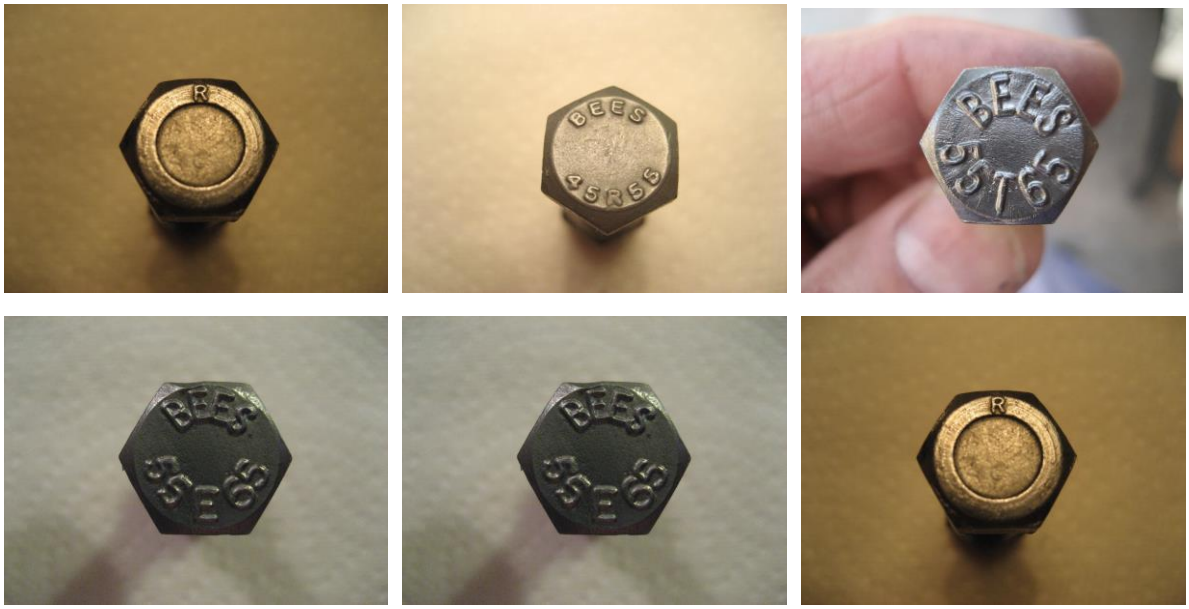
British Bolts, and Nuts - Letter Strength Ratings Decoded **DRAFT**

By Curt Arndt – Chairman, Austin Healey Concours Registry Committee - August 2015

Among the markings on the heads of British bolts, there may be a letter, a number or a number letter combination which denotes the strength rating of the bolt, e.g., "B", "S", "R", "45R55", "R 45-55", "45/55" or just "55".



Over the many years that I've been working around with British cars, I've often wondered how these British letter based strength ratings (B, R, S, T, etc.) compared to the traditional numbered strength rating grades of US bolts and nuts (Grades 2, 5 and 8). As I collected British bolts for my restorations, I also noticed that there were more than the typical B, R, S and T ratings that I was used to seeing marked on the heads of hex bolts. I even started to find letter ratings stamped on the flats of hex nuts, but these seemed to be somewhat rare. I set about researching various sources and I finally believe that I have come up with the most comprehensive understanding of these rating codes and how they apply to the basic engineering of our cars.

First let's discuss the types of steel used in fasteners.

Mild Steel

Any of a class of strong, tough, low-carbon steel, containing no more than 0.25 percent carbon and typically used for light duty bolts and screws and most nuts. Minimum ultimate tensile strength was 28tsi* (430MPa) as set out in British Standards of the period. Steel hexagon bolts and screws with no lettering or number markings are likely to be of this material. Grade letters are still attributed to these mild steels (in the UK): **A, B,** & **C**, for bolts and screws, and **K** for nuts.

*tsi is ton force per square inch (the British measurement of the period) and will be discussed in detail in the next section.

High Tensile Steel

Alloy steels that have been heat-treated to increase their strength. Accordingly, the Grade letters attributed to these high tensile steel fasteners prior to 1950 were: **D, E, F**, & **G** for bolts and screws. Some British vendors labeled even their bolts "**HT**" or sometimes "**HITENSILE**" with or without a letter rating. I have bolts in my collection labeled "NEWALL **HITENSILE R**" and "WODEN **H-T**".

US/SAE Grading Markings (Radial Lines)

In the USA, grading is by numbers, with the three most common Grades being 2, 5, & 8.

Mild steel, Grade 2 specifies minimum tensile strength of 74,000psi (33tsi [long]/510MPa). And as with British fasteners, there are no markings on the heads of Grade 2 (mild steel) bolts.

High tensile hex bolts or screws were marked with radial lines: 3 equally spaced lines (pointing to corners) for grade 5, and 6 lines (pointing to the 6 corners) for grade 8.

Grade 5 minimum tensile strength = 120,000psi (54tsi [long]/827MPa).

Grade 8 minimum tensile strength = 150,000psi (67tsi [long]/1035MPa).

US Grade 2
Mild Steel

US Grade 5
High Tensile Steel

US Grade 8
High Tensile Steel

<u>Standard Pressure Measurements & Definitions</u>

Strength ratings on bolts and nuts are measured in a number of ways. We will discuss these various systems for both British fasteners and how these equate to other measurement systems used throughout the world.

British fastener strength is typically measured in Ton-force per square inch (tsi), also denoted as Tons Tensile, while US fasteners are measured in Pounds per square inch. Other systems include the Megapascal and Newton per square millimeter.

Note: When we refer to tons with regard to British measurements, it is a "British" [long] ton which is equal to…

1 ton/square inch [long] = 2,240 pound/square inch, and not the US ton [short] of 2,000 pounds.

Below are some of the measurements referenced to bolt strength from a number of sources.

TSI - Ton-force per square inch (long UK) also referred to as <u>tons tensile</u> (**TT**) for British bolts.

PSI – Pounds per square inch, or more accurately pound force per square inch (lb_f/in^2). This is typically used to measure the strength of American fasteners.

MPa – Megapascal. A Pascal (Pa) is the SI (International System of Units) unit of pressure. 1 mega pascal (MPa) = 1,000,000 Pa.

N/mm^2 - Newton per square millimeter. *Note: 1 N/mm^2 = 1,000,000 pascal, so 1 MPa = 1 N/mm^2.*
So now that we know some of the measurement standards for steel… how is the information used? They are a measurement of **Yield Strength**, **Proof Load**, and **Tensile Strength**.

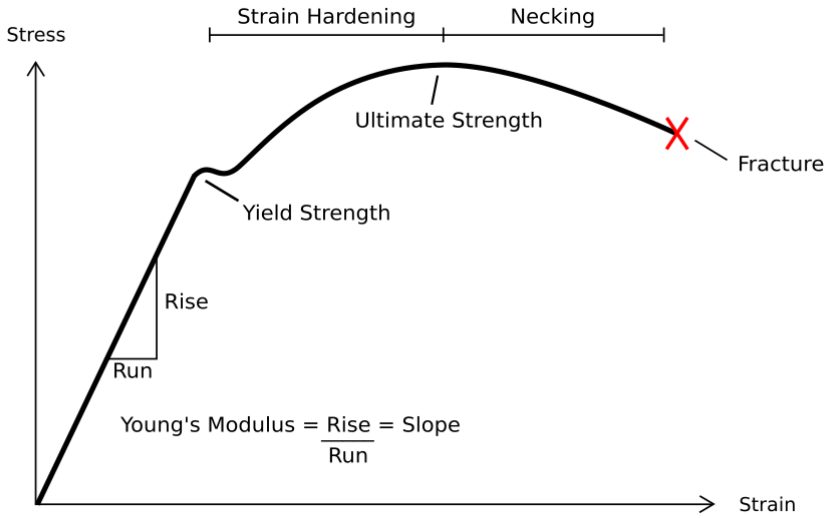
Yield Strength - The stress at which a material begins to deform plastically. Prior to the yield point the material will deform elastically and will return to its original shape when the applied stress is removed. Once the yield point is passed, some fraction of the deformation will be permanent and non-reversible. Also termed **Minimum Tensile Strength.**

Proof Load - The proof load of a nut is the axially applied load the nut must withstand without thread stripping or rupture. The proof load of a bolt, screw or stud is the specified load the product must withstand without permanent set.

Bolts that have exceeded both their Yield Strength and Ultimate Strength, and have begun "Necking" (see the graph below). These examples are 1/4 & 5/16 BSF Grade "B" (Mild steel). The example on the far left has indeed stretched permanently since this is as far as the nut will smoothly screw onto the threads.

Note: I have discussed with restorer's issues that they have had trying to figure out if a bolt was UNF or BSF. When I told them that the bolt in question was a BSF thread they stated that it couldn't be since a BSF nut would not thread on all the way. In reality the bolt had simply stretched slightly, having exceeded its Yield Strength.

Ultimate Tensile Strength (UTS), often shortened to Tensile Strength (TS) or Ultimate Strength – This is simply the maximum resistance to fracture, or more specifically he maximum load applied in breaking a tensile test piece divided by the original cross-sectional area of the test piece. Originally quoted as tons per square inch (tsi) or tons tensile (TT), it is now measured as newtons per square millimeter (N/mm^2) and/or pound (force) per square inch (lb_f/in^2 or psi). *Also termed Maximum Stress and Ultimate Tensile Stress.*



Brinell Hardness

Brinell hardness is determined by forcing a hard steel or carbide sphere of a specified diameter under a specified load into the surface of a material and measuring the diameter of the indentation left after the test. The Brinell hardness number, or simply the Brinell number, is obtained by dividing the load used, in kilograms, by the actual surface area of the indentation, in square millimeters. The result is a pressure measurement, but the units are rarely stated and provided here just for reference, since they are quoted in some charts.

British Bolt Grade Markings (Letters)

So as stated earlier, along with the markings that identify the manufacturer, most British fasteners have markings on them to indicate the strength grade. In the UK prior to 1950, this letter grading system went from **A** to **G**, with markings required on bolts/screws for grades from **D** upwards, and the letter **K** reserved for nuts. The "K" referenced Grade for nuts are not listed anywhere else that I could find, and I've never seen a nut marked with this letter.

However, by the early 1950s, this system had changed, plus some new intermediate ratings were added…

Old grades **A**, **B** & **C** remained as before for mild steel, and the **K** rating for nuts now became **P**.

Old grades **D, E**, **F** & **G** were eliminated and now became new grades **R**, S, **T**, U**, V**, W, & **X** etc., for high tensile steel respectively, therefore…

Old grade **D** became new grade **R** and equates to numbered strength rating of 45/55tsi*;
…new grade **S** was created = 50/60 tsi & there is no equivalent old letter grade;

Old grade **E** became new grade **T** = 55/65 tsi.
…new grade **U** was created = 60/70 tsi & there is no equivalent old letter grade;

Old grade **F** became new grade **V** = 65/75 tsi.
…new grade **W** was created = 70/80 tsi & there is no equivalent old letter grade;

Old grade **G** became new grade **X** = 75/85 tsi.

*tsi is ton force per square inch (the British measurement of the period) and will be discussed in detail in the next section.

This grading system applied to the new at the time Unified fasteners (UNF & UNC) stocked in the UK as well as Whitworth thread form fasteners (BSW, BSF, BSP, etc.)

Conversion Chart

26 ton/square inch [long] =	58,240 pound/square inch ≈	400 N/mm² =	400 megapascal
28 ton/square inch [long] =	62,720 pound/square inch ≈	430 N/mm² =	430 megapascal
	> 74K psi, US/SAE Grade 2		
35 ton/square inch [long] =	78,400 pound/square inch ≈	540 N/mm² =	540 megapascal
40 ton/square inch [long] =	89,600 pound/square inch ≈	625 N/mm² =	625 megapascal
45 ton/square inch [long] =	100,800 pound/square inch ≈	700 N/mm² =	700 megapascal
50 ton/square inch [long] =	112,000 pound/square inch ≈	775 N/mm² =	775 megapascal
	> 120K psi, US/SAE Grade 5		
55 ton/square inch [long] =	123,200 pound/square inch ≈	850 N/mm² =	850 megapascal
60 ton/square inch [long] =	134,400 pound/square inch ≈	925 N/mm² =	925 megapascal
65 ton/square inch [long] =	145,600 pound/square inch ≈	1,000 N/mm² =	1,000 megapascal
	> 150K psi, US/SAE Grade 8		

70 ton/square inch [long] = 156,800 pound/square inch ≈ 1,075 N/mm² = 1,075 megapascal
75 ton/square inch [long] = 168,000 pound/square inch ≈ 1,150 N/mm² = 1,150 megapascal
80 ton/square inch [long] = 179,200 pound/square inch ≈ 1,225 N/mm² = 1,225 megapascal
85 ton/square inch [long] = 190,400 pound/square inch ≈ 1,310 N/mm² = 1,310 Megapascal

A handy online pressure conversion calculator may be found at…
http://www.onlineconversion.com/pressure.htm

Therefore, as a quick reference…

Letter ratings of **W** or **X** fall solidly above the US/SAE Grade 8 range.

A letter rating of **V** is slightly below US/SAE Grade 8 range.

Letter ratings of **U** and **T** are slightly above US/SAE Grade 5 range.

Letter ratings of **R** and **S** are slightly below US/SAE Grade 5 range.

A letter rating of **B** or unmarked are solidly in the mild steel US/SAE Grade 2 range.

So given the fact that most bolts on Austin Healeys and other British cars are either an R (1953 to 1963) or a S (1964 on) rating, then most Austin Healey fasteners are below a US/SAE Grade 5.

The Old British Strength Rating Letter Codes, pre 1950

I have good evidence to support most of the letter strength rating codes from actual bolt heads, from engineering charts and technical references as well as the "British Standards", where I could access them. However, some are calculated assumptions since I do not have actual fasteners or reference material. I would appreciate any insight from those knowledgeable individuals who may be able to fill in the gaps.

Most British bolts referenced show a Grade listing a letter, which corresponds to two numbers, e.g., Grade "**D**" = **45**/**55**tsi. Given the comparisons with US graded fasteners, the first number, in this case 45, is the Yield Strength and the second number, 55 is the Ultimate Tensile Strength.

Mild Steel

A – **26-28 TONS TENSILE (TONS / INCH² or TSI),** I've never seen a bolt with this rating in 40 years of working on British cars, however I have seen it listed on several tables of bolt strength ratings referencing both the 26 and 28 TT rating. This is most likely because markings for mild steel bolts of Grades A, B, & C were not required. There are a number of bolts in low stress applications that have no strength rating letter, and therefore we may assume them to be mild steel.

A BSF Grade "A" or "B" Bolt with the "NEWTON" vendor name.

B – **28/35 TONS TENSILE**, This should equate to the newer Grade P and as such my research shows that it had a strength rating in the 35 TT range. The ⅜" Bolts that hold the bumper brackets to the frame on my BN1 are this rating and I've seen them in many other low stress applications.

The 5/16" bolts that hold my air cleaners to the carburetors on my BN1 are also a "B" rating with the "WODEN" vendor name. The ¼" "Speed Nut" bolts that hold the wings to the shrouds are also Grade "B" and have both the "SA" and "WILEY" vendor names. I have seen a bolt labeled "RUBERY OWEN B28-35" in my collection. These bolts were and should be used in low stress applications only as it is also quite easy to exceed their "Yield Strength" (See photo above).

C - Unknown, but should be equivalent to Grade Q which I suspect may have a range UTS of 35/45 or more likely 40/50 TT.

High Tensile Steel

D - 45/55 TONS TENSILE, This is the same as the later R rating. I have several bolts in my collection labeled "BEES 45D55."

E - 55/65 TONS TENSILE, this is the same as the later T rating. I have a bolt in my collection, most likely from an older Jaguar, labeled "BEES 55E65."

F - Unknown, as I have no charts referencing this rating, however I suspect given my research that this is the same as the V rating of 65/75 TT. I have a ¼" bolt in my collection with the MARWIN vendor name and the "F" rating.

Actual photo TBD

G – **75/85 TONS TENSILE,** this is the same as the later “X” rating. I have a bolt in my collection, most likely from an older Jaguar, labeled "BEES 75G85."

Actual photo TBD

The New British Strength Rating Letter Codes, post 1950

Mild Steel

P - 35 TONS TENSILE, this seems to fit the pattern and this is referenced somewhere in my research but I don't have any examples on bolt heads, and I believe that this rating is for nuts only. This supposedly replaced the old “K” rating for nuts but I have very little evidence to support this assumption. I would suspect that this SHOULD be a 35/45 strength rating. Although I've also never seen a "P" rating labeled on any bolt… this marking is sometimes found on the flats of British hex nuts.

Q - Unknown (40/50 TT as per the information below), however I have never seen a British bolt or nut marked with this rating code.

**However I have a chart referencing this grade that indicates a…*
UTS (Ultimate Tensile Strength) of 625 to 775 N/mm² *and a “Brinell” Hardness of 179 to 229 - minimum and maximum for this rating.*
625 N/mm² ≈ **40** ton/square inch [long] = 89,600 pound/square inch
775 N/mm² ≈ **50** ton/square inch [long] = 112,000 pound/square inch

High Tensile Steel

R - 45/55 TONS TENSILE, the most common rating code for fasteners on my 1955 Austin Healey 100 (BN1) and seems so be the predominant rating code on a lot period cars through the end of the 1950s and into the early 1960s. I have plenty of bolts labeled "BEES 45R55." According to Phillip Brown, the original owner at British Tools & Fasteners, this is roughly equal (but less) than a U.S. Grade 5, and is confirmed from many other sources. Some hex nuts were also labeled “R” on one flat, or in rare cases on the face as in the third photo below.

**Again the same chart references this grade and indicates a…*
UTS of 700 to 850 N/mm² *and a “Brinell” Hardness of 201 to 255.*
700 N/mm² ≈ **45** ton/square inch [long] = 100,800pound/square inch
850 N/mm² ≈ **55** ton/square inch [long] = 123,200 pound/square inch




S - **50/60 TONS TENSILE**, the S rating appears to have replaced the R rating after 1960 and as you can see it's slightly stronger. I have a bolt in my collection labeled "RUBERY OWEN S5060." Later Austin Healeys (BJ8s) predominately had “S” rated fasteners versus the “R” rated ones on early cars.

**Again the same chart references this grade and indicates a…*
UTS of 775 to 925 N/mm² *and a “Brinell” Hardness of 223 to 277.*
775 N/mm² ≈ **50**.ton/square inch [long] = 112,000 pound/square inch
925 N/mm² ≈ **60** ton/square inch [long] = 134,400 pound/square inch

T - **55/65 TONS TENSILE**, I have bolts in my collection labeled "BEES 55T65."

**Again the same chart references this grade and indicates a…*
UTS of 850 to 1000N/mm² *and a “Brinell” Hardness of 248 to 302.*
850 N/mm² ≈ **55** ton/square inch [long] = 123,200 pound/square inch
1,000 N/mm² ≈ **65** ton/square inch [long] = 145,600 pound/square inch

U - I have a bolt in my collection labeled “NEWTON U.” The question I now have is… does the “U” rating correspond to a 60/70 TONS TENSILE strength? It would seem to fit the overall pattern, however to date; there is no reference that I could find, and there are no bolts marked with the both the “U” and the corresponding number ratings.

V - **65/75 TONS TENSILE**, once again, I have many examples labeled "BEES 65V75."

W - **Unknown**, (I would assume 70/80 TT?) I have found several - 5/16 inch bolts with the "AUTO" vendor name with this rating (Austin Healey Sprite gearbox). Given the letters sequences, and the other strength ratings as a reference, I would guess, SWAG (Scientific Wild Assed Guess) the rating to be 70/80 TONS TENSILE.

X - **75/85 TONS TENSILE**, I have several bolts in my collection labeled WILEY X, APN X and BEES 75X85. To my knowledge, this strength rating was used on Jaguars but not Austin Healeys.

Actual photo TBD

Torque Specifications for British Bolts

Now, how do we as restores make use of this information? Very simply, if we know that the typical flywheel bolt is a Grade "T" with the "WILEY" vendor name, then we should know that we would not want to substitute the same sized "WILEY" bolt with a "B" rating or, worse yet, no marking at all, as it would be mild steel. Also if we cannot find a British Grade "T" bolt, we also know to use a

proper grade new bolt, e.g., a Grade 8 SAE bolt. Better yet is to also know the proper torque for each bolt rating so that we do not exceed its Yield Strength.

Below is a standard chart with torque (Q) specifications for Whitworth Steel Bolts (coarse threads so therefore BSW). However, since this chart is for coarse fasteners, it is not applicable to British Standard Fine (BSF) bolts which is what you will find on most early Austin Healeys, BN1/2s. What is nice about this chart is that it gives equivalent psi ratings for the various British letter strength grades.

Whitworth Steel Bolts Torque Specifications					
Bolt Size Inches	Coarse Threads Per Inch	Standard Dry Torque in Foot-Pounds			
		Grades A & B 62,720 psi Med Carbon Steel	Grade S 112,000 psi Med Carbon Steel	Grade T 123,200 psi Med Carbon Steel	Grade V 145,600 psi Med Carbon Steel
1/4	20	5	7	9	10
5/16	18	9	15	18	21
3/8	16	15	27	31	36
7/16	14	24	43	51	58
1/2	12	36	64	79	89
9/16	12	52	94	111	128
5/8	11	73	128	155	175
3/4	11	118	213	259	287
7/8	9	186	322	407	459
1	8	276	497	611	693

This series of Torque setting charts below gives a much better reference to the various British types, both Whitworth and Unified in the various grades, i.e., “A”, “P”/“B”, “R”/ “D”, “S”, “T”/“E”, and ”X”/G”. Interestingly, there are no charts for either the “U”, “V”, or “W” strength ratings. http://www.jag-lovers.org/xk-lovers/library/torque.htm

Torque Settings for Steel Fasteners

Grade "A"				
Diameter of thread	BSW	BSF	UNC	UNF
1/4"	3.6	4	3.6	4
5/16"	7.4	7.9	7.4	8.2
3/8"	13	14	13	15
7/16"	21	23	21	23
1/2"	31	34	32	36
9/16"	46	50	46	52

5/8"	64	66	64	72
3/4"	113	118	114	126
7/8"	181	191	183	201
1"	272	288	274	299
1 1/8"	367	411	389	434
All measurements are in ft-lbs				
To convert to Nm multiply by 0.1386				

Grade "B" or "P"				
Diameter of thread	BSW	BSF	UNC	UNF
1/4"	5.3	5.9	5.3	6
5/16"	11	12	11	12
3/8"	19	21	19	22
7/16"	31	33	31	34
1/2"	46	50	47	53
9/16"	68	73	68	76
5/8"	93	100	94	106
3/4"	166	173	167	185
7/8"	266	280	269	295
1"	400	422	402	438
1 1/8"	567	602	570	637

Grade "R" or "D"				
Diameter of thread	BSW	BSF	UNC	UNF
1/4"	8.2	9.1	8.2	9.3
5/16"	17	18	17	19
3/8"	30	32	30	34
7/16"	48	51	48	53
1/2"	70	77	73	82
9/16"	104	113	105	117
5/8"	144	154	145	164
3/4"	256	268	256	286
7/8"	411	433	415	456
1"	617	652	621	678
1 1/8"	876	931	881	964

Grade "S"

Diameter of thread	BSW	BSF	UNC	UNF
1/4"	9.1	9.1	10	10
5/16"	19	19	20	21
3/8"	33	33	36	36
7/16"	53	53	58	60
1/2"	79	82	85	91
9/16"	117	117	126	131
5/8"	161	162	172	183
3/4"	286	288	300	319
7/8"	460	464	464	510
1"	690	695	729	757
1 1/8"	979	985	1041	1100

Grade "T" or "E"				
Diameter of thread	BSW	BSF	UNC	UNF
1/4"	11	12	11	12
5/16"	22	23	22	24
3/8"	38	41	39	44
7/16"	62	67	62	69
1/2"	91	100	94	106
9/16"	135	146	137	152
5/8"	187	200	188	212
3/4"	331	347	333	370
7/8"	532	580	537	590
1"	799	844	804	877
1 1/8"	1134	1205	1140	1273

Grade "X" or “G”				
Diameter of thread	BSW	BSF	UNC	UNF
1/4"	15	17	15	17
5/16"	31	33	31	34
3/8"	55	59	55	63
7/16"	88	95	89	99
1/2"	130	143	135	152
9/16"	194	210	195	217
5/8"	267	286	269	304
3/4"	474	497	477	529
7/8"	762	802	769	845

1"	1144	1208	1152	1255
1 1/8"	1624	1725	1632	1823

Below is an excerpt from British Standards 5.2 which also references the "X" strength rating code. Also note that Grades "S", "U", and "W" are not listed. I have to assume that these afore mentioned ratings were for the later Unified threads.

Table 5.2 British Standards (BS 1083, BS 1768) (BSW and BSF Threads)

Code Symbol	Minimum Tensile Strength
A	26 t.s.i.
B	28 t.s.i.
P	35 t.s.i.
R	45 t.s.i.
T	55 t.s.i.
V	65 t.s.i.
X	75 t.s.i.