Machine checking gauge (MCG) tools user's guide

Documentation part number: H-1000-5420-01-D

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ORIGINAL LANGUAGE VERSION

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Packaging component	Material	94/62/EC code	94/62/EC number
Outer box	Corrugated fibreboard	PAP	20
Outer box	Polypropylene	PP	5
Packaging insert	Low density polyethylene	LDPE	4
Packing foam	Low density polyethylene	LDPE	4

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Introduction

Full calibration of a CMM's performance is time consuming and costly, using fixed length ball-ended bars or step gauges and laser measurement systems.

Renishaw's MCG (machine checking gauge) enables the rapid and effective interim checking of a CMM's performance as recommended in many international standards. It gives a fast and automatic assessment of machine capability and can also be used for machine characterisation.

MCG tools is an Microsoft Excel workbook that manages the machine checking gauge (MCG). MCG tools allows the user to generate a DMIS part program in order to execute the MCG test on a co-ordinate measuring machine (CMM). It can then import the MCG data to analyze and identify whether geometrical errors exist on the CMM. Also, the results from every MCG test can be archived in order to follow the evolution of the geometry of a CMM over time.

The major worksheets are:

Setup	The setup page is used to record the characterics of the CMM, environmental conditions and MCG. This information is required for performing the test.
Data	Displays the calculated and target points from the results files (*yourfile*.DMO). Basic calculations include Sphere locations and geometric errors. This page also provides the option to review and record the dataset into the database.
Analysis	Displays the planar results of the squareness and form errors.
Database	Displays a list of all saved MCG database results.
Database charts	Displays a historical snap-shot of min / max, spread and squareness errors over all MCG results stored in the database.

Requirements:

- Microsoft Excel
- Renishaw MCG

MCG tools setup worksheet

MCG tools setup home page

The setup page provides the one portal required to enter all the parameters required to prepare MCG tools for a CMM verification.

The setup page is divided into four catagories:

- CMM setup
- Measurement configuration
- Measuring conditions
- DMIS sequence

See also:

- CMM setup parameters
- Measurement configuration parameters
- Measuring condition parameters
- MCG part program generation
- Languages supported by MCG

CMM setup parameters

On the setup worksheet, the user identifies the CMM with the following fields:

Machine

- This field holds a description of the CMM
- This field is archived

Serial number

- This field holds the serial number of the CMM
- This field is archived

Squareness sign convention

The user selects the sign convention from the dropdown list. As there are different ways to apply a squareness compensation, that lead to different sign convention, the user can select the convention that corresponds to his machine so the squareness errors compensation value will be presented with the correct sign and therefore could be applied without sign modification.

Scale resolution

- This field holds the machine scale resolution in mm
- This is for information only
- This field is archived

Single point repeatability

- This field holds the single point repeatability of the CMM
- This is for information only
- This field is archived

Accuracy formula

From the dropdown list, the user selects one of the following standards

- VDI/VDE 2617 U3
- ISO 10360-2 MPEe
- ASME B89.4.1

The user can then set up the accuracy formula of his machine. The maximum admissible error calculated for the MCG arm length will be used to determine whether the machine comply with its formula accuracy during the MCG test.

See also:

- MCG tools setup worksheet
- Measurement configuration parameters
- Measuring condition parameters
- MCG part program generation
- Languages supported by MCG

Measurement configuration parameters

On the set up worksheet, the user identifies the machine checking gauge with the following fields:

MCG identification

- This field holds the serial number of the MCG
- This field is archived

Arm length

- The user selects form the dropdown list the length of his MCG arm
- This field is archived

Operator

- This filed holds the operator identification
- This field is archived

Probe type

- This field holds the probe type
- This field is archived

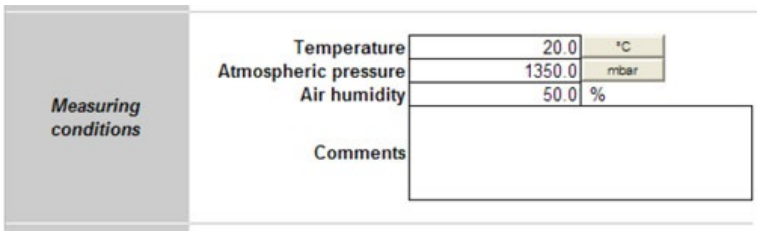
Probe identification

- This field holds the serial number of the probe
- This field is archived

See also:

- MCG tools setup worksheet
- CMM setup parameters
- Measuring condition parameters
- MCG part program generation
- Languages supported by MCG

Measuring condition parameters



Temperature

- This field holds a temperature recorded during the MCG test
- This is a manual entry
- This field is archived

Atmospheric pressure

- This field holds the atmospheric pressure recorded during the MCG test
- This is a manual entry
- This field is archived

Air humidity

- This field holds the percentage of humidity recorded during the MCG test
- This is a manual entry
- This field is archived

Comments

- The user can enter four lines of comments
- These four fields are archived

See also:

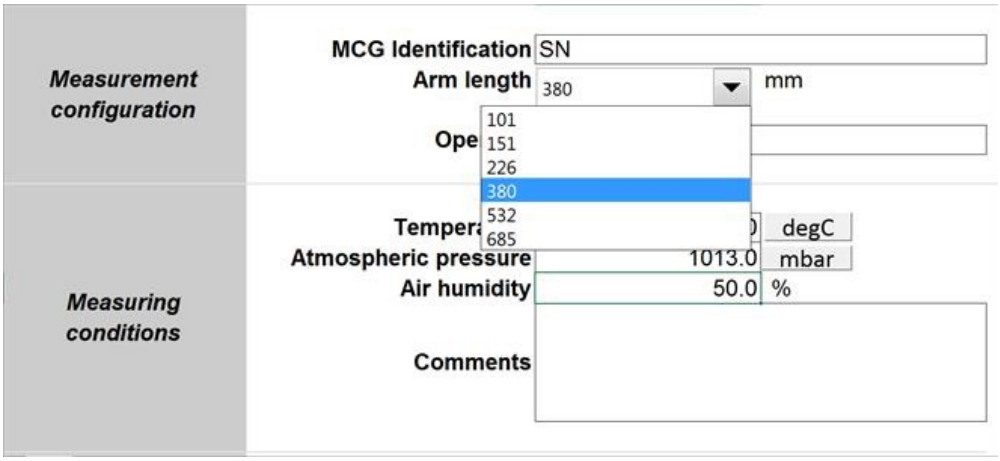
- MCG tools setup worksheet
- CMM setup parameters
- Measurement configuration parameters
- MCG part program generation

MCG part program generation

DMIS sequence generator

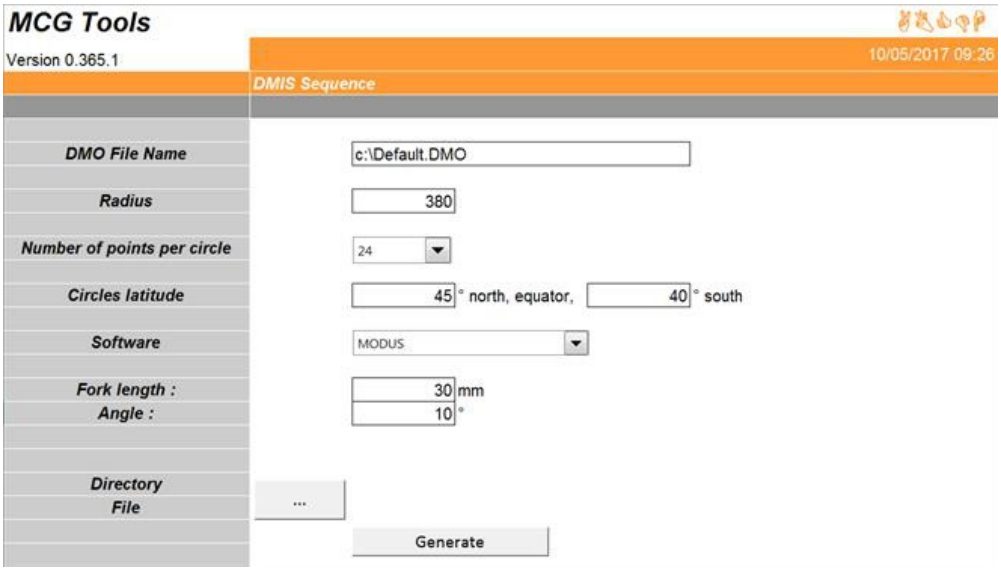
To generate a part programe please do the following:

- Select the length of the MCG arm from the 'Arm length' dropdown list:



- Click on 'Write DMIS sequence' button:

- The following window will be displayed:



- Having defined requested parameters press the 'Generate' button to save a DMIS part program.

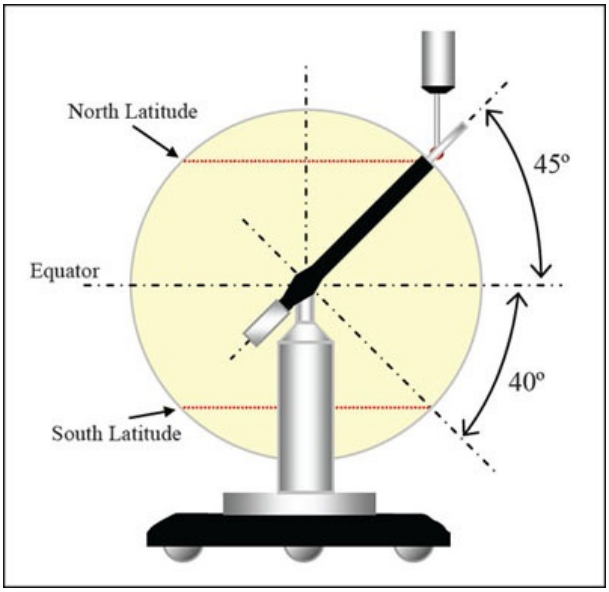
See also:

- DMIS part program generation parameters
- MCG tools setup worksheet
- CMM setup parameters
- Measurement configuration parameters
- Measuring condition parameters
- Point distribution
- DMIS program sequence
- Supported languages

DMIS part program generation parameters

The user can choose both the north and south latitudes. The default values are:

- 45° of north latitude
- 40° of south latitude



See also:

- MCG tools setup worksheet
- CMM setup parameters
- Measurement configuration parameters
- Measuring condition parameters
- Point distribution
- DMIS program sequence
- Supported languages

Point distribution

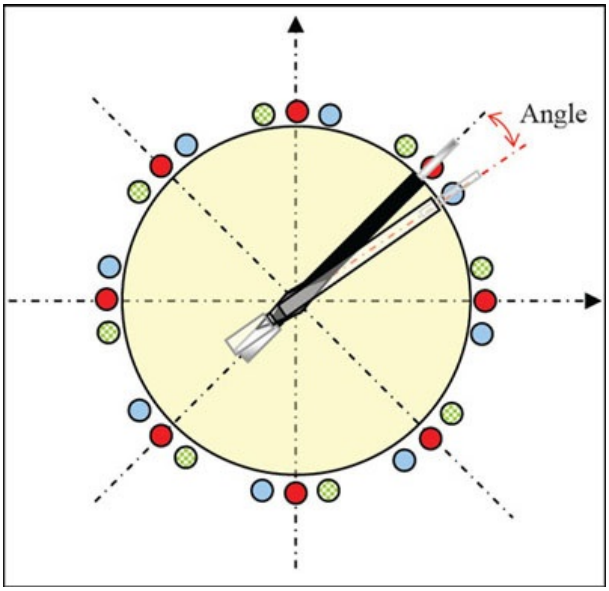
The user can choose to measure 8, 16 or 24 points per circle in order to improve the repeatability of the analysis results.

- The eight points, indicated as , are distributed every 45º.
- With the 16 points per circle, an extra set of eight points, indicated as , is measured on the circle and is shifted by an angle. This angle is a parameter available on the 'Data' page of the 'MCG sequence' form.
- With the 24 points per circle option, a second set of 8 points, indicated as , is added but is shifted by an apposite angle.

Data distribution for the three options:

Number of points	Representation
8 points per circle:	
16 points per circle:	
24 points per circle:	

Data distribution on the sphere:



See also:

- DMIS part program generation parameters
- MCG tools setup worksheet
- CMM setup parameters
- Measurement configuration parameters
- Measuring condition parameters
- Point distribution
- DMIS program sequence
- Supported languages

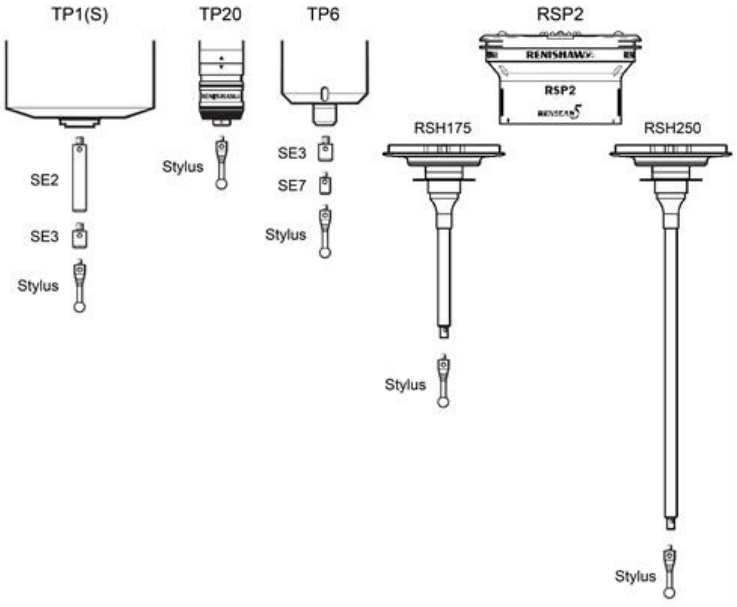
DMIS program sequence

Load the DMIS part program into your metrology software.

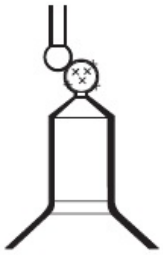
The DMIS program is written as a series of manual steps to establish a coordinate system on the MCG pilar, then switches to automatic to capture and record the required data points.

The part program first asks the operator to agree as liability statement.

NOTE: The MCG is not suitable for use with TP7M, SP600 or SP80 probes, and not recommended for use with TP200 probes. SP25M requires a TM25-20 and TP20 module. Attach the special, calibrated stylus of the MCG (this can be readily identified by the two grooves cut within the stylus stem) to your touch-trigger probe. If necessary, use the extensions and adaptors supplied to allow the calibrated stylus to be fitted to the probe.

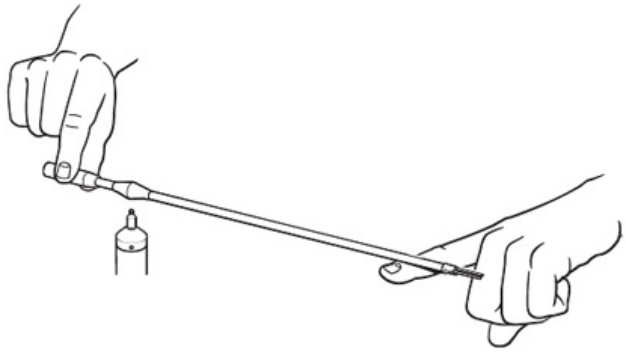


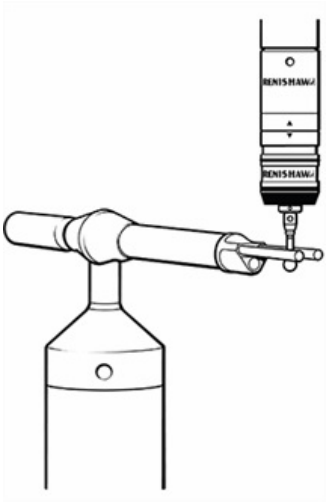
The program advances and pauses to prompt the operator to capture five data points around the MCG pivot.



NOTE: This centre is not important for the metrology analysis but is only used to generate the target points on the MCG.

The origin of the part program is moved to the centre of the MCG pivot. The machine is set to auto mode and the tip will move along the X-axis of the machine in the positive direction so the MCG arm can be fitted. At the end of the move the operator is asked to engage the MCG arm on the pivot and on the probe.





The program collects the points on the MCG arm, starting form the points on the equator, then the points on the north latitude and finally the points on the south latitude. At the end of the program the co-ordinates of the points are exported.

See also:

- DMIS part program generation parameters
- MCG tools setup worksheet
- CMM setup parameters
- Measurement configuration parameters
- Measuring condition parameters
- Point distribution
- DMIS program sequence
- Supported languages

MCG metrology software tools compatibility

The MCG tools spreadsheet creates a DMIS part program that can be used by many metrology software packages that are certified DMIS compliant.

At this time, the following metrology software packages are supported.

MCG tools spreadsheet

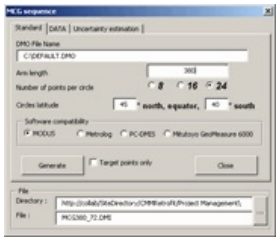
Software
MODUS
Metrolog
PC-DMIS
Mitutoyo GeoMeasure 6000

See also:

- MODUS

Target points for a manual CMM

Capturing MCG data points utilizing a manual CMM.



To create Target Points for use on a manual CMM, begin the process by selecting the **<Write DMIS sequence...>** button from the setup page on the MCG Tools spreadsheet.

A setup tool is displayed where you confirm the basic settings. On this tool there is a check box labelled "Target points only". Place a check here to develop a list of target positions required for the MCG test. These target positions will appear on the "Data" page of the MCG Tools spreadsheet and will not be written to a DMIS sequence file.

When performing the MCG test, capture the target points in the same order as listed on the "Data" page. At the completion of the target point capturing, record the actual positions on the "Data" page in the Calculate columns.

See also:

- MCG part program generation
- Point distribution

Data analysis

MCG tools analyses the form error of the sphere that is generated by the MCG arm around its pivot in order to identify six of the main CMM geometrical errors: three squareness errors and three relative scale errors.

The analysis first best fits a sphere onto the MCG points. This identifies a best fitted centre and radius. From this best fitted sphere, the form errors that are the radial deviation from the best fitted spherical surface are analysed in order to identify the CMM geometrical errors. This form error analysis is also a linear best fit of the effect of the CMM errors onto the MCG points. This identifies the three squareness errors of the CMM as well as its three relative scale errors.

Reported parameters

What are the reported parameters the MCG tools provides?

The analysis reports various parameters that are displayed on the page 'Data' and on the page 'Analysis'.

The 'Sphere' section

Sphere	Radius		149.6312	mm	min	-57.90	µm
					max	59.20	µm
		O.x	-0.0002	mm	span	117.11	µm
	Centre O	O.y	-0.0016	mm	Standard deviation	33.93	µm
		O.z	-0.0024	mm			
					Admissible error	3.10	µm
					Max measured error	59.20	µm

The parameters of the best fitted sphere are displayed as 'Radius' and 'Centre O' with its three co-ordinates O.x, O.y and O.z.

The radial errors from the best fitted sphere are analysed, the minimum and maximum errors are displayed as well as the span (max-min) and the standard deviation of the radial errors.

The admissible error is computed from the CMM accuracy formula and the MCG arm length used for the test. The maximum absolute error is also reported to ease the comparison with the machine specification.

The 'Identified geometrical errors' section

Identified geometrical errors	Relative scale errors	Jx	31.76	µm/m	min	-0.91	µm
		Jy	-42.37	µm/m	max	1.12	µm
		Jz	12.05	µm/m	span	2.03	µm
					Standard deviation	0.53	µm
		XY	-14.08	µrad			
	Squareness	YZ	546.30	µrad	Admissible error	3.10	µm
		ZX	-545.33	µrad	Max residual error	1.12	µm

The section displays:

- Three relative scale errors
- Three squareness errors
- Remaining radial errors are analysed as the raw sphere radial errors
- The minimum and maximum errors, the span (max-min) and the standard deviation of the remaining form errors
- This form errors analysis that is virtual calculates the machine performance if the six CMM errors were corrected

The 'Pivot' section

Pivot	Offsets	TX	-0.92	µm
		TY	0.92	µm
		TZ	-0.20	µm

During the analysis of the form errors a pivot offset is best fitted in order to identify whether the centre of the elliptical form errors differs from the sphere centre. A big offset would indicate that either some data points are incorrect or that the machine has important errors that are not squareness or scale errors. What is considered as A BIG offset?

The 'Database' section

When a data set has been analysed the results can be archived. The 'Record in Database' button will copy the results and the set up parameters in the workbook data base. See the section 'What is archived' for more details.

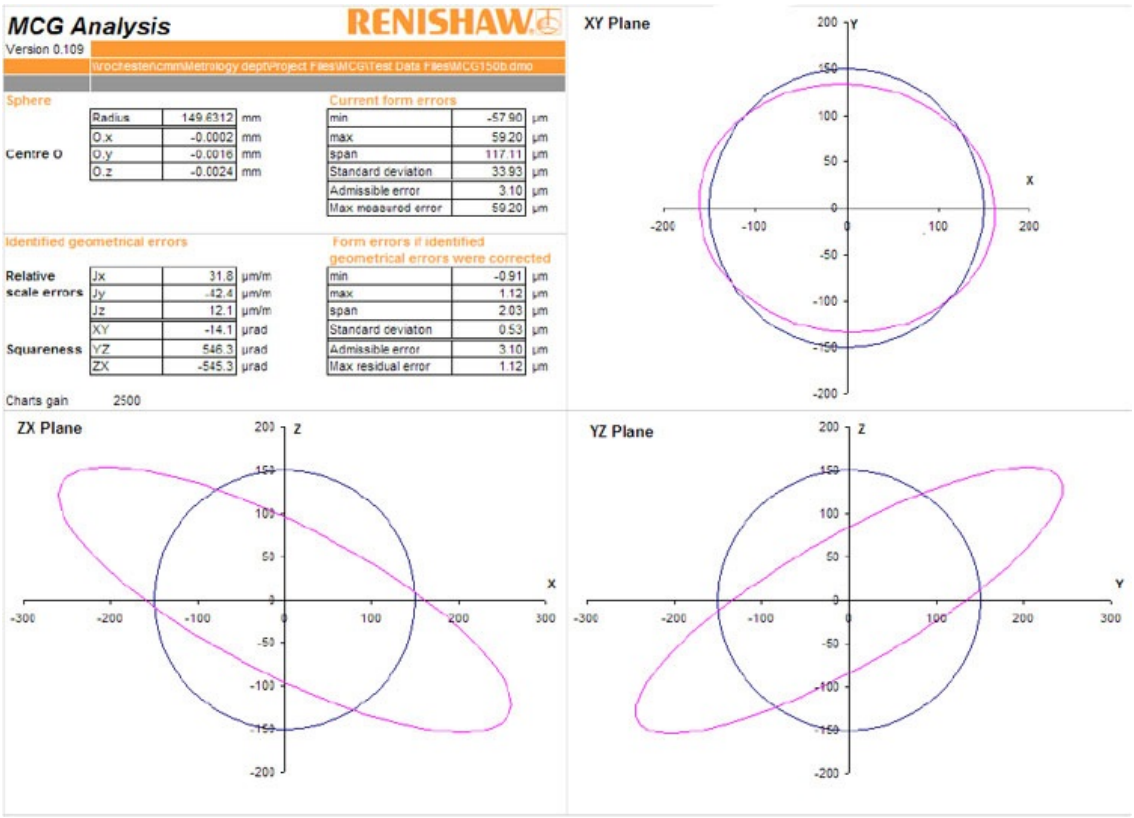
The 'Gain' section

The geometrical errors are also displayed on the 'Analysis' page as circular plot. The form errors are multiplied by a gain that can be changed on the 'Data' page. In order to take effect, the data has to be reanalysed by clicking the 'Calculate' button again.

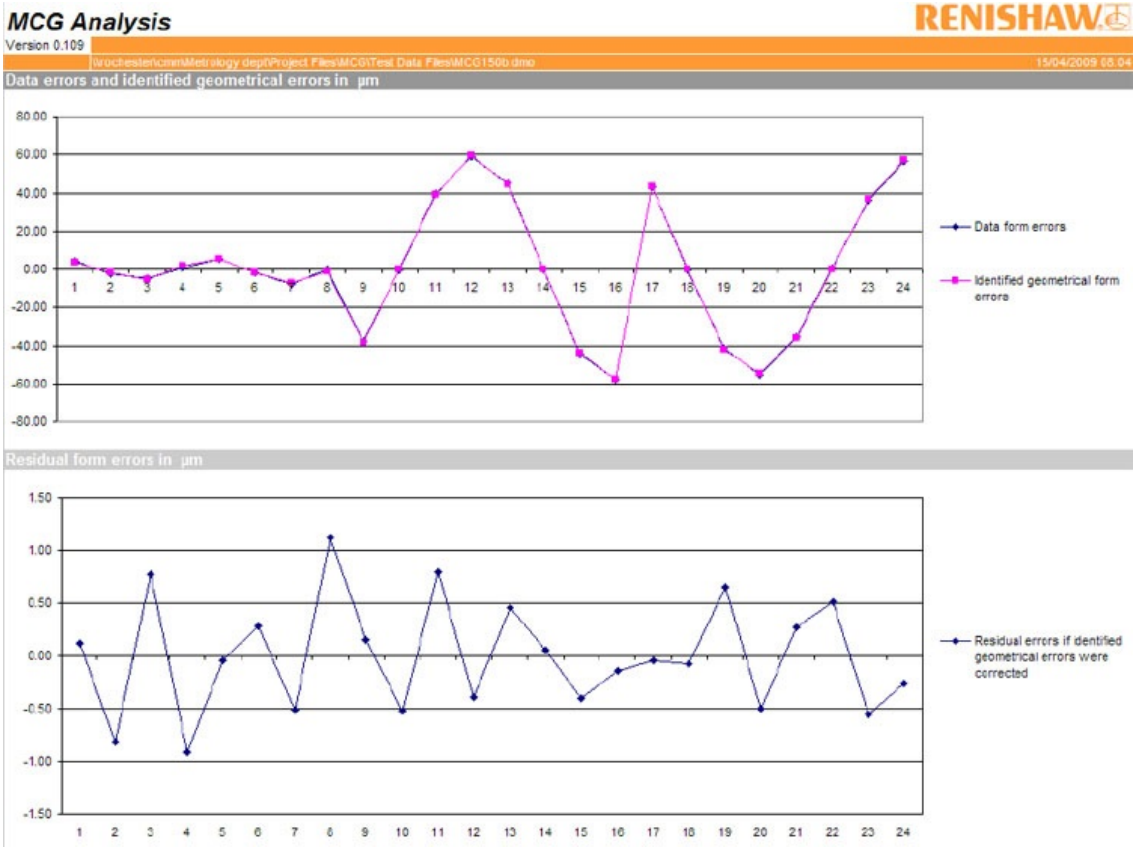
Analysis charts

What do the MCG tools analysis charts represent?

The page 'Analysis' presents a printer friendly version of the analysis results. The first part displays the analysed result along with three 2D plots. There is a plot for each principal plane of the machine: the XY plane, the YZ plane and the ZX plane. The effect of the identified CMM errors on the MCG arm length is plotted. The effect is magnified by a gain.



The second part presents the individual radial error of the data with the identified radial errors. Finally, the residual errors (that cannot be identified as squareness errors or as scale mismatch) are plotted.



See also:

- Changing the characteristics of the chart controls

Changing the characteristics of the chart controls

How can the chart be expanded to better understand the nominal versus actual deviations?

Viewing charts that show graphic elements overlaying each other cannot always visually distinguish the separation between the actual and nominal values. To enhance the readability of MCG Tools charts, a gain can be applied to the graphic elements to separate the actual from the nominal.

On the 'Analysis' worksheet, there is a data field labelled 'Charts gain'. Increase the value to apply more visual variance to the charts.

When the new value has been entered, press the 'Calculate' button.

See also:

- Analysis charts

Data file import

The user can import directly into the MCG tools a properly formatted file that contains the actual data for analysis.

On the 'MCG tools setup' worksheet you will find the 'Data import' button. Press this button and a standard Windows file open tool appears that is used to navigate to your file for selection.

If you are opening a file that was created by the DMIS part program, the location and name of the file was previously established when the DMIS sequence generator was completed.

The import tool supports two basic formats.

DMIS output file:

FA(PT1)=FEAT/POINT,CART,149.065,-13.053,-0.005,0.996191,-0.087199,$0.000000

ASCII text:

-74.81179 74.81179 105.79985

Each co-ordinate is separated by a character. The separator can be a space, tabulation or a comma.

When imported, the data poulates the 'Data' worksheet.

See also:

- Import file formats

Supported file formats

MCG tools recognises different file formats including the DMIS output file format and several text files.

The DMIS file format reports each probed point as:

FA(PT1)=FEAT/POINT,CART,149.065,-13.053,-0.005,0.996191,-0.087199,$0.000000

The supported text files present each probed point on a single line:

-74.81179 74.81179 105.79985

Each co-ordinate is separated by a character. The separator can be a space, tabulation or a coma.

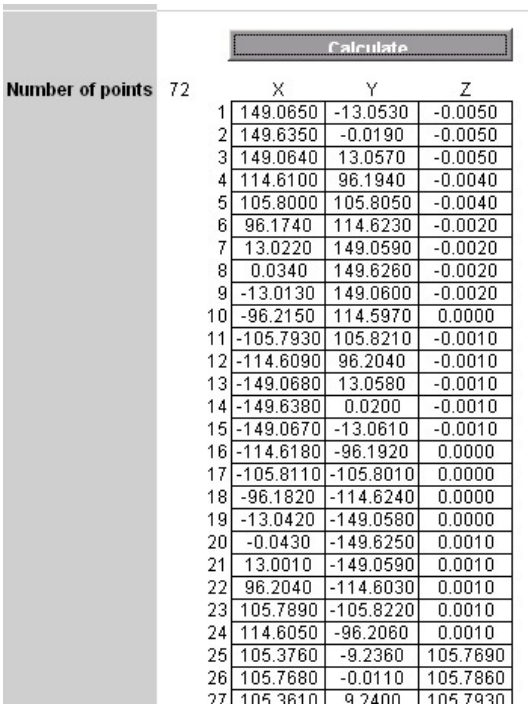
See also:

- Data file import

The manual data input

It is possible to manually enter data into the MCG tools data worksheet. The data has to be entered in the X, Y and Z columns under the 'Calculate' button.

The data field that reports the number of data points, currently showing 72 in the image at right, must be updated to reflect the actual number of points entered.



Calculate

Number of points 72

	X	Y	Z
1	149.0650	-13.0530	-0.0050
2	149.6350	-0.0190	-0.0050
3	149.0640	13.0570	-0.0050
4	114.6100	96.1940	-0.0040
5	105.8000	105.8050	-0.0040
6	96.1740	114.6230	-0.0020
7	13.0220	149.0590	-0.0020
8	0.0340	149.6260	-0.0020
9	-13.0130	149.0600	-0.0020
10	-96.2150	114.5970	0.0000
11	-105.7930	105.8210	-0.0010
12	-114.6090	96.2040	-0.0010
13	-149.0680	13.0580	-0.0010
14	-149.6380	0.0200	-0.0010
15	-149.0670	-13.0610	-0.0010
16	-114.6180	-96.1920	0.0000
17	-105.8110	-105.8010	0.0000
18	-96.1820	-114.6240	0.0000
19	-13.0420	-149.0580	0.0000
20	-0.0430	-149.6250	0.0010
21	13.0010	-149.0590	0.0010
22	96.2040	-114.6030	0.0010
23	105.7890	-105.8220	0.0010
24	114.6050	-96.2060	0.0010
25	105.3760	-9.2360	105.7690
26	105.7680	-0.0110	105.7860
27	105.3610	9.2400	105.7930

To begin the analysis process, click the calculate button.

Calculate

Results archive

Archiving your results of the MCG tools analysis.

The MCG tools spreadsheet will maintain a history of analysed results. This is recorded on the 'Database' worksheet.

To record the results, navigate to the 'Data' worksheet, locate and press the 'Record in Database' button illustrated above.

An entry will be made in the 'Database' worksheet noting the following data:

Item archived	Description	Archived from
Date Time	Date and time of the test	Imported data file
Jx (µm/m)	Relative X scale error	Analysis worksheet
Jy (µm/m)	Relative Y scale error	Analysis worksheet
Jz (µm/m)	Relative Z scale error	Analysis worksheet
X⊥Y (µrad)	XY squareness error	Analysis worksheet
Y⊥Z (µrad)	YZ squareness error	Analysis worksheet
Z⊥X (µrad)	ZX squareness error	Analysis worksheet
Min (*1000)	Minimum radial error in µm	Analysis worksheet
Max (*1000)	Maximum radial error in µm	Analysis worksheet
Span (*1000)	Span of the radial error in µm	Analysis worksheet
File	File name of the data file	Analysis worksheet
Temperature	Temperature recorded during the test	Setup worksheet
Atmospheric pressure	Atmospheric pressure recorded during the test	Setup worksheet
Air humidity	Air humidity recorded during the test	Setup worksheet
MCG identification	Identification of the MCG	Setup worksheet
Arm length	Arm length of the MCG	Setup worksheet
Probe type	Probe identification	Setup worksheet
Operator	Operator name	Setup worksheet
Comments	4 lines of comments	Setup worksheet

The actual data points used in the analysis are not saved. Should you elect to archive the data point, save the original file in a archive folder. These files can always be imported into the MCG tools worksheets and produce another analysis.

MCG archived data

The following table details the fields that are recorded in the data base.

Item archived	Description	From
Date time	Date time of the test	File
Jx (µm/m)	Relative X scale error	Analysis results
Jy (µm/m)	Relative Y scale error	Analysis results
Jz (µm/m)	Relative Z scale error	Analysis results
X⊥Y (µrad)	XY squareness error	Analysis results
Y⊥Z (µrad)	YZ squareness error	Analysis results
Z⊥X (µrad)	ZX squareness error	Analysis results
Min (*1000)	Minimum radial error in µm	Analysis results
Max (*1000)	Maximum radial error in µm	Analysis results
Span (*1000)	Span of the radial error in µm	Analysis results
File	File name of the data file	Analysis results
Temperature	Temperature recorded during the test	Setup page
Atmospheric pressure	Atmospheric pressure recorded during the test	Setup page
Air humidity	Air humidity recorded during the test	Setup page
MCG identification	Identification of the MCG	Setup page
Arm length	Arm length of the MCG	Setup page
Probe type	Probe identification	Setup page
Operator	Operator name	Setup page
Comments	4 lines of comments	Setup page

Historical database charts

Reviewing the historical results using the database charts.

The 'Database' worksheet provide a variety of charts to display the historical data stored from all the MCG program runs that have been archived. By monitoring these charts, you will see CMM errors as trend lines over time.

The charts available are:

Chart ID	Description
Jx (µm/m)	Relative X scale error
Jy (µm/m)	Relative Y scale error
Jz (µm/m)	Relative Z scale error
X⊥Y (µrad)	XY squareness error
Y⊥Z (µrad)	YZ squareness error
Z⊥X (µrad)	ZX squareness error
Min (*1000)	Minimum radial error in µm
Max (*1000)	Maximum radial error in µm
Span (*1000)	Span of the radial error in µm

See also:

- Archived data
- Analysis charts
- Data file import

Languages supported by MCG

Supported languages within the MCG tool spreadsheet.

From the translation dropdown list on the set up page, the user can select one of the following languages:

- English
- Français
- Deutsch
- Español
- 日本語

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