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November 15, 1984

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

Subject: Byron Station Units 1 and 2
Braidwood Station Units 1 and 2
Elimination of Arbitrary
Intermediate Pipe Breaks
NRC Docket Nos. 50-454/455 and 50-456/457

Dear Mr. Denton:

Representatives of the Commonwealth Edison Company met with members of the NRC Staff on September 17, 1984 to discuss the possibility of applying alternative pipe break criteria in the design of our Braidwood Station. At that meeting, we discussed our approach toward elimination of arbitrary intermediate pipe breaks for various piping systems which was consistent with the approach accepted by the NRC for the Catawba and Vogtle Stations. The NRC Staff was receptive to our approach and encouraged our formal submittal for NRC approval. Enclosed for NRC Staff's immediate review are the alternative pipe break criteria which we propose to apply to our Braidwood Station, and now also to our Byron Station which would obviate the need to postulate arbitrary intermediate pipe breaks.

Arbitrary intermediate pipe breaks are those break locations, which based on piping stress analysis results are below the stress and fatigue limits specified in Branch Technical Position (BTP) MEB 3-1, but which are arbitrarily selected as the two highest stress locations between the terminal ends of a piping system as required by the BTP. It has become apparent to both the NRC Staff and the nuclear industry that this particular criterion requiring the postulation of arbitrary intermediate pipe breaks can be overly restrictive and result in an excessive number of pipe rupture protection devices which do not provide a compensating level of safety. It is for this reason as further explained and justified in detail in the Enclosure to this letter that the Commonwealth Edison Company is pursuing the application of alternative pipe break criteria in the design of our Byron and Braidwood Stations.

As discussed with members of the NRC Staff during a meeting on November 14, 1984, recent developments concerning the crush strength of the energy absorbing material (EAM) utilized in certain pipe whip restraints at our Byron Unit 1 may financially impact the Commonwealth Edison Company beyond that presented in the Enclosure.

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We have decided to replace the potentially defective EAM contained in 21 pipe whip restraints at Byron Unit 1 which are technically required and which can be replaced with relative ease. However, there are 42 additional pipe whip restraints with potentially defective EAM at arbitrary break locations. Expeditious NRC approval of this request to eliminate arbitrary intermediate breaks would resolve the EAM concern for these 42 whip restraints with no financial impact on Commonwealth Edison Company. However, if timely NRC approval of this request is not granted, alternate plans to resolve the EAM issue including further analysis and probable replacement of additional EAM would be required. Implementing these alternate plans prior to completion of the Byron Unit 1 startup program, if required, would delay the completion of the startup program and cause a financial impact on Commonwealth Edison Company. Therefore, it is imperative that the NRC expeditiously review the Enclosure and provide us with approval and or comments as soon as possible.

Attachments A and B provide a list by piping system of the ASME Class 1, 2 and 3 piping intermediate break locations which are candidates to be eliminated. Attachment C provides the technical justification for the employment of the alternative pipe break criteria. Attachments D, E, F, and H provide detailed descriptions of our provisions for minimizing stress corrosion cracking in high energy lines, minimizing the effects of thermal and vibration induced piping fatigue, minimizing steam and water hammer effects, and minimizing local stresses from welded attachments. Attachment I provides a summary of the benefits derived from elimination of the arbitrary breaks.

Attachment G is provided to supplement Attachment F and provides a detailed discussion of the water hammer prevention features of our main feedwater system. Although we recognize that the NRC has not approved the elimination of the intermediate breaks in the feedwater system at other plants due to concerns with water hammer, we believe that our Byron and Braidwood plants have adequate provisions for minimizing such affects to justify their elimination.

It is important to note that the Enclosure is based on Byron Unit 1 as-built pipe whip restraint locations and final pipe stress analyses. While the actual number of pipe whip restraints and specific break locations are finalized on Byron Unit 1, they are not yet finalized on Byron Unit 2 and Braidwood Units 1 and 2. We therefore request that the NRC review and approval of the application of the alternative pipe break criteria on Byron Unit 2 and Braidwood Units 1 and 2 be in terms of piping systems and methodology, and not in terms of the actual numbers and locations of pipe whip restraints.

Although we discussed the enclosed submittal with members of the NRC Staff at the November 14, 1984 meeting, we are available to discuss this submittal in further detail as necessary. Please advise this office as soon as possible as to your intentions and further requirements in this matter.

Very truly yours,

E. Douglas Swartz

E. Douglas Swartz
Nuclear Licensing Administrator

EDS/lm

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BYRON/BRAIDWOOD STATIONS

ARBITRARY INTERMEDIATE PIPE BREAKS

Commonwealth Edison Company (CECo) has followed closely the recent activities of the Nuclear Regulatory Commission (NRC) staff and the nuclear industry related to the treatment of design basis pipe breaks in high energy piping systems. In particular, it is noted that the NRC staff has expressed an interest in the industry's proposal to modify the current pipe break criteria to eliminate from design consideration those intermediate breaks generally referred to as arbitrary intermediate breaks, i.e., those break locations which, based on stress analysis, are below the stress limits and/or the cumulative usage factors specified in the current NRC criteria, but are selected to provide a minimum of two breaks between terminal ends. NRC staff and industry discussions with the Advisory Committee on Reactor Safeguards (ACRS) on March 29 and June 2, 1983 have indicated general agreement with these objectives and recognition that elimination of the arbitrary intermediate breaks offers considerable benefits due to the deletion of the associated pipe whip restraints and other provisions currently incorporated in plant designs to mitigate the effects of such breaks.

The break selection criteria currently employed by CECo for the Byron/Braidwood Stations is taken from NRC Branch Technical Positions ASB 3-1 and MEB 3-1. These documents require that pipe breaks be considered at terminal ends and at intermediate locations where stresses or cumulative usage factors exceed specified limits. If two intermediate locations cannot be determined based on the above, i.e. stresses and cumulative usage factors are below specified limits, then the two highest stress locations are selected.

CECo concurs with the nuclear industry in the belief that current knowledge and experience supports the conclusion that designing for the arbitrary intermediate breaks is not justified and that this requirement should be deleted. This conclusion is supported by extensive operating experience in over 80 operating U.S. plants and a number of similar plants overseas in which no piping failures have been known to occur that would suggest the need to design protective features to mitigate the dynamic effects of arbitrary intermediate breaks. Arbitrary intermediate breaks are often postulated at locations where stresses are well below the ASME Code allowables and within a few percent of the stress levels at other points in the same system. This results in complicated protective features being provided for specific break locations in the piping system that provide little to enhance overall plant safety.

In practice, consideration of these two arbitrary intermediate breaks is particularly difficult because the location of the high stress points may move several times as the seismic design and analysis of structures and piping develops. The industry recognizes that the revised MEB 3-1, which was included in the July 1981 revisions to the Standard Review Plan (NUREG-0800), provides criteria for not having to relocate intermediate break points when highest stress locations shift as a result of piping reanalysis. As a practical matter, however, these criteria provide little relief, since the burden is on the designer to prove that not postulating breaks at relocated highest stress points does not degrade safety. This may require extensive additional analysis of break/target interactions for the relocated break points and could result in design, fabrication and installation of additional pipe whip restraints at the relocated break points and elimination of previously installed restraints at abandoned break points. Early determination of exact break locations is quite important because of all the secondary effects of the pipe break to be considered.

The benefits to be realized from the elimination of the arbitrary intermediate break locations center primarily around the elimination of the associated pipe whip restraints and other structural provisions to mitigate the consequences of these breaks. While a substantial reduction in capital costs for these restraints and structures can be realized immediately, there are also significant operational benefits to be realized over the 40-year life of each plant. As identified in NUREG CR-2136, these effects are particularly in the areas of overall plant reliability and exposure of plant personnel to radiation when excessive pipe whip restraints are installed.

Access during plant operation for such activities as maintenance and inservice inspection is improved due to the elimination of congestion created by these restraints and the supporting structural steel, and in some cases due to the need to remove some restraints to gain access to welds. In addition to the decrease in maintenance effort, a significant reduction in man-rem exposure can be realized through fewer manhours spent in radiation areas. Also, the need to verify appropriate cold and hot clearances between pipes and restraints during initial heatup, which requires additional hold points during the startup phase, can be dispensed.

Recovery from unusual plant conditions would also be improved by elimination of this congestion. In the event of a radioactive release or spill inside the plant, decontamination operations would be much more effective if the complex shapes, represented by the structural frameworks supporting the restraints, were eliminated. This results in decreasing man-rem exposures associated with decontamination and restoration activities. Similarly, access for control of fires within these areas of the plant would be improved, especially under low visibility conditions. Substantial overall benefits in these areas would be realized by reducing the number of whip restraints required.

By design, whip restraints fit closely around the high energy piping with gaps typically being on the order of half an inch. These restraints and their supporting steel increase the heat loss to the surrounding environment significantly. Also, because thermal movement of the piping system during start-up and shutdown could deform the piping insulation against the fixed whip restraint, the insulation must be cut back in these areas, creating convection gaps adjacent to the restraint, which also increases heat loss to the environment. This is a major contributor to the tendency of many containments to operate at temperatures near technical specification limits. The elimination of whip restraints associated with arbitrary intermediate breaks would assist in controlling the normal environmental temperatures and improving system operational efficiency.

For the above reasons, CECo requests NRC approval of the following for the application of alternative pipe break criteria which would eliminate the need to postulate arbitrary intermediate pipe breaks, i.e., those break locations which, based on stress analysis, are below the stress limits and the cumulative usage factors specified in the current NRC criteria, but are selected to provide a minimum of two breaks between terminal ends:

<u>ASME Section III Piping Inside Containment</u>

- Piping systems shall be designed to accommodate pipe breaks at terminal ends and locations where the stress or usage factor criteria of MEB 3-1 are exceeded. No arbitrary intermediate breaks will be postulated when the stress and/or usage factor criterion are not exceeded.

- For breaks that must be taken, the design will accommodate pipe whip, jet impingement, and compartment pressurization resulting from mechanistic treatment of the break. Current acceptable methods for limiting break opening, moderate and low energy exclusions, limited duration operation, etc. may still be applied.

- For flooding evaluation, environmental qualification of equipment and structural design of areas traversed by high energy piping systems, breaks will continue to be postulated in accordance with the present project criteria, i.e., in each area traversed by the high energy piping system, non-mechanistic breaks are postulated at the location that results in the most severe environmental consequences. Therefore, elimination of the arbitrary intermediate breaks will not impact the flooding evaluation, environmental qualification program or plant structural design.

<u>ASME Section III and Seismically Designed Non ASME Section III Piping Outside Containment</u>

- o Piping systems shall be designed to accommodate pipe breaks at terminal ends and locations where the stress criteria of MEB 3-1 are exceeded. No arbitrary intermediate breaks will be postulated when the stress criterion are not exceeded.

- o For breaks that must be taken, the design will accommodate pipe whip and jet impingement effects resulting from mechanistic treatment of the break. Compartment pressurization and flooding effects from breaks postulated in accordance with MEB 3-1 will be accommodated in the design. Current acceptable methods for limiting break opening, moderate and low energy exclusions, limited duration operation, etc. may still be applied.

- o For environmental qualification of equipment and structural design of areas traversed by high energy piping systems, breaks will continue to be postulated in accordance with the present project criteria, i.e., in each area traversed by the high energy piping system, non-mechanistic breaks are postulated at the location that results in the most severe environmental consequences. Therefore, elimination of the arbitrary intermediate breaks will not impact the environmental qualification program or plant structural design.

Applicaton of the alternative pipe break criteria described above will not alter the commitment to quality in the design of structures, systems, and components important to safety. The quality assurance program will continue to ensure that structures, systems and components important to safety are designed, fabricated, erected, and tested to the quality standards commensurate with the safety function to be performed.

Attachment A lists by subsystem the Class 1 arbitrary intermediate breaks and pipe whip restraints which can be eliminated from the design (since the stress and usage factor limits are not exceeded). The FSAR will be revised after NRC approval of this submittal to show the physical location of the restraints within a given system. A total of approximately 154 breaks per unit are to be eliminated.

Attachment B lists the ASME Class 2 and 3 piping intermediate break locations that are to be eliminated. A total of approximately 81 breaks per unit are to be eliminated.

In this submittal we are providing additional technical information to justify further that request. Specific NRC concerns are addressed in Attachments C through H as follows:

1.	Technical justification for elimination of arbitrary intermediate breaks	Attachment C
2.	Provisions for minimizing stress corrosion cracking in high energy lines	Attachment D
3.	Provisions for minimizing the effects of thermal and vibration induced piping fatigue	Attachment E
4.	Provisions for minimizing water/steam hammer effects	Attachment F
5.	Provisions for minimizing local stresses from welded attachments	Attachment H

The application of the proposed criteria changes will result in the deletion of approximately 235 break locations and 67 pipe whip restraints in Class 1, 2 & 3 piping. The breaks and restraints currently targeted for elimination are listed in Attachments A & B. However, it should be noted that piping and system design is an iterative process and that postulated break locations could potentially move as the system design and analysis of structures and piping develops over the course of the design process. Owing to the iterative nature of the design process and its potential for affecting postulated break locations, changes affecting high energy systems are continuously monitored and evaluated to determine the impact on break location. We propose to apply these alternative criteria to any potential break locations in the systems identified herein, provided the stresses at those locations are below the break selection threshold, and the operational concerns in attachments (E) through (H) are adequately adressed. This flexibility is necessary to minimize future requests for break elimination as the location of intermediate break points change during the evolution of the plant design.

Also, for those piping systems, or portions thereof, which are not included in this submittal, the existing guidelines in MEB 3-1 of the SRP (NUREG-0800) Revision 1 will be met. If other piping subsystems included in the systems identified in Table D-1, but not specifically identified in this submittal, subsequently qualify for the conditions described herein, the implementation of the proposed elimination of the arbitrary intermediate break criteria may be used. If this criteria is to be applied to additional systems not included in Table D-1, those systems will be appropriately identified to the staff.

CECo has evaluated the potential cost savings and operational benefits that result from the elimination of arbitrary intermediate breaks. These benefits include $11.5 million savings in analysis, design, fabrication, and installation of associated pipe whip restraints and jet impingement barriers and 1000 man-rem in dose reductions for both Byron and Braidwood Stations over their 40-year plant lives. A detailed breakdown of the benefits realized by the elimination of the arbitrary intermediate breaks is provided in Attachment I. The actual benefits that CECo will realize are expected to be higher than these due to the hidden factors and intangibles that are difficult to identify at this time. It is clear, however, that elimination of the arbitrary intermediate breaks is both safety effective and cost effective.

The percentage of the total potential benefits that can be realized by CECo for the Byron and Braidwood Stations becomes a matter of timing due to the advanced stage of design and construction at Byron-2 and Braidwood, and the pending completion of the Byron-1 startup program which may be affected by the pipe whip restraint energy absorbing material (EAM) issue. To make it possible for CECo to realize the maximum benefits afforded by this proposed change in the pipe break criteria, immediate attention by the NRC is requested with a favorable response to the proposed change in the pipe break criteria by December 31 1984.

ATTACHMENT A

**Summary of Class 1 Piping
Intermediate Break Reductions**

System	Subsystem	Intermediate Break Locations	No. of Breaks Eliminated	No. of Pipe Whip Restraints Eliminated
Seal Water Injection	1CV34, 36 40, 41	Socket Welds at Valves 1CV8772A-D	8	0
Loop Fill	1CV12, 13 14, 24	Socket Welds between Crossover Leg Nozzle and 1st Valve	20	0
Safety Injection to Hot Leg	1SI10, 11	Elbow Butt Welds between Hot Leg Nozzle and 1st Valve	4	0
Normal Letdown	1CV06, 23	Butt Welds at Class 1 Valves	6	1
Residual Heat Removal	1RH02	2nd Elbow from Hot Leg	2	2
		12" X 12" X 6" Tee	2	0
RC Bypass	1RC01-04, 16-19	1st and 3rd 8" Elbow Welds from Cold Leg Loop Stop Valve	16	4
		1-1/2" Valve Welds	16	0
		1-1/2" Flange Welds	8	0

ATTACHMENT A

Summary of Class 1 Piping
Intermediate Break Reductions

System	Subsystem	Intermediate Break Locations	No. of Breaks Eliminated	No. of Pipe Whip Restraints Eliminated
Excess Letdown	1CV09, 11, 15, 16, 25	Socket Welds between Hot Leg Nozzles and 1st Valve	12	0
		Socket Welds between Crossover Leg Nozzle and 2nd Valve	40	0
Surge Line	1RY05	Elbow/Welds	2	0
Accumulator and Cold Leg Injection	1SI01, 03, 04 09, 16, 17	10" X 10" X 6" Tee	4	4
		Socket Welds between 6 X 2 Branch and 1st Valve on 2" Sl	14	0
		TOTAL	154	11

ATTACHMENT B

Summary of Class 2 and 3 Piping Intermediate Break Reductions

System	Building	Subsystems	No of Breaks Eliminated	No. of Pipe Whip Restraints Eliminated
CVCS	C	1CV04,05, 07, 22, 23	5	0
CVCS	A	1CV01, 18, 38, 39, 44 53, 71, 72	15	0
Main Steam	C	1MS05, 06, 07, 08	8	12
Main Steam	A	1MS01	20	23
Main Feedwater	C	1FW02, 03, 04, 05	8	17
Bypass Feedwater	C	1FW06, 07, 08, 09	8	0
SG Blowdown	C	1SD01-06, 11, 12	15	4
SG Blowdown	A	1SD07-10, 25	2	0
		TOTAL	81	56

ATTACHMENT C

TECHNICAL JUSTIFICATION FOR ELIMINATION OF ARBITRARY INTERMEDIATE BREAKS

The following items provide generic technical justification for the elimination of arbitrary intermediate pipe breaks and the associated pipe whip restraints.

1. The operating procedures and piping and system designs minimize the possibility of stress corrosion cracking, thermal and vibration induced fatigue, and water/steam hammer in these lines in which arbitrary pipe breaks are currently postulated. Detailed descriptions of the design provisions for these phenomena are provided in Attachments D, E & F, respectively.

2. Welded attachments are not located in close proximity to the breaks to be eliminated. Consequently, local bending stresses resulting from these attachments will not significantly affect the stress levels at the break locations (refer to Attachment H).

3. The remaining postulated pipe breaks and whip restraints provide an adequate level of protection in areas containing high energy lines. Potential environmental effects are still considered in the design.

4. Pipe breaks are postulated to occur at locations where stresses are only 80% of Code allowables (Class 2 and 3) or where the cumulative usage factor is only 10% of the allowable 1.0. The arbitrary breaks to be eliminated all exhibit stresses and usage factors below these conservative thresholds.

5. Pipe rupture is recognized in Branch Technical Position MEB 3-1 as being a "rare event which may only occur under unanticipated conditions".

6. Arbitrary intermediate breaks are only postulated to provide additional conservatism in the design. There is no technical justification for postulating these breaks.

7. Elimination of pipe whip restraints associated with the arbitrary breaks will facilitate in-service inspection, reduce heat losses from the restrained piping, and reduce the potential for restraining pipe due to unanticipated thermal growth and seismic motion.

8. Pipe break related equipment qualification (EQ) requirements will not be affected by the elimination of the arbitrary breaks. Breaks are postulated non-mechanistically for EQ purposes.

It is concluded that the elimination of arbitrary intermediate breaks is technically justified, based on the reasons stated above.

ATTACHMENT D

PROVISIONS FOR MINIMIZING STRESS CORROSION CRACKING IN HIGH ENERGY LINES

Industry experience has shown (NUREG-0691) that stress corrosion cracking (SCC) will not occur unless the following conditions exist simultaneously; high tensile stresses, susceptible piping material, and a corrosive environment. Although any stainless or carbon steel piping will exhibit some degree of residual stress and material susceptibility, Commonwealth Edison Company minimizes the potential for SCC by choosing piping material with low susceptibility to stress corrosion and by preventing the existence of a corrosive environment. The material specifications consider compatibility with the system's operating environment (both internal and external), as well as other materials in the system, applicable ASME code requirements, fracture toughness characteristics, and welding, processing, and fabrication techniques.

The likelihood of stress corrosion cracking in stainless steel increases with carbon content. Consequently, only the lower carbon content stainless steels (304, 304L, 316, 316L) have been used for the primary systems* at the Byron/Braidwood Stations. The existence of a corrosive environment is prevented by strict criteria for internal and external pipe cleaning, and water chemistry control during start-up and normal operation.

For the secondary systems **, ferritic type carbon steel has been the choice for the piping, fittings, and valve bodies forming the pressure boundaries. This ferritic material has been found satisfactory from the standpoint of non-susceptibility to stress corrosion cracking for the service conditions encountered. Since in the case of PWR's the secondary systems are not made of stainless steels, the question of stress corrosion cracking as reported in stainless steels does not arise.

All piping involved in the elimination of arbitrary intermediate breaks will be cleaned and flushed as part of the start-up test program. The piping will be flushed with demineralized water subject to written criteria for limits on total dissolved solids, conductivity, chlorides, fluorides, and pH. Flush water quality is monitored periodically. The flushing is controlled by detailed procedures written for each system. Water chemistry for pre-operational testing is controlled by written specifications.

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* Primary Systems: Reactor Coolant (RCS), Chemical and Volume Control (CVCS), Safety Injection (SI), Residual Heat Removal System (RHRS).

** Secondary Systems: Main Steam (MS), Main Feedwater (MFW), Auxiliary Feedwater (AFW), Steam Generator Blowdown (SGBDS)

During plant operation, primary and secondary side water chemistry will be monitored in the stainless steel and carbon steel piping. Contaminant concentrations will be kept below the thresholds known to be conducive to stress corrosion cracking. The major water chemistry control standards will be included in the plant operating procedures for the lines in which arbitrary breaks were previously postulated. Oxygen content is expected to be less than 0.005 ppm during normal power operation, thus further minimizing the likelihood of stress corrosion cracking.

Table D-1 summarizes the systems in which currently postulated arbitrary intermediate breaks are to be eliminated. Note that a number of these systems operate at temperatures below 200°F. Industry wide experience shows that stress corrosion is not a problem at temperatures this low. The recommended water chemistry requirements for primary systems are provided in Table 5.2-3 of the FSAR. Operating water chemistry guidelines for secondary side piping are given in Table 10.3-1 of the FSAR. Commonwealth Edison has developed and implemented a secondary water chemistry program based upon the Steam Generator Owners Group Secondary Water Chemistry Guidelines.

ATTACHMENT D

Table D-1

Elimination of Arbitrary Break Systems Summary

Piping System	Piping Material	Operating Temp. (°F)	No. of Breaks Deleted (Per Unit)
Safety Injection	SS	120	22
CVCS - Charging	SS	516/130	8
CVCS - Letdown	SS	556	68
CVCS - RCP Seal Inj.	SS	130	10
RCS - Surge Line	SS	653	2
RCS - Bypass	SS	619	40
CVCS - Loop Fill	SS	120	20
Bypass Feedwater	CS	445	8
Steam Generator Blowdown	CS	454	17
Main Steam	CS	545	28
Main Feedwater	CS	445	8
Residual Heat Removal	SS	619/350	4
			235

SS - Stainless Steel
CS - Carbon Steel

ATTACHMENT E

PROVISIONS FOR MINIMIZING THE EFFECTS OF THERMAL AND VIBRATION INDUCED PIPING FATIGUE

I. GENERAL FATIGUE DESIGN CONSIDERATIONS

For Class 1 lines, fatigue considerations are addressed by the cumulative usage factor (CUF). To ensure that piping will not fail due to fatigue, the ASME Code has set the CUF limit at 1.0. By definition, all arbitrary intermediate break locations have CUFs below 0.1.

For Class 2 and 3 lines, fatigue is considered in the allowable stress range check for thermal expansion stresses. This stress is included in the total stress value used to determine postulated break locations. All arbitrary break locations exhibit stresses less than 80% of the code allowables. If the number of thermal cycles is expected to be greater than 7,000, then the allowable stresses are further reduced by an amount dependent on the number of cycles.

II. THERMAL DESIGN CONSIDERATIONS

By limiting the mixing of low velocity, low temperature auxiliary feedwater with high temperature water in the steam generator inlet nozzle, cyclic thermal stresses in the auxiliary feedwater piping are minimized.

Mixing is prevented in the auxiliary feedwater supply to the 6-inch auxiliary feedwater steam generator inlet nozzle with a vertical piping arrangement followed by a 90-degree elbow welded to the 6-inch inlet nozzle. Feedwater temperature instrumentation is provided in the vertical run of the inlet elbow to the 6-inch steam generator inlet nozzle to monitor and alarm the backflow of high temperature water.

Mixing of the low velocity, low temperature main feedwater with high temperature water in the steam generator is prevented in the main 16-inch feedwater nozzle by isolating flow to the main nozzle and introducing feedwater to the 6-inch auxiliary feedwater steam generator inlet nozzle for power levels below 20 percent.

The physical layout of the auxiliary feedwater piping, temperature monitoring/alarm instrumentation, and minimum feedwater flow rates are in compliance with the Westinghouse design criteria for the main/auxiliary feedwater supply piping to the steam generators.

Cyclic thermal stress is prevented in the other lines containing arbitrary intermediate breaks by maintaining uniform temperatures with no mixing.

III. VIBRATION DESIGN CONSIDERATIONS

Piping in the Byron/Braidwood Stations is designed and supported to minimize transient and steady state vibration. Testing will be performed as described in Section 3.9.2 of the FSAR to ensure that vibration of the piping systems is within allowable levels. Plant personnel will be trained to recognize excessive piping vibration so that potential problems can be resolved. In addition, a formal test program, as outlined in the FSAR, will be completed to verify the acceptability of the piping steady state vibration.

ATTACHMENT F

PROVISIONS FOR MINIMIZING STEAM/WATER HAMMER EFFECTS

Systems within Westinghouse scope of supply are not in general, susceptible to water hammer. The reactor coolant, chemical and volume control and residual heat removal systems have been specifically designed to preclude water hammer. Preoperational testing and operating experience have verified the Westinghouse design approach and furthermore, have indicated that significant water hammer events have usually been initiated in secondary systems within the Balance of Plant (BOP) scope of supply. In these systems, anticipated hydraulic transients have been included in the design loads and design features have been incorporated to prevent water hammer.

Westinghouse has conducted a number of investigations into the causes and consequences of water hammer events. The results of these investigations have been reported to Westinghouse operating plant customers and have been reflected in design interface requirements to the BOP designer for plants under construction, to assure that water hammer events initiated in the secondary systems do not compromise the performance of the Westinghouse-supplied safety-related systems and components.

Some of the lines in which arbitrary intermediate breaks are to be eliminated have the potential for water/steam hammer effects. These lines have been designed to minimize or preclude such effects. Water hammer in each of the systems involved in the elimination of arbitrary breaks is described below:

1. Safety Injection System

   The safety injection lines are all water solid and at ambient temperature, thus no water hammer is expected.

2. Chemical and Volume Control System (CVCS)

   Normally, the CVCS is water solid. In the low temperature lines (less than 125^{O}F) water hammer would not be expected because of the small probability of steam void formation. In the high temperature lines, the piping has been designed to maintain water solid conditions during normal operation, thus minimizing the possibility of water hammer effects.

3. Reactor Coolant System

   There is a low potential for water hammer in the reactor coolant system, because it is designed to preclude steam void formation. However, excessive cooling of the reactor coolant system, which initiates safety injection, could potentially result in water hammer. If any problems are experienced during preoperational testing, they will be eliminated by modifying operating procedures.

4. Main Steam

The main steam piping from the 5-way restraints just outside containment to the main turbine is sloped at 1/16 of an inch per foot to assure proper drainage during the various phases of operation. 18-inch diameter drip legs approximately five feet long are installed upstream of the main turbine inlet on the 36-inch and 38-inch main steam lines to collect and dispense drainage to the condenser. The branch lines that tee off the main steam lines are properly sloped with drain provisions to eliminate the possibility of water hammer to occur due to condensate-drain water pockets collecting in low points or pipe loops.

5. Steam Generator Blowdown (SGBS)

Blowdown flow from the steam generator is normally two-phase and of 0-10 percent quality. The piping layout is generally routed downward starting from the steam generator blowdown nozzle connection and continuing to the containment penetration thus minimizing the formation of water pockets. Therefore, the potential for water hammer is minimized for the blowdown lines within containment. Water hammer may occur downstream of the isolation valves upon reinitiation of blowdown flow following isolation. Operating procedures will provide for gradual repressurization of the downstream piping before establishing full flow, thereby minimizing any potential water hammer problems.

6. Auxiliary Feedwater

The Auxiliary Feedwater (AF) system provides feedwater to the steam generator auxiliary nozzle via a connection to the feedwater bypass piping. Each steam generator auxiliary nozzle utilizes a 90° elbow connected immediately to a vertical run of pipe to minimize steam voids. Under normal operating conditions, the main feedwater split flow arrangement (described in Section 7) ensures that the bypass line is kept filled with water, and steam is thereby prevented from leaking back into the Auxiliary Feedwater piping.

The following design features are included to avoid a bubble collapse water hammer event:

1. Temperature sensors are installed on the bypass piping close to the auxiliary nozzle to detect backleakage of hot water or steam.

2. If backleakage is detected, the piping will be slowly refilled or the plant brought to a cold shutdown condition, depending on the circumstances. An analytical study

performed by Westinghouse shows that the bypass piping can be slowly refilled safely. The recommended flowrate is on the order of 15 gpm.

3. The steam generator water level should be maintained above the auxiliary nozzle discharge pipe so that if backleakage does occur, water instead of steam will leak back into the pipe.

4. The Auxiliary Feedwater System check valves will be maintained to minimize backleakage.

5. Consistent with Westinghouse recommendations, there are at least two check valves in each flow path by which backleakage could occur into the Auxiliary Feedwater or Main Feedwater System.

7. Main Feedwater

The routing of the main feedwater piping, which varies in temperature from approximately 300°F at low load to 445°F at full load into the steam generators, which operate between 545°F to 557°F during normal operation, is in compliance with the Westinghouse criteria for layout, temperature monitoring/alarm, and operational procedures to minimize or eliminate water hammer. Water hammer prevention features of the main feedwater system are described in detail in Section 10.4.7.3 of the Byron/Braidwood FSAR (Attachment G).

The Byron/Braidwood Stations have Westinghouse Model D preheater type steam generators. The main supply of feedwater enters the preheater through the main 16-inch nozzle in the lower shell. The other supply of feedwater is through the 6-inch diameter auxiliary nozzle located in the upper shell.

The Feedwater Bypass System is designed to prevent the introduction of cold water into the preheater section. In those circumstances where it is necessary to introduce cold water into the steam generator, the Feedwater Bypass System operates to direct the cold water to the upper auxiliary nozzle. This bypass consists of a 6-inch diameter line which connects the main feedwater line to the auxiliary nozzle. The Auxiliary Feedwater System also provides feedwater to the steam generator through the bypass piping and the auxiliary nozzle in the event of a loss of main feedwater.

Steam backleakage into the bypass piping is very unlikely. During power operation, the Byron/Braidwood Stations utilize a split flow scheme which provides a continuous flow through the bypass piping to the auxiliary nozzle of about 10% of the main feedwater flow. This continuous flow effectively prevents the backflow of steam from the steam generator.

During the normal operations of heatup, cooldown and hot standby (rated flow less than 15% and temperatures less than 250°F), feedwater is supplied only through the 6" auxiliary nozzle. However, only relatively small amounts of feedwater are required, not enough to always permit a continuous flow so that the opportunity for steam backleakage does exist if the check valves fail and the steam generator water level falls below the auxiliary nozzle internal extension. Possible steam backleakage is detected by surface mounted resistance temperature detectors which are provided on each feedwater pipe. These are monitored by the plant process computer and are alarmed in the main control room so that actions can be taken to initiate feedwater flow to the upper nozzle before potential feedwater hammer conditions may develop. Also, the plant operator is instructed to feed continuously rather than intermittently as much as possible. This practice reduces the likelihood of steam backleakage and, therefore, water hammer.

In the eventuality that the presence of steam is suspected in the bypass line of one or more loop, based on temperature data and water level status and history, the recommended course of action is to slowly refill one loop at a time with the Auxiliary Feedwater System. An analytical study by Westinghouse shows that the safe refilling flow rate is in the range of 15 to 123 gpm per steam generator. To be conservative, Westinghouse has recommended the value of 15 gpm or as close to this as can be provided.

Based on another analysis performed by Westinghouse which considered the classical water hammer case of feedwater line break followed by check valve closure, Westinghouse recommended that the valve close to the auxiliary nozzle should be removed and the other check valve in the bypass line should be replaced with a slow closing valve. Commonwealth Edison has implemented this recommendation.

The design features and operating procedures described above will preclude or minimize the effects of water hammer.

ATTACHMENT G

WATER HAMMER PREVENTION FEATURES

(B/B-FSAR AM.44)

10.4.7.3 Water Hammer Prevention Features

Several water hammer prevention features have been designed into the feedwater system. These features are provided to minimize the possibility of various water hammer phenomena in the steam generator preheater, steam generator main feedwater inlet piping and the steam generator upper nozzle feedwater piping. The following discussion is typical for each of the four steam generators and their associated feedwater piping.

10.4.7.3.1 Start-Up, Low Load Conditions

a. Under start-up and low load conditions when NSSS rated flow is less than 15% and temperatures are less than 250^{O}F, feedwater will only be admitted to the upper nozzle of the steam generator by the use of flow through the feedwater bypass tempering line and/or flow through the feedwater preheater bypass line via the feedwater bypass control valve and feedwater preheater bypass valve. The 6-inch diameter upper nozzle is located on the upper shell of the steam generator, below the normal, full power water level. Level control in the steam generator is provided by the feedwater bypass control valve at these conditions.

b. Surface mounted resistance temperature detectors (RTD) are provided on each of the feedwater pipes, leading to and very near the steam generator's upper nozzle to detect during start-up and low load conditions as well as other operating conditions, possible back leakage of steam from the steam generator into the feedwater piping. These RTD's are monitored by the plant process computer and alarmed in the main control room so that actions can be taken to initiate feedwater flow to the upper nozzle before potential feedwater hammer conditions may develop.

10.4.7.3.2 Increasing Load

a. As load increases about 15% of NSSS rated flow and feedwater temperatures rise above 250^{O}F, forward feedwater flushing of the main feedwater piping may be initiated by opening the feedwater isolation bypass valve. A small controlled flow through the 3-inch feedwater isolation bypass line is provided to flush the main feedwater piping between the isolation valve and the steam generator.

b. Three sets of three RTD's are provided on the main feedwater piping upstream and downstream of the feedwater isolation valve and near the steam generator feedwater nozzle to detect when the feedwater flushing temperature rises above 255°F. Two out of three logic is provided for each set of three RTD's and all three must be satisfied to meet the forward flushing temperature requirements.

c. If flow in the 3-inch feedwater isolation valve bypass line (forward flushing flow) remains above a preset minimum and below a preset maximum and the flushing temperatures remain satisfied, a timed period occurs after which a permissive signal is provided to automatically open the feedwater isolation valves. Automatic opening of a feedwater isolation valve can be blocked by placing its control switch in the main control room in the closed position. This automatic permissive to open occurs after a timed period to allow approximately two volumes of water to be purged from the piping between the feedwater isolation valve and the steam generator main feedwater nozzle. Feedwater flow at the main feedwater flow-element must also be above a preset minimum in order for the feedwater isolation valve to open.

d. After the feedwater isolation valve has opened, the feedwater isolation bypass valve will be manually closed.

e. Prior to opening of the feedwater isolation valve, transfer from the feedwater bypass control valve to the feedwater control valve will occur in order to provide steam generator level control at the higher feedwater flow conditions.

f. If flow to the steam generators remains continuous during a load transient and above a minimum flow rate, feedwater will not be terminated to the main feedwater nozzle even if temperature of the feedwater has dropped below 250°F. Interruption or a reduction in flow below the minimum rate however, will cause the feedwater preheater section of the steam generator to be bypassed.

g. Steam generator low level trips are provided to close all of the feedwater isolation valves, feedwater isolation bypass valves and feedwater preheater bypass valves. Steam generator low pressure trips are provided to close all of the feedwater isolation valves, feedwater isolation bypass valves, feedwater preheater bypass valves and the feedwater bypass tempering valves.

10.4.7.3.3 Split Feedwater Flow

a. Prior to opening of the feedwater isolation valve, the majority of feedwater flow at the lower power level is introduced to the upper nozzle of the steam generator by the preheater bypass pipe.

b. At higher power levels after the feedwater isolation valve has opened, only a small portion of the feedwater flow bypasses the preheater, with the bypass portion contributing to approximately 10% of full feedwater flow at 100% power. This split feedwater flow arrangement provides an approximate 90% of full flow limit to the main feedwater nozzle at higher power levels in order to minimize the potential for tubing vibration in the steam generator. The feedwater flow rate to the steam generator nozzle is monitored and alarmed, if flow rises above approximately 90%, in order for actions to be taken to reduce flow.

c. The preheater bypass valve remains open throughout the start-up and low load conditions, as well as up to and including full power operation.

10.4.7.3.4 Other Upper Nozzle Feedwater Line Uses

Inasmuch as there is water flowing to the upper nozzle of the steam generator during normal operation, and it is the required location for introducing cold fluid into the steam generator, auxiliary feedwater and chemical feed are connected to the upper nozzle feedwater lines rather than to the main feedwater lines. The chemical feed lines are used to add chemicals directly to the steam generators under low load conditions prior to wet layup. The chemical feed and auxiliary feedwater lines are Safety Category I, Quality Group B out to, and including their isolation valves.

ATTACHMENT H

PROVISION FOR MINIMIZING LOCAL STRESSES FROM WELDED ATTACHMENTS

CECo has reviewed all arbitrary intermediate break locations to be eliminated and has determined that in no case are welded attachments placed in close proximity to postulated break locations. As a result, local bending stresses induced by the attachment will not affect the stresses at the postulated break point. To ensure that this is the case, the local stresses have been determined and added to the primary stress report.

ATTACHMENT I

SUMMARY OF BENEFITS FOR THE ELIMINATION OF ARBITRARY INTERMEDIATE PIPE BREAKS - BYRON/BRAIDWOOD STATIONS

Changes Resulting from Break Elimination	Cost Savings (1983 Rates)	Operational Benefits
Elimination of 67 Pipe Whip Restraints per Unit	o Design, Fabrication and Installation Costs*	o Potential improvement in quality of inservice inspection (ISI)
	o Dose Reduction Costs	o Dose reduction from improved personnel access during maintenance, ISI and recovery from unusual plant conditions, e.g., radioactive spills, fires, etc.
		o Improved capability to recover from unusual plant conditions, e.g., decontamination following radioactive spills, access for fire lighting, etc.
		o Reduced system heat loss resulting from improved insulation design.
		o Dose reduction and improved construction schedule by eliminating the need to set and maintain restraint clearance gaps.
Elimination of Jet Barriers and/or Equipment Relocation	o Barrier Design, Fabrication, and Installation	o Dose reduction from improved personnel access during maintenance and recovery from unusual plant conditions, e.g., radioactive spills, fires, etc.
	o Dose Reduction Costs	
	o Relocation Costs	o Improved capability to recover from unusual plant conditions, e.g., decontamination following radioactive spills, access for fire fighting, etc.
Elimination of Analyses Associated With the Dynamic Effects and Loading Conditions	o Jet Impingement Load and Pipe Whip Analyses Costs*	o Improved system layout and design for future plant modifications
TOTAL SAVINGS (UNITS 1 AND 2)	$11.5 Million	1000 man-rem in dose reduction over the 40-year plant life.

*One Cost Applicable to both Units.