*TB 9-5220-212-40

DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

CALIBRATION PROCEDURE FOR GRANITE SURFACE PLATE

Headquarters, Department of the Army, Washington, DC
20 June 2007

REPORTING OF ERRORS AND RECOMMENDING IMPROVEMENTS

You can improve this manual. If you find any mistakes or if you know of a way to improve these procedures, please let us know. Mail your letter or DA Form 2028 (Recommended Changes to Publications and Blank Forms) directly to Commander, US Army Aviation and Missile Command, ATTN: AMSAM-MMC-MA-NP, Redstone Arsenal, AL 35898-5000. A reply will be furnished to you. You may also provide DA Form 2028 information to AMCOM via e-mail, fax, or the World Wide Web. Our FAX number is: DSN 788-6546 or Commercial 256-842-6546. Our e-mail address is: 2028@redstone.army.mil. Instructions for sending an electronic 2028 may be found at the back of this manual. For the World Wide Web, use: https://amcom2028.redstone.army.mil.

*This bulletin supersedes TB 9-5220-212-50, dated 31 October 1985, including all changes.

SECTION I
IDENTIFICATION AND DESCRIPTION

1. Test Instrument Identification. This bulletin provides instructions for the calibration of Granite Surface Plate. Federal Specification GGG-P-463C was used as the prime data source in compiling these instructions. The equipment being calibrated will be referred to as the TI (test instrument) throughout this bulletin.

a. Model Variations. Variations among models are described in text.

b. Time and Technique. The time required for this calibration is approximately 8 hours, using the physical technique.

2. Forms, Records, and Reports. Forms, records, and reports required for calibration personnel at all levels are prescribed by TB 750-25.

3. Calibration Description. TI parameters and performance specifications which pertain to this calibration are listed in table 1.

Table 1. Size and Accuracy

Work Surface Size (Inches)		Work Surface Accuracy (micro inches)			Work Surface Size (mm)		Work Surface Accuracy (micrometers)		
Width	Length	Grade AA	Grade A	Grade B	Width	Length	Grade AA	Grade A	Grade B
12	12	50	100	200	300	300	1.3	2.6	5.2
12	18	50	100	200	300	450	1.5	2.9	5.9
18	18	50	100	200	450	450	1.6	3.3	6.6
18	24	75	150	300	450	600	1.9	3.8	7.6
24	24	75	150	300	600	600	2.2	4.3	8.6
24	36	100	200	400	600	900	2.9	5.7	11.5
24	48	150	300	600	600	1200	3.9	7.8	15.5
36	36	150	300	600	900	900	3.6	7.2	14.4
36	48	200	400	800	900	1200	4.6	9.2	18.4
36	60	250	500	1000	900	1500	5.9	11.8	23.6
36	72	300	600	1200	1500	1800	7.5	15.0	29.9
48	48	200	400	800	1200	1200	5.6	11.2	22.4
48	60	300	600	1200	1200	1500	6.9	13.8	27.6
48	72	350	700	1400	1200	1800	8.5	17.0	33.9
48	96	500	1000	2000	1200	2400	12.5	25.0	50.0
48	120	700	1400	2800	1200	3000	17.7	35.4	70.8
60	120	750	1500	3000	1500	3000	18.5	36.9	73.9
72	96	600	1200	2400	1800	2400	15.4	30.8	61.6
72	144	1100	2200	4400	1800	3600	26.9	53.8	107.7

SECTION II
EQUIPMENT REQUIREMENTS

4. Equipment Required. Table 2 identifies the specific equipment to be used in this calibration procedure. This equipment is issued with Secondary Reference Calibration Standards Set NSN 4931-00-621-7878. Alternate items may be used by the calibrating activity when the equipment listed in table 2 is not available. The items selected must be verified to perform satisfactorily prior to use and must bear evidence of current calibration. The equipment must meet or exceed the minimum use specifications listed in table 2. The accuracies listed in table 2 provide a four-to-one ratio between the standard and TI. Where the four-to-one ratio cannot be met, four-to-one accuracy of the equipment selected is shown in parenthesis.

5. Accessories Required. The accessories listed in table 3 are issued as indicated in paragraph **4** above and are used in this calibration procedure. When necessary, these items may be substituted by equivalent items, unless specifically prohibited.

Table 2. Minimum Specifications of Equipment Required

Common name	Minimum use specifications	Manufacturer and model (part number)
AUTOCOLLIMATOR W/ ACCESSORY EQUIPMENT	Range: 10 minutes Accuracy: ±0.6 s of arc for any 1 minute of arc	Kollmorgen, Model K221 (7911743), K10 w/ accessories (7912242)
DIFFERENTIAL ELECTRONIC LEVEL	Range: 10 minutes Accuracy: ±0.6 s of arc	Federal Products Corp., Model 232P68 (7916264)

Table 3. Accessories Required

Common name	Description (part number)
BENCH LEVEL	Federal Specification GGG-L-21A, Type II, Class B, Style 2 (7902565)
C-CLAMP[1]	Part of calibration tool kit (7959911)
STRAIGHT EDGE	72-in., steel (MIS-S15769, Type 2)
STRAIGHT EDGE	48-in., steel (7903703)

[1]Two required.

SECTION III
CALIBRATION PROCESS USING AUTOCOLLIMATOR

6. Preliminary Instructions

a. The instructions outlined in paragraphs **6** and **7** are preparatory to the calibration process. Personnel should become familiar with the entire bulletin before beginning the calibration.

b. Items of equipment used in this procedure are referenced within the text by common name as listed in tables 2 and 3.

c. Unless otherwise specified, verify the result of each test and, whenever the test requirement is not met, take corrective action before continuing with the calibration.

Adjustments required to calibrate the TI are included in this procedure. Additional maintenance information is contained in manufacturer's manual for this TI.

d. Unless otherwise specified, all controls and control settings refer to the TI.

7. Equipment Setup. The following conditions must prevail before starting calibration:

a. TI must be supported at same points used by manufacturer. If support feet are missing, replace at points specified by manufacturer.

b. TI must be level as indicated by bench level.

c. Temperature of mass must be in equilibrium.

d. Vibration must be excluded.

e. TI must be clean.

8. Flatness Tolerance

a. Performance Check

(1) Select carriage from autocollimator accessory equipment with support points approximately 8 percent of TI width.

NOTE

Use 4-inch carriage if 8 percent of TI width exceeds 4 inches.

(2) Designate north, south, east, and west as shown in figure 1.

(3) Set up perimeter, diagonal, and centerlines on TI as shown in figure 1, following sequence listed in (a) through (d) below:

(a) Lay out two diagonal lines, making sure that they bisect physical center of TI.

NOTE

Any marks made on TI surface must not be made where carriage will travel. If possible, mark only on clamping ledges of TI.

(b) Lay out even number of increments (stations) along each diagonal line, using length of carriage base selected in (1) above. Each diagonal line will have same number of stations. Do not extend stations onto clamping ledges of TI.

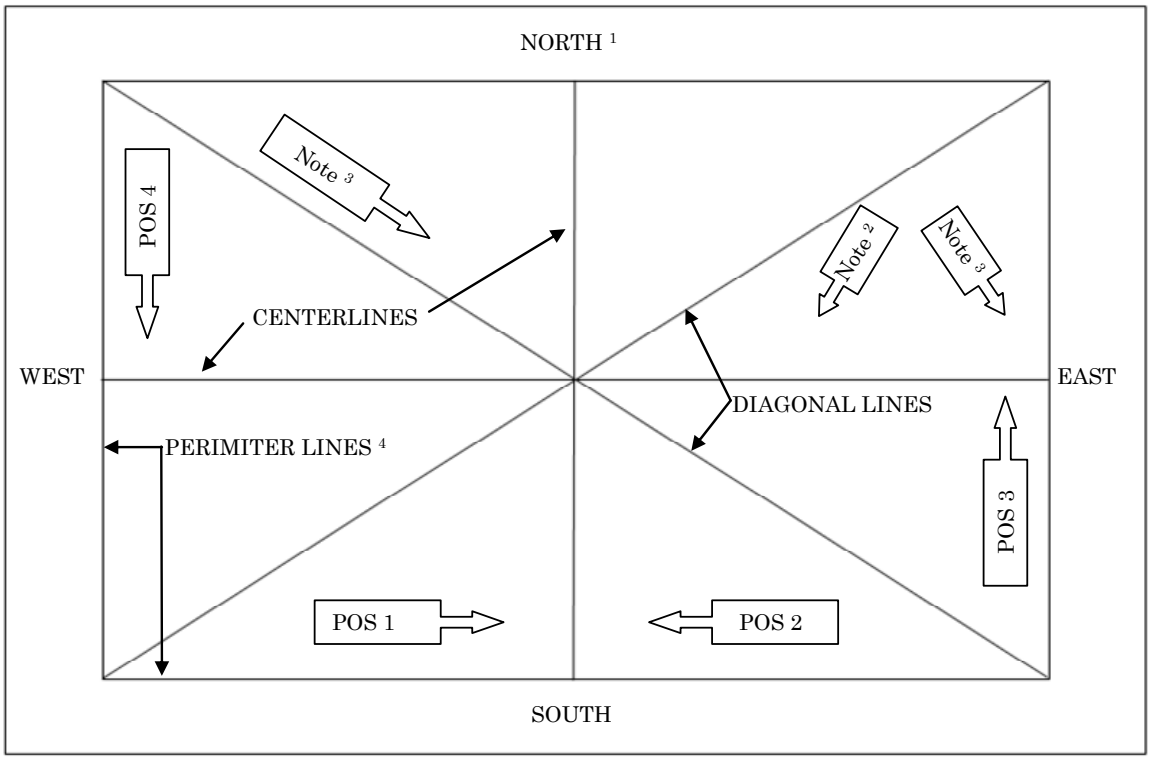
(c) Lay out four perimeter lines connecting with diagonal lines, and observe conditions listed in (1) through (3) below:

1) Each perimeter line will have even number of stations.

2) No station will extend to clamping ledge of TI.

3) North perimeter line will have same number of stations as south perimeter line, and east perimeter line will have same number of stations as west perimeter line.

(d) Lay out centerlines, observing conditions listed in (1) through (3) below:



[1]North will be designated by manufacturer's label.
[2]For small TI surfaces, position autocollimator in POS 2.
[3]Position of autocollimator for small TI's for WEST-EAST CENTERLINE.
[4]The PERIMETER LINES should be a minimum 1 inch in from edge if length of diagonal is 48 inches or less and 1 ½ inches in from edge if diagonal is over 48 inches.
Footnotes 2 and 3 do not apply when using differential electronic level in Section IV.

Figure 1. Granite surface plate - calibration setup.

1) Each centerline will pass through physical center of TI.

2) Ends of centerlines will tie at midpoints of respective perimeter lines.

3) Each centerline will have same number of stations as respective parallel perimeter lines.

NOTE

Make sure that end stations of perimeter lines tie in with end stations of diagonals and that end stations of centerlines tie in with midpoints of perimeter lines as closely as possible.

(4) Place autocollimator at position 1 (fig. 1).

NOTE

It may not be possible to position autocollimator exactly as shown because of size.

(5) Lay straight edge immediately adjacent to line that is to be calibrated and clamp to TI.

NOTE

Each line is designated by number corresponding to autocollimator position number (fig. 1).

(6) Mount mirror on carriage and position adjacent to straight edge at first station to be measured.

(7) Place corner mirror approximately 45 degrees from longitudinal axis of autocollimator.

NOTE

Angle of corner mirror to longitudinal axis of autocollimator varies according to position of autocollimator in relation to line being measured.

(8) Zero in autocollimator and corner mirror with carriage at first station (0-1).

(9) Prepare tables exactly as shown in sample tables 4, 5, and 6, completing column 1 as determined by the number of stations for each line being calibrated. Be sure to record the direction the lines are run.

NOTE

The first station number is zero and is added for computation purposes. Insert zero in columns 2 through 5 for station 0. For both diagonal lines, insert zero in columns 2 through 7 for station 0.

(10) Measure angular displacement and record in column 2 for station 1.

(11) Advance carriage to each station on line and record angular displacement in respective table.

NOTE

After the last reading of a respective line, move the carriage back to the first station and take another reading. If the reading is not within ±0.5 seconds of arc of first reading, repeat the line readings.

(12) Repeat technique of (4) through (11) above for each line in (3) above.

(13) Calculate the angular displacement for each station in column 3 by subtracting the value of station 1, column 2, from the value of each station in column 2. Record the results in column 3 with proper sign.

NOTE

Refer to sample tables.

(14) Calculate values for column 4 by multiplying each value in column 3 by a factor of 5, 10, 15, or 20 as determined by the respective 1-, 2-, 3-, or 4-inch carriage used in (1) above.

NOTE

Record value to nearest whole number. The carriage used in sample table is 3 inches.

(15) Calculate values for column 5 as indicated in (a) through (d) below:

(a) Add column 4, station 0 and station 1 values, and enter sum in column 5 for station 1.

(b) Add column 4, station 2 value, to column 5, station 1 value.

(c) Enter sum in column 5 for station 2.

(d) Repeat technique of (b) and (c) above, increasing station numbers by one for each operation.

(16) Values calculated in (a) through (c) below for columns 6, 7, and 8 apply only to diagonal lines (table 6).

(a) Values for column 6 are calculated as indicated in (1) through (4) below:

1) Divide value of last station in column 5 by number of stations (do not count station 0). Round off to less than four significant digits and change sign.

2) Enter value determined in (1) above in column 6 for station 1. Round off number to nearest whole number.

3) Multiply value determined in (1) above by two, round off to nearest whole number, and enter in column 6 for station 2.

4) Complete values for column 6 by multiplying value recorded in (1) above by respective station number, rounding off to nearest whole number, and entering product in column 6 for that station.

(b) Algebraically add value in column 5 to value in column 6 and enter in column 7.

(c) Calculate column 8 values for diagonal lines as indicated in (1) through (4) below:

1) Enter value of zero for center station in column 8.

2) Change sign of center station value in column 7.

3) Add value of (2) above to column 7, station 0, and record sum in column 8 for station 0.

4) Repeat (3) above by adding value found in (2) above to each station in column 7 and recording results in column 8.

(17) Calculate values for columns 6 and 7 in table 4 for north perimeter line (west to east) as indicated in (a) through (f) below:

(a) Enter value from table 6, diagonal (northwest to southeast), column 8, station 0 to table 4 north perimeter line (west to east), columns 6 and 7, stations 0.

NOTE

This is the northwest corner.

NOTE

When tying the lines together, station 0 and the last station values of connecting lines may be reversed from this example. Note direction in which line runs and always tie in with appropriate end values.

(b) Enter value from table 6 diagonal (northeast to southwest), column 8, station 0 in table 4 north perimeter line (west to east), column 7 for last station.

(c) Enter in column 6 for last station, the difference between last stations of columns 5 and 7, using appropriate sign so that column 5 plus column 6 will equal column 7.

(d) Subtract value of column 6 last station from station 0, divide by number of stations (not counting station 0), and change sign of answer.

(e) Complete values for column 6 by making an arithmetic progression, using answer obtained in (d) above.

NOTE

For north perimeter line, the value obtained in (d) above is 21.28 per sample table. To find column 6, station 1 value, add 21.28 to station 0 value of -179. The rounded-off value is -158, which is entered for station 1. Station 2 value is calculated by adding 21.28 to value to station 1 (not rounded off), rounding off result to nearest whole number. The remaining values for column 6 are calculated by repeating the sequence.

(f) Complete values for column 7 by adding respective stations of columns 5 and 6.

(18) Repeat technique of (17) above for remaining perimeter lines.

(19) Calculate values for column 6 and 7 in table 5 for north-south centerline (north to south) as indicated in (a) through (f) below:

(a) Enter value from table 4, north perimeter line, column 7 center station in columns 6 and 7 for station 0 of north-south line.

NOTE

In table 4, value is shown as -154.

(b) Enter value from table 4, south perimeter, column 7, center station in column 7 last station of north-south centerline.

(c) Subtract column 5 last station value from column 7 last station value and enter result in column 6 for last station.

(d) Subtract column 6 last station from station 0, divide by number of stations (not counting station zero), and change sign of answer.

(e) Complete column 6 by making an arithmetic progression, using answer obtained in (d) above and technique described in (17) (e) above.

(f) Complete values for column 7 by adding respective stations of columns 5 and 6.

(20) Repeat technique of (19) above for east-west centerline.

(21) Check column 7, tables 4 and 5, and column 8 of table 6 for the highest and lowest points. Find difference between the two values and divide by two. Record this + value as surface plate accuracy.

(22) Compare surface plate accuracy recorded in (21) above with plate specifications listed in table 1. The surface plate will be within tolerance specified.

NOTE

For surface plates that do not have grade AA, A, or grade B accuracy, prepare a test report. Plot and state accuracy and furnish report to user.

(23) Plot deviations in column 7 of tables 4 and 5, and column 8 of table 6, as shown in figure 2.

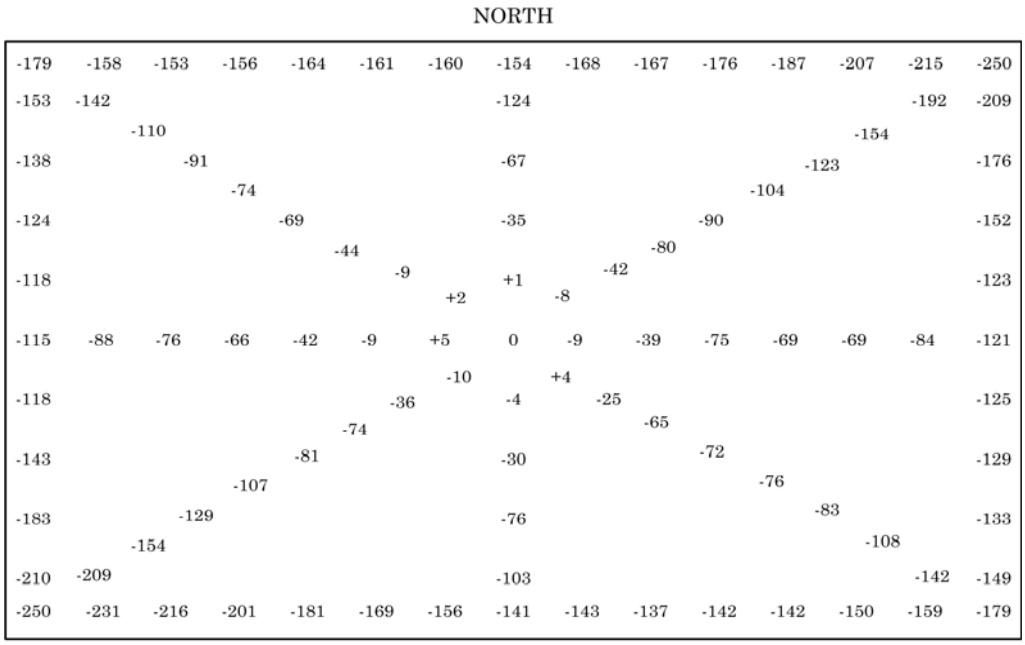
(24) Compare midpoints of centerlines and diagonal lines. Midpoints will not be off zero by more than 20 percent of the difference between highest and lowest points on plate or 0.000030 inch, whichever is greater.

(25) An estimate of uncertainty in the calibration is 3.0 micro inches/inch X length of carriage used plus one-half the absolute sum (added without regard to sign) of the midpoints of the two centerlines.

NOTE

A copy of surface-plate deviations is to accompany the surface plate.

b. Adjustments. No adjustments can be made.



(36 X 48 IN. PLATE)
NOTE: VALUES REPRESENT DEVIATIONS FROM DATUM PLANE IN UNITS OF MICROINCHES

Figure 2. Sample plot of surface plate deviations.

Table 4. Sample Calibration Stations (Perimeter Lines)

Column 1 Station Number	Column 2 Readings (Seconds of Arc)	Column 3 Angular Displacement (Seconds Of Arc)	Column 4 Linear Displacement (Micro-Inches)	Column 5 Cumulative Displacement (Micro-Inches)	Column 6 Cumulative Correction Factor (Micro-Inches)	Column 7 Linear Displacement From Datum Plane (Micro-Inches
North Perimeter Line (West To East)						
0	0	0	0	0	-179	-179
1	16.0	0	0	0	-158	-158
2	14.9	-1.1	-17	-17	-136	-153
3	14.4	-1.6	-24	-41	-115	-156
4	14.1	-1.9	-29	-70	-94	-164
5	14.8	-1.2	-18	-88	-73	-161
6	14.6	-1.4	-21	-109	-51	-160
7	15.0	-1.0	-15	-124	-30	-154
8	13.7	-2.3	-35	-159	-9	-168
9	14.6	-1.4	-21	-180	+13	-167
10	14.0	-2.0	-30	-210	+34	-176
11	13.9	-2.1	-32	-242	+55	-187
12	13.3	-2.7	-41	-283	+76	-207
13	14.0	-2.0	-30	-313	+98	-215
14	12.3	-3.7	-56	-369	+119	-250
West Perimeter Line (North to South)						
0	0	0	0	0	-179	-179
1	15.9	0	0	0	-153	-153
2	15.2	-0.7	-11	-11	-127	-138
3	15.1	-0.8	-12	-23	-101	-124

Table 4. Sample Calibration Stations (Perimeter Lines) - Continued

Column 1 Station Number	Column 2 Readings (Seconds of Arc)	Column 3 Angular Displacement (Seconds Of Arc)	Column 4 Linear Displacement (Micro-Inches)	Column 5 Cumulative Displacement (Micro-Inches)	Column 6 Cumulative Correction Factor (Micro-Inches)	Column 7 Linear Displacement From Datum Plane (Micro-Inches
West Perimeter Line (North to South)						
4	14.6	-1.3	-20	-43	-75	-118
5	14.4	-1.5	-23	-66	-49	-115
6	13.9	-2.0	-30	-96	-22	-118
7	12.5	-3.4	-51	-147	+4	-143
8	11.5	-4.4	-66	-213	+30	-183
9	13.0	- 2.9	-44	-257	+56	-201
10	10.9	-5.0	-75	-332	+82	-250
East Perimeter Line (North to South)						
0	0	0	0	0	-250	-250
1	13.6	0	0	0	-209	-209
2	13.1	-0.5	-8	-8	-168	-176
3	12.5	-1.1	-17	-25	-127	-152
4	12.8	-0.8	-12	-37	-86	-123
5	11.0	-2.6	-39	-76	-45	-121
6	10.6	-3.0	-45	-121	-4	-125
7	10.6	-3.0	-45	-166	+37	-129
8	10.6	-3.0	-45	-211	+78	-133
9	9.8	-3.8	-57	-268	+119	-149
10	8.9	-4.7	-71	-339	+160	-179
South Perimeter Line (East to West)						
0	0	0	0	0	-179	-179
1	15.2	0	0	0	-159	-159
2	14.5	-0.7	-11	-11	-139	-150
3	14.4	-0.8	-12	-23	-119	-142
4	13.8	-1.4	-21	-44	-98	-142
5	14.2	-1.0	-15	-59	-78	-137
6	13.5	-1.7	-26	-85	-58	-143
7	14.0	-1.2	-18	-103	-38	-141
8	12.9	-2.3	-35	-138	-18	-156
9	13.0	-2.2	-33	-171	+2	-169
10	13.1	-2.1	-32	-203	+22	-181
11	12.5	-2.7	-41	-244	+43	-201
12	12.9	-2.3	-35	-279	+63	-216
13	12.9	-2.3	-35	-314	+83	-231
14	12.6	-2.6	-39	-358	+103	-250

Table 5. Sample Calibration Stations (Centerline)

Column 1 Station Number	Column 2 Readings (Seconds of Arc)	Column 3 Angular Displacement (Seconds of Arc)	Column 4 Linear Displacement (Micro-Inches)	Column 5 Cumulative Displacement (Micro-Inches)	Column 6 Cumulative Correction Factor (Micro-Inches)	Column 7 Linear Displacement from Datum Plane (Micro-Inches
West-East Centerline						
0	0	0	0	0	-115	-115
1	14.7	0	0	0	-88	-88
2	13.7	-1.0	-15	-15	-61	-76
3	13.6	-1.1	-17	-32	-34	-66
4	14.6	-0.1	-2	-34	-8	-42
5	15.0	+0.3	+5	-29	+20	-9
6	13.9	-0.8	-12	-42	+47	+5
7	12.3	-2.4	-36	-77	+74	-3
8	12.5	-2.2	-33	-110	+101	-9
9	10.9	-3.8	-57	-167	+128	-39
10	10.5	-4.2	-63	-230	+155	-75
11	13.4	-1.3	-20	-250	+181	-69
12	12.9	-1.8	-27	-277	+208	-69
13	11.9	-2.8	-42	-319	+235	-84
14	10.5	-4.2	-63	-382	+261	-121
North-South Centerline						
0	0	0	0	0	-154	-154
1	16.9	0	0	0	-124	-124
2	18.7	+1.8	+27	+27	-94	-67
3	17.1	+0.2	+3	+30	-65	-35
4	17.3	+0.4	+6	+36	-35	+1
5	15.2	-1.7	-26	+10	-5	+5
6	14.3	-2.6	-39	-29	+25	-4
7	13.2	-3.7	-56	-85	+55	-30
8	11.9	-5.0	-75	-160	+84	-76
9	13.1	-3.8	-57	-217	+114	-103
10	12.4	-4.5	-68	-285	+144	-141

Table 6. Sample Calibration Stations (Diagonal Lines)

Column 1 Station Number	Column 2 Readings (Seconds of Arc)	Column 3 Angular Displacement (Seconds of Arc)	Column 4 Linear Displacement (Micro-Inches)	Column 5 Cumulative Linear Displacement (Micro-Inches)	Column 6 Cumulative Correction Factor (Micro-Inches)	Column 7 Linear Displacement from Datum Line (Micro-Inches)	Column 8 Linear Displacement from Datum Plane (Micro-Inches)
Diagonal (Northwest To Southeast)							
0	0	0	0	0	0	0	-179
1	12.6	0	0	0	+37	+37	-142
2	12.3	-0.3	-5	-5	+74	+69	-110
3	11.4	-1.2	-18	-23	+111	+88	-91
4	11.3	-1.3	-20	-43	+148	+105	-74
5	10.5	-2.1	-32	-75	+185	+110	-69
6	11.8	-0.8	-12	-87	+222	+135	-44
7	12.5	-0.1	-2	-89	+259	+170	-9

Table 6. Sample Calibration Stations (Diagonal Lines) - Continued

Column 1 Station Number	Column 2 Readings (Seconds of Arc)	Column 3 Angular Displacement (Seconds of Arc)	Column 4 Linear Displacement (Micro-Inches)	Column 5 Cumulative Linear Displacement (Micro-Inches)	Column 6 Cumulative Correction Factor (Micro-Inches)	Column 7 Linear Displacement from Datum Line (Micro-Inches)	Column 8 Linear Displacement from Datum Plane (Micro-Inches)
Diagonal (Northwest To Southeast)							
8	10.9	-1.7	-26	-115	+296	+181	+2
9	10.1	-2.5	-38	-153	+332	+179	0
10	10.4	-2.2	-33	-186	+369	+183	+4
11	8.2	-4.4	-66	-252	+406	+154	-25
12	7.5	-5.1	-77	-329	+443	+114	-65
13	9.7	-2.9	-44	-373	+480	+107	-72
14	9.9	-2.7	-41	-414	+517	+103	-76
15	9.7	-2.9	-44	-458	+554	+96	-83
16	8.5	-4.1	-62	-520	+591	+71	-108
17	7.9	-4.7	-71	-591	+628	+37	-142
18	7.7	-4.9	-74	-665	+665	0	-179
Diagonal (Northeast to Southwest)							
0	0	0	0	0	0	0	-250
1	16.2	0	0	0	+58	+58	-192
2	14.9	-1.3	-20	-20	+116	+96	-154
3	14.4	-1.8	-27	-47	+174	+127	-123
4	13.6	-2.6	-39	-86	+232	+146	-104
5	13.3	-2.9	-44	-130	+290	+160	-90
6	13.0	-3.2	-48	-178	+348	+170	-80
7	14.9	-1.3	-20	-198	+406	+208	-42
8	14.6	-1.6	-24	-222	+464	+242	-8
9	12.9	-3.3	-50	-272	+522	+250	0
10	11.6	-4.6	-69	-341	+581	+240	-10
11	10.6	-5.6	-84	-425	+839	+214	-36
12	9.8	-6.4	-96	-521	+697	+176	-74
13	11.9	-4.3	-65	-586	+755	+189	-81
14	10.6	-5.6	-84	-670	+813	+143	-107
15	10.9	-5.3	-80	-750	+871	+121	-129
16	10.7	-5.5	-83	-833	+929	+96	-154
17	8.72	-7.3	-113	-946	+987	+41	-209
18	9.6	-6.6	-99	-1045	+1045	0	-250

9. Final Procedure

a. Deenergize and disconnect all equipment.

b. Annotate and affix DA label/form in accordance with TB 750-25.

SECTION IV
CALIBRATION PROCESS USING DIFFERENTIAL ELECTRONIC LEVEL

10. Preliminary Instructions

a. The instructions outlined in paragraphs **10** and **11** are preparatory to the calibration process. Personnel should become familiar with the entire bulletin before beginning the calibration.

b. Items of equipment used in this procedure are referenced within the text by common name as listed in tables 2 and 3.

c. Unless otherwise specified, verify the result of each test and, whenever the test requirement is not met, take corrective action before continuing with the calibration. Adjustments required to calibrate the TI are included in this procedure. Additional maintenance information is contained in manufacturer's manual for this TI.

d. Unless otherwise specified, all controls and control settings refer to the TI.

11. Equipment Setup

a. The following conditions must prevail before starting calibration:

(1) TI must be supported at same points used by manufacturer. If support feet are missing, replace at points specified by manufacturer.

(2) Temperature of mass must be in equilibrium.

(3) Vibration must be excluded.

(4) TI must be clean.

b. Place differential electronic level on TI. Connect to 115 V ac power source.

c. Set amplifier **MODE** switch to **MTR** (power on) and allow 20 minutes for warm-up.

d. Position controls on differential electronic level as listed in (1) through (3) below:

(1) **RANGE** selector switch to **0.5**.

(2) Polarity switch heads **A** and **B** to NORMAL.

(3) **HEAD SELECT** switch to **HEAD A**.

e. Level TI using differential electronic level.

12. Flatness Tolerance

a. Performance Check

NOTE

While performing this procedure, column 2 and 3 of tables 4, 5, and 6 in section III contain the same values. This is because differential electronic level is zeroed prior to making measurement.

(1) Select adjustable base with support points approximately 8 percent of TI width.

NOTE

Use 5-inch base if 8 percent of TI width exceeds 5 inches.

(2) Designate north, south, east, and west as shown in figure 1.

(3) Set up perimeter, diagonal, and centerlines on TI as shown in figure 1, following sequence listed in (a) through (d) below:

(a) Lay out two diagonal lines, making sure that they bisect physical center of TI.

NOTE

Any marks made on TI surface must not be made where base will travel. If possible, mark only on clamping ledges of TI.

(b) Lay out even number of increments (stations) along each diagonal line, using length of base selected in (1) above. Each diagonal line will have same number of stations. Do not extend stations onto clamping ledges of TI.

(c) Lay out four perimeter lines connecting with diagonal lines, and observe conditions listed in (1) through (3) below:

1) Each perimeter line will have even number of stations.

2) No station will extend to clamping ledge of TI.

3) North perimeter line will have same number of stations as south perimeter line, and east perimeter line will have same number of stations as west perimeter line.

(d) Lay out centerlines, observing conditions listed in (1) through (3) below:

1) Each centerline will pass through physical center of TI.

2) Ends of centerlines will tie at midpoints of respective perimeter lines.

3) Each centerline will have same number of stations as respective parallel perimeter lines.

NOTE

Make sure that end stations of perimeter lines tie in with end stations of diagonals and that end stations of centerlines tie in with midpoints of perimeter lines as closely as possible.

(4) Place differential electronic level heads A and B at center of TI adjacent to northwest to southeast line. Adjust zero control for 0 (midrange) indication on each head. Set polarity switch head **B** to **REV** and **HEAD SELECT** switch to **BOTH**.

NOTE

Both heads must be parallel to line of movement and each other at all times. Reposition head **B** as appropriate to maintain this orientation.

NOTE

At the start of each path the level must be adjusted for zero reading.

(5) Lay straight edge immediately adjacent to line that is to be calibrated northwest to southeast and clamp to TI.

(6) Position head **A** adjacent to straight edge at first station to be measured. Head **B** will remain stationary.

NOTE

Movement of the head is regulated so that, at each succeeding step, the centerline of the back rest pad positions precisely at the point occupied by the front pad.

(7) Prepare tables exactly as shown in sample tables 4, 5, and 6, completing column 1 as determined by the number of stations for each line being calibrated. Be sure to record the direction the lines are run.

NOTE

The first station number is zero and is added for computation purposes. Insert zero in columns 2 through 5 for station 0. For both diagonal lines, insert zero in columns 2 through 7 for station 0.

(8) Measure angular displacement and record in column 2 for station l.

(9) Advance head **A** to each station on line and record angular displacement in respective table.

NOTE

After the last reading of a respective line, move the head back to the first station and take another reading. If the reading is not within ±0.5 seconds of arc of first reading, repeat the line readings.

(10) Repeat technique of (6) through (9) above for each line in (3) above.

(11) Reenter values of column 2 in column 3.

NOTE

Refer to sample tables.

(12) Calculate values for column 4 by multiplying each value in column 3 by a factor of 5, 10, 15, or 20 as determined by the respective 1-, 2-, 3-, or 4-inch carriage used in (1) above.

NOTE

One arc second equals 25 micro inches per 5 inches.

NOTE

Record value to nearest whole number. The carriage used in sample table is 3 inches.

(13) Calculate values for column 5 as indicated in (a) through (d) below:

(a) Add column 4, station 0 and station 1 values, and enter sum in column 5 for station 1.

(b) Add column 4, station 2 value, to column 5, station 1 value.

(c) Enter sum in column 5 for station 2.

(d) Repeat technique of (b) and (c) above, increasing station numbers by one for each operation.

(14) Values calculated in (a) through (c) below for columns 6, 7, and 8 apply only to diagonal lines (table 6).

(a) Values for column 6 are calculated as indicated in (1) through (4) below:

1) Divide value of last station in column 5 by number of stations (do not count station 0). Round off to less than four significant digits and change sign.

2) Enter value determined in (1) above in column 6 for station 1. Round off number to nearest whole number.

3) Multiply value determined in (1) above by two, round off to nearest whole number, and enter in column 6 for station 2.

4) Complete values for column 6 by multiplying value recorded in (1) above by respective station number, rounding off to nearest whole number, and entering product in column 6 for that station.

(b) Algebraically add value in column 5 to value in column 6 and enter in column 7.

(c) Calculate column 8 values for diagonal lines as indicated in (1) through (4) below:

1) Enter value of zero for center station in column 8.

2) Change sign of center station value in column 7.

3) Add value of (2) above to column 7, station 0, and record sum in column 8 for station 0.

4) Repeat (3) above by adding value found in (2) above to each station in column 7 and recording results in column 8.

(15) Calculate values for columns 6 and 7 in table 4 for north perimeter line (west to east) as indicated in (a) through (f) below:

(a) Enter value from table 6, diagonal (northwest to southeast), column 8, station 0 to table 4 north perimeter line (west to east), columns 6 and 7, stations 0.

NOTE

This is the northwest corner.

NOTE

When tying the lines together, station 0 and the last station values of connecting lines may be reversed from this example. Note direction in which line runs and always tie in with appropriate end values.

(b) Enter value from table 6 diagonal (northeast to southwest), column 8, station 0 in table 4 north perimeter line (west to east), column 7 for last station.

(c) Enter in column 6 for last station, the difference between last stations of columns 5 and 7, using appropriate sign so that column 5 plus column 6 will equal column 7.

(d) Subtract value of column 6 last station from station 0, divide by number of stations (not counting station 0), and change sign of answer.

(e) Complete values for column 6 by making an arithmetic progression, using answer obtained in (d) above.

NOTE

For north perimeter line, the value obtained in (d) above is 21.28 per sample table. To find column 6, station 1 value, add 21.28 to station 0 value of -179. The rounded-off value is -158, which is entered for station 1. Station 2 value is calculated by adding 21.28 to value to station 1 (not rounded off), rounding off result to nearest whole number. The remaining values for column 6 are calculated by repeating the sequence.

(f) Complete values for column 7 by adding respective stations of columns 5 and 6.

(16) Repeat technique of (15) above for remaining perimeter lines.

(17) Calculate values for column 6 and 7 in table 5 for north-south centerline (north to south) as indicated in (a) through (f) below:

(a) Enter value from table 4 north perimeter line, column 7 center station in columns 6 and 7 for station 0 of north-south center line.

NOTE

In table 4, value is shown as -154.

(b) Enter value from table 4, south perimeter, column 7, center station in column 7 last station of north-south centerline.

(c) Subtract column 5 last station value from column 7 last station value and enter result in column 6 for last station.

(d) Subtract column 6 last station from station 0, divide by number of stations (not counting station zero), and change sign of answer.

(e) Complete column 6 by making an arithmetic progression, using answer obtained in (d) above and technique described in (15) (e) above.

(f) Complete values for column 7 by adding respective stations of columns 5 and 6.

(18) Repeat technique of (17) above for east-west centerline.

(19) Check column 7, tables 4 and 5, and column 8 of table 6 for the highest and lowest points. Find difference between the two values and divide by two. Record this + value as surface plate accuracy.

(20) Compare surface plate accuracy recorded in (19) above with plate specifications listed in table 1. The surface plate will be within tolerance specified. If not, proceed to (21) through (23) below.

NOTE

Surface plates that meet AA, A, or grade B accuracy must be labeled with appropriate grade. For surface plates that do not have grade AA, A, or grade B accuracy, prepare a test report and deviation. Plot and state accuracy and furnish report to owner/user.

(21) Plot deviations in column 7 of tables 4 and 5, and column 8 of table 6, as shown in figure 2.

(22) Compare midpoints of centerlines and diagonal lines. Midpoints will not be off zero by more than 20 percent of the difference between highest and lowest points on plate or 0.000030 inch, whichever is greater.

(23) An estimate of uncertainty in the calibration is 3.0 micro-inches/inch X length of carriage used plus one-half the absolute sum (added without regard to sign) of the midpoints of the two centerlines.

b. Adjustments. No adjustments can be made.

13. Final Procedure

a. Deenergize and disconnect all equipment.

b. Annotate and affix DA label/form in accordance with TB 750-25.

By Order of the Secretary of the Army:

GEORGE W. CASEY, JR.
General, United States Army
Chief of Staff

Official:

JOYCE E. MORROW
Administrative Assistant to the
Secretary of the Army

0710803

Distribution:

To be distributed in accordance with STD IDS No. RLC-1500, 2 January 2003, requirements for calibration procedure TB 9-5220-212-40.

Instructions for Submitting an Electronic 2028

c. The following format must be used if submitting an electronic 2028. The subject line must be exactly the same and all fields must be included; however, only the following fields are mandatory: 1, 3, 4, 5, 6, 7, 8, 9, 10, 13, 15, 16, 17, and 27.

d. From: "Whomever" whomever@redstone.army.mil
e. To: <2028@redstone.army.mil

f. Subject: DA Form 2028
g. 1. **From**: Joe Smith
h. 2. Unit: home
i. 3. **Address**: 4300 Park
j. 4. **City**: Hometown
k. 5. **St**: MO
l. 6. **Zip**: 77777
m. 7. **Date Sent**: 19-OCT –93
n. 8. **Pub no:** 55-2840-229-23
o. 9. **Pub Title**: TM
p. 10. **Publication Date**: 04-JUL-85
q. 11. Change Number: 7
r. 12. Submitter Rank: MSG
s. 13. **Submitter FName**: Joe
t. 14. Submitter MName: T
u. 15. **Submitter LName**: Smith
v. 16. **Submitter Phone**: 123-123-1234
w. 17. **Problem**: 1
x. 18. Page: 2
y. 19. Paragraph: 3
z. 20. Line: 4
aa. 21. NSN: 5
bb. 22. Reference: 6
cc. 23. Figure: 7
dd. 24. Table: 8
ee. 25. Item: 9
ff. 26. Total: 123
gg. 27. **Text**
hh. This is the text for the problem below line 27.