GPU Nuclear

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June 30, 1981

Director, Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Sir:

Subject: Implementation of NUREG-0313 Rev. 1, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping" (Generic Task A-42) (Generic Letter 81-04)

The contents of NUREG 0313 Rev. 1 have been reviewed with regard to ASME Code Class 1 and 2 systems at Oyster Creek as per your written request dated February 26, 1981. At this time, augmented inservice inspection, additional leak detection requirements and material replacement, are not considered to be necessary. Please refer to the attachment which will provide the necessary justification for our position.

In the event that you have any questions or comments, please contact Mr. J. Knubel of my staff at (201) 299-22 .

Sincerely,

J T Carroll Jr for
I. R. Finfrock, Jr.
Vice President - JCP&L
Director - Oyster Creek

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Attachment

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ATTACHMENT FOR NUREG
0313 SUBMITTAL 6/8/81

In accordance with the requirements of NUREG 0313 Rev. 1, the following evaluations were conducted.

Piping - The stainless steel piping systems were reviewed and identified by Piping Class as follows:

Class 1 - Recirculation
Reactor water clean up
Shut down Heat Exchanger

Class 2 - Isolation Condenser
Core Spray
Hydraulic Control
Poison System

Service Sensitive Piping - The stainless steel piping systems were reviewed under the NUREG criteria in which the following systems are designated service sensitive within Oyster Creek.

Isolation Condenser
Core Spray
Hydraulic Control
Shut down heat exchanger
Recirculation (bypass portion only)

Chemistry - Piping - All of the defined stainless steel piping systems were reviewed regarding piping chemistry. The piping systems are all fabricated from type 316 austenitic stainless steel with the carbon content ranging from .043 to .08 percent within the total piping systems.

Filler Metal - All of the Subject piping welds were made using type 316.

Inspection History

Representative weldments including the heat effected zones have been ultrasonically inspected under the first ten year inservice inspection period with no flaws detected.

Performance History

The Oyster Creek Nuclear Generating Station over its operating period has not experienced any intergranular stress corrosion events within its type 316 austenitic stainless steel piping systems. The only event has taken place within the core spray spargers which are fabricated from type 304, austenitic stainless steel.

It is well documented in various literature that IGSCC has occurred in furnace sensitized 304SS, 316SS and weld sensitized 304SS in high temperature (550°F) oxygenated water in BWR nuclear power plants. However, there are no reported incidences of IGSCC in weld sensitized 316SS piping systems at Oyster Creek or other nuclear plants utilizing this material as reported by the Pipe Cracking BWR Owners Group.

As a further explanation of the satisfactory performance of 316SS in BWR environments it is advantageous to examine the kinetics affecting sensitization (i.e. weld sensitization). It is the rate of diffusion of chromium to the grain boundaries. Therefore, any factor affecting the rate of diffusion of chromium will affect the rate of sensitization and consequently the degree of sensitization existing at any weld HAZ. Molybdenum has the ability to slow down the chromium diffusion rate. Due to its large atomic diameter, which is approximately 11% larger than the other major alloying elements (Fe, Ni, Cr), Molybdenum introduces severe compressive strains in the crystal lattice. These strains can be accommodated by the creation and trapping of atomic vacancies or by the segregation of Mo atoms to vacancy rich grain boundaries or free surfaces. This vacancy trapping produced by Molybdenum has a strong effect in reducing the rate of chromium diffusion and consequently the rate of chromium carbide formation at the grain boundaries.

In view of the above information General Electric has included 316SS as a "candidate" for alternate BWR piping materials in their EPRI Project RP701-1, "Evaluation of Near-Term BWR Piping Remedies". In this project G.E. tested 4" diameter schedule 160 piping segments butt welded together. These pipe segments then formed a cylindrical autoclave with 550°F, 8 ppm oxygenated water in contact with the internal pipe surfaces. These welded pipe segments were then subjected to axial cyclic loading up to 1.36 and 1.75 of the 550°F yield strength of 304SS. Some of the pertinent results of this test program are as follows:

1. Several heats of reference type 304SS in the as welded condition can be made to fail routinely at 1.36 of the 550°F yield strength in 8 ppm oxygenated high purity water in cyclic tension and in cyclic bending.

2. Both type 316 and 316L stainless steel were observed to provide added margins of resistance to intergranular stress corrosion cracking in the laboratory pipe tests. No intergranular stress corrosion cracking was observed for either material at 1.36 and 1.75 of the 550°F yield strength even in the low temperature sensitized condition.

The final consideration is in regard to the weld filler metal. As in the case of the 316SS base metal, there have been no reported incidences of IGSCC in as deposited 316 weld metal. This inherent immunity apparently stems from the presence of a duplex austenite-ferrite microstructure in weld metal. According to the theory promoted by General Electric, the presence of the ferrite leads to early formation of chromium rich $M_{23}C_6$ precipitation occurs exclusively along the austenite-ferrite boundaries, depleting the austenite of carbon and thereby preventing sensitization of austenite-austenite boundaries. While this may result in sensitization of austenite-ferrite boundaries after very short annealing times, it does totally prevent the sensitization of austenite-austenite grain boundaries. Further, the austenite-ferrite boundaries themselves quickly become immune to intergranular corrosion and stress corrosion cracking, since with continued chromium depletion of the ferrite due to $M_{23}C_6$ precipitation, the ferrite decomposes and the austenite-ferrite boundary migrates into the ferrite phase away from the chromium depleted zones. In order to impart this immunity, it has been defined by NUREG-0313 that the deposited weld metal shall have 5% ferrite minimum. At present the only information attesting to the resistance of the weld metal used in service sensitive lines is the operating field history. To date, there have been no incidence of IGSCC in any 316SS welds at Oyster Creek. Further substantiation of the weld quality does not appear warranted at this time in light of the service history. This is based on the fact that there is a high probability that cracking will be observed in the weld HAZ before cracking is observed in the weld metal itself if ferrite is present.

Piping Evaluation Conclusion

Although the piping materials in service in Oyster Creek, in the strictest sense, appears to be non conforming to the NUREG criteria, it is believed that there is sufficent plant specific field response data and laboratory data to indicate that type 316 displays a high resistance to intergranular stress corrosion cracking and therefore as far as plant reliability is concerned should be identified as service conforming.

Corrective Actions

Based on the excellent performance of type 316 austenite stainless steel piping within Oyster Creek, we feel that the imposing of augmented inspection criteria and other corrective and/or detection measures identified within the NUREG are not warranted.

Safe End Evaluation

All stainless steel safe ends were removed and replaced with Inconel 600 before commercial operation. Also by design there is no evidence of crevice conditions. Therefore, under the criteria of the NUREG, the safe end material and design meet the definition of conforming materials.