UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

USBR 1007-89

PROCEDURE FOR

CALIBRATING DIAL INDICATORS

INTRODUCTION

This procedure is under the jurisdiction of the Geotechnical Services Branch, code D-3760, Research and Laboratory Services Division, Denver Office, Denver, Colorado. The procedure is issued under the fixed designation USBR 1007. The number immediately following the designation indicates the year of acceptance or the year of last revision.

1. Scope

1.1 This designation outlines the procedure for calibrating dial indicators for laboratory and field applications.

1.2 Method A outlines the calibration procedure using precision gauge blocks; Method B outlines the calibration procedure using a micrometer fixture.

2. Applicable Documents

2.1 *USBR Procedures*:

USBR 1000 Standards for Linear Measurement Devices
USBR 3900 Standard Definitions of Terms and Symbols Relating to Soil Mechanics

2.2 *ASME Standard*:

ANSI B89.1.10 Dial Indicators (for Linear Measurement)

2.3 *Federal Specification*:

GGG-G-15C Gage Blocks and Accessories

3. Summary of Method

3.1 Comparison readings between a dial indicator and either precision gauge blocks (method A) or a micrometer fixture (method B) are used to determine the accuracy, repeatability, and hysteresis of the dial indicator. The results are used to evaluate the acceptability of dial indicators for laboratory and field use.

4. Significance and Use

4.1 Accurate linear measurements are required to obtain proper data for laboratory and field use.

4.2 Calibrate dial indicators when purchased and annually thereafter.

5. Terminology

5.1 Definitions are in accordance with USBR 3900.

5.2 Terms not included in USBR 3900 specific to this designation are:

5.2.1 *Accuracy.*–The degree to which displayed dial indicator readings vary from known spindle displacements.

5.2.2 *Graduation.*–The least measured value which is marked on the dial indicator face.

5.2.3 *Hysteresis.*–The difference in displayed dial indicator readings at any particular spindle displacement within the specified range, when the dial indicator reading is approached first with increasing and then with decreasing spindle displacements.

5.2.4 *Range.*–The measured values over which the dial indicator is intended to measure, specified by upper and lower limits.

5.2.5 *Repeatability.*–The degree to which displayed dial indicator readings vary for successive measurements of the same reference.

6. Apparatus

6.1 *Dial Indicator.*–A dial indicator used for standard laboratory or field applications.

6.2 *Method A — Precision Gauge Block Calibration*:

6.2.1 *Precision Gauge Blocks* (fig. 1a).–A set of steel gauge blocks (inch-pound or metric), usually rectangular, meeting the requirements of Federal Specifications GGG-G-15C and those requirements identified in USBR 1000 for precision gauge blocks. A gauge block set should contain sizes (or combination of sizes) necessary to satisfactorily perform the calibration procedure as outlined in paragraph 10.

6.2.2 *Dial Indicator Comparator Stand* (fig. 1b).–A stand consisting of a base; ground to a guaranteed flatness and warp-free stability; a support column and an adjustable arm onto which the dial indicator can be securely attached.

6.3 *Method B — Micrometer Fixture Calibration*:

6.3.1 *Micrometer Fixture* (fig. 2a).–A precision instrument capable of obtaining comparison readings over the full range of the dial indicator. The spindle must be nonrotating and spring loaded. The micrometer fixture is to be calibrated annually by the manufacturer.

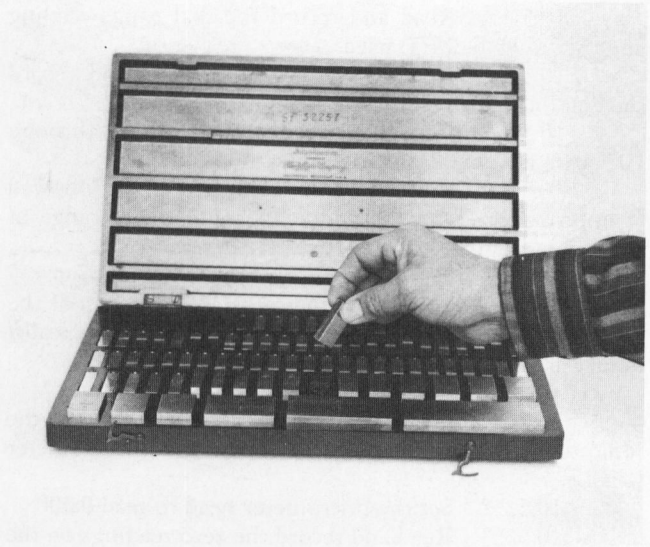
6.3.2 *Magnetic Base Dial Indicator Holder* (fig. 2b).–A magnetic base with a solid upright post adapted with a swivel snug, gauge rod, and dial indicator clamp with fine adjustment capabilities.

7. Precautions

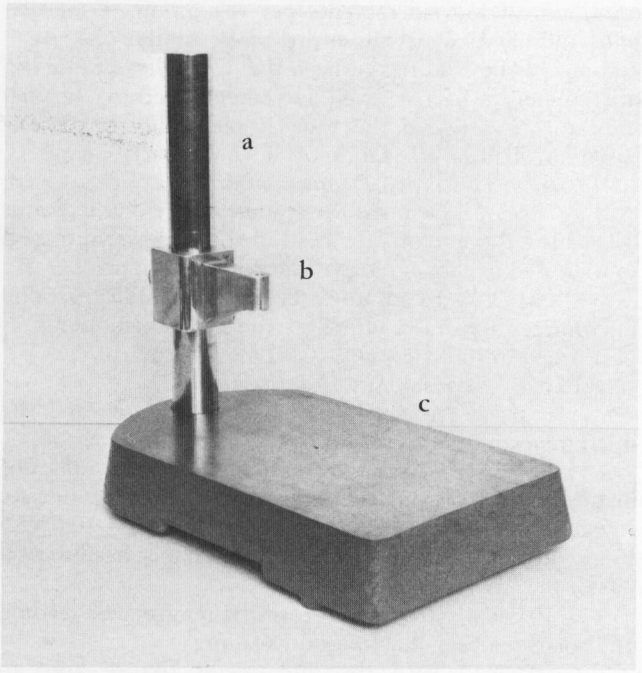
7.1 *Safety Precautions.*–The dial indicator case, stem, spindle, and contact point are to be examined for burrs and sharp edges.

7.2 *Technical Precautions*:

7.2.1 The dial face is to be examined for clarity of graduations.



(a) Precision gauge blocks.

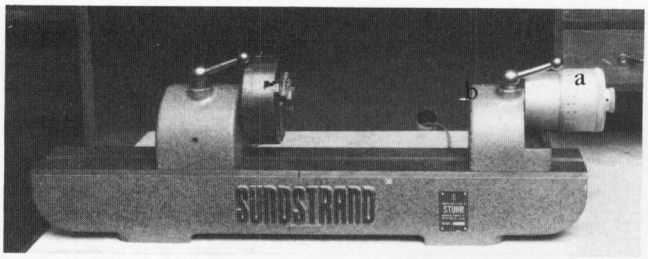


(b) Dial indicator comparator stand. a) support column, b) adjustable arm, and c) base.

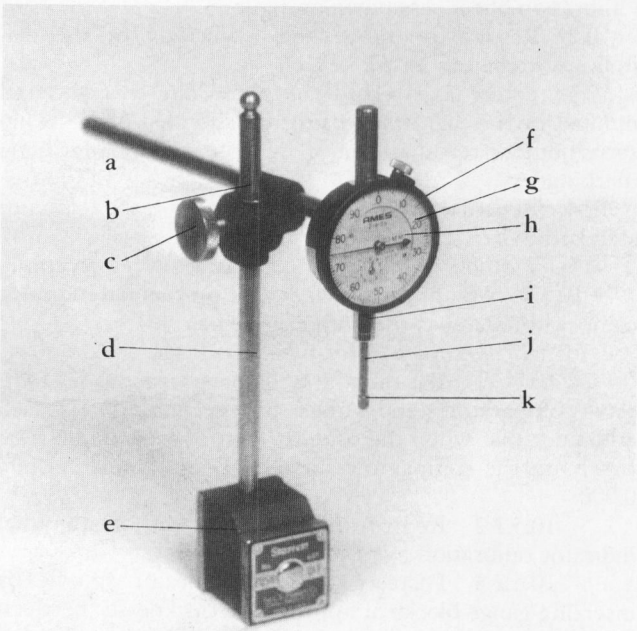
Figure 1. – Dial indicator calibration equipment (method A).

7.2.2 The dial indicator is to be replaced if there is any evidence of binding or twisting when the spindle is pushed into the stem.

7.2.3 Extreme caution is to be used when inscribing or marking control numbers on the dial indicator to prevent interference with operation or reliability of the dial indicator.



(a) Micrometer fixture. a) micrometer head, and b) spindle.



(b) Magnetic base dial indicator holder. a) gauge rod, b) swivel snug, c) dial indicator clamp, d) post, e) magnetic base, f) case, g) dial face, h) hand, i) spindle, j) stem, and k) contact point.

Figure 2. – Dial indicator calibration equipment (method B).

7.2.4 Dial indicators are to be stored in a suitable box or case when not in use.

8. Calibration and Standardization

8.1 Verify that gauge blocks used for obtaining dial indicator comparison readings (method A) are currently calibrated in accordance with USBR 1000. If the gauge block calibration is not current, perform the calibration before using the gauge blocks for this procedure.

8.2 Verify that the micrometer fixture has been currently calibrated by the manufacturer. If the calibration is not current, perform the calibration before using the micrometer fixture (method B) for this procedure.

9. Conditioning

9.1 Perform this calibration in an environment as close to 68 °F (20 °C) as possible.

9.2 The dial indicator, calibration gauge blocks, and dial indicator comparator stand and base should be in the environment in which they are to be calibrated for at least 24 hours prior to calibration.

10. Procedure

10.1 All data are to be recorded on the "Dial Indicator Calibration Sheet" as shown on figure 3.

10.2 Record the range and graduation of the dial indicator to be calibrated.

10.3 Locate and record the manufacturer and serial number of the dial indicator to be calibrated. If it has no serial number, record the model number and any identifying marking.

10.4 Record the type and serial number of the reference standard to be used.

10.5 *Method A — Precision Gauge Block Calibration*:

10.5.1 Mount the dial indicator on the dial indicator comparator stand as shown on figure 4a.

10.5.2 *Accuracy Determination*:

10.5.2.1 Position the dial indicator on the dial indicator comparator stand. Adjust the dial indicator in such a manner that when the contact point of the spindle rests firmly on the comparator stand base, the hand registers 0.000.

10.5.2.2 Record the zero reading on the dial indicator calibration form.

10.5.2.3 Displace the dial indicator spindle by inserting gauge blocks of appropriate thicknesses between the comparator base and the contact point of the dial indicator as shown on figure 4b. These gauge blocks should be of such thickness that the hand can be displaced in approximately equal increments (a minimum of four increments per revolution of the dial indicator hand) over the entire range of the dial. Record the gauge block(s) used (reference standard length) and the dial indicator reading at each increment. Record the dial indicator readings to the highest readability possible—based on smallest graduation of the dial indicator dial.

10.5.3 *Hysteresis Determination*:

10.5.3.1 Displace the spindle of the dial indicator by inserting the same gauge blocks as used in subparagraph 10.5.2.3. This time insert the gauge blocks in reverse order; i.e., thickest block to thinnest.

10.5.3.2 Read and record dial indicator readings for each gauge block used.

10.5.4 *Repeatability Determination*:

10.5.4.1 Remove all gauge blocks from beneath the contact point. Readjust the dial indicator on the support column so that the hand registers 0.000 with the contact point resting on the comparator base and record the value.

10.5.4.2 Rotate the hand of the dial indicator by displacing the dial indicator spindle using an appropriate size (or combination of) gauge block(s). (See subpar. 10.5.4.6.)

10.5.4.3 Read and record the dial gauge reading and the gauge block(s) used.

10.5.4.4 Remove the gauge block(s) and record the dial indicator reading.

10.5.4.5 Repeat subparagraphs 10.5.4.1 through 10.5.4.4 a minimum of three times.

10.5.4.6 Subparagraph 10.5.4 should be followed at approximately 25, 50, and 75 percent of full range of the dial indicator.

10.6 *Method B — Micrometer Fixture Calibration*:

10.6.1 Mount the dial indicator on the bench of the micrometer fixture utilizing the magnetic base dial indicator holder as shown on figure 5.

10.6.2 *Accuracy Determination*:

10.6.2.1 Displace the dial indicator spindle so the indicator hand registers 0.000 by turning the micrometer head.

10.6.2.2 Set the micrometer head to read 0.000.

10.6.2.3 Read and record the zero readings on the dial indicator calibration form.

10.6.2.4 Displace the dial indicator spindle by turning the micrometer head in equal increments (a minimum of four increments per revolution of the dial indicator hand) over the entire range of the dial. Read and record the readings of both the dial indicator and the micrometer fixture at each increment. Record the dial indicator readings to the highest readability possible—based on smallest graduation of the dial indicator hand.

10.6.3 *Hysteresis Determination*:

10.6.3.1 Displace the spindle of the dial indicator by turning the micrometer head in the opposite direction to that used in subparagraph 10.6.2.1.

10.6.3.2 Read and record dial indicator and micrometer fixture readings at the same increments as performed in subparagraph 10.6.2.4.

10.6.4 *Repeatability Determination*:

10.6.4.1 Adjust both the dial indicator and the micrometer fixture to read 0.000.

10.6.4.2 Displace the spindle of the dial indicator by turning the micrometer fixture to cause the appropriate revolution of the dial indicator hand. (See subpar. 10.6.4.8.)

10.6.4.3 Turn the micrometer fixture head to read 0.000.

10.6.4.4 Read and record the micrometer reading and corresponding dial indicator reading.

10.6.4.5 Turn the micrometer fixture head to return the micrometer back to zero.

10.6.4.6 Read and record the micrometer reading and corresponding dial indicator reading.

10.6.4.7 Repeat subparagraphs 10.6.4.1 through 10.6.4.6 a minimum of three times.

10.6.4.8 Subparagraph 10.6.4 should be followed at approximately 25, 50, and 75 percent of full range of the dial indicator.

11. Calculations

11.1 Calculations for determining the accuracy, hysteresis, and repeatability of the dial indicator are as shown on the "Dial Indicator Calibration Sheet" (fig. 3).

7-2349 (5-86) Bureau of Reclamation	DIAL INDICATOR CALIBRATION SHEET	Designation USBR 1007-89

DIAL INDICATOR RANGE/ GRADUATIONS 0-1.000 inch / 0.001 inch

MANUFACTURER Example SERIAL NO. DI-115281

REFERENCE STANDARD USED: ☐ GAUGE BLOCKS SERIAL NO. MF-100

☒ MICROMETER FIXTURE SERIAL NO. _____

CALIBRATION PERFORMED BY _____ DATE _____

CALIBRATION CHECKED BY _____ DATE _____

ACCURACY				HYSTERESIS				REPEATABILITY			
TRIAL NO.	REFERENCE STANDARD LENGTH	DIAL INDICATOR READINGS	DIFFERENCE (2) - (3)	TRIAL NO.	REFERENCE STANDARD LENGTH	DIAL INDICATOR READING	HYSTERESIS (3) - (7)	BASE DIAL READING	RETRACTED READING	RETURN READING	REPEATABILITY
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(9) - (11)
1	0.000	0.000	0.000	89	.0.000	0.000	0.000	———	1/2 REVOLUTION	———	
2	0.025	0.025	0.000	88	0.025	0.024	0.001				
3	0.050	0.050	0.000	87	0.050	0.050	0.000	0.000	0.050	0.000	0.000
4	0.075	0.075	0.000	86	0.075	0.074	0.001	0.000	0.050	0.000	0.000
5	0.100	0.100	0.000	85	0.100	0.100	0.000	0.000	0.050	0.000	0.000
6	0.125	0.125	0.000	84	0.125	0.125	0.000				
7	0.150	0.150	0.000	83	0.150	0.150	0.000	———	2 1/2 REVOLUTIONS	———	
8	0.175	0.175	0.000	82	0.175	0.175	0.000				
9	0.200	0.200	0.000	81	0.200	0.199	0.001	0.000	0.250	0.000	0.000
								0.000	0.250	0.000	0.000
								0.000	0.250	0.000	0.000

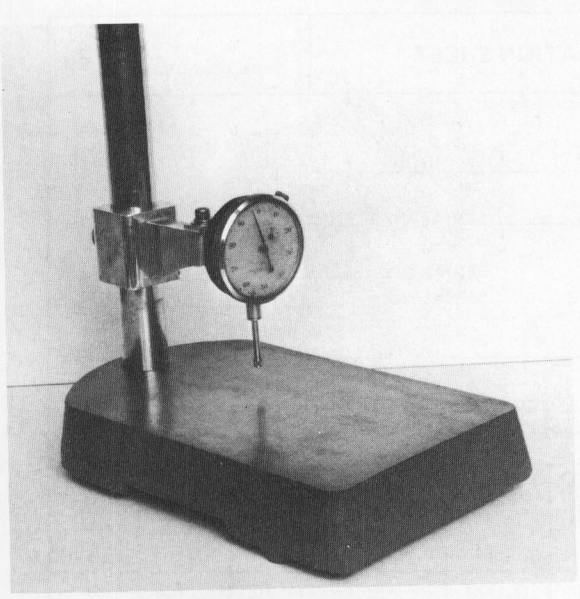
ACCURACY: ACCEPT ☒ HYSTERESIS: ACCEPT ☒ REPEATABILITY: ACCEPT ☒

REJECT ☐ REJECT ☐ REJECT ☐

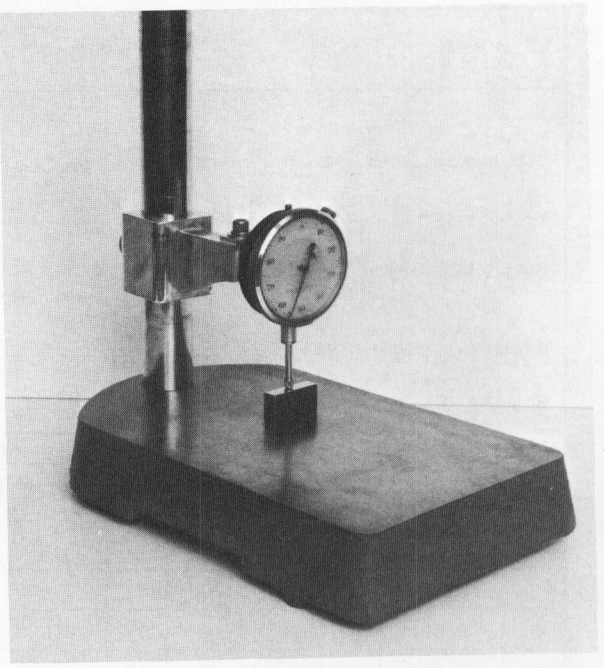
REMARKS: Only partial calibration data shown.

GPO 850-947

Figure 3. – Dial indicator calibration sheet — example.



(a) Dial indicator mounted to comparator stand.



(b) Displacement of dial indicator with gauge block.

Figure 4. – Dial indicator calibration assembly (method A).

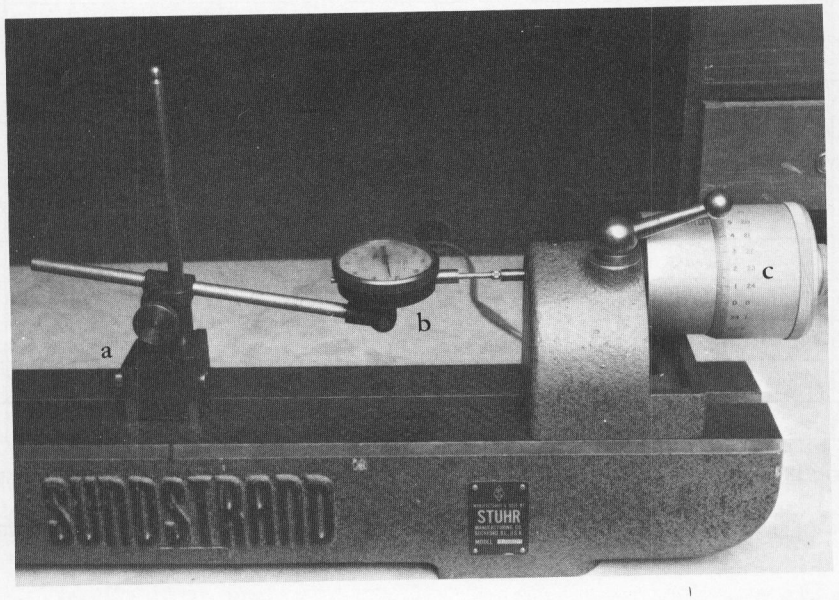


Figure 5. – Dial indicator calibration assembly (method B). (a) magnetic base dial indicator holder, (b) dial indicator, and (c) micrometer head.

12. Interpretation of Results

12.1 Table 1 shows maximum allowable deviation and is to be used to evaluate the acceptability of the dial indicator.

12.2 If deviation of the dial indicator exceeds the limits listed in table 1 for repeatability, hysteresis, or accuracy, the dial indicator must be rejected.

13. Report

13.1 The report is to consist of a completed and checked "Dial Indicator Calibration Sheet" (fig. 3). This information is to be filed with the laboratory equipment calibration records.

13.2 All calculations are to show a checkmark.

Table 1. – Dial indicator maximum deviation.

Smallest graduation inch	Smallest graduation mm	Repeatability	Hysteresis	Accuracy First 2-1/3 revolutions	Accuracy First 10 revolutions	Accuracy First 20* revolutions
		Deviation in units of smallest graduation				
0.00005	0.001	±0.2	0.50	±1	±4	
.00010	.002	±0.2	.50	±1	±3	±4
.00050	.010	±0.2	.33	±1	±3	±4
.00100	.020	±0.2	.33	±1	±2	±4

* Over 20 revolutions consult with individual manufacturers for standard procedure.
Table 1 taken from ANSI B 89.1.10-1978 dial indicators for linear measurements.