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U. S. Nuclear Regulatory Commission
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Subject: Arkansas Nuclear One - Unit 2
Docket No. 50-368
License No. NPF-6
Steam Generator Tubes Research Plan

Gentlemen:

Entergy Operations has initiated a research program to generate and analyze circumferential cracks in Alloy 600 steam generator tubing. These cracks are intended to be typical of the cracks found in the Arkansas Nuclear One, Unit 2 (ANO-2) steam generators. The purpose of this letter is to provide an overview of the program for your information. The results of this program will be used to assess the structural significance of circumferential cracks and better quantify the accuracy of nondestructive examination (NDE) methods for detecting circumferential cracks like those found in ANO-2.

The defects will be produced in 0.75 inch outside diameter (OD) Alloy 600 tubing at the secondary face of a simulated tube sheet. The tubing will be explosively expanded (explanded) in the simulated tubesheet with the same process used for the initial fabrication of the steam generators. The circumferential cracks will be examined using all appropriate NDE methods available. Following NDE, leak and burst testing will be conducted on each defect. The tubes subsequently will undergo metallographic examination to determine the actual crack dimensions. This information and data will then be analyzed by statistical methods to determine the probability of detection and sizing error.

A more complete description of the planned program is included in the attachment. This program may be changed as determined appropriate. Should you have any questions or comments regarding the program, please contact me.

A001 1/1

Very truly yours,

Dwight C. Mims

Dwight C. Mims
Director, Licensing

DCM/jjd

Attachment

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1.0 INTRODUCTION

Arkansas Nuclear One, Unit 2 (ANO-2), has contracted Asea Brown Boveri-Combustion Engineering Inc. (ABB-CE) to generate and analyze circumferential cracks in Alloy 600 steam generator tubing. These cracks are intended to be typical of the cracks found in the ANO-2 hotlegs. The defects will be produced in 0.75 inch OD Alloy 600 tubing, similar to that used in ANO-2, at the secondary face of a simulated tube sheet. The tubing will be explanded in the simulated tubesheet with the same process used for the initial fabrication of the steam generators. The circumferential cracks will be examined by several different NDE vendors using all appropriate NDE methods available. Following the NDE examination, leak and burst testing will be conducted on each defect. The tubes subsequently will undergo metallographic examination to determine the actual crack dimensions. This information and data will be analyzed by statistical methods to determine the probability of detection and sizing error.

2.0 PURPOSE

This program will develop a database of laboratory produced circumferential cracks that are prototypical of those found in ANO-2 steam generators. The information and data developed within this study, along with field data, will be subjected to a statistical evaluation to establish a correlation between actual flaw size and NDE projections. These results, along with other data, will be utilized to help assess actual crack growth rates and predict the probability of cracks exceeding Regulatory Guide 1.121 acceptance criteria in future cycles.

The objectives of this program are:

- Provide additional data to support the MRPC depth versus actual depth correlation
- Provide insight into crack initiation and propagation.
- Provide additional structural integrity/performance data to support further Regulatory Guide 1.121 correlations.
- Provide insight into comparisons of various NDE techniques.

3.0 PROGRAM SCOPE

3.1 Defects

The scope of this program will involve explanding 0.75" OD, 48 mil wall Alloy 600 tubes in a simulated low alloy steel tubesheet. The tubes will be axially loaded to provide the stress required to produce circumferential cracks. The stressed tubes will be exposed to an acidic environment to produce OD initiated intergranular stress

corrosion cracking (IGSCC). The basic scope of this program will produce 42 tubes with defects for NDE and leak/burst testing. The crack sizes will be targeted to range in length from 45° to 360° and in average percent throughwall from 5% to 80%.

The protocol for the making of circumferential defects will include:

- design and operation of the test fixture
- heat treatment of steam generator tubing
- explansion of tube into simulated tubesheet
- use of strain gauges to monitor the initiation of cracks
- use of eddy current to monitor the growth of defects
- matrix of target defect sizes
- neutralization of corrosion solution

3.2 NDE Inspection

This task will be performed in accordance with an ABB-CE NDE procedure. This ABB-CE procedure will be based on the field procedure used at ANO. Analysis practices will be consistent with ANO Engineering Standard HES-28, "ANO Steam Generator ECT Data Analysis Guidelines."

A complete set of NDE data will be collected on each defect. The results of the NDE inspection will be included in a task report. The NDE employed will include but not be limited to bobbin coil, motorized rotating probe coil (MRPC), high speed MRPC, "Cecco" probe, ultrasonic (UT), Oak Ridge National Laboratory 16-coil array probe, and any other method deemed potentially useful. Selected defects, as agreed upon by ANO and ABB-CE, will be made available to Entergy-ANO for NDE examination to be conducted by third party NDE vendors. The NDE data will be analyzed with the appropriate state-of-the-art techniques to characterize the defect.

Alternative NDE methods can also be tested on these defects as directed by ANO. The use of some alternative NDE methods could include additional non-destructive tests such as liquid penetrant test (PT) on the inner diameter (ID) of the tube and insitu pressure test.

3.3 Leak Rate and Burst Pressure Testing

When the NDE examinations are completed, a safety related leak/burst test will be conducted on the defects in accordance with industry guidelines. In order to provide

the in steam generator geometry, a section of steam generator tubing will be attached to the defective tube to provide a tube extension. This tube extension will be supported by an eggcrate. This tube support configuration is to mock-up the conditions in the steam generator to provide a realistic leak-rate and burst test. A simulated eggcrate support will be installed at the ANO-2 steam generator elevation of the first support. Industry accepted adjustments will be applied to the data to satisfy the requirements of Reg. Guide 1.121.

3.4 Metallography

Following the burst test, each defect will be examined to measure the actual extent of the defect. This examination will include optical measurements to size the defects. A montage of scanning electron microscope (SEM) photomicrographs of selected defects will be used to validate the optical measurements. Light microscopy to document the microstructure of the alloy and defects will also be performed on selected defect specimens. The data from the metallographic examination will provide a basis for the verification of the NDE results.

A protocol for examination will be submitted to ANO for approval. This protocol will include all of the standard metallographic methods used by ABB-CE for defect assessment.

3.5 Data Analysis

All of the data from the NDE inspection, metallographic examination, leak-rate measurements and burst testing will be analyzed by appropriate statistical methods. In addition to the defects developed in this program, the circumferential crack database from field data developed by ANO and ABB-CE will be analyzed. The purpose of the data analysis is to establish a larger, more statistically accurate database which can be used to validate the accuracy of NDE methods for detecting cracks like those found in ANO-2.

3.6 Residual Stress Measurements

The residual stress measurements will consist of three tube-in-tubesheet mockups. These mockups will be made by explanding Alloy 600 (48 mil wall) tubing in a simulated tubesheet. The residual stresses present on the OD surface of the tubing will be measured by X-ray diffraction, which has been recognized for some years as a reliable method for measuring surface residual stresses. By electropolishing away layers of OD, surface stress variations can be determined as a function of depth through the tube wall.

These stress measurements will provide an understanding as to the amount of cold work imparted to the transition region at the top of the tubesheet by explansion. This information will be useful in calculating crack growth rates.

4.0 REPORT

Results of all tasks will be included in a final report. It is Entergy Operations' intent to share the results of this report with the NRC as a part of future communications on the status of the ANO-2 steam generators.