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Welding consumables — International Institute of Welding (IIW) position statement on the use of trace element analyses in welding consumable specifications

Produits consommables pour le soudage — Position de l'Institut international de la soudure (IIW) sur l'utilisation d'analyses d'éléments-trace lors de la spécification de consommables

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Foreword

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This document was prepared by the International Institute of Welding.

Requests for official interpretations of any aspect of this document should be directed to the ISO Central Secretariat, who will forward them to the IIW Secretariat for an official response.

Introduction

This document is the result of study and deliberations of the International Institute of Welding.

Welding consumables — International Institute of Welding (IIW) position statement on the use of trace element analyses in welding consumable specifications

1 Scope

This document, based on round robin tests for chemical analysis conducted within IIW, considers interlaboratory reproducibility of measurement of trace element concentrations in steel and weld metals, and offers guidance in respect to application of accept/reject criteria in welding filler metal procurement as can be applied using, for example, ISO 14344 or API RP 934-A.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
trace element
chemical element, generally considered to have an undesirable effect but unavoidably present in steel at concentrations significantly below 1 % by weight, whose concentration is normally determined in parts per million (ppm)

3.2
Bruscato Factor
weighted sum of concentrations of P, Sb, Sn and As, each element expressed in parts per million in steel and corresponding weld metal, as follows:

$$Bruscato\ Factor = \frac{10\mathrm{P} + 5\mathrm{Sb} + 4\mathrm{Sn} + \mathrm{As}}{100}$$

3.3
Reheat Cracking Composition Factor
*K*f
weighted sum of concentrations of Pb, Bi and Sb, each element expressed in parts per million in steel and corresponding weld metal, as follows:

$$K\mathrm{f} = \mathrm{Pb} + \mathrm{Bi} + 0{,}03\mathrm{Sb}$$

4 Background

Recognizing that disputes have arisen between consumable suppliers and consumable users concerning acceptability of lots of welding consumables based on trace element measurements and calculation of various accept/reject criteria such as the Bruscato Factor or the Reheat Cracking Composition

Factor, IIW undertook round robin testing of Cr-Mo steel and corresponding weld metal to examine interlaboratory reproducibility of measurement of trace elements. Interlaboratory reproducibility is important in determining accept/reject decisions due to the uncertainty associated with the sum of several measurements. When the calculated factor is slightly higher than or slightly lower than the acceptance criterion, there is a certain amount of doubt as to whether the correct decision to accept or to reject is being made.

5 IIW round robin results

5.1 Bruscato Factor

Fabrication standards, such as API RP 934-A, require the Bruscato Factor to be limited to 15 ppm maximum. The IIW round robin of measurements of trace elements[3] found the interlaboratory standard deviation of the Bruscato Factor calculated from the measurements made by each participating laboratory to be 1,0 ppm when the interlaboratory average was 12,0 ppm. A 95 % confidence interval for the true value for a given lot of consumables near the level of 15 ppm would be plus or minus two standard deviations. In other words, if a value of the calculated Bruscato Factor for a given lot of consumables is between 13 ppm and 17 ppm, it cannot be said with confidence that the lot of consumables should properly be accepted or rejected.

5.2 Reheat Cracking Composition Factor

Fabrication standards, such as API RP 934-A, have considered incorporation of the Reheat Cracking Composition Factor originally proposed by Chauvy and Pillot[5] but concerns about expense and reproducibility of measurement of Pb and Bi at levels of around 1 ppm have been raised. It is presently unclear whether or not the proposed accept/reject criterion of the Reheat Cracking Composition Factor of 1,5 ppm maximum will be imposed. The IIW round robins[3][4] concluded that the only suitably reproducible analytical methods currently available are inductively coupled plasma mass spectrometry (ICP-MS) and glow discharge mass spectrometry (GD-MS). Furthermore, when the analytical methods were restricted to ICP-MS and GD-MS, the 95 % confidence interval for a calculated value of the Reheat Cracking Composition Factor is about plus or minus 0,5 ppm about the interlaboratory average value. In other words, if a value of the calculated Reheat Cracking Composition Factor for a given lot of consumables is between 1,0 and 2,0, it cannot be said with confidence that the lot should properly be accepted or rejected.

6 Conclusion

Considering the results of the IIW round robin tests, it should be clear that application of accept/reject criteria need to take into account the degree of uncertainty that accompanies the use of the factors as described above. At the very least, decisions on acceptance or rejection of consumables for which the factors calculated as above fall within the uncertainty area around the stated limit should allow for retests by other laboratories before deciding upon disposition.

Bibliography

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[2] API RP 934-A, *Materials and Fabrication of 2 1/4Cr-1Mo, 2 1/4Cr-1Mo-1/4V, 3Cr-1Mo, and 3Cr-1Mo-1/4V Steel Heavy Wall Pressure Vessels for High-temperature, High-pressure Hydrogen Service*

[3] KOTECKI D.J. Round robin of trace elements. *Welding in the World.* 2014, **V58** (N4), pp. 577–592

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[5] CHAUVY C., & PILLOT S. ASME PVP paper 2009-78144, "Prevention of Weld Metal Reheat Cracking During Cr-Mo-V Heavy Reactors Fabrication," 2009