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SUBJECT: Forwards addl info re util proposed steam generator tube periphery sleeving plan, per 880907 request.

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October 12, 1988

U.S. Nuclear Regulatory Commission
Document Control Desk
Attn: Mr. Carl Stahle
PWR Project Directorate No. 1
Washington, D.C. 20555

Subject: Steam Generator Tube Periphery Sleeving
R.E. Ginna Nuclear Power Plant
Docket No. 50-244

Dear Mr. Stahle:

This letter is in response to a September 7, 1988 request for additional information concerning RG&E's proposed steam generator tube periphery sleeving plan. The responses to the questions are provided in the enclosure.

As noted in the responses, RG&E is willing to discuss further any data referenced in the responses, on an expedited basis. RG&E is planning to install these periphery steam generator tube sleeves during the spring 1989 refueling outage, pending approval of the process by the NRC.

Very truly yours,

Robert C. Mecredy

Robert C. Mecredy
General Manager
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Attachments

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ENCLOSURE 1

REQUEST FOR INFORMATION ON GINNA PERIPHERY SLEEVING PROGRAM

1. QUESTION:

Which experimental techniques will be used to determine the magnitude of residual stresses introduced by the bending/straightening operation? Will enough specimens be tested to ensure that the "worst case" condition is tested?

RESPONSE:

The peripheral sleeves are sleeves fabricated from the same material used by C-E for the straight welded sleeves. The main difference is that the peripheral sleeves are formed to a bend radius to minimize the vertical clearance required to access steam generator tubes further out on the periphery. The forming process of curving and subsequent straightening during installation increases the level of residual stress in the installed sleeve over that of the present straight sleeves. Several approaches have been employed to ensure that the residual stresses do not result in a condition leading to corrosion failure of the installed sleeve.

First, the selected material, thermally treated Inconel 690 has not been shown to fail in accelerated pure water stress corrosion cracking laboratory tests where the specimens tested were reverse U-bends. The residual stress for this condition is far in excess of that developed in the sleeve forming and installation.

The bend radius of the sleeve was maximized to minimize the residual stress. The sleeves are stress relieved after forming to minimize the residual stresses in the installed sleeve. The bend radius is well above many of the bend radii found in C-E steam generators which have operated many years without failure and where the tubing is Inconel 600, known to be more susceptible to corrosive attack than the thermally treated Inconel 690 material used for the sleeve. Sleeves processed through bending and straightening have been characterized with respect to residual stress employing:

1) Sach's splitting method.
2) Two angle beam X-ray diffraction method.

The results of these tests have been applied to the process development to minimize the residual stress as much as practical.

C-E intends to further employ these two techniques to bound the sleeve bending and straightening operations with respect to residual stress. This will be done by testing of maximum conditions such as bend radius which most significantly affect the residual stress. A number of tests have been performed to date and additional tests will be performed to verify the final process parameters.

2A. QUESTION:

What modifications to the previously reviewed and approved welding tools and ultrasonic testing devices are being made? How will the new tools be qualified?

RESPONSE:

The tooling for installation of peripheral sleeves utilizes the proven technology of the tooling used for installation of straight sleeves. The main difference is that the shafts connecting the tool bases to the tool heads have been made from "flexible" material. Since the bases and heads are the same and the flexible shafts have been demonstrated to be rotationally accurate, the tools will operate to the same parameters used for straight sleeve installation.

As an example, the upper weld tool was converted to a peripheral sleeving tool by replacing approximately 20 inches of the 27 inch rigid shaft with a flexible sheath and a multi strand copper conductor vs. the stainless steel sheath and rigid copper conductor in the straight sleeve installation tool. The weld tool base and the weld head consisting of the weld tip, insulation, gas passage, and fit to the sleeve inner diameter are unmodified. The ultrasonic tool also uses the same transducer and tool base while joining them with a flexible sheath and couplant lines in place of the stainless sheath and couplant lines used for straight sleeve tools.

An extensive demonstration program will be undertaken before the periphery sleeving tools are used in actual steam generators. The purpose of this demonstration is to qualify the tools, such as the welding and U.T. tools, and to verify overall system operation. The demonstration will consist of installation of a number of sleeves in a mockup utilizing actual periphery sleeve tooling. The sleeving system will be qualified based on acceptable results of these demonstration sleeves. As an example, welds made for the upper joint will be 100% ultrasonically inspected and some of these will be sectioned, polished and examined to verify weld size and penetration.

GINNA RESPONSE

2B. QUESTION:

What are the "stress relief and thermal treatment" specifications for the Inconel 690 sleeve material?

RESPONSE:

The thermal processing history of the Inconel 690 sleeve material begins with the purchased raw tubing stock which is ordered in the "Thermally Treated" (TT) condition. The TT condition is produced by annealing at 1300 degrees fahrenheit for 5 hours in vacuum subsequent to all production process steps. This heat treatment is the same for both periphery and rigid sleeves.

During periphery sleeve fabrication an intermediate stress relief anneal is employed to reduce residual stresses induced during bending. This stress relief anneal is carried out at 1300 degrees fahrenheit for 2 hours. Upon stress relieving, the periphery sleeve is ready for insertion and welding.

3. QUESTION:

Have the effects of the multiple heat treatments (stress relief, and weld heat effect, and thermal treatment) been fully examined with respect to mechanical properties and corrosion resistance?

RESPONSE:

Mechanical property tests have not been performed on the welded joints of the peripheral sleeve since the welds are made in areas of the sleeve that have not been bent and restraightened. A four inch length at the top and a two inch length at the bottom of the sleeve remains

undisturbed with respect to bending and constitutes "as received" raw tubing stock. The minor exception to this statement is the additional two hours at 1300 degrees fahrenheit the ends are exposed to during stress relieving of the curved configuration. This constitutes a time extension of the thermal treatment time employed at the tube mill is a positive effect. Sleeve expansion, flaring and welding takes place in sleeve ends that have not been bent with tooling and processes duplicating those used for straight sleeve installation. Therefore, the data presented in the original licensing document is applicable.

4. QUESTION:

In view of the extensive corrosion testing to qualify the original sleeve configuration, extensive corrosion testing should be performed on the new concept. Of particular interest is the effect of the additional deformation and the added stress relief heat treatment on the corrosion resistance.

For example, accelerated corrosion condition test should be conducted. The effects of faulted chemistry conditions should also be examined.

RESPONSE:

Since sleeve end locations where bulging, flaring and welding are performed are never bent, the original licensing document submittal applies for these areas. That portion of the sleeve that was bent, stress relieved and straightened constitutes the "new concept".

The plastic strain introduced as a result of bending and straightening is small, and is much less than that present in Reverse U-Bend Specimens (RUBS) that have been used to show that Inconel 690 is essentially immune to Pure Water Stress Corrosion Cracking (PWSCC). These RUB tests were accelerated laboratory tests, ie., 680-690 degrees fahrenheit, and annealed Inconel 690 has never cracked in this environment.

In addition to extensive testing of Alloy 690 in primary water, the alloy has also been extensively tested in various environments that may occur on the secondary side of steam generators. References 1 and 2 describe a test program where Alloy 690 as small radius U-bend heat transfer tubes were exposed in model boilers to severely faulted secondary environments. Under both acid forming and caustic forming conditions, Alloy 690 had the best corrosion performance of the alloys tested. The small

radius U-bend tubes in these tests were more severely strained than the bent and straightened sleeves will be. The Alloy 690 tubes did not crack in these environments.

Reference (3) describes an extensive test program in which Alloy 690 (and Alloys 600 and 800) were exposed to 18 different environments. The Alloy 690 in these tests was in the mill annealed condition. Available data indicate that thermal treatment enhances the already excellent SCC resistance of Alloy 690. The Alloy 690 did not crack in 17 of the 18 environments (compared to cracking in 14 of 18 for Alloy 600) evaluated. There are numerous other data in the literature and in C-E files which support these observations.

All of this data indicate that Alloy 690 will perform well in any postulated secondary side environment. The relatively low residual stresses resulting from straightening the curved sleeve will have no adverse effects or SCC susceptibility. Since the available data base includes data from specimens that were more severely deformed, there is no need to conduct additional tests in faulted secondary side environments.

The impact of the stress relief heat treatment on corrosion performance is positive, that is, residual stress will be reduced. Further, when considering chromium carbides, the stress relief can be considered an extension in time of the TT originally applied to the raw tubing stock prior to bending and straightening.

5. QUESTION:

Confirm that the eddy current testing system has performed to the sensitivity and accuracy as stated in the original licensing basis for the welded sleeves.

RESPONSE:

The sleeve in the area of the upper weld including the expanded and the unexpended area above the expansion is the same as that for the straight sleeve. This length as well as the bottom of the sleeve starting at least one inch above the taper is not curved or straightened during the sleeving process. The eddy current testing, therefore, has the same flaw detection capability in these areas as that demonstrated for the straight sleeve.

The area of the sleeve affected by the peripheral sleeving process is the portion several inches below the upper expansion to several inches above the bottom of the sleeve. This is the area which has been curved and straightened as part of the installation process. Preliminary testing with a bobbin coil of straightened sleeve samples indicated a minimal increase in noise. This increase, attributed to an ovality condition of the straightened tube, would not impair flaw detection capability as demonstrated in the original report.

As with the sleeve installation equipment, the eddy current equipment will be verified by testing prior to installation of peripheral sleeves. This verification program will demonstrate flaw detection capability equal to that described in the report CEN-337-P for straight sleeves.

In addition, C-E is also proceeding with a development program for an improved eddy current inspection probe. This probe is a surface riding segmented bobbin coil and preliminary results are favorable for the larger diameter areas of the sleeve such as the tapered area at the lower end and the expansion/weld area near the top of the sleeve. It is anticipated that this program will be completed in January, 1989. If the final results show improved detection and sizing capability, this system will be qualified and used for the steam generator sleeve inspections. If the surface riding segmented bobbin coil testing is not successful, then the existing eddy current equipment will be used. This equipment is capable of detecting 40%, 3/16" diameter flaws in the parent tube or sleeve in any region of the sleeve/tube assembly as noted in report CEN-320-P, Section 5.2.

<u>REFERENCES</u>:

(1) J.J. Krupowicz, D.B. Scott, and G.C. Fink, "Corrosion Performance of Alternative Steam Generator Materials and Designs, Volume 2: Posttest Examination of a Seawater Faulted Alternative Materials Model Steam Generator," EPRI NP-3044, July 1983.

(2) J.J. Krupowicz, D.B. Scott, and G.C. Fink, "Corrosion Performance of Alternative Steam Generator Materials and Designs, Volume 3: Posttest Examination of a Freshwater Faulted Alternative Materials Model Steam Generator", EPRI NP-3044, July 1983.

(3) F.W. Pement, I.L.W. Wilson and R.G. Aspden, "Stress Corrosion Cracking Studies of High Nickel Austenitic Alloys in Several High Temperature Aqueous Solutions," <u>Materials Performance</u>, Vol. 19, pp. 43-49, April 1980.