Procedure Name: The Calibration Of Indexing Tables By The Method Of Subdivision
Procedure Number: MSQP-821-14030S-00

1. PURPOSE

The purpose of this procedure is to measure the angular deviations from nominal at specified increments on rotary indexing tables.

2. SCOPE

The calibration of indexing tables by subdivision requires two indexing tables and a method of rotating them through several sets of measurements. Any angular increment on an indexing table can be measured depending on the starting position and the number of intervals at which the data is collected. An NIST standard indexing table is always measured with a customer table. The NIST table is then considered a check standard and the results from this table are used to determine if the calibration was performed correctly.

Sign convention is critical during indexing table calibration and must be carefully monitored to insure the measured deviations are in the proper direction and associated with the correct angular interval.

3. DEFINITIONS AND REFERENCES

NBSIR 75-750 "The Calibration of Indexing Tables by Subdivision".

Dimensional Metrology Group Procedures:
> Unpacking and Logging of Artifacts
> Logging out and Shipping of Artifacts

Autocollimator, check standard, rotary table, sign convention, eyeloop, hood, etc.

4.0 PRE-CALIBRATION PROCEDURES

4.1 The indexing table is unpacked and logged into the database according to standard procedures.

4.2 The serial number and manufacturer is recorded on the data sheets provided in the laboratory.

Any other pertinent information regarding the calibration is also recorded.

4.3 The direction of the numbered increments on the table must be carefully denoted on the data sheets. This is critical for proper calibration.

4.4 The indexing table to be calibrated must be checked to insure the integrity of the results.

4.4.1 The indexing table is inspected for damage. Damage may include rust, dents, broken handles. Denote any damage on the data sheets.

4.4.2 The locking mechanism of the table must be checked for proper tension. This tension is required for proper calibration. If the locking mechanism is not working properly. contact the customer for further instructions.

4.5 The NIST master indexing tables must be checked to insure the integrity of the results.

4.5.1 The NIST master 1440 and 513 tables must be inspected for damage and wear. Any rust must be removed. If the 1440 table is leaking excessive oil, the fittings must be replaced.

4.5.2 The locking mechanisms for each table must be checked for proper performance. The locking arm must be under tension to insure proper seating of the table.

4.6 The autocollimator voltage output must be checked for linearity.

4.6.1 Turn on the autocollimator power supply and voltmeter.

4.6.2 Connect the J-3 and J-4 terminal cords to the proper input terminals on the power supply. The polarity of the input must be correct to insure the proper sign convention.

4.6.3 Flip the autocollimator power unit B to "MANUAL" so the output on the autocollimator can be manually adjusted.

4.6.4 Adjust the dial on the autocollimator to read 0 revolutions.
Record the output from the voltmeter.

4.6.5 Adjust the dial forward exactly one full revolution. Record the voltage on the voltmeter. Continue this until the full range has been calibrated.

4.6.6 The calibration should result in one revolution being equivalent to one volt over most of the range of the autocollimator. One revolution is equivalent to one second of angular deflection.

4.6.7 If the calibration does not perform as expected, adjust the gain on the power supply and recalibrate the range. Continue until one dial revolution is equivalent to one volt of output.

4.6.8 Reset power unit B to "AUTO".

5.0 SETUP PROCEDURE

5.1 Center the customer indexing table on top of the NIST table 513 using a dial indicator and stand. Use epoxy to secure the test table to the 513.

5.2 Center the mirror on the top of the customer table. Secure the mirror with hex bolts. DO NOT OVERTIGHTEN HEX BOLTS!

5.3 Adjust the height of the autocollimator so the mirror is centered in the field of view of the collimator.

5.4 Move the NIST standards 1440 and 513 to the 0 degree locations. Also move the test table to 0 degrees.

5.5 Turn on the power to the autocollimator and check that the horizontal axis is being measured.

5.6 Using the Moore rotary table, move the entire assembly around until the mirror is in alignment with the autocollimator. Carefully adjust the angle until the dial output is centered in the operating range on the voltmeter.

5.7 Use the eyeloop to view the reflection in the autocollimator. Check that the full mirror reflection is within the field of view.

5.8 Position the mirror hood over the mirror without moving the position of the autocollimator or the indexing table assembly. This is shown in Figure 1. The hood must cover the mirror completely so extraneous light from the room does not interfere with the readings. (The measurement may be performed in a dark room if possible).

Figure 1

5.8 The assembly must be allowed to warm up and come to equilibrium. This may take 1 or 2 hours.

6.0 CALIBRATION PROCEDURES

NOTE: The direction of the numbering on the customer indexing table is critical to the proper sign convention. If the customer table is numbered in the COUNTERCLOCKWISE direction, the table must be compared with the NIST STANDARD 1440. If the customer table is numbered in the CLOCKWISE direction, the table must be compared with the NIST STANDARD 513.

A second check must be performed to insure the proper sign convention. If the customer table is numbered COUNTERCLOCKWISE and the NIST 1440 is used, the autocollimator must have a positive deflection when the test table is turned in the direction of an increasing angle. If the customer table is numbered CLOCKWISE and the NIST 513 is used, the autocollimator must have a negative deflection when the test table is turned in the direction of an increasing angle.

6.1 Choose the proper data recording sheet depending on the NIST check standard being used. Also choose either the 13 measurements per cycle test or the 7 measurements per cycle test. The 13 measurements per cycle test will result in a lower uncertainty value than the 7 measurement test.

6.2 After the proper warm up time, the calibration may begin. Insure that each table is well seated by using the lever arms to reseat each table. Each table MUST be at the 0 degree position. If the autocollimator is not on scale, re-adjust using the Moore rotary table.

6.3 Begin the calibration by recording the voltage reading at the 0 degree position. Follow the data sheets and rotate the test table +30 degrees and the NIST table +30 degrees. Be sure to carefully seat the table after each turn. The mirror should again be centered with the autocollimator and the voltage should be recorded.

NOTE: If the table is seated too hard or dropped into position, the voltage output will jump substantially indicating the assembly has moved. If this occurs, only the immediate cycle needs to be remeasured. The data in already completed cycles is still good.

6.4 Continue taking measurements according to the data sheet until a full cycle is complete.

NOTE: If the 13 measurements per cycle test is being used, the table positions at the beginning and the end of the cycle are the same. The voltage output should be approximately the same, within 0.25 volts. If this is not achieved, the cycle should be repeated.

6.5 After the cycle is finished, the entire assembly must be moved +30 degrees for the next cycle. Using the NIST table not under test or the Moore rotary table, turn the assembly +30 degrees relative to the customer table. Reset the positions according to the data sheet and continue on through the cycle.

NOTE: The output can be readjusted to the middle of the operating range if desired by using the Moore rotary only at the beginning of a cycle. Any adjustment during a cycle will result in an incorrect
calibration.

6.6 Continue taking data and rotating the assembly according to the data sheets. The calibration of the 30 degree subdivisions is complete when all the data is taken. If the customer only requires 30 degree subdivisions to be calibrated, continue on to 7.0.

6.7 If the customer requires that a 30 degree division be divided into 5 degree increments, use the next page of the data sheet and reset the tables to the 0 degree positions.

6.8 Record the data for the 5 degree subdivisions following the same procedure as with the 30 degree divisions. Continue through each cycle until the data collection is complete.

6.9 If the customer requires that a 5 degree division be divided into 1 degree increments, reset the

table positions to 0 degrees and continue through the next set of cycles.

6.10 After all data is collected for each set of cycles, continue to the program "INDEX" to analyze the data.

7.0 DATA ANALYSIS

7.1 Using the program named "INDEX", follow the instructions for entering the data.

7.1.1 Input the serial number of the top (customer) table.

7.1.2 Input the serial number of the bottom (NIST Standard) table.

7.1.3 Input the number of primary subdivisions. This is equivalent to the amount each table is rotated at any one time during the calibration. For most calibrations, this is 30 degrees. Therefore the number of subdivisions is 12.

7.1.4 Input the number of measurements taken per cycle (7 or 13).

7.1.5 Input the sign of the measurements. This is critical for the proper sign convention for the measurements. If the top (customer) table was rotated CLOCKWISE and the bottom (NIST Standard) table rotated COUNTERCLOCKWISE the correct sign of the measurements is positive "+". If the top (customer) table was rotated COUNTERCLOCKWISE and the bottom (NIST Standard) table was rotated CLOCKWISE the correct sign of the measurements is negative "-".

THIS IS THE ONLY SIGN CHANGE MADE TO THE DATA. The data must be entered into the program exactly how it was read from the voltmeter.

7.1.6 Input the next subdivision for the table. The program expects "1" to be entered.

7.1.7 Input the readings by columns (cycles). Separate the data with commas. Do not include decimal points in the voltage data. The program will insert these later. (EXAMPLE: Input 4.32 as 432)

7.1.8 After all data is put into the computer, the program will ask for the next subdivision. If 30 degree increments are all that is required, enter 0 to exit and go to 7.2. If the customer wants a 30 degree increment to be subdivided into 5 degree increments, input 6.

7.1.9 Input the data from the partial closure design calibration of the 5 degree subdivisions. The data

entry is the same as for the 30 degree subdivisions.

7.1.10 After the data is entered, The program will ask for the next subdivision. If the 5 degree increments are all that is required, enter 0 to exit and go to 7.2. If the customer wants a 5 degree increment to be subdivided into 1 degree increments, input 5.

7.1.11 Input the data from the partial closure design calibration of the 1 degree subdivisions. The data entry is the same as for the 30 degree subdivisions.

7.1.12 After the data is entered for the one degree subdivisions, the program will calculate the deviations from nominal.

7.2 Create the calibration report according to the instructions in the program. The report must be generated and a copy signed by the group leader.

7.3 If historical data is available on the customer indexing table, compare the results and note any large fluctuations.

7.4 Record the data for the NIST check standard in the history logs. The data should agree with historical data for the standard. If the data does not agree, the entire calibration needs to be performed again.

8.0 POST-CALIBRATION PROCEDURES

Compile the lab folder and file accordingly.
Compile the test folder as required.
Prepare the shipping documents as required.
Pack the gage in its original packing material.

Calibration of Indexing Tables – 30 ˙ Intervals (7 Measurements)

Top Table SN._____ (Rotated CW – Positive Dir.)   DATE _____

COMPANY _____   OBS. _____

Bottom Table is 1440   (Rotated CCW - POSITIVE DIR.)

Third Table is 513   (Rotated CW – used to rotate the assembly between sets).

NOTATION 0/0 \0   {TOP/BOTTOM \THIRD}

0/0	30/60	60/120	90/180
30/30	60/90	90/150	120/210
60/60	90/120	120/180	150/240
90/90	120/150	150/210	180/270
120/120	150/180	180/240	210/300
150/150	180/210	210/270	240/330
180/180	210/240	240/300	270/0
120/240	150/300	180/0	210/60
150/270	180/330	210/30	240/90
180/300	210/0	240/60	270/120
210/330	240/30	270/90	300/150
240/0	270/60	300/120	330/180
270/30	300/90	330/150	0/210
300/60	330/120	0/180	30/240
240/120	270/180	300/240	330/300
270/150	300/210	330/270	0/330
300/180	330/240	0/300	30/0
330/210	0/270	30/330	60/30
0/240	30/300	60/30	90/60
30/270	60/330	90/30	120/90
60/300	90/0	120/60	150/120
OK TO PAUSE AFTER EACH SET OF 7 READINGS			

Comments

Calibration of Indexing Tables – 30 ˙ Intervals (7 Measurements)

Top Table SN._____ (Rotated CCW – Positive Dir.)   DATE _____

COMPANY _____   OBS. _____

Bottom Table is 513   (Rotated CW - POSITIVE DIR.)

Third Table is 1440   (Rotated CCW – used to rotate the assembly between sets).

NOTATION 0/0 \0   {TOP/BOTTOM \THIRD}

0/0	30/60	60/120	90/180
30/30	60/90	90/150	120/210
60/60	90/120	120/180	150/240
90/90	120/150	150/210	180/270
120/120	150/180	180/240	210/300
150/150	180/210	210/270	240/330
180/180	210/240	240/300	270/0
120/240	150/300	180/0	210/60
150/270	180/330	210/30	240/90
180/300	210/0	240/60	270/120
210/330	240/30	270/90	300/150
240/0	270/60	300/120	330/180
270/30	300/90	330/150	0/210
300/60	330/120	0/180	30/240
240/120	270/180	300/240	330/300
270/150	300/210	330/270	0/330
300/180	330/240	0/300	30/0
330/210	0/270	30/330	60/30
0/240	30/300	60/30	90/60
30/270	60/330	90/30	120/90
60/300	90/0	120/60	150/120
OK TO PAUSE AFTER EACH SET OF 7 READINGS			

Comments

Calibration of Indexing Tables - 5 Intervals

Notation: * 0 {513}   :   0/0 {Test/1440}   **Date _____**

(Take Readings Column by Column)

* 25 xxxxxxxxx	10/20	20/20	30/20
0/25	15/25	25/25	* 345 xxxxxxxxx
5/30	20/30	30/30	15/0
* 20 xxxxxxxxx	* 5 xxxxxxxxx	* 355 xxxxxxxxx	20/5
0/20	0/5	5/0	25/10
5/25	5/10	10/5	30/15
10/30	10/15	51/10	* 340 xxxxxxxxx
* 15 xxxxxxxxx	15/20	20/15	20/0
0/15	20/25	25/20	25/5
2/20	25/30	30/25	30/10
10/25	* 0 xxxxxxxxx	* 350 xxxxxxxxx	* 355 xxxxxxxxx
15/30	0/0	10/0	25/0
* 10 xxxxxxxxx	5/5	15/5	30/5
0/10	10/10	20/10	
5/15	15/15	25/15	

Calibration of Indexing Tables - 1 Intervals

(Take Readings Column by Column)

* 4 xxxxxxxxx	3/5	3/3	3/1
0/4	* 1 xxxxxxxxx	4/4	4/2
1/5	0/1	5/5	5/3
* 3 xxxxxxxxx	1/2	* 359 xxxxxxxxx	* 357 xxxxxxxxx
0/3	2/3	1/0	3/0
1/4	3/4	2/1	4/1
2/5	4/5	3/2	5/2
* 2 xxxxxxxxx	* 0 xxxxxxxxx	4/3	* 356 xxxxxxxxx
0/2	0/0	5/4	4/0
1/3	1/1	* 358 xxxxxxxxx	5/1
2/4	2/2	2/0	

OK to pause after each set of readings