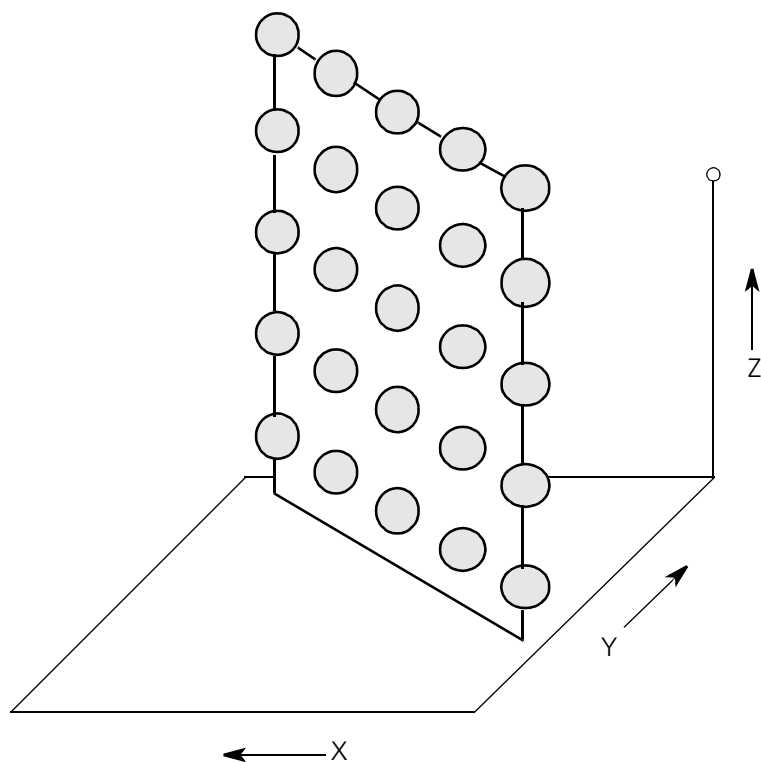


UMESS

Option 15 Sphere Test Standard for UNIX and LINUX



Operating Instructions



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Preface

This manual describes the function, operation and application possibilities of the **UMESS Option 15** measuring program.

It is here assumed that the user is familiar with the coordinate measuring machine and the **UMESS** basic software. Please keep all printed materials delivered with the measuring machine ready to hand at all times.

All rights pertaining to changes in the measuring machine version, scope of delivery, the software packages and the pertaining documentation reserved.

Principles in this operating manual

Before starting to work with this manual, the user has to familiarize himself with the applied principles.

In the following, you will find information on the used font types, signs and symbols.

Typographic principles

The font types and font schemes used in this manual have the following meaning:

- **bold face**
 - Dialog element on the screen
Example: "... the button **<TERMIN>**"
 - Term
Example: "During calculation the location of a **measuring element** in relation to a **reference element** is determined."
 - File and directory names
Example: **/home/zeiss/UB**
- *italic*
 - Highlighted text of which the contents are very important
Example: "Click with the *right* mouse button ..."
 - Cross reference
Example: "..., see also ► *"Signs and symbols" on page -4*"

- **Courier bold face**
Text in dialog windows and records

Signs and symbols

Special signs and symbols are used in this manual.

Symbols for warnings and information



Danger!

In this case, special care is called for. The warning triangle indicates risk of injury. Non-observance of this warning may cause personal injury.



Note!

This symbol warns against situations which may lead to loss of data, measuring errors, errors in the measuring run, collisions or damage to the machine and workpiece.



The **Note** symbol is shown next to important text and helpful additional information.

Symbol for function call

There are several possibilities:

- Direct input by means of the DI number
- Function selection by means of the pull-down menu
- Selection by means of icons

Example:



Symbol for softkey

Reference to softkeys in dialogs.

Overview of chapters

This manual describes the function, operation and application possibilities of the UMESS Option 15 measuring program.

The following subjects are described:

- Chapter 1 "General" on page 1-1<Default Pa>
- Chapter 2 "Programming a CNC run" on page 2-1<Default Pa>
- Chapter 3 "CNC run" on page 3-1<Default Pa>
- Chapter 4 "Evaluation" on page 4-1<Default Pa>
- Chapter 5 "Appendix" on page 5-1<Default Pa>

Direct input functions

DI No.	Input abbrev.	Function	Page
2605		Sphere test standard, entering CNC code data	➤ Page 2-2
2610		Sphere test standard, generating control data	➤ Page 2-9
1640	CNCABL	Starting CNC run	➤ Page 3-3
2620		Sphere test standard, output of measuring results	➤ Page 4-3

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Chapter

1

General

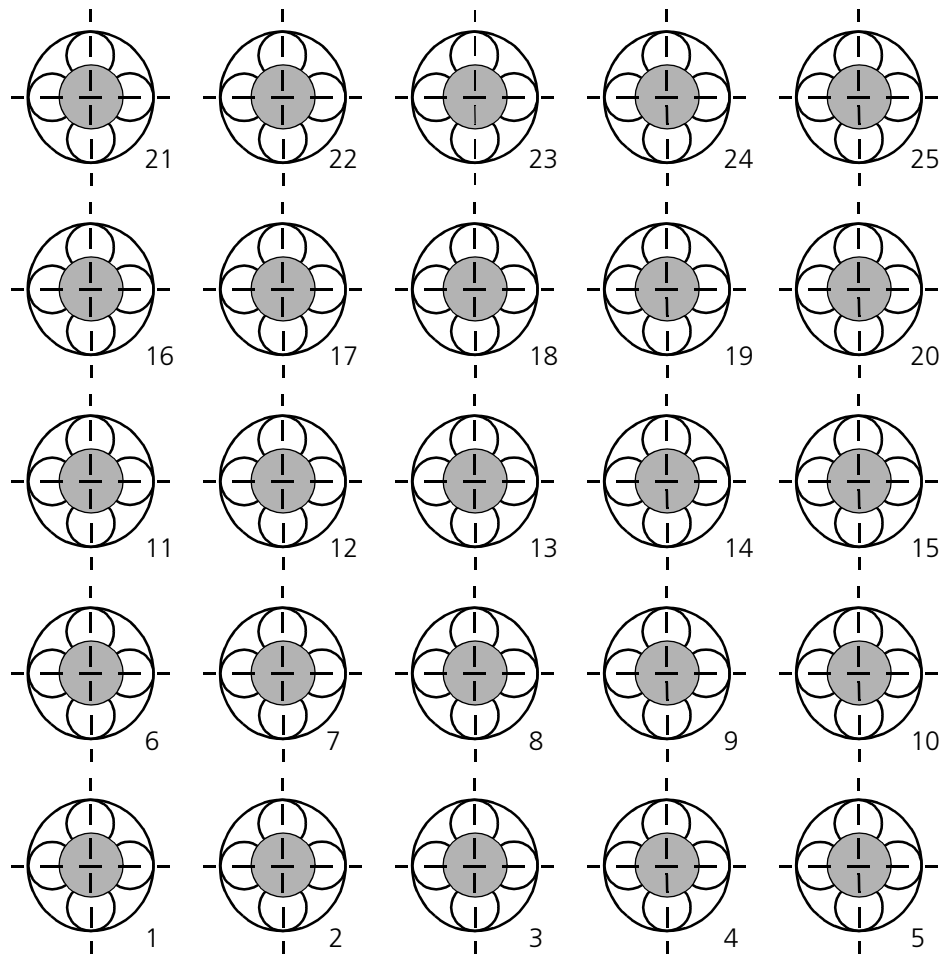
With a ball plate you can check the coordinate measuring machine at regular intervals. The result is especially telling as the same environmental conditions are present as in normal measuring mode. The software described here for measurements on the ball plates corresponds to the specifications, which have been drawn up by the study group for manufacturer-independent monitoring of coordinate measuring machines Appendix. ► *“Appendix” on page 5-1*. The relevant ball plate is calibrated by the Physikalisch-Technischen Bundesanstalt (Physical-Technical Federal Office) or by a body recognized by the DKD (German calibration service).

This chapter contains:

Structure of the ball plate	1-2
Principle of testing	1-3
Branching of the input masks.	1-4

Structure of the ball plate

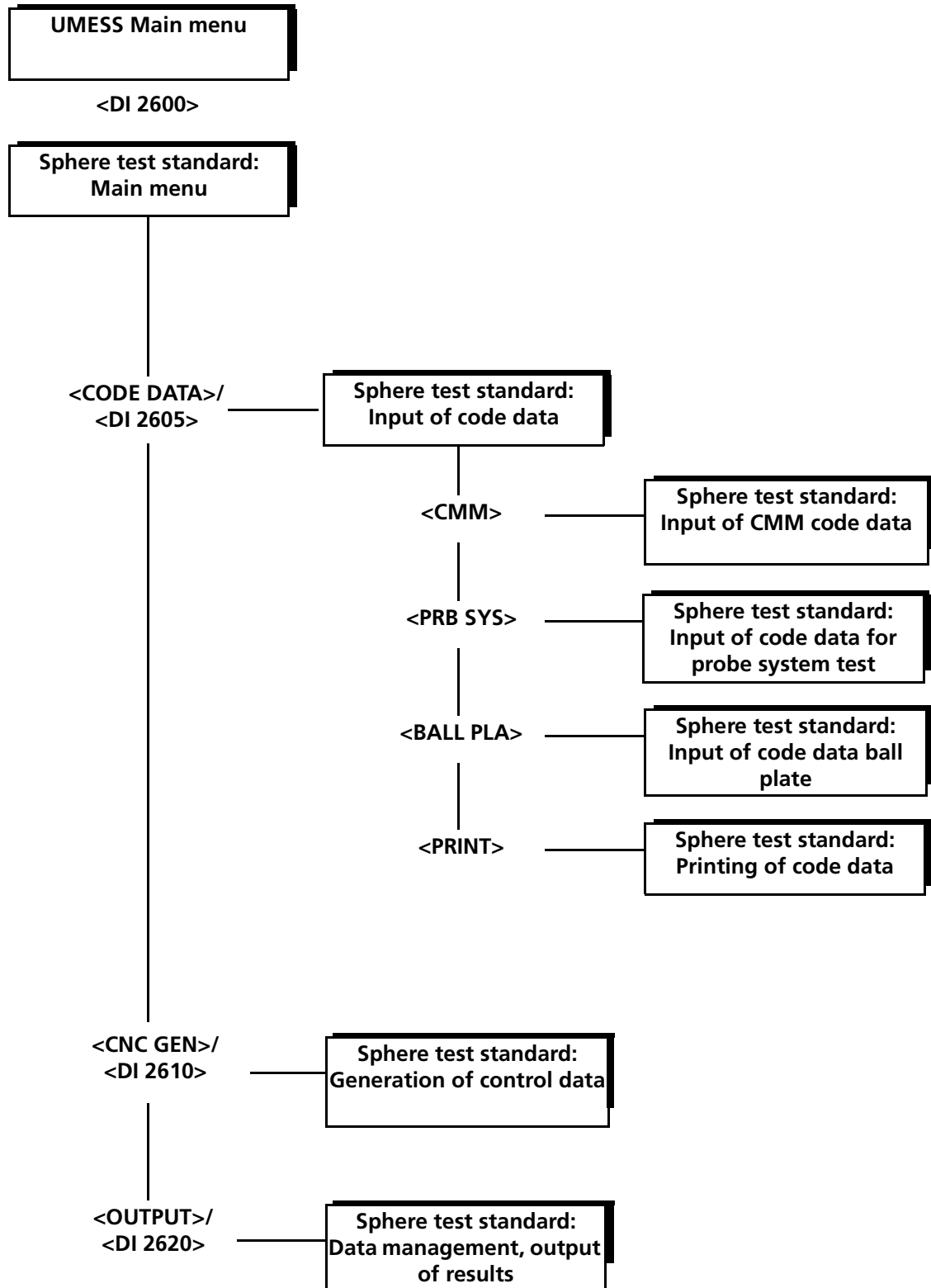
The ball plate consists of 25 high precision ceramic spheres which are arranged symmetrically in a carrier plate made of steel. Due to the steel material, the measurement result is also influenced by the temperature. Due to this the behavior of common work pieces is imitated intentionally. The total measuring uncertainty therefore also contains the correction of thermal expansion.



Principle of testing

- The measuring machine determines the location of the balls on the ball plate. Using the measured values and the values of the calibration, the software determines whether the deviations lie within the permissible limiting values. You specify the permissible limiting values corresponding to the requirements (A and K according to VDI/VDE 2617).
- In addition you check the probing system on an individually clamped adjusting ring and a ball.
- You can also output the following:
 - A tabular hardcopy of the gaps between the balls with nominal-actual comparison
 - The position of the ball plate in the measuring volume
 - A graphical display of all gap deviations

Branching of the input masks



Chapter

2

Programming a CNC run

This chapter contains:

Entering code data.	2-2
Generating control data.	2-9

If you want to program a CNC run for measuring the ball plate, you have to proceed as follows:

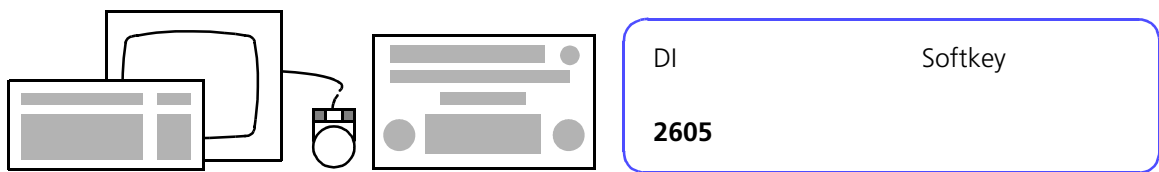
- Enter code data
- Generate control data

Entering code data

Before you program the first measuring run, you have to enter the calibration code data. This is managed under the respective ident number and stored together with the CNC runs. The measuring runs and the ball plate data, ring and ball are then on the same data carrier.

When you enter the ident number, the software accesses the correct calibration data. It loads the geometry data (gaps between the balls, ring and ball diameter) and the expansion coefficients from the stored data file into the control and evaluation part of the software.

Function call



Dialog window

Sphere test standard: Input of code data

< CMM > Input of code data for coordinate measuring machine

<PRB SYS > Input of code data for probe system test

<BALL PLA> Input of code data ball plate

<PRINT> Printing of code data

<RETURN> back to main menu

CMM

PRB SYS

*

BALL PLA

PRINT

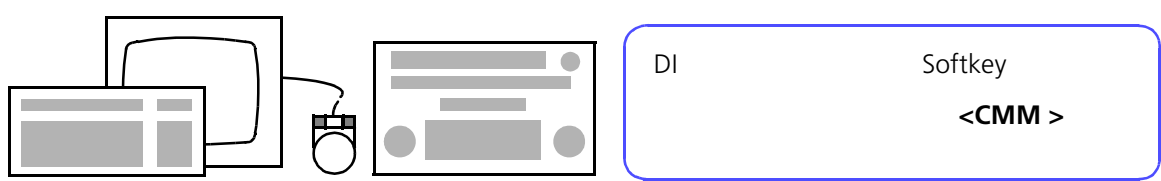
RETURN

INFO

Code data of the coordinate measuring machine

The code data of the measuring machine is requested in two input masks which follow on from one another. The general code data is used for documentation purposes, it is specified for clear assignment in the test protocol. The data on the measuring range and measuring uncertainty is taken into consideration during the evaluation.

Function call



Dialog window

Sphere test standard: Input of CMM code data

	Coordinate measuring machine	Probe system
Ident No.		
Type identification		
Manufacturer		
Serial number		
Location		
Department		
Purchased on		
last service on		

Measuring or trigger

* YES	NO			*				TERMIN
	PRE MENU							INFO

Softkeys

TERMIN

Branching

Input fields

Ident number	Digits and/or letter combination for forming the file designation for the code data. If this already exists, the subsequent entries are preassigned automatically.
Coordinate measuring machine/ Probe system/ Type identification ...	Code data of the coordinate measuring machine and probe head.
Measuring or trigger	<YES>/<NO> for type selection of the probe system.

Dialog window

Sphere test standard: Input of CMM code data

CMM measuring range

Measuring uncertainty

Probing uncertainty

thermal length expansion

max. temporal temp. deg/day

max. temporal temp. deg/hour

ambient temperature deg.

rel. air humidity

permissible probing speed

X

u3

v3

um +

um

um/m/K

K/d

K/h

K/m

%

mm/s

Z

um/m <=

*

TERMIN

BACK

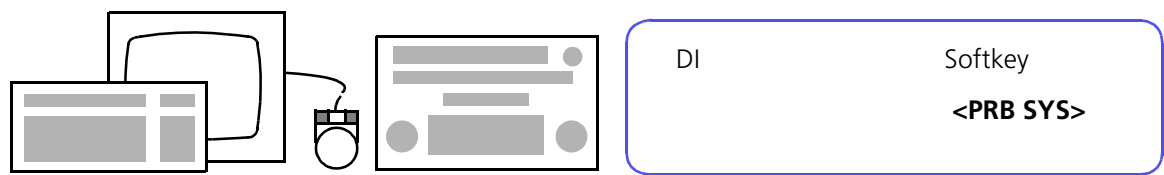
PRE MENU

INFO

Probe system code data

The data for the ball and the ring gauge are stored for the probe system test in the following input mask.

Function call



Dialog window

Sphere test standard: Input code data for probe system test

	Sphere	Ring gauge
Ident. No.	<input type="text"/>	<input type="text"/>
Type identification	<input type="text"/>	<input type="text"/>
Manufacturer	<input type="text"/>	<input type="text"/>
Serial number	<input type="text"/>	<input type="text"/>
Test certificate number	<input type="text"/>	<input type="text"/>
Purchase date	<input type="text"/>	<input type="text"/>
last calibration on	<input type="text"/>	<input type="text"/>
Diameter	<input type="text"/>	<input type="text"/>
thermal length expansion	<input type="text"/>	<input type="text"/>

*

TERMIN

BACK

INFO

Input fields

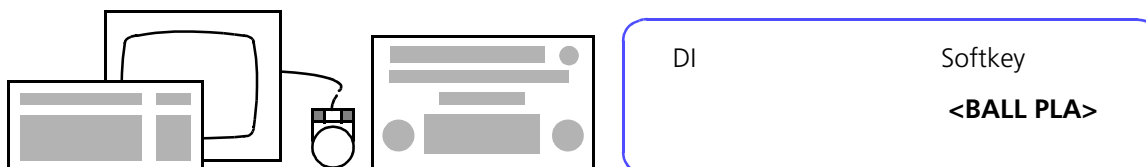
Ident number

Digits and/or letter combination from which the file name is formed for the CMM code data. If the ident number already exists, the following entries are automatically preassigned.

Ball plate code data

For the ball data, general code data is to be specified first. The calibration data of the ball plate is to be entered in the 2nd input mask.

Function call



Dialog window

Sphere test standard: Input code data ball plate

Ident No.	
Type identification	
Manufacturer	
Serial number	
Test certificate number	
Purchase date	
last calibration on	
thermal length expansion	
Sphere diameter	

<table border="1"> <tr> <td></td><td></td><td></td><td></td></tr> </table>					*	<table border="1"> <tr> <td></td><td></td><td></td><td>TERMIN</td></tr> </table>				TERMIN
			TERMIN							
<table border="1"> <tr> <td>BACK</td><td></td><td></td><td></td></tr> </table>	BACK					<table border="1"> <tr> <td></td><td></td><td></td><td>INFO</td></tr> </table>				INFO
BACK										
			INFO							

Softkeys

TERMIN

Branching

Input fields

Ident number

Digits and/or letter combination from which the file name is formed for the CMM code data. If the ident number already exists, the following entries are automatically preassigned.

**thermal length
expansion**

Input of the expansion coefficient of the ball plate.

Sphere diameter

Data for generating the probe routes in the CNC run.

Dialog window

Sphere test standard: Input calibration data for ball plate

No	X	Y	Z
1	0.0000	0.0000	0.0000
2	82.9990	0.1495	-0.2525
3	166.0000	0.1588	-0.2543
4	249.1823	0.3604	-0.2801
5	331.8917	0.0000	0.0000
6	0.0042	83.0675	-0.1231
7	83.1690	83.2525	-0.1759
8	166.0617	83.2532	-0.1849
9	249.1130	83.3151	-0.3091
10	331.8885	83.1530	-0.0283
11	-0.0583	166.0948	0.0232
12	82.9845	166.1502	-0.1877
13	165.8406	166.0304	-0.2682

*

CONTINUE

BACK

PRE MENU

INFO

Softkeys

CONTINUE

Branching to the following input fields.

TERMIN

End of input.

Input fields

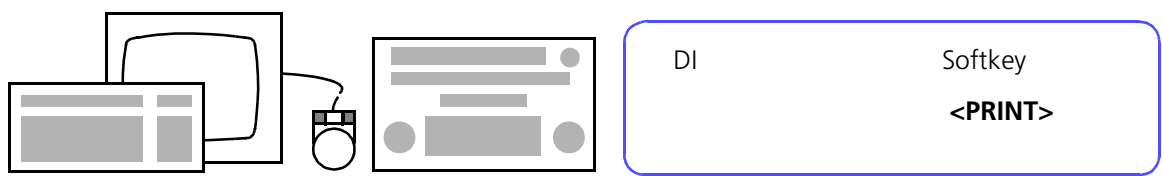
No. / X / Y / Z

Input of the calibration data for each ball position.

Printing code data

The files stored can be printed for control and documentation purposes:

Function call



Dialog window

Sphere test standard: Print code data

Name of CMM code file : SSM

B

Name of sphere code file : STS

B

Name of ring code file : SSR

B

Name of plate code file : SSP

B

*

TERMIN

BACK

INFO

Input fields

Name of code file...

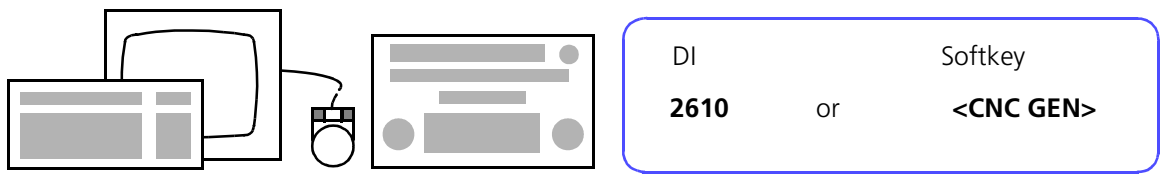
If a printout is required for the individual code files, the relevant ident number must be entered.

By pressing <TERMIN> the printout is started.

Generating control data

The input of control data is limited to a few items of data which cannot be taken from the stored calibration values.

Function call



Dialog window

Sphere test standard: Generation of control data

Probe number1Combination 1Configuration 1

Probe sphere diameter8.0 mm

Entry in catalogwith WP code

File nameCNC KMGPRF B overwrite

Workpiece nameKUGELPLATTE X-ACHSE

Meas. without ring

RingIdent No. calibration

Sphere

Sphere plate

CMM

Ring insertion depth5.0 mm

Backaway path12.0 mmClearance distance25.0 mm

* YESNO

BACK

*TERMIN

INFO

Softkeys

TERMIN

Branching

Input fields

Workpiece name	Name of the CNC run under which the workpiece can be started.
File name	The CNC run is stored on the hard disk under this designation. Before starting a CNC run, the file name must be entered in the control data catalog using the <ENTER> (DI 1634) function, giving the file name (CNCKMGPRF).
CNC B overwrite	This field is active if the file name already exists. Every time the test standard structure is changed, the existing file must be overwritten and re-entered in the control data catalog. Overwrite by pressing <YES> .
Entry in catalog	<YES> The control data just generated is stored as file in the current control data catalog. A check is made to see whether the workpiece code and the workpiece name already exist in the current control data catalog. <NO> The control data is stored under the file name selected above in the directory CZ_MES_UB .
Meas. without ring	<YES> Control data is generated <i>without</i> the ring measurement for the probe system determination. Instead of the ring measurement, a sphere measurement is generated on a ball plate with 12 probings. Thus the measuring program corresponds to the " <i>Manufacturer-independent monitoring of coordinate measuring machines with ball plates</i> " product requirements specification from January 1994. <NO> Control data is generated with the ring measurement for the probe system determination.

Dialog window

Sphere test standard: Select spheres

21: 2

22: 1

23: 1

24: 1

25: 1

0: do not measure

16: 1

17: 1

18: 1

19: 1

20: 1

1: measure

11: 1

12: 1

13: 1

14: 1

15: 1

2: W-pos.

6: 1

7: 1

8: 1

9: 1

10: 1

1: 2

2: 1

3: 1

4: 1

5: 2

*

TERMIN

BACK

INFO

Input fields

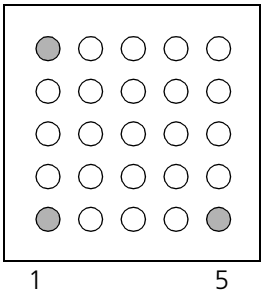
1: ... 25:

NOTE

You have to define how each ball is to be treated in the measuring run by assigning it the code number 0, 1 or 2.

- The balls for determining the W-position must be arranged in a right angle.

21



- Only the outer ball rows or ball columns can be excepted from the measurement.

Chapter

3

CNC run

This chapter contains:

General	3-2
CNC start.	3-3
Assessing the probe system	3-5
Assessing the measuring machine	3-6

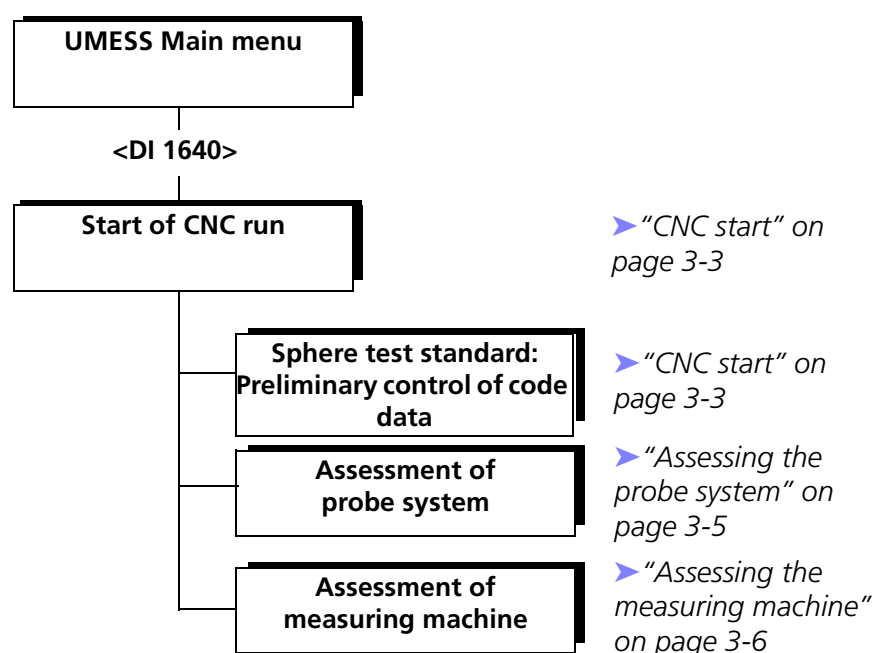
General

The test program can be run on all Carl Zeiss coordinate measuring machines which are equipped with a CNC control and a computer with UNIX/LINUX operating system. When used on a coordinate measuring machine with point to point control, the ball plate and ring gauge must be arranged parallel to one of the measuring planes in order to avoid collisions when probing the spheres.

The following preparations must be made:

- Clamp the sphere test standard in the measuring range of the coordinate measuring machine. Clamp the ring gauge so that the front face is parallel to the sphere test standard.
- Insert the probe combination with monitoring probe sphere so that its probe shafts are vertical to the sphere test standard. Balance the probe system.
- If necessary, clean the measuring surfaces of the test standard and the probe.
- Preselect the probe number (as for **Generating probe data**) and carry out the probe calibration. If the deviation is too high, repeat the probe calibration. The axis exchange must not be activated here.
- The probe bend correction must be activated for measuring probe systems when calibrating and measuring.

The CNC run takes place as follows:

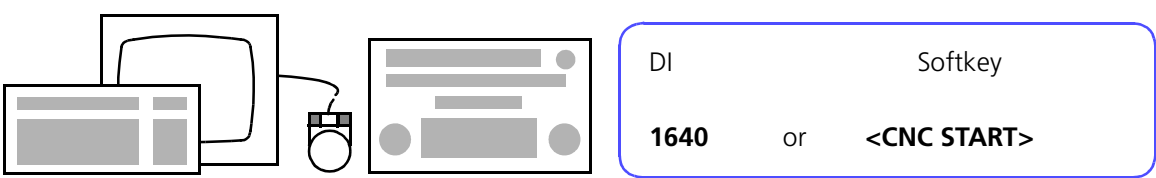


CNC start

Once the CNC run generated has been entered in the workpiece catalog (► *"Generating control data" on page 2-9*), the measurement can be started.

The program stops again before starting the measurements in order to check the code data. If the coordinate measuring machine is not equipped with temperature sensors, the temperature for the scales and the ball plate must be entered manually. The temperature of the measuring volume is only required for documentation purposes. The CNC run is continued, once the input mask **Preliminary control of code data** has been concluded with **<TERMIN>** .

Function call



Dialog window

CNC adm: Start CNC run Cat name: Catalog for MEAS library

WP code kuplax Workpiece name BALLPLATE X AXIS

Comment

YES	NO	WP INFO	*		CATALOG		TERMIN
BACK							INFO

Sphere test standard: Preliminary control of code data

Location		CMM manufacturer	Carl Zeiss
Department		CMM Type	UPMC850
Operator	frb	Inventory number	90372
Date	01.10.1994		
Time	10:50		
Ident. No.	Ring 325_91.14	Sphere 330_91.14	Sphere plate 600_91.08
last calibration	12.07.1993	12.5.1993	25.10.1994
Expansion coefficient	11.50	5.50	11.50
Limit value for distance deviations	A	3.0000	K 3.0000
Temperature: Meas. volume	24.55	Sphere plate	24.55
Meas machine X	20.00	Y 20.00	Z 20.00

				*				TERMIN
BACK								INFO

Information on selecting A and K

The gaps between the balls are three dimensional. Therefore the values for A and K refer to the manufacturer's specifications for u_3 . The measurement of the gaps between the balls is subject to criteria other than the measurement of gauge blocks according to VDI/VDE 2617. You therefore have to apply larger values for A and K than the manufacturer's specifications for u_3 .

V_3 (three dimensional probing uncertainty) must be entered as the value for A. If this is not specified for your measuring machine, select a value which is two to three times higher than the constant element for u_1 .

The limiting value for u_3 can be used for K if the temperature conditions have been kept to. The machines are mostly installed on the shopfloor and the permissible temperature fluctuations and limiting values are exceeded.

Please take this into consideration and enter the relevant uncritical value for K.

Assessing the probe system

Measuring the ring gauge

The computer prompts you to probe a surface and circle on the ring gauge in order to determine the workpiece position. The probe system is then checked by automatic probing (3 runs each with 12 probings).

Display/prompt on the computer	User action
Please probe 3 surface points on the ring gauge with probe ..(<CONT>)	<CONT>
Surface prb point 1	Probe at least 3 points on the front face of the gauge ring , conclude the program with <TERMIN>.
Please probe 3 circle points on the ring gauge with probe ..(<CONT>)	<CONT>
Circle prb point 1	Probe at least 3 points on the borehole of the ring gauge , conclude the program with <TERMIN>.
Please position to ring center (<CONT>)	Position the probe in the borehole of the ring gauge. Then <CONT>

Measuring the calibration ball

After concluding the measurements on the ring gauge, the workpiece position of the calibration ball must be defined. The ball is then determined in 3 runs each with 9 probings.

Display/prompt on the computer	User action
Please probe at the sphere pole in shaft direction with probe ..(<CONT>)	<CONT>
Point prb point 1	Probe a point, conclude the program with <TERMIN>.

Cancel criteria

The probe system test determines the form and diameter deviation of the ball or ring. The program compares these values with the following limiting conditions:

- Form deviation $f < A$
- Diameter deviation $|\Delta d| < A + K \times d$

A and K are the values you have specified in the record header.

If a deviation is larger than permitted, it is not usually worth measuring the ball plate. The program therefore cancels the measurement and outputs the percentage of tolerances exceeded. If the deviations are smaller than permitted, the program continues without any message.

Assessing the measuring machine

After the probe system test, the program prompts you to probe three balls on the ball plate for determining the workpiece position.

Display/prompt on the computer	User action
Please probe sphere No. ... with probe ... (<CONT>)	<CONT>
Point prb point 1	Probe the ball indicated in the direction of the shaft at the highest point, conclude program with <TERMIN>. This procedure is repeated for each of the 3 W-position balls.
Position probe in front of ball (<CONT>)	Move the probe to the position described <and call CONT>.

After the three W-position balls the program automatically measures all balls which you have selected while programming with **Measure**. The three W-position balls are measured again at the end in order to determine whether they have moved during the measurement.

NOTE

The three W-position balls determine the control coordinate system and thus also the workpiece coordinate system. This however does not affect the gap deviations as they are calculated as direct 3D ball center-gaps and compared with the calibration data.

If a monitoring factor >1 is displayed for the measurement on the ball plate, then at least one of the 300 gaps between the balls does not fulfill the specified limiting values. If the monitoring factor is <1 , then the coordinate measuring machine is in order.

Chapter

4

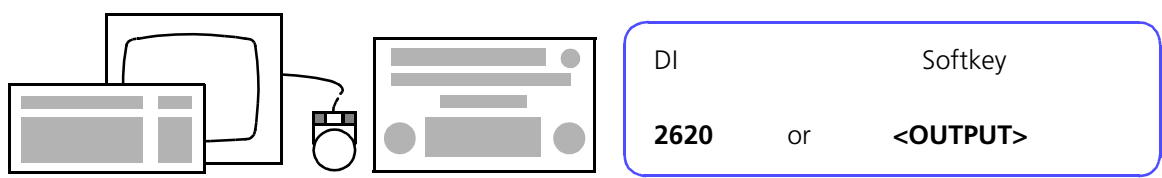
Evaluation

This chapter contains:

Example of a periodical inspection	4-3
Graphical output of the gap deviations	4-7
Table of the gap deviations	4-8
Arrangement of the ball plate in the measuring range as graphics	4-10

Once the CNC run has been concluded, the measuring results of the last measuring run (or any other measuring run) can be output in various forms.

Function call



Dialog window

Sphere test standard: Data administration

Evaluation result file: KPE_____ 0_B

			TESTREC	*	LMU DIA	DISTANCE	POS_DISP	
BACK					OUTPUT			INFO

Softkeys

TESTREC

Output of the monitoring record ➤ “Example of a periodical inspection” on page 4-3.

LMU DIA

Graphical output of the gap deviations ➤ “Graphical output of the gap deviations” on page 4-7.

DISTANCE

Table of the gap deviations ➤ “Table of the gap deviations” on page 4-8.

POS_DISP

Arrangement of the ball plate in the measuring range as graphics ➤ “Arrangement of the ball plate in the measuring range as graphics” on page 4-10.

Input field

Evaluation result file:
KPE_____ _B

Input of the result file which is to be evaluated.

Example of a periodical inspection

MEASURING RECORD			
PERIODICAL INSPECTION OF COORDINATE MEASURING MACHINE			
Location..: Main factory		Date : 18.2.92	
Department: Inspection		Time : 11.35	
Operator : Maier			
Measuring instrument =====		Artifact =====	
		Ident number	Dat.last calibration
Manufacturer : ZEISS		Ring : DK.NR.3391	= 11.01.1991
Type : UMC		Ball : 86313	= 11.01.1991
Invent.No. : 8721		Ball plate : DK.NR.3391	= 11.01.1991
Expansion coefficients =====			
Scales = see below		Ball : $5.50 \cdot 10^{-6}/K$	
Ball plate = $11.5 \cdot 10^{-6}/K$		RING : $10.5 \cdot 10^{-6}/K$	
Probe configuration =====			
Probe sphere diameter		: 8 mm	
Lateral deflection of probe		: 120 mm	
Measuring run =====			
Name of measuring run		: PLATE_ZX_3	
Record No.		: 7	
Limit values for the distance deviation =====			
A = 3.5 um			
K = 5 um/m			
Temperatures taken into consideration in the assessment =====			
Measuring volume = 22 °C			
Recording of further temperature value via internal module. See below for recording.			
Comments:			
.....			

Probe system assessment table

		Number of tols exceeded	U Factor
Ring	Range	0	0.8
	Diameter	0	0.4
Ball	Range	0	0.5
	Diameter	0	0.4

U Factor: monitoring factor

- for the form deviation:

$$U = R_{\max} / A_u$$

U = Monitoring factor

R_{\max} = Greatest form deviation from the three measurements

A_u = Limit value for A

- for the dimension deviation

$$U = |\Delta D|_{\max} / U_u$$

U = Monitoring factor

$|\Delta D|_{\max}$ = Highest value of the dimension deviation from the three measurements

U_u = Limit value for the measuring uncertainty

Position of the test standard

Coordinates 1st measurement			
	X	Y	Z
Ball 1	309.1392	-350.3396	-439.8169
Ball 5	569.7081	-555.8951	-439.9698
Ball 21	310.8728	-348.2373	-107.6551
Coordinates Repetition			
	X	Y	Z
Ball 1	309.1372	-350.3378	-439.8185
Ball 5	569.7060	-555.8949	-439.9714
Ball 21	310.8721	-348.2372	-107.6575
Differences			
	X	Y	Z
Ball 1	0.0020	0.0009	0.0016
Ball 5	0.0021	-0.0001	0.0016
Ball 21	0.0007	-0.0001	0.0024

Summary of gap deviations

Number of of intervals		Number of tols exceeded			
				U factor	
300		0		0.7	

U Factor:
Monitoring factor for the gap deviation on the sphere test standard

$U = (\Delta L/U_u)_{\max}$

U = Monitoring factor

$|\Delta L| = L_{\text{nom}} - L_{\text{act}}$ with L = length between the balls

U_u = Limit value for the measuring uncertainty

Graphical output of the gap deviations

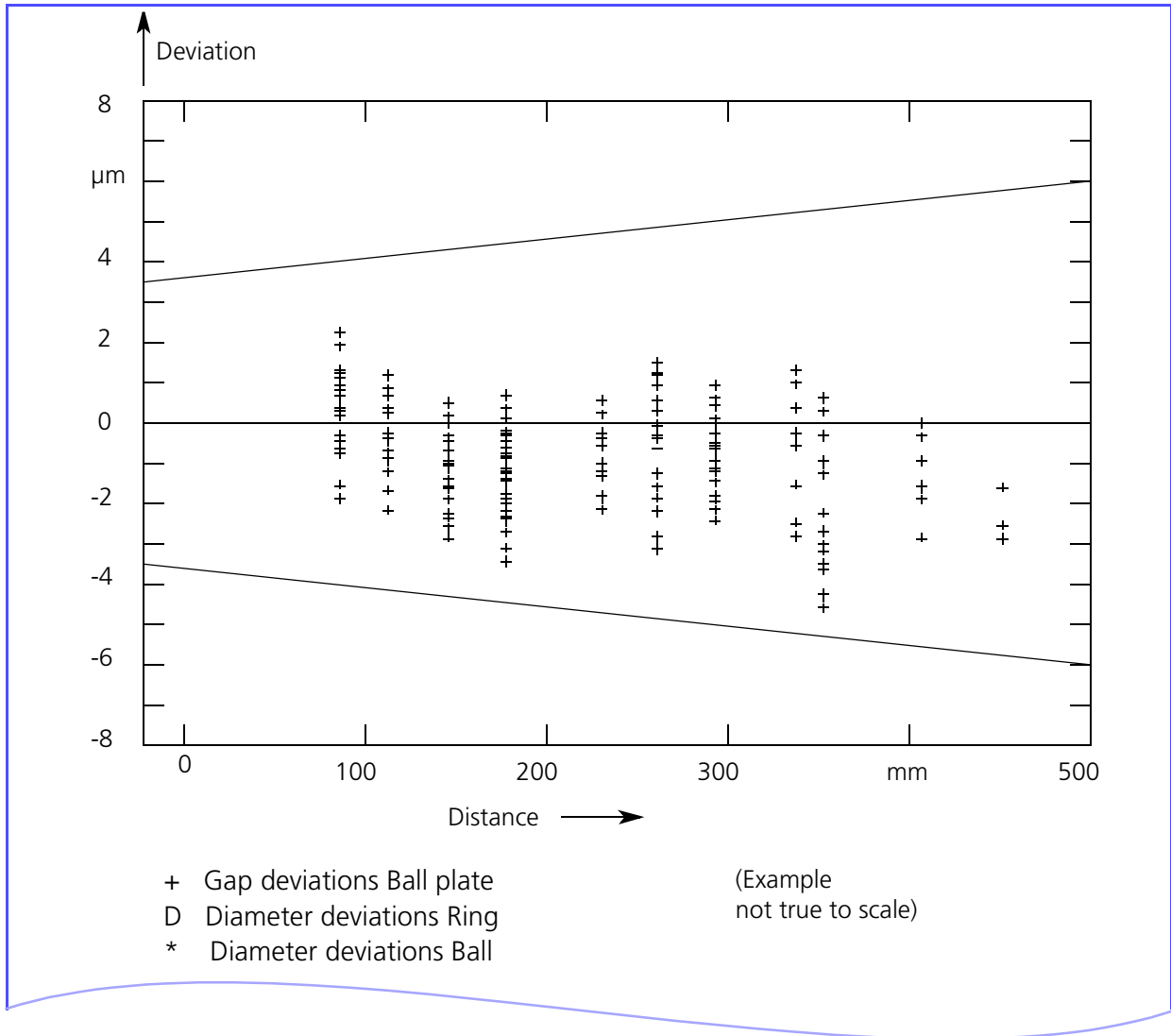


Table of the gap deviations

Interval ball/ball	Nominal mm	Actual mm	Deviation mm	Tols exceeded mm
1 / 2	82.9987	82.9974	-0.0013	
1 / 3	165.9978	165.9970	-0.0008	
1 / 4	249.1790	249.1779	-0.0011	
1 / 5	331.8890	331.8882	-0.0008	
1 / 6	83.0654	83.0638	-0.0016	
1 / 7	117.6773	117.6753	-0.0020	
1 / 8	185.7601	185.7584	-0.0017	
1 / 9	262.6745	262.6726	-0.0020	
1 /10	342.1445	342.1432	-0.0013	
1 /11	166.0922	166.0910	-0.0013	
1 /12	185.7192	185.7178	-0.0024	
1 /13	234.6658	234.6639	-0.0019	
1 /14	299.1800	299.1769	-0.0030	
1 /15	371.2782	371.2753	-0.0029	
1 /16	249.2043	249.2018	-0.0025	
1 /17	262.4903	262.4873	-0.0030	
1 /18	299.2437	299.2410	-0.0027	
1 /19	352.2632	352.2599	-0.0034	
1 /20	415.0903	415.0878	-0.0025	
1 /21	332.1739	332.1705	-0.0034	
1 /22	342.3282	342.3244	-0.0038	
1 /23	371.5208	371.5174	-0.0035	
1 /24	415.1227	415.1191	-0.0030	
1 /25	469.7909	469.7878	-0.0030	

Table of the gap deviations, continued

1 / 2	82.9987	82.9974	-0.0013	
1 / 3	165.9978	165.9970	-0.0008	
1 / 4	249.1790	249.1779	-0.0011	
1 / 5	331.8890	331.8882	-0.0008	
1 / 6	83.0654	83.0638	-0.0016	
1 / 7	117.6773	117.6753	-0.0020	
1 / 8	185.7601	185.7584	-0.0017	
1 / 9	262.6745	262.6726	-0.0020	
1 / 10	342.1445	342.1432	-0.0013	
1 / 11	166.0922	166.0910	-0.0013	
1 / 12	185.7192	185.7178	-0.0024	
1 / 13	234.6658	234.6639	-0.0019	
1 / 14	299.1800	299.1769	-0.0030	
1 / 15	371.2782	371.2753	-0.0029	
1 / 16	249.2043	249.2018	-0.0025	
1 / 17	262.4903	262.4873	-0.0030	
1 / 18	299.2437	299.2410	-0.0027	
1 / 19	352.2632	352.2599	-0.0034	
1 / 20	415.0903	415.0878	-0.0025	
1 / 21	332.1739	332.1705	-0.0034	
1 / 22	342.3282	342.3244	-0.0038	
1 / 23	371.5208	371.5174	-0.0035	
1 / 24	415.1227	415.1191	-0.0030	
1 / 25	469.7909	469.7878	-0.0030	
<hr/>				
3 / 4	82.9987	82.9974	-0.0013	
3 / 5	165.9978	165.9970	-0.0008	
3 / 6	185.7192	185.7178	-0.0024	
3 / 7	117.6773	117.6753	-0.0020	
3 / 8	83.0654	83.0638	-0.0016	
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A3.2				
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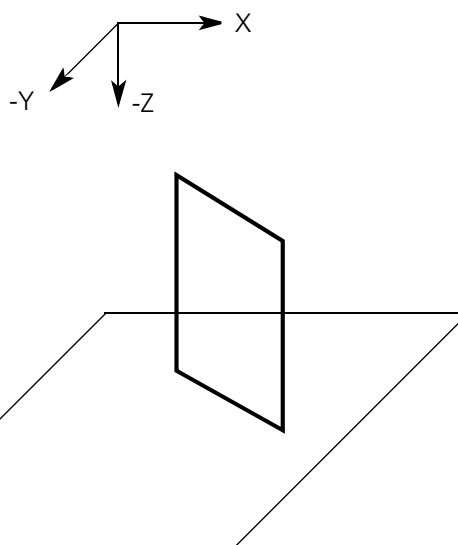
Arrangement of the ball plate in the measuring range as graphics

Measuring range:

X: 850

Y: 1200

Z: 600



Appendix

Study group of manufacturer-independent monitoring of coordinate measuring machines

The monitoring of coordinate measuring machines with ball plates is based on the specifications of a study group which has been formed on the initiative of the companies Bosch and Volkswagen AG and to which the following companies/institutions belong:

- Bayerische Motorenwerke AG, Munich
- Robert Bosch GmbH, Stuttgart
- IBM Deutschland, Sindelfingen
- Siemens AG, Munich
- Volkswagenwerk AG, Wolfsburg/Salzgitter
- Bundesamt für Wehrtechnik und Beschaffung
- Physikalisch-Technische Bundesanstalt, Braunschweig

The following companies produce ball plates with 25 balls:

- Kolb und Baumann, Aschaffenburg
- KOMEG Präzision, Völklingen
- Retter, Albstadt

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