

BOLT TIGHTENING

General

The alloy steel bolts and studs in the high pressure and/or high temperature flanges, should be tightened sufficiently to produce a definite amount of stretch as outlined in these instructions.

Amount of Stretch

The amount of stretch in alloy steel bolts or studs should be .0015 per inch of free length. This produces the required stress of 45,000 pounds per square inch.

The free length of a stud is the thickness of the flange from joint face to spot facing, plus one stud diameter and plus washer thickness, if washers are used. The free length of a stud bolt extending through both flanges, is the thickness of both flanges between spot facing, plus one bolt diameter, plus thickness of both washers if washers are used.

Lubrication

The threads of bolts and studs, and the bearing faces of nuts, should be well lubricated with a good non-seizing compound to reduce friction and to avoid thread seizures in high temperature service. We recommend a compound of the following materials and proportions:

- 4-1/2 lbs. of powdered white or red lead
- 1-1/4 lbs. of finely powdered graphite (U.S. Graphite Company's #205 or equivalent)

The above to be mixed with one quart of heavy turbine oil.

Stretching

Bolts and studs 2-1/4" diameter and larger are provided with holes in center for stretching by means of heating elements. (Never use a gas flame directly on the bolt or stud because of possible damage to the material).

Bolts and studs smaller than 2-1/4" diameter must be stretched by wrenching. It is preferable to tighten these with a steady pull by using an extension wrench.

Measuring Stretch by Micrometer

The only positive way to determine the stretch of a bolt or a stud is by micrometer measurement.

Bolts and studs 2" diameter and larger are provided with holes for measuring the stretch with a rod, adapter and depth micrometer as per Figure 1. Studs without holes can usually be measured by means of special adapters, slipped over the nut, and a depth micrometer. Through bolts with standard hex nuts but without holes, can be measured over the bolt ends with ordinary outside micrometers.

Bolts and Studs Impossible to Measure

Where it is impossible to measure the stretch, apply a force, as per table below, at the end of wrench. This method, which is not very accurate because of friction variations, is calculated to produce approximately the stress of 45,000 lbs. per square inch, required for alloy steel bolts.

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Nominal Diameter of Stud	Threads Per Inch	Torque Inch Pounds
1/2"	13	540
5/8"	11	680
3/4"	10	800
7/8"	9	880
1"	8	9425
1-1/8"	8	6400
1-1/4"	8	9000
1-3/8"	8	12,225
1-1/2"	8	14,400
1-5/8"	8	19,800
1-3/4"	8	27,000
1-7/8"	8	36,000
2"	8	39,750

EXAMPLE: The force to be applied to a wrench at a point 20 inches from the center of a 3/4 inch 10 thread bolt would be 1800 divided by 20, or 90 pounds.

Measuring Stretch by Turning Nuts

It has been found that the calculated amount of nut turn, based only on the pitch of threads, will not produce sufficient stretch because of the deformation of threads, nuts and flanges.

Measuring Large Bolts and Studs by Heating

The stretch of large bolts and studs, stretched by heating, cannot be measured until after cooling, hence the amount of nut turn must be predetermined and include an allowance for deformation of threads, etc. which will vary from 50% to 75% of the total stretch calculated from the pitch of the threads.

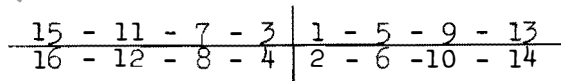
Nuts turned through the following arcs would produce a stretch of .001" if no deformation of threads, nuts and flanges occurred.

2.88 degrees (2 degrees and 50 minutes) for 8 threads per inch
2.16 degrees (2 degrees and 10 minutes) for 6 threads per inch

It is suggested that the required nut turn be determined by trial for each size of heated bolt or stud and that this be used as a guide for other bolts and studs of the same size in the same flange; however all of these bolts and studs must be measured after cooling, with the rod and adapter measuring device.

Tightening Sequence for Cylinder Joint Bolting

Start tightening at the middle of the large diameter bolt group and work toward both ends as indicated below.



Air Cooling after Heating Large Bolts and Studs

The cooling of large bolts and studs, stretched by the use of heating elements, should be hastened, to avoid flange expansion, by blowing compressed air into the bolt hole. The end of the air hose should be fitted with a 1/4" pipe, long enough to extend to within 2" of the bottom

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of the bolt hole. If the hole extends through the entire length of the bolt and nut, close the bottom end with the screw plug supplied with each bolt. A simple air manifold is suggested so that a number of bolts can be cooled simultaneously.

Procedure for Tightening Large Bolts and Studs with Heating Elements

- a. Determine the required stretch (see paragraph 2).
- b. Lubricate threads and face of nut with a good non-seizing compound (see paragraph 3).
- c. Run on nuts to insure of free fitting threads.
- d. Clean bottom of hole with compressed air followed by a swabbing with a rod having a piece of cloth securely fastened to the end, the cloth to be smeared with a little clean grease.
- e. Measure the stud or bolt, with nut loose, using the proper adapter and extension rod shown in Figure 1.
- f. Tighten with extension wrench, with a steady pull just enough to insure a small amount of cold stretch (.001" or .002" is sufficient).
- g. Measure the stud or bolt in this condition. Subtract the free measurement from the cold stretch measurement. The difference will be the cold stretch.
- h. Subtract the cold stretch from the total required stretch. The difference will be the stretch remaining to be obtained by heating. Multiply this by the nut turn for .001" stretch and add for deformation (see paragraph 8) to determine nut turn.
- i. Place reference marks on the nut and flange. If a through bolt, then the holding nut on the opposite end, and the flange should also be marked to observe if the bolt turns during the tightening.
- j. Heat stud or bolt and turn nut until the reference marks coincide. Follow up with the nut as the bolt extends, otherwise the ground circuit will be impaired. Remove heating element and introduce compressed air.
- k. After the stud or bolt has cooled to the same temperature as before heating, clean bottom of hole and measure to see if the required stretch, within a tolerance of minus 10% or plus 20%, has been obtained. Caution: If a low voltage electric heating element is used, and a poor contact exists between end of electric heating element and bottom of hole, burning will occur and will result in a misleading measurement.
 1. In case the correct stretch has not been obtained, the bolts or studs should be reheated.

Example of Dimensions for Stretching Large Studs

Diameter of stud (8 threads per inch).....	3"
Thickness of flange from joint face to spot face 10", plus washer thickness 1/2", plus one stud diameter	
3", gives a free length of.....	13-1/2"
Free length 13-1/2 x .0015" equals total required stretch	.020"
Micrometer measurement, nut loose.....	.750"
Micrometer measurement after slight cold stretch.....	.752"
Difference between these two measurements equals the cold stretch.....	.002"
Stretch to be obtained by heating is .020" less .002"....	.018"
Amount to turn nut for .001" stretch without allowance for deformation of threads, etc.	2.88°
Amount to turn nut for .018" stretch by heating is 18 x 2.88° plus 50% for deformation of parts.....	78°
After cooling, measure the obtained stretch.	

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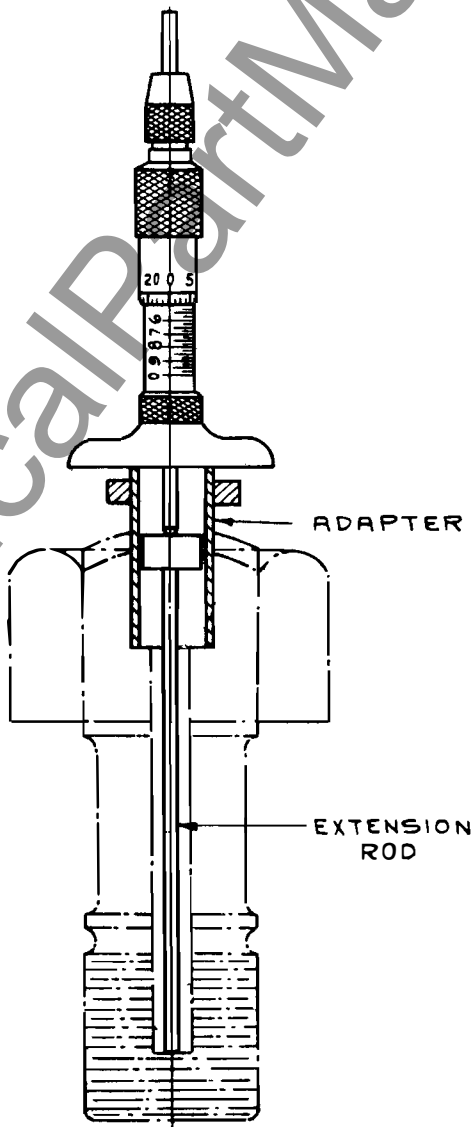


Figure 1