PK/TIC/06/003

GUIDANCE ON THE WELDING OF WEATHERING STEELS

Bruce Cannon

1.0 INTRODUCTION

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

2.0 PRECAUTIONS

2.1 Consumable selection

Whilst 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 WR350L0, other consumables may be used if required. The suitability of all electrodes though should be established via appropriate weld procedure qualification testing as specified in AS/NZS 1554.1.

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 therefore be made to AS/NZS 1554.1 or WTIA Technical Note 1 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 Steel have reduced the carbon content of these steels to offset and reduce the risk of hot cracking, and provide a guaranteed carbon equivalent limit 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 method or the Transvarestraint test [7]. Further information on the influence of weld metal composition upon the avoidance of hot cracking can be found in BS 5135 [8].

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 AWS D1.1 [1, 4]. 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:

(a) 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.

(b) 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.

(c) 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 2.2.

(d) 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 and Flux Cored Arc Welding

Suitable nickel bearing manual metal arc (MMAW) and flux cored arc (FCAW) 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.

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.

3.2 Consumables for Gas Metal Arc and Submerged Arc Welding

Gas metal arc (GMAW or Mig) welding consumables for use in the capping runs of multi run fillet or butts welds applied to weathering steels have not been included in AS/NZS 1554.1, however, nickel bearing ESNi1, ESNi2 and ESNi3 (see AS/NZS 2717.1 [2]) type consumables with a tensile strength classification of W50X or W55X would be expected to provide atmospheric corrosion resistance and patina colouring similar to the equivalent FCAW consumables. The user should therefore establish their suitability for use via appropriate accelerated corrosion tests prior to the commencement of welding.

Similarly, submerged arc (SAW) welding consumables for use in the capping runs of multi run fillet or butts welds applied to weathering steels have not been included in AS/NZS 1554.1, however, nickel bearing ENi1, ENi2 and ENi3 (see AS 1858.2 [3]) type consumables would be expected to provide atmospheric corrosion resistance and patina colouring similar to the equivalent FCAW consumables. The user should therefore establish their suitability for use via appropriate accelerated corrosion tests prior to the commencement of welding.

In addition to the above requirements, the wire and flux combination should be chosen to match the required tensile strength of the weathering steel or structural carbon steel as appropriate (typically types W50XY or W55XY).

3.3 Consumables permitted within AWS D1.1 [4]

Whilst the choice of consumables deemed prequalified within AS/NZS 1554.1 is limited to certain MMAW and FCAW consumables, the American Welding Society's Standard AWS D1.1 [4] 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 and consumables meeting these requirements may be used to weld BlueScope Steel's WR350 and HW350 grades.

4.0 REFERENCES

1. AS/NZS 1554.1 Structural steel welding Part 1: Welding of steel structures, Joint publication of Standards Australia and Standards New Zealand, 2004
2. AS/NZS 2717.1 Welding—Electrodes—Gas metal arc Part 1: Ferritic steel electrodes, Standards Australia and Standards New Zealand, 1996
3. AS 1858.2 Electrodes and fluxes for submerged-arc welding Part 2: Low and intermediate alloy steels, Standards Australia, 1989
4. AWS D1.1/D1.1M:2004 Structural Welding Code—Steel, American Welding Society, 2004
5. AS 2205.9.1 Methods for destructive testing of welds in metal—Method 9.1: Hot cracking test, Standards Australia, 2003
6. WTIA Technical Note 1 The Weldability of Steels, Welding Technology Institute of Australia, TN1-96, 1996.
7. 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.
8. BS 5135:1984 Specification for arc welding of carbon and carbon manganese steels, British Standards Institute.

Approved by: F. Barbaro

Date: February 2006

Table 1: **Prequalified welding consumables with similar weathering resistance to WR350 and HW350 [1].**

Manual Metal Arc	Flux Cored Arc
E4815 C1L	W50XXNi1
E4816 C1L	W55XXNi1
E4818 C1L	W50XXNi2
E4815 C2L	W55XXNi2
E4816 C2L	W50XXNi3
E4818 C2L	W55XXNi3
E5516 C1L	
E5518 C1L	
E5516 C2L	
E5518 C2L	

Table 2: AWS D1.1 Filler Metal Requirements for Exposed Bare Applications of Weathering Steels (Table 3.3 from [4])

Process	AWS Filler Metal Specification	Approved Electrodes[1]
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.

General 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- Ni1.
  - 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.