WEP Closure Statement --- Evaluation Report	EMPLOYEE CONCERN GROUP CLOSURE WELD PROCEDURE NOT FOLLOWED FOR INTERPASS TEMPERATURE MONITORING WEP GROUP IDENTIFIER EC-SPL-18	Page 1 of 4 Date 01/12/87 Revision 0 WEP Group No 215

Approved _____ Date _____

Reviewed G. E. Bradford 1/12/87 Prepared Luther H. Jones

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1. Employee Concern(s)/Quality Indicator(s) (Reference 7.1)

Employee Concern IN-85-185-001
Employee Concern IN-85-834-002

2. Characterization of Issue

On safety-related stainless steel piping welds, interpass temperature limitations set by the weld procedure may not have been monitored and may have been exceeded. This could result in a sensitized microstructure in the heat effected zone, which could, under some conditions, lead to intergranular stress corrosion cracking.

Exceeding maximum interpass temperature is a violation of ASME Section IX, Part QW-282.2 (Reference 7.2), which states "Essential Variables-All welding processes. The Weld Procedure Specification (WPS) shall be set up as a new WPS and shall be completely requalified when any of the following changes are made:--(e) a decrease of more than 100°F in the preheat temperature qualified or an increase in the specified maximum interpass temperature. The minimum temperature for welding shall be specified in the WPS."

3. Summary

Not applicable.

4. Evaluation Methodology

In accordance with Department of Energy Weld Evaluation Project (DOE/WEP) Assessment Plan 215, (Reference 7.3) an engineering evaluation of the problem of possible excessive heat input caused by exceeding interpass temperature was conducted. The evaluation consists of a review of the effect of lack of interpass temperature control on weldment integrity and addresses sensitization in the heat affected zone and possible intergranular stress corrosion cracking that may have resulted from excessive heat input.

5. Findings

Higher than specified interpass temperature is a violation of the provisions of Section IX Part QW-282.2(e). However, in a study performed by DOE/WEP (Reference 7.4) to resolve TVA employee concerns related to exceeding maximum specified interpass temperatures during welding operations, a literature search was conducted to evaluate previously performed investigations. The reported results show that:

5.1 For one test using 304L, 316L and 316H stainless steels, interpass temperatures as high as 572°F for SMA welding process and 752°F for GTAW Process (considerably higher than the 350°F maximum interpass temperature specified on TVA welding procedures for welding stainless steel) resulted in no appreciable effect on the weld microstructure, weld soundness, transverse tensile strength, and weld metal and heat affected zone (HAZ) toughness.

5.2 In another investigation, the effect of weld heat input and preheat temperatures on the sensitization of two heats of 304 stainless steel (0.057 and 0.078 weight percent carbon) was measured. These results show the importance of carbon content on response to sensitization. Also, the results show that interpass temperature to 750°F (402°F above the specified maximum interpass temperature of the welding procedure) had no appreciable effect on the weld microstructure, weld soundness, transverse strength, and weld metal and HAZ toughness. However, the level of sensitization may vary appreciably, particularly if the carbon content is on the high side; 0.076 to 0.08 weight percent. In pressurized water reactors, the level of sensitization is not critical because the normal coolant chemical environment does not support stress corrosion cracking.

5.3 Mechanical properties of tensile specimens removed from a 26 inch diameter 304 schedule 80 pipe with interpass temperatures of 752°F showed a considerable increase in the yield strength of the weld and heat affected zone relative to the base material.

5.4 Fatigue data generated from welded 304 tested in air at ambient temperature and at 500°F exceeded the low cycle fatigue behavior of the unwelded base metal. The welded specimens were prepared with normal heat input (30-KJ/inch) and high heat input (64-KJ/inch). These data show that the fatigue behavior of the weldments are better than unwelded 304 even with high heat input welding.

5.5 Other tests show that 304 and 316 heated to temperatures of 1200°F for 527 and 200 hours respectively do not alter the mechanical properties appreciably.

5.6 Intergranular stress corrosion cracking (IGSCC) in austenitic stainless steel is caused by a combination of three factors:

1. A sensitized microstructure

2. Tensile stresses in the vicinity of the yield stress of the material

3. An environment that supports the process.

It is important to note that all three factors, sensitized microstructure, tensile stress and environment must be present to cause IGSCC. If one of the factors is removed IGSCC will not occur.

For PWR plants the chemistry of the coolant in the primary system does not support IGSCC. In one test Double U-Bend test samples of 304 and 316 stainless steel sensitized for 0, 12 and 40 hours at 1150 to 1175°F were exposed for 6 months to simulated coolant with maximum allowable contaminants. No cracking was observed on any test specimen. This demonstrates the totally innocuous nature of the PWR primary coolant regarding IGSCC.

6. Conclusions

The DOE/WEP studies determined that if excessive interpass temperatures were present in some stainless steel welds, there would be no impact on weld quality other than sensitized microstructure. If a sensitized microstructure is present in any welds, it will not result in cracking since the essential chemical environmental element is missing from PWR's, which includes WBN-1.

DOE/WEP considers this group closed.

7. References

7.1 Employee Concerns as listed in Section 1.

7.2 ASME Boiler and Pressure Vessel Code, Section IX, Part QW-282.2, 1983.

7.3 DOE/WEP Assessment Plan No. 215, Revision 0.

7.4 Joseph C. Danko, "Responses to Eight Employee Concerns Relating to Improper Welding of Austenitic Stainless Steel," August, 1986.