New Screw Thread Standards

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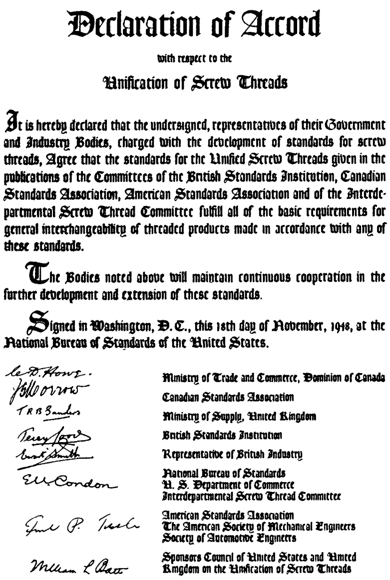
ON NOVEMBER 18, 1948, a group of distinguished gentlemen representing governmental bureaus, engineering and standards associations, and industries of Great Britain, Canada, and the United States signed an important document. That document was the Declaration of Accord with respect to the Unification of Screw Threads and is reproduced here (Fig. 1).



Declaration of Accord

with respect to the

Unification of Screw Threads

It is hereby declared that the undersigned, representatives of their Government and Industry Bodies, charged with the development of standards for screw threads, Agree that the standards for the Unified Screw Threads given in the publications of the Committees of the British Standards Institution, Canadian Standards Association, American Standards Association and of the Interdepartmental Screw Thread Committee fulfill all of the basic requirements for general interchangeability of threaded products made in accordance with any of these standards.

The Bodies noted above will maintain continuous cooperation in the further development and extension of these standards.

Signed in Washington, D. C., this 18th day of November, 1948, at the National Bureau of Standards of the United States.

Ministry of Trade and Commerce, Dominion of Canada

Canadian Standards Association

Ministry of Supply, United Kingdom

British Standards Institution

Representative of British Industry

National Bureau of Standards
U. S. Department of Commerce
Interdepartmental Screw Thread Committee

American Standards Association
The American Society of Mechanical Engineers
Society of Automotive Engineers

Sponsors Council of United States and United Kingdom on the Unification of Screw Threads

FIG. 1.

Announcement of the signing was made in a few daily newspapers and national magazines. Since then the public seems to have forgotten it, screws and screw threads apparently being so prosaic as to invite only passing interest. There was nothing about the event to make it as dramatic as nuclear fission, atomic energy, a test for detecting the presence of cancer, or jet propulsion, and yet its effects are momentous.

Screw threads are essential to the mechanisms and structures of our modern technologic society. One has only to think how many objects in his immediate surroundings are held together by bolts, nuts, and screws to realize the great number of industries that are involved. Almost all assembly line and durable goods industries are affected by the new standards.

The first attempt at a standard thread form was made about a hundred years ago by a British toolmaker named Joseph Whitworth. British industry adopted this standard in 1841 or about then and it became known as the British Whitworth Thread. It is distinguished from the thread we have used in this country by its 55° thread angle and its rounded crest and root as shown in the contour sketch, Fig. 2.

In 1864 a Philadelphian by the name of William Sellers urged the Franklin Institute of that city to establish and adopt a different design of thread. A number of contentions were advanced to demonstrate

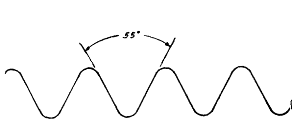


FIG. 2. Contour of British Whitworth Thread.

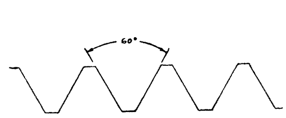


FIG. 3. Contour of American National Thread.

why the Sellers thread was a better one for our industry. It was subsequently adopted as the standard for the United States and has been known recently as the American National Thread. It is principally distinguished from the British Whitworth Thread by its 60° thread angle and its flat crest and root as shown in contour in Fig. 3.

It is not necessary to discuss many of the scientific and engineering factors which reacted against each other when an attempt was made to interchange products made in accordance with the two systems. The interference is self-evident in a comparison of Figs. 2 and 3. It is this lack of interchangeability that caused so many difficulties over the years, not only here but in Britain and Canada as well. Canada suffered doubly because its trade and commerce were of such a nature as to require some products to be adaptable to either one of the standards.

It is natural for a group of people to consider its own particular product, principal, or standard to be the best. For years Britain insisted upon requiring the use of a 55° thread and the United States was just as insistent upon a 60° thread. The loss in trade between the two countries, where threads or threaded fasteners were important, has never been measured.

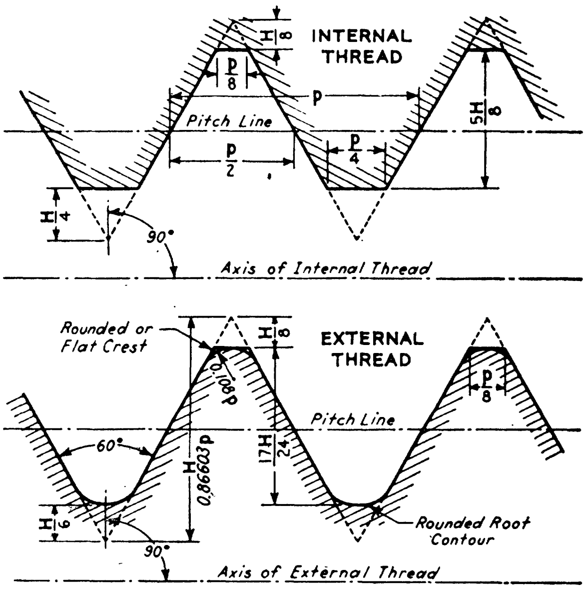


FIG. 4. Unified form of thread (maximum metal condition).

The need for adjusting these differences between the two systems must have been written and talked about almost from the very moment we adopted the Sellers thread. For years, however, nothing much was done about it. It has taken two world wars to bring all parties to the realization that action was necessary.

There are some appalling stories about the loss of time and money incurred by Allied nations because of noninterchangeable screw threads. It has been said that it took us ten months to start manufacture of the British Rolls Royce engine. Supposedly, most of that time was lost because our factories had to be specially set up to produce the British thread. Another story has it that it took six months to adapt the Bofors gun to American manufacture, largely because of thread differences. It has been estimated that the differences between the British and American threads cost the recent war effort no less than a hundred million dollars. That statement, if true, becomes all the more realistic when we think of it in terms of time, effort, and blood. These examples represent a very few of the serious situations which finally brought about the signing of the Declaration of Accord.

In fairness to all concerned, however, we owe a debt of sincere gratitude to the early leaders in the screw thread movement. Those old systems stood the test of time for over 75 years.

In the United States there has been, over the years, a great deal of criticism of our system. In developing the new standards, careful consideration was given to these complaints, and where possible the objectionable features were avoided. The new standards therefore serve a twofold purpose in providing a unified screw thread, interchangeable among Britain, Canada, and the United States, and in overcoming many of the other objections to the old standards.

It is important to note that these new standards resulted from a cooperative attack on the problem by the three governments, the producers of threaded articles and tools, and the consumers of such articles. All interests were represented. Numerous bodies, such as governmental bureaus and trade associations, other than those specifically mentioned in the Declaration of Accord, have participated over the years in this program.

The new standard is known as the Unified Thread and Fig. 4 indicates its characteristics for both internal and external threads. In comparing Fig. 4 with Figs. 2 and 3 it is immediately evident that the new form is a compromise. Certain characteristics of both the Sellers and the Whitworth forms are evident.

Note that the new thread form does not differ too greatly from the old American National form. The thread angle is the same—60°. The principal difference is at the thread root in the external thread, which is shown rounded rather than flat-bottomed. This round form is not mandatory with new tools. At the crest of the external thread, it will be noted that two forms are shown. One is rounded, which is the form preferred by the British, and will be published in their standards. The other is flat, which is preferred by the United States and will be shown in the American publication.

The various classes of thread provided in the new standards, while similar in form, differ principally by the amount of pitch diameter tolerance and allowance specified. These classes are:

External thread	*Internal thread*
1A (Allowance)	1B
2A (Allowance)	2B
3A	3B
2	2
3	3

Generally speaking, classes 1A and 1B will find their greatest application in Britain among the so-called black bolt manufacturers. In this country their greatest application will be for ordnance work, plastic molded threads, or die cast threads. Classes 2A and 2B will be the recognized standards for normal production of bolts, nuts, and screws. Classes 3A and 3B are included to provide for close tolerance work. These classes are expected eventually to replace classes 2 and 3, which were the standards largely in use prior to the signing of the Declaration of Accord. These two latter classes are not unified threads, but have been retained in the standards because of their widespread current usage. They will continue to serve through the difficult transition period from the old to the new standards.

The new standard thread dimensions overcome various faults found in the old system. The old standards took into consideration only one variable—thread pitch. The new standards consider at least two additional variables, namely, basic major diameter and length of engagement.

The tolerances and allowances of the unified threads, classes 1A, 2A, 3A, 1B, 2B, and 3B, are based uniformly upon a new empirical formula. It was developed through a study by fastener manufacturers and represents normal accuracy in present-day threading practice. This formula contains a multiplying factor, C, which is introduced to proportion the formula for the various classes of thread. Inspection of this formula will show that the tolerance or allowance depends upon three variables: the major diameter, length of engagement, and pitch of the thread.

The following formula is applied in setting up allowances on all diameters and tolerances on pitch diameter of the unified classes of threads:

Tolerance (or allowance) =

$$C(0.0015\sqrt[3]{D}+0.0015\sqrt{Le}+0.015\sqrt[3]{p^2}).$$

Where C = factor for each allowance or tolerance,
D = basic major diameter,
Le = length of engagement, and
p = pitch.

Class	Factor C For tolerance	Factor C For allowance
1A	1.500	0.300
1B	1.950	....
2A	1.000	0.300
2B	1.300	....
3A	0.750	0.000
3B	0.975	....

As the list of class designations shows, there is an allowance in classes 1A and 2A.

For years users of threaded articles have been plagued with the metal-to-metal contact between internal and external threads under the maximum metal conditions permitted in the old standards. The allowance in the new standard is actually a small air gap or neutral clearance between mated internal and external threads, even under maximum metal conditions. This air gap is so small as to have practically no effect upon the strength of mated members, yet it serves a useful purpose. The mass production assembly line industries in particular will be grateful for this allowance. Some of its advantages are:

1. It facilitates high cycle wrenching. In the past it has not been unusual to develop heat through friction, when power wrenches are used. This often caused the internal member to expand, and galling and seizure of the threads resulted.

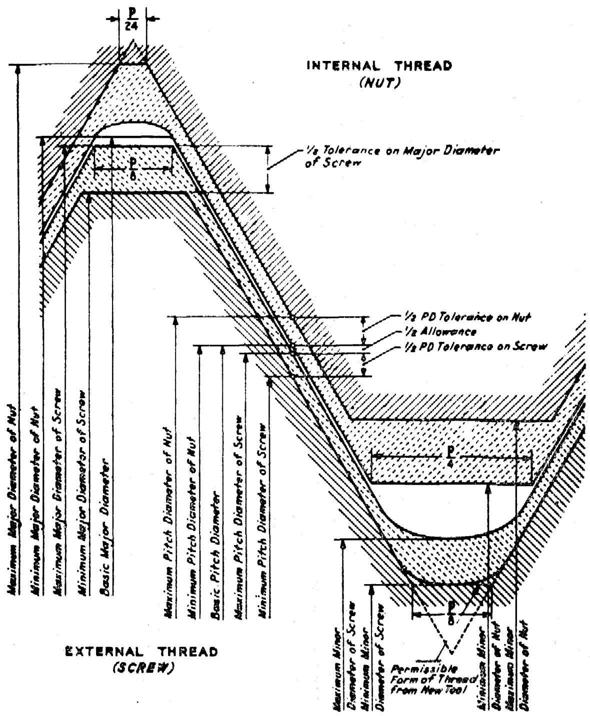


FIG. 5. Tolerances, allowance, and crest clearances for classes 1A, 1B, 2A, and 2B.

2. The allowance solves the problem of interference between mated members due to plating.

3. Handling of threaded articles, such as bolts, nuts, and screws, occasionally results in the burring and nicking of threads. The producer's plant may contribute a few burrs and these are added to by the wholesaler, the retailer, and finally the consumer. Excessive burrs formerly caused interference between threaded parts to be mated, but the allowance in the new standard eliminates the interference.

4. Much of the freezing of threads under conditions of elevated temperatures will be avoided.

Fig. 5 goes into greater detail as to the general contour of the new thread and shows tolerances, allowance, and crest clearances for classes 1A, 1B, 2A, and 2B.

No attempt is being made here to delve into the intricacies of screw thread theory. The scientific and engineering aspects have been in good hands and the new standard tables speak for themselves in this respect. Several articles have been published on these phases of the problem (*1–5*).

The most widely used thread class for bolts, nuts, and screws in the old standard is designated as class 2. Its related classes in the new standard are 2A for

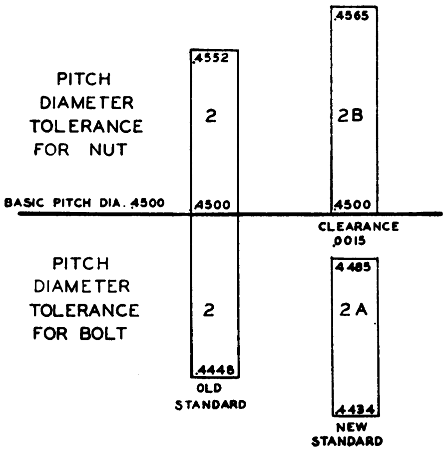


FIG. 6. Comparison of present standard class 2 pitch diameter tolerances with the new standard class 2A and 2B for ½–13 national coarse thread.

external threads, such as on bolts and screws, and class 2B for internal threads, such as on nuts. Fig. 6 gives a clear graphical example of the difference between the old and the new standards. This difference is shown for one size only, that is ½ inch, 13 threads per inch.

Tables have been compiled for the new standards, covering every conceivable screw dimension for every size and class of fit, and every thread pitch series. For example, the limiting dimensions for the ¼-inch-diameter, 20-threads-per-inch, coarse Unified and American Thread Series, class 2A, for external threads, are:

Size	¼ inch
Threads per inch	20
Thread symbol	UNC2A
Allowance	0.0011
Major diameter limits—maximum	0.2489
Major diameter limits—minimum A	0.2408 for finished and semifinished items
Major diameter limits—minimum B	0.2367 for unfinished items
Major diameter tolerance A	0.0081 for finished and semifinished items
Major diameter tolerance B	0.0122 for unfinished items
Pitch diameter limits—maximum	0.2164
Pitch diameter limits—minimum	0.2127
Pitch diameter tolerance	0.0037
Minor diameter maximum	0.1876

These few figures serve as an indication of the great amount of engineering, mathematical, and editorial work that went into the tables. It is little wonder that it took so many years to accomplish the task.

The impact of a change such as this one could very well upset the economy of the producer, distributor, and consumer of threaded articles. These three groups represent possibly 90 percent of the world's trade and commerce in manufactured durable articles. An approach to such a world-wide problem calls for extreme caution. The three principally affected groups are now faced with the problem of placing the new standards in effect. However, the job cannot be done fully in a month or a year. It has been estimated that it may take five years from the time of publication of the new tables to complete the conversion.

The producer of threaded fasteners and articles must produce and purchase the necessary new tools,

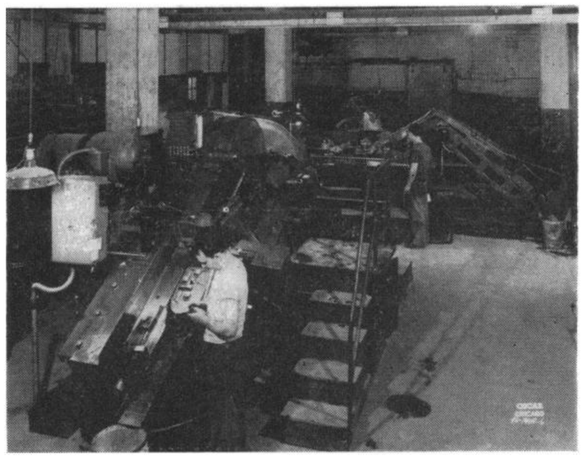


FIG. 7. Modern screw thread rolling machine.

dies, and gauges. If his operations are broad, he may be manufacturing in accordance with both the old and the new standards at the same time, but during the transition period he will gradually increase production of new standard parts and decrease production of the old. He will have products made with both standards in his inventory at the same time. It is fortunate indeed that the old standard threaded fasteners are interchangeable with the related new standard counterpart. If this were not true there would indeed be chaos. A photograph of a modern thread rolling machine, upon which will fall the burden of producing the new standard threads on bolts and screws, is shown in Fig. 7.

The distributor's problem is somewhat simpler, in that he will only need to cope with his inventory, which will contain some of the old standard parts and some of the new during the transition period. Here again, the problem is minimized because of the interchangeability of the old and the new.

The consumer is the man who buys threaded fasteners or threaded articles to be assembled in his plant into manufactured durable goods—automobiles radios, washing machines, and any number of other articles. He too has a problem during the transition period. His inspection will need to cover either the old or new standard. His warehousing, manufacturing, and assembly operations will need to be flexible to accommodate both standards. He will find it expedient to accept purchased articles, during the transition period, which may have been produced in accordance with either the old or the new standard. His inspectors will no doubt be instructed to accept either standard during the transition period, regardless of which specific standard may have been ordered. It would be simple, from the consumer's standpoint, if on a certain day he could discontinue using the old and start using only new standard threaded articles, but this is obviously impractical. What might have been a complex transition, however, is made easier by the interchangeability of the old and new standard articles.

The entire problem resolves itself into the elements of time, patience, and money. The time, as noted, may be as much as five years, and the patience of both producers and consumers will be tested during this transition. The money is a real consideration—many thousands of dollars will have to be spent on new standard tools, dies, and gauges, on product identification, and on storage systems.

The new standards offer so many advantages to everyone concerned that they will be placed in effect as quickly as possible by all producers and users of threaded articles. Requests for new standard threaded fasteners are already being received from some of the leading national industries. The wheels of industry have been set in motion to accomplish this gigantic task and it may be completed much sooner than we expect.

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Solar Eruption of May 10, 1949

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National Bureau of Standards

An outstanding solar flare and its effects on the ionosphere were observed in unusual detail on May 10, 1949, at the Sterling Field Station of the National Bureau of Standards. In addition to the usual magnetic variation and continuous wave radio field intensity observations that are always in progress, data were also obtained with solar noise radiometers (Wurzberg) at 480 and 160 megacycles, and rapid sequence, vertical incidence multifrequency (h′-f) observations of the ionosphere. Preliminary determinations of the times of significant activity have been communicated by Helen Dodson, of the McMath-Hulbert Observatory, who estimates the flare as of importance 3+, the greatest reportable on the scale of the International Astronomical Union.

All observations of the eruption and its absorption effects show that it began between 20:00 and 20:03 Universal Time (see Table 1). The solar burst of radio noise seems to have been detected before any terrestrial effect. Estimated errors in time determination are ±0.25 minute for solar noise observations, and ±1 minute for ionospheric measurements. The precision of the McMath estimates is not known. The maximum effect was reached for all types of observation of the phenomenon at between 20:10.5 and 20:12.5; again the solar burst attained maximum first. The duration of the extremely intense portion of the solar noise burst lasted only two or three minutes. The severe ionospheric absorption effects lasted considerably longer, the duration being greatest for oblique incidence paths.

The intensity of the noise burst, presumably emanating from the small visibly active area, was about 290 times the normal energy output of the entire disk of the quiet sun on 160 megacycles, while the intensification on 480 megacycles was probably 1000 times the background radiation. The mirror and antenna of the 480-megacycle radiometer were not set directly on the sun at the time of maximum of the burst, so that the value given is an estimate; the possible range of intensification ratio appears to be between 800 and 1550. This is the strongest burst observed thus far