

## Total Integrated Solutions

Petracarbon (Thailand) Co., Ltd is a hi-tech company with their primary goal to promote advanced repair & maintenance technologies for oil & gas, chemical, petrochemical, oil refining industries in Thailand and in neighbouring countries.

Beside the usual services, we are also an approved training provider from ECITB (Engineering Construction Industry Training Board) for delivering the Mechanical Joint Integrity (MJ) training courses, that is in line with industry standards and practices.

This ECITB MJ course which focus on skills in performing various techniques using range of bolting tools, which enable delegates to learn isolation, dismantling, alignment and tightening techniques on various type of flanges, as well as inspection of components as per industry requirements.

- MJ10: Hand Torque Bolted Connection
- MJ18: Hydraulically Tensioned Bolted Connections
- MJ19: Hydraulically Torqued Bolted Connection

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## this issue

Bolt Yield Strength & Ultimate Tensile Strength

P.1 to P.6

## How to determine the Bolt Yield Strength?

In most cases, the strength of a given material used to make a fastener has strength requirements or parameters described as pounds per square inch (psi) or thousands of pounds per square inch (ksi).

This is helpful when analyzing what grade of material should be used for a given application, but this doesn't tell us the actual strength of that diameter of material.

In order to calculate the actual strength values of a given diameter, one would use the following formula:

$$\text{Bolt Yield Strength} = S_{\text{yield}} = Y_{\text{min}} \times A_T$$

Where:

- $Y_{\text{min}}$  or minimum yield in psi of the ASTM grade. This value can be obtained from strength requirements from the bolt grade chart (refer to page 3 and 4).
- $A_T$  is the Tensile Stress area of the specific diameter. This value can be obtained from thread pitch chart (refer to page 6) or by formula.

For example, to find the ultimate yield strength of a Bolt Diameter 2-1/2" – 8UN thread of carbon steel A193 Grade B7, we'll obtain as:

$$\begin{aligned} S_{\text{yield}} &= 105,000 \text{ psi} \times 4.44 \text{ in}^2 \\ &= 466,200 \text{ lbs} \end{aligned}$$

For another example, to find the ultimate yield strength of a same bolt size of 2-1/2" – 8UN thread, but of a stainless steel bolt of A193/A320 Grade B8M, it gives:

$$\begin{aligned} S_{\text{yield}} &= 30,000 \text{ psi} \times 4.44 \text{ in}^2 \\ &= 133,200 \text{ lbs} \end{aligned}$$

Looking at the results, ones must be careful when performing any bolt tightening work. As many a time, mistake might occurred if using the carbon steel parameters for tightening of bolted joint of stainless steel bolts. If this has been occurred, the stainless steel bolts may yield due to excessive bolt loads. And this may lead to failure and/or resulted to serious leakages during equipment start up.

## ECITB MJJ Trainings



## How to determine the Ultimate Tensile Strength of a bolt?

In this case, the tensile strength of the bolts would use the following formula:

$$\text{Ultimate Tensile Strength} = S_{\text{tensile}} = T_{\text{min}} \times A_T$$

Where:

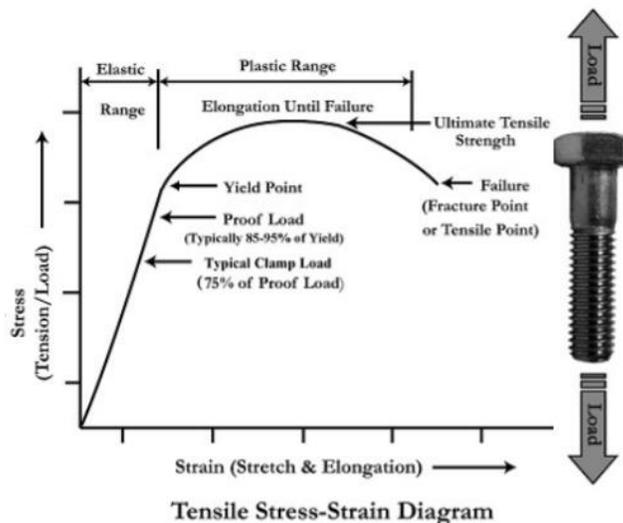
- $T_{\text{min}}$  or minimum Tensile Strength in psi of the ASTM grade. This value can be obtained from strength requirements from the bolt grade chart (refer to page 3 and 4).
- $A_T$  is the Tensile Stress area of the specific diameter. This value can be obtained from thread pitch chart (refer to page 6) or by formula.

For this example, we'll use the same bolt grade and size as per the earlier to find the Ultimate Tensile Strength of a Bolt Diameter 2-1/2" – 8UN thread of carbon steel A193 Grade B7 bolt, we'll obtain as:

$$\begin{aligned} S_{\text{tensile}} &= 125,000 \text{ psi} \times 4.44 \text{ in}^2 \\ &= 555,000 \text{ lbs} \end{aligned}$$

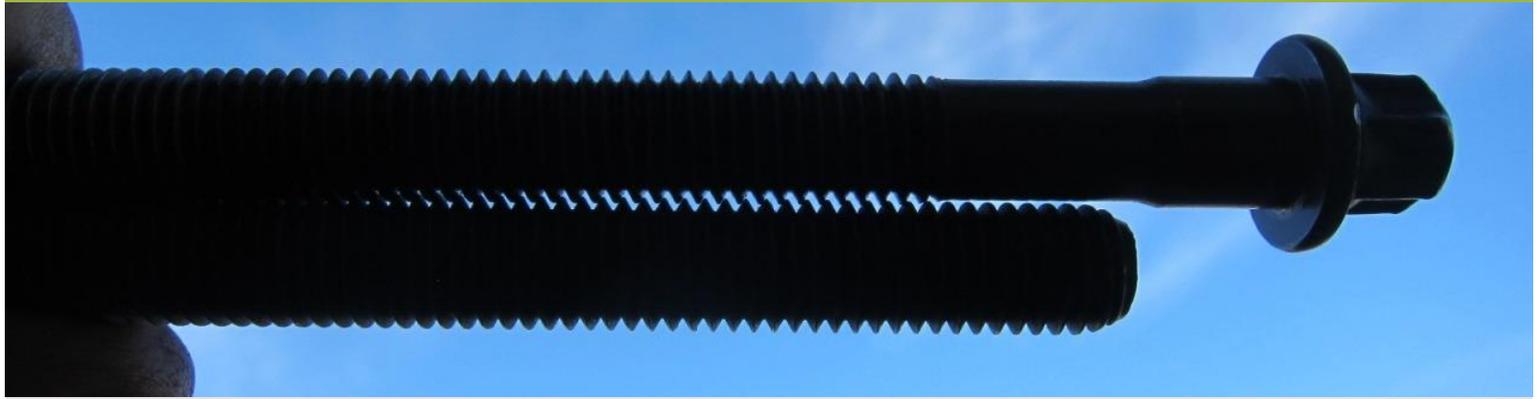
And for the same bolt size with stainless steel grade, the Ultimate Tensile Strength of a Bolt Diameter 2-1/2" – 8UN thread of A193/A320 Grade B8M, we'll obtain as:

$$\begin{aligned} S_{\text{tensile}} &= 75,000 \text{ psi} \times 4.44 \text{ in}^2 \\ &= 333,000 \text{ lbs} \end{aligned}$$



| Grade Marking   | Specification                                   | Material and Treatment                       | Nominal Size (In.)   | Mechanical Properties |                          |                            |                            |                          | Hardness  |              |
|---|---|--|--|-----------------------|--------------------------|----------------------------|----------------------------|--------------------------|--|--------------|
|   |   |  |  | Proof Load Min (ksi)  | Yield Strength Min (ksi) | Tensile Strength Min (ksi) | Elong % Min <sup>[9]</sup> | RA % Min <sup>[10]</sup> | Min  | Max          |
|                      | <a href="#">SAE J429 Grade 1</a>                | Low or Medium Carbon Steel                   | 1/4" - 1 1/2"  | 33                    | 36                       | 60                         | 18                         | 35                       | B70  | B100         |
|                      | <a href="#">A307 Grade A</a>                    | Low or Medium Carbon Steel                   | 1/4" - 4"  | -                     | -                        | 60                         | 18                         | -                        | B69  | B100         |
|                      | <a href="#">A307 Grade B</a>                    | Low or Medium Carbon Steel                   | 1/4" - 4"  | -                     | -                        | 60 min<br>100 max          | 18                         | -                        | B69  | B95          |
| <br>One End Green    | <a href="#">A307 Grade C</a> <sup>[7]</sup>     | Low or Medium Carbon Steel                   | 1/4" - 4"  | -                     | 36                       | 58 min<br>80 max           | 23                         | -                        | -  | -            |
| <br>One End Blue     | <a href="#">F1554 Grade 36</a>                  | Low or Medium Carbon Steel                   | 1/2" - 4"  | -                     | 36                       | 58 min<br>80 max           | 23                         | 40                       | -  | -            |
| <br>One End Yellow | <a href="#">F1554 Grade 55</a>                  | Low or Medium Carbon Steel                   | 1/2" - 2"<br>2 1/4" - 2 1/2"<br>2 3/4" - 3"<br>3 1/4" - 4" | -                     | 55                       | 75 min<br>95 max           | 21<br>21<br>21<br>21       | 30<br>30<br>30<br>30     | -  | -            |
|                    | <a href="#">SAE J429 Grade 2</a> <sup>[8]</sup> | Low or Medium Carbon Steel                   | 1/4" - 3/4"<br>7/8" - 1 1/2"                               | 55<br>33              | 57<br>36                 | 74<br>60                   | 18<br>18                   | 35                       | B80<br>B70   | B100<br>B100 |
|                    | <a href="#">A193/A320 Grade B8 Class 1</a>      | AISI SS304 Stainless                         | No Restrictions  | -                     | 30                       | 75                         | 30                         | 50                       | -  | B96          |
|                    | <a href="#">A193/A320 Grade B8M</a>             | AISI SS316 Stainless Steel                   | No Restrictions  | -                     | 30                       | 75                         | 30                         | 50                       | -  | B96          |
|                    | <a href="#">F3125 Grade A325 Type 1</a>         | Medium Carbon Steel, Q & T                   | 1/2" - 1 1/2"  | 85                    | 92                       | 120                        | 14                         | 35                       | C24  | C35          |
|                    | <a href="#">F3125 Grade A325 Type 3</a>         | Atmospheric Corrosion Resistant Steel, Q & T | 1/2" - 1 1/2"  | 85                    | 92                       | 120                        | 14                         | 35                       | C24  | C35          |
|                    | <a href="#">SAE J429 Grade 5</a>                | Medium Carbon Steel, Q & T                   | 1/4" - 1"<br>1 1/8" - 1 1/2"                               | 85<br>74              | 92<br>81                 | 120<br>105                 | 14                         | 35                       | C25<br>C19   | C34<br>C30   |

| Grade Marking   | Specification                                | Material and Treatment                       | Nominal Size (In.) | Mechanical Properties |                          |                            |                            |                          | Hardness <br>Rockwell |      |
|---|--|--|--------------------|-----------------------|--------------------------|----------------------------|----------------------------|--------------------------|--|------|
|   |  |  |                    | Proof Load Min (ksi)  | Yield Strength Min (ksi) | Tensile Strength Min (ksi) | Elong % Min <sup>[9]</sup> | RA % Min <sup>[10]</sup> | Min  | Max  |
|                 | <a href="#">A449 Type 1</a>                  | Medium Carbon Steel, Q & T                   | 1/4" - 1"          | 85                    | 92                       | 120                        | 14                         | 35                       | C25  | C34  |
|   |  |  | 1 1/8" - 1 1/2"    | 74                    | 81                       | 105                        |                            |                          | C19  | C30  |
|   |  |  | 1 5/8" - 3"        | 55                    | 58                       | 90                         |                            |                          | B91  | B100 |
|                 | <a href="#">A449 Type 3</a>                  | Weathering Steel, Q & T                      | 1/4" - 1"          | 85                    | 92                       | 120                        | 14                         | 35                       | C25  | C34  |
|   |  |  | 1 1/8" - 1 1/2"    | 74                    | 81                       | 105                        |                            |                          | C19  | C30  |
|   |  |  | 1 5/8" - 3"        | 55                    | 58                       | 90                         |                            |                          | B91  | B100 |
|                 | <a href="#">A193 Grade B7</a>                | Medium Carbon Alloy Steel, Q & T             | 1/4" - 2 1/2"      | -                     | 105                      | 125                        | 16                         | 50                       | -  | C35  |
|   |  |  | 2 5/8" - 4"        |                       | 95                       | 115                        | 16                         | 50                       | -  | C35  |
|   |  |  | 4 1/8" - 7"        |                       | 75                       | 100                        | 18                         | 50                       | -  | C35  |
|                 | <a href="#">A354 Grade BC</a>                | Medium Carbon Alloy Steel, Q & T             | 1/4" - 2 1/2"      | 105                   | 109                      | 125                        | 16                         | 50                       | C26  | C36  |
|   |  |  | 2 5/8" - 4"        | 95                    | 94                       | 115                        | 16                         | 45                       | C22  | C33  |
| <br>One End Red | <a href="#">F1554 Grade 105</a>              | Medium Carbon Alloy Steel, Q & T             | 1/2" - 3"          | -                     | 105                      | 125 min<br>150 max         | 15                         | 45                       | -  | -    |
|                | <a href="#">A320 Grade L7</a>                | AISI 4140, 4142, or 4145                     | 1/4" - 2 1/2"      | -                     | 105                      | 125                        | 16                         | 50                       | -  | -    |
|               | <a href="#">A320 Grade L43</a>               | AISI 4340                                    | 1/4" - 4"          | -                     | 105                      | 125                        | 16                         | 50                       | -  | -    |
|               | <a href="#">F3125 Grade A490 Type 1</a>      | Medium Carbon Alloy Steel, Q & T             | 1/2" - 1 1/2"      | 120                   | 130                      | 150 min<br>173 max         | 14                         | 40                       | C33  | C38  |
|               | <a href="#">F3125 Grade A490 Type 3</a>      | Atmospheric Corrosion Resistant Steel, Q & T | 1/2" - 1 1/2"      | 120                   | 130                      | 150 min<br>173 max         | 14                         | 40                       | C33  | C38  |
|               | <a href="#">SAE J429 Grade 8</a>             | Medium Carbon Alloy Steel, Q & T             | 1/4" - 1 1/2"      | 120                   | 130                      | 150                        | 12                         | 35                       | C33  | C39  |
|               | <a href="#">A354 Grade BD <sup>[6]</sup></a> | Medium Carbon Alloy Steel, Q & T             | 1/4" - 2 1/2"      | 120                   | 130                      | 150                        | 14                         | 40                       | C33  | C39  |
|   |  |  | 2 5/8" - 4"        | 105                   | 115                      | 140                        |                            |                          | C31  | C39  |



1. All specifications are ASTM unless otherwise noted.
2. All specifications shall be marked by the manufacturer with a unique identifier to identify the manufacturer or private label distributor, as appropriate.
3. Q & T - Quenched and Tempered.
4. Although markings are shown on hex heads, stamping is a requirement on one end of rods and studs. The exception is F1554 and A307 grade C in which stamping is a supplemental requirement while color coding is required.
5. Although markings are shown on hex heads, grade markings apply equally to products with other head configurations.
6. All Grade BD products shall be marked "BD". In addition to the "BD" marking, the product may be marked with 6 radial lines 60° apart.
7. ASTM A307 grade C has been [replaced by ASTM F1554 grade 36](#).
8. Grade 2 requirements for diameters ranging from 1/4" through 3/4" only apply to headed fasteners up to and including 6" in length, and to studs of all lengths. For headed fasteners longer than 6", see SAE J429 grade 1.
9. Percent Elongation
10. Percent Reduction of Area
11. In 2016, ASTM specifications A325 and A490 were officially withdrawn and replaced by F3125.

"-" = no requirement.

## Thread Pitch Chart

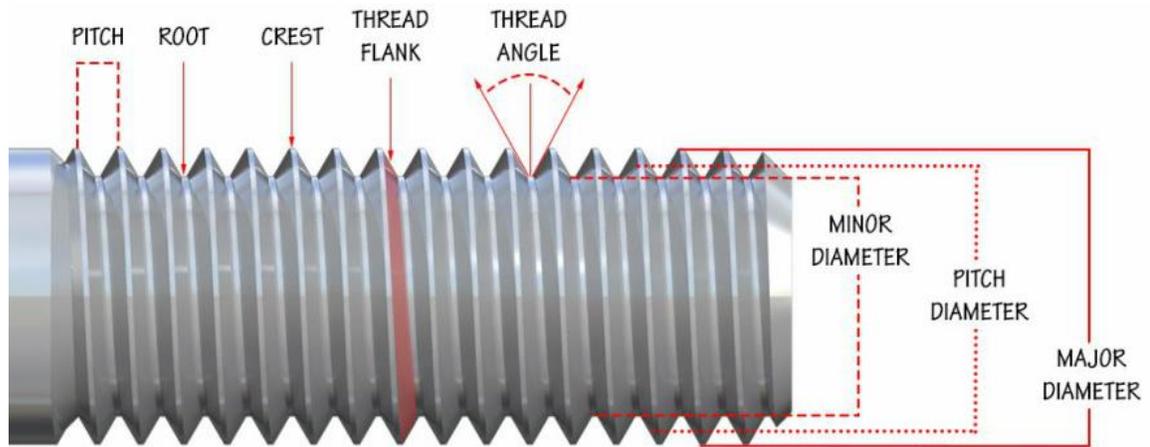
Thread series cover designations of diameter/pitch combinations that are measured by the number of threads per inch (TPI) applied to a single diameter.

**Coarse Thread Series (UNC/UNRC)** is the most common designation for general application bolts and nuts. Coarse thread is beneficial, because they are less likely to cross thread, more tolerant in adverse conditions and facilitate quick assembly.

**Fine Thread Series (UNF/UNRF)** is commonly used in precision applications. Because of the larger tensile stress areas, they have high tension strength. However, a longer engagement is required for fine thread applications than for coarse series threads to prevent stripping.

**8 – Thread Series (8UN)** is the specified thread forming method for several ASTM standards including A193 B7, A193 B8/B8M, and A320. This series is used for diameters one inch and above.





| Coarse Thread Series - UNC       |                  |                       |                     | Fine Thread Series - UNF         |                  |                       |                     | 8-Thread Series - 8UN            |                  |                       |                     |
|----------------------------------|------------------|-----------------------|---------------------|----------------------------------|------------------|-----------------------|---------------------|----------------------------------|------------------|-----------------------|---------------------|
| Nominal Size and Threads Per In. | Basic Pitch Dia. | Section at Minor Dia. | Tensile Stress Area | Nominal Size and Threads Per In. | Basic Pitch Dia. | Section at Minor Dia. | Tensile Stress Area | Nominal Size and Threads Per In. | Basic Pitch Dia. | Section at Minor Dia. | Tensile Stress Area |
|                                  | In.              | Sq In.                | Sq In.              |                                  | In.              | Sq In.                | Sq In.              |                                  | In.              | Sq In.                | Sq In.              |
| 3/8 - 16                         | 0.3344           | 0.0678                | 0.0775              | 3/8 - 24                         | 0.3479           | 0.0809                | 0.0878              | -- --                            | --               | --                    | --                  |
| 1/16 - 14                        | 0.3911           | 0.0933                | 0.1063              | 1/16 - 20                        | 0.4050           | 0.1090                | 0.1187              | -- --                            | --               | --                    | --                  |
| 1/2 - 13                         | 0.4500           | 0.1257                | 0.1419              | 1/2 - 20                         | 0.4675           | 0.1486                | 0.1599              | -- --                            | --               | --                    | --                  |
| 9/16 - 12                        | 0.5084           | 0.162                 | 0.182               | 9/16 - 18                        | 0.5264           | 0.189                 | 0.203               | -- --                            | --               | --                    | --                  |
| 5/8 - 11                         | 0.5660           | 0.202                 | 0.226               | 5/8 - 18                         | 0.5889           | 0.240                 | 0.256               | -- --                            | --               | --                    | --                  |
| 3/4 - 10                         | 0.6850           | 0.302                 | 0.334               | 3/4 - 16                         | 0.7094           | 0.351                 | 0.373               | -- --                            | --               | --                    | --                  |
| 7/8 - 9                          | 0.8028           | 0.419                 | 0.462               | 7/8 - 14                         | 0.8286           | 0.480                 | 0.509               | -- --                            | --               | --                    | --                  |
| 1 - 8                            | 0.9188           | 0.551                 | 0.606               | 1 - 12                           | 0.9459           | 0.625                 | 0.663               | 1 - 8                            | 0.9188           | 0.551                 | 0.606               |
| 1 1/8 - 7                        | 1.0322           | 0.693                 | 0.763               | 1 1/8 - 12                       | 1.0709           | 0.812                 | 0.856               | 1 1/8 - 8                        | 1.0438           | 0.726                 | 0.790               |
| 1 1/4 - 7                        | 1.1572           | 0.890                 | 0.969               | 1 1/4 - 12                       | 1.1959           | 1.024                 | 1.073               | 1 1/4 - 8                        | 1.1688           | 0.929                 | 1.000               |
| 1 3/8 - 6                        | 1.2667           | 1.054                 | 1.155               | 1 3/8 - 12                       | 1.3209           | 1.260                 | 1.315               | 1 3/8 - 8                        | 1.2938           | 1.155                 | 1.233               |
| 1 1/2 - 6                        | 1.3917           | 1.294                 | 1.405               | 1 1/2 - 12                       | 1.4459           | 1.521                 | 1.581               | 1 1/2 - 8                        | 1.4188           | 1.405                 | 1.492               |
| -- --                            | --               | --                    | --                  | -- --                            | --               | --                    | --                  | 1 5/8 - 8                        | 1.5438           | 1.68                  | 1.78                |
| 1 3/4 - 5                        | 1.6201           | 1.74                  | 1.90                | -- --                            | --               | --                    | --                  | 1 3/4 - 8                        | 1.6688           | 1.98                  | 2.06                |
| -- --                            | --               | --                    | --                  | -- --                            | --               | --                    | --                  | 1 7/8 - 8                        | 1.7938           | 2.30                  | 2.41                |
| 2 - 4 1/2                        | 1.8557           | 2.30                  | 2.50                | -- --                            | --               | --                    | --                  | 2 - 8                            | 1.9188           | 2.65                  | 2.77                |
| 2 1/4 - 4 1/2                    | 2.1057           | 3.02                  | 3.25                | -- --                            | --               | --                    | --                  | 2 1/4 - 8                        | 2.1688           | 3.42                  | 3.56                |
| 2 1/2 - 4                        | 2.3376           | 3.72                  | 4.00                | -- --                            | --               | --                    | --                  | 2 1/2 - 8                        | 2.4188           | 4.29                  | 4.44                |
| 2 3/4 - 4                        | 2.5876           | 4.62                  | 4.93                | -- --                            | --               | --                    | --                  | 2 3/4 - 8                        | 2.6688           | 5.26                  | 5.43                |
| 3 - 4                            | 2.8376           | 5.62                  | 5.97                | -- --                            | --               | --                    | --                  | 3 - 8                            | 2.9188           | 6.32                  | 6.51                |
| 3 1/4 - 4                        | 3.0876           | 6.72                  | 7.10                | -- --                            | --               | --                    | --                  | 3 1/4 - 8                        | 3.1688           | 7.49                  | 7.69                |
| 3 1/2 - 4                        | 3.3376           | 7.92                  | 8.33                | -- --                            | --               | --                    | --                  | 3 1/2 - 8                        | 3.4188           | 8.75                  | 8.96                |
| 3 3/4 - 4                        | 3.5876           | 9.21                  | 9.66                | -- --                            | --               | --                    | --                  | 3 3/4 - 8                        | 3.6688           | 10.11                 | 10.34               |
| 4 - 4                            | 3.8376           | 10.61                 | 11.08               | -- --                            | --               | --                    | --                  | 4 - 8                            | 3.9188           | 11.57                 | 11.81               |