Measurement of Miniature Screw Threads

by Larry Borowski

Miniature Screw Threads are small screws that are used in time pieces, optical instruments, electrical meters, measuring instruments, etc. They are used to fasten very small parts into delicate assemblies, and therefore are delicate themselves.

Currently there are no gaging standards for screws smaller than 1.6mm in diameter. These are commonly referred to as miniature screw threads, and there are (14) different diameter/pitch combinations that fall into this category. These start as small as .3mm diameter. Luckily there are several standards that do govern the design of such product threads and give guidance for inspection as well. It should be noted that all the standards agree that below 1.0mm diameter these screws do vary from the common basic form in the area of thread height. The common basic thread height is derived from the equation .5412659P, where the miniature screw thread series uses .4800P to derive thread height. The difference is primarily related to the tapping process of internal threads and the likelihood of breaking taps using the larger thread height.

There are (8) different countries that are the custodians of miniature screw thread standards. These are:

Standard	Country of origin
NIHS 06-02, 05: 1970	Switzerland
GB/T 15054.1, .2, .3, .4, .5: 1994	China
NF E03-501, - 502, -503, -504: 1970	France
BS 4827: 1972, BS ISO 1501:2009	UK
JIS B0201: 1973	Japan
DIN 14-1, -2, -3, -4: 1997	Germany
GOST 8724:2002, GOST 9000:1981, GOST 3199:1984	The Russian Federation
ASME B1.10M:2004	USA

Unfortunately, all these standards do not agree with each other 100% which makes it difficult to define universally acceptable gaging. As stated in the BS ISO 1501:2009 standard, there are three main differences between the above listed standards:

1. Five of the countries/standards restrict the use of miniature screw threads with diameters from 1mm to 1.4mm.
2. The tolerances of the USA standards are different from the tolerances of the other countries. For instance, USA does not designate different classes of fit.
3. The designations for these threads are presented differently, where three of the countries/standards do not use S as the symbol for miniature screw threads. The standards that do not use S are, DIN, GOST, and ASME.

The following table was taken from BS ISO 1501:2009 to summarize the differences between the various miniature screw thread specifications.

Table C. 1 -- Differences between the ISO International Standards and those of eight countries concerning miniature screw threads

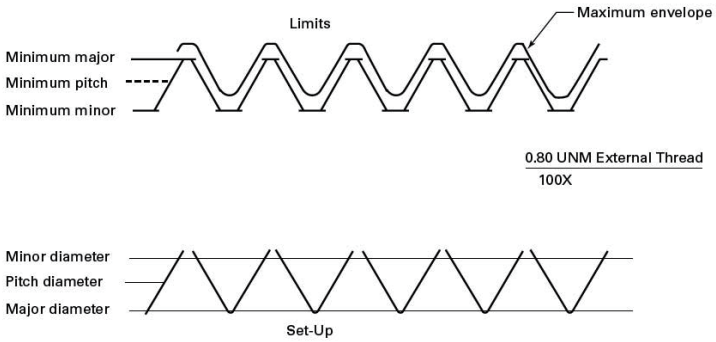
Standard	Range of nominal diameter	Design profile H1, h3	Series d-p	Tolerance		Thread symbol
				Position	Grade	
ISO	0,3mm~1,4mm	H_1=0,48P; h_3=0,56P	Two series of diameters. 14diameters.	Internal thread: G, H; External thread: h.	D_2:3, 4; D_1:5, 6; d:3; d_2: 5; d_3: 4	S
NIHS	ISO	ISO Add D_4 to replace D	One series. Delete 0, 45, 0,55 and 1,1	Internal thread: G; External thread: h.	D_2:3; D_1:5, 6; d:3; d_2: 5; d_3: 4	S
GB	ISO	ISO	ISO	ISO	ISO Add 5 for d.	S
NF	ISO; 1 mm ~ 1,4mm only for horology industry.	ISO	ISO	ISO	ISO	S
BS		ISO	ISO	ISO	ISO	S
JIS		ISO	ISO	ISO	ISO	S
DIN	0,3mm~0.9mm	ISO	Delete 0,45and 0,55. Only one diameter in 2nd series.	ISO	ISO	M
GOST	0,25mm~0,9mm	ISO	Add 0,25mm diameter.	ISO	ISO Add 5 for d.	M
ASME	ISO	h_3=0,572 6P Add $D_4$to replace D	ISO	Internal thread: H; External thread: h.	Different from ISO tolerance. Establish new tolerance formulae.	UNM

For purposes of this article, we are only going to focus on how to measure or inspect the threads rather than get into the particulars about sizes and tolerances. For the most part, the standards refer to the inspection methods of miniature screw threads as informative or suggested techniques. In conjunction with the suggested techniques, it is highly advised that an agreement is reached between purchaser and vendor regarding the basis of determining product acceptance. The following gaging suggestions are the interpretation of the author when compiling sound practices outlined in the various standards.

External Threads

The major diameter of external threads should be measured using either hard contact gaging, such as a micrometer, or other means through optical projection, or laser inspection equipment. GO and NOT GO plain diameter gages can also be used if extreme care is taken.

Pitch diameter, lead, thread form, and minor diameter may be checked using optical projection methods with a recommended magnification of 100X. Lesser magnification such as 50X can be used if the diameter and pitch combination provide enough clarity of the projection to see deviations in thread form. A suggested chart for this method should include minimum, nominal, and maximum sized thread form, and include approximately 5 pitches. The limits of size for the minor diameter are typically used for design of the threading tools, and normally are not checked for conformance. Below is an example of a chart that can be used for this method.



Should ring gages be chosen over optical projection, product would be acceptable if a GO thread ring could pass freely over the entire thread length, and a NOT GO thread ring does not thread on more than 3 turns. For sizes under 1.0mm in diameter, it should only be necessary to check conformance using a GO thread ring gage. This is a suggestion found in several standards due to the delicate nature of these miniature threads. For practical purposes, it is suggested that all miniature screw threads be gages using only the GO thread ring. This in conjunction with the major diameter measurement should insure proper thread height and functional fit.

A third alternative for measuring pitch diameter would be the use of measuring wires, although due to the small nature and fine pitch of these thread forms it may not be practical.

Internal Threads

Minor diameter of internal threads is normally gaged with GO and NOT GO plain cylindrical plug gages. Due to the delicate nature of internal miniature screw threads, it is recommended that the NOT GO plain cylindrical plug gage be used first, and inserted only once until resistance is felt.

Subsequently, the GO plain cylindrical gage is then used and only inserted once. The act of gaging these threads can wear the threads oversized if repeated checking or applying force is used.

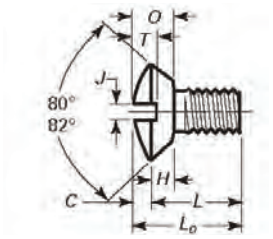
All other thread elements including pitch diameter, lead, thread form, and major are checked by means of a GO thread plug only. There should only be one insertion of the GO thread plug as well for reasons stated above.

Miniature screw threads are delicate in nature, and it should be stressed that any hard gaging or contact gaging can damage the threads or wear them out of specification if care is not taken. Miniature screw threads are not designed for strength, but designed for functional fit, which should be the only acceptance criteria.

In the absence of gaging standards, the above inspection methods should provide the end user with acceptable product to use in next higher assembly operations with confidence that components will function as intended. It is the authors recommendation that optical means be used over contact means when practical.

Length Measurement Correction

In my last article on measuring fastener lengths, I created some confusion with my diagram and labeling of Length vs Overall Length on oval head screws, which I would like to clarify. The diagram below is a better pictorial representation of the length measurement, and the subsequent comments and excerpts from the ASME standard should clear up any confusion.



ASME B18.6.3:2010 in section 3.3 states: The Nominal Length of screw, L, shall be measured, parallel to the axis of screw, from the extreme point to the plane of the bearing surface for screws having perpendicular bearing surface type heads, and to the theoretical intersection of the top surface of head with the head diameter for screws having countersunk type heads. For all oval heads, the overall length Lo (overall length) shall be measured, parallel to the axis of the screw, from the extreme point to the top of the head, where Lo (overall length) = L (nominal length) + C (head crown height).

The next section 3.4 states: The length tolerance shall apply to Lo (Overall length) for all oval heads, and to L (nominal length) for all other head styles. The tolerance on the length of tapping screws shall conform to the following for the respective screw types.

From these statements, Lo (overall length) is the feature to be measured on oval head screws, and that same dimension must be within the length tolerances given. L (Nominal Length) for oval head screws is not subject to length tolerances, therefore should not be subject to inspection criteria for acceptance.