Calibrating Plug Gages Using the "Three Wire Method"

by:
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The proper calibration of gages is one of the foundational elements of a good quality program. A company can have the most sophisticated statistical process control (SPC) system that uses the latest computerized data collection system, follow every inspection procedural requirement and still obtain completely meaningless and inaccurate data if the gages being used are not properly calibrated.

Threaded Plug Gages

One of the fundamental gages used in the control and inspection of threaded products is the threaded plug gage. Several types of plug gages are used for different purposes depending on the types of threaded products being manufactured and the style of gages being used. Go and NoGo work plug gages are used to inspect internal threads in nuts and internally threaded tapped holes. Go and NoGo setting plugs are used to set Go and NoGo ring gages. Single-end, full-form setting plugs are used for setting tri-roll and segment type gages used for the inspection of external threads.

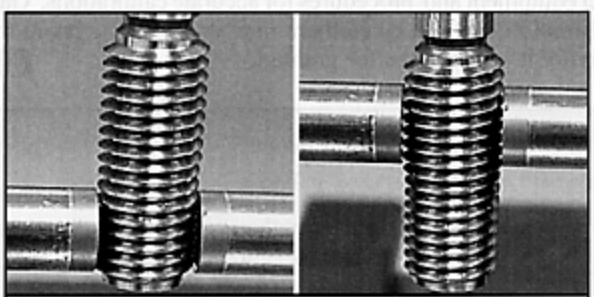
Depending upon the type and style of the plug gage, a minimum of four measurements, and as many as eight measurements, are required to properly calibrate threaded plug gages. The measurements are taken on the major diameter and the pitch diameter of the threaded plugs.

Plug Gage Major Diameter Must be Calibrated

The major diameter is calibrated by simply measuring the largest diameter of the exterior of the threaded portion of the plug gage. The best practice in measuring the major diameter is to take the measurement using the same measurement equipment and the same measurement pressure that is required for measuring the pitch diameter.

The number of major diameter measurements taken per element are as follows:

Work plugs	One
Truncated setting plugs	Two
High-low setting plugs	Two
Full-form setting plugs	One



Major diameter being measured on setting plugs.

Three Wire Method of Pitch Diameter Measurement

The most critical calibration measurements on setting plugs are those of the pitch diameter. Unfortunately, there is no simple, direct approach for taking pitch diameter measurements. The **American Society of Mechanical Engineers (ASME)** establishes the only acceptable pitch diameter measurement method in the standard, *ASME B1.2, Appendix B.*

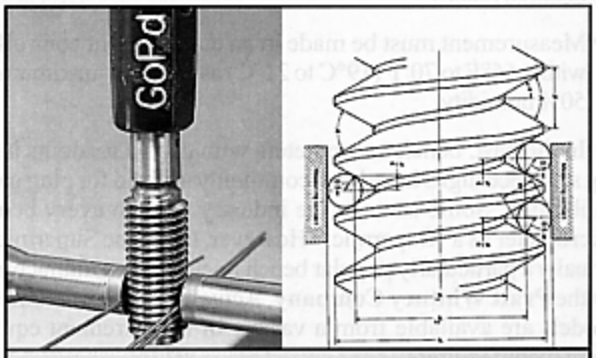
ASME has established specific wire diameters to be used in this method for the measurement of each thread pitch. These wire sizes are referred to as the "Best Size" wire diameters. Each Best Size wire has an associated "constant" that is tabulated in *Table B1* in the *ASME B1.2* standard.

The pitch diameter measurement method described that is in *ASME B1.2* is called the "Three Wire Method" or is frequently referred to as the "Over-Wire Method."

The Three Wire Method of calibration is just what the name suggests. Three very precisely measured and matched wires are placed in a particular relationship relative to the gage's thread. After the wires are properly positioned in the measuring equipment, the measurement over the wires is taken.

Wires are positioned as shown below and a measurement is taken over the wires using these measuring pressures:

Threads/Inch	Measuring Force (±10%)
20 or less	2.5 lb
Over 20 but not over 40	1 lb
Over 40 but not over 80	8 oz
Over 80 but not over 140	4 oz
Over 140	2 oz



Positioning of the wires in the "Three Wire Method."

Once the over the wires measurement is obtained, the Best Size constant is subtracted from that measurement to determine the threaded plug's pitch diameter size. For example:

Work plug thread size	1/4-20 2B
Thread size limits	0.2175"-0.2224"
"Best Size" wire	0.02887"
"Best Size" constant	0.043301"
Measuring pressure	2.5 lb
Actual measurement "over wires"	0.263801"
Work plug's pitch diameter size (actual measurement "over wires" minus the "best size" constant)	0.2205"

The number of pitch diameter measurements taken per element are as follows:

Work plugs	Three	Front, center, back
Truncated setting plugs	Three	Front, center, back
High-low setting plugs	Six	Front, center, back (high & low sections)
Full-form setting plugs	Three	Front, center, back

Calibration Measurement Equipment

According to *ASME B1.2, Appendix B, Section B4* and *Section B5*, the equipment and the environment utilized for the plug gage calibration process must meet the following requirements:

- The Best Size wires used must be calibrated to be within 0.000020" (0.0005 mm) of their specified size. The three wire set must be within 0.000010" (0.00025 mm) of one another. The taper of a 1" (25 mm) long wire must not exceed 0.000010" (0.00025 mm). The wires must be made of steel and have a minimum hardness rating of 776 on the Knoop hardness scale.
- The measurement indicator must have a resolution of 0.000010" (0.00025 mm) or smaller.
- The two measurement surfaces should be parallel to one another within 0.000004" (0.0001 mm).
- The wires must be free to assume their best position without restraint.
- Pitch diameter measurements should be reported to five decimal places.
- Measurement must be made in an environment controlled within 66°F to 70°F (19°C to 21°C) as well as a maximum of 50% humidity.

In the past, bench micrometers with digital readouts having six-place digits have been commonly utilized for plug gage calibration. Some users in the industry refer to every bench micrometer as a "Supermic." However, the name Supermic is actually a particularly popular bench micrometer manufactured by the **Pratt Whitney Company**. Actually, bench micrometer models are available from a variety of measurement equipment manufacturers.

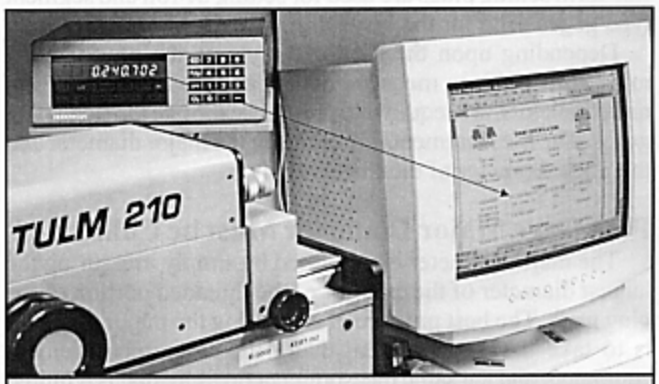
Today's more sophisticated calibration laboratories and QC facilities make use of what are referred to as universal measuring machines. Some users of these advanced equipment systems choose to hand write their measurement results and manually subtract the wire constants in order to determine the gage's pitch diameter. However, it is possible for calibration laboratories to take their measurements directly from the universal measurement machine through an interface into a computer.

In these cases, the actual pitch diameter measurements are automatically calculated for printing directly into the calibration certificate forms.

The direct computer input approach is the most efficient as well as the most error-free method of calibrating threaded plug gages along with the generation of the associated calibration certificates.

Many calibration laboratories now use the universal measuring machine.

Universal measurement system provides measurements traceable to NIST specifications.



Results of measurements made on universal measuring machines are directly recorded into certificate forms.

Garbage In – Garbage Out

Plug gage users should remember they can do everything perfectly in their quality system, yet still produce and ship nonconforming threaded products if the gages are not properly calibrated. Calibrations must be performed using the correct equipment and procedures for accurate calibrations. Gage calibration is a crucial element in every quality system that should never be taken for granted. **FTI**

Greenslade & Company, Inc. *is a supplier of fastener inspection products and A2LA-Accreditation Calibration Services.*

Joe Greenslade *is a regular contributor of articles to this magazine. He has been active in the fastener industry since 1970 and has held positions with major fastener producers.*