Liné alignment report January 4 - 5, 2006

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SUMMARY

Document contains data collected on a number of Line alignment tests conducted January 4th and 5th, 2006.

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Line Alignment Report – January 4-5, 2006

SR-2006-01

T. Osmond

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Introduction

Liné alignment tests were conducted during January 4th and 5th, 2006 to ascertain the alignment values for the newly installed spindle. Guy Collins and Stan Butler conducted tests 1 – 7, January 4th. Test 8 was conduced by Tony Randell on the following day. This report contains the findings of these tests.

Almost all measurements of misalignment were made using a dial gauge with a magnetic base that could hold to either flat or curved metal surfaces. For non-metallic surfaces the base could be taped or held in place using some other method. The dial gauge itself was accurate to approximately +- 0.00025" and it connected to the base via an adjustable arm.

All tests were conducted using a granite reference table located in the milling pit. Before testing could commence the reference table was levelled to be parallel with the XY plane of the Liné. The table was placed on jacks and micro adjusted to be parallel. A dial gauge was attached to the Liné yoke and the gauge was run in the X direction and the table was adjusted until runout was 0.0000". The gauge was then run in the Y direction and the table was adjusted until the runout was 0.0000" (see Figure 1). From this point forward the table was considered to be parallel with the XY plane of the Liné and was thereafter used as a reference plane.

Test 1

The purpose of the first test was to investigate whether or not the rotational C axis is orthogonal to the XY plane of the Liné. To test this the center of the spindle was brought to approximately the center of the reference table about 6" above the table (in the - z direction). The base of the dial gauge was attached to the yoke and the dial gauge extended out and touched off the table at a radius of approximately 8" (see Figure 2). The C axis was then rotated through 0, +90, +180, -90, -180 degrees and the runout was recorded at each rotation (see Table 1). Note here that negative runout indicates that there is an increasing distance between the table and the yoke.

Degree	Runout (Inches)
0	0.00000
90	0.00050
180	-0.00050
-90	-0.00075
-180	0.00000

Table 1

Trigonometry of these values gives a maximum misalignment of the C axis to be 0.0054 degrees, which is negligible.

These results not only indicate a negligible angle of misalignment in the C axis but because we have a difference of 0.00050" at 180 and -180 degrees our data would indicate that we have a noise band of approximately 0.00050” given that the two values should be equivalent.

Test 2

Once the orthogonality of the C axis was established the second test could be conducted. The purpose of the second test was to establish the orthogonality of the spindle rotation with respect to the XY plane. For this test the base of the dial gauge was attached to the spindle as oppose to the yoke. The dial gauge was extended out and touched off the table at measured distances, similar to Test 1 (see Figure 3). For this test the spindle was rotated by hand and the runout was again recorded. For this test two different radii were tested; approximately 3.5” and approximately 6”. The runout values for both cases were seen to be 0.0000” as measured by the dial gauge. This test indicated that the misalignment of the spindle axis of rotation is effectively 0 degrees with respect to the XY plane.

For the next set of tests a granite angle block having two sides perfectly perpendicular was needed. The angle block was put in place and checked to be parallel with x axis (see Figure 4). The stone block was carefully tapped into place using a plastic hammer and measured using the dial gauge. The dial gauge was attached to the yoke and ran in the + x direction across the surface of the stone. The stone was considered to be in place when the runout from this measurement was 0.0000”.

Test 3 A, B

For the next set of tests the ram runout was measured in both the XZ plane and the YZ plane. This was accomplished by running the dial gauge up two surfaces of the angle block, the surface parallel with the XZ plane and the surface parallel with the YZ plane. The dial gauge base was attached to the yoke of the Liné (see Figure 5). For both experiments the z = 0” is 45.5” from the z home location of the Liné. The dial gauge is moved upward in the - z direction. The results of each experiment are shown in Table 2 and Table 3.

A – Checking Z Ram for Y runout of the XZ plane

Travel Position		Runout
z =	0"	0.00000
	6"	-0.00075
	10"	-0.00150
	21"	-0.00150
	30"	-0.00100
	35"	-0.00500

Table 2

B – Checking Z Ram for X runout of the YZ plane

Travel Position		Runout
z =	0"	0.00000
	6"	0.00100
	11"	0.00000
	21"	-0.00250
	30"	-0.00300
	35"	-0.00350

Table 3

These measurements indicate that there is some runout in the z ram in both planes. This is due to the fact that the z ram tracks are not perfectly planar.

For Tests 4, 5 and 6 a benchmark tool was used. The benchmark tool is a 12" long, 2" diameter straight, balanced cylindrical reference tool that is dimensionally accurate to a very high tolerance.

Test 4

The next test was a simple experiment conducted to ensure that the B axis rotation of 90 degrees is exactly 90 degrees. For this test the benchmark tool was but in the Liné spindle and the B axis was rotated to 90 degrees. The C axis was fixed at 0 degrees rotation so that the tool was parallel with the X axis. To measure to see if the B axis was indeed rotated to exactly 90 degrees the height of the tool above the reference table was measured at both ends of the tool (see Figure 6). The difference in height would indicate the misalignment of the B axis. The test found that the difference in height was effectively 0". This confirmed the accuracy of the B axis angle of rotation.

Test 5

Further checks were required to verify the complete accuracy of the B axis. Next the B axis was checked to confirm that when it was rotated to a full 90 degrees that the spindle tool would indeed be parallel with the X axis. For this test the distance of the tool was again measured at both ends but this time it was measured from the angle block as oppose to the reference table (see Figure 7). For this test the difference between both measurements was again found to be 0". This confirmed the alignment of the B and C axes with respect to angle of rotation.

Test 6

For the final B axis test, the sweep runout was measured as the B axis was rotated from 0 to 45 degrees. The distance from the tip of the benchmark tool to the angle block was measured as the tool was rotated 45 degrees and the runout was recorded (see Figure 8). In this experiment as runout of -0.00050" was measured from 0 to 45 degrees, which is within the noise band. Therefore the runout of the B axis through a sweep of 45 degrees is negligible.

Test 7

This test was conducted to measure skewness of the X and Y tracks or the perpendicularity between the two tracks. For this measurement the reference block was used as the reference angle of 90 degrees. To measure this angle the angle block was laid down on it's face (see Figure 9). The dial gauge was attached to the yoke of the Liné and the Liné was moved back and forth in the X direction running the dial gauge along the XZ surface of the angle block. The runout was measured in the XZ plane and the angle block was tapped and adjusted until the runout was measured to be 0.0000" across the bottom surface of the block. Next the runout was measured across the YZ surface of the block assuming the XZ and YZ surfaces of the angle block to be perfectly perpendicular. The runout of the dial gauge across the YZ plane of the angle block was measured over 33" to be 0.0000" therefore we are able to conclude that the X and Y tracks of the Liné are perpendicular.

Test 8

The final test conducted to explore the proper alignment of the Liné was an investigation into the alignment of the spindle rotational axis with respect to the rotational C axis. For this experiment a bearing with an outer radius of 4.333" was used as a reference circle. The bearing was laid out flat on the reference table and held in place using two-sided tape. The base of a dial gauge was attached to the spindle and the gauge was touched off the outside of the bearing. The spindle was turned by hand and small XY adjustments were made until the spindle axis was dead center of the bearing center point (at this location, turning the spindle a complete revolution would produce no change in the dial gauge reading). Next the C axis was rotated to +90, +180, 0, -90, and -180 degrees. At each rotation position the dial gauge was rotated completely around the bearing by turning the spindle by hand (see figure 10).[1] The dial gauge readings were recorded for four angles of rotation (0, 90, 180 and 270) for the spindle, for each rotation position of the C axis and are contained in Appendix A.

The results of Test 8 confirm that there is a misalignment between the spindle and C axis. The results show a maximum runout in the gauge at 180 or -180 degrees rotation of the C axis. At this rotation there was no runout in the y direction and between 0.0030" and 0.0035" runout in the X direction. This reveals that the spindle is properly aligned in the Y direction but is ahead of the C axis in the X direction by approximately 0.00175" as the runout for the misaligned spindle will be doubled when rotated 180 degrees.

[1] Ideally a perfectly aligned spindle and C axis will yield a dial gauge readout of 0 for all angles of rotation of both axes.

Figure 1

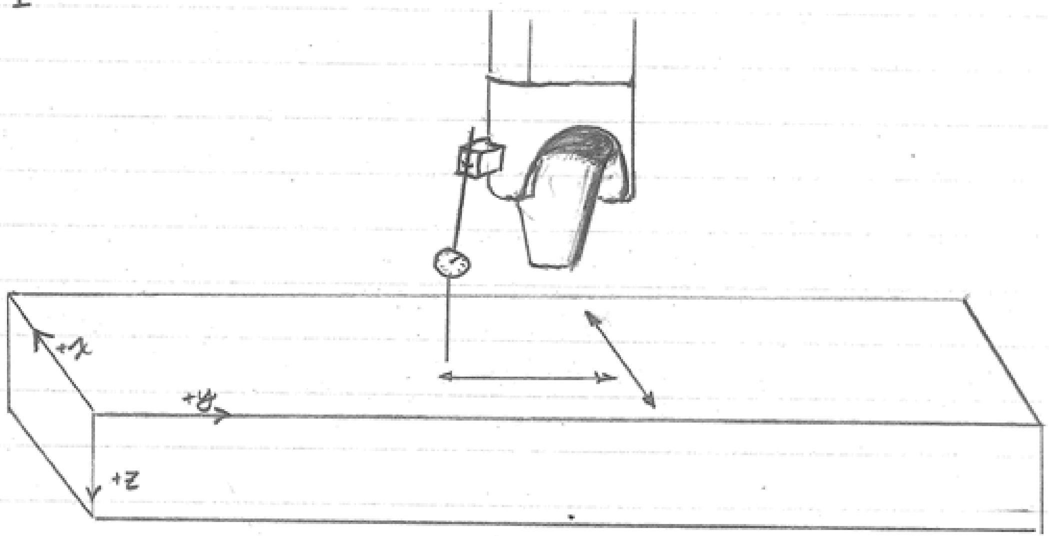


Figure 2

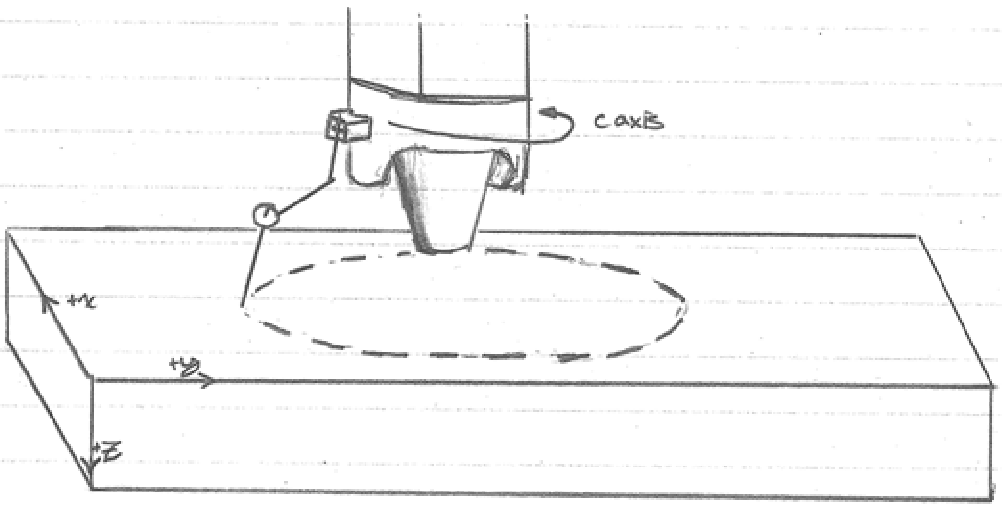
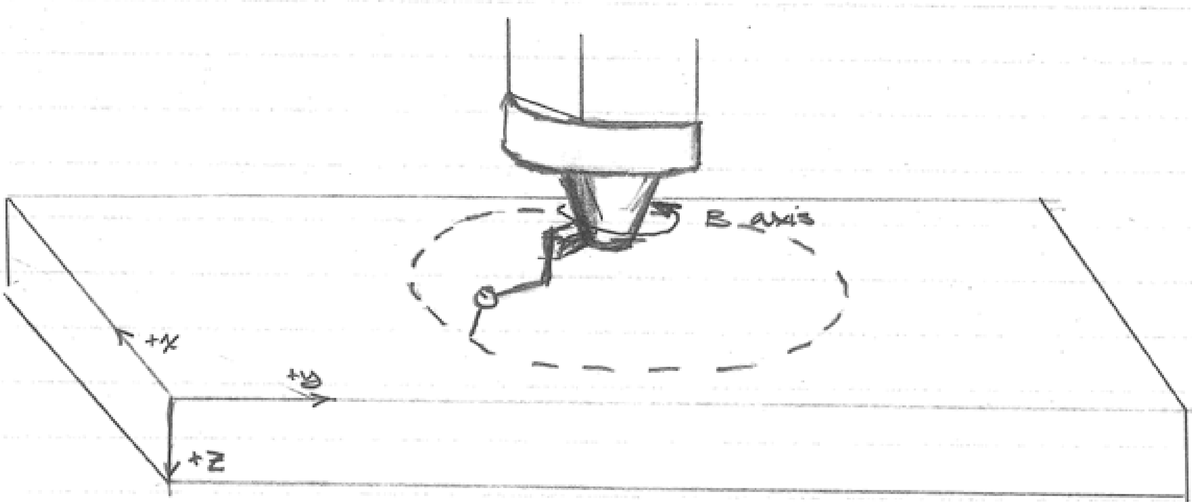


Figure 3



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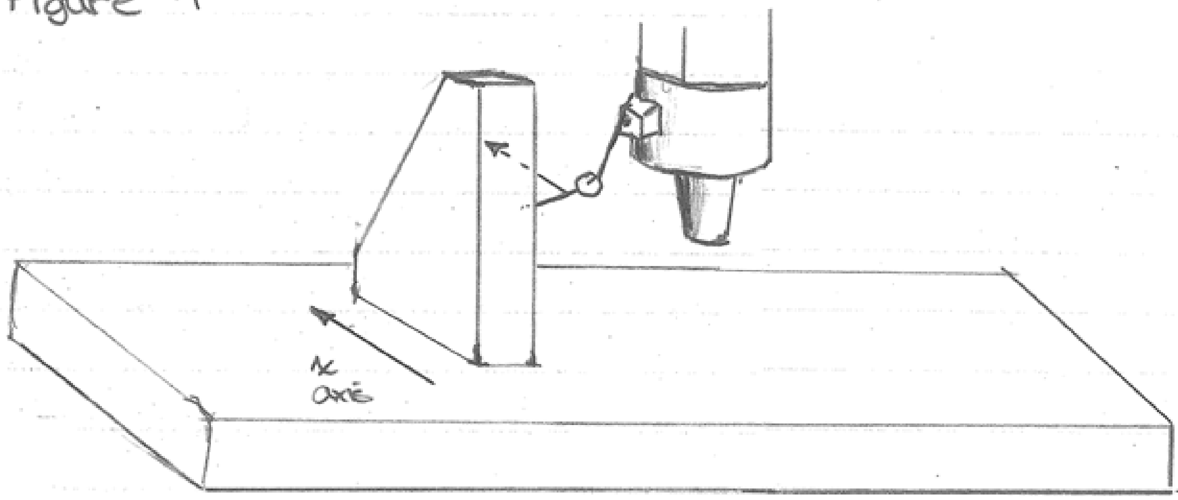

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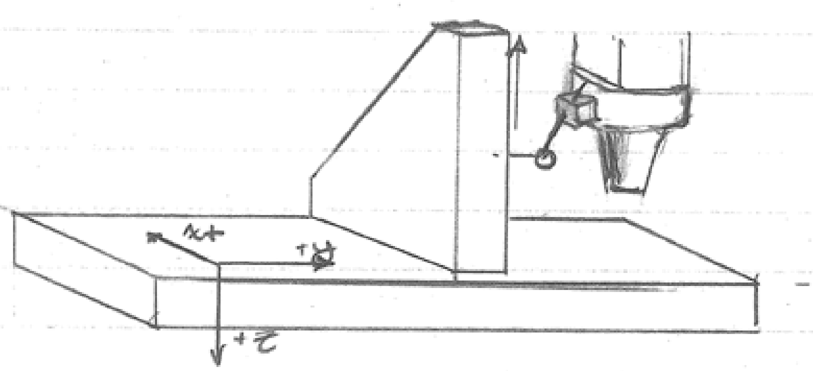

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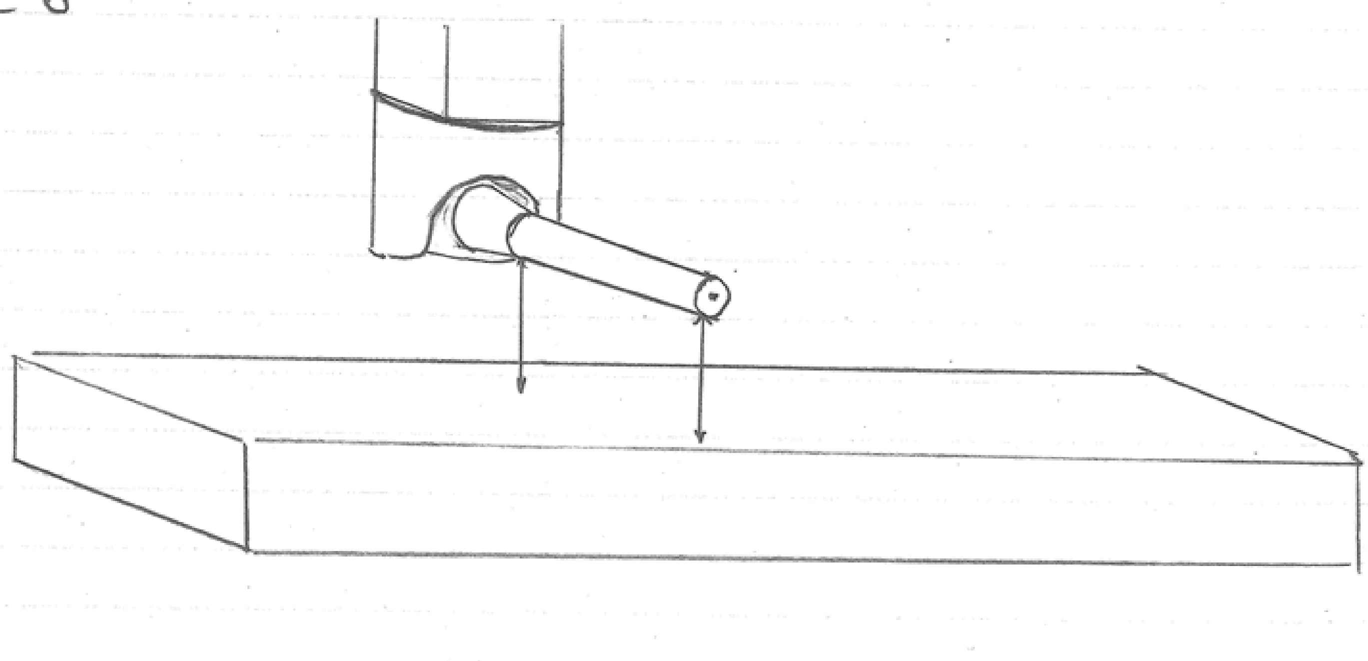


Figure 7

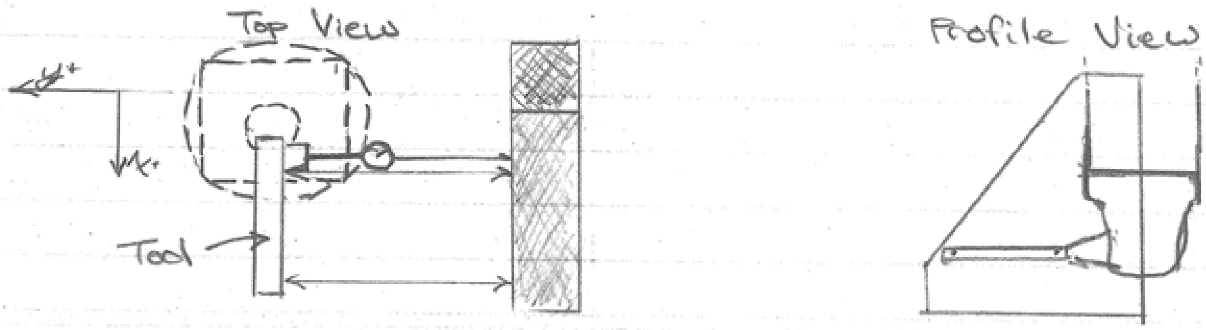


Figure 8

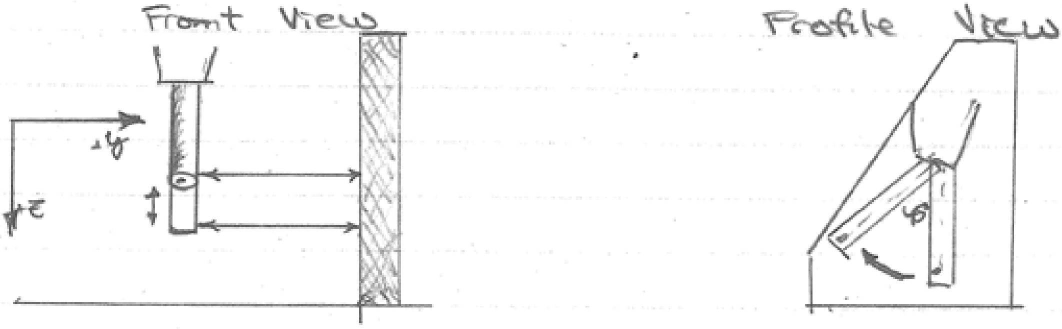


Figure 9

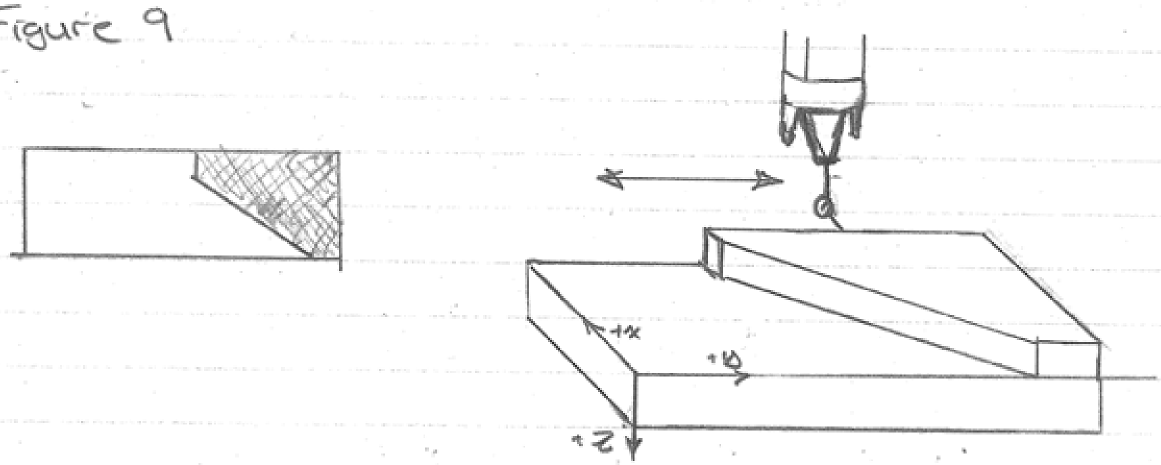
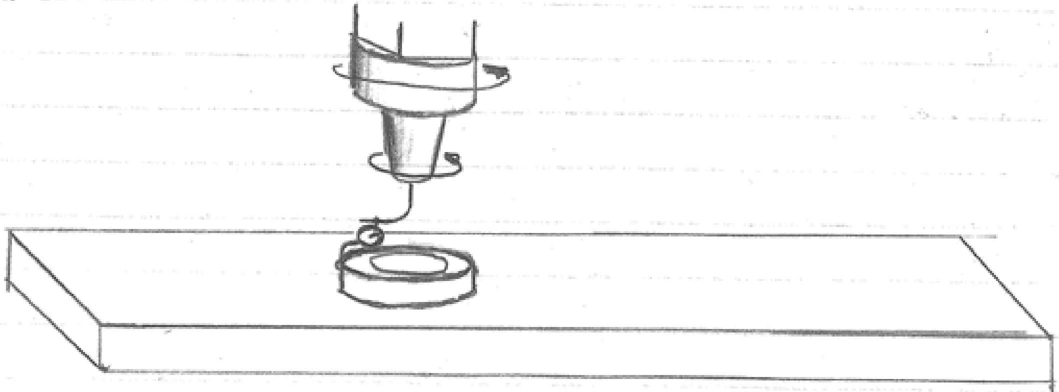


Figure 10

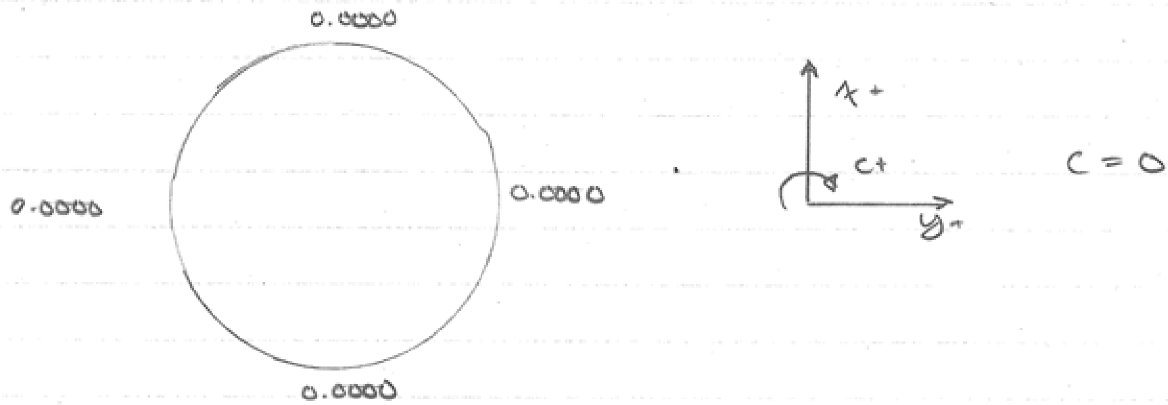


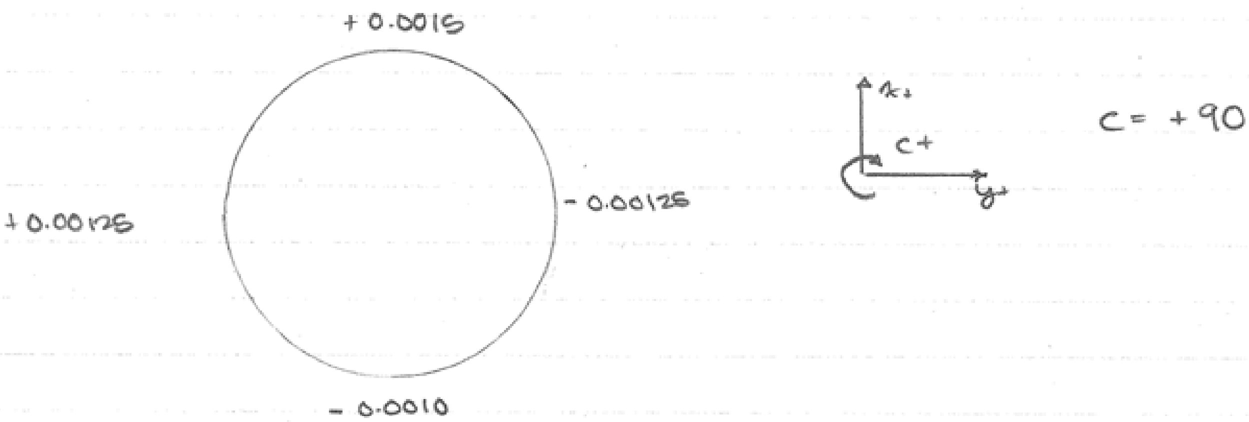
APPENDIX A – RESULTS OF TEST 8

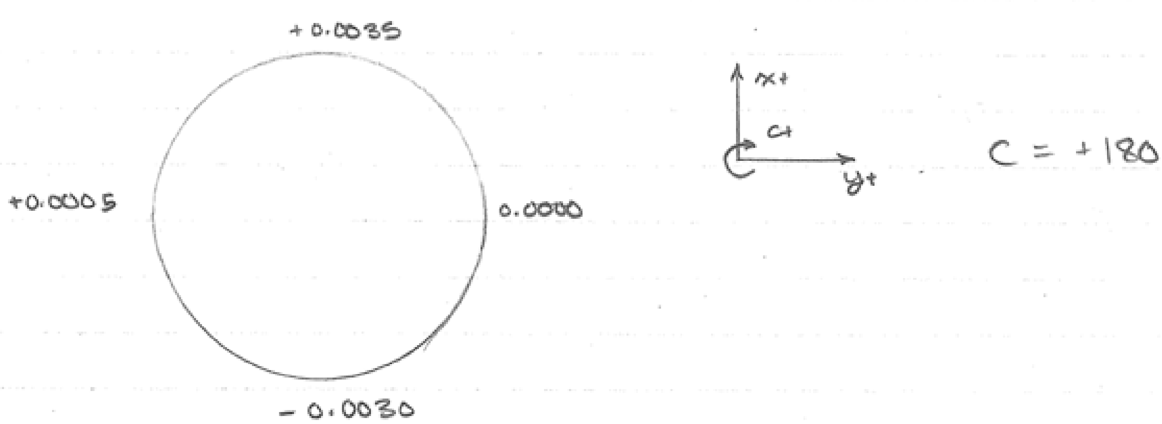
Appendix A

Results of Test 8

Dial Gauge readouts at four locations around bearing







Appendix A

The c axis was next taken back to zero and the gauge was rechecked