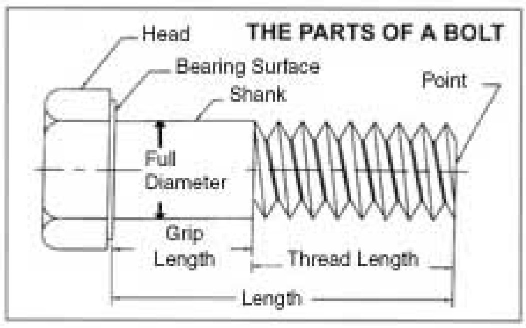
Bolt, Stud or Screw Size		Torque Values in Inch-Pounds for Tightening Nuts			
		On standard bolts, studs and screws having a tensile strength of 125,000 to 140,000 psi		On bolts, studs, and screws having a tensile strength of 140,000 to 160,000 psi	On high-strength bolts, studs, and screws having a tensile strength of 160,000 psi and over
		Shear type nuts (AN320, AN364 or equivalent)	Tension type nuts and threaded machine parts (AN-310, AN365 or equivalent)	Any nut, except shear type	Any nut, except shear type
8–32	8–36	7–9	12–15	14–17	15–18
10–24	10–32	12–15	20–25	23–30	25–35
1/4–20		25–30	40–50	45–49	50–68
	1/4–28	30–40	50–70	60–80	70–90
5/16–18		48–55	80–90	85–117	90–144
	5/16–24	60–85	100–140	120–172	140–203
3/8–16		95–110	160–185	173–217	185–248
	3/8–24	95–110	160–190	175–271	190–351
7/16–14		140–155	235–255	245–342	255–428
	7/16–20	270–300	450–500	475–628	500–756
1/2–13		240–290	400–480	440–636	480–792
	1/2–20	290–410	480–690	585–840	690–990
9/16–12		300–420	500–700	600–845	700–990
	9/16–18	480–600	800–1000	900–1,220	1,000–1,440
5/8–11		420–540	700–900	800–1,125	900–1,350
	5/8–18	660–780	1,100–1,300	1,200–1,730	1,300–2,160
3/4–10		700–950	1,150–1,600	1,380–1,925	1,600–2,250
	3/4–16	1,300–1,500	2,300–2,500	2,400–3,500	2,500–4,500
7/8–9		1,300–1,800	2,200–3,000	2,600–3,570	3,000–4,140
	7/8–14	1,500–1,800	2,500–3,000	2,750–4,650	3,000–6,300
1"–8		2,200–3,000	3,700–5,000	4,350–5,920	5,000–6,840
	1"–14	2,200–3,300	3,700–5,500	4,600–7,250	5,500–9,000
1 1/8–8		3,300–4,000	5,500–6,500	6,000–8,650	6,500–10,800
	1 1/8–12	3,000–4,200	5,000–7,000	6,000–10,250	7,000–13,500
1 1/4–8		4,000–5,000	6,500–8,000	7,250–11,000	8,000–14,000
	1 1/4–12	5,400–6,600	9,000–11,000	10,000–16,750	11,000–22,500

Figure 5-34. Standard torque table (inch-pounds).

AN, MS, NAS Bolts

Most bolts used in aircraft structures are either (a) general-purpose, (b) internal-wrenching or (c) close-tolerance AN, NAS, or MS bolts. Design specifications are available in MIL-HDBK-5, USAF T.O. 1-1A-8, or Navy NAVAIR 01-1A-8. References should be made to military specifications and industry design standards such as NAS, the Society of Automotive Engineers (SAE), and Aerospace Material Standards (AMS).

General purpose aircraft structural bolts manufactured in accordance with the AN3—20 standards are commonly high strength 8740 alloy steel with a minimum tensile strength around 125 000 PSI, but other steel alloys are included in the specification. The standard bolts have hexagonal heads, are centerless ground and roll threaded after heat treatment, then cadmium plated and are used in shear or tension applications. The bolt head and/or shank may have holes drilled for safety wire or cotter pins. Aluminum bolts are also included in the specification but such bolts are unlikely to be used in a structural role in a light aircraft.



AN3—20 bolts are identified by a multi-part code:

- Firstly the AN specification identity, then
- One or two numbers that indicate the shank diameter in 1/16 inch increments starting at AN3 [3/16"] and ending at AN20 [1 1/4"], which may be followed by
- A dash indicating the material is the standard cadmium plated 8740 or 4037 alloy steel, otherwise one or two letters for the material (e.g. 'C' indicates CRES, "DD" is 2024 aluminum.)
- Then, if the hexagonal head is drilled for safety wire, the letter 'H'
- One or two numbers which indicates the length of the shank from under the head to the tip in 1/8 inch increments, if two numbers the first indicates whole inches and the second indicates the 1/8 inch increments (e.g. 23 indicates a shank length of 2 3/8" — but there may be variations from this system), then
- The letter 'A' indicating the bolt shank is not drilled and thus intended for use with a self-locking nut (which is the norm); the letter is absent if the shank is drilled for castle nut and cotter pin locking.

  For example: AN6-H7A

- AN6 denotes the specification for general purpose hexagonal head bolts with a 3/8" [6/16"] diameter shank
- The dash indicates the material is the standard cadmium plated alloy steel

- H indicates the bolt head is drilled for safety wire
- 7 = 7/8 inch shank length and
- A = indicates the shank is not drilled.

Bolt threads. The standard aircraft thread is the 'unified national' form either in the fine [UNF] series or the coarse [UNC] series. Both series are based on a 60° thread; that is if the thread is viewed in cross section each thread forms an equilateral triangle but with the roots and crests of the threads rounded during the rolling process to avoid sharp corners and thus minimize stress concentrations. The coarse series have fewer threads per inch [TPI] for the same bolt diameter.

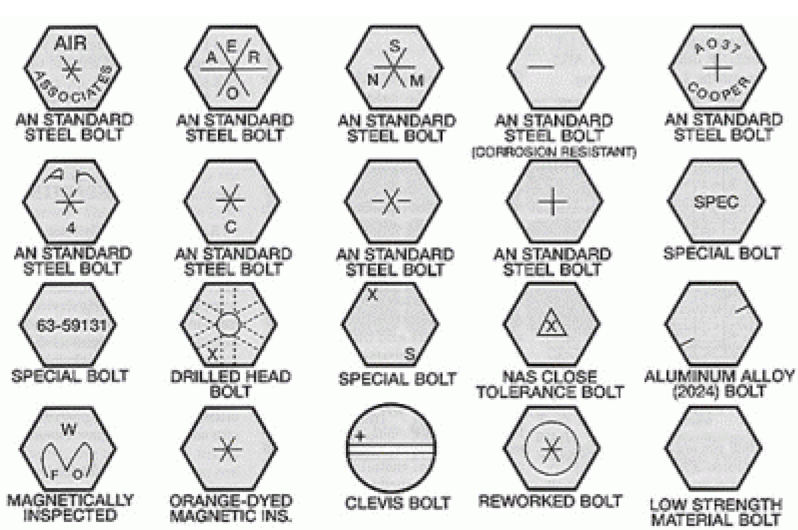
The AN3—20 bolts use only the UNF threads; the AN3 bolt has 32 TPI, the AN4 is 28 TPI, AN5 and AN6 are 24 TPI, AN7 and AN8 are 20 TPI.

Thread length and grip. The threaded length of AN bolts is about 3/8" for AN3, 7/16" for AN4, 1/2" for AN5 and 9/16" for AN6–AN8. The grip is the shank length minus the threaded length, which for the AN6-H7A bolt would be 7/8" shank length minus 9/16" thread length = 5/16" grip. Thus an AN3-4 bolt would have a grip of only 1/8" and might, at first glance, present the appearance of a fully threaded shank.

The threaded length should not be subject to shear loads. The specification allows shank lengths to be from 1/32 to 3/32 inches longer than the nominal length.

In general, bolt grip lengths of a fastener are the thickness of the material the fastener is designed to hold when two or more parts are being assembled. Bolts of slightly greater grip length may be used, provided washers are placed under the nut or bolt head. The maximum combined height of washers that should be used is 1/8 inch. This limits the use of washers necessary to compensate for grip, up to the next standard grip size. All bolt installations, which involve self-locking or plain nuts, should have at least one thread at the end of the bolt protruding through the nut.

Only the unthreaded portion of the shank – the grip – should carry shear loads, so a maximum of one or 1.5 inner end threads are acceptable within the grip length, though the nut should not be run down to the inner end of the threaded length.



Aircraft bolts may be identified by code markings on the bolt heads. These markings generally denote the material of which the bolt is made, whether the bolt is a standard AN-type or a special-purpose bolt, and sometimes include the manufacturer.

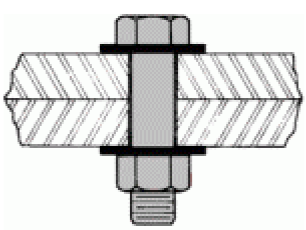
a. AN standard steel bolts are marked with either a raised cross or asterisk [most of those pictured], corrosion resistant steel is marked by a single dash [row 1, number 4], and

AN aluminum-alloy bolts are marked with two raised dashes [row 3, number 5].

b. Special-purpose bolts include high-strength, low-strength, and close-tolerance types. These bolts are normally inspected by magnetic particle inspection methods. Typical markings include “SPEC” (usually heat-treated for strength and durability) [row 2, number 5] , and an aircraft manufacturer’s part number stamped on the head [row 3, number 1]. **Bolts with no markings are low strength.** Close-tolerance NAS bolts are marked with either a raised or recessed triangle [row 3, number 4]. The material markings for NAS bolts are the same as for AN bolts, except they may be either raised or recessed. Bolts requiring non-destructive inspection (NDI) by magnetic particle inspection are identified by means of colored lacquer, or head markings of a distinctive type.

Bolt holes, particularly those of primary connecting elements, have close tolerances. Generally, **it is permissible to use the first-lettered drill size larger than the nominal bolt diameter**, except when the AN hexagon bolts are used in light-drive fit (reamed) applications and where NAS close-tolerance bolts or AN clevis bolts are used. A light-drive fit can be defined as an interference of 0.0006 inch for a 5/8 inch bolt. Bolt holes should be flush to the surface, and free of debris to provide full bearing surface for the bolt head and nut. In the event of over-sized or elongated holes in structural members, reaming or drilling the hole to accept the next larger bolt size may be permissible. Care should be taken to ensure items, such as edge distance, clearance, and structural integrity are maintained.

There are a number of names (*bolts, screws, machine screws, set screws, cap screws*) for headed, external screw threaded fasteners designed either (a) for use with an internally threaded nut to clamp two or more parts together or (b) to clamp one or more parts to another internally threaded metal body. Generally it can be said that fasteners tensioned by turning a threaded nut are bolts while those tensioned by turning the head are screws, however there is a class of bolt, often referred to as 'engine bolts', where the joint is tensioned by turning the bolt head to screw it into an internally threaded metal body. Machine/cap screws are threaded for their full length and are manufactured from carbon steels; structural screws have an unthreaded grip length and are made from alloy steels. In this section we will concentrate on bolt and nut applications in airframe structures.



There are two commonly used structural bolted joint designs, one type where the high tensile strength of the bolt shank is used to clamp members together and the joint functionality relies on the surface friction between the members rather than the bolt shank; the joint will hold as long as the friction force is greater than any shear force applied. The other joint type is where the joint primarily relies on the shear strength of the bolt shank, such as seen in aluminum tubular struss structures, and there is only sufficient tensile load applied to the bolt/nut to prevent movement after locking.

If a turning force or torque is applied with a wrench to the nut of a bolt and nut pair already 'snugged up' — i.e. holding all joint interfaces in intimate contact but with little or no tension in the bolt — the under surface of the bolt head and the inner surface of the nut (or intermediate washers if fitted) will apply a compressive force to the members, clamping them together. Dependent on the stiffness of the joint members the periphery of that compressive effect extends to around 4–5 times the diameter of the bolt shank. The greater the torque applied to the nut the greater the tension in the bolt and the greater the compression in the members (or the crushing force applied to the member/s and any intermediate sealing gasket). 'Hard' joints may only require the nut to be rotated through a 30° angle from the snugged position to achieve the full torque, a 'soft' gasketed joint may require a rotation of two full turns from the snugged position.

Referring to the stress-strain diagram in the properties of metals module it can be seen that as long as the tensile stress in the bolt is less than the yield strength the resulting bolt stretch [the strain] will stay within the elastic region. While that tension continues the bolt elasticity [the potential energy] will apply the clamping force holding the joint together. This clamping force is called the **pre-load** or pre-tension, which, for a high-stress joint (such as a propeller hub/crankshaft flange joint) might be set at 70% or more of the bolt yield strength — the position indicated by the small green cross in that stress-strain diagram.

Because bolt threads act as stress concentrators permanent deformation will occur at loads a little below yield strength — maybe around the 95% level. This is termed the bolt proof strength, proof stress or **proof load**.

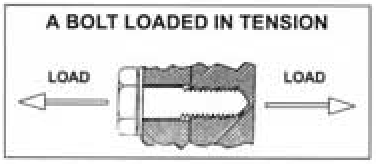
The compressive force in the members is equal to the tensile force in the bolt(s) but if the members are stiffer than the bolts the amount of compressive movement would be less than the amount of bolt elongation.

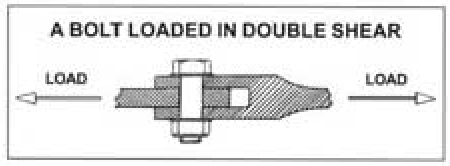
The stretch in a pre-tensioned bolt is probably less than 0.25% of its initial length. But of course a 0.25% strain in a bolt 100 mm long is 10 times the physical stretch of a 0.25% strain in a bolt 10 mm long.

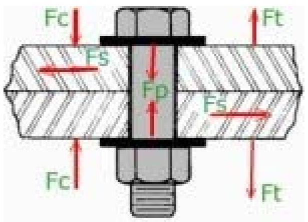
Note on turning force: only about 10%–15% of the torque applied increases bolt tension i.e. stretches it. Perhaps 40%–50% of the turning force is needed to overcome the friction between the male and female threads; the balance is needed to overcome the turning friction between the undersurface of the nut and the material being clamped. Thus if some form of thread lubricant is used the torque required to produce the same pre-load is perhaps 25% less. The cadmium plating on the bolt and nut for corrosion protection also acts as a lubricant so torque required is reduced.

The turning force to be applied to a nut (or the angle through which it is to be turned from the snugged position) to achieve a particular pre-load will be specified in torque charts or by the designer. If any coating, corrosion inhibiting compound/paste or lubricant is used that is not specified by the designer then there is a very good chance that applying the specified torque will stress the bolt beyond its yield point and lead to joint failure. Also torque wrenches may have only an accuracy of plus/minus 25%.

Having calculated the in-service loads which will be applied to a structural joint the aircraft designer will determine the number of bolts required and their spacing plus tensile strength, physical dimensions, thread type, thread pitch, corrosion protection and then the pre-load to be applied. Most of the resistance to shear within the joint comes from the friction between the clamped surfaces of the joint members, so of course there may be quite a number of bolts within the joint.







The diagrams above and left show the forces acting within a pre-loaded joint. When there are no external tension forces the compressive force [Fc] in the joint members equals the pre-load force [Fp] in the bolt. In flight the joint will be loaded with external tension forces [Ft] and shear forces [Fs]. The external tension forces decrease the pre-load joint compression, however such joints are designed so that the members are quite stiff and the bolts resilient so that a quite high external load will cause a decrease in joint load, but not to the point of separation, and only a slight increase in the tensile load on the bolt(s). Designers will generally opt for a larger number of smaller diameter bolts in a joint rather than a smaller number of larger diameter bolts; for example the center joint of the left and right main wing spars for a twin engine Piper aircraft utilizes fourteen 3/8 inch bolts to join the top spar caps, a similar arrangement for the bottom spar caps and sixteen 3/16 inch bolts for joining the webs — 44 bolts in one joint.

External forces acting on a structural joint are generally not pure tension or pure shear, the force vector will have a tension component and a shear component. As long as the external load is somewhat less than the pre-load a joint clamping load exists but this ceases if those tension forces exceed the pre-load force. Then the tensile stress on the bolts will increase, the bolts elongate (still elastically) and the mating parts begin to slip reducing joint functionality and imposing all the shear forces in the joint onto the bolt shanks. The tensile stress may take the bolts past their yield point and the combination of shear and tension will cause the bolts to bend so that even if the external load is released the joint will no longer be functional.

Pre-load and metal fatigue. Pre-loading has the effect of reducing the dimension of the fatigue cycles to which the fastener is exposed. The forces applied to the bolt from in-flight loads are generally much less than the pre-load so the increases in bolt tension are comparatively slight thus reducing the level of cyclic stress and keeping it inside the fatigue limit.

After some exposure to flight loads joint surfaces tend to embed into each other (the rougher the surfaces the greater the embedding), which has the effect of relaxing the bolt pre-load.

The importance of correct torque application cannot be overemphasized. Under torque can result in unnecessary wear of nuts and bolts, as well as the parts they secure. Over torque can cause failure of a bolt or nut from overstressing the threaded areas. Uneven or additional loads that are applied to the assembly may result in wear or premature failure. The following are a few simple, but important procedures that should be followed to ensure that correct torque is applied.

Be sure that the torque applied is for the size of the bolt shank not the wrench size.

a. Calibrate the torque wrench at least once a year, or immediately after it has been abused or dropped, to ensure continued accuracy.

b. Be sure the bolt and nut threads are clean and dry, unless otherwise specified by the manufacturer.

c. Run the nut down to near contact with the washer or bearing surface and check the friction drag torque required to turn the nut. Whenever possible, apply the torque to the nut and not the bolt. This will reduce rotation of the bolt in the hole and reduce wear.

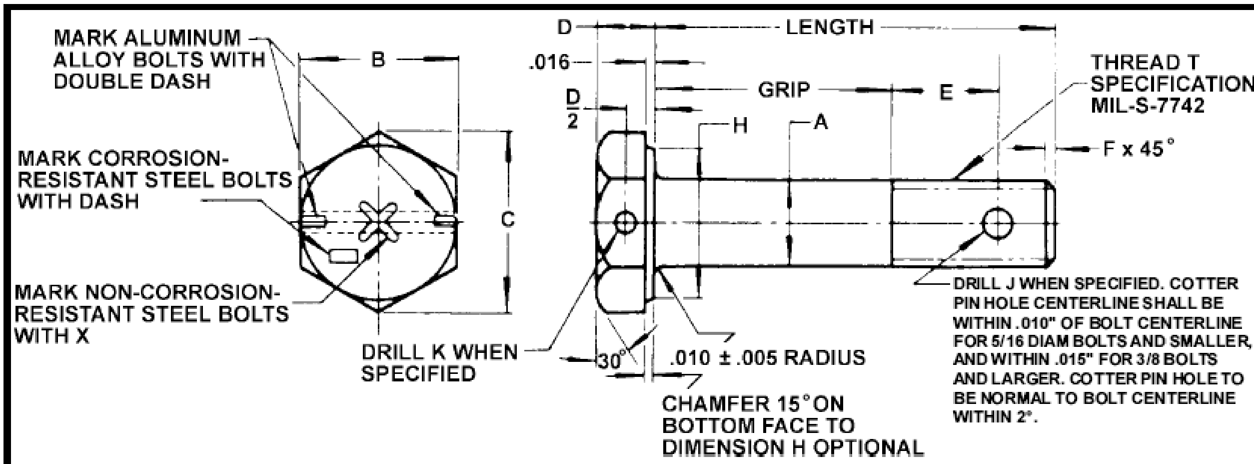
d. Add the friction drag torque to the desired torque. This is referred to as “final torque,” which should register on the indicator or setting for a snap-over type torque wrench.

e. Apply a smooth even pull when applying torque pressure. If chattering or a jerking motion occurs during final torque, back off the nut and retorque.

NOTE: Many applications of bolts in aircraft/engines require stretch checks prior to reuse. This requirement is due primarily to bolt stretching caused by over torquing.

f. When installing a castle nut, start alignment with the cotter pin hole at the minimum recommended torque plus friction drag torque.

NOTE: Do not exceed the maximum torque plus the friction drag. If the hole and nut castellation do not align, change washer or nut and try again. Exceeding the maximum recommended torque is not recommended.



Dimensions in inches. Unless otherwise specified, tolerances: decimals ± .010, angles ± 5°.

Basic AN Part No.	Thread T	A Diameter		B		C	D		E	F		H Diam	J Drill Diam +.010 .000	K Drill Dia +.010 -.000
		Max	Min	Max	Min		Max	Min		Max	Min	Min		
AN3 AN4	#10-32 NF-3A 1/4-28 UNF-3A	.189 .249	.186 .246	.377 .440	.365 .428	.430 .510	.141 .172	.109 .140	.266 .313	.047	.015	.359 .422	.070 .076	.046
AN5 AN6	5/16-24 UNF-3A 3/8-24 UNF-3A	.312 .374	.309 .371	.502 .565	.490 .553	.580 .650	.204 .235	.172 .203	.359 .438	.063	.031	.484 .547	.076 .106	.070
AN7 AN8	7/16-20 UNF-3A 1/2-20 UNF-3A	.437 .499	.433 .495	.627 .752	.615 .740	.720 .870	.266 .297	.234 .265	.484 .609			.609 .734	.106	
AN10	5/8-18 UNF-3A	.624	.620	.940	.928	1.090	.360	.328	.734	.078	.046	.922	.141	

MATERIAL: Non-corrosion-resistant steel, corrosion-resistant steel, or aluminum alloy. See procurement spec.

FINISH: See procurement spec.

Add "C" before dash number for corrosion-resistant steel bolt.
Add "DD" before dash number for aluminum alloy steel bolt.
Add "A" after dash number for undrilled bolt. See illustration below.
Add "H" before dash number for bolt with drilled head and shank. See illustration below.
Add "H" before dash number and "A" after dash number for bolt with drilled head only. See illustration below.

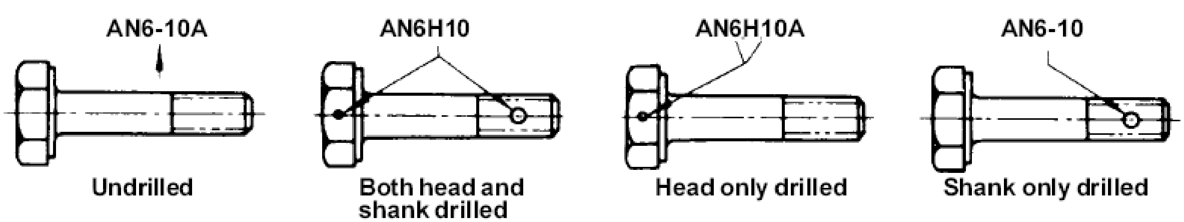
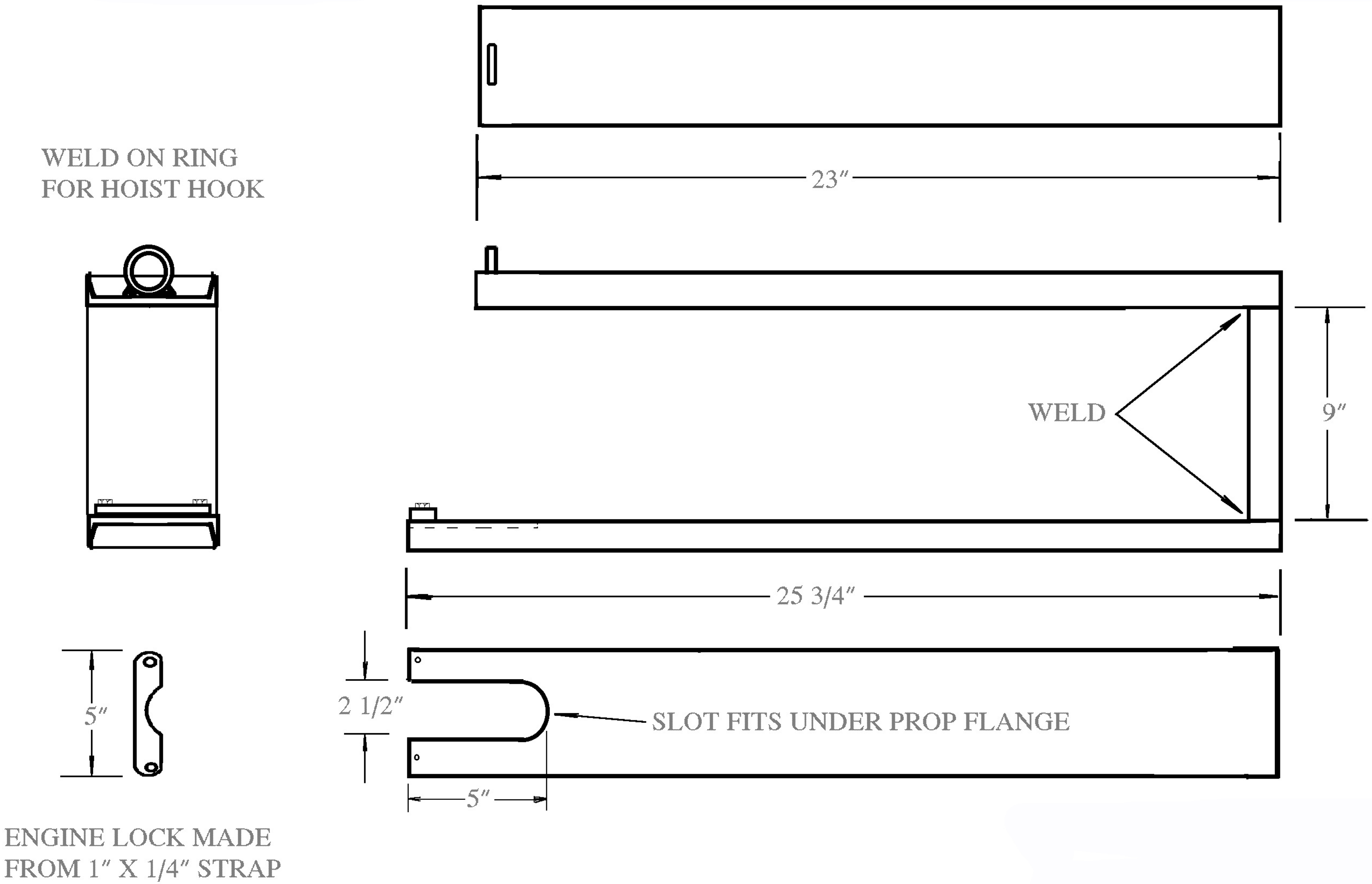


ILLUSTRATION OF DRILLED AND UNDRILLED BOLTS AND PART NUMBERS

Bolts shall be free from all hanging burrs and slivers which might become dislodged under usage. Countersinking of drilled holes in head is mandatory. Countersinking of drilled holes in shank is optional.

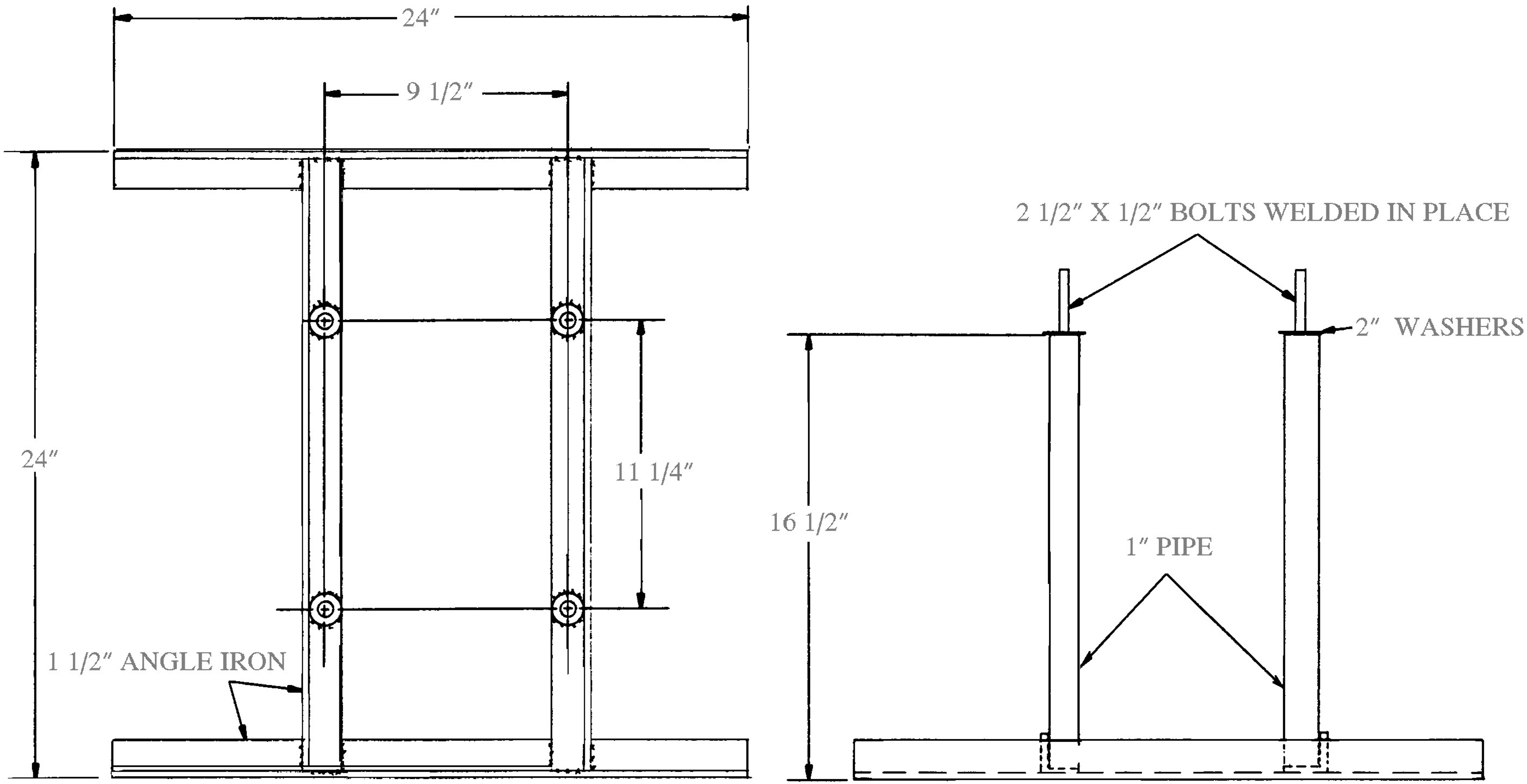
PROCUREMENT SPECIFICATION	TITLE	CLASSIFICATION
MIL-B-6812	BOLT, MACHINE, AIRCRAFT	STANDARD PART AN3 THRU AN10

Dash No.	AN3		AN4		AN5		AN6		AN7		AN8		AN10	
	Grip	Length	Grip	Length	Grip	Length	Grip	Length	Grip	Length	Grip	Length	Grip	Length
3	.063	.469	.063	.469										
4	.125	.531	.063	.531	.063	.594								
5	.250	.656	.188	.656	.188	.719	.063	.703	.063	.719				
6	.375	.781	.313	.781	.313	.844	.188	.828	.188	.844	.063	.844		
7	.500	.906	.438	.906	.438	.969	.313	.953	.313	.969	.188	.969	.063	1.02
10	.625	1.03	.563	1.03	.563	1.09	.438	1.08	.438	1.09	.313	1.09	.188	1.14
11	.750	1.16	.688	1.16	.688	1.22	.563	1.20	.563	1.22	.438	1.22	.313	1.27
12	.875	1.28	.813	1.28	.813	1.34	.688	1.33	.688	1.34	.563	1.34	.438	1.39
13	1.00	1.41	.938	1.41	.938	1.47	.813	1.45	.813	1.47	.688	1.47	.563	1.52
14	1.13	1.53	1.06	1.53	1.06	1.59	.938	1.58	.938	1.59	.813	1.59	.688	1.64
15	1.25	1.66	1.19	1.66	1.19	1.72	1.06	1.70	1.06	1.72	.938	1.72	.813	1.77
16	1.38	1.78	1.31	1.78	1.31	1.84	1.19	1.83	1.19	1.84	1.06	1.84	.938	1.89
17	1.50	1.91	1.44	1.91	1.44	1.97	1.31	1.95	1.31	1.97	1.19	1.97	1.06	2.02
20	1.63	2.03	1.56	2.03	1.56	2.09	1.44	2.08	1.44	2.09	1.31	2.09	1.19	2.14
21	1.75	2.16	1.69	2.16	1.69	2.22	1.56	2.20	1.56	2.22	1.44	2.22	1.31	2.27
22	1.88	2.28	1.81	2.28	1.81	2.34	1.69	2.33	1.69	2.34	1.56	2.34	1.44	2.39
23	2.00	2.41	1.94	2.41	1.94	2.47	1.81	2.45	1.81	2.47	1.69	2.47	1.56	2.52
24	2.13	2.53	2.06	2.53	2.06	2.59	1.94	2.58	1.94	2.59	1.81	2.59	1.69	2.64
25	2.25	2.66	2.19	2.66	2.19	2.72	2.06	2.70	2.06	2.72	1.94	2.72	1.81	2.77
26	2.38	2.78	2.31	2.78	2.31	2.84	2.19	2.83	2.19	2.84	2.06	2.84	1.94	2.89
27	2.50	2.91	2.44	2.91	2.44	2.97	2.31	2.95	2.31	2.97	2.19	2.97	2.06	3.02
30	2.63	3.03	2.56	3.03	2.56	3.09	2.44	3.08	2.44	3.09	2.31	3.09	2.19	3.14
31	2.75	3.16	2.69	3.16	2.69	3.22	2.56	3.20	2.56	3.22	2.44	3.22	2.31	3.27
32	2.88	3.28	2.81	3.28	2.81	3.34	2.69	3.33	2.69	3.34	2.56	3.34	2.44	3.39
33	3.00	3.41	2.94	3.41	2.94	3.47	2.81	3.45	2.81	3.47	2.69	3.47	2.56	3.52
34	3.13	3.53	3.06	3.53	3.06	3.59	2.94	3.58	2.94	3.59	2.81	3.59	2.69	3.64
35	3.25	3.66	3.19	3.66	3.19	3.72	3.06	3.70	3.06	3.72	2.94	3.72	2.81	3.77
36	3.38	3.78	3.31	3.78	3.31	3.84	3.19	3.83	3.19	3.84	3.06	3.84	2.94	3.89
37	3.50	3.91	3.44	3.91	3.44	3.97	3.31	3.95	3.31	3.97	3.19	3.97	3.06	4.02
40	3.63	4.03	3.56	4.03	3.56	4.09	3.44	4.08	3.44	4.09	3.31	4.09	3.19	4.14
41	3.75	4.16	3.69	4.16	3.69	4.22	3.56	4.20	3.56	4.22	3.44	4.22	3.31	4.27
42	3.88	4.28	3.81	4.28	3.81	4.34	3.69	4.33	3.69	4.34	3.56	4.34	3.44	4.39
43	4.00	4.41	3.94	4.41	3.94	4.47	3.81	4.45	3.81	4.47	3.69	4.47	3.56	4.52
44	4.13	4.53	4.06	4.53	4.06	4.59	3.94	4.58	3.94	4.59	3.81	4.59	3.69	4.64
45	4.25	4.66	4.19	4.66	4.19	4.72	4.06	4.70	4.06	4.72	3.94	4.72	3.81	4.77
46	4.38	4.78	4.31	4.78	4.31	4.84	4.19	4.83	4.19	4.84	4.06	4.84	3.94	4.89
47	4.50	4.91	4.44	4.91	4.44	4.97	4.31	4.95	4.31	4.97	4.19	4.97	4.06	5.02
50	4.63	5.03	4.56	5.03	4.56	5.09	4.44	5.08	4.44	5.09	4.31	5.09	4.19	5.14
51	4.75	5.16	4.69	5.16	4.69	5.22	4.56	5.20	4.56	5.22	4.44	5.22	4.31	5.27
52	4.88	5.28	4.81	5.28	4.81	5.34	4.69	5.33	4.69	5.34	4.56	5.34	4.44	5.39
53	5.00	5.41	4.94	5.41	4.94	5.47	4.81	5.45	4.81	5.47	4.69	5.47	4.56	5.52
54	5.13	5.53	5.06	5.53	5.06	5.59	4.94	5.58	4.94	5.59	4.81	5.59	4.69	5.64
55	5.25	5.66	5.19	5.66	5.19	5.72	5.06	5.70	5.06	5.72	4.94	5.72	4.81	5.77
56	5.38	5.78	5.31	5.78	5.31	5.84	5.19	5.83	5.19	5.84	5.06	5.84	4.94	5.89
57	5.50	5.91	5.44	5.91	5.44	5.97	5.31	5.95	5.31	5.97	5.19	5.97	5.06	6.02
60	5.63	6.03	5.56	6.03	5.56	6.09	5.44	6.08	5.44	6.09	5.31	6.09	5.19	6.14
61	5.75	6.16	5.69	6.16	5.69	6.22	5.56	6.20	5.56	6.22	5.44	6.22	5.31	6.27
62	5.88	6.28	5.81	6.28	5.81	6.34	5.69	6.33	5.69	6.34	5.56	6.34	5.44	6.39
63	6.00	6.41	5.94	6.41	5.94	6.47	5.81	6.45	5.81	6.47	5.69	6.47	5.56	6.52
64	6.13	6.53	6.06	6.53	6.06	6.59	5.94	6.58	5.94	6.59	5.81	6.59	5.69	6.64
65	6.25	6.66	6.19	6.66	6.19	6.72	6.06	6.70	6.06	6.72	5.94	6.72	5.81	6.77
66	6.38	6.78	6.31	6.78	6.31	6.84	6.19	6.83	6.19	6.84	6.06	6.84	5.94	6.89

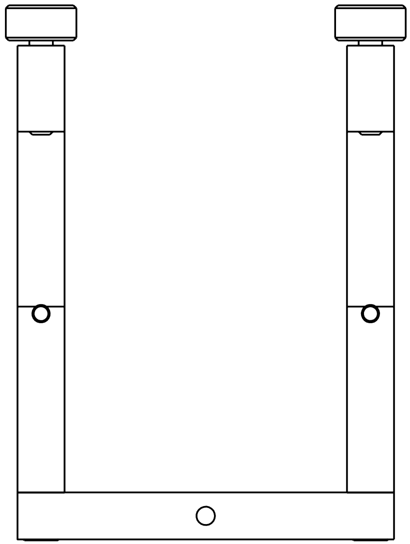


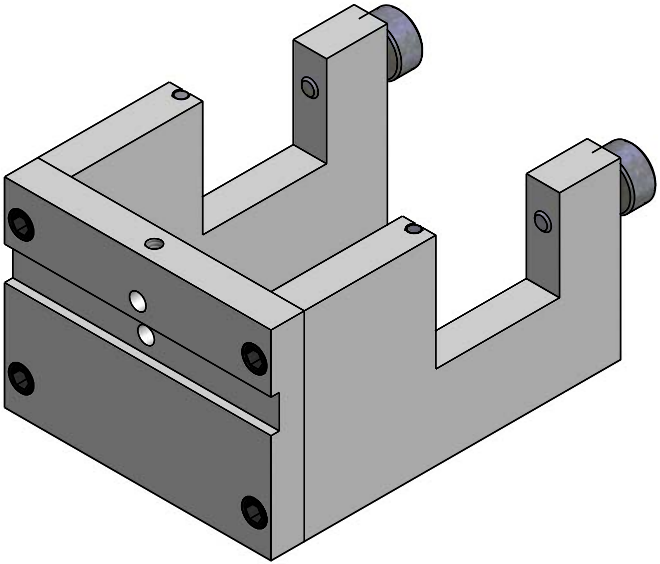
ENGINE HOIST PLAN

MATERIAL: 6″ CHANNEL IRON

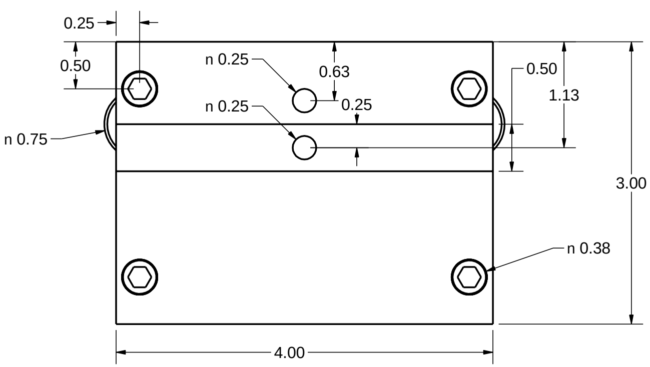


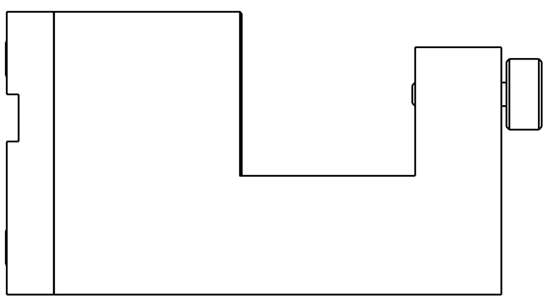
ENGINE STAND PLAN

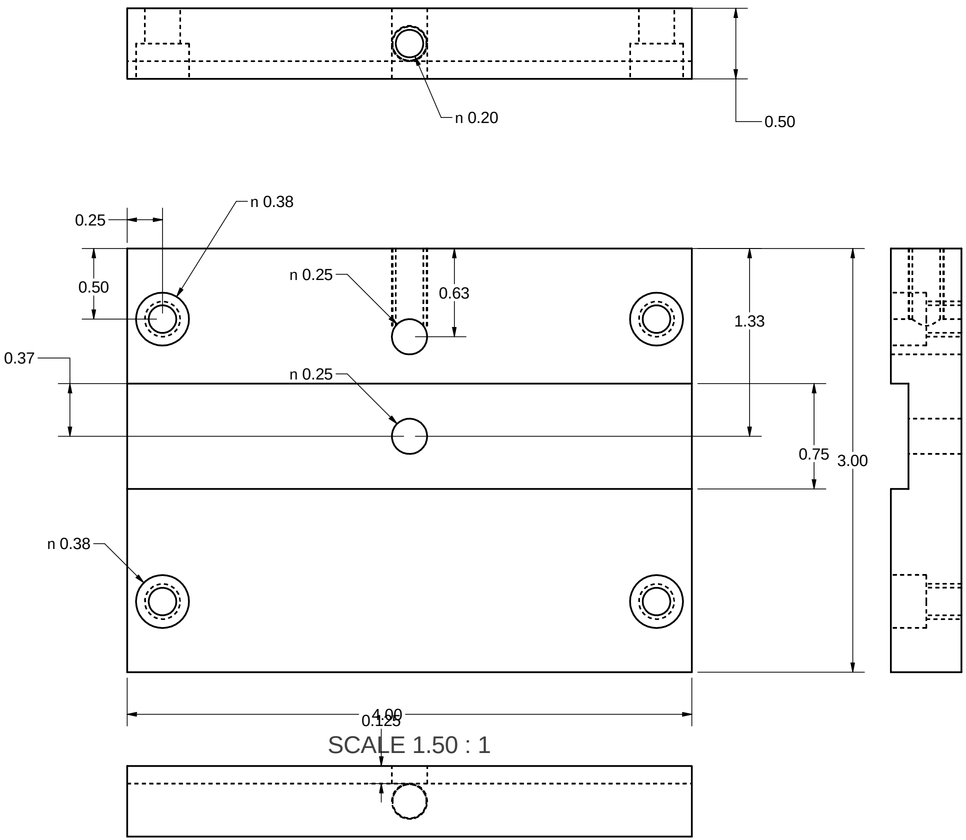


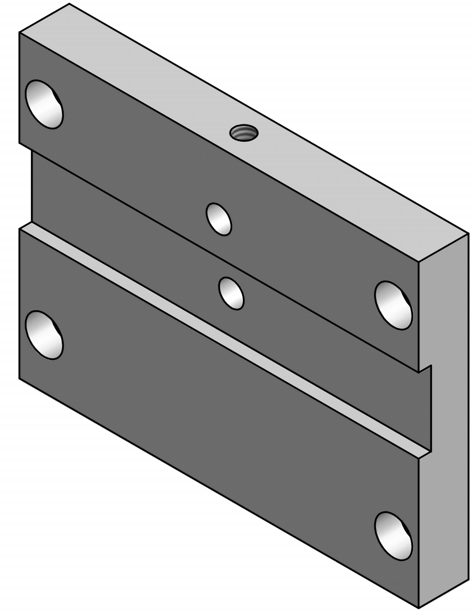


SCALE 1 : 1



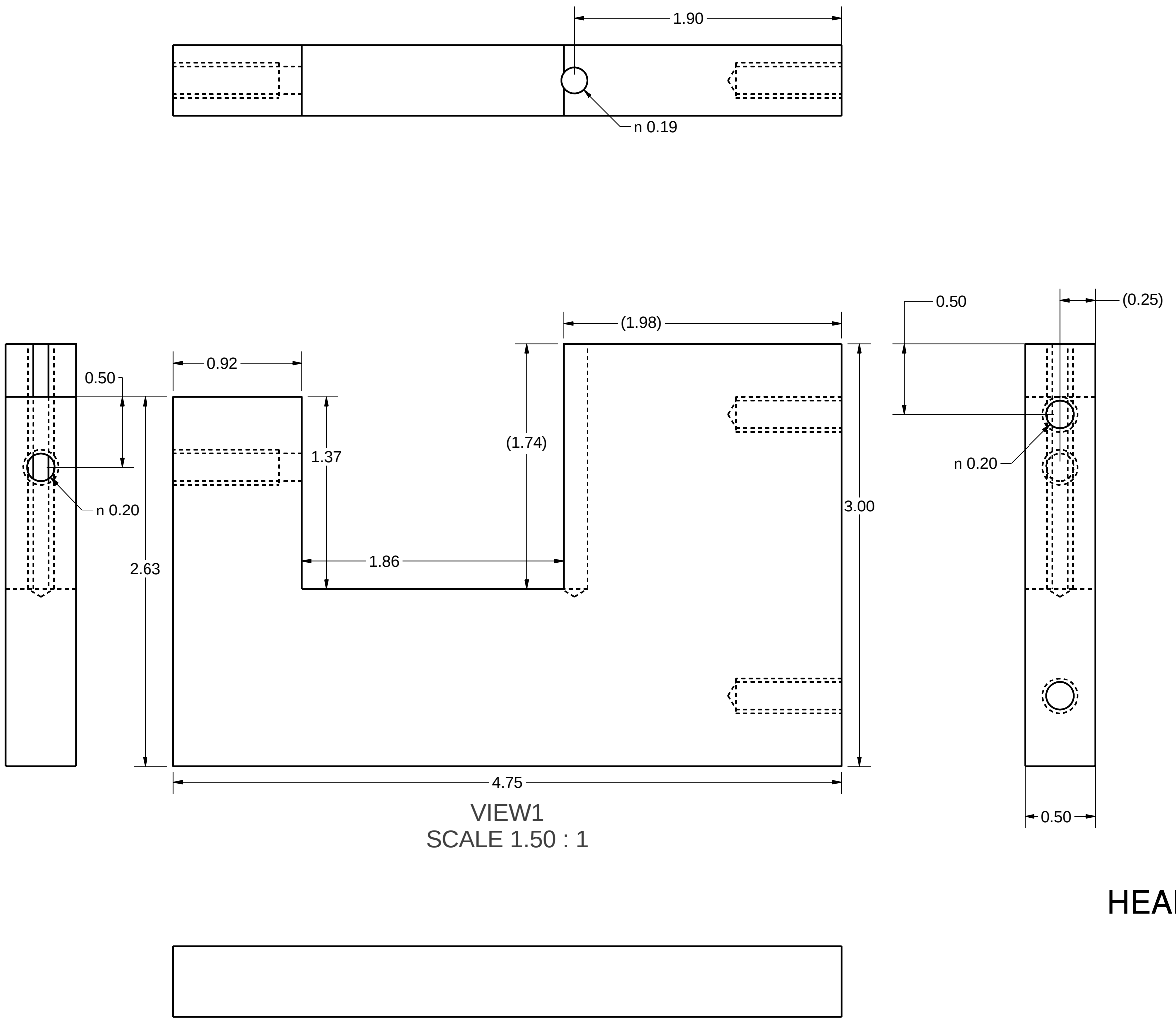




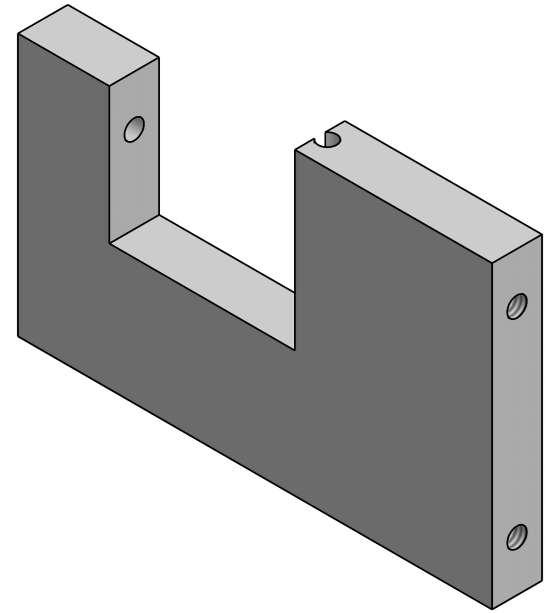


SCALE 1.50 : 1

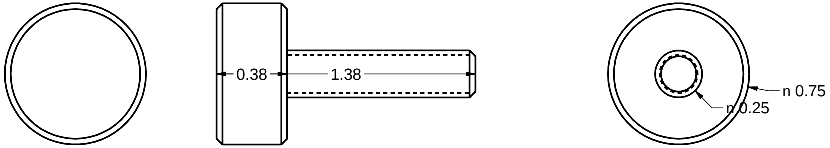
HEAD RIGGING TOOL FRONT



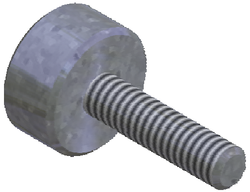
VIEW1
SCALE 1.50 : 1

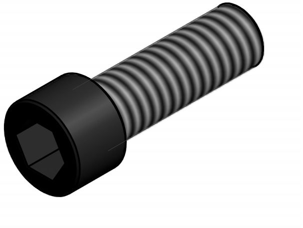


HEAD RIGGING TOOL SIDE PRINT

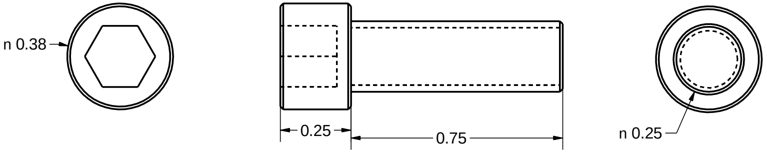


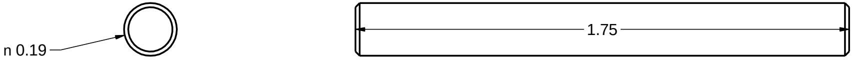
SCALE 2 : 1





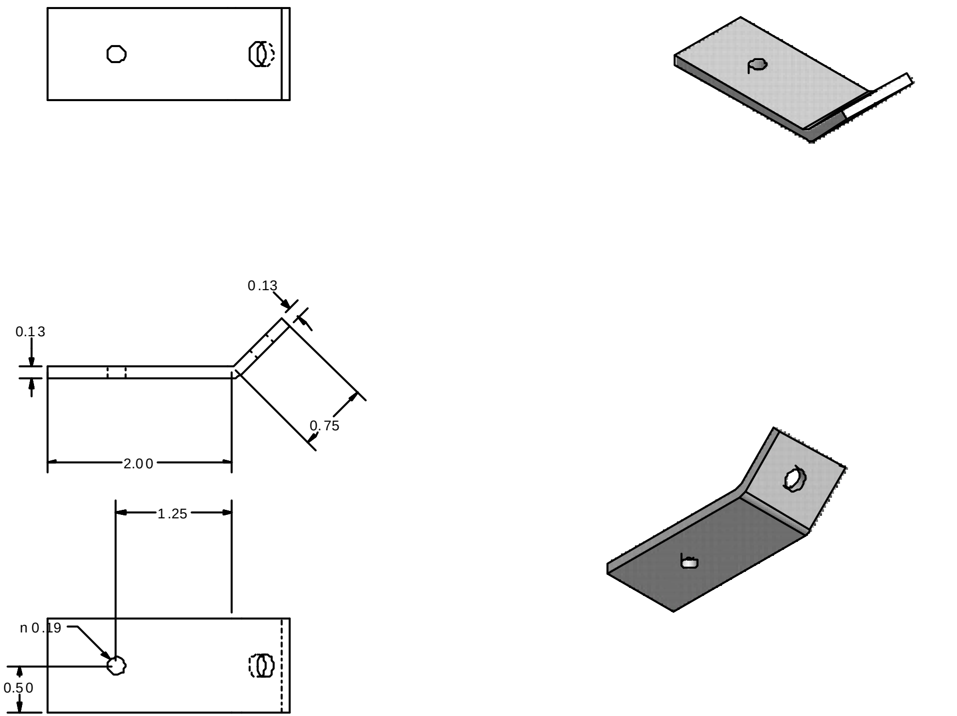
SCALE 3 : 1



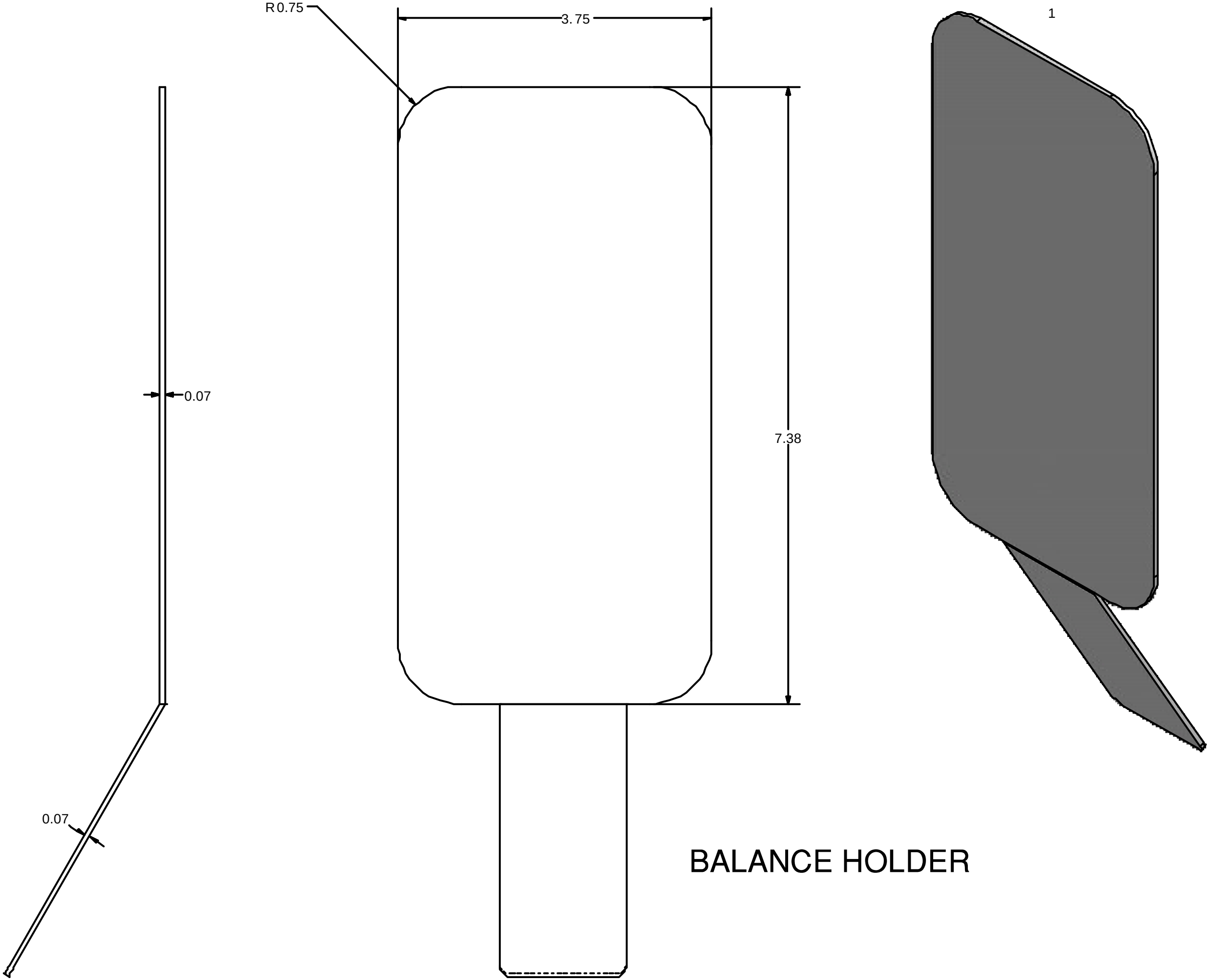


SCALE 3 : 1

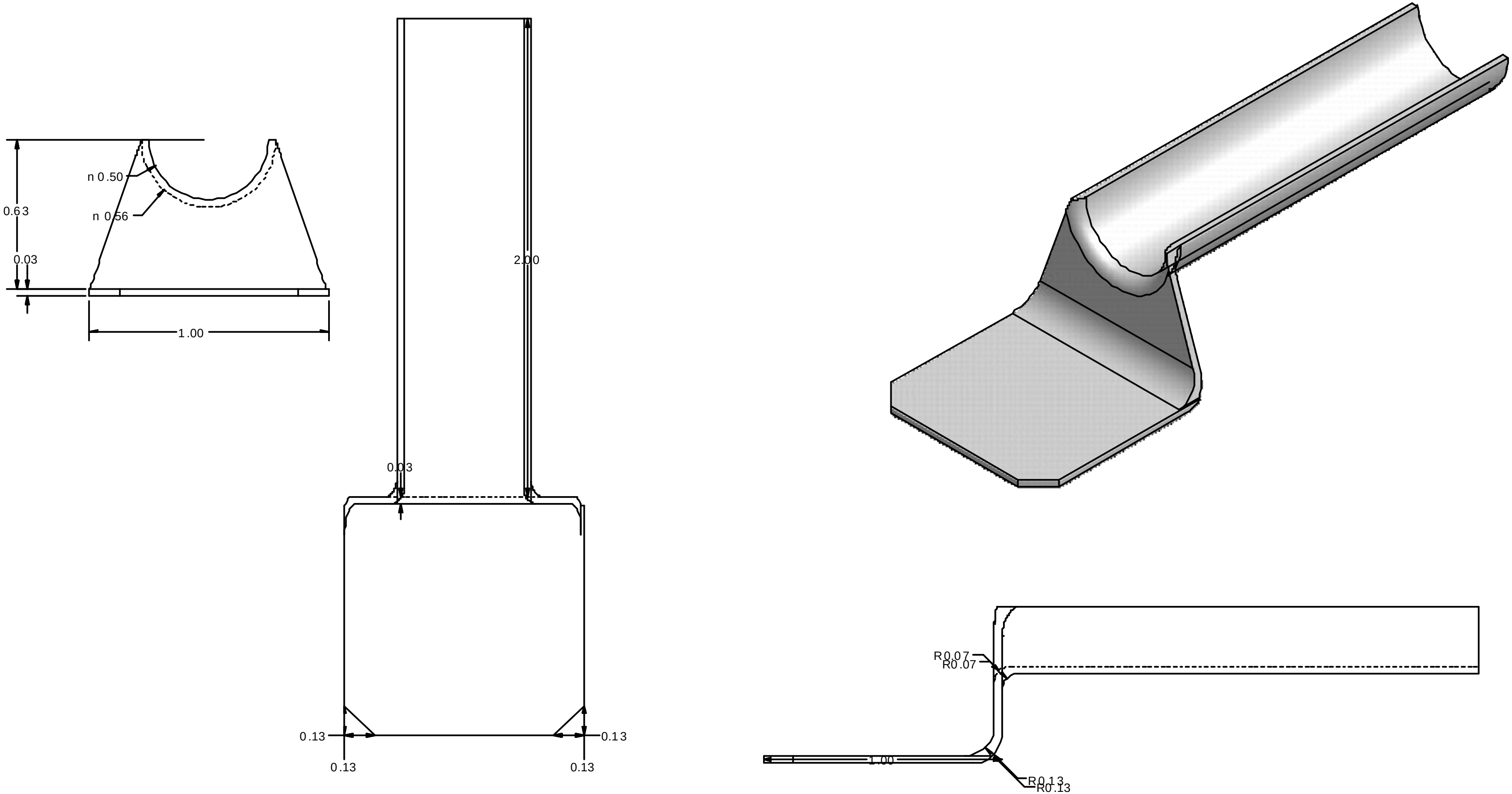
HEAD RIGGING TOOL KNOBS/BOLTS/PINS



ACCELEROMETER BRACKET

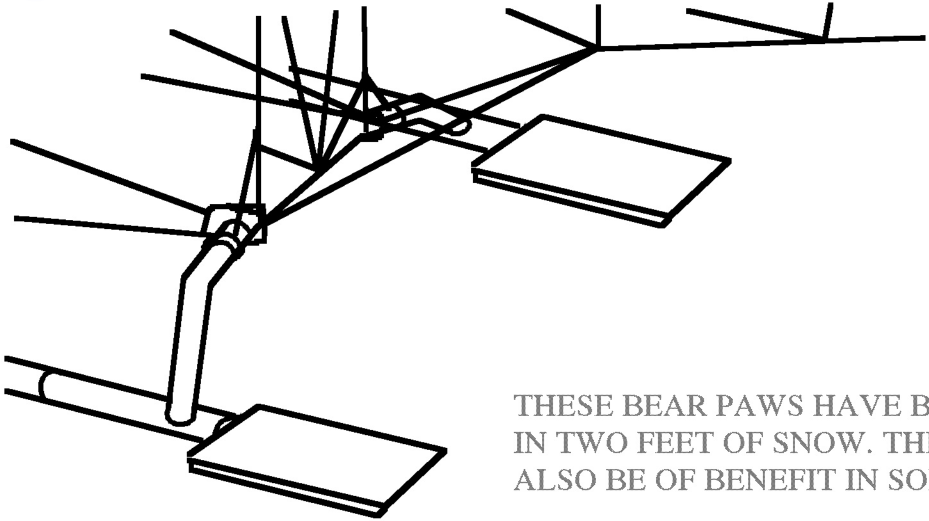


BALANCE HOLDER

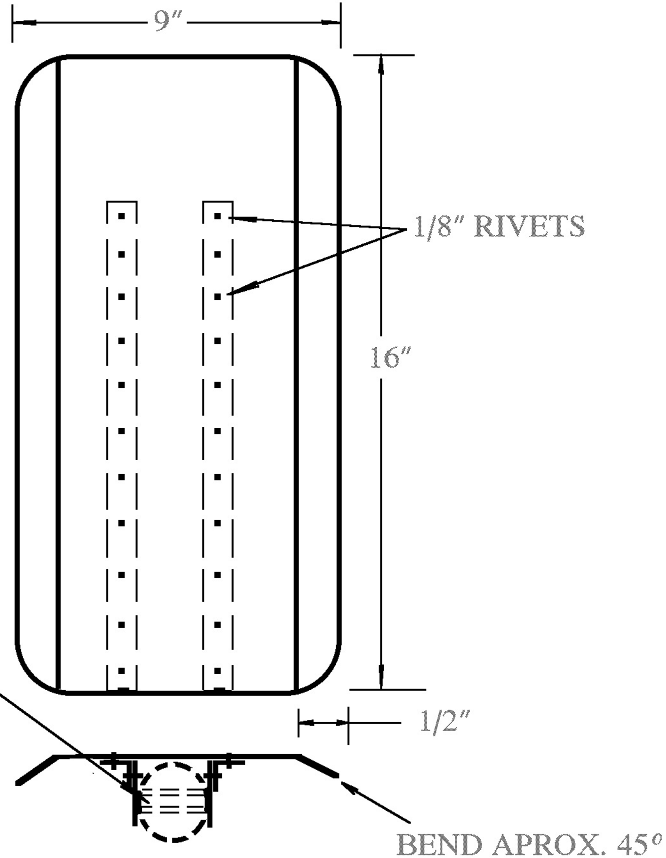


REFLECTOR BRACKET TOOL

MATERIAL: .065″ 6061-T6 ALUMINUM

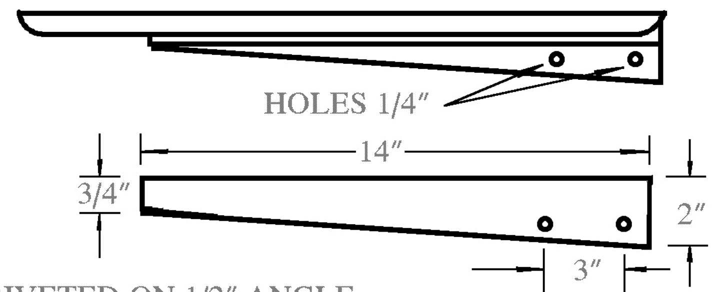


THESE BEAR PAWS HAVE BEEN TESTED IN TWO FEET OF SNOW. THEY MAY ALSO BE OF BENEFIT IN SOFT GROUND



1/2″ x .125″ ALUMINUM BUSHING MUST BE WELDED IN SKID TO PREVENT COLAPSE WITH BOLTS

SIDE VIEW



1/8″ THICK RIB RIVETED ON 1/2″ ANGLE ALUMINUM WHICH IS RIVETED ON PLATE

BEAR PAW PLANS