

# TECHNICAL NOTE ON THE WELDING OF WEATHERING STEELS

## SUPPLEMENT TO TECHNICAL BULLETIN 26

### TECHNICAL NOTE



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## 1.0 INTRODUCTION

BlueScope weathering steel grades WR350 and hot rolled coil HW350 have similar welding characteristics to the conventional hot rolled AS/NZS 3678-350 grade. For general structural welding this means that no special welding consumable requirements apply unless a matching surface patina or comparable corrosion resistance is required on the finished weld. This Technical Note therefore describes the general precautions and consumable requirements for the welding of BlueScope's weathering steel grades.

## 2.0 PRECAUTIONS

### 2.1 Consumable selection

In all cases the use of hydrogen controlled welding consumables is preferred for the welding of high tensile steels including AS/NZS 1594-HW350, AS/NZS 3678-WR350 and AS/NZS 3678-WR350LO. Whilst other consumables may be used, the suitability of all electrodes should be established via appropriate weld procedure qualification tests as specified in AS/NZS 1554.1 [1].

For general structural steel welding where matching patina is not required, any of the welding consumables selected in accordance with *Table 4.6.1(A)* of AS/NZS 1554.1 [1] may be used. Where the weld metal applied to the weathering steel is required have a similar corrosion resistance or to develop a patina similar to that of the steel being welded, consumables should be selected in accordance with Section 3 of this Technical Note.

### 2.2 Preheat

The welding of thicker section weathering steels (as with the welding of thicker section high tensile steels such as AS/NZS 3678-350), and the use of non hydrogen controlled welding consumables, may require the application and maintenance of preheat to the weld joint to avoid excessive weld heat affected zone hardening and thus minimise the risk of delayed cracking (also known as cold cracking or hydrogen assisted cold cracking). Reference should be made to AS/NZS 1554.1 [1] or the Welding Technology Institute of Australia (WTIA) Technical Note 1 [2] to calculate minimum preheat temperature requirements.

### 2.3 Hot cracking susceptibility

As weathering steels typically contain levels of phosphorous and copper significantly higher than that found in general structural steels, in certain joint configurations and higher heat inputs (>2.5kJ/mm) the weld may be at increased risk of hot cracking. Conversely, because of the increase in strength gained from using these alloying elements, BlueScope have reduced the carbon content of these steels to offset and

reduce the risk of hot cracking, and to maintain the good weldability characteristics of these BlueScope steels. At normal heat inputs used in manual welding the risk of hot cracking is considered low, however at higher heat inputs, particularly >2.5kJ/mm, it is recommended that suitable hot cracking tests be conducted as part of the weld procedure qualification test requirements to verify freedom from hot cracking. Suitable tests include the AS 2205.9.1 [3] method or the Transvarestraint test [4].

### 2.4 Weld procedure qualification tests

The information provided in this Technical Note does not override the user's obligations to demonstrate their ability to produce sound welds via documented weld procedure and welder qualification tests as required by application standards including AS/NZS 1554.1 and the American Welding Society's standard AWS D1.1 [1, 5]. Where consumables are not deemed pre qualified within these standards, additional qualification tests may be required to establish suitability for use within the chosen application.

## 3.0 WELDING CONSUMABLE SELECTION

### 3.1 General

Where the weld metal to be applied to the weather-resistant steel is required to have similar atmospheric corrosion resistance and similar patina colouring to that of the parent steel, nickel bearing low alloy steel electrodes may be required, particularly for multirun welds. With relatively small single pass welds, dilution effects between the weld metal and parent material will ensure that sufficient alloying elements are present in the weld for adequate resistance to corrosion. If the reinforcement can be left in place, some added protection against metal loss is gained.

The specific recommendations applicable to various weld joint configurations and welding techniques are:

- For single-run fillet welds and butt welds made with a single run or a single run each side and where the welds are made with no weave, welding consumables should be selected in accordance with *Table 4.6.1(A)* of AS/NZS 1554.1.
- For single-run fillet welds and butt welds made with a single run or a single-run each side and where weaving is used during the run, welding consumables should be selected in accordance with *Table 4.6.1(C)* of AS/NZS 1554.1 or *Table 1* of this Technical Note.
- For capping runs on multi-run fillet or butt welds, welding consumables should be selected in accordance with *Table 4.6.1(C)* of AS/NZS 1554.1 or *Table 2* of this Technical Note.
- For runs other than capping runs on multi-run fillet or butt welds, welding consumables should be selected in accordance with *Table 4.6.1(A)* of AS/NZS 1554.1.

Again, the use of hydrogen controlled welding consumables is preferred.

**3.2 Consumables for Manual Metal Arc, Flux Cored Arc and Submerged Arc Welding**

Suitable nickel bearing manual metal arc (MMAW), flux cored arc (FCAW) and gas metal arc (GMAW or Mig) welding consumables known to have similar weathering resistance to AS/NZS 1594 HW350, AS/NZS 3678 WR350 and AS/NZS 3678 WR350L0 steels are listed in Table 1 of this Technical Note.

These consumables are deemed 'pre qualified in the standard AS/NZS 1554.1 thus minimal testing is required prior to use other than that necessary to establish and qualify the proposed weld procedure in accordance with AS/NZS 1554.1.

For the gas metal arc welding of weathering steels, the user should be aware that AS/NZS 2717.1 has been superceded by AS/NZS 14341 and the consumables listed in Table 1 of this Technical Note are equivalent to the former AS/NZS 2717.1 designations. Consumables with the AS/NZS 14341 SN3 or SN7 suffix may also be suitable for use in this application but are not currently deemed prequalified for patina matching purposes and additional qualification tests may be required to establish suitability for use.

The use of alloyed submerged arc consumables is not deemed prequalified for patina matching purposes in the 2011 and prior editions of AS/NZS 1554.1. Whilst this may change in later editions of the standard, in the interim when required, users may consider using consumables of the appropriate specified strength with the AS/NZS ISO 14171 composition designations B SUN2, B-SUN21, B SUN3, B SUN31, B SUN5 or B SUN7, but should note that qualification tests may be required to establish suitability for use.

**3.3 Consumables permitted within AWS D1.1 [5]**

Whilst the choice of consumables deemed prequalified within AS/NZS 1554.1 is limited to certain MMAW, FCAW and GMAW consumables, the American Welding Society's Standard AWS D1.1 [5] provides a broader range of consumable options for the four common welding processes where a matching patina is required on multipass welds in particular. These are shown in Table 2 of this Technical Note and consumables meeting these requirements may be used to weld BlueScope's WR350 and HW350 grades.

**4.0 REFERENCES**

1. AS/NZS 1554.1:2011 Structural steel welding Part 1: Welding of steel structures, Joint publication of Standards Australia and Standards New Zealand.
2. AS 2205.9.1 Methods for destructive testing of welds in metal – Method 9.1: Hot cracking test, Standards Australia, 2003.
3. WTIA Technical Note 1 The Weldability of Steels, Welding Technology Institute of Australia, TN1-96, 1996.
4. ISO/TR 17641-3:2005 Destructive tests on welds in metallic materials – Hot cracking tests for weldments – Arc welding processes – Part 3: Externally loaded tests.
5. AWS D1.1/D1.1M:2010 Structural Welding Code – Steel, American Welding Society, 2010.

Table 1: Welding consumables with similar weathering resistance to WR350 and HW350 [1].

| STEEL GRADE         | CONSUMABLES (SEE NOTES)        |                                   |                              |
|---------------------|--------------------------------|-----------------------------------|------------------------------|
|                     | MANUAL METAL-ARC (AS/NZS 4855) | FLUX-CORED ARC (AS/NZS ISO 17632) | GAS-METAL ARC (AS/NZS 14341) |
| AS/NZS 1594 HW350   | A E42 2 2Ni                    | A T42 2 1.5Ni                     | A G42 2 3Ni1                 |
|                     | A E46 2 2Ni                    | A T46 2 1.5Ni                     | A G46 2 3Ni1                 |
| AS/NZS 3678 WR350   | A E42 2 3Ni                    | A T42 2 2Ni                       | A G42 2 2Ni2                 |
|                     | A E46 3 3Ni                    | A T46 2 2Ni                       | A G46 2 2Ni2                 |
| AS/NZS 3678 WR350L0 | B E49XX N5                     | A T42 2 3Ni                       | B G492U SN2                  |
|                     | B E55XX N5                     | A T46 2 3Ni                       | B G552U SN2                  |
|                     | B E49XX N7                     | B T492U N2                        | B G492U SN5                  |
|                     | B E55XX N7                     | B T552U N2                        | B G552U SN5                  |
|                     |                                | B T492U N3                        | B G492U SN71                 |
|                     |                                | B T552U N3                        | B G552U SN71                 |
|                     |                                | B T492U N5                        |                              |
|                     | B T552U N5                     |                                   |                              |
|                     | B T492U N7                     |                                   |                              |
|                     | B T552U N7                     |                                   |                              |

**NOTES:**

1. Any listed consumable may be used with any listed steel grade.
2. Consumables with a higher impact grading than that shown are also acceptable.
3. The letter 'X' represents the flux covering.
4. Guidance on the selection of welding consumables for weathering steel not listed in this table should be sought from the steel manufacturer.

Table 2: AWS D1.1 Filler Metal Requirements for Exposed Bare Applications of Weathering Steels (Table 3.3 from [5]).

| PROCESS     | AWS FILLER METAL SPECIFICATION | APPROVED ELECTRODES <sup>1</sup>  |
|-------------|--------------------------------|---|
| SMAW (MMAW) | A5.5                           | All electrodes that deposit weld metal meeting a B2L, C1, C1L, C2, C2L, C3 or WX analysis per A5.5.           |
| SAW         | A5.23                          | All electrode-flux combinations that deposit weld metal with a Ni1, Ni2, Ni3, Ni4 or WX analysis per A5.23.   |
| FCAW        | A5.29                          | All electrodes that deposit weld metal with a B2L, K2, Ni1, Ni2, Ni3, Ni4, or WX analysis per A5.29.          |
| GMAW        | A5.28                          | All electrodes that meet filler metal composition requirements of B2L, G1, Ni1, Ni2, Ni3, analysis per A5.28. |

**NOTES:**

- Filler metals shall meet requirements of Table 3.1 of AWS D1.1 in addition to the compositional requirements listed above. The use of the same type of filler metal having next higher tensile strength as listed in AWS filler metal specification may be used.
  - Composite (metal cored) electrodes are designated as follows:
    - SAW: Insert letter "C" between the letters "E" and "X," e.g., E7AXECXXX- Ni<sup>i</sup>.
    - GMAW: Replace the letter "S" with the letter "C," and omit the letter "R," e.g., E80C-Ni1.
1. Deposited weld metal shall have a chemical composition the same as that for any one of the weld metals in this table.

