

PRODUCT CONFORMITY AND CONFORMITY ASSESSMENT TO GET THE STEEL SPECIFIED

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ABSTRACT

This paper considers the role that product conformity and conformity assessment of structural steel products play in ensuring building and asset owners get the steel that design engineers have specified. It examines the recent changes to Australian and New Zealand Standards and their impact in reducing the likelihood of non-compliant product being used thereby reducing the risk for each participant in the steel building project delivery chain. Opportunities for compliance and conformity assessment systems in New Zealand which currently exist for other products and in other jurisdictions are provided for consideration for future adoption.

A manufacturer or supplier must demonstrate product conformity in order to claim that a product meets the requirements of an Australian/New Zealand Standard. From 2009 through to 2011 Standards New Zealand together with Standards Australia published revisions of AS/NZS 1163:2009 Cold-formed structural steel hollow sections, AS/NZS 3678:2011 Structural steel - Hot-rolled plates, floorplates and slabs, AS/NZS 3679.1:2010 Structural steel - Hot-rolled bars and sections and AS/NZS 3679.2:2010 Structural steel - Welded I sections. The revisions to these four steel product Standards include requirements for minimum information on test certificates, and where relevant, provided by accredited laboratories, mandatory product markings for traceability and normative appendices dealing with product conformity.

These market driven changes to the product Standards provides an increased level of confidence in the steel supply chain (specifically for design engineers, builders and asset owners) that the steel supplied is consistent with the design assumptions and the specified product. While the test certificates are provided by an accredited laboratory, independent assessment of the product from a third party would provide greater confidence that the steel product and their certificates comply with the requirements of the design.

Conformity assessment is an appraisal carried out by a third party, to evaluate and provide attestation of a manufacturer's ability to consistently manufacture, test and represent a product to be compliant with a specific Standard and its designated characteristics. In Australia third party certification for reinforcing products have been demanded by the construction market for over a decade, and since then, this requirement has extended to post-tensioning strand and more recently to structural steels. Consideration should be given by the construction industry in New Zealand to adopt a similar compliance infrastructure of product conformity and conformity assessment to ensure the steel supplied is the steel specified.

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Introduction

Australian and New Zealand Standards AS/NZS 1163:2009 Cold-formed structural steel hollow sections, AS/NZS 3678:2011 Structural steel - Hot-rolled plates, floorplates and slabs, AS/NZS 3679.1:2010 Structural steel - Hot-rolled bars and sections and AS/NZS 3679.2:2010 Structural steel - Welded I sections (herein referred to as the “steel product Standards”) were revised from their previous editions which were published between 15 and 18 years ago. During the period of time between editions there had been changes to both production and testing techniques which need to be reflected in the latest editions of these Standards. However, arguably of greater significance were the changes to the supply chain of the products covered by these Standards. Up until the nineties, the source of steel products in both Australia and New Zealand was predominately from local mills that were well known to the procurers and so could be held accountable for the quality of product supplied.

The requirements for compliance and traceability in the previous editions of the steel products Standards reflected the situation where the market had significant knowledge of the supplier and influence over them. Consequently, mandatory traceability and product conformity requirements of those Standards were minimal – if not non-existent. However, those Standards did not cater for the globalisation of suppliers which is prevalent today. If present, an example of product conformity requirements in the previous editions of the steel product Standards typically referred to an appendix entitled ‘Means for demonstrating compliance’ which was informative rather than normative. That is, it was provided for information only and was not a mandatory requirement. This meant that a manufacturer could demonstrate that it was manufacturing compliant product by whatever means it chose without restriction or the need for justification via other established methods – e.g. statistical analysis.

As previous decades of supply from local manufacturers were basically without issues, this vindicated the informative status of the product conformity requirements. However, more recent events supported the need for change. In Australia, there have been some significant structural failures which have been due, either wholly or in part, to the lack of conformance of the product to the Standard and the identification of its source manufacturer. Unfortunately legal restrictions on the reporting of these failures means they cannot be readily identified or discussed in this paper. The UK system for the Confidential Reporting of Structural Safety (CROSS 2013a) however, undeniably confirms that the lack of product conformity and traceability are contributing to structural failures. CROSS reports which highlight failures that are linked to forged certificates (CROSS 2012) and the quality of imported components (CROSS 2013b) amongst other concerns, supports the need for action to be taken to avoid similar problems in Australia and New Zealand.

While the changes in the latest editions of these steel product Standards provide additional confidence to various key stakeholders (including designers, specifiers, builders and asset owners) that the product supplied complies with the Standards upon which the structure was designed, much more needs to be done. This paper will highlight to design engineers, how the changes can be utilised to reduce the risk of getting non-compliant material and how other changes need to be made to provide greater confidence that they are getting the steel they specified.

The changes relating to product conformity in detail

There are three key changes that relate to improving traceability and product conformity, these are:

- Mandatory product marking at the time of production;
- Mill Certificates - mandatory information to be provided and testing to be conducted by an accredited laboratory; and
- Mandatory product conformity requirements.

Product marking at the time of production

The Standards Australia/Standards New Zealand Committee drafting the steel products Standards (BD-023) acknowledged the markets’ desire for steel products to have identifying marks to facilitate traceability. In meeting this requirement consideration was given to the additional cost which would ultimately be borne by the market. The criteria the Committee used in deciding the method of marking was that the mark should:

- Improve traceability between the product and its respective test certificate;
- Be provided without imposing any significant cost to production; and
- Be applied during the manufacturing process to ensure its integrity.

In the case of AS/NZS 3679.1:2010 product, a rolled-in mark was deemed to be most appropriate. The

production process and capital equipment for inclusion of the mark on hot-rolled sections is unchanged by this requirement. A mark identifying the mill and the letters "AS" is simply engraved into the final roll to produce a permanent mark facilitating the identification of the manufacturer and the Standard to which it was produced. This mark, typically done with other text by such manufacturers around the world, is at a regular spacing along the product and effectively permanent unless significant effort was exerted to remove it. Furthermore, local Australian manufacturers stencil the size, grade and heat number which allows the individual length to be directly traceable to a unique test certificate. This rolled-in marking requirement is mandatory for all hot-rolled sections that are at least 150mm deep, and for angles with leg lengths that total at least 150mm, on the basis that these were typically used for the more critical members in a structure.

The mark allows design engineers and indeed all stakeholders to identify if the steel used on a project complies with AS/NZS 3679.1:2010 at any stage of the project. Steel compliant with the steel product Standards are also deemed compliant to structures designed to AS 4100 and NZS 3404, the respective Australia and New Zealand steel structures design standards. Therefore, if engineers are able to see the AS mark on a steel section, they have a higher degree of confidence that the steel is compliant and consistent with their designs.

To mandate a rolled-in mark or permanent embossing for cold-formed sections (such as structural steel hollow sections) and hot-rolled plates was neither practical nor acceptable to a majority of market stakeholders. Cold-formed sections are frequently used in applications where the external surface finish is of aesthetic importance and any distortion or protrusion of the surface finish would need rectification for the finished item. Similarly, hot - rolled plates and merchant bar sections are used in a range of applications where a protrusion or indent in the plate or bar as a result of the identifying mark would need to be repaired in the finished product and hence not practical.

It is on this basis that AS/NZS 1163:2009 and AS/NZS 3678:2011 provides the requirement for a durable mark be made by painting (or using ink jet technology) in lieu of stamping or application of a rolled-in mark. In the case of AS/NZS 1163:2009, the mark is required to provide details of the product including the manufacturer, manufacturer's site and/or mill, a unique serialised identification number (e.g date/time of manufacture or heat, etc) which enables the section to be traceable to its matching test certificate. AS/NZS 3678:2011 requires the mark to include a traceable plate or identification number which provides full traceability.

Welded I Sections manufactured to AS/NZS 3679.2:2011 are required to simply have an adhesive label as a means for identification. While this offers less confidence to the integrity of the material compared with the other steel products, it is the most appropriate, given the nature of its production.

Mill Certificates

Both AS 4100 and NZS 3404 acknowledge that a test certificate issued by the mill is sufficient evidence that the steel supplied to a design is compliant with the particular design standard. This implies that the test certificate is of significant importance. Incongruously, with this importance placed by the design Standard on test certificates was the steel products Standard's reference to this same document. The clauses relating to test certificates in previous editions of the steel products Standards was limited to a reference to an informative Appendix which simply required that the results of tests performed by the manufacturer for the purpose of establishing compliance with the Standard be recorded on the certificate. This left significant latitude to the manufacturer about what tests were required, who could perform those tests and which were to be listed on the certificate.

The latest editions of the steel products Standards are quite clear in their requirements of what is to be reported in test/compliance certificates and the accreditation of the laboratories reporting those test results. It is appropriate to note before further discussion that AS/NZS 3679.2:2011 Structural steel - Welded I Sections, unlike the other 3 steel products Standards, does not require a test certificate, but rather a certificate of conformance. This was on the basis that welded sections are essentially a fabricated product as distinct from the others which are considered manufactured products. More recently there has been discussion about this inconsistency and it is likely that AS/NZS 3679.2 will be brought into line with the other Standards at the next revision which is currently being drafted. Local manufacturers provide checklists for engineers to utilise when they are inspecting and approving test certificates for assessing the steels compliance with AS 4100 and/or NZS 3404. A copy of a checklist is included for engineers for this purpose in Appendix A. Most of these requirements are self-explanatory and their inclusion in the Standards gives

procurers the right to demand that this information be provided.

The requirement to include the chemical composition with specific reference to all the chemical elements listed in the respective steel product Standards (and also any others added intentionally) perhaps needs some explanation. The carbon equivalence, which has a direct impact on the weldability of the steel, is affected by the elements: carbon, manganese, chromium, molybdenum, vanadium, nickel and copper. Titanium, niobium and vanadium are not considered as micro alloying elements as long as they are below the set limits, therefore their quantities need to be disclosed on the certificate. Silicon affects the galvanizing of the steel products, therefore, it is important that its content in a steel product is provided. Phosphorous and sulphur cause segregation and reduce the toughness of the steel significantly phosphorous also has some effect in hot-dip galvanizing), while aluminium is a grain refining agent provided it does not exceed 0.15%. Given that these elements have an effect on the properties of the steel it is important that they are listed on a test certificate to confirm that they are within the limits required by the relevant steel products Standard.

The requirement that test results provided on test certificates are to be provided by laboratories accredited by signatories to the International Laboratories Accreditation Cooperation (ILAC) through their Mutual Recognition Agreement (MRA) provides a level of confidence that the test results are ascertained by a competent laboratory, and are of a consistent quality and accuracy. In Australia the ILAC-MRA signatory is National Association of Testing Authorities (NATA) accredited laboratories and in New Zealand it is International Accreditation New Zealand (IANZ). Laboratories accredited by NATA or IANZ in the relevant field and class of testing, fulfil this requirement. Hence, on each test certificate there must be a ILAC (eg NATA or IANZ if from Australia or New Zealand respectively) logo and identification of the ILAC laboratory for each test (chemical and mechanical) indicating it was produced by an accredited laboratory acceptable to the steel product Standards.

Mandatory Product Conformity requirements

The product conformity requirements are now consistent across the steel products Standards and are, importantly, normative. In the superseded editions, these requirements were under the informative appendix titled Means for demonstrating compliance. In today's manufacturing and supply chains, it is inappropriate (if not naïve) for compliance requirements being informative and not mandatory. The superseded steel product Standards effectively allowed the manufacturer to determine their own rules for assessing whether they made compliant product.

Perhaps the explanation for this loop-hole in the steel products Standards not being exploited was because local manufacturers would be held accountable by the market and would face their backlash. As we move more and more into a global market, the same confidence about manufacturers and the market's power to ensure they implemented good practice to demonstrate compliance is not assured. The new normative requirements mandating chemical analysis, mechanical testing, sampling frequencies and their subsequent reporting on test certificates give a greater degree of assurance that the steel products supplied are compliant with the Standards to which they are manufactured.

Conformity Assessment

Optimal conformity assessment is an assessment carried out by a third party, to evaluate and provide attestation of a manufacturer's ability to consistently manufacture, test and represent product to a specific Standard. This differs from product conformity in a number of ways. The assessment is conducted by a third party who independently reviews the manufacturing processes and testing procedures to ensure the manufacturer's factory production control will consistently produce compliant product and their accredited testing is consistent with the requirements of the relevant Standard. While product conformity provides chemical and mechanical test results for each batch produced, conformity assessment provides confidence that these results are an accurate reflection of the entire batch, and indeed, the complete product range represented to comply with the relevant Standard and grade nominated. Conformity assessment bodies may also conduct routine surveillance of their accredited manufacturers between annual assessments to ensure ongoing compliance.

In Australia conformity assessment of reinforcing steels has been in existence for over a decade, prestressing steels for over 5 years and structural steels for the past 2 years. Its introduction was in response to the significant amount of products used in construction projects which were ultimately found to be non-compliant with the Standards to which suppliers claimed they were manufactured. The non-conformances

were in four main areas (ACRS 2013):

1. Inadequate product traceability
2. Misleading and false supporting documentation
3. Excessive variation in material properties
4. Inappropriate product markings

The introduction of the Australian Certification Authority for Reinforcing Steels (ACRS) as a conformity assessment body in the early 2000's saw a marked improvement in the quality of reinforcing steels. This in turn has arguably reduced the cost of construction through reductions in potential delays, rectification work, redesign and even litigation.

The improvement in the quality of reinforcing products as a result of the introduction of third party certification has led the Australian steel and construction industries to introduce certification for structural steels. The acknowledgement of the advantages that third party certification brings has led Australia's leading steel products certifier, ACRS, increase to its list of certified mills to over 40 companies in 12 countries around the world for reinforcing, prestressing and structural steel products manufactured to Australian & New Zealand Standards (ACRS 2011).

In other parts of the world, Europe and the UK in particular, third party certification has been in existence for some time. CARES in the United Kingdom, the equivalent to ACRS, has been in operation for the past 30 years (Cares 2013a) and the European Commission's CE mark required by the Construction Products Directive was introduced in 1988. The CE Mark is a third party certification that a product conforms to the relevant harmonised Standard. This Directive was replaced by the Construction Products Regulation in March 2011 making it mandatory for construction products used in all European Union states to be CE marked from 1 July 2013. Interestingly the mark was used to improve competition rather than to impede it. Products carrying the mark can be freely traded with full knowledge that a third party has certified the product as conforming to the requirements of the Standard.

In Australia third party certified construction products are not a mandatory requirement. However, almost all government infrastructure projects in Australia over the past 10 years have specified ACRS certified reinforcing steel as the quality of construction material is of significant importance. Governments have recognised that in the longer term, public funds have greater efficacy, the quality of the material supplied is assured as this has a significant impact on the durability of the structure and reduces whole-of-life maintenance costs. This trend has flowed through to private developments with the number of projects requiring ACRS certified steel steadily increasing.

Grading by selection – A practice which undermines product conformity

While the changes to the steel products Standards has resulted in providing engineers with greater confidence that steel products supplied to their projects are compliant with the Standards and therefore consistent with their designs, the practice of (re)grading by selection is cause for concern and hence needs addressing.

Some manufacturers and distributors use a process of testing specifically for the purpose to re-grade product. Re-grading or grading by selection is a practice that is undertaken by rogue mills and/or distributors because Standards both in Australia/New Zealand and overseas have in the past not made it sufficiently clear that this practice is not acceptable based on the testing frequencies provided in the relevant Standard. This is of concern because it is not the intent of the steel product Standards to produce compliant steel product in this manner and creates a potential public safety issue.

An example of grading by selection

To illustrate this situation, an example of how a rogue mill or distributor may market product using a process of (re)grading by selection compared with a mill producing steel compliant to the Standard is described. The long term histograms of yield strength for product manufactured by these two mills are shown in Figure 1(a) and Figure 1(b) below.

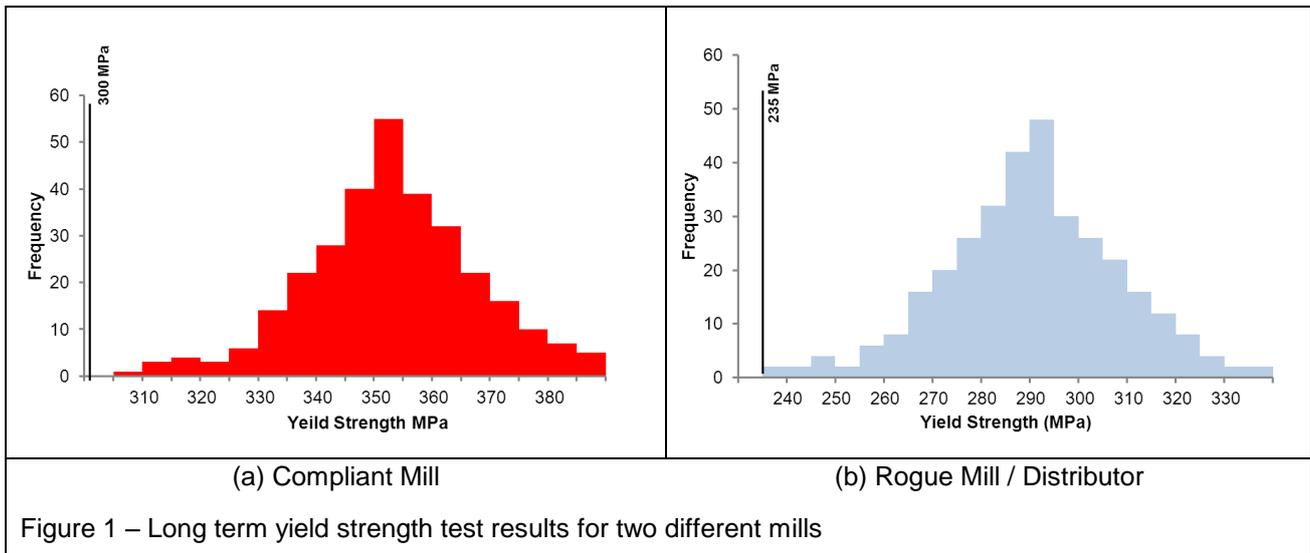


Figure 1 – Long term yield strength test results for two different mills

The compliant mill (Figure 1(a)) targets a mean yield strength value well above the minimum requirement of AS/NZS 3679.1 300 Grade. Obviously some of this material will be above the average and some below the targeted average, however all batch test results will be above the 300 MPa minimum.

The (rogue) mill manufactures to a generic Standard with grade 235 MPa product compared with the compliant mill producing the Australian Standard 300 grade. Even though the rogue mill is targeting 235 MPa (Figure 1(b)) it will produce a certain percentage of product which when batch tested will return values in excess of the required 300 MPa for AS/NZS 3679.1 Grade 300 product. The rogue mill/distributor will market the material that exceeds the 300MPa tensile test result as AS/NZS 3679.1 Grade 300 product with mill certificates supporting that claim.

Why grading by selection does not produce compliant product?

Even though the batch testing of the product returns results that meet the strength requirements of AS/NZS 3679.1, the variation within a batch is not taken into account by this grading process. AS/NZS 3679.1 requires that one test is taken for a batch size of under 50 tonnes and two tests are required if the batch exceeds 50 tonnes. For a typical 120 tonne batch of 310UB40 beams or 3000 metres of beam, just two sections of approximately 0.5m in length will be taken for testing. Although steel is a relatively homogeneous material there are still variations in a batch which are not identified with just two samples.

The testing requirements of AS/NZS3679.1 and other major recognised steel manufacturing Standards around the world is adequate provided the testing is for the purpose of purely verifying that the manufacturing process remains in control. It is not adequate if the purpose of testing is for grading or re-grading. A manufacturer is required to have a process that will consistently produce steel products that meet that Standard. The conformance criteria in the steel product Standards are to ensure that production remains in control and subsequently will meet the criteria set down in the Standard.

Consequently, downstream (or post-mill) testing and inspection of manufactured products should not be used to (re)grade or categorise the product. In the example above, variations in a batch is not considered and therefore are not consistent with the structural steel design standards such as AS 4100 and NZS 3404 which utilise these steel products. The safety indices relating to structural designs to AS 4100 and NZS 3404 have been calibrated assuming a normal distribution of yield properties as shown in Figure 1(a). To use the 300 Grade products with a yield strength distribution as shown in Figure 2 would compromise the designs to AS 4100 or NZS 3404 and most other overseas national standards.

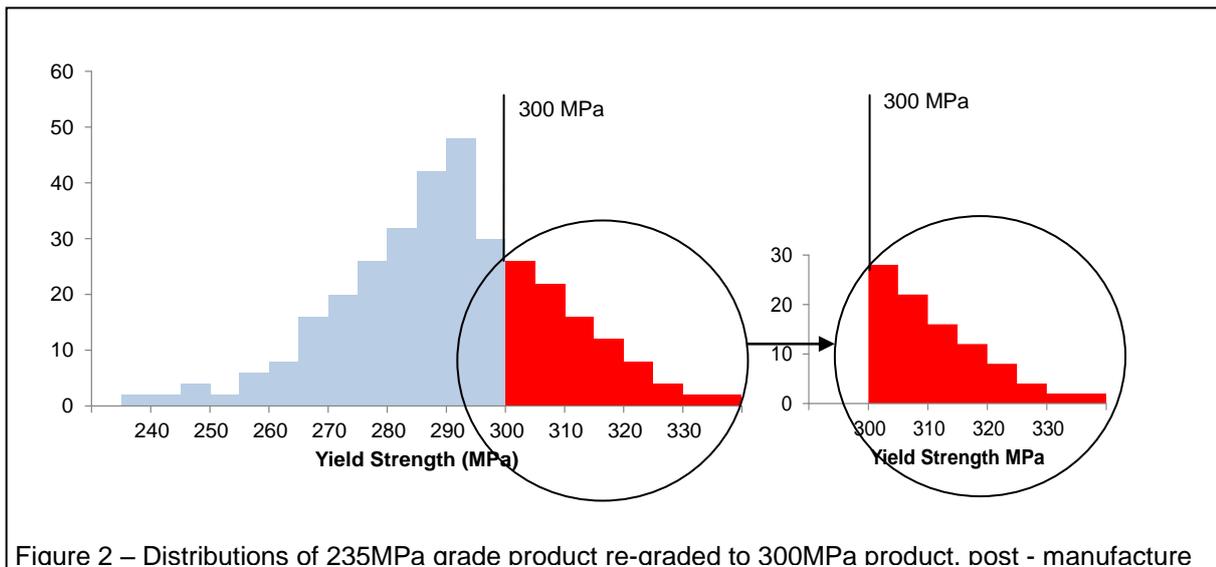


Figure 2 – Distributions of 235MPa grade product re-graded to 300MPa product. post - manufacture

While the data and preceding discussion focuses on AS/NZS 3679.1 product, the issue is the same for products manufactured to AS/NZS 1163, AS/NZS 3678 and AS/NZS 3679.2

The solution to prevent re-grading

Currently there are several of measures that exist to prevent re-grading. Third party certification requires the certification body to assess the mill’s manufacturing process and thus ensures such practices are not employed. However, unlike Europe, third party certification is not mandatory. The rolled-in mark provides a unique solution for hot rolled structural steel products by ensuring manufactures and subsequently distributors are not able to misrepresent product which is identified with a permanent mark that is made as part of the manufacturing process and cannot be made retrospectively by either the mill or a distributor. Also preventing re-grading is the requirement of unique identifiers on steel products linking it to the test certificate where a manufacturer must declare the target Standard and grade of product being manufactured.

A further requirement that should seriously be considered is that test certificates provide the Mills’ long term data for the mean and standard deviations for the mechanical test results of these products provides an additional measure to guard against re-grading. This requirement precludes mills and distributors from re-grading without highlighting in the test certificates that their distribution statistics are highly irregular and therefore questionable unless they are fraudulently manipulated being manufactured.

Conclusions

Changes to the current editions of Australian and New Zealand Standards AS/NZS 1163:2009 Cold-formed structural steel hollow sections, AS/NZS 3678:2011 Structural steel - Hot-rolled plates, floorplates and slabs, AS/NZS 3679.1:2010 Structural steel - Hot-rolled bars and sections and AS/NZS 3679.2:2010 Structural steel - Welded I sections provide engineers with greater confidence in product conformity. To capitalise on these changes, engineers should request that test certificates are provided for all steel products supplied to their projects. At least one certificate for each steel section size and grade specified on the project should be provided by the fabricator/steel contractor for checking. Checklists such as those included in Appendix A should be utilised to ensure all the requirements of the test certificate are met.

For further confidence and risk mitigation, the New Zealand steel and construction industries should advocate and specify that products supplied be manufactured by third party accredited manufacturers. Furthermore, engineers and other stakeholders should support statistical data being included on test certificates. If this is successfully changed in future editions of the steel product Standards, it will provide further confidence that the steel product supplied to a project conforms to the intent of the Standards, and guard against products which have been (re)graded by selection.

Appendix A – Test Certificate Checklist (OneSteel 2011)

The Test Certificate:

A Test Certificate that complies with AS/NZS 1163:2009, and AS/NZS 3679.1:2010 must contain all items on the following checklist, written in English and alpha numeric characters:

- Manufacturer's, supplier's and testing authority's name
- Test Certificate number and test number
- The date
- Product, testing specification and grade, e.g. AS/NZS 3679.1-350 or AS/NZS 1163-C450LO
- Product designation e.g. 530UB82.0 or product dimension and size, e.g. 200x100x5.0 RHS
- Product steelmaking process, e.g. basic oxygen-slab cast
- Length, bundle, pack or unique identifier to which the Test Certificate applies
- Heat number
- Mechanical properties:

Tensile tests	Yield stress MPa	Tensile strength in MPa	% elongation
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- Impact test results at the specified test temperature only for low temperature (LO) and seismic (SO) grades (not required for 300PLUS or 350 Grade).
- Chemical analysis type, e.g. cast analysis 'L' or product 'P'
- Chemical composition with ALL the following listed:

Carbon (C)	Phosphorus (P)	Manganese (Mn)
Silicon (Si)	Sulphur (S)	Chromium (Cr)
Molybdenum (Mo)	Vanadium (V)	Nickel (Ni)
Titanium (Ti)	Niobium (Nb)	Copper (Cu)
Aluminium (Al)	Carbon equivalence (CE)	Any element intentionally added

- Additional tests agreed between the purchaser and the manufacturer
- Statement acknowledging material being supplied in accordance with items above
- A third party accrediting body, recognised by ILAC (MRA) e.g. NATA accredited laboratory
- Signatory from manufacturer, supplier and testing authority attesting to items above.

Australian / New Zealand Standards

AS/NZS 1163:2009 Cold Formed structural steel hollow sections. Standards Australia / Standards New Zealand, SAI Global, Sydney.

AS/NZS 3678:2011 Structural steel – Hot-rolled plates, floorplates and slabs. Standards Australia / Standards New Zealand, SAI Global, Sydney.

AS/NZS 3679.1:2010 Structural steel Part 1: Hot-rolled bars and sections. Standards Australia / Standards New Zealand, SAI Global, Sydney.

AS/NZS 3679.2:2010 Structural steel Part 2: Welded I sections. Standards Australia / Standards New Zealand, SAI Global, Sydney.

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ACRS 2013. Australian Certification Authority for Reinforcing Steels, Crows Nest New South Wales, Australia, viewed 18 Jan 2013 < <http://www.steelcertification.com/>>

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CROSS 2013b Quality of some imported steel components, *CROSS Newsletter 29 - Report ID: Cross259* Cross - Confidential Reporting on Structural Safety. January 2013

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