

Procedure Title: Mechanical Calibration of Short Gage Blocks (10010)
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Purpose: This procedure establishes the requirements for the calibration by mechanical comparison of standard size metric and English gage blocks.

NOTE! This procedure assumes the operator is familiar with all functions of the NIST "GAGE" Software. For guidance using the software refer to reference [2]. Additionally, this procedure does not explain the statistical process control theory and calculations performed, for detailed information on this issue refer to reference [1].

- References:**
- [1] NIST Monograph 180, *The Gage Block Handbook*, T. Doiron & J. Beers, June 1995
 - [2] NISTIR 6387, *The NIST Gage Block Calibration Software System User's Manual*, J. Zimmerman, January 2000
 - [3] NIST Technical Note 1297, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, B. Taylor & C. Kuyatt, 1994
 - [4] ANSI/ASME B89.1.9M, *Precision Gage Blocks for Length Measurement (Through 20 in. and 500 mm)*. ANSI/ASME, Current Publication
 - [5] T. D. Doiron and J. R. Stoup, "Uncertainty and Dimensional Calibrations," *Journal of Research of the National Institute of Standards and Technology*, Volume 102, pp.647-676, 1997.

Definitions:

Equipment Required/Items Needed:

- Tongs (with plastic tips)
- 200 Proof Ethyl Alcohol
- Lint free cloth towels
- Puffer
- Federal Comparator
- Gage Block Calibration software + computer
- Aluminum soaking tray
- Master Gage Blocks (Steel + Chrome Carbide, English and Metric)
- Mylar wrap
- Foot pedal
- Customer Summary Sheets
- Blank disks
- Pen
- Masking tape

- Holding trays
- Varsol
- Voltmeter
- 0.01°C Temperature Indicator
- 22-caliber gun rod for cleaning
- Lint free paper towels
- Latex gloves

General: The mechanical calibration of standard size English and metric gage blocks are performed using a two point contact mechanical comparator along with one steel master and one chrome carbide master gage block of the same nominal size as the test block being measured. The primary uncertainty components of this calibration include: uncertainty in the master calibration, thermal expansion of coefficient of the master and test blocks, temperature gradients between the gage blocks being compared, deformation corrections (if comparing dissimilar materials), and process reproducibility.

1.0 Setup

1.1 Moving gage blocks from box to holding tray

- 1.1.1 Select set from the “To Do” drawer.
- 1.1.2 Since this is the first step in the process, it is always a good idea to look each block over and inspect for damage prior to proceeding. (If damaged, document this on the customer summary sheet)
- 1.1.3 Select an appropriate size holding tray for the set.
- 1.1.4 Place masking tape on the bottom of the holding tray and label it with the following information: Name of company, Brief Description of the set, starting date, initials of person performing measurements. This step is simply for identification since there is often more than one set being calibrated at the same time in the lab.
- 1.1.5 Next, move the entire set of blocks from the box to the holding tray. However, it is important to clean any grease off the blocks before placing them on the tray. If the blocks are steel, they will be greased and that grease must be removed with Varsol. [Follow Varsol procedure (according to section 1.2)] If the blocks are any other material, they most likely will not be greased and can be transferred directly from the box to the holding tray. (In some cases customers will grease other materials, if this is the case, clean them as you would the steel blocks)
- 1.1.6 Once all blocks are on the holding tray, place lint free paper towel on top.

1.2 Cleaning Greased Gage Blocks with Varsol

Note: (If none of your blocks need to be degreased, skip to 1.3)

- 1.2.1 Place greased gage block on plastic coated wire mesh in the Varsol container. (No more than 5 or 6 blocks at a time to avoid hitting one another)
- 1.2.2 Brush block generously with Varsol and then towel off Varsol and any remaining grease. If blocks are hoke, follow step 1.2.3. Otherwise, skip to step 1.2.4.

- 1.2.3 With hoke blocks, which may have grease in the hole, that hole must also be degreased. For thin sizes, this can easily be accomplished with the towel. However, for larger sizes, when the towel cannot reach into the hole, the gun rod must be used. Tear pieces of the lint free paper towels and manipulate them so that they fit into the gun rod eyelet. Slide the pieces of paper towels through the hole of the block with the gun rod until the grease stops coming out and the wipe comes out dry. You may have to change the pieces of paper several times.
- 1.2.4 Once blocks have been cleaned with the Varsol and placed on the wooden tray, proceed to the next step.

NOTE! It is important to keep all cloth towels used with Varsol separate from towels used with alcohol.

1.3 Filling out a Customer Summary Sheet

- 1.3.1 When blocks are on the holding tray, and in order from the smallest to the largest blocks, write the nominal sizes of the blocks on a Customer Summary Sheet.
- 1.3.2 Next, fill in IDs for each block. It is important to check each and every block even if it appears that the entire set has the same block ID because it is quite common that all blocks in a set but one or two have the same ID.
- 1.3.3 The last column to fill out is labeled, “MATL” and that is where you fill in the material descriptions (i.e. Steel, Chrome Carbide, Tungsten Carbide, Ceramic, etc.) next to each corresponding block.

1.4 Making the setup file

- 1.4.1 From the BRANCH MENU, select SETUP – File setup for GAGE Program.
- 1.4.2 This brings you to a screen with NIST GAGE BLOCK CUSTOMER SETUP DATABASE PROGRAM at the top. Select ENTER to continue.
- 1.4.3 Now you should be at the SETUP PROGRAM CONTROL MENU. Highlight NEW to make a setup file and press ENTER.
- 1.4.4 Then it will ask you: “Enter new gage block setup file name or type STOP?” Make up a name and write that filename (no more than 8 characters) on the Customer Summary sheet. Press Enter when done.
- 1.4.5 Now it will ask you to “Select gage block setup master type: (E)nglish, (M)etric?” Select one.
- 1.4.6 Then it asks, “Enter smallest size in customer gage block set?” Enter size and press Enter.
- 1.4.7 Then it asks, “Enter largest size in customer gage block set?” Enter size and press Enter.
- 1.4.8 At this point, it may ask “Want to include _____ series block series? (Yes No)” Obviously, if you have blocks that fall in that series, it would be a good idea to Select Yes so that you do not have to add them at a later point. If No is selected, the series of blocks will be omitted so obviously select this if you have no blocks in that series.
- 1.4.9 Then it asks, “Select calibration method: (I)nterferometric, (M)echanical?” Select (M)echanical.

- 1.4.10** Next it asks to select a measurement method. Select: “Method 04 3-6 Design: 2 masters and 1 unknown, 6 Measurements Each”
- 1.4.11** Then it asks “Assign customer gage blocks with same serial identification? (Yes No)” If the blocks do have the same serial identification or most of the them do, select Yes-proceed to step 1.4.12. If No, you will manually need to type them in under the VIEW screen.
- 1.4.12** If Yes, it asks, “Enter serial number identification for gage blocks or type STOP?” Enter the ID.
- 1.4.13** Next it asks, “Assign customer gage blocks with same material code? (Yes No)” If all the blocks are the same material, select Yes. In No, proceed to step 1.4.15.
- 1.4.14** If yes, the MATERIAL SELECTIONS FOR GAGE BLOCKS IN CUSTOMER SET screen will come up. Select material and press Enter.
- 1.4.15** Next it will ask, “Thermal Coefficient okay? (Yes No)” Select Yes.
- 1.4.16** Then it will ask, “Elastic constant okay? (Yes No)” Select Yes.
- 1.4.17** Finally this will bring you back to the SETUP PROGRAM CONTROL MENU screen.
- 1.4.18** From the SETUP PROGRAM CONTROL MENU, evaluate the setup file you have made by selecting VIEW. There are three things you should look for here: 1) look to see if all the sizes for the set are present or if any need to be deleted, 2) check to make sure that all material codes are correct, 3) ensure that all block serial identifications are accurate (if you selected NO in step 1.4.11 you will need to open each individual record by highlighting the proper size, pressing enter to open the record, and move down to the BLOCK ID LINE and fill in the correct serial number). It is best to proceed carefully and slowly here block by block to ensure that the setup file is accurate. If any of these three things need to be changed, follow the appropriate directions (Section 1.4.5 through 1.4.7). Otherwise, proceed to Step 1.4.19 after everything is correct.
- 1.4.19** Press F8 to return to SETUP PROGRAM CONTROL MENU. Highlight Store and press Enter.
- 1.4.20** It will ask, “Store gage block setup file now? (Yes, No)” Select Yes.
- 1.4.21** Now it asks, “Enter gage block setup file name to store or type STOP? / C:\GAGE\WORK\SETUPFILENAME.IDS” Accept default file name by pressing Enter.
- 1.4.22** Again, it will ask, “Store C:\GAGE\WORK\SETUPFILENAME.IDS okay? (Yes, No)” Select Yes.

1.4.5 Adding sizes that are in the set.

- 1.4.5.1** After selecting VIEW from the SETUP PROGRAM CONTROLMENU, press F2 (Append Document).
- 1.4.5.2** “Enter new Metric/English gage block setup master (in millimeters/inches) or type STOP?” Enter size and then press Enter.
- 1.4.5.3** Next, the screen for the individual block comes up. The top of the screen reads, “Information for (size) MASTER FILENAME.IDS.”

1.4.5.4 Fill in:

- Gage Block Identification - whatever the ID is
- Gage Block Material Code - 1 for Steel, 2 for Ceramic, 3 for Chrome Carbide, 4 for Tungsten Steel, 5 for Stainless Steel, or 6 for Mitutoyo Steel
- Thermal Coefficient - whatever corresponds to the material
- Elastic Constant - whatever corresponds to the material
- Testing Method Code - always select 4

1.4.5.5 Press F8 to go back to the VIEW screen where the entire setup file is displayed. (After this is done, proceed to Section 1.4.19)

1.4.6 Deleting sizes that are not in the set.

1.4.6.1 Select VIEW from the SETUP PROGRAM CONTROL MENU.

1.4.6.2 Highlight size that is listed but is not actually in the set.

1.4.6.3 Press F4 (DELETE RECORD) to delete the size.

1.4.6.4 Repeat as necessary.

1.4.7 Changing material codes or block serial identifications.

1.4.7.1 Select VIEW from the SETUP PROGRAM CONTROL MENU.

1.4.7.2 Highlight the block size that needs to be corrected and press Enter.

1.4.7.3 Type is changes in appropriate spaces. If changing the Gage Block Material Code, remember to enter new Thermal Coefficient and Elastic Constant (follow Section 1.4.5.4's directions).

1.4.7.4 Press F8 to go back to the VIEW screen where the entire setup file is displayed.

1.5 Preparing gage blocks for measurement

1.5.1 For sizes <30 mm or ≤ 1 inch, follow these steps. For large sizes, skip to 1.5.2.

1.5.1.1 Find a soaking tray and clean the surface with a cloth towel and 200 Proof Alcohol.

1.5.1.2 On the soaking tray, there should be three rows of gage blocks (1, CUSTOMER BLOCKS, 2, CHROME CARBIDE MASTERS, and 3, STEEL MASTERS). For the row of CUSTOMER BLOCKS, clean each block with 200 Proof alcohol and a cloth towel to remove any smudges from the block. Set up 15-20 blocks.

1.5.1.3 For the row of CHROME CARBIDE MASTERS and the STEEL MASTERS, repeat the previous cleaning procedure.

1.5.1.4 Once all three rows are cleaned and on the soaking tray, place soaking tray next to the comparator and let them sit for at least two-three hours. **This allows the block temperature to adjust to the temperature of the comparator.**

1.5.2 Preparing gage blocks (sizes >30mm or >1 inch) for measurement
NOTE! 30mm, 40mm, 50mm, 60mm, 70mm, 75mm, 80mm, 90mm, 100mm, 1inch, 2inch, 3inch, and 4inch size blocks should be set up for at least six hours prior to measuring. It is recommended that they be set up before leaving one night and then measured first thing the next day.

- 1.5.2.1** Clean all master and customer blocks with 200 Proof Alcohol and a cloth towel.
- 1.5.2.2** All three blocks (Steel [S] and Chrome Carbide [C] Masters and Customer [1]) are to be set up directly on the anvil of the comparitor. Before placing the blocks on the anvil, clean anvil with the cloth towel and 200 Proof Alcohol.
- 1.5.2.3** Next, place Steel Master block directly underneath the probe tip. Follow Section 1.7.1.
- 1.5.2.4** Place Chrome Carbide and Customer block on anvil and let all three blocks (S, C, 1) sit for at least 6 hours (preferably overnight).
- 1.5.2.5** When measuring, follow regular measurement procedure (see Section 2.0).

1.6 Loading Gage Block Program to run calibration

- 1.6.1** Default screen should always be BRANCH MENU.
- 1.6.2** Select GAGE, the Gage Block Calibration Program.
- 1.6.3** An overview and description of the Gage Block Calibration Program comes up on the screen. Press ENTER to continue.
- 1.6.4** Now it asks you to: Select (G)age or (T)est. Gage should be selected during the initial measurements and will store any data directly on the IDS file. If you select Gage, proceed to step 5. Test should be selected for remeasures and for special measurements and will not be stored anywhere in the computer's memory. If you select Test, proceed to Loading Gage Block Program (Test) procedure.
- 1.6.5** It will ask you to "Select gage block setup master type: (E)nglish or (M)etric?" Select the appropriate type.
- 1.6.6** Next it will ask you to "Select calibration method: (I)nterferometric or (M)echanical." Always select Mechanical.
- 1.6.7** Now it asks you to, "Enter customer gage block setup file to run in series?" It always defaults to 1 and that should always be selected.
- 1.6.8** It will then ask you to "Enter observer initials or type STOP." Enter your initials to proceed. Only type in STOP if you have made a mistake or would like to exit the program for any reason.
- 1.6.9** Now a screen will have GAGE BLOCK COMPARITORS written at the top. Always select the default comparitor (either WS#1 / WS#2 / WS#3).
- 1.6.10** Next it asks you to "Select Measurement method: (A)utomatic or (M)annual?" Typically, select Automatic as that will enable you to enter data from the comparitor by using the foot pedal. Manual should only be selected for special tasks (for example, if a block was measured in Test and needed to be imported into the IDS file, this is one method to do that). If you select Manual, follow all the steps that follow except that you will simply be entering in the numbers from a Test sheet on the keyboard instead of actually taking measurements.

- 1.6.11 Next you will have to select the IDS file and press ENTER.
- 1.6.12 The screen that shows up here has GAGE PROGRAM CONTROL MENU written at the top. This basically shows you all of the selections you have just made and gives you some options for what to do now. Assuming you are ready to take some measurements, Select RUN to continue.

1.7 Setting the comparator up to prepare for measuring a gage block.

NOTE! When doing this, all previous steps should have been completed and so the soaking tray should be next the comparator and ready to measure.

- 1.7.1 Place STEEL MASTER under the contact, but not at the gage point. It is important that the following steps be done on a part of the block other than the gage point!
- 1.7.2 Rotate control so that the tip is approximately 1/16 of an inch above the STEEL MASTER gage block.
- 1.7.3 Move lever on the side of the comparator from RETRACT to GAGE.
- 1.7.4 Carefully, lower or raise contact by slowly moving the rotating knob on the top of the comparator left or right until the display is reading between -50 and 50.
- 1.7.5 Move lever on the side of the comparator from GAGE to RETRACT.
- 1.7.6 Place lock down to the right.
- 1.7.7 Move lever on the side of the comparator from RETRACT to GAGE.
- 1.7.8 Slide STEEL MASTER out and begin measurement scheme.

2.0 Measurement

NOTE! All short gage blocks measurements should be made at 20.00 ± 0.50°C. Tungsten Carbide customer gage blocks should be measured between 20.00 ± 0.25°C.

- 2.1.1 After comparator has been prepared, type in temperature and press ENTER (please note the temperature correction that is indicated on the top of the instrument and use the corrections from the latest calibration date)
- 2.1.2 Make sure that blocks are lined up in the following order (closest to the contact first): STEEL MASTER [S], CHROME CARBIDE MASTER [C], CUSTOMER BLOCK[X or 1].
- 2.1.3 Slide the STEEL MASTER underneath the CONTACT TIP and center the block so that the contact is on the GAGE POINT. Step on the foot pedal and a reading should show up on the screen next to the S. Repeat this step, following the measurement scheme (S C X C S X C S X S C X C S X C S X).
- 2.1.4 Once all measurements are completed, the screen on the computer will show you the results of the test. Generally, if the F-Test and T-Test are around 2.80 or lower, you will pass the test. At this point, simply remove the blocks and start on a new size. Press (C)ONTINUE to move on. Otherwise, if the F-Test and/or T-Test is/are above 2.80, the test will fail and the following will be written underneath the statistics: “Process not in statistical control . . .” If the F-Test caused the failure, it is recommended to press (R)EPEAT and try measuring the block again. If it fails a second time, investigate to see why the block is failing our statistics (sometimes this is obvious). If you are having trouble, please seek lab manager’s assistance. (NOTE: Do not keep measuring the block failure upon failure. This will cause incorrect information to be stored in the statistics.

NOTE: Once all of these steps are completed, the procedure until all blocks in the set are completed!

3.0 Data Analysis

3.1 Opening the setup file and history file, checking your new data against the old, and archiving.

- 3.1.1 Go to the HISTORY program
- 3.1.2 Go to "OPEN SETUP", press ENTER
- 3.1.3 The program will show you a screen with a listing of all the "IDS" files on the C:\GAGE\WORK directory. Move the highlight bar down to the file name you recorded on your customer summary sheet, press ENTER. Otherwise, skip to Step 3.1.7.
- 3.1.4 If you have a history disk with previous history for the set put it in the 3 ½" disk drive (this will most likely be the "A" or "B" drive. Go to the "OPEN HISTORY FILE" option on the screen, press ENTER.
- 3.1.5 The program will bring up a screen with a directory of HIS files on the C:\GAGE\HISTORYS directory, if there is any files. Press TAB then move the highlight bar to the appropriate drive, then press enter.
- 3.1.6 The program will bring up a directory of HIS files on the history disk you have in the drive. Press the SHIFT and TAB keys at the same time, this moves your highlight bar over to the one HIS file you have on your history disk. If more than one file is shown you need to choose the proper one, this will only occur if you have more than one history file on the history disk, which is rare but exists for specific reasons. Once you highlight the proper file, press ENTER.
- 3.1.7 Now go to "RUN", press ENTER.
- 3.1.8 It will ask "Generate customer gage block history?" Select YES.
- 3.1.9 It will then ask "Enter gage block customer history file name or type STOP." It will provide you with a default "C:\GAGE\HISTORYS\YOURSETUPFILENAME.HIS", just accept this by pressing ENTER.
- 3.1.10 It will ask "Generate C:\GAGE\HISTORYS\YOURSETUPFILENAME.HIS okay?", select YES.
- 3.1.11 Select VIEW to visually evaluate new data with old. Select PLOT to graphically review new and old data. Select the other two history evaluation functions for further aids to help you determine whether your data is acceptable. **NOTE! PLEASE REFER TO APPENDIX 1 FOR FURTHER INSTRUCTION.**
- 3.1.12 If you have no remeasures then you are ready to archive your data, otherwise exit the HISTORY Program without archiving.
- 3.1.13 To archive (short cut), select EXIT in the HISTORY program menu, it will ask you if you want to "Archive gage block customer history file now?", select YES.
- 3.1.14 Next will ask you "Enter gage block customer history file to archive now or type STOP." Here you must change the path so that it saves or archives the file to your floppy disk or history disk. In this case the default is not correct. You should change the "C" to a "B" or "A" drive

and delete GAGE\HISTORY.S. Your entry should look like the following:

B:\TheHistoryFileName.HIS or A:\TheHistoryFileName.HIS

The default file name will be the name of the history file on your floppy disk which will be correct. If there is no history file then you will be archiving only your new data, in which case, you may use the setup file name you gave it when you started or you can change it to something else.

- 3.1.15 It will then confirm the path “Archive B:\TheHistoryFileName.HIS okay?”. Select YES.
- 3.1.16 It will then say “Overwrite B:\TheHistoryFileName.HIS?” Select YES.
- 3.1.17 It will then ask “Exit history B:\TheHistoryFileName.HIS?” Select YES.
- 3.1.18 Then select EXIT HISTORY from the menu options to go back to the main menu.

3.2 **Saving your setup file on the history disk or floppy so that you can transfer it to another system to do your report.**

- 3.2.1 You now want to go to EDIT in the main menu so that you can save the IDS file on the history disk. This is done so that you can take it to a computer connected to the internet to do a report.
- 3.2.2 Press F5, highlight the setup file (IDS) name from your customer summary sheet, then press F2. It will ask “Enter file name” and present you with a default. Accept the default by pressing ENTER.
- 3.2.3 To save the IDS file to your disk select F3, it will ask you “Enter file name” and present you with a default. Here you need to change the path to B:\YourSetUpFileName.IDS then press ENTER. It will ask you for the file type and give you three choices with the third highlighted “Ordinary DOS ASCII” accept this by pressing ENTER.
- 3.2.4 It is now saved.

3.3 **Verifying that you have properly archived and that you have saved your setup file or IDS file to the disk.**

- 3.3.1 You can verify that you have properly archived the new data and saved the IDS file by pressing F7, pressing the END key to erase the default option provided for the prompt to “Enter the storage mass storage device and directory”, type in “B:\”, then press ENTER. Now press F5 and the program will give you a listing of all files on the history or floppy disk. Verify that the HIS and IDS files are there and have a very recent date in not today’s date (computer date may be slightly off).
- 3.3.2 Press F8 then press F8 again. It will ask you “Want to store text?” select NO. Then it will ask you “Really want to exit EDIT?” select YES.