NEWSLETTER FOR MANUFACTURING COMMUNITY

Maintenance Circle

Word for the day: **THREADS – PART TWO**

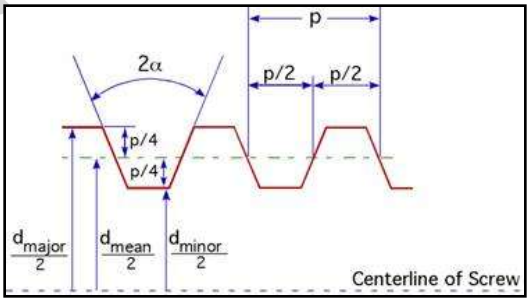
Welcome to the second part of the article on interesting world of threads. With some solid background that that we gained in first part, let us get started on the most common type of thread profiles used. Each of these thread profiles have a specific intended end use which can vary from lifting heavy objects to sealing a high pressure fluid line to setting time on wrist watch. We will have PROFESSOR NUTTY help us understand some common myths, do's and don'ts about threads.

Another common terminology used with regard to thread profile is the "number of starts" it has. As we know, a thread is a continuous profile generated on a circular rod. A thread having only one profile is called as ***SINGLE START THREAD***. If more than one profile is generated on same circular rod, it is called as ***MULTI START THREAD***. Some lead screws used for converting rotary motion to linear motion has multi start thread profiles. For a given length, multi start threads will have less pitch compared to a single start thread, and advances – moves – more faster.

ACME THREAD FORM (or TRAPEZOIDAL THREAD FORM):

The Acme thread form is a common profile that offers high strength with ease of manufacture. It is typically found in applications where large loads need to be lifted or held in place as in bench-vices, screw jacks and the lead screw of a lathe. Standardized variations include multiple-start threads, left-hand threads, and self-centering threads. Because of their thread profile and angle, they do not get "stuck" – more technically called binding – under heavy loads.

The Acme thread form has a 29° thread angle with a thread height half of the pitch. The crest and trough are flat and looks like a trapezoid. This shape allows the use of a thread milling machine for manufacture, which is much cheaper than the single point cutter used in machining square threads. The tooth shape also has a wider base which means its stronger (thus, the screw can carry a greater load) than a similarly sized square thread. This thread form also allows for the use of a split nut, which can compensate for nut wear. The disadvantages of the Acme thread form are that much lower efficiency and the greater radial load on the nut, due to the thread angle.



Following table shows pitch dimension for lead screw with certain commonly used nominal diameters.

Nominal diameter [mm]	Pitch [mm]	Nominal diameter [in]	Pitch (P) [in]
24, 28	5	1/4	1/16
32, 36	6	5/16	1/14
40, 44	7	3/8	1/12
48, 52	8	1/2	1/10
60	9	5/8	1/8
70, 80	10	3/4, 7/8	1/6
90, 100	12	1, 1 1/4	1/5
		1 1/2, 1 3/4, 2	1/4
		2 1/2	1/3
		3	1/2

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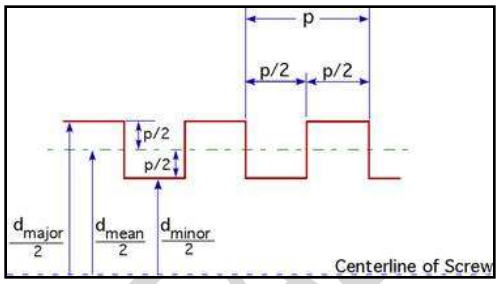
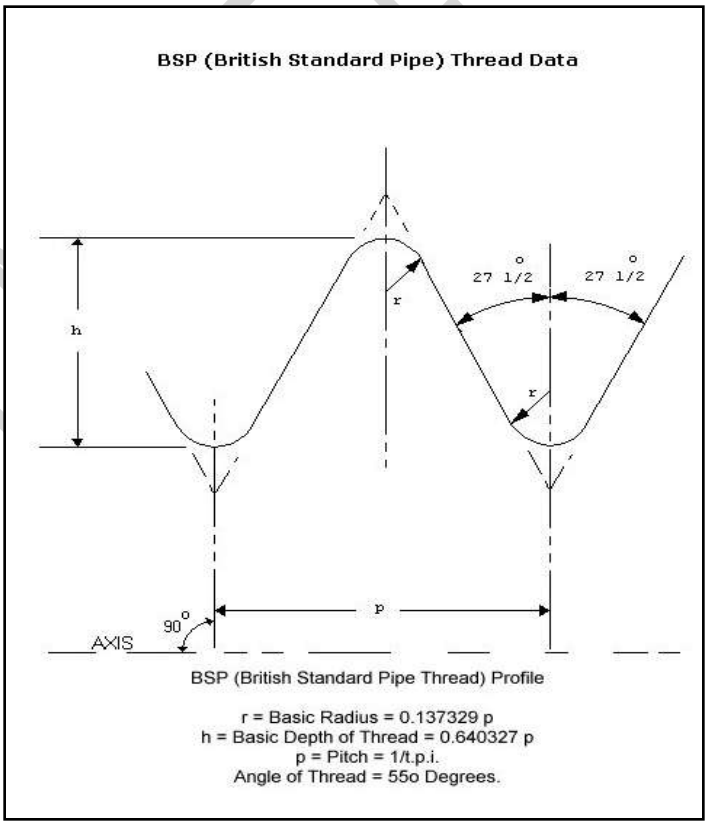
SQUARE THREAD FORM:



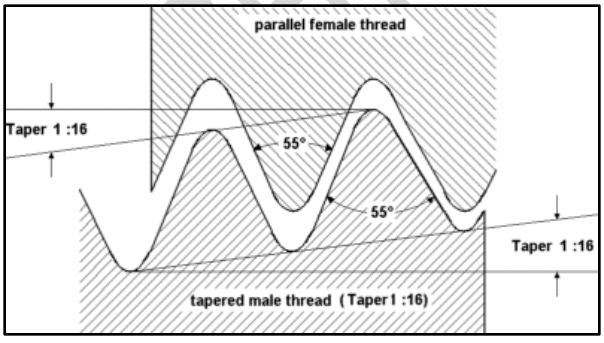
Although square threads are not very popular now, they are used in special purpose lead screws used for lifting or moving very heavy loads like ship hauling, adjusting shut height on large presses and aero plane moving trailers. Since the thread angle is precisely 90°, it is difficult to generate a square thread profile. And, also the right angle profile angle increases friction making it difficult to rotate.

BRITISH STANDARD PIPE (BSP) THREAD:



This is the most commonly used thread profiles for pipes, fittings and most of joint applications. It is also called as British Standard Whitworth thread profile, in recognition of its inventor, Sir Joseph Whitworth. Because of the very design of thread profile, male & female profiles "seal" into each other creating an almost tight joint preventing flow of liquids or gases under certain conditions. Water lines, air lines, intermediate connectors and many similar fittings use this thread profile. As you can see from the adjacent drawing, the crest and troughs are ROUNDED to radius, ***r***. The profile angle is 55° on both male and female (bolt & nut) profiles which ensures reduced friction and less effort in tightening. Because of the smooth profile given by 55° thread angle, this thread can be easily machined on conventional lathes and special thread rolling machines as well. Normally, the BSP threads are mentioned in inches although equivalent millimeter dimensions are mentioned.

The BSP threads are also available in TAPERED profile. In this type of profile, the overall diameter INCREASES (or DECREASES). Tapered thread profiles are used in flexible fittings of high pressure systems like hydraulic pipes, steam and chemical lines. Since the threads are tapered, guiding a female profile over a male profile is easy and reduces risk of wrong threading. In some applications where tapered threads are used, a chemical sealant can be used in thread area to give more leak proof joint. Adjacent drawing shows the profile of a tapered BSP thread profile. 1:16 is the normal ratio for a tapered thread, which means for every 16 units of length measured, the diameter should either increase or decrease by 1 unit. So for a 16 inch long thread profile, the diameter difference between fathest points will be equal to one inch.



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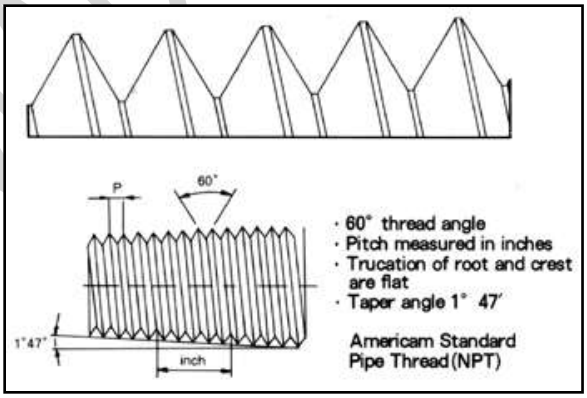
Following table gives different thread dimensions for commonly used BSP thread diameters.

Nominal Size (inches)	T P I (Threads Per Inch)	Pitch (inches)	Major Diameter (inches)	Minor Diameter (inches)	Tapping Drill Size
1/16	28	0.0357	0.304	0.2583	Letter drill G (6.6 mm)
1/8	28	0.0357	0.383	0.3372	8.73 mm (11/32 inch)
1/4	19	0.0526	0.518	0.4546	11.8 mm (0.4646 inch)
3/8	19	0.0526	0.656	0.5886	15.25 mm (0.6004 inch)
1/2	14	0.0714	0.825	0.7336	19.05 mm (3/4 inch)
5/8	14	0.0714	0.902	0.8106	21 mm (0.8268 inch)
3/4	14	0.0714	1.041	0.9496	24.5 mm (0.9646 inch)
7/8	14	0.0714	1.189	1.0976	28.25 mm (1.1122 inch)
1 inch	11	0.0909	1.309	1.1926	30.75 mm (1.2106 inch)

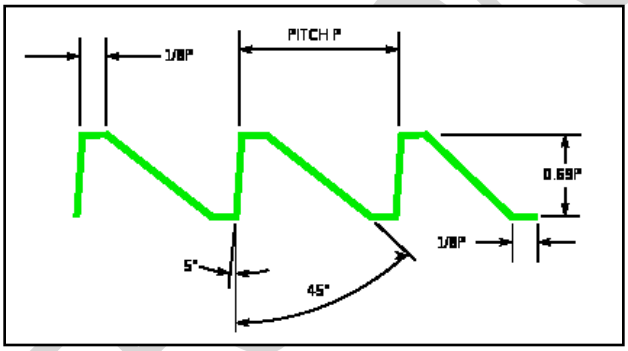
NATIONAL PIPE THREAD (NPS,Straight or NPT,Tapered):

The NPT or NPS thread profile looks very similar to BSP profile. But NPT / NPS thread profile has a 60° angle and sharp crest and trough. Tapered version is more widely used on fittings, joints in liquid, gas and similar installations. This thread profile standard is followed more in USA. Adjacent figure shows a typical national pipe tapered thread profile.



In a tapered thread profile, the male and female components not only slide into each other, but also "compress" into each other providing an almost tight joint.

BUTTRESS THREAD FORM:



The buttress thread profile is a combination of square thread on one side and a 45° angle on other side. In one direction, the buttress thread has an extremely high axial load carrying capacity. This type of thread is widely used in oil field equipments like rigs, pipe holders, artillery (military) equipments and door openings of military air crafts. One side of face can have 90° or 95° or 97° as the profile angle. Although buttress thread profile is not used in many equipments or machines, you have to pay special attention to this profile, since it looks quite similar to a trapezoid threads.

ISO METRIC THREAD FORM:

This is the most common and widely used thread profile worldwide. It is commonly represented by prefix, M and followed by the major diameter and pitch, both measured in millimeters. The thread has a precise V shape with 60° as profile angle. The crest and trough points of thread profile are slightly made flat to reduce friction, increase load bearing ability. It also prevents the "edge" damage which might result in material binding during tightening.

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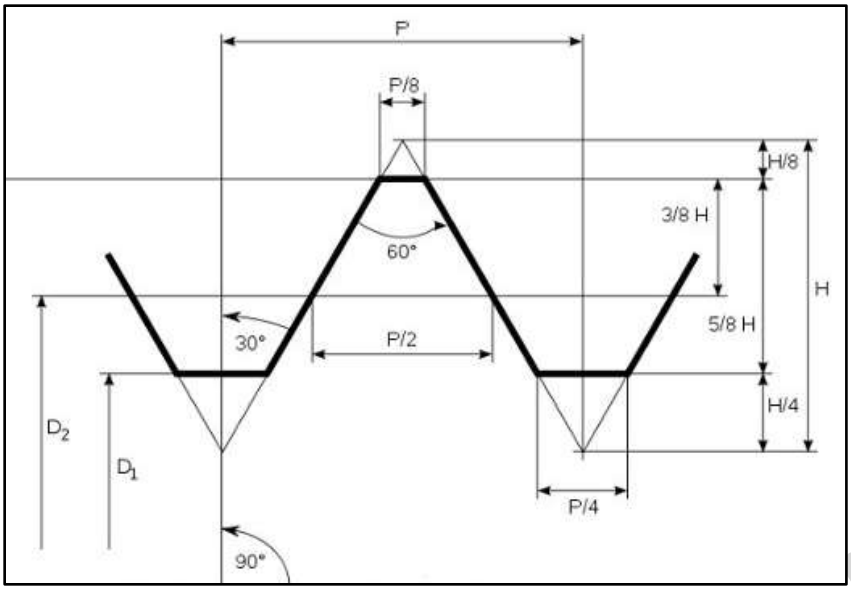
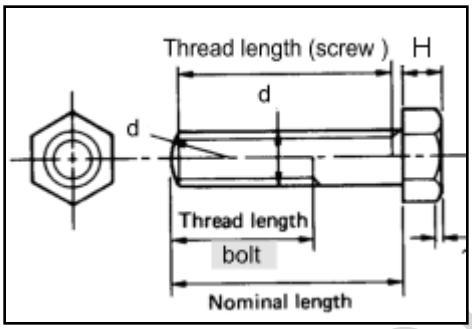


Relating to our explanation in part one, the thread profile can be either "coarse" or "fine". Normal standard is coarse profile unless explicitly specified. The screw length is also mentioned in the specification.

For example, **M10 x 40** means metric thread of 10 millimeter major diameter and a screw length of 40 millimeters. The total – bolt – length will be GREATER than 40 millimeters. Refer to the adjacent figure for reference. This M10 screw has a coarse thread profile and its pitch is equal to 1.5 millimeters, as per the international standards. Instead, if it is designated as **M10 x 1.25 x 40**, it has a fine thread profile and its pitch is 1.25 millimeters. Refer to the table at the end of this article for commonly used standard thread dimensions. ISO 261 is the international standard used for designation of these metric threads.



Apart from these commonly used standards, there are many special thread profiles manufactured for certain applications. For example, the thread profile of wood screw is tapered with 60° profile angle and has a very coarse pitch. On contrary, a screw profile for manual fly press – used in many sheet metal fabrication industries – has a square thread with a very large pitch and more than 100° profile angle to instantly convert the rotary motion into high press force.

Threads profiles are not only generated on metal but also on wood and plastics. In fact, injection molding of plastic screws for various not so heavy load applications is becoming common. Now let us delve into some of the common operational do's & don'ts that we should consider when working with threads. PROFESSOR NUTTY will take us thru this exercise.

Another important element that forms an integral part of the thread assembly is washer. Based on application, the type of washer used may vary. Washer is a small piece of metal that sits between nut or bolt head and has multi purposes. One, it prevents heads "digging" into the component or equipment, preventing head jamming. Second, it distributes the axial load of the bolt head equally.

FLAT & SPRING (split-lock) type are the two most commonly used washers, although there are many special washer types available. Refer to image library at the end of this article for different type of washers.

Spring washers have a split profile which always tries to "expand." So, when it is inserted and tightened in the thread path, it prevents the nut / bolt assembly from loosening. Selection of washer made from proper material is also critical. For instance, when the nut / bolt assembly is used in a corrosive environment, zinc-plated or non-ferrous washers will be selected to prevent thread locking or jamming problems. Washers are made from variety of materials like brass, copper, steel, zinc-coated steel, plastic, stainless steel.

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When selecting thread profile for a particular application, following points should be considered:

Load type – Lifting, Moving, Radial, Axial, Turning or Compressing

Load cycle – Normal, Continuously loading and unloading, random, high vibrations, random overloads

Environmental conditions – High temperature, high moisture content, Corrosive chemicals, Safety,

End Application – Pressure line, load bearing, conveying, continuously rotating, static

Type of material for thread – Steel, Aluminum, Copper, Brass, Plastic

Type of head for fastening – Hexagonal, Allen head, Counter sunk, Flat, Phillips

Interchangeability – It is always good to standardize a particular thread type for the entire application than mixing different profiles.

End user convenience – The thread / bolt profile should within one standard as much as possible to avoid multiple inventory levels, different tools for tightening and chances of using wrong thread profiles.

Professor Nutty is not very happy when you do following things to a thread profile:

Over tightening the nut-bolt couple beyond its specified torque limits – this will result in either thread jamming, head shearing and thread wear out resulting in reduced load carrying capacity

Using thread profiles that are not similar but looks very similar – for example, NPT thread looks very similar to BSP threads but will never match. Sometimes even metric and BSP threads look very similar, but should never be confused.

Improper entry of threads – called wrong threading – and then forcing it to enter into each other

Not using "thread sealant solutions" wherever necessary – The sealant will help in preventing "corrosion" or "rusting" between thread profiles further preventing thread jamming

When thread profiles are used in applications that have vibrations – like DG set mountings, rotating clutch plates, motor housing – not using thread "locking" solutions to prevent threads from loosening

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Professor Nutty is very happy when you do following things for a thread profile

Select proper thread profile for the application – for example to lift heavy objects, a square or acme thread is more suitable than a metric thread

Replace or repair the worn out thread profile at the earliest to prevent major damages to end equipment

Use proper washers, sealant solutions and tighten within "torque" limits specified for the bolt

Not mixing fine and coarse thread profiles, just to fix the problem immediately

Not using excessive cotton or Teflon tape or other material to compensate for worn out thread profile

Regular usage of "thread gauge" to measure pitch before replacing a worn out thread profile.

Re-tapping is carried out for moderately worn out thread profile for perfect fit

In multiple thread profile, following proper tightening sequence – For example in shaft couplings, aligning circular components like clutch plates, fly wheels, vehicle tires and more.

WASHER TYPES LIBRARY

 **Flat** A flat washer, used to distribute load. Available in SAE, USS and other patterns.	 **Fender** An oversize flat washer used to further distribute load especially on soft materials.	 **Finishing** A washer used to obtain a 'finished' look. Usually used with oval head screws.

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Split Lock
The most common style of washer used to prevent nuts and bolts from backing out.

External Tooth Lock
A washer with external 'teeth'. Used to prevent nuts and bolts from backing out.

Internal Tooth Lock
A washer with internal 'teeth'. Used to prevent nuts and bolts from backing out.

Square
A square shaped washer.

Dock
Dock washers have a larger outside diameter and are thicker than standard.

Ogee
Thick, large diameter, cast iron washers with a curved or sculpted appearance. Typically used in dock and wood construction.

ISO-METRIC COARSE THREAD CHART

METRIC SCREW THREADS ISO 724 (DIN 13 T1)

Nominal diameter d = D	Pitch P	root radius r	pitch diameter d2=D2	minor diameter d3	minor diameter D1	thread height h3	thread height H1	drill diameter mm
M 1.00	0.25	0.036	0.838	0.693	0.729	0.153	0.135	0.75
M 1.10	0.25	0.036	0.938	0.793	0.829	0.153	0.135	0.85
M 1.20	0.25	0.036	1.038	0.893	0.929	0.153	0.135	0.95
M 1.40	0.3	0.043	1.205	1.032	1.075	0.184	0.162	1.1
M 1.60	0.35	0.051	1.373	1.171	1.221	0.215	0.189	1.25
M 1.80	0.35	0.051	1.573	1.371	1.421	0.215	0.189	1.45
M 2.00	0.4	0.058	1.74	1.509	1.567	0.245	0.217	1.6
M 2.20	0.45	0.065	1.908	1.648	1.713	0.276	0.244	1.75
M 2.50	0.45	0.065	2.208	1.948	2.013	0.276	0.244	2.05
M 3.00	0.5	0.072	2.675	2.387	2.459	0.307	0.271	2.5
M 3.50	0.6	0.087	3.11	2.764	2.85	0.368	0.325	2.9
M 4.00	0.7	0.101	3.545	3.141	3.242	0.429	0.379	3.3
M 4.50	0.75	0.108	4.013	3.58	3.688	0.46	0.406	3.8
M 5.00	0.8	0.115	4.48	4.019	4.134	0.491	0.433	4.2
M 6.00	1	0.144	5.35	4.773	4.917	0.613	0.541	5
M 7.00	1	0.144	6.35	5.773	5.917	0.613	0.541	6
M 8.00	1.25	0.18	7.188	6.466	6.647	0.767	0.677	6.8
M 9.00	1.25	0.18	8.188	7.466	7.647	0.767	0.677	7.8
M 10.00	1.5	0.217	9.026	8.16	8.376	0.92	0.812	8.5
M 11.00	1.5	0.217	10.026	9.16	9.376	0.92	0.812	9.5
M 12.00	1.75	0.253	10.863	9.853	10.106	1.074	0.947	10.2
M 14.00	2	0.289	12.701	11.546	11.835	1.227	1.083	12

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M 16.00	2	0.289	14.701	13.546	13.835	1.227	1.083	14
M 18.00	2.5	0.361	16.376	14.933	15.394	1.534	1.353	15.5
M 20.00	2.5	0.361	18.376	16.933	17.294	1.534	1.353	17.5
M 22.00	2.5	0.361	20.376	18.933	19.294	1.534	1.353	19.5
M 24.00	3	0.433	22.051	20.319	20.752	1.84	1.624	21
M 27.00	3	0.433	25.051	23.319	23.752	1.84	1.624	24
M 30.00	3.5	0.505	27.727	25.706	26.211	2.147	1.894	26.5
M 33.00	3.5	0.505	30.727	28.706	29.211	2.147	1.894	29.5
M 36.00	4	0.577	33.402	31.093	31.67	2.454	2.165	32
M 39.00	4	0.577	36.402	34.093	34.67	2.454	2.165	35
M 42.00	4.5	0.65	39.077	36.479	37.129	2.76	2.436	37.5
M 45.00	4.5	0.65	42.077	39.479	40.129	2.76	2.436	40.5
M 48.00	5	0.722	44.752	41.866	42.857	3.067	2.706	43
M 52.00	5	0.722	48.752	45.866	46.587	3.067	2.706	47
M 56.00	5.5	0.794	52.428	49.252	50.046	3.374	2.977	50.5
M 60.00	5.5	0.794	56.428	53.252	54.046	3.374	2.977	54.5
M 64.00	6	0.866	60.103	56.639	57.505	3.681	3.248	58
M 68.00	6	0.866	64.103	60.639	61.505	3.681	3.248	62

ISO-METRIC FINE THREAD CHART

Nominal diameter d = D	Pitch P	Root Radius R	pitch diameter d2=D2	minor diameter d3	minor diameter D1	thread height h3	thread height H1	drill diameter
M1.0x0.2	0.2	0.029	0.87	0.755	0.783	0.123	0.108	0.8
M1.1x0.2	0.2	0.029	0.97	0.855	0.883	0.123	0.108	0.9
M1.2x0.2	0.2	0.029	1.07	0.955	0.983	0.123	0.108	1
M1.4z0.2	0.2	0.029	1.27	1.155	1.183	0.123	0.108	1.2
M1.6x0.2	0.2	0.029	1.47	1.355	1.383	0.123	0.108	1.4
M1.8x0.2	0.2	0.029	1.67	1.555	1.583	0.123	0.108	1.6
M2x0.25	0.25	0.036	1.838	1.693	1.729	0.153	0.135	1.75
M2.2x0.25	0.25	0.036	2.038	1.893	1.929	0.153	0.135	1.95
M2.5x0.35	0.35	0.051	2.273	2.071	2.121	0.215	0.189	2.1
M3x0.35	0.35	0.051	2.773	2.571	2.621	0.215	0.189	2.6
M3.5x0.35	0.35	0.051	3.273	3.071	3.121	0.215	0.189	3.1
M4x0.5	0.5	0.072	3.675	3.387	3.459	0.307	0.271	3.5
M4.5x0.5	0.5	0.072	4.175	3.887	3.959	0.307	0.271	4
M5x0.5	0.5	0.072	4.675	4.387	4.459	0.307	0.271	4.5
M5.5x0.5	0.5	0.072	5.175	4.887	4.959	0.307	0.271	5
M6x0.75	0.75	0.108	5.513	5.08	5.188	0.46	0.406	5.2
M7x0.75	0.75	0.108	6.513	6.08	6.188	0.46	0.406	6.2
M8x0.75	0.75	0.108	7.513	7.08	7.188	0.46	0.406	7.2
M8x1.0	1	0.144	7.35	6.773	6.917	0.613	0.541	7
M9x0.75	0.75	0.108	8.513	8.08	8.188	0.46	0.406	8.2
M9x 1	1	0.144	8.35	7.773	7.917	0.613	0.541	8
M10x0.75	0.75	0.108	9.513	9.08	9.188	0.46	0.406	9.2
M10x1	1	0.144	9.35	8.773	8.917	0.613	0.541	9

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M10x1.25	1.25	0.18	9.188	8.466	8.647	0.767	0.677	8.8
M11x0.75	0.75	0.108	10.513	10.08	10.188	0.46	0.406	10.2
M11x1	1	0.144	10.35	9.773	9.917	0.613	0.541	10
M12x1	1	0.144	11.35	10.773	10.917	0.613	0.541	11
M12x1.25	1.25	0.18	11.188	10.466	10.647	0.767	0.677	10.8
M12x1.5	1.5	0.217	11.026	10.16	10.376	0.92	0.812	10.5
M14x1.0	1	0.144	13.35	12.773	12.917	0.613	0.541	13
M14x1.25	1.25	0.18	13.188	12.466	12.647	0.767	0.677	12.8
M14x1.5	1.5	0.217	13.026	12.16	12.376	0.92	0.812	12.5
M15x1	1	0.144	14.35	13.773	13.917	0.613	0.541	14
M15x1.5	1.5	0.217	14.026	13.16	13.376	0.92	0.812	13.5
M16x1	1	0.144	15.35	14.773	14.917	0.613	0.541	15
M16x1.5	1.5	0.217	15.026	14.16	14.376	0.92	0.812	14.5
M17x1.0	1	0.144	16.35	15.773	15.917	0.613	0.541	16
M17x1.5	1.5	0.217	16.026	15.16	15.376	0.92	0.812	15.5
M18x1.0	1	0.144	17.35	16.773	16.917	0.613	0.541	17
M18x1.5	1.5	0.217	17.026	16.16	16.376	0.92	0.812	16.5
M18x2.0	2	0.289	16.701	15.546	15.835	1.227	1.083	16
M20x1.0	1	0.144	19.35	18.773	18.917	0.613	0.541	19
M20x1.5	1.5	0.217	19.026	18.16	18.376	0.92	0.812	18.5
M20x2.0	2	0.289	18.701	17.546	17.835	1.227	1.083	18
M22x1.0	1	0.144	21.35	20.773	20.917	0.613	0.541	21
M22x1.5	1.5	0.217	21.026	20.16	20.376	0.92	0.812	20.5
M22x2.0	2	0.289	20.701	19.546	19.835	1.227	1.083	20
M24x1.0	1	0.144	23.35	22.773	22.917	0.613	0.541	23
M24x1.5	1.5	0.217	23.026	22.16	22.376	0.92	0.812	22.5
M24x2.0	2	0.289	22.701	21.546	21.835	1.227	1.083	22
M25x1.0	1	0.144	24.35	23.773	23.917	0.613	0.541	24
M25x1.5	1.5	0.217	24.026	23.16	23.376	0.92	0.812	23.5
M25x2.0	2	0.289	23.701	22.546	22.835	1.227	1.083	23
M27x1.0	1	0.144	26.35	25.773	25.917	0.613	0.541	26
M27x1.5	1.5	0.217	26.026	25.16	25.376	0.92	0.812	25.5
M27x2.0	2	0.289	25.701	24.546	24.835	1.227	1.083	25
M28x1.0	1	0.144	27.35	26.773	26.917	0.613	0.541	27
M28x1.5	1.5	0.217	27.026	26.16	26.376	0.92	0.812	26.5
M28x2.0	2	0.289	26.701	25.546	25.835	1.227	1.083	26

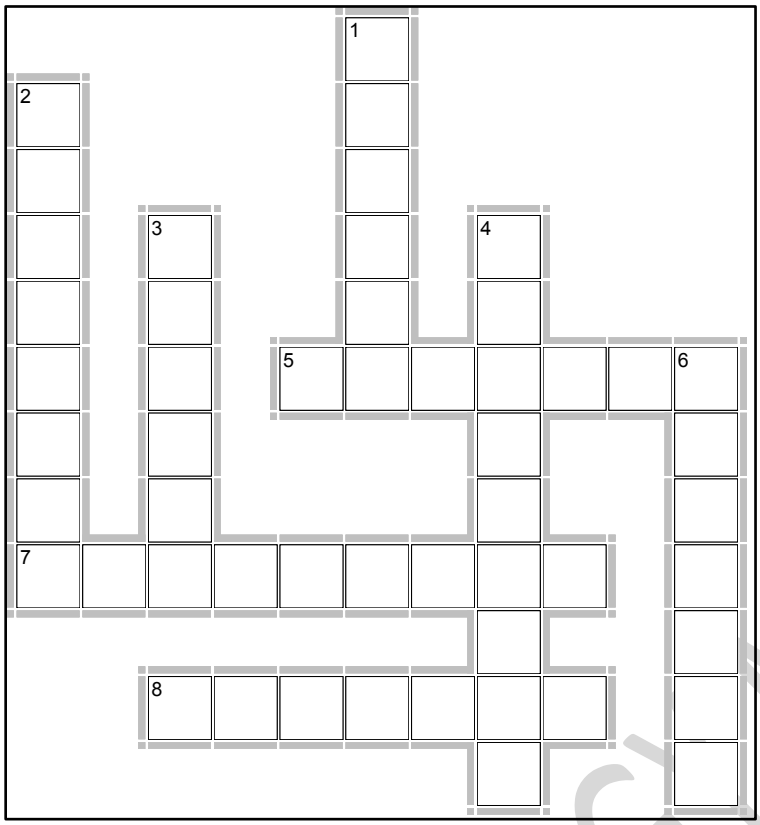
Threads – a wonderful engineering piece that hold many things "together" like a family and helps in accomplishing intended objective. It is virtually impossible to imagine any component or an equipment without some thread profile made into it for one or other purpose.

In this article, we have not touched upon various technologies available for generating a thread profile. Also, we have selectively excluded discussing on different materials used for threads. These and other related topics are a subject in itself and will be explained separately in near future.

NEWSLETTER FOR MANUFACTURING COMMUNITY

Maintenance Circle

And now, it is time to loosen your head bolts and open it for some puzzle solving on threads!!



Across

5. Six sided bolt head
7. Lift your automobile using this
8. Diameter reduces in this type of thread profile

Down

1. Over tightening beyond this limit will damage threads
2. Thread profile that almost looks like a saw tooth
3. A piece of metal - Does a lot of work
4. This uses acme thread very widely
6. Another name for major diameter