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~~SHOP~~ INSPECTION OF TAPER THREAD GAGES.

The measurement of taper pipe thread gages in manufacturing establishments, where special facilities for making such measurements are not available, offers peculiar difficulties since the methods ordinarily applied to the measuring of thread gages cannot be used without modification. In this communication are presented methods which may be used in measuring taper thread gages.

PLUG GAGES.

Measurement of Pitch Diameter: Pitch diameter of a taper plug gage is measured by means of a three-wire method which is very nearly the same as that employed in the measurement of ordinary thread gages. A point at a known distance "L" from the end of the gage is located by means of precision gage blocks, such as the Johansson or Hoke Gages, and the cone point furnished as an accessory with these gages, as illustrated in Fig. 1. The gage is set vertically on a surface plate, the cone point is placed with its axis horizontal at the height desired, and the plug is turned until the point fits accurately into the thread. The position of this point is marked by prussian blue or a bit of wax. A single "best-size" wire is placed in the thread at this point and the other two wires are placed in the adjoining threads, on the opposite side. Measurement is made over the wires by means of a micrometer caliper in the usual manner but care must be taken that the gaging surfaces make contact with all three wires since the micrometer is not perpendicular to the axis of the screw when there is proper contact. See Fig. 2. Owing to this inclination the measurement over the wires must be multiplied by a constant which is the secant of the half-angle of the taper of the thread. The pitch diameter of a Briggs Standard pipe thread gage having correct angle and taper is then given by the formula:

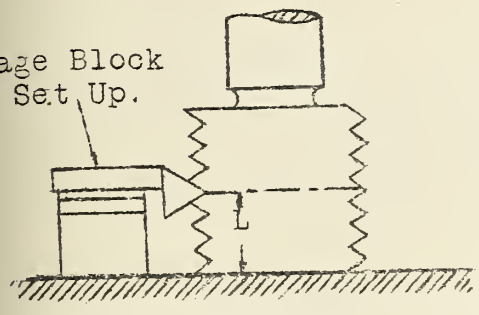

Fig. 1.

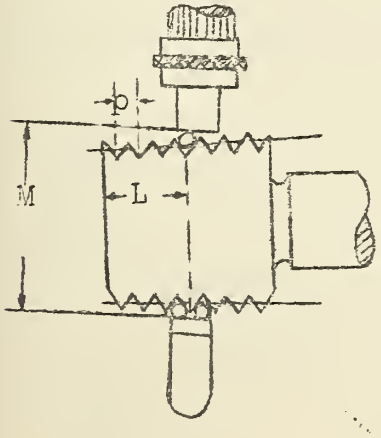

Fig. 2.

$$E = 1.00048\ M + .86603\ p - 3\ G.$$

The general formula for the pitch diameter of any tapered thread gage has the form:

$$E = M \sec.y + p/2 \cot.a - G(1+\csc a)$$

in which:

E = pitch diameter,
M = measurement over wires.
y = half-angle of taper of thread,
p = pitch,
a = half-angle of thread,
G = diameter of wires.

The pitch diameter at any other point along the thread may be obtained by multiplying the distance between the points, parallel to the axis of the thread, by the taper per inch and adding or subtracting this product to or from the measured pitch diameter, depending on the direction in which the second point is located with respect to the first.

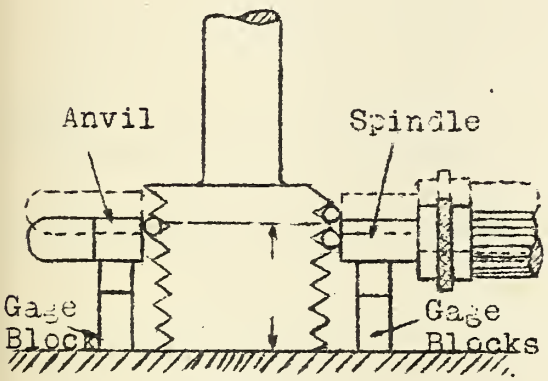

Fig. 3.

The following method, illustrated in Fig. 3 has a theoretical advantage over the first method in that it is independent of the taper of the thread and, therefore, requires less computation; or, if the taper is not measured but assumed to be correct, it is more accurate. The gage is set up on a surface plate with its axis vertical, and two equal combinations of precision blocks are used to support the micrometer anvil and spindle horizontally, that is, with the axis of the micrometer perpendicular to the axis of the screw. A single wire is placed in the thread at a known distance from the small end of the gage, this point having been located as in the previous method. The other wire is inserted in the upper thread on the opposite side of the gage and a measurement is taken over the two wires by means of a micrometer caliper. The second wire is then moved to the thread immediately below and a second reading is taken. The mean of these two readings is substituted as the value M in the formula:

$$E = M + p/2 \cot.a - G (1 + \csc a);$$

or as the value M in:

$$E = M + .86603\ p - 3G$$

for a Briggs Standard pipe thread having correct angle and taper.

Taper: The taper can be readily computed by taking readings over the wires, first in any thread at the small end, and then at any thread at the large end, the exact number of threads between the two points being known.

Major Diameter: Two methods, similar to those described for measuring pitch diameter, may be used for measuring the major diameter of taper plug gages. In either case the anvil of a micrometer is placed in contact with the crest of the thread directly opposite the point located at a known distance 'L' from the end as shown in Fig. 1. In this case the axis of spindle of the micrometer is perpendicular to the taper of the thread and it has contact with two or more threads. See Fig. 4. To obtain the correct outside diameter at the distance 'L' from the end of the gage it is necessary to multiply the measurement 'B' by the secant of the half-angle

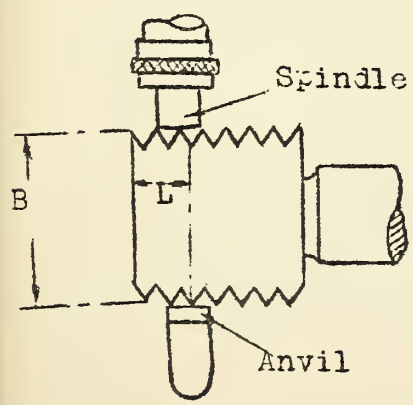

Fig. 4.

of the taper, which for a Briggs Standard pipe thread is the constant 1.00048.

In the other method the axis of the micrometer is constrained perpendicular to the axis of the screw as shown in Fig. 5. In making the measurement the anvil of the micrometer has contact with the single crest as shown and two readings are taken one with the spindle of the micrometer directly below and another with it on the crest above the point at the root of the thread at the distance 'L' from the end of the gage. The taper being known the diameter at any other point on the gage is then readily computed.

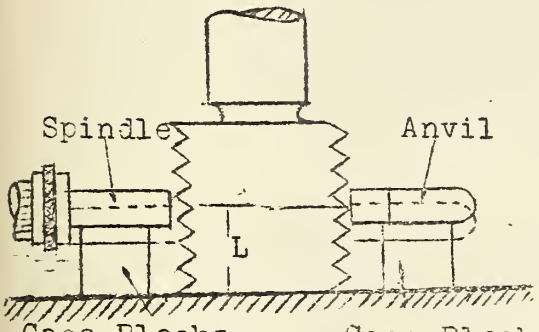

Fig. 5.

It is not good practice, in determining either pitch or major diameters to rely on the measurements taken at a single point but check measurements should be made at two or three different points.

Lead and Angle: The measurement of lead and thread angle of taper thread gages, without apparatus which has been designed for laboratory use for that special purpose, is a particularly difficult operation. It may be possible for the inspector to adapt his own methods, used for measuring ordinary thread gages, to this purpose. Lead should be measured parallel to the axis of the screw but if it is measured parallel to the taper the values obtained should be multiplied by the cosine of the half-angle of the taper of the thread. If the thread has a taper of one to sixteen, as in the case of Briggs Standard pipe threads, the correction is made by multiplying the measurements obtained by .99951 or by subtracting the amount .00049 per inch.

The optical projection method, which is being quite extensively adopted by manufacturers of thread gages for the measurement of thread angle and the determination of thread form is the best suited for the inspection of the thread angle of a taper thread gage. However, if a projection lantern is not available, a simple device for testing the included angle of a thread, which is finding application in some manufacturing plants, consists of a special base carrying two center supports for holding the gage and a rear support or slide for holding cone-pointed inspection rods. Since, with few exceptions, practically all thread gages, including Briggs Standard pipe thread gages, have the bisector of the thread angle perpendicular to the axis of the screw, these rods are constrained on the slide perpendicular to the axis of the centers. The cone points used should be carefully ground and lapped to the correct angle. The procedure followed in using this device is to place the plug to be measured in the centers and then locate one of the cone-pointed rods in the space between the threads. A sheet of white paper, for illuminating purposes, is placed below the gage and the fit of the cone in the thread is viewed thru a magnifying glass.

If it is desired to determine the error in angle, rods having points ground to included angles greater and less than 60° may be used. The values of these angles would be 59° 30' and 60° 30' or

other values depending on the tolerances permitted. Usually, however, the thread is tested for "light", and if the cone point does not bear evenly on the sides for the depth of the thread, it is not passed. By using two points which are spaced a distance which is some exact multiple of the pitch, it is possible to test the lead with this device.

RING GAGES.

Satisfactory methods, which do not require rather expensive special apparatus, for the measurement of the various elements of ring thread gages have not been worked out. Accordingly, the only procedure available is to fit a taper thread ring gage on a correct master plug. The pitch diameter of such a ring may be checked by fit on a threaded check plug and the minor diameter (core diameter) on a plain tapered plug.

SPECIAL APPARATUS.

For the measurement of lead of Briggs Standard pipe thread plug and ring gages the Gage Section, Bureau of Standards, has developed a special lead testing device, the design and specifications of which are available in Bureau of Standards Communication B514.

An optical projection method which is used at this Bureau affords the best means by which the thread angle can be measured, and the accuracy of the thread form, and clearance at the root can be determined. The thread form and angle of a thread ring gage may be inspected by examining a cast of the thread made by pouring a fused mixture of about 90% sulphur and 10% graphite into the thread.

To overcome the difficulty encountered in applying the three wire system of measurement, due to the necessity of retaining all three wires accurately in the grooves of the thread, this Bureau has developed a balanced micrometer holder. Two types have been developed; one is designed so that the micrometer is not rigidly constrained and the other constrains the micrometer perpendicularrto the axis of the gage so that the diameters of tapered thread gages may be measured according to the second method described above.

The specifications and designs covering any of this apparatus will be furnished upon request.

TABLE OF CONSTANTS FOR BRIGGS STANDARD PIPE GAGES.

The following table of constants will not apply strictly except where the angles of taper and included thread angle are correct. They will serve however to correlate the formulae with the tables of trigonometric functions in which the values for angles other than standard may be found.

Full taper of thread = 1/16 inch on diameter per inch of length.
Included angle of taper, Y = 3° 34' 48".
Half-angle of taper, y = 1° 47' 24".
Secant y = 1.00048
Cosine y = 0.99951
Thread Angle A = 60°
Half angle of thread, a = 30°
Sin a = 0.50000
Cosine a = 0.86603
Cotangent a = 1.73206
Cosecant a = 2.00000

Dimensions of Briggs Standard Pipe Gages.

Taper is 1/16 inch per inch. Thread angle 60°.

Diameters at Small End of Plugs.

A Nominal Size of Pipe.	B Number of Threads per Inch	G Best Wire Diameter	Pitch Diameter c	C Plug Outside Diameter c + F	Ring Core Diameter c - F
1/8 inch	27	.02139	.3635	.3931	.3339
1/4 "	18	.03208	.4774	.5218	.4330
3/8 "	18	.03208	.6120	.6565	.5676
1/2 "	14	.04124	.7584	.8156	.7013
3/4 "	14	.04124	.9677	1.0248	.9105
1 "	11 1/2	.05021	1.2136	1.2832	1.4441
1 1/4 "	11 1/2	.05021	1.5571	1.6267	1.4877
1 1/2 "	11 1/2	.05021	1.7961	1.8657	1.7265
2 "	11 1/2	.05021	2.2690	2.3386	2.1995
2 1/2 "	8	.07217	2.7195	2.8195	2.6195
3 "	8	.07217	3.3406	3.4406	3.2406
3 1/2 "	8	.07217	3.8375	3.9375	3.7375
4 "	8	.07217	4.3344	4.4344	4.2344
4 1/2 "	8	.07217	4.8313	4.9313	4.7313
5 "	8	.07217	5.3907	5.4907	5.2907
6 "	8	.07217	6.4461	6.5461	6.3461

Dimensions of Briggs Standard Pipe Gages.

A Nominal Size of Pipe.	Diameters at American Briggs Notch. $D = C + \frac{H}{16}$ Pitch Diam. d	Plug Outside Diam. d + F	Ring Core Diam. d - F	Diams. at Large End of Plug Full Briggs Ring. $E = C + \frac{I}{16}$ Pitch Diam. e	Plug Outside Diam. e + F	Ring Core Diam. e - F
1/8"	.3748	.4044	.3451	.3800	.4096	.3504
1/4"	.4899	.5343	.4455	.5025	.5469	.4581
3/8"	.6270	.6715	.5826	.6375	.6819	.5931
1/2"	.7784	.8356	.7213	.7918	.8489	.7347
3/4"	.9889	1.0460	.9317	1.0018	1.0589	.9447
1 "	1.2386	1.3082	1.1691	1.2563	1.3259	1.1867
1 1/4"	1.5834	1.6530	1.5138	1.6013	1.6709	1.5317
1 1/2"	1.8223	1.8919	1.7526	1.8414	1.9109	1.7717
2 "	2.2963	2.3658	2.2267	2.3163	2.3859	2.2467
2 1/2"	2.7622	2.8622	2.6622	2.7906	2.8906	2.6906
3 "	3.3885	3.4885	3.2885	3.4156	3.5156	3.3156
3 1/2"	3.8888	3.9888	3.7888	3.9158	4.0156	3.8156
4 "	4.3871	4.4871	4.2871	4.4158	4.5156	4.3158
4 1/2"	4.8859	4.9859	4.7859	4.9156	5.0156	4.8156
5 "	5.4493	5.5493	5.3493	5.4736	5.5786	5.3786
6 "	6.5060	6.6060	6.4060	6.5406	6.6406	6.4406

Dimensions of Briggs Standard Pipe Gages.

A Nominal Size of Pipe	F Depth of Thread	G Increase in Diam. per turn.	H Distance Small End To American Briggs Notch and Ring.	I Distance Small End to full Briggs Ring and Plug.	K Outside Diam. of Pipe.
1/8"	.02962	.00231	.180	.2638	.405
1/4"	.04444	.00347	.200	.4018	.540
3/8"	.04444	.00347	.240	.4078	.675
1/2"	.05714	.00446	.320	.5337	.840
3/4"	.05714	.00446	.339	.5457	1.050
1 "	.06957	.00543	.400	.6828	1.315
1 1/4"	.06957	.00543	.420	.7068	1.660
1 1/2"	.06957	.00543	.420	.7235	1.900
2 "	.06957	.00543	.436	.7565	2.375
2 1/2"	.10000	.00781	.682	1.1375	2.875
3 "	.10000	.00781	.766	1.2000	3.500
3 1/2"	.10000	.00781	.821	1.2500	4.000
4 "	.10000	.00781	.844	1.3000	4.500
4 1/2"	.10000	.00781	.875	1.3500	5.000
5 "	.10000	.00781	.937	1.4063	5.563
6 "	.10000	.00781	.958	1.5125	6.625