UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

OCT 27 1983

Docket No. 50-237
LS05-83-10-063

Mr. Dennis L. Farrar
Director of Nuclear Licensing
Commonwealth Edison Company
Post Office Box 767
Chicago, Illinois 60690

Dear Mr. Farrar:

SUBJECT: IPSAR SECTION 4.7, EFFECTS OF PIPE BREAK ON STRUCTURES, SYSTEMS AND COMPONENTS INSIDE CONTAINMENT FOR DRESDEN NUCLEAR POWER STATION, UNIT 2

In the Integrated Plant Safety Assessment Report (IPSAR) for the Dresden Unit 2 Nuclear Power Station, NUREG-0823, dated February 1983, Section 4.7 identified four issues requiring refined engineering analysis or continuation of an ongoing evaluation.

As discussed in the enclosed Safety Evaluation Report, the staff considers IPSAR Section 4.7 to be complete.

Sincerely,

Dennis M. Crutchfield, Chief
Operating Reactors Branch #5
Division of Licensing

Enclosure:
As stated

cc w/enclosure:
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DRESDEN NUCLEAR POWER STATION, UNIT 2
IPSAR SECTION 4.7

Section 4.7, Effects of Pipe Break on Structures, Systems and Components Inside Containment

I. INTRODUCTION

At the time of the Integrated Plant Safety Assessment for Dresden Unit 2, the licensee had not completed its review of the effects of high energy line breaks. Review methodology and screening criteria for acceptable interactions had been provided and reviewed by the staff. The staff safety evaluation was issued by letter dated September 21, 1982 (Reference 1). The Integrated Plant Safety Assessment Report (IPSAR), NUREG-0823, dated February 1983 (Reference 3) identified four items for further evaluation. Resolution of each item is discussed below. In addition, the results of the licensee's analyses as provided in Reference 2 are discussed.

II. DISCUSSION

A. Section 4.7.1, Jet Impingement on Target Pipe

In the Integrated Plant Safety Assessment Report, the staff reported that in considering the damage criteria, the licensee has used the assumption that a jet or whipping pipe is considered to inflict no damage on other pipes of equal or greater size and equal or greater thickness.

The licensee provided some justification leading to the conclusion that the same rule that is applicable to pipe whip should also be applicable to jet impingement considerations. However, the staff's position was that the energy absorption mechanism for a pipe-to-pipe impact is different from that for jet impingement on a pipe and, therefore, the staff required the licensee to evaluate and address the effects of jet impingement regardless of the ratio of impinged and postulated broken pipe sizes.

In responses to the staff's concern, the licensee submitted Reference 2 which described the assumptions and criteria used in its final evaluation of jet impingement effects. Based on the information provided in Reference 2, we have found that the licensee has reassessed its jet impingement evaluation in accordance with the staff's position as described above and that the licensee's evaluation is acceptable.

B. Section 4.7.2, Broken-Pipe Impact on Target Piping

In the Integrated Plant Safety Assessment Report, the staff reported that in determining the acceptability of target piping, the licensee has used the criterion that the limiting factor for an applied equivalent static load is that the resulting strain in the target piping material should not exceed 45% of the minimum ultimate uniform strain of the material at the appropriate temperature. This criterion is acceptable for avoiding cascading pipe breaks. However, some piping systems are required to deliver certain rated flow and should be designed to retain dimensional stability when stressed to the allowable limits associated with the emergency and faulted conditions; i.e., the functional capability of the piping is required to be demonstrated. The licensee was requested to provide justification to ensure that the target piping will remain functional as a result of jet impingement and pipe whip interactions.

The licensee indicated that a parametric study has been performed covering a range of geometric and load parameters. The results of the nonlinear finite-element dynamic analysis indicated the coexistence of large localized strain levels and small global deformations. Thus, the licensee determined that it is possible to achieve strain levels approaching 45% of the minimum uniform ultimate strain of the material in a localized region without effecting the overall deformation or functional capability of the target piping.

In reviewing the example in the licensee's parametric study submitted in its August 23, 1982 letter (Reference 7), the staff found that the 45% of the minimum uniform ultimate strain reached at the point of load application was a global strain because a beam model was used for analysis. The licensee was requested to demonstrate that the resulting localized deformation, i.e., the flow area reduction, would not affect the systems capability to deliver the required fluid flow.

In response to the staff's concern, the licensee submitted References 2 and 4. The licensee indicated that a more detailed shell model analysis using ANSYS was performed to further substantiate its previous conclusion. The shell analysis showed that the maximum strain was 25% of the minimum uniform ultimate strain of the material and that the maximum flow area reduction was 20%. The licensee further stated that the functional capability of the target pipe is not significantly affected as a result of a postulated 20% reduction in flow area. Based on a review of the information in References 2 and 4, we have determined that the licensee's target pipe evaluation is acceptable.

C. IPSAR Section 4.7.3, Detectability Requirements

One method acceptable to the staff for resolution of pipe break scenarios where remedial measures are impractical consists of (1) fracture mechanics evaluation to show stability of flaws under postulated loads; (2) demonstration that smaller flaws are detectable via leak detection systems; and (3) augmented inservice inspection. In its screening review, the licensee proposed use of this general approach in resolving pipe break interactions.

In the IPSAR, the staff noted that the licensee's proposed approach for detection of cracks as part of this method was not acceptable. During the licensee's detailed review of break interactions, all interactions were resolved without recourse to the fracture mechanics/leak detection approach. Therefore, this issue is no longer applicable.

D. IPSAR Section 4.7.4, Criteria Implementation

Two areas were identified during the topic review where the licensee's approach was found to be generally acceptable pending staff review of the results.

The staff requested the licensee to provide information on pipe whip load formulation including a discussion of how the kinetic energy of the whipping segment was determined. In Reference 8, the licensee has described its method for determining the pipe whip impact velocity, plastic hinge formulation and deformation of the impacting target and whipping pipe. Based on our review of the information provided in the licensee's submittal, we have determined that the licensee's methodology for pipe whip load formulation is acceptable.

The second item was concerned with integrity of the drywell liner. As discussed in the Integrated Plant Safety Assessment, the licensee was requested to address whether there were any break locations that could result in sharp edges perforating the liner from large piping (>14") impacting with the liner. Test results (Reference 6) have previously shown that when the liner is loaded over a large enough area, deformation of more than three inches can occur without failure of the liner. However, the staff was concerned that the liner could be punctured if a jagged edge whipped into the liner over a local area.

In Reference 2, the licensee presented an analysis of the containment liner to show that perforation would not occur. Missile impact test results were used along with the above static load test to support the analysis.

As part of these tests, a 12 inch diameter steel pipe was driven into a 3/4 inch steel plate end-on. Displacement without rupture of more than three inches resulted. These tests are considered to be appropriate for evaluation of the Dresden Unit 2 liner since it is at least 3/4 inch thick and the gap is three inches. The test velocity exceeded the calculated pipe whip velocity for all but one case. In Reference 5, the licensee provided additional information on the one case in which contact with the liner occurs at a feedwater line reducer (18" to 12"). The whipping feedwater pipe forms a plastic hinge and then the reducer contacts the liner along the pipe and thus flattens against the liner. Therefore, the consequences of this case are considered to be bounded by the above tests.

Based on our review, the staff concludes that the licensee has demonstrated that postulated high energy line breaks will not violate the integrity of the liner. Therefore, this issue is resolved.

E. Pipe Break Interactions

As discussed in the licensee's submittals and the staff's SER (Reference 1), the licensee developed screening criteria for considering pipe break interactions. Those cases that met the criteria (e.g., limit load analysis or no interaction physically possible) did not require further investigation. For those interactions which failed to meet the screening criteria, more detailed analyses were conducted. There were 27 break locations (40 interactions) in this category. Seventeen (17) of the interactions involved electrical components. In these cases, the licensee determined either that the affected equipment (generally a cable tray) was not required to mitigate the break or that redundant equipment capable of performing the same function was available.

Four cases involved target piping. These interactions were resolved by more refined analyses of thrust forces considering the individual characteristics of each line. Three interactions on the biological shield wall and one with the RPV pedestal were resolved in a similar manner; an additional shield wall case was resolved since the broken pipe would hit the liner first.

For the remaining 14 interactions, finite element models of the source piping were developed and the ANSYS code was used to perform a non-linear dynamic transient analysis. In one case, this detailed analysis showed that the target would not be contacted by the whipping pipe. The other cases were interactions with the liner or at a penetration sleeve/liner junction. In each case, the penetration sleeve did not become plastic and the maximum plastic strain in the vicinity of the impact was 1.54%, which is below the ultimate strain level.

III. CONCLUSIONS

Based on the discussion above, the staff concludes that the licensee has adequately addressed the effects of high energy line breaks inside containment. Therefore, IPSAR Sections 4.7.1, 4.7.2, 4.7.3, and 4.7.4 are resolved.

IV. REFERENCES

1. Letter from P. O'Connor (NRC) to L. DelGeorge (CECo), dated September 21, 1982.

2. Letter from J. J. Rausch (CECo) to P. O'Connor (NRC), dated November 17, 1982, transmitting the Final Report 1105 CECO-01.

3. NUREG-0823, Integrated Plant Safety Assessment Report, Systematic Evaluation Program for Dresden Nuclear Power Station, Unit 2, dated February 1983.

4. Letter from T. J. Rausch (CECo) to P. O'Connor (NRC), dated January 10, 1983.

5. Letter from B. Rybak (CECo) to R. Gilbert (NRC), dated September 12, 1983.

6. Thullen, P., "Loads on Spherical Shells," Oak Brook Engineering Department, Chicago Bridge & Iron Company, August 1964.

7. Letter from T. J. Rausch (CECo) to P. O'Connor (NRC), dated August 23, 1982.

8. Letter from B. Rybak (CECo) to R. Gilbert (NRC), dated October 3, 1983.