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QC20 ballbar volumetric testing using a single program

Introduction

One of the benefits of the QC20 ballbar and Ballbar 20 software is the ability to carry out partial arc data capture and analysis. This allows the user to capture data over three test planes using a single mechanical set-up.

This application note provides information to create a single part program which enables the user to carry out three plane testing without the need to remove the QC20 ballbar, or switch machine programs between test planes, further reducing test time.

This application note breaks the procedure down into three sections:

- Descriptive overview of procedure
- Example part program
- Look-up table of machine co-ordinates for different length ballbars

NOTE: All examples and tables in this document assume that the 360° test is in the X,Y plane and that the work offsets on the machine are set to '0.0' in X, Y and Z before carrying out any testing.

Testing procedure

Using a single part program for data capture allows the user to carry out a test on all three planes without the need to remove the ballbar from the mounts or switch machine programs for different test planes.

The table below details what happens at each stage of the test process:

- Steps in **orange** text are the same as using the conventional 'three program' set-up.
- Steps in **black** text are the steps which must be added to create a single part program.

Ballbar 20	• Select the XY test from the machine folder. • Load the QC20 into the machine. • Run the XY test in the usual manner and save when finished.	
Machine program	• Press 'cycle start' on the machine. • The machine moves to the start of the ZX test in an arc. *(There is no need to remove the QC20)*	
Ballbar 20	• Go back to the machine folder and select the ZX test. • Click the forward arrow until you are back at the 'run test' screen. • Start the software and press 'cycle start' on the machine. • Save when finished.	
Machine program	• Press 'cycle start' on the machine. • The machine moves to the start of the ZY test in an arc. *(There is no need to remove the QC20)*	
Ballbar 20	• Go back to the machine folder and select the ZY test. • Click the forward arrow until you are back at the 'run test' screen. • Start the software and press 'cycle start' on the machine. • Save when finished.	
Machine program	• Press 'cycle start' on the machine. • The machine moves to the start of the XY test in an arc. *(There is no need to remove the QC20)* • At this point the test can be repeated if required.	
Ballbar 20	• Click the 'analysis' button. • Click the 'volumetric mode' button to import the tests from the XY and ZX tests.	

Example part program:

NOTE: The program is written for 100 mm ballbar length and code may vary on some machine controllers.

The simplest way to generate a single part program is to create three part programs (one for each test plane) using Ballbar 20 software and then edit them using a text editor program to add the 'connecting moves' (in black below). These moves can be written using the machine co-ordinates 'look up' table on the following page.

- Sections in **orange** text can be generated from Ballbar 20 Part Program Generator.
- Sections in **black** text must be manually written using the look-up table.

Example machine part program	QC20 ballbar
	
(XY PLANE 360/45') G21 G54 G90 G17 G64 G98 F1000.000 G01 X101.500 Y0.000 Z0.000	Machine moves to first position (start of XY plane).
M00 (LOAD BALLBAR) G01 X100.000 Y0.000 G03 X100.000 Y0.000 I– 100.000 J0.000 G03 X0.000 Y100.000 I–100.000 J0.000 G01 X0.000 Y101.500 G04 X3.	Machine performs 360° counterclockwise rotation with 45° overshoot on XY plane.
G01 X0.000 Y100.000 G02 X0.000 Y100.000 I0.000 J–100.000 G02 X100.000 Y0.000 I0.000 J–100.000 G01 X101.500 Y0.000	Machine performs 360° clockwise rotation with 45° overshoot on XY plane.
(ZX PLANE 22') G18 G03 X94.109 Z–38.023 I–101.500 K0.000 M00	Machine moves in an arc to start of fi rst partial arc test - ZX plane. (*The QC20 does not need to be removed)*
(SELECT ZX TEST 220/2') G01 X92.718 Z–37.461 G02 X–92.718 Z–37.461 I–92.718 K37.461 G01 X–94.109 Z–38.023 G04 X3.	Machine performs 220° clockwise rotation with 2° overshoot on ZX plane.
G01 X–92.718 Z–37.461 G03 X92.718 Z–37.461 I92.718 K37.461 G01 X94.109 Z–38.023 G04 X1.	Machine performs 220° counterclockwise rotation with 2° overshoot on ZX plane.
(XY plane 90') G17 G02 Y94.109 Z–38.023 I–94.109 K38.023 M00 (SELECT ZY TEST)	Machine moves from end of first partial arc test ZX plane to beginning of YZ plane. *(The QC20 does not need to be removed)*
(ZY TEST 220/2') G01 Y92.718 Z–37.461 G03 Y–92.718 Z–37.461 J–92.718 K37.461 G01 Y–94.109 Z–38.023 G04 X3.	Machine performs 220° counterclockwise rotation with 2° overshoot on YZ plane.
G01 Y–92.718 Z–37.461 G02 Y92.718 Z–37.461 J92.718 K37.461 G01 Y94.109 Z–38.023 G04 X1.	Machine performs 220° clockwise rotation with 2° overshoot on YZ plane.
G03 Y101.500 Z0.000 J–94.109 K38.032 G17 G02 X101.500 Y0.000 I0.000 J–101.500 M30	Machine returns to the original start position

Look up table of co-ordinates for different length ballbars

The tables below gives a list of co-ordinates for X, Y, Z start positions in each of the machine planes depending on the length of ballbar which is being used and the I, J, K co-ordinates for moving between test planes.

NOTES: The user must be sure that the I,J,K values are correct in the program for the moves between tests and that the start positions for X,Y,Z are also correct to avoid potential for damage to the ballbar / machine tool.

All co-ordinates assume that the work co-ordinates of the machine are set to '0.0' during mechanical set-up of the ballbar.

Ballbar length (mm)	Start position for plane:								
	XY			YZ			ZX		
	X	Y	Z	X	Y	Z	X	Y	Z
50	51.000	0.000	0.000	0.000	47.286	–19.105	47.286	0.000	–19.105
100	101.500	0.000	0.000	0.000	94.109	–38.023	94.109	0.000	–38.023
150	151.500	0.000	0.000	0.000	140.468	–56.753	140.468	0.000	–56.753
250	251.500	0.000	0.000	0.000	233.187	–94.214	233.187	0.000	–94.214
300	301.500	0.000	0.000	0.000	279.546	–112.944	279.546	0.000	–112.944
400	401.500	0.000	0.000	0.000	372.264	–150.405	372.264	0.000	–150.405
450	451.500	0.000	0.000	0.000	418.624	–169.135	418.624	0.000	–169.135
550	551.500	0.000	0.000	0.000	511.342	–206.596	511.342	0.000	–206.596
600	601.500	0.000	0.000	0.000	557.701	–225.326	557.701	0.000	–225.326

Ballbar length (mm)	Co-ordinates to move from:								
	XY to ZX			YZ to ZY			ZX		
	I	J	K	I	J	K	I	J	K
50	–51.000	0.000	0.000	–47.286	0.000	–19.105	47.286	0.000	–19.105
100	–101.500	0.000	0.000	–94.109	0.000	–38.023	94.109	0.000	–38.023
150	–151.500	0.000	0.000	–140.468	0.000	–56.753	140.468	0.000	–56.753
250	–251.500	0.000	0.000	–233.187	0.000	–94.214	233.187	0.000	–94.214
300	–301.500	0.000	0.000	–279.546	0.000	–112.944	279.546	0.000	–112.944
400	–401.500	0.000	0.000	–372.264	0.000	–150.405	372.264	0.000	–150.405
450	–451.500	0.000	0.000	–418.624	0.000	–169.135	418.624	0.000	–169.135
550	–551.500	0.000	0.000	–511.342	0.000	–206.596	511.342	0.000	–206.596
600	–601.500	0.000	0.000	–557.701	0.000	–225.326	557.701	0.000	–225.326

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Summary

Generating a single part program for volumetric ballbar testing reduces test time by eliminating the need to remove the QC20 ballbar in between test planes and switching between the conventional three machine plane programs.

The simplest way to create the single part program is to generate three part programs using the Ballbar 20 software and then copy them into a text editor program such as WordPad / TextPad. At this point three 'connecting moves' must be entered into the program to move the machine between machine planes and back to the start position at the end of the test.

The 'connecting moves' can be written using the machine co-ordinates in the look-up table on this application note as reference for the required ballbar length.

- Care should be taken when entering the co-ordinates to ensure that they are for the correct length ballbar.
- The part program should always be tested first without the ballbar in place to ensure that it is correct.

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