



Service

Article #4

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# “Cylinder Head Studs”

by Tony Cripps.

## 1. Introduction

One may not think that cylinder head studs would wear out, but they do. Prolonged periods under tension and at high temperature results in creep on a microscopic scale and the original strength rating may become reduced, not to mention loss of tension which may result in a leaking head gasket. In this article we examine what can be done about this problem.

## 2. Head Studs (Mini Range)

An examination of various Service Parts Lists shows a number of head studs in use<sup>1</sup>.

|                                | Head Stud Part No. (S,L)  |                  | Strength Grade   |
|--------------------------------|---|------------------|------------------|
| HYL2980<br>PUB1011M<br>PUB1052 | 51K256, 51K254 <sup>2</sup> (6), 51K255<br>AYA175, AYA174 (bolts) | All<br>1098 Mini | T<br>SAE Grade 8 |
| PUB1011M<br>PUB1052            | 51K276, 51K275<br>51K276, 51K277                                  | 12Y<br>1275      | W<br>W           |
| PUB1056M<br>PUB1029            | 51K276, 51K277  | All              | W                |
| PUB7                           | 51K280 (short)  | 1275             | X                |
| PUB23<br>PUB27                 | CAM151, CAM150 <sup>3</sup>                                       | All              | EN24 - Y         |

**Table 1** Summary of Head Studs, Mini range

## 3. Strength Grades

The steel specified for head studs, as well as manifold and rocker pedestal studs, is governed by standards, usually a letter that denotes the tensile strength, that is, the maximum tensile stress that a stud may withstand without breaking. In the metric system, stress in materials is usually measured in MPa, or sometimes GPa. In the imperial system, we may see stress expressed in units tfsi (or tons force per square inch).

<sup>1</sup> The A series Mini engine used head studs and nuts, although there was a period in which bolts were used to due shortages of supply of studs.

<sup>2</sup> In 1964 this stud (of which one only is used and sourced locally rather than in the CKD pack) was found to be below specification. Dealers were advised to replace with 51K256.

<sup>3</sup> These improved studs have a conical projection on the nut end with no dimple and were introduced in 1977.

The table below shows the strength rating for those grades of interest. Also shown are the specification for hardness of which we shall discuss further.

|                  | <b>Grade T</b>           | <b>Grade W</b>           | <b>Grade X</b>           | <b>EN24-Y</b> |
|------------------|--------------------------|--------------------------|--------------------------|---------------|
| Tensile Strength | 55 tfsi (850 MPa)        | 70 tfsi (1080 MPa)       | 75 tfsi (1160 MPa)       | 1225-1375 MPa |
| Hardness         | 248-302 BHN<br>25-30 HRC | 311-375 BHN<br>33-41 HRC | 345-401 BHN<br>38-43 HRC | 363-429 BHN   |

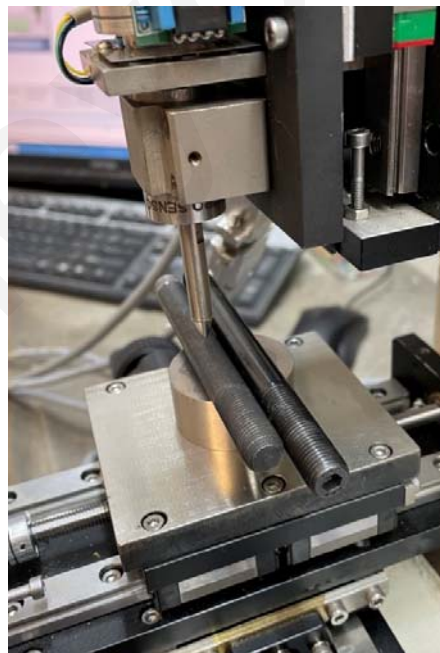
**Table 2.** Book value properties of Grade T, W and X steels. (<https://www.steelexpress.co.uk/steel-hardness-conversion.html>)

## 4. Hardness

Testing specimens in a tensile testing machine to determine their strength is somewhat cumbersome. There is a more convenient way to measure the strength properties of steel and that is by measuring its hardness. The hardness steel is about a factor of three times the yield stress, which is in turn related to the tensile strength.

Hardness is also measured in MPa or GPa, but historically, is measured on an industrial scale such as Brinell, Rockwell, Vickers, Shore, etc depending on the type of measuring instrument used. Broadly speaking, a hardness tester uses a precisely shaped “indenter” which is forced into the surface of the specimen and the resulting impression measured along with the load applied. More modern hardness testing instruments measure the depth of penetration of the indenter rather than the size of the impression.

So, by measuring the hardness of a head stud, we can get some idea of the yield strength of the stud which in practice, determines the capacity of the stud to withstand tension from combustion and also the tightening torque that is to be applied.



**Fig. 1** Hardness test measurement

To measure the hardness, a stud is indented in the prescribed manner and the hardness, and also (in the case of an instrumented indentation technique), the elastic modulus is calculated from the measurements.

## 5. Results

In this article, two different types of studs are of interest. Those sold by present-day Mini parts suppliers as unbranded items, usually finished in black, for “standard” use; and higher specified products such as those branded ARP, for high performance use. These studs were tested and their hardness and also the elastic modulus measured.

The elastic modulus is not affected by the tensile strength or the hardness and so we would expect any steel of much the same composition to have the same elastic modulus.

The results were:

Elastic modulus (for both studs) about 220 GPa (which is close to book value of 210 GPa). This result also confirms that the measuring instrument was correctly calibrated.

Standard Stud: 20 HRC.

ARP stud: 40 HRC.

This means that “standard studs” measured some 20% lower than the low end of specification for the lowest specified head stud (Grade T: 25-30 HRC). The ARP ones are measuring to grade W specification and probably even meet grade X specifications (Grade X: 38-43).

Although a higher hardness indicates a higher yield strength, high hardness also leads to a greater chance of brittle fracture. As a material becomes harder, it becomes more brittle, and so head studs are designed to have the highest yield strength possible without being too brittle.

It can be seen from the Table above that BMC increased the specifications of the head studs over the years for the Mini range from Grade T in the 1950s to Grade W and X in the 1970s and then further to Type Y in 1977.

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