Florida
Power
CORPORATION
Crystal River Unit 3
Docket No. 50-302

August 17, 1992
3F0892-05

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

Subject: High Energy Line Break (HELB) in the Intermediate Bui'uing

Reference: FPC to NRC letter 3F0492-10, dated April 21, 1992

Dear Sir:

Florida Power Corporation (FPC) is submitting this letter to respond to NRC questions which were discussed in a July 21, :992 telecon between the NRC and FPC. The questions concern the HELB conclusions provided in the reference letter. An attachment to this letter provides a detailed response to each NRC question.

Based on FPC's April 21, 1992 submittal and the supplemental discussions included here, FPC still concludes the additional inspections and fracture mechanics evaluations are not necessary nor required. The 3 inch end of the 6 x 3 inch reducer component is the most likely location for a terminal end break in the EFP turbine supply piping.

Sincerely,

Gary Boldt

G. L. Boldt
Vice President
Nuclear Production

GLB/JWT

200088

Attachment

xc: Regional Administrator, Region II
Senior Resident Inspector
NRR Project Manager

9208210143 920817
PDR ADOCK 05000302
P PDR

A001

INTRODUCTION

Four FPC calculations, CR-4, CR-5, CR-4A, and CR-56, address the piping described in this letter. Calculation CR-4 qualifies the 24 inch main steam piping which connects to valve MSV-55. Likewise, calculation CR-5 qualifies the 24 inch main steam piping which connects to valve MSV-56. Calculation CR-4A qualifies the branch line downstream of MSV-55 and calculation CR-56 qualifies the branch line downstream of MSV-56.

The Code of Record (COR) for the existing Crystal River Unit 3 (CR-3) piping analysis discussed in this letter is ANSI B31.1-1967. The Stress Intensification Factors (SIF or i) and Code equations were used consistently to develop the reported stress results for the piping components. These stresses were used to postulate HELB and Crack locations in accordance with CR-3 criteria for HELB design "Pipe Rupture Analysis Criteria Outside the Reactor Building."

For comparison purposes, piping stresses presented in this letter were also calculated using more recent Code guidance. The Code used was ASME Section III, Subsection NC, 1980. This Code differs from the CR-3 COR in two important areas. The NC Code has generally higher reported SIF values for piping components than the CR-3 COR. However, this Code considers intensification of Primary (0.75i) and Secondary (1.0i) stresses in a different manner than the CR-3 COR where both are multiplied by 1.0i. The comparison stresses reported here take both of these differences into account.

NRC Question 1

*The licensee's evaluation did not address the stresses at the 6 inch weldolet connection to the main steam line. The weldolet has a stress intensification factor that should be included in the evaluation of relative stresses.*

FPC Response

The Analysis of Record (AOR) decouples the two EFP turbine supply lines from the main steam piping, based on the ratio of the run (main steam) and branch (EFP turbine supply) section properties. The 24 inch main steam piping is modeled as a rigid member for the branch line analyses. A rigid anchor is modeled at the main steam piping centerline. The 6 inch weldolet, 6 inch x 3 inch reducer, and 3 inch valve are all accounted for in the model. Conservative section properties for all the piping components were used in the AOR, along with Stress Intensification Factors (SIF) of 1.0 as required by the COR for the weldolet and reducer.

In the CR-56 analysis problem, the calculated weldolet stresses (Pressure + Deadweight + OBE + Thermal Expansion) are approximately one-fourth the AOR stresses at the 3 inch reducer end. For the CR-4A analysis problem, the weldolet stresses are approximately one-fifth the AOR stresses at the 3 inch reducer end. These local stresses are tabulated below.

TABLE 1

| EFP Turbine Supply Calculations | | | | | | |
|---|---|---|---|---|---|---|
| | CR-4A | | | CR-56 | | |
| Component | Node | COR Stress (psi) | NC Stress (psi) | Node | COR Stress (psi) | NC Stress (psi) |
| Weldolet-24" Connection | 50A | 4350 | 5461 | 151 | 3663 | 4476 |
| Weldolet-6" End | 99 | 4313 | 5450 | 151A | 3644 | 4449 |
| Reducer-6" End | 99 | 9168 | 11955 | 151A | 7707 | 9669 |
| Reducer-3" End | 100 | 21411 | 34853 | 150 | 14128 | 23491 |

Using more recent Code guidance such as ASME Section III, Subsection NC, 1980, the reducer has a calculated SIF of 2.0 and the weldolet, a calculated SIF of 1.9. The NC based stresses are also shown in the table. Thus, the 3 inch reducer end has the highest expected stress. The reducer is the limiting component in the EFP turbine supply piping using either the COR or other Code methods which are applied consistently for determining pipe component stress.

Because the reducer is the limiting component for the postulation of a terminal end HELB location based on stress, a discussion of the background of the development of the reducer component stress is in order. This discussion will help clarify which location on the reducer is the most critical local section of the component, based on the SIF methodology, and help support the selection of the reducer location with the potential for the largest stress.

The calculated stress for the reducer component is based on a SIF value experimentally determined by A.R.C. Markl in the early 1950s. This SIF value is the one documented in ANSI B31.1-1967. Based on this work, the controlling location for the reducer in response to cyclic moment loadings was the smaller end.

This result was later confirmed by Rodabaugh and Moore, and presented in WRC Bulletin 285 (1983). WRC 285 contains the basis for the later Code changes in SIF values for reducer components. This evaluation also showed that for moment loadings, the smaller end had the higher stress. Pressure loadings were also addressed in WRC 285. For the specific component at hand, a 6 x 3 Schedule 40 reducer, the calculated pressure stress at the small end was equal to or greater than the pressure stress at the larger end (within the accuracy of the analysis results.)

Thus, the conclusion reached on the basis of a review of the background for determining reducer stresses is that the smaller end of the component is the limiting section.

## NRC Question 2

*The licensee's evaluation did not address the stresses in the main steam line at the weldolet connection. Since this is a branch connection, the main steam line will also see a local stress intensification at the connection.*

## FPC Response

Weldolets are generally used in applications where the branch-to-run pipe ratio is less than one-half, as in the EFP turbine supply/main steam line case. The SIF equation in the Bonnie Forge Weldolet Addendum, dated January 30, 1976 is based on tests with a 1.0 ratio (4 x 4 x 4 piping). This gives conservative results when compared to other branch/run methods, such as ASME Section III, Subsection NC, 1980, which may also be used for branch piping ratios below 0.5.

Weldolet SIFs for the main steam run piping were calculated to be 2.12 and 1.5 based upon manufacturer and ASME III guidance, respectively. The main steam piping AORs were reviewed and the piping moments at the weldolet connection were tabulated.

Recent Code methods were used with the AOR moments to compare the resulting stresses with the COR results. All stresses would meet recent Code requirements. The break postulation stresses (Pressure + Deadweight + OBE+ Thermal Expansion + SRV lift) for the main steam piping are tabulated below.

TABLE 2

| Main Steam Calculations | | | | | | |
|---|---|---|---|---|---|---|
| Main Steam Problem | Weldolet Node | Weldolet SIF | COR Break Stress (psi) | "Recent" Break Stress (psi) | Break Threshold (psi) | "Recent" Break Ratio |
| CR-4 | 50 | 2.12 | 12777 | 18383 | 30000 | 0.613 |
| CR-5 | 73 | 2.12 | 11561 | 18484 | 30000 | 0.616 |
| CR-4 | 50 | 1.5 | 12777 | 14483 | 30000 | 0.483 |
| CR-5 | 73 | 1.5 | 11561 | 14555 | 30000 | 0.485 |

Comparing these values to the reducer component values in Table 1 leads to the conclusions:

> The 3 inch reducer end with a SIF of 2.0 results in reducer stresses of 23.5 ksi (CR-56) and 34.9 ksi (CR-4A) as shown in Table 1. The 3 inch reducer end stresses in Table 1 are all significantly higher than the expected 14.6 ksi in Table 2, and a minimum of 27% higher than the most conservatively calculated main steam line stresses.

Therefore, FPC concludes that no breaks need to be postulated at the main steam weldolet location based on stress considerations which use either the methods of B31.1 or the more recent Subsection NC methods. The 3 inch end of the reducer is the most limiting component in the main steam/EFP turbine supply piping configuration.

## NRC Question 3

*The licensee's evaluation did not include a comparison of thermal stresses including thermal transient stresses in the piping components. These stresses can not be evaluated based on a simple comparison of section properties.*

## FPC Response

FPC's analysis for the main steam piping did take thermal expansion loading into account for qualification to the B31.1 stress limits and these loadings were intensified to develop local stresses. An assessment of thermal transient effects is not required by B31.1 or the more recent ASME III, Subsections NC or ND. Thermal cycling would be covered as part of the thermal expansion evaluation.

The impact of thermal gradients is reduced for this piping because the EFP turbine supply lines are kept "hot" by maintaining steam flow through them. The weldolet, reducer, and steam isolation valve in each line do not experience large thermal gradients when the EFP turbine is required to operate, and as a result thermal transient effects are small. In the past, the EFP turbine supply lines were isolated by the steam isolation valves (MSV-55 & MSV-56) located just downstream of the reducer. The operation of these supply lines was changed several years ago because of turbine overspeed problems caused by water entering the turbine. The water came from the condensed steam that remained in the line after isolation.

The NRC expressed a concern during the telecon that this past overspeed problem could have had some effect on the weldolets and reducers which might not be reflected in the calculations FPC performed to resolve the HELB problem. Before responding to that concern, a description of the EFP turbine supply piping from the turbine back to the main steam connections is in order to understand our conclusions.

Over 20 feet of the 4 inch EFP turbine inlet piping is connected to a 10.5 foot long, 5 inch Schedule 40 header, to which both the CR-4A and CR-56 piping segments are connected. The header run has a four-way anchor (i.e., restrain all 3 forces and 1 of 3 moments) at a tee connection less than 2 feet away. There are five-way anchors at the elbows at either end of the header run of pipe. These two anchors only allow for axial thermal growth. The CR-56 piping goes though 13 changes of direction, 12 dynamic restraints, and over 190 feet of pipe to reach the reducer/weldolet area. Similarly, the CR-4A piping goes through 7 changes of direction, 6 dynamic supports, and over 80 feet of piping before reaching the reducer/weldolet area.

Dynamic effects of the turbine overspeed events could not propagate to the reducer/weldolet location without significantly damaging the piping local to the three anchors just upstream of the turbine. FPC can find no objective evidence that water hammer occurred or that either end of the supply lines experienced any excessive movement due to a potential water hammer. FPC has examined its records relating to the turbine overspeed and the decision to open these lines. This review also included a discussion with an engineer present at the EFP turbine during the overspeeding problem. He does not recall any unusual noises in the pipe which would indicate water hammer or movement of the supply piping. The problem was limited to turbine overspeeding. FPC considers any loading effects to have been local to the turbine inlet. These events are judged not to be significant to the main steam connection due to the distance and number of supports between the turbine and the main steam connection.

In conclusion, the thermal transient effects on this piping in the vicinity of the main steam connection are small. Thermal expansion (and thermal cyclic operation) have been considered in the qualification of main steam/EFP turbine supply high energy piping.

## NRC Question 4

*In the December 4, 1991 meeting, the licensee stated that it may be necessary to perform additional examinations and fracture mechanics analyses to support the postulation of the breaks in the 3 inch end of the reducers. The licensee's submittal concluded that these examinations and analyses were not necessary based on the evaluation in the submittal. However, the staff does not consider the licensee's current evaluation sufficient to support this conclusion.*

## FPC Response

Based on our responses to the other three questions, FPC can conclude that further examinations and/or analyses are not necessary because we have shown:

1. The 3 inch end of the reducer component is a more limiting component than the weldolet component using either the B31.1 Code or the more recent ASME III Code when the piping component stresses are considered.

2. The weldolet connection will not produce main steam line stresses above the break postulation threshold, even considering conservative Code methods.

3. Thermal expansion loadings have been included and thermal transient effects are considered small for the local main steam/EFP turbine supply piping connection.

4. The past turbine overspeeding problem was corrected by changing the operating practices. There is no objective evidence that the overspeeding influenced the stresses at the weldolet/reducer locations.