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October 3, 1983

Mr. Robert Gilbert
Operating Reactors Branch No. 5
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Dresden Station Unit 2
SEP Topic: III-5.1,
Section 4.7.4
NRC Docket No. 50-237

Reference (a): D. M. Crutchfield letter to D. L. Farrar dated March 16, 1983; Enclosure 2, Para. 1.

Dear Mr. Gilbert:

In response to the NRC's questions in the referenced letter and paragraph which asks for additional information about the final report on pipe breaks inside the containment, the responses are provided in the attachment to this letter. The referenced paragraph consists of four distinct questions, each one being answered separately.

Responses to the remaining questions of the referenced letter, namely Enclosure 1 and Paragraph 2 of Enclosure 2, are to follow in a separate letter.

Please address any questions you may have concerning this matter to this office.

One signed original and forty (40) copies of this transmittal is provided for your use.

Very truly yours,

B. Rybak

B. Rybak
Nuclear Licensing Adminstrator

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cc: Region III Inspector Dresden (w/a)
Greg Cwalina, SEP Project Manager (w/a

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Response to Questions
Dresden Nuclear Power Station, Unit 2
Pipe Break Inside Containment
SEP Topic III-5.A, IPSAR Section 4.7.4

1.0 Q. Please describe how your formulation of pipe whip loads compares with the criteria of SRP Section 3.6.

A. As indicated in References 1 and 2, the procedure used to formulate pipe whip loads for interaction evaluation involves determining the impact velocity and from it the impact force of the whipping pipe on a target. The equations used to evaluate the velocity and force incorporate the criteria for dynamic analysis as presented in SRP Section 3.6. Impact forces predicted by calculation were compared to those analyzed through detailed mathematical models meeting the model criteria of SRP Section 3.6 and were found to be comparable but conservative.

The impact velocity is calculated by one of two equations depending on the existence of sufficient driving energy to create a plastic hinge in the ruptured pipe. Impact velocity for a pipe experiencing a plastic hinge is calculated from Equation 1.1, and for a pipe moving elastically it is calculated from Equation 1.2

$$V = L\left[\frac{2(TL-M_p)\Theta}{I}\right]^{\frac{1}{2}} \qquad \text{(Eq. 1.1)}$$

$$V = \left[\frac{\delta}{m}(2T - k)\right]^{\frac{1}{2}} \qquad \text{(Eq. 1.2)}$$

where:

k = stiffness of cantilever elastic whipping pipe

m = effective mass of the whipping pipe

I = rotational mass moment of inertia of pipe

L = span length of whipping pipe

T = thrust force of jet

M_p = plastic moment of whipping pipe

δ = deflection of elastic pipe at impact

Θ = displacement angle between initial and impact position of pipe

2.0 Q. How was it determined whether a plastic hinge was formed and thus what the available kinetic energy of the whipping pipe segment was?

A. In order to ascertain the potential for plastic hinge formation in a ruptured pipe, a pivot point is postulated. From inspection of piping isometric drawings and evaluation of the effects of jet direction, piping bend locations and adjacent supports the potential pivot point of the ruptured pipe is selected. The whipping pipe is considered to be a cantilever, free at the break location and fixed at the pivot point. The length of this whipping pipe span is used in kinetic energy and velocity calculations as discussed in the response to Question 1.

Depending upon the length of the whipping pipe and the distance from the break point to the target, the whipping pipe may either form a plastic hinge or behave as an elastic single-degree-of-freedom system. Using the cantilever model, the minimum deflection at which a plastic hinge can form is given by:

$$\delta_p = \frac{M_p L^2}{3EI} \qquad \text{(Eq. 2.1)}$$

If the distance from the initial pipe position to the target, δ, is $\geq \delta_p$ then plastic hinge formation in the whipping pipe may be assumed and the calculation of impact velocity is performed using Eq. 1.1. If $\delta < \delta_p$, the ruptured pipe will not form a plastic hinge and its impact velocity will be calculated using Eq. 1.2. In either event, once the impact velocity is computed either the whipping pipe's kinetic energy or the statically equivalent force imparted to the target may be calculated.

3.0 Q. How was Reference 1 (Enis, R.O.: Bernal, D.B.; and Burdette, E.G.; "A Design Guide for Evaluation of Barriers for Impact from Whipping Pipes " - Paper from Second ASCE Conference on Civil Engineering and Nuclear Power, September 1980) used in this evaluation?

A. The TTL Final Report 1105 CECO-01, Dresden Unit 2 SEP Topic III-5.A, Effects of Pipe Break on Systems Structures and Components Inside Containment states in Section 4.1.1 that local crushing characteristics of the impacting and target pipes are considered in determining the strain energy of deformation upon impact. These crushing characteristics are determined according to the method presented in the subject Reference 1. This method combines the contribution of ring crush and indentor crush to define the pipe stiffness k as shown in Equation 3.1.

$$k = 4.86\ \sigma_y \ell_e\ [(t/D)^2/(1-t/D)]+(80000/D)(t/.349)^2(4.5/D)^{.27}\ \text{lb/in.} \quad \text{(Eq. 3.1)}$$

where t = wall thickness

D = mean diameter

ℓ_e = length of pipe crushing as a ring, assumed to be two times the outside diameter

The deformation of impacting target and whipping pipes may be expressed in terms of their respective stiffnesses, k_W and k_T, and the force causing the deformation as follows:

$$\delta_W = F/k_W \quad \text{and} \quad \delta_T = F/k_T \qquad \text{(Eq. 3.2)}$$

Using these expressions for deformation and equating the kinetic energy of the whipping pipe at impact to the deformation strain energies of the whipping and target pipes results in the following equation for the impact load F:

$$F = V\left[\frac{m_W}{2(1/k_W + 1/k_T)}\right]^{\frac{1}{2}} \qquad \text{(Eq. 3.3)}$$

where V = velocity of the whipping pipe at impact

m_W = mass of the whipping pipe

4.0 Q. Were rebound effects considered?

A. The analytical procedures utilized in establishing criteria for acceptable pipe whip interaction did not explicitly include adjustments for rebound effects. It was considered that conservatisms incorporated in establishing the criteria provide adequate margin to cover such effects.

References

(1) Dresden Unit 2, SEP Topic III-5.A, "Effects of Pipe Break on Systems Structures and Components Inside Containment, TTL Final Report 1105-CECO-01, October, 1982.

(2) Dresden 2 Nuclear Power Station, SEP Topic III-5.A, High Energy Pipe Break Inside Containment, Interim Progress Report, TTL Report No. 1105-CECO-PR-1, May, 1982.