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# High temperature mechanical properties of AISI 316 weld metal*

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Type 316 stainless steel is currently in use in various power plant installations and is also a candidate material for the construction of certain advanced nuclear systems. Welded joints are likely to be areas of particular importance and there is some evidence in the literature to suggest that the long-term ductility of the weld metal is inferior to that of the base material. However, little systematic data exist on the high temperature mechanical properties of as-welded deposits, although recent work (Cole *et al.* 1974) on AISI 308 has indicated that certain residual elements, notably Ti, B and P, play an important part in determining both tensile and creep properties and achieve their effects by influencing microstructural stability and crack formation along interphase boundaries.

The manual metal arc (m.m.a.) process is widely used in the manufacture of thick-section weldments and it is possible to control the weld metal composition and structure by controlling the constitution of the electrode. Thus by changing the basicity, deoxidant additions and alloy content of the electrode coating the oxygen potential and residual element content of the weld metal can be varied. In the present work the correlation between m.m.a. electrode constitution and tensile properties between 500 and 700 °C and creep properties at 600 °C has been investigated.

Weld deposits of *ca.* 5% δ-ferrite content were made from basic coated (containing *ca.* 48% $CaCo_3$) and rutile coated (containing *ca.* 40% $TiO_2$) electrodes, and in each case the amount of deoxidant additions (Ti, Zr, Mg) were varied to give a range of weld metal oxygen contents. Results showed that the deposits from rutile electrodes exhibited improved tensile strength and slightly reduced ductility compared with basic coated deposits. It has been possible to relate these differences in properties to variations in weld metal composition and to rationalize this in terms of the oxide: metal ratios $(MO)_{slag}$: (M) (where $(MO)_{slag}$ is the mass percentage metal oxide in slag and (M) is the mass percentage metal in weld deposit) which separated into two distinct categories corresponding respectively to basic and rutile formulations.

The effect of residual element levels on tensile and creep properties has also been investigated. In particular, variations in phosphorus and boron were achieved via the electrode coating and it was found that while phosphorus levels of up to 0.04% by mass had no effect on properties, the presence of boron at *ca.* 60 μg/g increased both tensile and creep strength but left ductility largely unaffected. From the analysis of the results it may be concluded that the difference between deposits from rutile and basic coated electrodes was not associated with any inter-relation between composition and the microstructural stability of the weld metal. However, with boron it is likely that its affect is achieved by influencing the phase transformations that occur at high temperature.

## Reference (Thomas)

Cole, N. C., Berggren, R. G., Goodwin, G. M., King, R. T. & Slaughter, G. M. 1974 Presented at American Welding Society 55th Annual Meeting, Texas, May.

* Extended abstract; the full paper appears in A.S.T.M. STP 679 (ed. C. R. Brinkman & H. W. Garvin) (1979).