Duquesne Light

Nuclear Construction Division
Robinson Plaza, Building 2, Suite 210
Pittsburgh, PA 15205

2NRC-5-112
(412) 787-5141
(412) 923-1960
Telecopy (412) 787-2629
7-31-85

United States Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: Mr. Harold R. Denton
Office of Nuclear Reactor Regulation

SUBJECT: Beaver Valley Power Station - Unit No. 2
Docket No. 50-412
Alternate Approach for Providing Protection Against Pipebreaks

Dear Mr. Denton:

In our meeting on Monday, July 22, 1985 we discussed an alternate approach for providing protection against pipe breaks, that we would like to employ at Beaver Valley Power Station Unit No. 2. We believe this alternate approach will lead to greater safety and reliability with lower costs then conventional methods.

You asked that a written overview of our proposed alternate method be sent to you. Our program which is entitled "WHIPJETS" is enclosed. After you and your staff have reviewed the program, we would be pleased to discuss it in detail with you.

Thank you for your consideration of this matter.

DUQUESNE LIGHT COMPANY

By J J Carey
J. J. Carey
Vice President

JJC:aev
Enclosure

Copies to: Mr. B. K. Singh, Project Manager-w/enclosure
Mr. G. Walton, NRC Resident Inspector-w/enclosure

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WHIPJET

A Proposal For Alternate Pipe Rupture Protection Using A Leak-Before-Break Approach

Beaver Valley Power Station - Unit 2
Duquesne Light Company

WHIPJET

1.0 INTRODUCTION

WHIPJET is a proposed program to provide for protection against pipe break by means of engineering analysis and design instead of arbitrary installation of protection devices of questionable value. In the following paragraphs, a brief technical and regulatory background for this proposed change is discussed. Next, the outlines of the basic engineering program are presented with specific reference to applicable methodology and technical justification.

2.0 BACKGROUND

In recent years, the NRC has been attempting to both provide better management and to consider the economic costs of regulations. In particular, as technology has advanced, the NRC has been receptive to alternate regulatory approaches provided safety issues are satisfied or improved. The advance of fracture mechanics technology in recent years is the catalyst that has led to changes in the regulatory environment surrounding pipe break protection. Advancing technology is the key. Within the last five years, engineers have developed proven and reliable theories to predict pipe failure, and in particular, to predict whether a given defect in a pipe will cause a leak or a catastrophic pipe break (Ref. 6, 7, 8 & 9). This leak-before-break (LBB) technology is being accepted by the NRC and is leading to change in traditional ways of protecting the health and safety of the public in the unlikely event of pipe breaks.

The movement to improve pipe break protection regulation saw its first measurable progress in 1983. In June of that year, the ACRS heard presentations from the NRC staff and its own Subcommittee on Metal Components (Ref. 1) regarding a proposed criterion to replace the double ended guillotine break (DEGB) with a leak-before-break (LBB) fracture mechanics concept. With certain caveats, the ACRS found "this procedure to be an acceptable and proper approach to the problem" including a decoupling of the loss of coolant accident and seismic loads.

In July of 1983, the NRC informed the ACRS (Ref. 2) that the NRC staff is "developing an approach to allow elimination of the DEGB on a case-by-case basis" and further that "this approach would also be applied in evaluating requests for elimination of the DEGB in other portions of the reactor coolant systems if the submittals accompanying such requests adhere to the staff's proposed criteria." The referenced letter mentioned some technical qualifications that would need to be considered and informed the ACRS that the Standard Review Plan (SRP) would be revised.

The Atomic Industrial Forum (AIF) has also been active in this area on the part of industry. Alternate pipebreak criteria have been developed and were suggested to the NRC in July 1983. A summary discussion of these activities and criteria is given in Reference 3.

In accepting the proposed resolution to Unresolved Safety Issue A-2, the Committee to Review Generic Requirements (CRGR) stated that "the CRGR observed that these findings and the technical justification in support of the findings could extend to other break locations and to assumptions previously made for piping loops and components of the reactor coolant system, for piping connected to the coolant system, and perhaps to the piping of other systems in the plant" (Ref. 3). The CRGR clearly recognized that the LBB engineering approach is applicable to essentially all piping.

On July 29, 1984, the Director of Nuclear Reactor Regulation requested that rulemaking be initiated regarding alternatives to the postulation of pipe breaks and protection against associated dynamic effects (Ref. 4). The letter requests that rulemaking be initiated "to enable the use of advanced fracture mechanics technology to determine the appropriate dynamic effects to be considered". It stated that the task is urgent, and requested that it be completed within one year (by June 1985).

The first instance of revised regulatory guidance to the industry was the NRC Generic Letter 84-04 on February 1, 1984 (Ref. 5) which permitted the use of LBB methodology to eliminate the need for postulating pipe breaks on the reactor coolant loop. Removal of pipe rupture mitigation hardware enhanced personnel and plant safety by:

- o minimizing personnel radiation exposure during maintenance and inspection,
- o minimizing restrictions to inservice inspection ,
- o providing early indications of leakage, and
- o minimizing unanticipated thermal expansion stress in piping due to interference with pipe rupture mitigation hardware.

In addition, the elimination of pipe rupture restraints and jet shields represents a significant cost saving during the design construction and commercial operation of the plant.

The relief was accorded primarily because:

1. Fracture technology has advanced to the point that relief can be honestly given.

2. The main loop has been extensively studied using LBB methodology.

It is clear that a genuine need exists to apply LBB to the other break locations. The remaining whip restraints and jet shields add many times more cost and encumber the plant much more than do the main loop devices. On the other hand, the engineering work has not been completed on other locations. That fact, and the fact that the leak-before-break technology is applicable to balance-of-plant piping, is the point of this proposal.

3.0 TECHNICAL APPROACH

Duquesne Light Company has received two exemptions to reduce the number of pipe rupture restraints and jet shields to be installed in Beaver Valley Power Station - Unit 2:

1. the schedular exemption of pipe breaks on the reactor coolant loops in response to NRC Generic Letter 84-04 (Ref. 5), and

2. the elimination of arbitrary intermediate breaks from piping for several systems other than the primary loops.

A substantial number of terminal end breaks and intermediate breaks beyond the scope of these requests will continue to require the installation of pipe rupture restrains and/or jet impingement shields.

The WHIPJET program is an alternate approach to the consideration of the remaining pipe breaks.

3.1 GENERAL CONSIDERATIONS

Several utilities have requested that the NRC permit the elimination of the arbitrary intermediate pipe breaks from the design basis. The NRC is judging these requests based upon a review which has specifically addressed:

- Cost/safety benefits
- Stress corrosion
- Thermal/vibration fatigue
- Water hammer
- Environmental effects
- Welded attachments

The logic of this approach is that the postulated arbitrary intermediate pipe breaks contributed only marginally to protection from postulated pipe ruptures and perhaps degraded overall plant and personnel safety. Therefore, they could be dropped from the design basis provided the above considerations were addressed and shown not to be serious weaknesses.

The logic associated with the approach proposed herein is to develop a program based upon the principles employed in consideration of the main loop pipe breaks. Specifically, the following is suggested.

- It is not proposed to drop pipe breaks from consideration
- It is proposed to analyze the potential for pipe breaks as discussed in Section 3.2 herein.

- o If the potential is sufficiently small, then eliminate the whip restraints or jet shields.
- o If the potential is significant, then retain the protection devices
- o Retain the equipment qualification requirements applicable to non mechanistic aspects of pipe rupture postulation.

More generally, the concept is to provide for pipe break protection by a higher level of engineering effort applied to evaluation of piping and plant design as well as considering the operations of the plant. In view of the fact that pipe leaks are or will be shown to be much more probable than pipe breaks, designing for leaks explicitly will significantly improve plant safety. Fundamentally, it is not proposed to circumvent a regulation, but rather that it be satisfied in a more rational manner which will lead to improved plant design, operation, and safety. This is basically the direction in which the NRC is moving.

The first step in this effort will be to establish the engineering program which is outlined in the following paragraphs.

3.2 ENGINEERING PROGRAM

All the factors that were evaluated in the request to eliminate the arbitrary intermediate breaks will need to be considered. Some of the work done in that effort will be sufficient, but it is expected some will require evaluation in greater depth. A fundamental component of the program will be the fracture mechanics leak-before-break analyses. It presently appears that an engineering program as outlined below would be appropriate.

3.2.1 Background

Give the background to the approach including a review of developments in the area of fracture mechanics and recent NRC actions.

3.2.2 Stress Corrosion

Review the potential for stress corrosion cracking of piping on a system-by-system basis. Assess stress levels, temperature, and corrosive environment, which are the three necessary conditions for stress corrosion. This is to be done for each class of piping materials.

3.2.3 Water Hammer

Assess the potential for harmful water hammer on each individual system based on system design and operating experience. Much of this work has been completed.

3.2.4 Fatigue

Assess the potential for the formation of fatigue cracks. In-depth fatigue analyses has been or will be completed for all Class 1 lines on the same basis as that for the main loop. It will be worthwhile to compare usage factors for Class 1 lines to that of the main loop.

The fatigue resistance of Class 2/3 high energy lines will be evaluated to assure that those attributes which are substantially different from Class 1 lines are not detrimental. The evaluation will address three broad groups.

1. Those which are directly attached to Class 1 piping. Quantitative inferences of the fatigue strength of these systems can be developed from the Class 1 fatigue analyses which are relatively applicable.

2. Cold lines which experience few or no thermal cycles and can be shown to have cumulative usage factors below 0.1 using approximate methods.

3. Lines which experience fatigue load but are not within the jurisdiction of existing Class 1 fatigue information. Specific fatigue information will be developed for this group and analyses performed as required.

It will be necessary to have a sound characterization of the fatigue capability of these systems to permit accurate conclusions to be drawn on leak-before-break potential. The results of this work will form a basis for postulating piping defects to be used as inputs to the fracture mechanics analysis.

3.2.5 Equipment Support Analyses

As part of the WHIPJET program, the effect of failure of major equipment supports must be considered. Support failure must be examined to ensure that piping integrity is not compromised. Generic Letter 84-04 discusses pump support, steam generator support, and core support modifications required in some Westinghouse plants for primary coolant loop whip restraints removal (Ref. 5). For the non-primary coolant loop piping, different equipment supports will be involved.

First, a criteria on which equipment supports need to be examined will be established. This criteria will be based on which supports can cause pipe failure. Next, a structural analysis will be performed to prove that the critical equipment supports do not cause failure. Should modifications to equipment supports be necessary, they will be made.

3.2.6 Leak-Before-Break Analyses

The purpose of this work will be to prove that the high energy piping containing postulated flaws will leak in detectable amounts before a catastrophic break will occur.

The first step will be to characterize the fracture properties of the materials. A materials testing program will be established and conducted using as far as possible actual materials in the plant obtained from fabrication remains and left overs.

Fracture mechanics analyses of two types will be performed. In the first place, small flaws based upon inspection standards will be postulated. Analyses will be performed using the amount of growth to be expected and the stability of the final crack. In the second place, through wall flaws will be postulated on a size that will leak enough to ensure detection. This configuration will be analyzed to determine the critical flaw size (the flaw size that causes a catastrophic failure) and margins on the leakage size flow will be established.

These steps are described in some detail in Reference 3 which contains recommendations of methodology and acceptance criteria by an NRC task group to NRC management. Generally, the approach outlined in Reference 3 will be followed for the individual analyses.

It is not believed that it will be necessary to perform such analyses at each tentative break location. Rather, it is believed that a serious effort of classification according to material, severity of loads (static and cyclic), pipe size and schedule, and geometrical details will permit a representative sample of tentative break locations to be selected for LBB calculations that will characterize the plant design.

3.2.7 Leak Detection

Leak detection capability at the plant will be assessed. The objective of this work will be to determine the ways and means to ensure that significant leakage from high energy lines will be detected. This will be accomplished by means of leak detection systems plus standard plant instrumentation such as pressure readings, water levels, make up flow, etc.

Technical specifications and operating instructions will be reviewed to ensure appropriate warnings and instructions are in place to ensure significant leakage will be detected and handled properly.

3.2.8 Benefit Analysis

A comprehensive analysis will be performed to establish the degree to which safety is improved due to implementation of the WHIPJET LBB program. It is clear that a comprehensive assessment of the likelihood of leakage and breakage, coupled with the improved plant layout, improves overall safety levels.

A cost/benefit analysis will also be performed. It is clear that there are significant cost savings to be quantified. Rough preliminary estimates of the overall cost savings during construction and commercial operation are shown in Section 5.

4.0 FOREIGN REGULATORY REQUIREMENTS

Many countries followed the lead of the U.S. Atomic Energy Commission (AEC) with regard to pipe breaks. With the exception of the Federal Republic of Germany (FRG), most countries accepted and retained the DEGB criteria.

German testing ruled out catastrophic failures in reactor coolant loops. Because the (1) optimum mechanical design reduced stresses, (2) materials are extremely tough, and (3) the manufacturing and processing quality is very high, postulated ruptures in the main coolant line were not needed. The FRG studies were part of the basis for the LBB justification used on axial and circumferential flaws.

In June 1984, it was reported at a Committee on the Safety of Nuclear Installations that the Italian Regulatory Authority (ENEAR) has adopted a position essentially the same as that of the FRG (Ref. 4).

5.0 COST CONSIDERATIONS

The cost considerations fall into two categories: those which can be immediately quantified in cost savings during engineering, construction, and start-up; and those which are not easily quantified, but which are important indirect cost savings.

5.1 Quantitative Cost Savings

An order-of-magnitude engineering estimate of the quantitative cost savings are shown below:

Hazards Analysis (rupture evaluation, resolution of interactions, and finite element analyses)	$ 1,420,000
Pipe Rupture Restraint & Jet Shield Design	330,000
Pipe Rupture Restraint & Jet Shield Fabrication	2,980,000
Pipe Rupture Restraint & Jet Shield Installation	1,890,000
Indirect Costs (moving equipment to accommodate restraints, reanalysis, hardening of component supports)	1,400,000
Total Quantifiable Cost savings	$ 8,020,000

5.2 Qualitative Cost Savings

Indirect "soft" cost savings associated with a leak-before-break approach include:

* increased flexibility in the construction sequence
* elimination of start-up, power ascension walkdowns, and gap adjustments
* elimination of structural changes which are due to pipe rupture restraint loads

* reduction of engineering and construction costs which are due to design and construction in congested areas

* increased outage costs due to ISI difficulties and congestion

* reduction in heat loss from piping to adjacent pipe rupture restraints

The estimated "soft" cost savings range from $4 to $8 million. Therefore, the total cost savings are in the range of $12 to $16 million.

6.0 CONCLUSIONS

By using an improved engineering analysis to provide for pipe breaks, a utility will realize many advantages. Such a course of action will physically improve the safety and the design of a nuclear power plant and will result in significant cost savings. If this approach is taken, it will improve the status of the utility with both the various State Public Utility Commissioners and the NRC Senior Staff, in that it will show reasonable aggressive management involvement to improve costs and safety.

REFERENCES

1. Letter, J.J. Ray, Chairman ACRS to William J. Dircks, Executive Director for Operations, NRC, June 14, 1983.

2. Letter, William J. Dircks, Executive Director for Operations, NRC, to J.J. Ray, Chairman, ACRS, July 29, 1983.

3. Report of the U.S. Regulatory Commission Piping Review Committee, NUREG-1061, Vol. 3, November 1984.

4. Letter, Harold R. Denton, Director, Office of Nuclear Regulatory to robert B. Minogue, Director, Office of Nuclear Regulatory Research, June 29, 1984.

5. NRC Generic Letter 84-04, "Safety Evaluation of Westinghouse Topical Reports Dealing with Elimination of Postulated Pipe Breaks in PWR Primary Main Loops" signed by D.G. Eisenhut, February 1, 1984.

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