



## Industrial Member Report Summary – Key Findings for Industry

### A Review of Post Weld Heat Treatment Effects on Welding Residual Stresses

TWI Core Research Programme

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#### Industrial need

The effects on welding residual stress due to a controlled post weld heat treatment (PWHT) in a furnace are indicated in BS 7910 and R6. For a controlled furnace PWHT in accordance with procedures such as those of PD 5500, the level of residual stress remaining in welds of carbon manganese and 2.25Cr1Mo steel after PWHT within the range of 580°C to 620°C or below 580°C, but above 550°C is advised.

For local PWHT, cautionary statements are also given in these defect assessment procedures. When local PWHT is carried out, the level of residual stress may be higher than that recommended for heat treatment carried out in an enclosed furnace. The level of residual stress depends on factors such as the temperature attained, the width of the heated band and the width of the insulated region. However, because of the wide range of variables no general recommendations can be made and expert advice should be sought, otherwise conservative assumptions should be made.

#### Key Findings

- The code requirements for PWHT (in terms of temperature, hold time, heating/cooling rate, heating method etc) vary from code to code; consequently, the level of relief of welding residual stress would be expected to vary too. From the viewpoint of welding residual stress, only PD 5500:2012, among the codes specifying PWHT procedures, has given an estimate of relieved welding residual stresses as '30% of yield for post-weld heat treated components'. It has not been clearly stated in this code whether this recommendation can be applied to both furnace PWHT and local PWHT, or only furnace PWHT. Furthermore, the code does not distinguish stress relief between longitudinal stress (parallel to weld) and transverse stress (perpendicular to weld).
- The degree of stress relief after a furnace PWHT as assumed in BS 7910:2013 is partly supported by the findings reported in the public domain, mainly in the stress parallel to the weld (30% of the yield after PWHT). It is not clear where the recommended relaxation in the stress component transverse to the weld after PWHT (20% of the yield) in BS 7910:2013 came from. R6 refers to BS 7910:2013 for these simple estimates of stress relief after a furnace PWHT.
- The research work on stress relief due to furnace PWHT or local PWHT has demonstrated that the holding temperature has a more significant effect than does the holding time.
- It is generally suggested by the research work that the relieved welding stresses after a furnace PWHT in accordance with the code procedures are approximately 30% of the yield strength.
- The effects of local PWHT variables (mainly the width of the heated band (HB), the soak band (SB) and the gradient control band (GCB) have not been quantified with confidence due to a number of factors involved in a local PWHT, although it appears that a HB width of the order of  $5\sqrt{Rt}$  (where R and t are pipe inner radius and thickness respectively) may be a good estimate for local heating of a circumferential weld in a cylinder.

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