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50-251 Turkey Point Plant, Unit 4, Florida Power and Light C 05000251
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SUBJECT: Forwards addl info re reactor vessel fracture toughness,per NRC 880531 SER request.

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JUNE 1 6 1989

L-89-190

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D. C. 20555

Gentlemen:

Re: Turkey Point Units 3 and 4
Docket Nos. 50-250 and 50-251
Reactor Vessel Fracture Toughness
NRC Tac Nos. 68249 and 55042

By letter dated May 31, 1988, the NRC provided a Safety Evaluation related to the Fracture Toughness of the Turkey Point Units 3 and 4 reactor vessels. That report identified the need for additional analysis and data collection.

Attached is Florida Power & Light Company's (FPL) response to that request for additional information.

FPL requested a 30-day extension of the May 31, 1989 submittal date specified in the May 31, 1988 NRC letter. That request was granted by the NRC Project Manager for the Turkey Point Plant on May 25, 1989.

If you have any questions, please contact us.

Very truly yours,

C. O. Woody
Acting Senior Vice President - Nuclear

COW/TCG/cm

Attachment

cc: Stewart D. Ebneter, Regional Administrator, Region II, USNRC
Senior Resident Inspector, USNRC, Turkey Point Plant

A047

ATTACHMENT

RE: Turkey Point Units 3 and 4
Docket Nos. 50-250, 50-251
REACTOR VESSEL FRACTURE TOUGHNESS
(TAC NOS. 68249 and 55042)

FPL submitted fracture toughness analyses (FPL letter Nos. L84-120 & L86-122) of the beltline welds for the Turkey Point reactor vessels in May 1984 and March 1986. Your safety evaluation of May 31, 1988 identified a need for additional analysis and data acquisition relative to the upper shelf energy issue. It was further recommended that FPL contact the ASME Section XI Working Group on Flaw Evaluation, which has been working on the A-11 low upper shelf issue since 1982, to determine the impact of their work on Turkey Point.

The purpose of this submittal is to: (1) inform you of what we have accomplished since that time; (2) outline the scope of our future plans; and (3) highlight the conservatisms incorporated in the analyses of 1984 and 1986 which assures that adequate margins of safety are being maintained while we continue to pursue these issues.

FPL has participated in the ASME Code Section XI Flaw Evaluation Working Group on A-11, the EPRI embrittlement task team, and the recently formed ASME Section XI Task Group on Margins. Basic issues such as flaw orientation for circumferential welds and appropriate safety factors have been discussed. Significant progress has been made and it appears that a consensus can be reached on the resolution of the A-11 issue.

Therefore, rather than continue to modify our previously submitted analysis of 1984 and 1986, we propose to incorporate the most recent developments in the industry into our characterization of the Turkey Point vessel fracture toughness. These developments include new analytical techniques, the progress made by the Working Groups and the additional material data to be provided by the Babcock & Wilcox Owner's Group (BWOG) as discussed later. We will be pleased to meet with your representatives at their convenience to discuss these activities further.

Based upon information currently available, it appears that the use of charpy data is a good method for detecting irradiation effects on embrittlement but a less effective method of determining the effect of irradiation on the ability of the irradiated material to resist tearing.

Therefore, even if the upper shelf energy of a reactor vessel material specimen is less than the fifty ft-lbs screening criterion in 10 CFR 50 Appendix G, the reactor vessel may still contain adequate margins of safety against failure. Thus, the significance of the upper shelf energy of a material specimen or a limited number of specimens should be determined within the context of a larger body of data.

In order to obtain more data applicable to the Turkey Point reactor vessels (which were manufactured by B&W), FPL has joined in a collective program with the BWOG.

The program as it relates specifically to the Turkey Point materials will supply 2 additional surveillance capsules which will be irradiated in B & W plants. One surveillance capsule with a target fluence of 3×10^{19} will be irradiated at Florida Power Corporation's Crystal River Plant and contain 9 charpy, 3 tension and 3 1T compact tension fracture mechanics specimens. A second capsule to be irradiated at Toledo Edison Company's Davis Besse Plant will contain charpy, tension and 1XWOL specimens. The charpy and tension specimens will be reconstituted from the PTN capsule V and the 1XWOL will be specimens which have been stored and unbroken from capsule V. The 1XWOL's will be appropriately modified to assure valid data is taken. This capsule will be irradiated to a target fluence of 1.7×10^{19}.

We know from published data that the first capsule from several surveillance programs at other nuclear units has supplied data below 50 ft-lbs and has subsequently supplied higher values after additional irradiation. This behavior is not understood and clearly does not fit any of the existing models. However, to try to determine the reason for the anomalous behavior of one surveillance point, FPL has attempted to locate additional weld material from weld SA-1094 which is the Turkey Point 4 surveillance material but does not actually exist in the Turkey Point vessels. Westinghouse, the NSSS vendor for Turkey Point, has been requested to identify any material they might have, but none has been located to date. FPL has used capsule material from Turkey Point, and this material may be suitable for performing a fracture surface examination, and/or a chemical analysis study to determine the reasons for such behavior. This material should be shipped from South West Research Institute to B & W this year, and its suitability for additional testing will be determined at that time.

In its May 31, 1988 letter, NRC requested an estimate of the charpy upper shelf energy at the next refueling outage and at the expiration date of the Turkey Point Units 3 and 4 operating licenses. Figure 2 is a plot of Cv upper shelf vs. fluence. The capsule data is shown on the plot for capsules V and T from Turkey Point Unit 3 and capsule T from Turkey Point Unit 4. The current fluence for Units 3 and 4 are approximately 8.5 X 10^{18} at the 1/4 T position. The A-9 model referenced on the plot is a regression model based on fluence and chemistry. The Regulatory Guide 1.99 Rev. 2 model is the same as the Rev. 1 model formulated in 1977 which was based on much less data than what is available now and has consistently been extremely conservative.

Although FPL is no longer relying upon its 1984 and 1986 analyses to demonstrate the acceptability of the Turkey Point reactor vessels over the lifetime of the plant, the results of these analyses provide confidence that the reactor vessels contain adequate margins of safety pending completion of new analyses using the industry analytical techniques currently being developed. In particular, the 1984 and 1986 analyses include the following conservatisms:

1. The analyses assumed a flaw in the weld 2 inches deep by 12 inches long oriented axially and radially. Turkey Point Units 3 and 4 only have circumferential welds. This is shown in Figure 1 which shows a schematic of both Turkey Point Units 3 and 4 reactor vessels with the welds identified. The critical weld in both vessels is the intermediate to lower shell weld No. SA-1101. There are no longitudinal welds since the shell courses are SA 508 Class 2 ring forgings. The most likely orientation for a fabrication induced weld flaw to occur would be in the circumferential direction. Locating the flaw in the axial and radial direction 2 inches deep and 12 inches long would, in reality, locate most of the crack in the forging material which has much better irradiated properties. The assumed crack location and material properties used are equivalent to assuming a longitudinal weld which has twice the applied load due to hoop stresses acting on it. This is a very conservative approach and similar to adding a safety factor of 2.

2. A factor of safety of 2 was applied on pressure assuming a nominal operating pressure of 2500 psi, resulting in a pressure of 5000 psi being used in the analysis. However, the power operated relief valve (PORV) setpoints are 2335 psi, the high pressure trip is set at 2385 psi and the code safety relief valves are set at 2485 psi. Thus, a safety factor of 2 on a nominal operating pressure of 2500 psi is extremely conservative.

3. FPL's 1984 and 1986 analyses included additional loads which are not typically considered, such as residual weld stresses and pressure on the crack surface.

4. Flow stresses were based on unirradiated properties, which is conservative because irradiated properties are higher for tensile and yield strength.

In addition to these conservatisms mentioned, FPL's analyses assumed the presence of a pre-existing crack 2 inches deep and 12 inches long. FPL has performed inservice inspections of the reactor vessel beltlines and determined that no detectable defects existed. The details of these examinations are listed in Appendix I.

Our analyses of 1984 and 1986 demonstrated a significant margin of safety through end of life. Based upon these results and the conservatisms mentioned above, FPL concludes that the Turkey Point reactor vessels will contain an adequate margin pending acquisition and analysis of the results of the BWOG program.

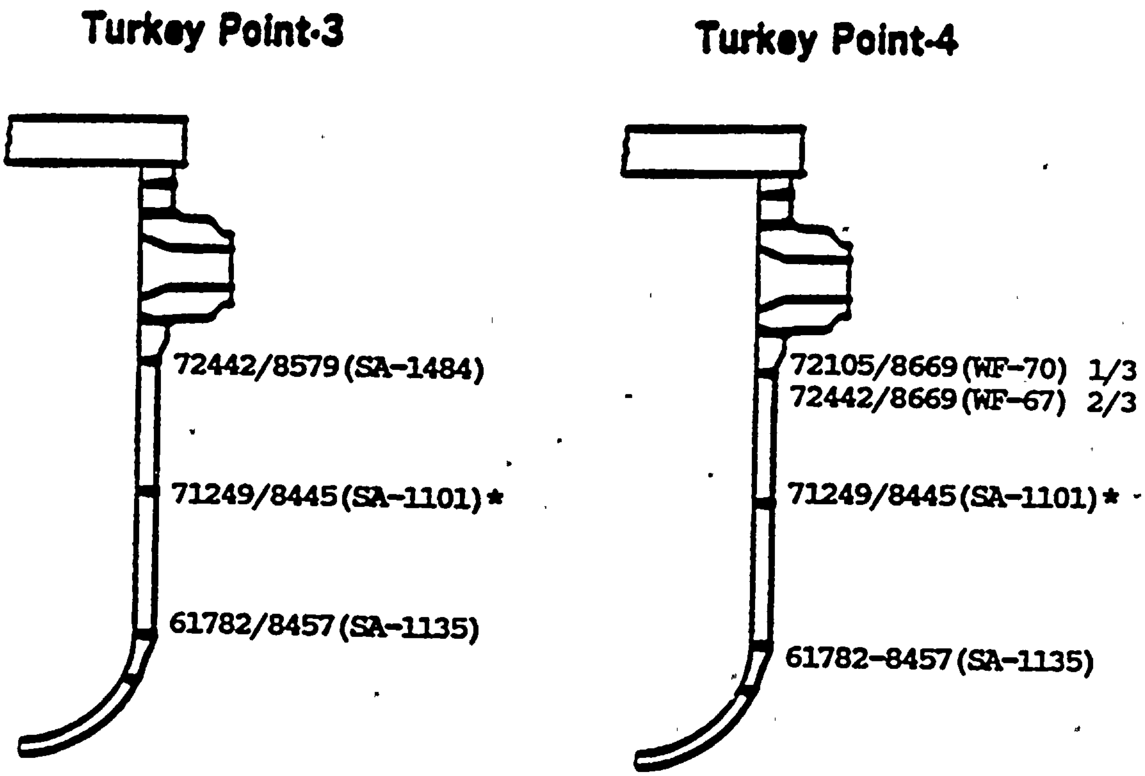
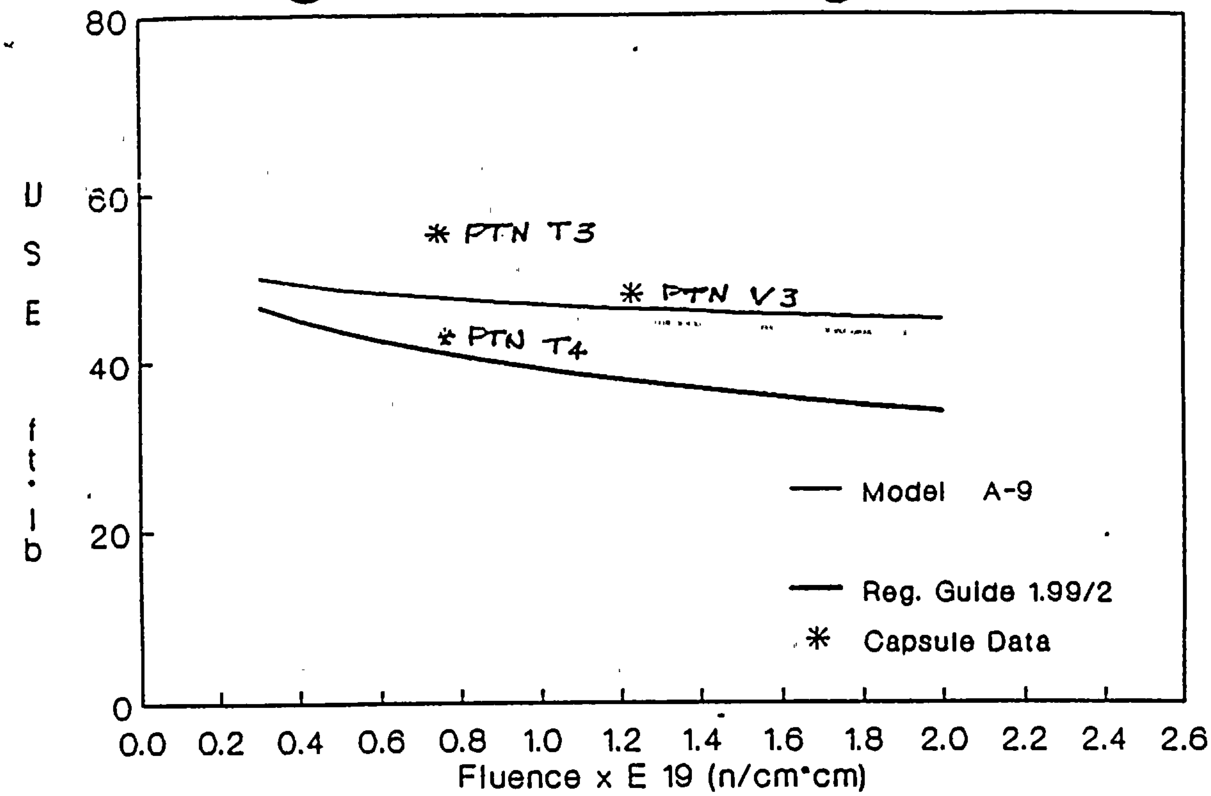

Turkey Point-3
72442/8579 (SA-1484)
71249/8445 (SA-1101) *
61782/8457 (SA-1135)
Turkey Point-4
72105/8669 (WF-70) 1/3
72442/8669 (WF-67) 2/3
71249/8445 (SA-1101) *
61782-8457 (SA-1135)

FIGURE 1



U S E ft•lb
80
60
40
20
0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6
Fluence x E 19 (n/cm•cm)
* PTN T3
* PTN V3
* PTN T4
Model A-9
Reg. Guide 1.99/2
* Capsule Data

FIGURE 2

ATTACHMENT 1

TURKEY POINT UNIT 4
REACTOR PRESSURE VESSEL EXAMINATION

Each weld and the adjacent base metal for a distance equal to one-half of the wall thickness was examined with ultrasound. Examinations were conducted in accordance with the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code and U.S. Nuclear Regulatory Commission Regulatory Guide 1.150.

To ensure accuracy, the ultrasonic instruments were adjusted to display specific responses from reflectors of known size and location. The reflectivity of detected flaws was compared to the known responses to determine relative size. Additional characteristics of these detected flaws were analyzed to determine relevance and size. For example, the return signal dynamics were carefully monitored for pattern changes which would be indicative of the presence of a crack.

Special techniques were utilized for the examination of the inner twenty-five percent of the material volume. This was to ensure that potentially injurious flaws were detected with adequate reliability. The Unit-4 Reactor Pressure Vessel was subjected to a double examination in this important area. The first examination employed a twin element seventy degree beam to interrogate the first two and one-half inches with high sensitivity. In this examination, the ultrasonic beam was transmitted in a refracted longitudinal wave mode in order to minimize the effects of the contact surface stainless steel cladding. Sensitivity was established with responses from one-sixteenth inch diameter side drilled holes located at the clad-base metal interface and incrementally deeper to the maximum effective search unit depth range.

The second examination employed a "full vee" forty-five degree beam which was directed at the outside surface where it was bounced back to the inner surface at a forty-five degree angle. This angle is the most favorable for the detection of the "corner" formed by a crack and the surface of the material. Calibration was in accordance with established ASME practice which included a .140 inch deep by 2.0 inch long notch located at the clad-base metal interface.

The seventy degree technique has a demonstrated capability of detecting cracks, under cladding, of one tenth of one inch deep with a ninety-five percent probability of detection. The redundant forty-five degree examination provided additional assurance that no cracks are present.