November 12, 1982

Docket No. 50-155
LS05-82-11-035

Mr. David J. VandeWalle
Nuclear Licensing Administrator
Consumers Power Company
1945 W. Parnall Road
Jackson, Michigan 49201

Dear Mr. VandeWalle:

SUBJECT: SEP TOPIC III-5.A, EFFECTS OF PIPE BREAK ON STRUCTURES, SYSTEMS AND COMPONENTS INSIDE CONTAINMENT BIG ROCK POINT NUCLEAR POWER PLANT

By letter dated September 30, 1982, you provided a safety assessment of this topic. The staff has reviewed your assessment and concludes that the methodology and acceptance criteria being used in your continuing evaluations of this topic are appropriate except for the following:

1. Provide information concerning the criteria used in identifying high energy piping systems considered for pipe break inside containment (Section V.B.1).

2. Assess the effects of large displacement pipe motion due to longitudinal breaks (Section V.B.3).

3. Justify the use of Model 2 jet expansion and jet thrust coefficient of 1.26 for feedwater line breaks (Section V.B.3).

4. Justify the functional capability of target piping under the jet impingement and pipe whip loadings (Section V.C).

5. Justify the ductility ratios for impacted steel structures and concrete used in the evaluation (Section V.C).

Although safety related targets for each postulated break location have been identified, the effects of each high energy line break on mitigating systems and plant shutdown capability have not been determined. Therefore, break locations for which protection from pipe break effects is required from the system performance standpoint have not been established. Your letter of September 30, 1982, stated that you would identify such locations and corrective measures as part of your input to the integrated assessment.

SE04
DSU USE EX(18) Add: Gary Staley

OFFICE ▶							
SURNAME ▶							
DATE ▶							

The need and schedule for plant changes as a result of these studies will be addressed in the integrated assessment. This evaluation may be revised in the future if your facility design is changed or if NRC criteria relating to this topic are modified before the integrated assessment is completed.

Sincerely,

Original signed by:

Dennis M. Crutchfield, Chief
Operating Reactors Branch No. 5
Division of Licensing

Enclosure:
As stated

cc w/enclosure:
See next page

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FMiraglia
11/ /82

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OFFICE	SEPB	SEPB	SEPB	SEPB	SEPB	ORB#5	ORB#5
SURNAME	PYChen:bl	EMcKenna	RSchell	RHermann	WRussell	REmch	DCrutchfield
DATE	11/2/82	11/2/82	11/ /82	11/9/82	11/9/82	11/10/82	11/10/82

Mr. David J. VandeWalle

cc
Mr. Paul A. Perry, Secretary
Consumers Power Company
212 West Michigan Avenue
Jackson, Michigan 49201

Judd L. Bacon, Esquire
Consumers Power Company
212 West Michigan Avenue
Jackson, Michigan 49201

Joseph Gallo, Esquire
Isham, Lincoln & Beale
1120 Connecticut Avenue
Room 325
Washington, D. C. 20036

Peter W. Steketee, Esquire
505 Peoples Building
Grand Rapids, Michigan 49503

Alan S. Rosenthal, Esq., Chairman
Atomic Safety & Licensing Appeal Board
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Mr. John O'Neill, II
Route 2, Box 44
Maple City, Michigan 49664

Mr. Jim E. Mills
Route 2, Box 108C
Charlevoix, Michigan 49720

Chairman
County Board of Supervisors
Charlevoix County
Charlevoix, Michigan 49720

Office of the Governor (2)
Room 1 - Capitol Building
Lansing, Michigan 48913

Herbert Semmel
Counsel for Christa Maria, et al.
Urban Law Institute
Antioch School of Law
2633 16th Street, NW
Washington, D. C. 20460

U. S. Environmental Protection Agency
Federal Activities Branch
Region V Office
ATTN: Regional Radiation Representative
230 South Dearborn Street
Chicago, Illinois 60604

Peter B. Bloch, Chairman
Atomic Safety and Licensing Board
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dr. Oscar H. Paris
Atomic Safety and Licensing Board
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Mr. Frederick J. Shon
Atomic Safety and Licensing Board
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Big Rock Point Nuclear Power Plant
ATTN: Mr. David Hoffman
Plant Superintendent
Charlevoix, Michigan 49720

Christa-Maria
Route 2, Box 108C
Charlevoix, Michigan 49720

William J. Scanlon, Esquire
2034 Pauline Boulevard
Ann Arbor, Michigan 48103

Resident Inspector
Big Rock Point Plant
c/o U.S. NRC
RR #3, Box 600
Charlevoix, Michigan 49720

Hurst & Hanson
311 1/2 E. Mitchell
Petoskey, Michigan 49770

SEP EVALUATION

OF

EFFECTS OF PIPE BREAK ON STRUCTURES, SYSTEMS AND COMPONENTS INSIDE CONTAINMENT

TOPIC III-5.A

FOR

BIG ROCK POINT NUCLEAR POWER PLANT

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SYSTEMATIC EVALUATION PROGRAM

TOPIC III-5.A

BIG ROCK POINT NUCLEAR POWER PLANT

TOPIC: III-5.A, Effects of Pipe Break on Structures, Systems and Components Inside Containment

I. INTRODUCTION

The safety objective of Systematic Evaluation Program (SEP) Topic III-5.A, "Effects of Pipe Break on Structures, Systems and Components Inside Containment," is to assure that pipe breaks would not cause the loss of required functions of "safety-related" structures, systems and components and to assure that the plant can be safely shutdown in the event of such breaks. The required functions of "safety-related" systems are those functions required to mitigate the effects of the pipe break and safely shutdown the plant.

II. REVIEW CRITERIA

General Design Criterion 4 (Appendix A to 10 CFR 50) requires in part that structures, systems and components important to safety be appropriately protected against dynamic effects, such as pipe whip and discharging fluids, that may result from equipment failures.

III. RELATED SAFETY TOPICS AND INTERFACES

1. This review complements that of SEP Topic VII-3, "Systems Required for Safe Shutdown."

2. The environmental effects of pressure, temperature, humidity, and flooding due to postulated pipe breaks are evaluated under USI A-24, "Environmental Qualification of Safety-Related Equipment."

3. The effects of potential missiles generated by fluid system ruptures and rotating machinery are evaluated under SEP Topic III-4.C, "Internally Generated Missiles."

4. The effects of containment pressurization are evaluated under SEP Topic VI-2.D, "Mass and Energy Release for Possible Pipe Break Inside Containment."

5. The original plant design criteria in the areas of seismic input, analysis, and design criteria are evaluated under SEP Topic III-6, "Seismic Design Considerations."

6. The effects of primary system breaks on the reactor core are evaluated under SEP Topic XV-19, "Loss of Coolant Accidents Resulting from Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary."

IV. REVIEW GUIDELINES

The current criteria for review of pipe breaks inside containment are contained in Standard Review Plan 3.6.2, "Determination of Break Locations and Dynamic Effects Associated with the Postulated Rupture of Piping," including its attached Branch Technical Position, Mechanical Engineering Branch 3-1 (BTP MEB 3-1).

The licensee's break location criteria and methods of analysis for evaluating postulated breaks in high energy piping systems inside containment have been compared with the currently accepted review criteria as described in Section II above. The review relied upon information submitted by the licensee, Consumers Power Company in Reference 1.

The scope of review under this topic was limited to avoid duplication of effort since some aspects of the topic were previously reviewed by the staff or are included under other SEP topics (see Section III above).

When deviations from the review criteria are identified, engineering judgement is utilized to evaluate the consequence of postulated pipe break and to assure that pipe break would not cause the loss of required function of "safety-related" structures, systems and components and to assure that the plant can be safely shutdown in the event of such a break.

V. EVALUATION

A. BACKGROUND

On July 20, 1978, the SEP Branch sent a letter (Reference 2) to KMC, Inc. requesting an analysis of the effects of postulated pipe breaks on structures, systems and components inside containment. In that letter, the staff included a position that stated three approaches were appropriate for postulating breaks in high energy piping systems (either $P \geq 275$ psig or $T \geq 200°F$). The approaches are:

1. Mechanistic
2. Simplified Mechanistic
3. Effects Oriented

The staff further stated that combinations of the three approaches could be utilized if justified.

In response to our letter, the licensee submitted Reference 1 concerning postulated high energy pipe rupture inside containment.

B. APPROACH AND CRITERIA

1. High Energy Systems

The licensee has identified the high energy fluid systems inside containment as follows:

a. Recirculation
b. Main Steam
c. Feedwater
d. Steam Drum and PRV Level Instrumentation
e. Core Spray
f. Shutdown Cooling
g. Control Rod Drive
h. Reactor Cleanup
i. Reactor Depressurization
j. Emergency Condenser
k. Liquid Poison
l. Redundant Core Spray

However, the licensee has not addressed the criteria used in its classification of high energy fluid systems. The licensee is requested to provide this information.

2. Pipe Break Locations and Types

The licensee has utilized a combination of the effects-oriented approach and the Simplified Mechanistic Approach in postulating high energy pipe break points inside containment. Based on the information submitted in Reference 1, we have concluded that the criteria used to define the break locations and the break types are in accordance with currently accepted standards.

3. Pipe Whip and Jet Impingement

Based on a review of the information in Reference 1, we have determined that the licensee's pipe whip and jet impingement criteria are consistent with currently accepted standards except as follows:

In evaluating the longitudinal break effects, pipe whip was generally not considered by the licensee except for the case of the tunnel room because pipe motion would result in potentially high loads on the containment penetrations in this area. It is the staff position that pipe whip effects should be considered as a result of circumferential breaks and for large displacement motion resulting from reactions due to longitudinal breaks. In the case of longitudinal breaks, piping movement should be assumed to occur in the direction of the jet reaction unless limited by structural members, piping restraints, or piping stiffness as demonstrated by analysis. The licensee is requested to reconsider its evaluation given the staff position.

With respect to jet impingement criteria, the licensee has utilized two jet expansion models set forth in ANSI-176 (Reference 3). The Model 1 assumes that the fluid jets expand uniformly at a 10° half angle. The Model 2 assumes that the fluid jets expand in accordance with Figure 7-2 of Reference 3. It should be noted that the jet expansion model as shown in Figure 7-2 of Reference 3 is only applicable to steam or water-steam blowdown. For water or sub-cooled water blowdown, the current acceptable criteria for jet expansion model is a half angle not exceeding 10 degrees. Our review of Appendix E1 of Reference 1 indicates that the licensee has utilized the Model 2 in its jet impingement calculation for feedwater line breaks. The licensee is requested to justify the use of Model 2 for feedwater line breaks.

Furthermore, the licensee assumed a maximum jet thrust coefficient of 1.26 in its jet thrust force calculation. It is the staff position that the assumption is only acceptable in the case of steam, saturated water, or steam-water mixtures blowdown. For subcooled, nonflashing water, a maximum jet thrust coefficient of 2 should be used. The licensee is requested to reconsider its evaluation given the staff position.

C. METHOD OF ANALYSIS

Based on a review of the information in Reference 1, we have determined that the licensee's method of analysis for the effects of jet impingement or whipping pipe on selected targets are consistent with the current accepted standards except as follows:

In determining the acceptability of the jet impingement and pipe whip interactions on target piping, the licensee has utilized the maximum allowable equivalent static jet impingement load based on the ultimate strengths of 63.3 ksi and 60.0 ksi, respectively, for stainless and carbon steel. The staff's concern is that some piping systems are required to deliver certain rated flows 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 should provide justification to assure that the target piping remain functional as a result of jet impingement and pipe whip interaction.

In performing the analysis for the structures impacted by whipping pipes, the licensee has used some general criteria for missile impact from a reference entitled "ASCE Structural Analysis and Design of Nuclear Facilities, 1976." Among those criteria used, the licensee has assumed that the material ductility ratio for impacted steel structures is 20 and the ductility ratio for concrete is 10. In SEP Topic III-6, "Seismic Design Considerations," the staff's position for the allowable ductility ratio is described in NUREG/CR-0098. Recognizing the fact that energy absorption phenomena may be different under different loading conditions, the licensee is requested to justify the ductility ratios assumed.

D. ANALYSIS RESULTS AND POTENTIAL SOLUTIONS TO PROBLEMS IDENTIFIED

Results of pipe whip and jet impingement analyses have been tabulated on Tables A-1 and A-2 in Appendix A of Reference 1. Safety-related structures and components (targets) that are in the vicinity of high energy line breaks have been identified. The licensee is continuing the study to determine the effect of each postulated break on systems needed to mitigate the consequences of the break and maintain safe shutdown. Failure modes for each of the systems in which targets have been identified are being defined. The importance of each target failure to safe shutdown will be determined.

It is the staff's position that the licensee should propose corrective measures or other justification for break locations where dynamic effects and a postulated single failure would disable mitigating functions.

The licensee has identified in Reference 1 a number of potential solutions to the interactions identified in the evaluation. These include equipment relocation, further analyses and jet barriers. One approach under consideration is augmented inservice inspection (ISI) plus leak detection. The staff has previously issued guidance (Reference 4) on a method acceptable to the staff for resolution of high energy line breaks when remedial measures are impractical. The method consists of a fracture mechanics evaluation plus leakage detection and ISI requirements to provide defense in depth. Deviations from the staff guidelines must be justified on a case-by-case basis.

The licensee has noted that the benefits of the proposed modifications varies considerably depending on the importance of the targets which are affected by the break and the cost of the proposed modifications, some of which may be very difficult and costly to implement. The potential cost of these modifications as well as an evaluation of their importance in reducing the risk associated with high energy piping ruptures will be provided as part of the licensee's input to the Big Rock Point Plant Integrated Assessment.

VI. CONCLUSIONS

The licensee has identified the following general conclusions concerning high energy line breaks inside containment:

1. Using the approaches described in Reference 1, several postulated break locations result in the disabling of safety-related piping, equipment, or cable trays in the Recirculation Pump Room.

2. The walls of the Recirculation Pump Room are structurally adequate to withstand pipe and jet impact for breaks inside and outside the room. Cracking, spalling, and scabbing of the concrete walls will occur locally, but will not effect the gross structural integrity of the walls.

3. Pipe whip inside the Steam Tunnel area may cause failure of the containment penetration bellows due to the effect of the pipe whip reaction.

4. The containment vessel is adequate to withstand the effects of jet impingement due to postulated high energy line breaks in the Steam Tunnel and Emergency Condenser Area.

5. Jet impingement inside the Steam Tunnel can cause failure of other safety-related piping routed through the Steam Tunnel.

6. There is a potential failure of the emergency condenser stack bellows, which is technically a part of the containment boundary, due to high energy line breaks in the Emergency Condenser Area.

7. In the Reactor Vessel Cavity, jets from the 14" and 20" recirculation piping can cause failure of safety-related piping routed into the reactor vessel.

Based on the information submitted by the licensee, we have reviewed the criteria pertaining to the locations, types, and effect of postulated pipe breaks in high energy piping systems inside containment. We have concluded that the criteria used to define the break locations and types are in accordance with currently accepted standards.

However, the licensee should address the following concerns:

1. Provide information concerning the criteria used in identifying high energy piping systems considered for pipe break inside containment (Section V.B.1).

2. Assess the effects of large displacement pipe motion due to longitudinal breaks (Section V.B.3).

3. Justify the use of Model 2 jet expansion and jet thrust coefficient of 1.26 for feedwater line breaks (Section V.B.3).

4. Justify the functional capability of target piping under the jet impingement and pipe whip loadings (Section V.C).

5. Justify the ductility ratios for impacted steel structures and concrete used in the evaluation (Section V.C).

6. In addition, the licensee should continue its evaluation of the effects of high energy piping failures on mitigation systems to determine if additional protection would be required (Section V.D).

VII. REFERENCES

1. Letter from D.J. VandeWalle (CPCo) to D.M. Crutchfield (NRC), "BIG ROCK POINT PLANT - SEP TOPIC III-5.A, EFFECTS OF PIPE BREAK ON STRUCTURES, SYSTEMS AND COMPONENTS INSIDE CONTAINMENT," dated September 30, 1982.

2. Letter from D. Davis (NRC) to J. McEwen (KMC, Inc.), "ASSESSMENT OF POSTULATED PIPE BREAK INSIDE CONTAINMENT FOR SEP PLANTS," dated July 20, 1978.

3. "DESIGN BASIS FOR PROTECTION OF NUCLEAR POWER PLANTS AGAINST EFFECTS OF POSTULATED PIPE RUPTURE," ANSI-176 (ANS-58.2).

4. Letter from D.M. Crutchfield (NRC) to R.A. Vincent (CPCo), Enclosure 2 entitled, "GUIDANCE FOR RESOLUTION OF OPEN ITEMS FOR TOPIC III-5.A, FOR THE PALISADES PLANT," dated December 4, 1981.