17th August 2017

Mr Peter Hobson
CEO Hobson Engineering
10 Clay Place
Eastern Creek NSW 2766

Dear Mr Hobson,

Re: Expert opinion on AS/NZS1252.2:2016 Verification Testing

This letter of opinion is made in response to a request from Mr Peter Hobson, CEO of Hobson Engineering.

Background:

A revision to AS/NZS1252 was made by the ME-029 standards committee with the involvement and feedback from the industry and released in December 2016 in two parts: "High-strength Steel Fastener Assemblies for Structural Engineering-Bolts, nuts and washers, Part 1: Technical Requirements; and Part 2:Verification Testing for bolt assemblies (AS/NZS1252.1 & AS/NZS1252.2:2016)". Swinburne University of Technology was a representative on the standard committee.

Conformity and verification:

While AS/NZS1252.1 Section 6: Identification certification and testing establishes the testing requirements, normative Appendix B establishes the complete product conformity assessment requirements. Therefore, if a product is manufactured to AS/NZS1252.1:2016 it is a conforming product as per the standard. This indicates that AS/NZS1252.1 is essentially equal to standards such as EN14399-3 and entirely establishes the product conformity requirements and assessment.

If the product does not have a successfully completed and verified conformity assessment conducted in accordance with AS/NZS1252.1:2016, then it is not a conforming product. It is our understanding that AS/NZS1252.2 verification testing is introduced in order to have further safeguard against a potential failure in the field. This verification testing totally relies on the product conforming to AS/NZS1252.1 where the conformity assessment completed in accordance with the guidelines of ISO16426: Fasteners-Quality assurance systems and ISO3269-Fasteners-Acceptance Inspection.

It should be clearly noted that AS/NZS1252.2 is not a conformity assessment standard and is only meant for verification of already assessed conformity and cannot stand on its own, whereas AS1252.1 could stand on its own similar to EN14399-3. Due to some misunderstanding and/or miscommunication, verification-testing requirements given in AS/NZS1252.2 Tables 2.1 and 2.2 are quite arduous and not fully justifiable, if the expense has already been made in procuring a fully verified conforming product from a reputable manufacturer.

Need to amend AS/NZS1252.2:2016

In light of feedback on commercial viability and technical standing of the current AS/NZ1252:2016, a rushed amendment to AS/NZS1252.2 was requested in early 2017. In this amendment; relaxing the dimensional testing requirements, removal of surface integrity non-destructive test

Faculty of Science, Engineering and Technology

PO Box 218 Hawthorn
Victoria 3122 Australia

T: +61 3 9214 5915
F: +61 3 9214 5916

swinburne.edu.au

requirements and a reduction of sample size from 8 to 3 for nut and washer hardness and a reduction of sample size from 3 to 1 for the assembly test were requested. This amendment was partially opposed by the committee and currently under review with respect to technical justification and commercial viability.

Based on our expertise in steel design as well as fastener engineering and fastening, except for the reduction in number of samples for assembly tests the requested amendment mentioned above can be justified as follows:

- Fact 1: The product is a conforming product to AS/NZ1252.1 with an independently verifiable paper trail (A necessary requirement for AS/NZ1252.2 verification testing).
- Fact 2: Fastener Acceptance Inspection in accordance with ISO 3269 has already been conducted on the fastener assembly manufactured in accordance with a manufacturing system similar to ISO16426.
- Fact 3: Assembly test simulates actual assembly and extreme potential design loading experienced by the fastener assembly in its design life. Therefore, this test entirely establishes the capability of the assembly in providing ultimate design loading and ductility requirements assumed in the design.
- Fact 4a: It is prudent to establish a "Fit for purpose" for the product (as tested in the assembly test for pre-loading in AS/NZ1252.1) in order to avoid any failures in applications when handled and assembled correctly. According to ISO16426 a defective product is defined as a product that is not fit for purpose. If the non-conformance does not influence the product's expected performance, a non-conforming product is not necessarily a defective product.
- Fact 4b. In the scope of AS/NZ1252:2016 it is stated that the bolt assemblies are fully intended to be pre-loaded which will be the determining "Fit for purpose" criteria. However, it should be noted that the "Fit for purpose" as tested in the Assembly test might not be the fit for purpose requirement if the bolts are strictly used for non-preloading applications. It was a decision made by the industry and the standard committee that it is not viable to carry two standards in Australia due to market size (for example in Europe, EN14399 is for pre-loaded applications and EN15048 is for non-preloaded applications). Therefore, "Fit for purpose" as tested in the Assembly test will be the only determining "Fit for purpose" criteria for AS/NZ1252:2016, irrespective of whether the product is used for pre-loaded applications or not.
- Fact 5: Any critical surface integrity defect would cause the assembly to fail in the assembly test.
- Fact 6: Any critical hardness defect of the nut would cause the assembly to fail in the assembly test by thread stripping before reaching the necessary tensile capacity and/or damage to nut surface during assembly.
- Fact 7: Any critical hardness defect of the washer would cause the assembly to fail in the assembly test as it would cause a bearing failure on the washer surface. However, as the assembly test only simulates a circular hole and the product can be used with slotted holes, we believe this is not adequate justification for the verification of function of the washer.

Since the assembly test essentially establishes all critical characteristics of a pre-loaded assembly, failing this test makes it a defective product. Based on the above facts, it is our opinion that the proposed amendment (except for reduction in sample size proposed for the assembly test) does not reduce the safety of the product compared to current AS/NZ1252.2:2016 test regime.

Defective vs non-conforming product:

It is important to understand the difference between a non-conforming product and a defective product. Fit for purpose is assessed by the ability of the product to provide desired performance. In case of a fastener assembly, assembly test performs this task. However, this test is an elaborate destructive test needing a large amount of resources and time. Therefore, this is not viable in a high volume-manufacturing environment.

In order to assure the manufacture of a "Fit for purpose" product, the critical characteristics of the product that directly influence the performance are identified and tolerance bands are established. Measurement of such characteristics are mostly through non-destructive testing, and even when they are based on destructive tests they are much simpler and less time and resource consuming than the assembly test.

For example, thread dimensions of a nut and the bolt must be within certain tolerance bands to assure fit and necessary load carrying capacity. These are measured using GO/NOGO gauges for the bolt and nut separately. These non-destructive tests are simple and less time consuming and can be performed frequently during manufacturing. When the nut and bolt have the correct thread dimensions and mechanical properties, they will be fit for purpose in terms of load carrying capacity when engaged. Mechanical properties of the bolt are established using a destructive tensile and proof load test while the mechanical properties of the nut are established using a proof load test. There is a resemblance of hardness to tensile strength of the material. Hardness test is non-destructive and once the correct tensile properties are established by necessary destructive testing and the manufacturing (especially heat-treatment) process is well controlled (proven by ITT and FPC) then corresponding hardness measurements can be used to simply establish the "Fit for purpose" as well as any variance to the process. It should be understood that hardness is not a direct performance measurement but an indicative measurement typically used in a manufacturing environment. Hardness range is established for the bolt and nut to mimic their tensile and proof load characteristics when the thread geometry is correct. Therefore, once the tensile and proof load tests are done on a sample, doing the hardness test on the same sample is not necessary.

In a similar example, the A/F dimension and A/C dimension for the nut and the bolt are set in order to fit a standard socket. The socket tolerances are also set to match with bolt and nut tolerances. If any of these dimensions are outside the set range then it is a non-conforming product. However, for it to be a defective product, a typical socket either should not fit the assembly or should round-off the head in the application of full tightening torque.

Based on a process similar to the above examples, tolerance bands are established for each critical characteristic of the product to ensure "Fit for purpose". If any characteristic of the product is beyond the set tolerance bands when tested in accordance with ISO3269 that product is identified as a non-conforming product. Such product would not be qualified under AS/NZ1252.1:2016.

It is very important to note that not all non-conforming products are defective although a non-conforming product has a higher probability of being defective. In some rare cases, conforming product may also be defective. For example, if the thread dimensions of nut and bolt are towards extremes with some decarburization as well as the tensile strength and engagement length are lower bound.

In earlier fastener standards, mandatory assembly tests were not included as all manufacturers tried to be at the middle of the tolerance band. However, recently due to economic considerations some manufacturers try to stay at the more economical end of the tolerance band. Due to this reason, more and more defective conforming products are found in the market place. As a result, later standards (initiated by JIS and followed by EN/ISO and to some level ASTM) made the assembly test mandatory as it can either detect a defective product and/or provide some tell-tale signs of presence of defective products in the assembly lot.

It is our opinion that current AS/NZ1252.2:2016 full verification testing regime is too arduous for a product which already has independently verified conformity to AS/NZ1252.1. The purpose of

AS/NZ1252.2 is not to establish and assess conformity but to provide verification or further assurance and hence it should not replicate conformity tests.

Proposed tests and sampling plan for AS1252.2:2016:

Based on the above explanations, we believe the following test regime and sampling plan would be more than adequate to achieve the desired confidence level expected by the verification testing specified in the current AS/NZ1252.2:2016.

FIT FOR PURPOSE TEST:

Assembly test in accordance with AS/NZ1252.1: 3 samples

DIMENSIONAL CHARACTERISTICS:

For dimensional verification tests, a calibrated (with documentation) Vernier calliper is adequate. In addition, it should be note that some bolt dimensions given in manufacturers ILAC test reports may be measured before galvanizing. Therefore, some allowance may need to be applied to account for this variation.

If the assembly test showed short assembly grip length, difficult assembly or bad fitment of sockets; then conducting dimensional testing for blots and nuts as specified in Table 2.1 of AS1252.2:2016 is justifiable. If OD of the bolt thread or ID of the nut thread is outside tolerance bands then GO/NO GO thread gauge testing is justifiable.

Washer dimensional tests as per Table 2.1 of AS/NZ1252.2:2016 are justifiable as verification tests, as these are not directly assessed by the assembly test.

MECHANICAL CHARACTERISTICS:

Testing and sampling plan given in Table 2.2 of AS/NZ1252.2 is applicable with the exception of surface integrity-non-destructive test and all sample sizes for all tests reduced to 3. Sample size of 8 for hardness tests and surface integrity non-destructive test is not justifiable as those are not directly related to a defect that cannot be picked up in the assembly test.

Furthermore, it should be noted that the sample size for hardness and proof load tests should be applied on manufacturing lot numbers of each component (bolt nut and washer) and assembly tests samples should be based on assembly lots sharing the same manufacturing lot bolt nut and washer combinations. Different length bolts may be included in the same manufacturing lot number.

It is our opinion that the suggested testing in this document will achieve the same confidence level as per the current AS/NZ1252:2016 and provides a better confidence level than the initially proposed amendments but at a reduced commercial burden.

If you need further technical details or clarifications on this letter, please contact the authors.

Yours sincerely,

Saman Fernando
CSI Professor
Swinburne University of Technology

Emad Gad
Professor and Dean of Engineering
Swinburne University of Technology