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September 5, 1985

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC. 20555

Subject: Byron Generating Station Unit 2
Braidwood Generating Station Units 1 & 2
Fluid Jet Impingement Analyses
NRC Docket Nos. 50-455, 50-456 & 50-457

Reference (a): August 16, 1984 letter from D.L. Farrar to J.G. Keppler

(b): January 21, 1985 letter from T.R. Tramm to H.R. Denton

Dear Mr. Denton:

This letter is intended to supply information as indicated in reference (a).

Attachment A to this letter explains the use of NUREG/CR-293 "Two Phase Jet Loads" in the review of the design of Byron Station Unit 2 and Braidwood Station Units 1 and 2 which was provided in reference (a).

One signed original and fifteen copies of this letter and Attachment A are provided for your review.

Very truly yours,

Anthony Miosi

A. D. Miosi
Nuclear Licensing Administrator

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ATTACHMENT A

BYRON 2
BRAIDWOOD 1 & 2
USE OF NUREG/CR-2913

NUREG/CR-2913, "Two Phase Jet Loads," is a document which provides a methodology for calculating HELB fluid jet loads on targets located at various distances from jet sources for different fluid properties. Sandia National Laboratory created the methodology to be consistent with test data obtained from various facilities. This data simulated typical nuclear power plant high energy line conditions and the resultant methodology is also consistent with EPRI-NP-3419. The methodology in NUREG/CR-2913 is considered to be the best available representation of the configuration of a steam or two phase jet and the resulting force on objects or surfaces near the break location. NUREG/CR-2913 does not address non-flashing subcooled liquid jets.

The Byron/Braidwood design includes many features which eliminate or mitigate damaging effects of postulated High Energy Line Breaks (HELB's). These features include design, routing, and locations of the high energy lines and the safety systems. As noted in the FSAR (Section 3.6.1.1.2), the basic design preceded NUREG/CR-2913 and also the Standard Review Plan (NUREG-75/087). The design does follow the SRP to the extent practicable in that the requirements of General Design Criteria (GDC) 4 of 10CFR50 are addressed by the design approach. This design approach follows the guidelines of Branch Technical Position APCSB 3-1 (Section 3.6.1 of the Standard REview Plan (SRP)). These guidelines state that plant designs should protect essential systems and components from the effects of high energy line failure. The preferred method of protection is separation of essential systems from HELB's by adequate distances or by structures. In the event separation cannot be used, redundant design features which are protected should be provided. If this separation or redundancy cannot be provided, restraints or barriers must be incorporated to protect essential systems.

The Byron/Braidwood design approach was centered around the early identification of the systems used for safe shutdown as well as the systems used to support safe shutdown systems. These systems were designed with adequate redundancy and functional diversity to insure that postulated events and single failures would not result in a loss of safe shutdown capability. This design was accomplished by providing separation between redundant equipment. Additional protection from HELB effects was provided by separating high energy lines from safe shutdown systems by distance or by structures (such as pipe tunnels). These separation approaches provide a high degree of protection from HELB effects such as pipe whip and jet impingement.

The Auxiliary Building compartmentalization lends itself to the separation discussed above. The Auxiliary Building structural walls and floors were designed to withstand the applicable jet impingement loads, calculated in accordance with FSAR Section 3.6.2, so that separation is maintained. More specifically, design jet loads were calculated based on Sargent & Lundy Technical Procedure No. 24 which is an application of ANS 58.2.

The Containment Building contains fewer structural barriers and, as a result, protection is, in some cases, provided by separation of HELB"s from essential components by distance or separation of redundant essential components by distance. Piping systems inside the containment are separated as a direct result of the 4-loop Westinghouse PWR Layout. Each primary loop is located in a different quandrant of the Containment. Shield walls, which are capable of withstanding dynamic pipe rupture loads, separate the primary loops from the secondary loops.

At the time electrical cables and instrument sensing lines were being routed, methodology was not available to realistically predict the extent of jet forces. In order to proceed with the design, a guideline was established for separation of redundant safe shutdown components. A separation distance of 20 feet was established. The basis for this separation distance is the very low probability of a line breaking and causing a jet that would damage two redundant cables or lines when these lines are separated by more than 20 feet. This probability is low because the breaks are postulated at discrete locations and the area affected (assuming a 10^{0} half angle per ANS 58.2) prior to reaching a significant structural component is unlikely to include two components separated by 20 feet or more. Any limitations which can be placed on jet force (beyond the effect of jet area increase) will further reduce the probability of damage.

It should be noted that this approach was only applied to dynamic effects. Environment qualification was required for safe shutdown equipment regardless of proximity to break locations.

NUREG/CR-2913 was not used in the design of the Byron/Braidwood Stations. However, it was utilized in the Byron Unit 1 design verification study completed in August 1984. The NUREG was used and additional justification for a "screening" criteria to identify the potentially important effects of jet impingement, and, in a few cases to calculate jet loads on components. For Byron 2 and Braidwood 1&2 a "screening" criteria is also used based upon NUREG/CR-2913. In a limited number of cases the NUREG will be used to calculate jet loads on components.

Each component required for safe shutdown of the plant after a HELB is identified and the potential for jet impingement is reviewed. Many of the components are easily shown to be unaffected because they are protected by structural barriers, or located such that a jet would not be oriented in the proper direction to strike the component.

Most of the components which are not obviously protected as described above are widely separated from redundant components. To avoid the lengthy process of checking lines of sight from all postulated break locations for all safe shutdown components to verify that no single jet could unacceptably damage the redundant components of a system, a screening criteria was defined to limit the review to those jets and components which could be actual concerns. NUREG/CR-2913 predicts very low loads for all applicable break conditions when the component is separated from the break by more than 10 break diameters.

Although the NUREG Indicates lower loads than the methodology endorsed by the Standard Review Plan, the differences are not very significant for most of the applicable situations with separation greater than 10 break diameters. The NUREG is applicable to steam breaks and liquid breaks which flash. Most breaks are liquid. Following the Standard Review Plan and ANSI N176 the flashing liquid break jet loading would be less than 20 psi. Loads in this range would not be expected to damage components such as structure and piping which may not be redundant. The steam line breaks, following ANSI N176, would result in a loading of up to 100 psi 10 diameters from the break. However, the only large steam breaks inside Containment are in the main steam piping which is removed from most safe shutdown components. The main steam lines exit the top of the steam generators and travel to the containment wall through a partially enclosed piping chase which limits the jet effects. Because of the arrangement of the piping, only the arbitrary intermediate breaks which now not be postulated are near safe shutdown components. NUREG/CR-2913 also shows that the ANSI N176 predictions for steam jet loading beyond 10 break diameters is excessively conservative.

The screening criteria is used to divide the Verification Procedure into steps. Potential pipe movement due to pipe whip are considered as well as jet spreading as predicted by NUREG/CR-2913. The components were considered undamaged by jet impingement if they were located more than a distance of ten diameters of the broken pipe away from the jet source. Components within ten pipe diameters were assumed to fail. Specific load calculations are performed using NUREG/CR-2913 only in those instances where failure of all components, when combined with a limiting single active failure, could adversely affect safe shutdown capability. Because the design approach utilized separation to a large extent, the number of specific calculations utilizing NUREG/CR-2913 are expected to be very few. Based upon the Byron 1 result, NUREG-CR/2913 is expected to be used for a very limited number of load calculations on structures or safe shutdown components.

The utilization of NUREG/CR-2913 leads to a conservative assessment of the design adequacy. Although the load predictions should be considered "best estimate" loads, the screening criteria is conservative because, for the applicable system conditions, loads generally become negligible at distance of less than 10 break diameters. In those cases where loads are calculated, data was used corresponding to the maximum conditions in the system. This is conservative because pressure losses due to the high break flow velocity are usually very significant but are not considered for the confirmatory study.

As noted, most components are evaluated and found acceptable not on the basis of separation from the break, but because failure will not affect safe shutdown capability. This is demonstrated even though credit is not taken for some potential shutdown methods (primary system feed and bleed, equipment repair, use of non-qualified equipment).

The limited number of components within the screening distance is a result of the basic design approach used. As demonstrated by the results of the Byron Unit 1 confirmatory study these components are generally affected only by intermediate breaks, which is also a result of the design approach. The screening and calculational procedure outlined here will be used on Byron Unit 2 and Braidwood Units 1 and 2.

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