Procedure Title: **Calibration of Polygons (14020)**
Revision Number: **Revision 1**
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1 Scope

Calibration of Polygons by Closure methods using indexing tables.

2 References

W. Tyler Estler, "Uncertainty Analysis for Angle Calibrations Using Circle Closure," J. Res. Natl. Inst. Stand. Technol. 103, 141 (1998).

3 Environmental Constraints

Angle measurements are not particularly affected by temperature change, and with a drift eliminating design the temperature of the lab may be within one degree of standard for a calibrations. Abnormal drift will cause the calibration, which has closure measurements as a test of consistency, to fail.

4 General

Optical polygons having sides equal to an integer divisor of 360 are calibrated optically on a stack of master index tables using the closure principle. Closure, or circle closure is the realization that the sum of all the errors in a 360 ° rotation of the index table must sum to zero, since the beginning and ending points are the same. Two index tables and an autocollimator are the equipment utilized for the calibration. The measured polygon angles are defined as the angle between reflective outward normals between adjacent faces. Each angular interval of the polygon is compared to one equal angular interval of the master index table, until all intervals of the polygon have been measured against all intervals of the indexing table, resulting in the index table errors dropping out. This happens because the error in any interval of the indexing table is constant and compared to each interval of the test polygon, when the average is determined for each polygon interval, the indexing table error becomes common mode and is averaged out of the polygon interval values. Each polygon is measured $(n+1)^2$ times. Calibration uncertainty is determined largely on two things, the long term reproducibility of the index tables, and the artifact geometry (flatness of each face). The calibration system is capable of measurement uncertainty on the order of 0.20 arc-sec, based on an artifact of exceptional geometry.

Each indexing table is set to its zero position. The test polygon is placed in the center of the top indexing table with its face labeled 1 facing the autocollimator. The autocollimator beam is aligned to the center of the polygon face. Fine adjustments are made by a third rotary table, located below the stack of two master tables, to rotate the stack and polygon until the polygon reflection is at the center of the autocollimator's measurement range. This constitutes the preparation part of the calibration. The polygon faces are cleaned one last time and the polygon is allowed to thermally stabilize.

Data is collected in the following manner. The autocollimator reading of polygon face 1 with each index table at zero is recorded. The top indexing table is rotated by the interval amount in a clockwise (CW) direction, and the bottom indexing table is rotated by the interval amount in a counterclockwise (CCW) direction. Another autocollimator reading is recorded and this process continues until the initial position is repeated. The initial position is repeated as a check to make sure that the system (as a whole) has not changed. The repeated reading should equal the initial reading to ~0.10 sec. If this amount is exceeded something happened, either the thermal drift is too large, one of the indexing tables was positioned down too quickly, or the polygon shifted. The data set is considered no good and the entire series must be repeated. Once a complete series is finished, the top indexing table is rotated CW one interval and now polygon face #2 is toward the autocollimator. The bottom index table is at the zero position. A reading is recorded, the top table increments one interval CW, the bottom table increments the same interval CCW and another reading is recorded on face #2. This continues until an allowable complete series is gathered. The polygon is measured in this manner until a complete series of acceptable data is obtained for all polygon faces.

The data is entered into the computer in the lab and the results are compared to the polygon's calibration history, if available.

1. Unpack and inspect for damage.
2. Pull a copy of the calibration history and calibration data sheet from computer in Bryon's office or in the drawer in B17.
3. Check for flatness measurement with Zygo, obtain if available and proceed to #6, else clean faces and measure faces with Zygo.
4. Fixture polygon on the 1440 / 513 stack.
5. Align available autocollimator. Warm-up instrument for 60 minutes before use.
6. Clean polygon faces with non-damaging lint-free cloth, allow to stabilize thermally.
7. Take data following data sheet.
8. Input and analyze data with software in lab, or Bryon's spreadsheet. Generate uncertainty using results and Zygo flatness data.
9. Compare results with calibration history. Generate report if permissible, else proceed to #5.
10. Repeat #4 thru #9 with NIST Check standard polygon (Davidson #325 12 sided, or Webber 6 sided) and update check standard history.
11. Carefully pack polygon in original packaging (if possible). Include report and customer comment card. Place in A02 for pickup by shipping.
12. Log test out of database.

List all auxiliary procedures needed to perform this calibration outside of the actual setup and measurement.   This section is a "catch-all" section and should provide guidance on how to proceed through the procedure. Any additional important documentation may be listed, such as instructions more detailed than those in the procedure. For example, listed documents may include owner's manuals, cleaning procedures, equipment calibration instructions, etc.