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Dear Mr Maevsky

**Public File – Updated submission at request of ADC**

**Investigation No. 290 and 298 – Anti-Circumvention inquiries - Zinc Coated (galvanised) Steel exported from Taiwan and Korea, and P R China**

## Overview

BlueScope Steel Limited ("BlueScope") seeks to address recent submissions that are concerned with the legitimate use of boron in continuously annealed zinc coated ("galvanised") steel. BlueScope disputes the Taiwanese exporter Yieh Phui's comments (Document No 14) regarding the intentional addition of Boron above 0.0008% as not for the purpose of circumventing anti-dumping measures imposed on its exports of galvanised steel from July 2013.

The assertion that the boron added galvanised steel ('other alloy') shipped to Australia from July 2013 is a different product (or not a 'like product') from the non-boron added galvanised steel shipped to Australia prior to that date is also vigorously disputed by BlueScope.

BlueScope also unequivocally rejects Yieh Phui' s claim that a new market requirement for the minimisation of strain ageing in galvanised steel occurred (allegedly, coincidentally) at the same time Yieh Phui had been found to have exported galvanised steel at dumped prices into Australia, resulting in material damage to the Australian industry. Yieh Phui's claims are, at best, disingenuous.

BlueScope has, and continues to supply, around two thirds of the total volume of galvanised steel required by the Australian market with *non boron* added steel. This includes direct supply to all the discrete market segments and indirect supply via the distribution channels also supplied by Yieh Phui. In other words, BlueScope supplies the same customers and end-users of galvanised steel in the Australian marketplace, to the same customers, for the same end uses, as Yieh Phui.

It is also noted that the other exporters of non boron added galvanised steel to Australia (that are not in the subject countries) have continued to sell around the same annual volume over each 12 month period before and after measures were imposed in July 2013 (except for Chinese exporters who exited the market after measures were imposed). BlueScope understands that there has been no change of customers buying galvanised steel, no change in the galvanised steel downstream processing and no change in the ultimate end uses of galvanised steel. There has also been no market segment or customer request to supply

galvanised steel that is either free from or has reduced strain ageing in their ongoing galvanised steel purchases.

It is clear from the Yieh Phui /Asiazone exporter questionnaire response that its Australian customers did not specifically seek or request alloyed galvanised steel; however, Yieh Phui/Asiazone provided boron added galvanised steel to its customers to allegedly resolve a technical issue that, in the real world of processing galvanised steel, did not exist. This occurred at the same time as measures were imposed and is viewed as a clear attempt by Yieh Phui to legitimise its circumvention strategy of switching to boron added galvanised steel to avoid/evade the imposed measures.

Whereas the explanation by Yieh Phui of adding boron to the hot rolled coil substrate to minimize the strain ageing appearance is technically correct, it is incomplete. BlueScope's clarification on the metallurgical mechanisms that can be employed to control strain ageing in continuously annealed galvanised steel is covered in detail later in this submission. The manifestation of strain ageing is commonly referred to as 'stretcher strain' and is essentially a visual blemish best described as a roughening of the steel surface. There is no technical or aesthetic requirement, nor is there a market driven requirement or need for any of the commercial quality forming grades or any of the structural grades of galvanised steel to be free or have reduced stretcher strain in the Australian market.

Whilst the levels of Boron intentionally added by Yieh Phui into its galvanised steel certainly exceeds the 0.0008% level to avoid the imposed measures; it is metallurgically insufficient to achieve the stated intent of controlling stretcher strain in continuously annealed galvanised steel. Yieh Phui also ignores the in-line heat treating impact on the galvanised steel product properties in the as supplied condition to the market. This is where Yieh Phui's explanation falls short.

Free Nitrogen and Carbon within the galvanised steel is the cause of strain ageing. Boron has to be added beyond the stoichiometric ratio of 0.80 to be effective in removing or tying up all the free Nitrogen. However even if this level of Boron addition is undertaken, (a 0.003% Nitrogen level would require at least a 0.0024% Boron addition at a 0.80 ratio of Boron to Nitrogen) it would not address the available Carbon that remains in the steel that is also a cause of ageing in continuously annealed galvanised steel.

In addition to the chemistry aspect above, it is the very nature of the processing path and thermal conditions for continuously annealed galvanised steel strip products, that the high strength structural products do not exhibit stretcher strain and are resistant to the development of stretcher strain from ageing during storage, while for the lower strength structural and formable grades, they are either effectively supplied in the aged condition, due to the processing path or guaranteed non-ageing condition. Hence storage life is not an issue for these products

In summary, continuously annealed products will always contain free carbon, which in the case of the lower strength and forming grades, will induce strain ageing and which will not be suppressed through the addition of boron. The exception is the specially designed non-ageing forming grades, where free carbon is also removed through other special alloy additions.

**Legitimate exports of "Other Alloy" galvanised steel**

Prior to the imposition of measures, imports of galvanised steel under the 'Other Alloy' steel classification were small in volume, especially from Taiwan, Korea and China.

**Table 1 – Increase in imports of "alloyed" galvanised steel pre and post measures**

| | Pre Measures (Jan 2013 - Sep 2013) | Post Measures (Oct 2013 - Jun 2014) | Percentage Increase |
|---|---|---|---|
| China, Korea, Taiwan | 354 | 22,440 | **6,240**% |
| Total | 882 | 24,268 | 2,652% |
| China, Korea, Taiwan as % of Total Imports | 40% | 92% | |

Table 1 confirms that for the nine months prior to the imposition of measures, January to September 2013, a total 882 tonnes of galvanised steel was imported under the "Other Alloy" tariff codes (with Taiwan, Korea and China accounting for 354 tonnes or 40% of the total).

Following the imposition of measures during the nine month period of October 2013 – June 2014 imports dramatically increased to 24,268 tonnes (with Taiwan, Korea and China accounting for 22,440 tonnes or 92% of the total).

The import volume supply pattern from Taiwan, Korea and China has continued to the present day (i.e. from June 2014).

It should be noted that the "Other Alloy" exports from all other countries (other than Japan and Vietnam) have been reducing since the measures were imposed. Japan's volumes have steadily increased, albeit at a slow rate and Vietnam had only started to export "Other Alloy" galvanised steel from the end of last year. The ongoing small volumes of "Other Alloy" galvanised steel that would be regarded as legitimate imports and have existing Tariff Concession Order's ("TCO's") in place can be exempted from the extension of the measures to include all flat rolled products of iron and steel (including non-alloy and alloyed) of a width less than 600mm, and equal to or greater than 600mm, plated or coated with zinc.

Similarly, the importers of the remaining minor volumes of legitimate "Other Alloy" galvanised steel imports may apply for TCO's and exemptions from any dumping duties. BlueScope is committed to supporting the legitimate import of steel products via the TCO process provided that these products are not manufactured by the Australian industry.

**The common types of Galvanised steel**

Galvanised steel manufactured in, and supplied to the Australia market, is described by National Standard AS 1397-2011, 'Continuous hot-dip metallic coated steel sheet and strip – Coatings of zinc and zinc alloyed with aluminium and magnesium [1]'. Steel products supplied to AS 1397-2011 fall into two key categories known as Formable ('soft') grades and Structural ('hard') grades. There is a common designation "G" for all grades that means these steels have been continuously annealed prior to the application of its protective zinc coating.

Formable grades of steel are designated G1- profiling, G2 - Commercial Forming or G3 - Drawing. The G3 grade steel is softer and more ductile than the G2 grade steel which in turn is softer and more ductile than the G1 grade steel. A third character, the letter N, is used to indicate non-ageing where applicable (e.g. G3N) Structural grades of steel are designated by three characters that represent the steel's minimum yield strength, in megapascals, namely G250, G300, G350, G450, G500 and G550. The higher the number, the higher the Yield Strength and the stronger the steel.

The metallic coated surface can be 'skin passed' after the coating process to produce a matte finish, typically for painting and designated by the suffix 'S'.(e.g. G3NS). Equivalent classifications of galvanised steel grades are used around the world per other regions Galvanised steel standards e.g. JIS G 3302- 2010[2].

**Non-Ageing or Stabilized Grades**

The phenomenon of strain age hardening, is described in AS 1397 Appendix D[1], as occurring at room temperature or more rapidly at elevated temperatures, and manifests in the appearance of stretcher strain markings on deformation (forming), a deterioration of ductility and an increase in yield strength. Stretcher strain markings are also referred to as Luders Bands or Fluting.
Stretcher strain appears as a furrowed roughening of the steel surface due to uneven yielding in the first stages of cold deformation. Visual representation of stretcher strain can be found in video https://vimeo.com/4586024. Because of the nature of these characteristics, it is essential that the period between final processing at the mill and pressing into a shape be kept to a minimum.[1] In practice this requirement is only applicable to the forming grades G2 and G3, as these grades are commonly press formed and the visual appearance of the final product may be important. Hence the range of formable grades includes a non-ageing option where the effects of ageing need to be suppressed. However, the structural steel grades G250 – G550 are not commonly used for pressing of shapes, rather they are principally used in roll-forming applications where deformation occurs by bending only and stretcher strain does not occur or is very limited and therefore not objectionable.

**The role of Boron In Galvanised Steel**

Strain ageing occurs as a result of solute or "free" nitrogen (N) and carbon (C) interstitials diffusing through the steel structure to the site of dislocations generated in the steel by cold work, whereby the dislocations are locked from further movement and resulting in a return of yield point behaviour to the steel. In continuously annealed (heat treated) galvanised steel, both free nitrogen and carbon will be present in the steel. Solute carbon levels of [redacted] have been reported (3) in continuously heat-treated steels, which are similar to or higher than usual solute/free nitrogen levels. Moreover, only very low levels of solute C or N [redacted] are required to produce strain ageing.(4)

Boron has a strong affinity to combine with nitrogen in steel to form boron nitride particles (BN). When boron is added in sufficient quantity to combine with all the nitrogen as BN, free nitrogen is removed, thereby eliminating room temperature nitrogen ageing. However, boron levels equal to or in excess of [redacted] are required to eliminate strain ageing by nitrogen at ambient temperatures. That is [redacted] for a steel with [redacted] and [redacted] for a steel with [redacted].

However, the addition of boron does not eliminate room temperature carbon ageing nor does it prevent higher temperature carbon ageing known as "Quench Ageing" or "Bake Hardening" that continuously annealed galvanised steels are particularly susceptible to.

Steel produced by in-line heat treatment prior to hot-dipping designated 'G' in AS 1397 are particularly susceptible to carbon ageing as carbon remains in solid solution after the continuous heat treatment applied during the steel processing, due to rapid cooling in the continuous process, leading to non-equilibrium conditions. Therefore the addition of boron to prevent strain ageing in continuously heat treated galvanised steels is ineffective.

In contrast, to achieve a guaranteed non-ageing capability in continuously heat treated galvanised steels, these are alloyed with sufficient titanium to combine with all the free nitrogen and free carbon, so both nitrogen and carbon ageing are eliminated. Such steels are commonly referred to as 'interstitial free' steels, due to the elimination of the interstitial elements, N and C (G3N is one such galvanised steel product).

**The Structural Galvanised Steels – Boron Addition**

The structural galvanised recovery annealed steels, known as "Hard Iron", such as G450 and G550 have been found by R. Scott[5] to exhibit little strain ageing even in the absence of boron additions due to the excess of mobile dislocations remaining from cold rolling and recovery annealing. Whilst these steels do show some limited ageing the ageing impact on the Yield Strength has been found, in BlueScope's experience, to be less than 5%, which for practical purposes classes this group of steel products as non-ageing.
This group of structural steel products does not benefit from the addition of boron as the usual levels of free nitrogen and carbon cannot lock the high density of dislocations in recovery annealed products, while the products are applied to end uses involving simple forming operations where stretcher strain does not occur or is not objectionable. BlueScope has not had any customer demand for non-ageing 'hard iron'.

The recrystallised annealed group of bare galvanised structural steels, commonly referred to as "Soft Iron", principally G300 in Australia, are supplied without addition of boron, in the unskin-passed condition after heat treatment and metallic coating. In effect they are supplied in a pre-aged condition subject to stretcher strain at time of delivery. Essentially, unless the product is supplied in the skin-passed condition, strain ageing cannot occur. If the product is supplied without being skin-passed post the final processing step, the product is essentially delivered in the aged condition and storage life is not relevant to this supply condition. Potentially some quench ageing from solute carbon could occur over time, but an addition of boron will not impact this ageing process.

If the steel product was supplied in the skin-passed condition, again boron would need to be added in sufficient quantity to combine with all the nitrogen to eliminate nitrogen ageing, ([redacted] x [N%], while solute carbon will be still available to progress strain ageing. Hence a small addition of boron will not eliminate strain ageing for this supply condition. Again BlueScope has not had any customer demand in Australia for non-ageing structural galvanised steel. Boron does however, find legitimate application at low levels (<0.0008 wt %) for control of secondary work embrittlement in certain classes of high strength and interstitial free automotive structural steels, for example those defined in GMW3032[6] and SAEJ2340[7]. BlueScope manufacture one such boron added structural steel

**The Formable Galvanised Steel – Boron Addition**

AS 1397 makes specific reference to the fabricating characteristics of several galvanised steel products in appendix D[1]. The most common formable grades G2 and G3 are described in the following manner.

- G2: Reasonably free from fluting but this is not guaranteed;
- G3: Levelled for control of coil break only; it is not free of fluting.

BlueScope finds that the demand for G2 galvanised steel in Australia, comprises in excess of 99% supplied in the as-aged and unskin-passed condition, without addition of boron or other stabilising elements and without suppression of strain ageing.

The BlueScope Australian market demand for G3 Drawing Steel products is entirely satisfied by guaranteed non-ageing Titanium stabilised alloy steels – G3N. BlueScope has found no demand for un-stabilised G3 products with the limitations described in AS 1397 Appendix D Section 2.2.

**Conclusions**

The following key points summarise BlueScope's position concerning the representations of Yieh Phui:

1. Continuously annealed low carbon steel strip contains soluble carbon, due to the rapid cooling rate from the annealing temperature, which contributes to strain ageing, in addition to strain ageing by soluble nitrogen. Therefore, whilst small boron additions may reduce the level of soluble nitrogen, soluble carbon will still be present and induce strain ageing.

2. For strain ageing to be activated, the final strip product must be supplied in the skin passed condition (skin passed post the final coating step). Otherwise the galvanised steel is already in the fully aged condition from the thermal cycles during processing. As such, boron additions are not relevant with respect to strain ageing minimisation.

3. For the higher strength grades, G450 and G550, processing leaves the steel with a very high density of iron lattice dislocations, which resists the return of fluting or stretcher strain from ageing during storage. Hence for these products strain ageing is not of practical consequence. The structural grades have sufficient formability for the applications these grades are used for. BlueScope has not received any demand for non-strain ageing structural grades.

4. A non-strain ageing or minimal strain ageing steel is only required in the Australian market and globally, for the low strength highly formable galvanised steel grades. Such a steel grade requires a special steel type known as 'Interstitial Free' steel, which eliminates both carbon and nitrogen ageing.

5. There are some grades where boron is beneficially utilised, but these are special grades, for specific applications, which are mostly automotive components and are relatively low volume applications.

Yieh Phui's claim that strain-ageing is limited by the addition of boron is misleading. The reality is that the minimal levels of boron incorporated in the galvanised steel are insufficient to address the strain-aging claims proffered by Yieh Phui. The only reasonable explanation as to the addition of boron in the galvanised steel has been to circumvent the anti-dumping measures – as evidenced by the increased trend in import volumes for alloyed galvanised steel post measures.

BlueScope requests the Commission to find that the alloyed galvanised steel is a like good to locally produced galvanised steel and amend the legal instruments to extend coverage of the measures to alloyed galvanised steel imports from China, Korea and Taiwan.

If you have any questions concerning this submission, please do not hesitate to contact me on (02) 4275 3859 (direct), or BlueScope's consultant John O'Connor on (07) 3342 1921.

Yours sincerely

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