Report on
Junker Vibration Tests
on a
BAMAC M8 Thread

Report completed for
BAMAC S.A.

Report completed by:
William Eccles CEng BSc MI MechE
Bolt Science Limited
(www.boltscience.com)
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Abstract and Introduction

A series of tests have been performed using a Junker vibration test machine on a modified M* thread designed to resist vibration loosening. In total, tests on five such threads were completed.

The tests involved measuring the clamp force provided by the bolt as a transverse displacement is imposed on the plate supporting the screw head. The results of the tests are presented in a graphical format, the clamp force is plotted against the test cycles. Such preload decay curves are a standard way of assessing a fastener’s (or fasteners’ in this case) loosening resistance.

The most influential paper on the subject to-date was published by Gerhard H. Junker in 1969 in which he reports on a theory he developed as to why fasteners self-loosen under vibratory loading. Junker found that transverse dynamic loads generate a far more severe condition for self-loosening than dynamic axial loads. The reason for this is that radial movement under axial loads is significantly smaller than that which is sustained under transverse loading. Junker showed that preloaded fasteners self-loosen when relative movement occurs between the mating threads and the fastener bearing surface. Such relative movement will occur when the transverse force acting on the joint is larger than the frictional resisting force generated by the bolt’s preload. For small transverse displacements, relative motion can occur between the thread flanks and bearing area contact surface. Once the thread clearances are overcome the bolt will be subject to bending forces, and if the transverse slippage continues slippage of the bolt head bearing surface will occur. Once this is initiated the thread and the bolt head will be momentarily free from friction. The internal off torque, present as a result of the preload acting on the thread helix angle, generates a relative rotation between the nut and the bolt. Under repeated transverse movements this mechanism can completely loosen fasteners. The machine used this series of tests was based upon Junker’s work.

It was initially difficult to unwind the nut from the bolt following the test. Following information provided by BAMAC, if, following the test the nut is tightened slightly more and a pin inserted in gap between the two threads, the nut could be removed. The conclusions that may be drawn from the tests are:

1. At the vibration levels tested, the BAMAC thread design resists self loosening. No nut rotation was noted during the tests.
2. A reasonably high settlement loss was observed on these tests. It is thought that the reason for this was that the socket head cap screw had a relatively small head size. The transverse movement rocked the head on the adapter in the machine resulting in a higher amount of settlement than would normally be anticipated.

A video of one of the tests was completed.

**Test Arrangement**

A diagram of the test arrangement is shown in Figure 2. The test machine consists of a fixed lower base and an upper moving section separated from the lower base by needle roller bearings. The bearings are used to eliminate friction between the two parts of the machine so that any transverse loading is sustained solely by the test fastener that secures the two sections together. A load cell is fitted in the lower base to allow the fastener preload to be continuously monitored during the test. The output from the load cell is fed, via a load cell transmitter, into an analogue to digital converter that is subsequently connected to a computer. The computer logs the preload values continuously during the test allowing graphs of preload versus number of cycles to be produced. Such graphs are often referred to as preload decay curves.

The test machine produces a relative movement between the upper and lower section (cross movement) of ± 0.65 mm. The test frequency was 12.5 Hz. The duration of the test can be varied but typically a test of 1000 cycle duration is used. All the tests conducted in this series of tests lasted at least 1000 cycles.

All the tests were completed using socket head cap screws, with a new screw and nut being used for each test. The parts were tested as-received i.e. there were trace amounts of oil present on the parts. The screws were tightened to a nominal preload of 10 kN.

![Figure 2 – Test Arrangement](image-url)
Test Results

The test results are presented in a series of graphs (graphs 1 to 7 on the following pages). No rotational movement of the nut was noted during the tests on the BAMAC thread. The loss in preload was due to settlement. Rotational movement of the standard thread and nut was noted.

The graphs plot filtered results (averaged over the test cycle). An unfiltered graph for test 1 is shown below in figure 3. As the locking mechanism is resisting loosening as transverse movement occurs, the bolt bends rather than loosening of the nut occurring. This bending changes the preload being measured by the load cell in the machine and hence the fluctuation on the graph. It is normal practice to show filtered results for the purposes of clarity.

![Figure 3 Unfiltered test results for test 1](image-url)
Graph 1 – Preload Decay Curve for Test 1
Graph 2 – Preload Decay Curve for Test 2
Graph 3 – Preload Decay Curve for Test 3
Graph 4 – Preload Decay Curve for Test 4
Graph 5 – Preload Decay Curve for Test 5
Graph 6 – Preload Decay Curves for all five tests
Graph 7 – Preload Decay Curve for Plain Thread with no Locking
Discussion and Conclusions

It was initially difficult to unwind the nut from the bolt following the test. Following information provided by BAMAC, if following the test the nut is tightened slightly more and a pin inserted in gap between the two threads, the nut could be removed.

The conclusions that may be drawn from the tests are:

3. At the vibration levels tested, the BAMAC thread design resists self loosening. No nut rotation was noted during the tests.
4. A reasonably high settlement loss was observed on these tests. It is thought that the reason for this was that the socket head cap screw had a relatively small head size. The transverse movement rocked the head on the adapter in the machine resulting in a higher amount of settlement than would normally be anticipated.

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