a defined number of measured values for the dynamic averaging for the data channel
  x = data rate (average number of received measured values per second).
- *Reference (X/Y/Z = 0):*
  Use this button to „zeroize“ the displayed measured value, i.e. the current measured value is saved as offset and deducted from all subsequent measured values.
  The function *Reference* must not be activated manually during a measurement and is therefore not visible in the meantime.
- *Maximum noise:*
  With this value you can define a noise criterion to supervise the stability of the last k (k → see above) measured values. When setting a positive maximum noise factor, the current PV value (peak-to-valley = maximum – minimum) of the last k measured values will constantly be compared to the maximum noise factor and each time it exceeds the maximum it is highlighted in yellow.
  A maximum noise factor of 0 disables the supervising of the PV or noise criterion.

If you have chosen the measurement mode *Manual input* for a data channel, the states/parameters described above are disabled and not shown. Determining the average, a reference copy and the noise criterion are considered useless for manually entered measured values in **RTM** and are thus omitted. Instead, you can find an input field at this position for entering your manually measured values. Each entry is immediately assigned to the respective data display.



Using the button *F9 - Settings* you can open a dialog in which on the index card *Measured value display* the number of the shown decimal places for all data channels and for the measuring position during the measurement can be changed. Changing these values does not affect how accurately the measured values are recorded.

In addition, it is possible to switch between the data displayed in several units and several colors

3.2.2 The measurement process display

The displays/function buttons in the *Measurement process* part of the measurement status window are only available during a measurement and have the following meaning:

- *Measurement template / Polygon (surface) / Measurement cycle / Measuring point:*
  Here the current measurement template and, if required, the used polygon with the number of the current polygon surface as well as the number of the current measurement cycle and the index of the current measuring position are displayed.
- *Current measurement position (in mm):*
  In this display you can see the calculated angle position according to positioning procedure, in which you have to put the measurement object for recording the next measured value. After each measured value recording it is updating up to the last measurement point. The arrow before the value defines the current positioning direction (arrow to the right = positive positioning direction; arrow to the left = negative positioning direction → *section 3.1.2*).
- *Progress bar measuring position, progress bar waiting time:*
  Here, the timely progress of the total measurement as well as the lapse of the waiting time until the next measured value recording after having started an automatic measured value recording are each displayed in a bar graphic.
- *Measurement flow control:*
  If the measurement flow control is activated for the measurement, here the status of the measurement flow control is displayed (→ *sections 3.3.1, 3.3.2*).
- *Button F5 - Measure:*
  This button (alternatively activated by pressing the F5 key or, with the respective setting, also by using the remote control) is used to transfer the measured values at the current position into the series of measurements (→ *section 3.3.1*). Then, the position indicator for recording the next measured value is refreshed. To avoid measured values being recorded several times by mistake, this function is locked for approximately one second after triggering. During this off-time the colors of the measurement position display are inverted, so you can visual realize a successful measured value logging.
  If no measured values are transmitted (display/causes see above), no measured value can be accepted. In this case causes an error message. **RTM** then waits until some measured values are available again and the measurement is triggered again or is canceled.
- *Button F6 - Automatic:*
  When using this button or pressing the F6 key the automatic measured value recording with waiting time is activated. Here, the measured values are automatically accepted and the position indicators refreshed once the preset waiting time has elapsed. However, you have to make sure that the measurement object can always be repositioned in time at the next measurement point, according to positioning procedure and direction, within the waiting periods. The alternative measurement recording via the button *F5 – Measuring* (see above) or the remote control is not influenced hereby and can be done parallel.
  When receiving invalid measured values the process is interrupted with an error message. Once this message is confirmed the waiting time starts again. This function can be cancelled with ESC at any time. You can change the waiting times in the global settings dialog (→ *section 3.4.1*) or the measurement status window settings dialog (→ *Button F9; section 3.2.1*)
- *Button F8 - Finish:*
  This button is activated after the last measured value of the current measurement has been recorded. In this case also you see the message *End → F8* in the measurement position display. With this button or, as an alternative, with the F8 key the measurement can be terminated. Note that after finishing the measurement you cannot re-measure the measurement positions (see below). Activating the belonging option you can also finish the measurement with the remote control (→ *section 3.4.1*).

- *Buttons << PgUp - Previous and PgDn – Next >>:*
  With these buttons (or the keys PgUp and PgDn on your keyboard) you can re-determine the measured values of already measured positions during the recording of a series of measurements (e. g. when receiving error messages). To do so, move the object to be measured back onto the required measurement position considering the approach direction and push the respective key until the required position can be seen in the positional display. Thus an examination and if necessary a repeated measurement for individual measuring points can be run. The previously collected measured values for the required position are graphically and tabular displayed at the lower end of the window and over-written in case of a repeated measurement.
  During the automatic collection of measurement values with a waiting time this function is disabled.
- *Button F9 - Settings:* → *section 3.2.1*
- *Button ESC - Cancel:*
  If the automatic measured value recording with waiting time or the measurement flow control is activated, you can terminate the function with this button. Otherwise, this button or the ESC key is used to interrupt the ongoing measurement, which can be continued after confirming a message, or it can be cancelled.
- *Measurement value table and graphics:*
  Here the process of the measured values is displayed graphically and tabular in real time. You can activate/deactivate this option in the measurement status settings dialog (*F9 key* → *section 3.2.1*).

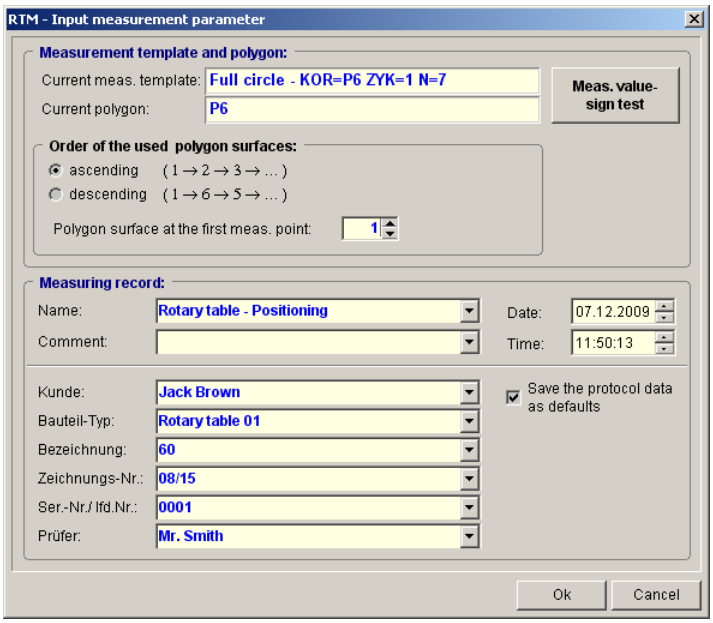
3.3 The measurement process

Select in the menu *Measurement process* or from the toolbar the command *New measurement* to run a measurement for determining the positional uncertainty and positioning accuracy with **RTM**. The measurement is then run in the following order:

1. **Selecting the required measurement template**

The dialog window ***RTM*** *– Select measurement template* is opened (→ *section 3.1.3)*. Select the required measurement template from the list of available templates and confirm your choice with the *Accept* key.

2. **Confirming the measurement template and entering and confirming additional measurement parameter and data for the measuring record**



After selecting the measurement template the alongside dialog is shown to display and specify the measurement data and to request additional measurement parameter.

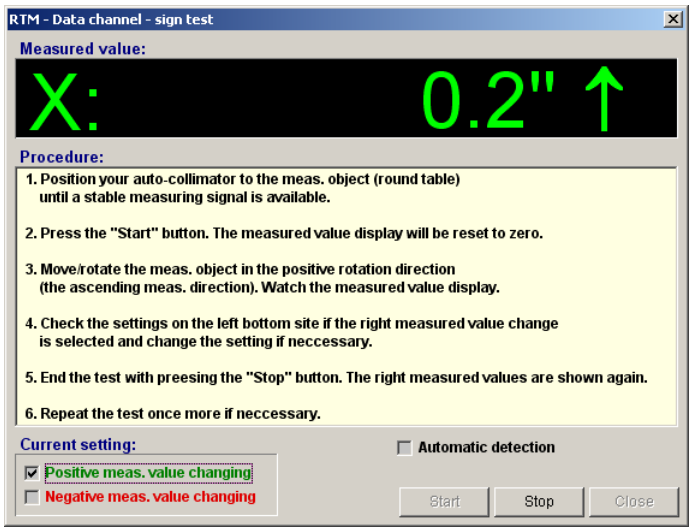
A important requirement for a correct measurement result is, that, independent from the measurement setup and the settings of the used auto-collimator, a positive change of the direction of rotation of the measurement object causes a positive change of the measured value in the **RTM** software and vice versa. Therefore a global presetting exist (→ *section 3.4.1 - Measured value conversion*).
Based of this presetting you can call an measured value *algebraic sign test* using the belonging button to check the setting for the current measurement and to correct it if necessary. For details to the algebraic sign test see the following section.
For using a polygon also the following measurement parameters must be entered:

- the order of the used polygon surfaces (the used polygon surface is the surface which is turned to the auto-collimator) contingent to the positive direction of rotation of the measurement object
- the polygon surface which is turned to the auto-collimator in the first measuring point.

The parameters must be entered for correctly charging the possibly existing polygon errors against the measured values.

Furthermore for a well-arranged measurement process and for labeling the measurement object you will be asked to enter the necessary measuring record data before the actual measurement.
All entries made here are optional, i.e. not compulsory, and can also be entered or altered after the measurement or during the evaluation of the measurement results.
Depending on the position they belong to, the measuring record data are stored in recall lists to be used later; furthermore the complete mask is displayed again before the next measurement when selecting the option *Save the protocol data as default,* i.e. the same data are shown (except for the date and the time).

3. The measured value algebraic sign test



After calling the algebraic sign test the alongside dialog is shown.
The procedure of the test are detailed explained in the text window and insist on the following steps:

- Resetting of the meas. value display
- Short movement of the measurement object in the positive rolling direction (inside of the auto-collimator measuring range)
- Detection of the direction of the change of the measured value (positive or negative)
- Comparison of the visible direction change with the current setting and correction if necessary.

More hints for the procedure:

- A correct algebraic sign test causes a correct measured value display regarding the algebraic sign during the following measurement, it means that a positive change of the direction of rotation of the measurement object causes a positive change of the measured value display and vice versa.
- The current setting is saved for all following measurements until a new algebraic sign test is called or the global presetting is changed (→ *section 3.4.1 - Measured value conversion*).

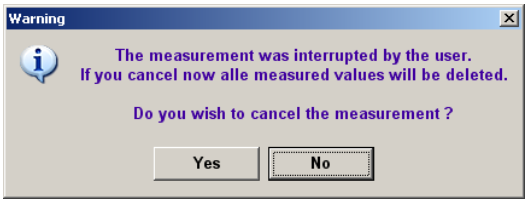
4. Display of the measurement status window, starting and running the measurement

Now the actual measurement is run. To do so, the measurement value status window for controlling the measurement parameters and values is shown (→ *section 3.2*).
The measurement consists of a order of collected measured values at all measuring positions, the number and the order of the measuring positions is determined by the parameters in the used measurement template (positioning process and direction, number of measurement cycles; → *section 3.1.2*).

All measured values are collected in the following order:

1. Positioning the measurement object on the displayed measuring position
2. Manual and/or automatic collection of measured values in accordance with the pre-set parameters
3. Updating the position display for the next measuring position in accordance with the template
4. Repeating the steps 2 – 3 until the last measured value has been collected
5. Finishing the measurement with key *F8 – Finish* after collecting the last measured value.

For collecting the measured values there are several options which also help you to run the complete measurement manually or automatically (→ *section 3.3.1*).

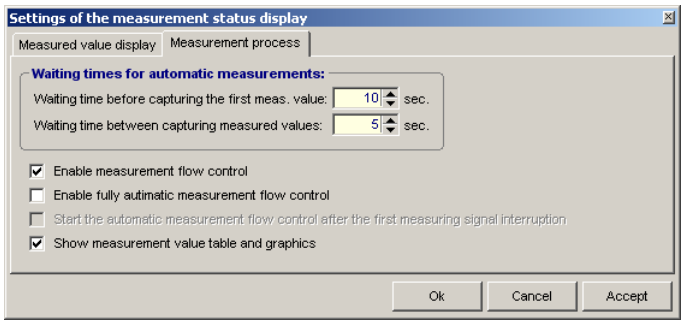


By pushing the *ESC - Cancel* key in the measurement status window an automatic measurement process can be stopped at any time and continued manually if necessary. If the measurement is run manually the key helps you to stop it completely.

After a successful measurement a separate *measured value file window* is generated for administering the measurement result which also allows you to enter the data for processing and storing the results. The window also displays the *measuring record* (→ *section 4.1*).

3.3.1 Options for the measurement value logging

For running a manual or automatically controlled measurement there are several options for collecting the values at the individual measuring positions.



The selection and/or setting of the parameters of the versions described below is done in a separated dialog called with the *F9 – Settings* key on the index card *Measurement process* and in the global **RTM** setting dialog (→ *section 3.4.3*).

Generally the following is applicable to all settable options:

- When activating the remote control (→ *section 3.4.1*) operating the remote control has the same effect as pushing the *F5 - Measure* key.
- The measured values can only be logged successfully if they are stable (*green* indication → *section 3.2.1*) and if the measurement flow control is activated (→ *section 3.3.2*) after the deadlock bound has been passed successfully.
- Every automatic measurement can be interrupted with the *ESC - Cancel* key and can be continued manually or automatically from the current measuring position; for interrupted or manual measurements the current measurement can be interrupted with the same key.
- After an unsuccessful collection of measured values an error is announced; automatic measurements are always interrupted in this case.
- Every successful and/or unsuccessful acceptance of measurement values can be accompanied by an acoustic signal. Configure this option on the index card *Acoustic signals* in the global **RTM** setting dialog (→ *section 3.4.1*).

1. **Manual collection of measured values without the measurement flow control**

The option *Enable measurement flow control* is deactivated.
After every positioning of a measurement object, please wait until the display stops fluctuating (“Green” indication) and then push the *F5 – Measure* key for immediately collecting the values. After a successful measurement the measuring position is updated for the next position.
In case of faulty measurements at individual positions you can re-measure these positions at this point without starting the complete process again. Please refer to → *section 3.2.2 The measurement process display* to find out how to re-measure individual measuring positions.

2. **Manual collection of measured values with the measurement flow control**

The option *Enable measurement flow control* is activated, the option *Enable fully automatic measurement flow control* is de-activated.
By pushing the *F5 – Measure* key at every measuring position a cycle is started (called *measurement flow control* in **RTM**) after which the measured value is accepted and the measuring position is updated supposed the cycle was successful.

3. **Automatic collection of measured values with waiting time**

The option *Enable measurement flow control* is activated or de-activated, the option *Enable fully automatic measurement flow control* is de-activated.
Here the collection of measured values is controlled on a time-related basis with constant intervals between the individual measuring positions. The length of the intervals is determined by the length of the waiting times in the setting dialog.
The measurement is started with the *F6 – Automatic* key. Now you – as the user – are only responsible for re-positioning the measurement object within the waiting time. **RTM** either collects the measured values immediately or with the measurement flow control; then the measuring position is updated; after that the waiting time starts again until the last measuring position has been reached.
If a measurement of individual measuring points must be repeated, it can only be done after the process has been completed or interrupted.

4. **Automatic collection of measured values with the measurement flow control**

This is the most comfortable and mostly applied method of measuring rotary tables because it allows you to collect the measured values at all measuring positions fully-automatic, independent from the speed of positioning the measurement object.
Both options – *Enable measurement flow control* and *Enable fully automatic measurement flow control* – are activated. The collection of measured values and the belonging update of the measuring position is controlled at and between the individual positions by recognizing and interrupting the measurement signal of the measuring sensor (AKF).
The measurement is started with the *F5 – Measure* key. After that the measurement flow control starts immediately at the first measuring position or - if you have selected a respective option – after interrupting the measuring signal. After a successful collection of a measured value the measuring position is updated and the next interruption of the measuring signal is waited for, which is normally interrupted when the measurement object is placed at the next measuring position. When the measuring signal re-sounds, the procedure re-starts until the last measuring position has been reached.

3.3.2 The measurement flow control

The measurement flow control is a time-related process for accepting stable measured values of your measurement which have been cleared of all external influences (such as transient oscillation). The process starts by recognizing the measuring signal at the respective position and ends either by accepting the measured values or after a pre-set timeout phase.
In the following this process is described in connection with the belonging parameters (limits for measured values, waiting and timeout times). For a successful and smooth measurement it is necessary to adapt these parameters to your measurement object, especially the preciseness of the measurement result must be defined.

Definition of the parameters:

FS_{Min}, FS_{Max} - limit of the error bound [wsec.];
The system operates within the error bound if the measured value is under the limits.

StS - deadlock bound [wsec];
The system is in the deadlock bound if it is under the error bound and the PV-value of the measured values (maximum - minimum) are smaller than this value.

t_0 - start of the measurement process [sec.],

t_{OutG} - maximum measurement and sojourn time total [sec.]

t_{FS} - point in time of entering the error bound [sec.],

t_{WFS} - waiting time after entering the error bound [sec.]

t_{OutFS} - maximum measurement and sojourn time within the error bound after the waiting time **t_{FS}** [sec.] has expired

t_{StS} - point in time of entering the deadlock bound [sec.],

t_{VStS} - sojourn time within the deadlock bound [sec.]
This is the minimum time the system must be in the deadlock bound. After this period of time the measurement value is generated.

t_M - measurement interval (time needed for generating a measured value) [sec.]

t - current time [sec.]

The following conditions are supposed to be valid:

$StS < FS_{Max} - FSMin$; $tOutG > t_{WFS} + t_{OutFS}$; $t_{OutFS} > t_{OutFS} > t_M$

When using the option Measurement flow control for your measurement, the following process is started at each measuring position:

1. The measuring signal of AKF is recognized: **$t_0 = t$**
2. It is cyclically checked if the system operates within the error bound.
3. It is recognized when the system enters the error bound: **$t_{FS} = t$**
4. The waiting time after entering the error bound expires.
5. It is cyclically checked if the system is in the deadlock bound.
6. It is recognized when the system enters the deadlock bound: **$t_{StS} = t$**
7. The sojourn time within the deadlock bound runs.
8. At the end of the sojourn time the generation of the measured value starts: **$t >= t_{StS} + t_{VStS} - t_M$**
9. The time for generating the measured value ends: **$t >= t_{StS} + t_{VStS}$**
10. The measurement process successfully finishes if the time for generating the measured value (measuring interval) expires while the system is within the deadlock bound.
    The mean value of those measured values collected during the measuring interval is accepted as the measured value for the measuring position.

During the process the following conditions are checked permanently:

- from point 2: compliance with the maximum measurement and sojourn time in total

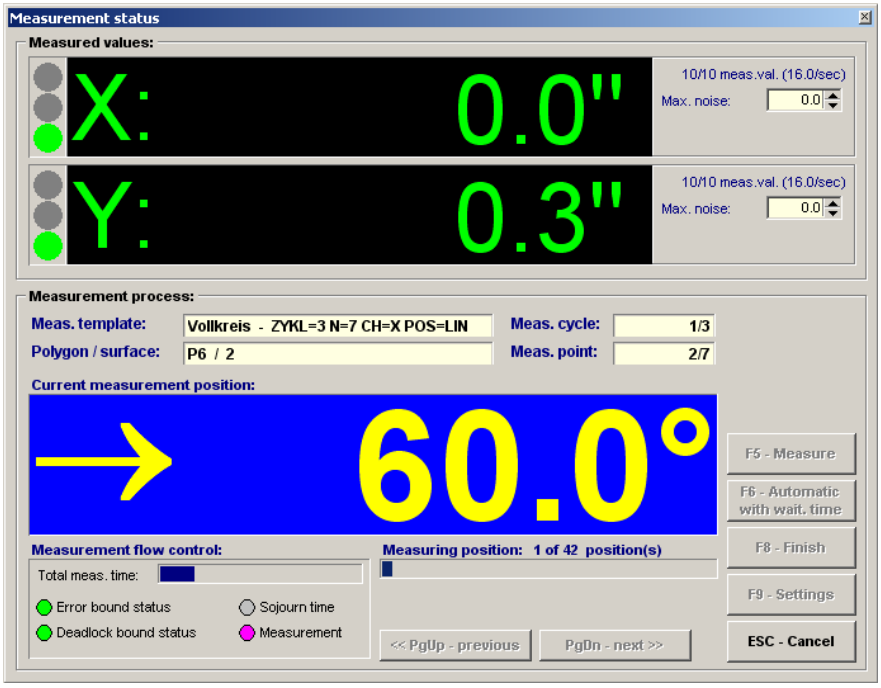
  $t < t_0 + t_{OutG}$

  If the condition is not met, the process is interrupted.
- from point 3: compliance with the error bound
  If the system does not operate within the error bound, it goes back to point 2.
- from point 6: compliance with the holdup bound
  If the system is not within the holdup bound, it goes back to point 5.
- from point 5: compliance with the maximum measurement and sojourn time in the error bound

  $t < t_{FS} + t_{WFS} + t_{OutFS}$

  If the condition is not met, the process is interrupted.

The settings and parameters for the measurement flow control can be configured on the correspondent index card in the global **RTM** setting dialog (→ *section 3.4.3*).



During a measurement the status of the measurement flow control is displayed in the measurement status window on the left in the bottom row. The icons stand for the following:

- *Total meas. time:*
  during a measurement with a recognized signal:
  status bar for showing the expired time from $t = t_0$ to $t = t_0 + t_{OutG}$
  between two measurement positions without a measuring signal: red blinking indication

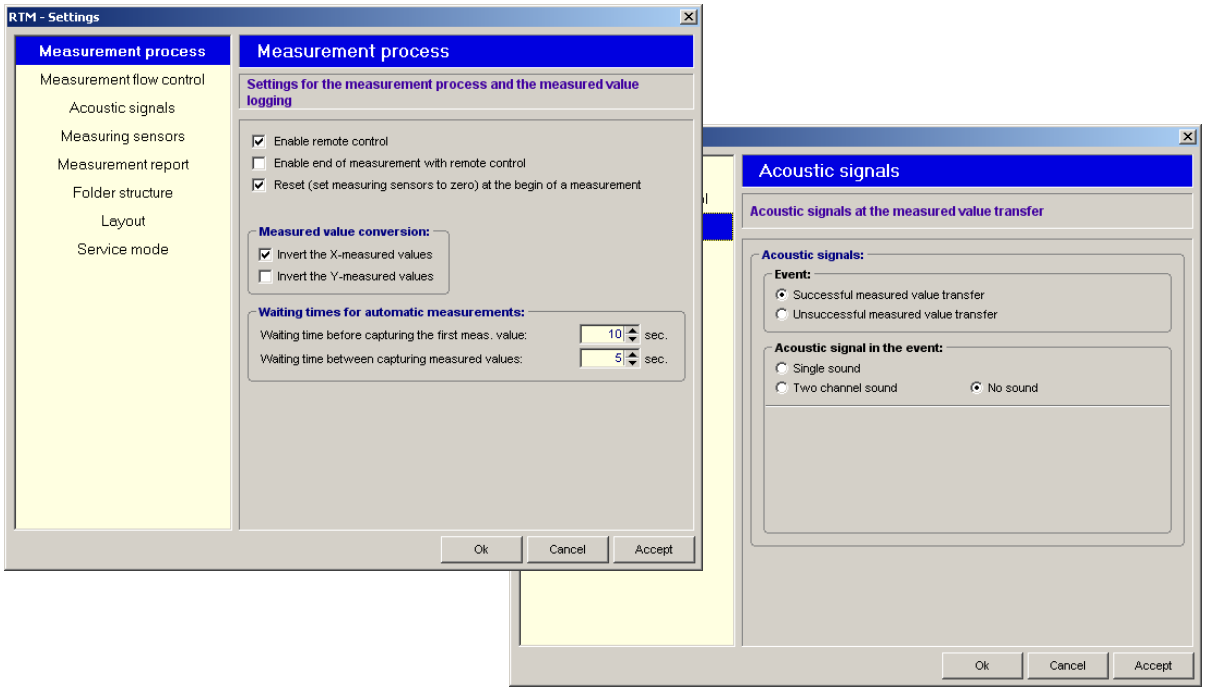
- *Status error bound:*	grey:	no measuring signal
	yellow:	measured values outside the error bound
	green:	measured values within the error bound
- *Status deadlock bound:*	grey:	no measuring signal or sojourn time active
	yellow:	measured values outside the deadlock bound
	green:	measured values within the deadlock bound
- *Sojourn time:*	grey:	sojourn time after entering the error bound does not run
	orange:	sojourn time after entering the error bound runs
- *Measurement:*	grey:	time for generating the measured value does not run
	violet:	time for generating the measured value runs

3.4 Settings for the measurement process

The main menu item *Settings → Settings* calls up a dialog window which allows you to configure measurements with **RTM** according to your requirements.
The dialog window is split into several index cards where the measurement process and other program settings can be changed.
All alterations on the individual index cards are saved when the card is changed or by pushing the keys *Accept* or *OK* (OK also closes the dialog window simultaneously).
After pushing the *Escape* key the alterations on the visible index card are reversed and then the dialog window is closed.
In the following the settings on the index cards related to *Measurement process, Measurement flow control, Acoustic signals* and *Measuring sensors* are explained.

3.4.1 The index cards Measurement process and Acoustic Signals

On the index cards *Measurement process* and *Acoustic signals* you can define the following settings (for explanations please see → *sections 3.2, 3.3*):



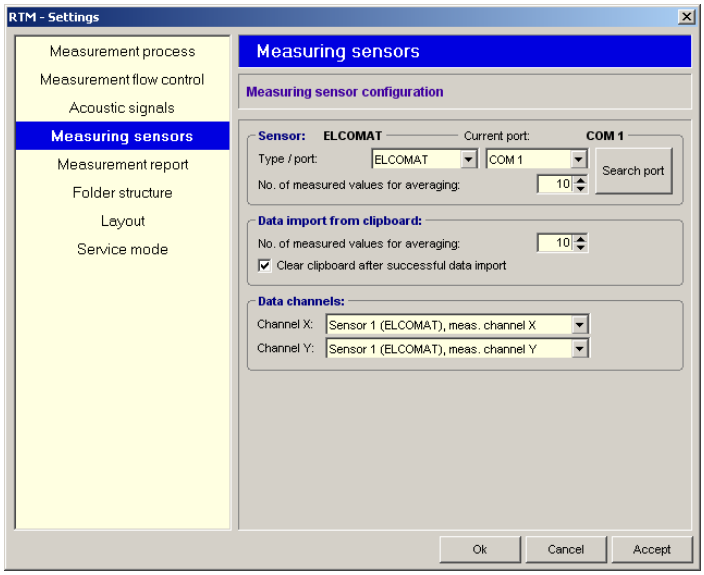
- *Enable remote control:*
  If this key is set, the capturing of measured values cannot only be started with the keyboard and the mouse but also with the optionally delivered (ELCOMAT-) remote control.
- *Enable end of measurement with remote control:*
  If this key is additional set with a enabled remote control, you can finish a measurement series with an additional click on the remote control after capturing the last measured value (note that after finishing the measurement series you cannot re-measure the measuring positions). Disabled this key you must finish a series of measurement with the F8-key or the corresponding button.
- *Reset (setting the measuring sensors to zero) at the begin of a measurement:*
  If this button is pressed, at the start of each measurement (before capturing the first measured value) all data channels will be zeroized (except for channels with manual input), otherwise, measurement values-offset values, which were possibly calculated before by resetting, will be deleted at the start. After finishing a measurement the measured values-offset values are always deleted.

- *Measured value conversion:*
  Set this key if the collected tilt angles of the belonging data channels should be multiplied by (-1) before the measured values are captured. This option is available for synchronizing the measurement system **RTM**/ELCOMAT and disposes of a positional indicator for the measurement object; it must be activated if a movement of the measurement object in a positive direction is registered as a negative positional deviation by the program or vice versa.

  Hint: This presetting is valid for the measured value display if no measurement is running. For a correct measurement value logging during the real measurements an algebraic sign test can be called before the start of the measurement to check the setting with the especially measurement setup (→ *section 3.3*).

- *Waiting times for automatically measurements:*
  Here you define the waiting times for automatically measurements (separated in a waiting time before capturing the first measured value and a waiting time between capturing two measured values → *section 3.3.1*).
- *Acoustic signals:*
  Here you can optionally define acoustic signals which (if your PC can do so) can be heard during the capturing of the individual measured values via the loudspeakers and/or the sound card.

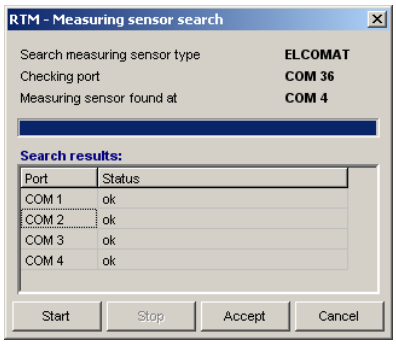
3.4.2 The index card measuring sensors



Entering measured values in **RTM** can either be done via a query of the connected ELCOMAT, by a data transfer via the windows clipboard or via a manually data input with the keyboard. You can set the corresponding configuration on the index card *Measuring sensors*.

Please select at first the current port for the ELCOMAT and match the ingoing measuring sensor axes to the **RTM** data channels. For the ELCOMAT set the number of the individual measured values to be read, over which a measurement result will be calculated by averaging (range of values 1 - 1000, entry 1 = no averaging). The number is valid for both measurement axes of the ELCOMAT. When the transmission of measured values is running, averaging is effected dynamically (display in **RTM** measurement status window) and will be restarted after every interruption in the data transmission.

It is also possible to use data channels without the ELCOMAT via the option *manually input*. In this case the calculated measured values have to be entered manually during a measurement (→ *section 3.2.1*).



If the ELCOMAT is connected to your PC and working, you can search the using serial port with the help function Search port.

In the appearing separately dialog you can start a test of all the serial ports in your PC to find a connected ELCOMAT. If the search is successful you can accept the located port to your program configuration.

RTM can also memorize data from the Windows clipboard. This enables a measured value transfer also from other programs, which are running on the computer at the same time. In this case the clipboard is used like an interface to the measuring sensor and is periodically memorized during the measurement. For this purpose the measurement values have to be permanently copied to the clipboard as a text line of the following form:

[N:xxxxx] [X:aaa.aaME] [Y:aaa.aaME]

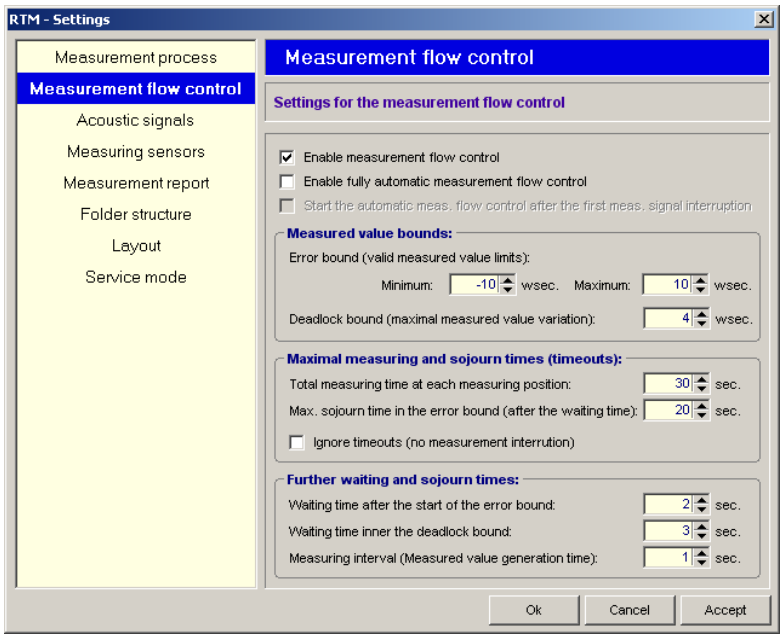
E.g.: N:0001 X:4.12wsec Y:-3.16wsec

Explanation:

- The square brackets mark the optional indication of the block (they must not be contained in the text). The order of the blocks (N,X,Y) is arbitrary, but each block must not exist more than once per measured value line.
- *N:xxx* (consecutive measured value number):
  Indication of a consecutive number of the current measured value (xxxxx = consec. No.). When a consecutive number is transmitted, it should be counted up with each new measured value; in case of several consecutive measured value lines with the same consecutive number only the first will be accepted.
- *X:aaa.aaME Y:aaa.aaME* (measured values):
  Measured value format for one measured value each from the X- or Y-data channel (aaa.aa = measured value in decimal form; ME = measuring unit). Only measured values of really existing data channels should be transferred to the text. The measuring units *arcsec*, *mrad* and *µrad* will be accepted.

An averaging can also be defined for measured values from the clipboard. In order to avoid that one measured value is memorized more than once (if no consecutive number is being transmitted → see above) the clipboard can be deleted automatically after each transfer of a measured value.

3.4.3 The index card Measurement flow control



Here you can set all settings and parameter of the measurement flow control. For more information and details → *section 3.3.2 The measurement flow control*.

.

4. Safe and evaluation of measurement results

A measurement result of an **RTM**-measurement for Determining the positional uncertainty and positioning Accuracy is defined as all captured tilt angle measured values (real values) and thereby calculated result parameters depending of the used evaluation method including their measuring and evaluation parameters. Individual tilt angle measured values are simply called *measured values*.

4.1 Measured value files and measured value file windows

The measurement results of all completed measurements are saved in ASCII files on the data carrier, the so-called *measured value files,* together with the belonging parameters.
Thus an **RTM** measured value file contains the following information:

- data of the using *measurement template* (→ *section 3.1*);
- course of the measured *tilt angle* (real values), course of the calculated *measuring functions* according to the used *evaluation method and acceptance guideline*;
- settings for the *measuring record*;
- *statistic data* (measuring specification, point of measuring time, comment) for the measuring record;
- additional *customer-specific data* for the measuring record;
- settings for the *graphical presentation of the measurement results*.

For every completed measurement a measured value file is generated in the program and written onto the data carrier when saved. A separate *measured value file window* is opened for every newly generated and every loaded measured value file on the screen.
The menu of the measured value file window allows you to edit the measurement results and generate a *measuring record* (→ *sections 4.2, 4.3*) using the following menu commands:

- Menu *File:*
  The commands *Save* and *Save As* save the measured value file under the current name or upon request under a new name (file copy). When the results are saved for the first time after a measurement, a file name is always asked for.
  The command *Close* closes the measured value file and the belonging window. **RTM** will ask you to save or cancel unsaved changes. For all other commands in this menu → *section 4.3.1.4*.
- Menu *Measuring record* and Menu *Edit measuring record:*
  Using these menu commands allows you to generate, edit and print-out your measuring record on the basis of a specific measuring record template (→ *section 4.3.1*). These menus are only available by activation the *Report text* view (choose the report text index card on the right side of the window).
- Menu *Evaluation:*
  Choose here the evaluation method / acceptance guideline using for the evaluation of the measurement result (→ *section 4.2*).
- Menu *Report*:
  The commands in this menu serves to control the presentation and output of the measuring record (→ *section 4.3*).

4.2 Evaluation of the measurement results

In this version of the program, the measurement results are analyzed in accordance with the acceptance guidelines for machine tools **VDI/DGQ 3441**, **VDI 2617** and **ISO 230**. Further acceptance guidelines and methods of analysis can be refitted upon request.

In the following the parameters and calculation formulas for defining the positional deviations and the positional uncertainties are explained in accordance with the above guidelines.

Definitions, abbreviations:

PA-pos., PA-neg.	-	Positional deviation at a measuring position in a positive approach direction, in a negative approach direction
pos. AF, neg. AF	-	positive approach direction, negative approach direction
MW, SA	-	mean value, standard deviation
i, z	-	index for the measurement cycle, number of measurement cycles
j, n	-	index for the measuring position, number of measuring positions
↑, ↓	-	marking for the positive/negative approach direction
$x_{ij}\uparrow$	-	measured value for PA-pos. in the meas. cycle i at the measuring position j
$x_{ij}\downarrow$	-	measured value for PA-neg. in the meas. cycle i at the measuring position j
SysA.	-	systematic deviation
US	-	backlash
PSB	-	Positional spread (Repeatability)

The following measured values are captured:

$x_{ij}\uparrow$	-	PA-pos. (i = 1..z ; j = 1..n)
$x_{ij}\downarrow$	-	PA-neg. (i = 1..z ; j = 1..n)

The following parameters are calculated from the measured values:

Mean value of PA-pos.
$$\bar{x}_j\uparrow = \frac{1}{z}\sum_{i=1}^{z} x_{ij}\uparrow$$

Mean value of PA-neg.
$$\bar{x}_j\downarrow = \frac{1}{z}\sum_{i=1}^{z} x_{ij}\downarrow$$

Standard deviation of PA-pos.
$$s_j\uparrow = \sqrt{\frac{1}{z-1}\sum_{i=1}^{z}(x_{ij}\uparrow - \bar{x}_j\uparrow)^2}$$

Standard deviation of PA-neg.
$$s_j\downarrow = \sqrt{\frac{1}{z-1}\sum_{i=1}^{z}(x_{ij}\downarrow - \bar{x}_j\downarrow)^2}$$

Average of the standard deviations
$$\bar{s}_j = \frac{s_j\uparrow + s_j\downarrow}{2}$$

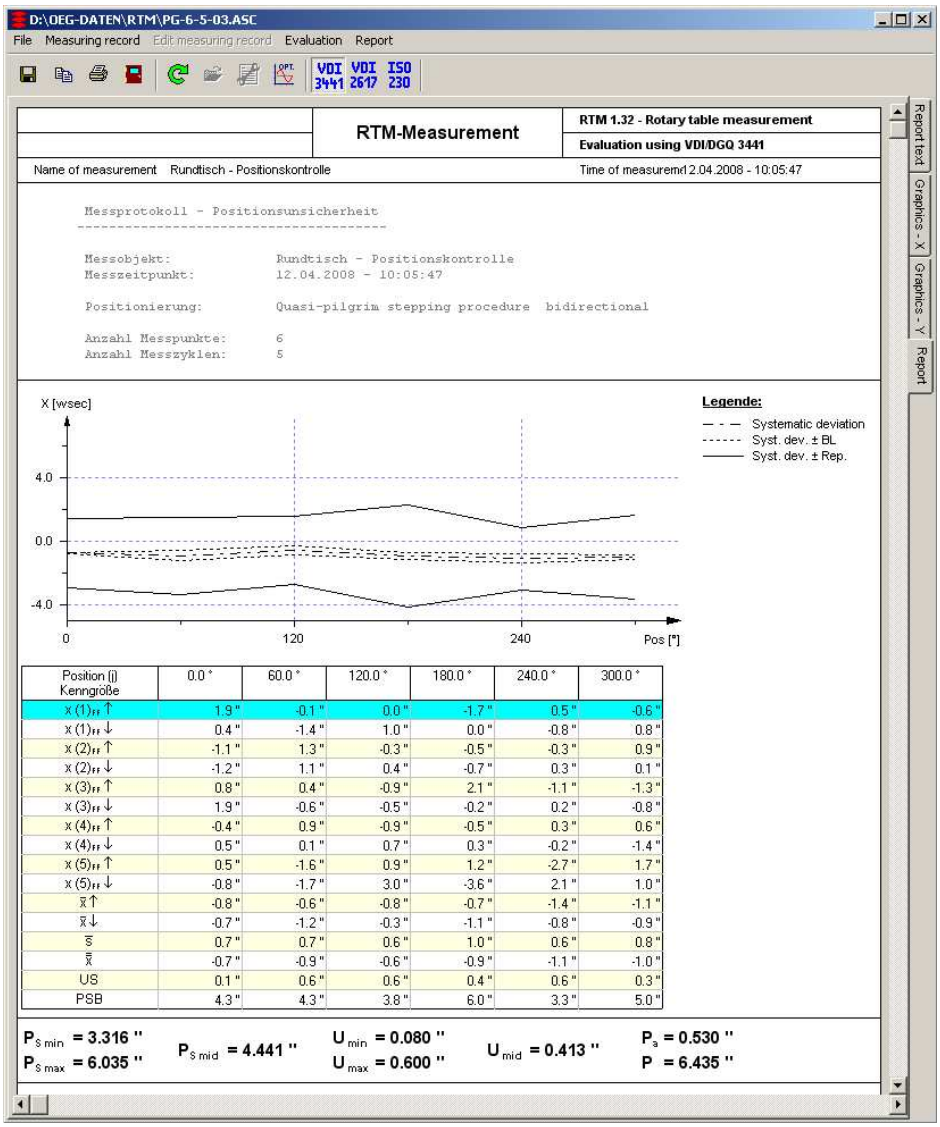
The following parameters are additionally calculated using the evaluation based on the acceptance guidelines **VDI/DGQ 3441** and **VDI 2617**:

PSB using VDI/DGQ 3441 / VDI 2617	$P_{S_j} = 6 * \bar{s}_j$	$P_{S_j} = 4 * \bar{s}_j$
minimal / maximal PSB	$P_{S_{min}} = \min \left(P_{S_j}\right)_{j=1}^{n}$	$P_{S_{max}} = \max \left(P_{S_j}\right)_{j=1}^{n}$
mean PSB	$\overline{P_S} = \frac{1}{n}\sum_{j=1}^{n} P_{S_j}$	
Backlash	$U_j = \left\lvert \bar{x}_j\downarrow - \bar{x}_j\uparrow \right\rvert$	
minimal / maximal backlash	$U_{j_{min}} = \min \left(U_j\right)_{j=1}^{n}$	$U_{j_{max}} = \max \left(U_j\right)_{j=1}^{n}$
mean backlash	$\overline{U_j} = \frac{1}{n}\sum_{j=1}^{n} U_j$	
Systematic deviation	$\bar{\bar{x}}_j = \frac{\bar{x}_j\uparrow + \bar{x}_j\downarrow}{2}$	
Positional deviation	$P_a = \left\lvert \bar{\bar{x}}_{j_{max}} - \bar{\bar{x}}_{j_{min}} \right\rvert$	
Positional uncertainty	$P = \max \left[\bar{\bar{x}}_j + \frac{1}{2}\left(U_j + P_{S_j}\right)\right]_{j=1}^{n} - \min \left[\bar{\bar{x}}_j - \frac{1}{2}\left(U_j + P_{S_j}\right)\right]_{j=1}^{n}$	

The following parameters are additionally calculated using the evaluation based on the acceptance guidelines **ISO 230**:

PSB (Repeatability) unidirectional, pos./neg. AF	$R_j\uparrow = 4 * s_j\uparrow$	$R_j\downarrow = 4 * s_j\downarrow$
mean. PSB unidirectional, pos./neg. AF	$\bar{R}_j\uparrow = \frac{1}{z}\sum_{i=1}^{z} R_j\uparrow$	$\bar{R}_j\downarrow = \frac{1}{z}\sum_{i=1}^{z} R_j\downarrow$
max. PSB unidirectional, pos./neg. AF	$R\uparrow = \max \left(R_j\uparrow\right)_{j=1}^{n}$	$R\uparrow = \max \left(R_j\uparrow\right)_{j=1}^{n}$
PSB (Repeatability) bi-directional	$R_j = \max \left[\max \left(4s_j\uparrow ; 4s_j\downarrow ; 2s_j\uparrow + 2s_j\downarrow + \left\lvert B_j \right\rvert\right)\right]_{j=1}^{n}$	
mean. PSB bi-directional	$\bar{R} = \frac{1}{z}\sum_{i=1}^{z} R_j$	
Backlash	$B_j = \bar{x}_j\uparrow - \bar{x}_j\downarrow$	
minimal backlash	$B_{min} = \min \left(B_j\right)_{j=1}^{n}$	
maximal backlash	$B_{max} = \max \left(B_j\right)_{j=1}^{n}$	
mean backlash	$\bar{B} = \frac{1}{n}\sum_{j=1}^{n} B_j$	
Positional uncertainty (Accuracy)	$A = \max \left[\bar{\bar{x}}_j + 2 * s_j\right]_{j=1}^{n} - \min \left[\bar{\bar{x}}_j - 2 * s_j\right]_{j=1}^{n}$	

4.3 The measuring record



Position (j) Kenngröße	0.0 °	60.0 °	120.0 °	180.0 °	240.0 °	300.0 °
x (1)ff ↑	1.9 "	-0.1 "	0.0 "	-1.7 "	0.5 "	-0.6 "
x (1)ff ↓	0.4 "	-1.4 "	1.0 "	0.0 "	-0.8 "	0.8 "
x (2)ff ↑	-1.1 "	1.3 "	-0.3 "	-0.5 "	-0.3 "	0.9 "
x (2)ff ↓	-1.2 "	1.1 "	0.4 "	-0.7 "	0.3 "	0.1 "
x (3)ff ↑	0.8 "	0.4 "	-0.9 "	2.1 "	-1.1 "	-1.3 "
x (3)ff ↓	1.9 "	-0.6 "	-0.5 "	-0.2 "	0.2 "	-0.8 "
x (4)ff ↑	-0.4 "	0.9 "	-0.9 "	-0.5 "	0.3 "	0.6 "
x (4)ff ↓	0.5 "	0.1 "	0.7 "	0.3 "	-0.2 "	-1.4 "
x (5)ff ↑	0.5 "	-1.6 "	0.9 "	1.2 "	-2.7 "	1.7 "
x (5)ff ↓	-0.8 "	-1.7 "	3.0 "	-3.6 "	2.1 "	1.0 "
$\bar{x}$ ↑	-0.8 "	-0.6 "	-0.8 "	-0.7 "	-1.4 "	-1.1 "
$\bar{x}$ ↓	-0.7 "	-1.2 "	-0.3 "	-1.1 "	-0.8 "	-0.9 "
$\bar{s}$	0.7 "	0.7 "	0.6 "	1.0 "	0.6 "	0.8 "
$\bar{\bar{x}}$	-0.7 "	-0.9 "	-0.6 "	-0.9 "	-1.1 "	-1.0 "
US	0.1 "	0.6 "	0.6 "	0.4 "	0.6 "	0.3 "
PSB	4.3 "	4.3 "	3.8 "	6.0 "	3.3 "	5.0 "

Definition (→ *also see section 3.1.2*):

X-measurement - measurement in the data channel X, usually for measuring the dividing error of a rotary table

Y-measurement - measurement in the data channel Y, usually for measuring the rolling error of a rotary table

The complete RTM measuring record, which is called *Report* in the software, consists of the following parts:

- the page header with details about the measurement specifications, the measurement time and the evaluation method;
- the text body on the basis of a freely definable template;
- the graphic presentation of the measurement results of the X-measurement ;
- the numeric presentation of the measurement results of the X-measurement in a table;
- the numeric presentation of the parameters calculated for the evaluation;
- the presentation of the measurement results of the Y-measurement as explained for the X-measurement.

Except for the page header all parts in the report can be optionally combined and their individual presentation can be configured with the help of different parameters. The presentation, processing and print-out of the individual parts and the complete report is done in the measured value file window.

4.3.1 The report text in the measuring record, measuring record templates

The text body in the upper part of the measuring record is the result of a freely definable general text mask which is called *measuring record template*; it contains wildcards for information to be inserted and for measurement data from the measurement. For displaying and processing the text please choose the tab *Report text* on the left margin of the measured value file window.

4.3.1.1 Definition, wildcards

A *measuring record template* is an ASCII file, which is used as a sample for generating a measuring record, i.e. a measuring record without data. Such a protocol form can be generated and edited with the text editor, which is integrated into the measured value file window, or with the help of any simple text editor (e.g. NOTEPAD). Editors which do not generate pure ASCII files (e.g. MS-WRITE, MS-WORD) are not suitable. The filenames of all measuring record templates receive the extension PVL as a standard.
In order to fill the measuring record template with data and measured values, *wildcards* are inserted into the spaces where later the belonging data should be filled in. A wildcard has the following format:

@NAME,Length,Decimals@

The parameter *NAME* allows the alphanumerical characters A to Z, 0 to 9, - and _; small letters are turned into capitals, the maximal length of a name is 12 characters.
The parameter *Length* is optional and determines the length of a field in characters where the belonging data are printed from the right margin. If there are no length parameter or if the length parameter is 0, the length of the output field corresponds to the number of the characters to be printed (data output without leading blank characters).
The parameter *Decimals* can additionally be defined by wildcards with data based on decimal figures and it determines the number of the decimals to be printed. If there is no decimal parameter, all significant decimals of a value are printed.

For generating (indexed) individual measured values in measured value tables the additional parameters *Initial value* can be entered optionally:

@NAME{,Length{,Decimals}}{|Initial value}@ Ex..: @X[1],8|31@

The initial value (the first figure after the vertical line) stands for the index of the measured value which is printed in the first line of the measured value table (if it is not entered, the initial value =1). This index is counted up within the measured value table with each new line (the maximum length is the measured value table, however, is limited).
After each measurement and after loading a measured value file the program automatically replaces all known wildcards with the belonging data using the current *standard measuring record template*. Recreating the measuring record template and the manually substitution of the wildcards is possible using the menu commands *Measuring record - Edit record template* and *Measuring record - Update* in the measured value file window (→ *section 4.3.1.4*).
The completed measuring record can than be edited as required; it can be changed in the text, saved as a text file, printed or copied into the clipboard in order to edit it / analyze the data in other programs.

4.3.1.2 The formula editor

Numbers and wildcards with numerically contents can also be linked mathematically in a measuring record. To do so you must enter a formula into the measuring record template. A formula has the following format:

@(TERM,Length,Decimals)

TERM	-	mathematically correct description consisting of wildcards, constants and functions mentioned below)
Length, Decimals	-	optional length of a display field and number of decimals (see above)

Example:

@XY@ mm	in the record	10.46 mm
@(@XY@ * 2,8,1) mm	converted in the record to	....20.9 mm (the dots displayed here are blank spaces in the measuring record)

Negative constants should always be put in brackets within a formula (e.g.: @((-2)*@XY@)).

The following mathematical functions can be calculated:

+ , - , * , / , abs() , sqr() , sqrt() , sin() , cos() , arctan() , exp() , ln() .

Wildcards whose results are not numeric must not be used in the formulas (e.g. @NAME@, @DATUM@).
If formulas cannot be calculated during a record update respective error messages appear.

4.3.1.3 The wildcard list using in RTM measuring record templates

The following wildcards for data and measurement results are implemented for **RTM**-measurements:

@DATEINAME@	-	Name of the measured value file
@DATEIPFAD@	-	Directory (folder) of the measured value file on the data carrier
@NAME@	-	Measuring sample name
@DATUM@	-	Date of measurement in the form dd.mm.yy
@UHRZEIT@	-	Time of measurement in the form hh:mm:ss
@COMMENT@	-	Measurement comments
@DATE-START@	-	Date of the start of the measurement in the form dd.mm.yy
@TIME-START@	-	Time of the start of the measurement in the form hh:mm:ss
@DATE-STOP@	-	Date of the end of the measurement in the form dd.mm.yy
@TIME-STOP@	-	Time of the end of the measurement in the form hh:mm:ss
@TIME-DIFF@	-	Total time of the measurement (TIME-STOP - TIME-START) in the form orm hh:mm:ss
@MS_MODE@	-	Positioning procedure name
@MS_ZYKL@	-	Number of measurement cycles
@MP_ANZ@	-	Number of measuring positions per measurement cycle
@MP_DIST@	-	angle difference between two neighboring measuring positions (angle difference) in ° at measurements with constant angle difference
@P[i]@	-	Measuring position i in ° according to the positioning procedure

Apart from the already implemented wildcards you can define up to 10 more customer specific wildcards to integrate further data into your measuring record which refer to your specific field of application (e.g. name of the tester, name of the customer, drawing no., material parameter etc.). To define your customer specific wildcards and input the belonging data use the menu command *File - Settings - Measurement report* in the measured value file window (→ *section 4.3.1.5*).

The following example shows on a simple measurement how to transform a measuring record template into a final measuring record:

Giving measurement data/parameter:

```
                        Measuring record
                       ------------------

  Meas. specificat.:    @NAME@
  Meas. time       :    @DATUM@ - @UHRZEIT@

  Customer         :    @ZUSATZ1@
  Sample           :    @ZUSATZ2@
  Name             :    @ZUSATZ3@
  Drawing no.      :    @ZUSATZ4@
  Serial no.       :    @ZUSATZ5@
  Comment          :    @COMMENT@
  Testing          :    @ZUSATZ6@

  Sign: _____________________________________
_____________________________________________________________________________

  Positioning      :    @MS_MODE@

  No. meas. cycles / meas. positions     : @MS_ZYKL@  / @MP_ANZ@
  First meas. position / pos.-difference : @P[1]@° / @MP_DIST@°
```

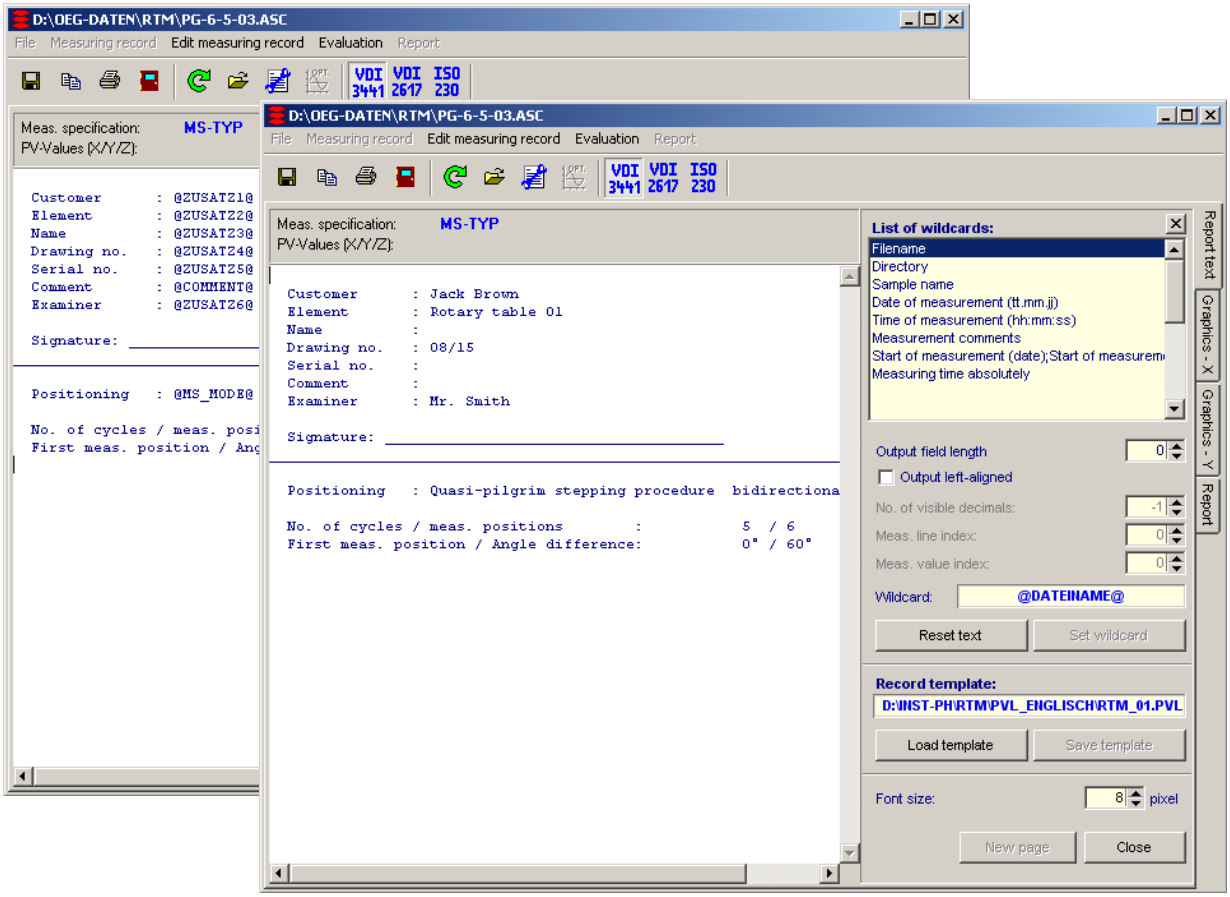
Resulting measuring record:

```
                        Measuring record
                       ------------------

  Meas. specificat.:    Rotary table - Positioning control
  Meas. time       :    12.04.2008    - 10:05:47

  Customer         :    Jack Brown
  Sample           :    Rotary table 01
  Name             :
  Drawing no.      :    08/15
  Serial no.       :    0001
  Comment          :
  Testing          :    Mr. Smith

  Sign: _____________________________________
_____________________________________________________________________________

  Positioning      :    Quasi pilgrim positioning bi-directionally

  No. meas. cycles / meas. positions     : 5  / 6
  First meas. position / pos.-difference : 0° / 60°
```

With the software installation several measuring record template files (*.PVL) are copied in the belonging folder to serve as examples for measurement templates for your measurements.

4.3.1.4 Editing a measuring record template

Choose the *Report text* tab on the left side of the measured value file window to display and edit the measuring record text and/or the measuring record template.



After activating the menu item *Measuring record – Edit template* all wildcard characters are shown at the right edge of the measured value file window and the functions for editing the measuring record template are made available. On the left in the editor, the current record template draft is shown.

To set a wildcard characters into your record template, select the respective entry from the list and enter (if the belonging data should be printed on the right in your record text) the desired length of the display field and, if necessary, the number of digits in the respective entry field.

In the field wildcard character the desired wildcard is shown in a way that it can be entered into the record template as you request it. Then set the text cursor onto the wanted position in the record template text and push *Set wildcard*. Repeat these steps for the wildcards of all parameters you want to enter into the measuring record.

Alternatively you can also enter the wildcard directly into the record template with the help of the keyboard.

In the following, you will get a description of all functions which are available for generating and editing record templates:

- *Update text / Reset text:*
  This function switches between displaying the record template and the resulting measuring record. Thus you can test the effect of the set wildcards onto your measuring record in the preview function.
- *Set wildcard:*
  This function pastes the term which is shown in the field wildcard into the current cursor position in the record template. The function is only available if the displaying of the record template is activated.
- *Load template:*
  Here you can load a new measuring record template basic for your measuring record. The name of the current measuring record template is displayed in the belonging text field.

- *Save template:*
  The current status of the displayed measuring record template is saved on the data carrier. Before that you will be asked to enter a filename; there should be a standard file extension which is .PVL. Using this function is only possible, if you see the record template in the text window.
- *Text size:*
  Here you can define the text font size in pixel. This setting affects the display on the screen and the printout of the measuring record.
- *New page:*
  A page change is inserted on the current cursor position in the measuring record template to affect the printout of the measuring record (format statement @\page → *section 4.3.1.2*). Using this function is only possible, if you see the record template in the text window.
- *Close:*
  ends the editing of the record template and closes the belonging window. In the editor of measured value file window, the finished measuring record is displayed.

If you have changed the record template and have not saved the last changes, the program will remind you of doing so when the measured value file is closed.

In order to generate and edit a *measuring record* the following menu commands are available in the measured value file window. Depending on the status of the measuring record, those menu commands, which cannot be executed, will be colored in gray.

1. Menu File

- *Settings:*
  A dialog window is opened wherein you can change specific data for your measuring record (→ *section 4.3.1.5*).

2. Menu Measuring record

- *Update:* (→ see above Update text)
  The displayed measuring record template is updated, i.e. all known wildcards are filled up with current data and measured values of the measured value file. As the result you can see the completed measuring record in the measured value file window.
- *Save:*
  The current measuring record text is saved as a text file on the data carrier. Before that you will be asked to enter a filename whereas the name of the measured value file with the extension .TXT is suggested.
- *Print:*
  The current measuring record text is given out on your printer.
- *Load template:*
  Here you can load a new measuring record template basic for your measuring record.
- *Edit template:*
  A separately window for editing the measuring record template will opened on the right side of the measured value file window (→ see above).

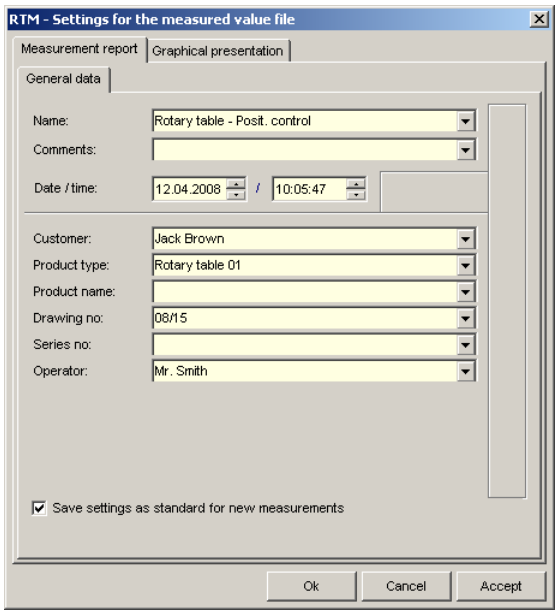
3. Menu Edit measuring record

This menu supplies some generally valid text editor commands for editing your record template / your measuring record. The majority of these commands served to move passages in the text into or out of the clipboard. If you enter the key combination displayed in the corresponds menu item you can also release the commands with these key combinations.
The following commands are available:

- *Undo (Ctrl-Z):* The last editor command (menu command resp. text input) is undone.
- *Cut (Ctrl-X)* The marked text is deleted in the text and copied into the clipboard.
- Copy *(Ctrl-C):* The marked text is copied into the clipboard.
- *Paste (Ctrl-V):* The text is copied from the clipboard to the cursor position into the text.
- *Delete (Del):*
  The marked text is deleted in the text. The contents of the clipboard are not changed.
- *Mark all:* The total text is marked.

In order to mark an individual text passage, move the mouse over it while pressing the left mouse button or move the cursor keys over it while pressing the shift key.

4.3.1.5 Customized data in the measuring record



After calling up the menu item *File – Settings* in the measured value file window, a dialog is shown on the index card *Measuring record* into which you can enter your specific data for your measuring record.

The above data *name, comments, date* and *time* are part of every measured value file and are displayed with the help of the wildcards @NAME@, @COMMENT@, @DATE@ and @TIME@ in the measuring record. Date and time are pre-set with the current time of measurement when a measurement is started.

The other entries can be freely configured upon request. There are maximally 10 test entries available the number of description of which can be set in the configuration file RTM.DAT in your program folder.

For changing the configuration, please take the following steps:

1. Close **RTM**.
2. Open the file ELC32.DAT in your **RTM** program directory with an ASCII text editor (e.g. EDITOR.EXE).
3. In this file you'll find the section `[Protokoll-Titel]` with the entries `Protokoll-Zusatztitel1=` to `Protokoll-Zusatztitel10=` (see example):

```
[Protokoll-Titel]
Protokoll-Zusatztitel1=Tester-name
Protokoll-Zusatztitel2=Drawing-no.
Protokoll-Zusatztitel3=Serial-no
Protokoll-Zusatztitel4=Order-no
Protokoll-Zusatztitel5=Object-no
Protokoll-Zusatztitel6=Customer
...
Protokoll-Zusatztitel9=
Protokoll-Zusatztitel10=
```

   and the section `[Protokoll-Daten]` with the entries `Protokoll-Zusatzdaten1=` to `Protokoll-Zusatzdaten10=` (see example):

```
[Protokoll-Daten]
Protokoll-Zusatzdaten1=Mr. Jones
Protokoll-Zusatzdaten2=08/15
...
Protokoll-Zusatzdaten9=
Protokoll-Zusatzdaten10=
```

4. From the line `Protokoll-Zusatztitel1=` behind the equals sign enter the description of your belonging specific data in an ascending order. All those entries that are not needed remain empty behind the equals sign.
   In the lines `Protokoll-Zusatzdaten1=` all data are saved which you have entered as default data for new measurements with the help of the above dialog box.
5. Save and close the file and re-start **RTM**. The current configuration is now displayed before each new measurement and in each measured value file.

In the measuring record, the entries are represented by the wildcards @ ZUSATZ1@ ... @ ZUSATZ10@.

Hint: In your measured value file, only the data entered by you, but not the belonging configuration is saved. If you must permanently change the configuration, the relation between data and configuration might be incorrect when loading older files.

After the first installation of **RTM** a default configuration of customized data is pre-set. To reconstruct the default configuration if necessary, delete the file RTM.DAT in your **RTM** program folder and re-start **RTM**.

4.3.2 The graphical presentation of the measurement results

4.3.2.1 General

The measurement results on the measuring record of an **RTM** measured value file are graphically presented in the measured value file window on the index cards *Graphics-X* and *Graphics-Y*, separately for the X- and Y-measurement, and in the report (which can be chosen on the right margin of the window). The evaluation for the individual measurements is done separately in a freely definable format on the index cards Graphics-X and Graphics-Y; those graphics are presented as a part of the complete measuring record in the report.
Depending on the acceptance guidelines (→ *section 4.2*) which the evaluation is based on, the measured values and the calculated parameters, which are called *Measuring function*s in the software and in the following, are presented in the graphics. For selecting the required analysis guideline chose the belonging menu command in the menu *Evaluation*. Every guideline has its own submenu with available graphical versions of presentation. Simultaneously the analysis guideline can be changed with the help of the belonging icons in the icon bar; if you do so, however, the default version *Total graphics* is always chosen in the submenu.

In the following, you can find a list of the measuring functions shown in the individual presentations (for the abbreviations, please see → *section 4.2*):

Evaluation guideline	Presentation	Shown measuring functions
VDI 3441, VDI 2617	Total graphics	SysA., SysA. + US, SysA. - US, SysA. + PSB, SysA. - PSB
	User defined	freely selectable
ISO 230-2	Total graphics	MV of PA-pos. (mean values positive), MV of PA-neg. (mean values negative), MV total = SysA (mean values total), MV of PA-pos. ± PSB/2 (MV pos. + Repeat.) MV of PA-neg. ± PSB/2 (MV neg. + Repeat.)
	Mean deviations	MV of PA-pos. (mean values positive), MV of PA-neg. (mean values negative)
	Positive directed deviations	MV of PA-pos. (mean values positive), MV of PA-pos. ± PSB/2 (MV pos. + Repeat.)
	Negative directed deviations	MV of PA-neg. (mean values negative), MV of PA-neg. ± PSB/2 (MV neg. + Repeat.)
	Backlash	Backlash
	User defined	freely selectable

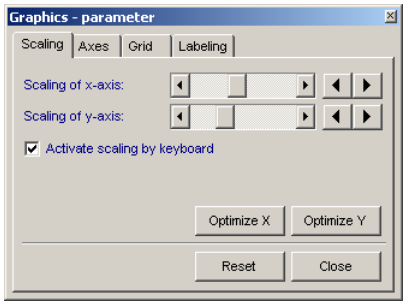
4.3.2.2 The configuration of the graphics presentation

To configure your graphics presentation please use the following menu commands in the *Graphics* popup menu (the menu appears, if the mouse cursor is situated in the graphics and you click the right mouse button):

- *Optimization horizontally, Optimization vertically:*
  The scaling of the respective axis is optimally adapted to the visible measuring functions. (→ *see below - Scaling*). In the same menu you have a undo and a redo function for each optimization separately for both graphics axes.
- *Graphics parameter:*
  A dialog window is opened where you can change the graphics presentation according to your requirements with the help of many functions. The individual functions will be explained in the following.

Some of the described functions become effective in the graphics immediately, for the others (especially for changes in the entry fields) you must press the *Accept* key, change to another index card or close the dialog down.

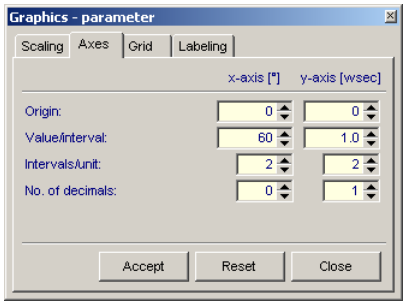
Graphics parameter – The index card Scaling



By using the scroll bars for scaling the axis you can minimize or stretch the graphics in either direction, i.e. the size of the intervals measured in pixels is decreased or increased (an interval is the distance between two little scale lines on a graphics axis).
The arrow keys next to the scroll bars move the origin of coordinates by one interval either into the positive or the negative direction.

Upon request the scale bars can also be displayed in the graphics directly (on the left of or under the axes) and serve the same function.
For *Optimizing* the individual axes (started with the respective menu commands – see above - or the belonging *Optimize…* keys) the parameters *Origin* and *Value/interval* of the respective axes (→ *see below - Axes*) are changed in a way that the complete development of the displayed functions is realized in the visible value area of the axes.

Graphics parameter – The index card Axes



On this index card you can change the following parameters for the two graphics axes:

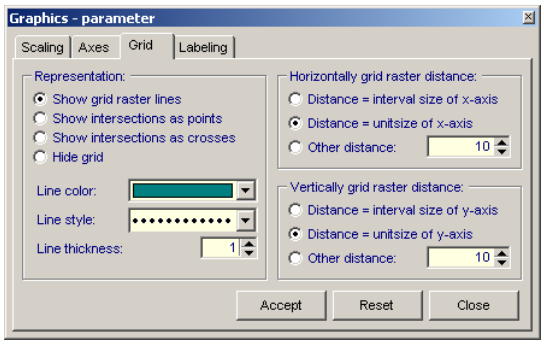
- *Origin:*
  This is the place to enter the real value for the position of the origin of coordinates in the x and the y-direction. These values
  can also be increased or decreased in steps of one interval with
  the help of the scaling arrow keys (→ see above - Scaling).

- *Value/interval:*
  An *interval* of a graphics axis is the distance between two little scale lines. This value defines how many real units an interval in the direction of the respective axis consists of.
- *Intervals/unit:*
  An interval of a graphics axis is the distance between two little scale lines; a unit is the distance between two big scale lines. The graphics axes are labeled with unit numbers at all big scale lines (if it comes to overlapping because the distance between two scale lines is too small, unit numbers are left out). Thus you decide about the density of unit numbers at the individual axes here.

- *No. of decimals:*
  Please determine the number of decimal places that should appear with the unit numbers at the axes.
- *Rel. position [pixel]:*
  Here you define the positions where the graphics axes are displayed which are relative to their real position in the graphics.

With a suitable variation of the parameters *Origin* and *Value/interval* any part of the graphics can be displayed in any size.

Graphics parameter – The index card Grid



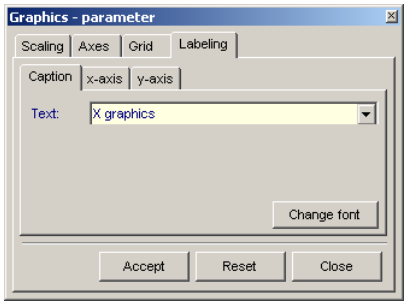
This is where you determine the parameters for the grid to be displayed in the graphics. You can show the grid as a network with freely selectable line parameters, but you can also simply show the network intersections.

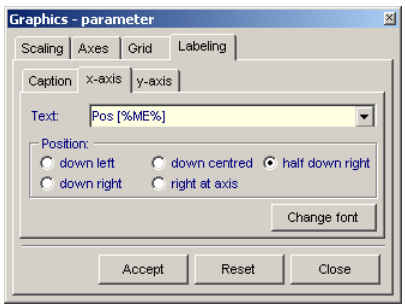
The distance between neighboring grid lines is normally adapted to the respective axis scaling (therefore please choose the interval or unit size); however, you can also choose any other distance (when selecting *Distance = 0* the grid is not displayed for the respective direction).

Hint: Interrupted lines are only displayed in line thickness 1 in the graphics. If you increase the line thickness, the line style is ignored and the line is drawn as a continuous one.

Graphics parameter – The index card Labeling

Please define the graphics headline and the labeling for the two graphics axes and their positions in the graphics on this index card.





You can use a wildcard instead of the current unit for labeling the individual axes in the text:

- The text sequence %ME% is replaced by the current unit.