UNITED STATES

ATOMIC ENERGY COMMISSION

WASHINGTON, D.C. 20545

Docket No. 50-305

January 18, 1973

R. C. DeYoung, Assistant Director for Pressurized Water Reactors, L
THRU: Karl Kniel, Chief, PWR Project Branch No. 2, L KK

MEETING WITH WISCONSIN PUBLIC SERVICE CORPORATION - KEWAUNEE NUCLEAR POWER PLANT

Enclosed is a summary of significant results of a meeting held with representatives of the Wisconsin Public Service Corporation on January 5, 1973, to discuss potential problems with the rupture outside containment of lines carrying high energy fluids. Persons present during the meeting are indicated in the attendance list.

L. P. Crocker, Project Manager
PWR Project Branch No. 2
Directorate of Licensing

Enclosures:
1. Meeting Summary
2. Revisions to Criteria
3. Additional Staff Position
4. Attendance List

cc: w/encls.
R. S. Boyd
D. Skovholt
D. Knuth
R. Maccary
R. Tedesco
H. Denton
PWR Branch Chiefs
R. W. Klecker
M. Rosen
RO (3)
L. Crocker
M. Service
J. C. Glynn
D. C. Fischer
T. J. Carter
W. F. Anderson
C. G. Long
R. Renfrow
Docket file
PWR-2 Reading
RP Reading
AEC PDR

Wisconsin Public Service Corporation
G. Charnoff, Esq.
D. Comey
S. E. Keane, Esq.
Local PDR

Memo

ENCLOSURE NO. 1

WISCONSIN PUBLIC SERVICE CORPORATION

KEWAUNEE NUCLEAR POWER PLANT

DOCKET NO. 50-305

MEETING NOTES OF JANUARY 5, 1973

A meeting was held on January 5, 1973 with representatives of the Wisconsin Public Service Corporation to discuss the potential for, and problems associated with, the rupture outside containment, of a line carrying high-energy fluid. The meeting was a follow-on to a previous meeting on the same subject held on November 16, 1972 and was in specific response to our letter of December 15, 1972 which provided criteria to be considered for the design of high-energy fluid systems outside containment.

The meeting was held at the request of the applicant to discuss the results of the applicants' stress analyses of the piping runs, the postulated break points in these piping runs together with the rationale for selection of these break points, and the applicant's interpretation of the criteria included with our December 15 letter. A meeting had been held the previous day on the same subject with the Northern States Power Company regarding the Prairie Island Nuclear Generating Plant. Since the architect-engineer (Pioneer Service & Engineering Co.) designed both Kewaunee and Prairie Island many items resolved at the Prairie Island meeting were equally applicable to Kewaunee.

The meeting began by having one of the representatives of Pioneer Service & Engineering Co. summarize the alterations to the criteria forwarded with the December 15 letter that had been agreed to the previous day. For the most part, these alterations were made to clarify the intent of the criteria, although one substantive change was made. These revisions are shown at Enclosure 2.

Starting with these revised criteria as a basis, the applicant described the steam line and branch line locations using an isometric drawing of the layout of the steam lines and presented his stress analyses of the main steam piping systems. The analyses indicated that the Kewaunee main steam line stresses are well within the allowable stresses for such lines. On the basis of these analyses, however, the applicant had selected those points where the stresses were highest as the postulated break points for the piping runs, in accordance with the criteria contained in our December 15 letter.

The applicant pointed out that, in order to meet our criteria, some modifications to the plant would be required, so as to avoid having potential breaks within the Auxiliary Building Special Ventilation Zone (ABSVZ). For the line from steam generator 1A, modifications to the design of the compartment immediately outside containment would be required. Otherwise, the line avoids the ABSVZ. For the line from steam generator 1B, relocation of the condenser steam dump and atmospheric steam dump lines would be required. These modifications would then leave only the 3 inch branch lines from each steam main to the auxiliary feedwater turbine within the ABSVZ and the applicant feels these lines can be readily protected.

Considerable discussion ensued between the staff and the applicant regarding the capability of the plant to accept pipe breaks in locations other than those indicated by the stress analyses. The applicant reported that, in general, such breaks would have little effect on protection and Engineered Safety Feature systems.

In response to a staff question regarding the impact of relocation of the steam lines, the applicant gave an estimate of $3.2 million in direct costs, with an attendant delay of 8 months in startup which would cost approximately $12 million in lost revenue. In addition, relocation of the main steam piping could result in a derating of the plant (due to the longer steam line runs) as well as abandonment of the atmospheric steam dump capability.

During the meeting, the staff was divided as to the necessity of protecting the plant only against the big breaks (double-ended rupture or equivalent splits) versus the desirability of protecting the plant protection and ESF systems against the environmental effects (including jet impingement) of other possible leaks in the system. The meeting ended on the note that the staff would resolve these internal differences and that we would inform the applicant of the staff position.

During the afternoon of January 5, 1973 the staff discussed this matter and ultimately arrived at the position shown in Enclosure 3. While the specific words may change somewhat, the position is that in addition to providing protection against the big breaks, the applicant also should consider, and provide suitable protection for, smaller leaks in the high-energy fluid lines. After staff concurrence with, and technical approval of, this position, I telephoned the information as shown at Enclosure 3 to the applicant and to the architect-engineer on the evening of January 5, 1973.

Further work on both the Kewaunee and Prairie Island units is proceeding on the basis of the position stated in Enclosure 3. Meanwhile, the staff is preparing a revised version of its criteria, to incorporate the alterations noted as necessary during the January 4-5, 1973 meetings and the position stated in Enclosure 3.

With this final position, it appears that necessary modifications to the Kewaunee plant can be accomplished largely within the time frame of the present schedule for plant completion. More precise schedule impact will have to await a submission from the applicant.

ENCLOSURE 2

General Information Required for Consideration of the Effects of a Piping System Break Outside Containment

The following is a general list of information required for AEC review of the effects of a piping system break outside containment, including the double ended rupture of the largest pipe in the main steam and feed-water systems, and for AEC review of any proposed design changes that may be found necessary. Since piping layouts are substantially different from plant to plant, applicants and licensees should determine on an individual plant basis the applicability of each of the following items for inclusion in their submittals.

1. The systems (or portions of systems) for which protection against pipe whip is required should be identified. Protection from pipe whip need not be provided if any of the following conditions will exist:

   * (a) Both of the following piping system conditions are met:

     (1) the service temperature is less than 200° F; and

     (2) the design pressure is 275 psig or less; or

   (b) The piping is physically separated (or isolated) from structures, systems, or components important to safety by protective barriers, or restrained from whipping by plant design features, such as concrete encasement; or

   (c) Following a single break, the unrestrained pipe movement of either end of the ruptured pipe in any possible direction about a plastic hinge formed at the nearest pipe whip restraint cannot impact any structure, system, or component important to safety; or

* Systems exceeding combined conditions of temperature and pressure are considered high-energy.

(d) The internal energy level[1] associated with the whipping pipe can be demonstrated to be insufficient to impair the safety function of any structure, system, or component to an unacceptable level.

2. The criteria used to determine the design basis piping break locations in the piping systems should be equivalent to the following:

(a) ASME Section III Code Class I piping[2] breaks should be postulated to occur at the following locations in each piping run[3] or branch run:

(1) the terminal ends;

(2) any intermediate locations between terminal ends where the primary plus secondary stress intensities S_m (circumferential or longitudinal) derived on an elastically

the immediate effect

[1]The internal fluid energy level associated with the pipe break reaction may take into account any line restrictions (e.g., flow limiter) between the pressure source and break location, and the effects of either single-ended or double-ended flow conditions, as applicable. The energy level in a whipping pipe may be considered as insufficient to rupture an impacted pipe of equal or greater nominal pipe size and equal or heavier wall thickness.

[2]Piping is a pressure retaining component consisting of straight or curved pipe and pipe fittings (e.g., elbows, tees, and reducers).

[3]A piping run interconnects components such as pressure vessels, pumps, and rigidly fixed valves that may act to restrain pipe movement beyond that required for design thermal displacement. A branch run differs from a piping run only in that it originates at a piping intersection, as a branch of the main pipe run.

calculated basis under the loadings associated with one-half safe shutdown earthquake and operational plant conditions[4] exceeds 2.0 S_m[5] for ferritic steel, and 2.4 S_m for austenitic steel;

(3) any intermediate locations between terminal ends where the cumulative usage factor (U)[6] derived from the piping fatigue analysis and based on all normal, upset, and testing plant conditions exceeds 0.1; and

(4) at intermediate locations in addition to those determined by (1) and (2) above, selected on a reasonable basis as necessary to provide protection. As a minimum, there should be two intermediate locations for each piping run or branch run.

(b) ASME Section III Code Class 2 and 3 piping breaks should be postulated to occur at the following locations in each piping run or branch run:

(1) the terminal ends;

---

[4] Operational plant conditions include normal reactor operation, upset conditions (e.g., anticipated operational occurrences) and testing conditions.

[5] S_m is the design stress intensity as specified in Section III of the ASME Boiler and Pressure Vessel Code, "Nuclear Plant Components."

[6] U is the cumulative usage factor as specified in Section III of the ASME Boiler and Pressure Vessel Code, "Nuclear Power Plant Components."

(2) any intermediate locations between terminal ends where either the circumferential or longitudinal stresses derived on an elastically calculated basis under the loadings associated with seismic events and operational plant conditions exceed $0.9 (S_h + S_A)$[7] or the expansion stresses exceed $0.8\ S_A$; and

0.9

(3) intermediate locations in addition to these determined by (2) above, selected on reasonable basis as necessary to provide protection. As a minimum, there should be two intermediate locations for each piping run or branch run.

3. The criteria used to determine the pipe break orientation at the break locations as specified under 2 above should be equivalent to the following:

(a) Longitudinal[8] breaks in piping runs and branch runs, 4 inches nominal pipe size and larger, and/or

---

[7] S_h is the stress calculated by the rules of NC-3600 and ND-3600 for Class 2 and 3 components, respectively, of the ASME Code Section III Winter 1972 Addenda.

S_A is the allowable stress range for expansion stress calculated by the rules of NC-3600 of the ASME Code, Section III, or the USA Standard Code for Pressure Piping, ANSI B31.1.0-1967.

[8] Longitudinal breaks are parallel to the pipe axis and oriented at any point around the pipe circumference. The break area is equal to the effective cross-sectional flow area upstream of the break location. Dynamic forces resulting from such breaks are assumed to cause lateral pipe movements in the direction normal to the pipe axis.

(b) Circumferential[9] breaks in piping runs and branch runs exceeding 1 inch nominal pipe size.

4. A summary should be provided of the dynamic analyses applicable to the design of Category I piping and associated supports which determine the resulting loadings as a result of a postulated pipe break including:

   (a) The locations and number of design basis breaks on which the dynamic analyses are based.

   (b) The postulated rupture orientation, such as a circumferential and/or longitudinal break(s), for each postulated design basis break location.

   (c) A description of the forcing functions used for the pipe whip dynamic analyses including the direction, rise time, magnitude, duration and initial conditions that adequately represent the jet stream dynamics and the system pressure difference.

   (d) Diagrams of mathematical models used for the dynamic analysis.

   (e) A summary of the analyses which demonstrates that unrestrained motion of ruptured lines will not damage to an unacceptable degree, structure, systems, or components important to safety, such as the control room.

---

[9] Circumferential breaks are perpendicular to the pipe axis, and the break area is equivalent to the internal cross-sectional area of the ruptured pipe. Dynamic forces resulting from such breaks are assumed to separate the piping axially, and cause whipping in any direction normal to the pipe axis.

5. A description should be provided of the measures, as applicable, to protect against pipe whip, blowdown jet and reactive forces including:

   (a) Pipe restraint design to prevent pipe whip impact;

   (b) Protective provisions for structures, systems, and components required for safety against pipe whip and blowdown jet and reactive forces;

   (c) Separation of redundant features;

   (d) Provisions to separate physically piping and other components of redundant features; and

   (e) A description of the typical pipe whip restraints and a summary of number and location of all restraints in each system.

6. The procedures that will be used to evaluate the structural adequacy of Category I structures and to design new seismic Category I structures should be provided including:

   (a) The method of evaluating stresses, e.g., the working stress method and/or the ultimate strength method that will be used;

   (b) The allowable design stresses and/or strains; and

   (c) The load factors and the load combinations.

7. The structural design loads, including the pressure and temperature transients, the dead, live and equipment loads; and the pipe and equipment static, thermal, and dynamic reactions should be provided.

8. Seismic Category I structural elements such as floors, interior walls, exterior walls, building penetrations and the buildings as a whole should be analyzed for eventual reversal of loads due to the postulated accident.

9. If new openings are to be provided in existing structures, the capabilities of the modified structures to carry the design loads should be demonstrated.

10. Verification that failure of any structure, including nonseismic Category I structures, caused by the accident, will not cause failure of any other structure in a manner to adversely affect:

    (a) Mitigation of the consequences of the accidents; and

    (b) Capability to bring the unit(s) to a cold shutdown condition.

11. Verification that rupture of a pipe carrying high energy fluid will not directly or indirectly result in:

    (a) Loss of nominal redundancy in any portion of the protection system (as defined in IEEE-279), Class IE electric system (as defined in IEEE-308), engineered safety feature equipment, cable penetrations, or their interconnecting cables required to mitigate the consequences of that ~~the steam line break~~ accident and place the reactor(s) in a cold shutdown condition; or

Covered by (a)

(b) ~~Loss of the ability to cope with accidents due to ruptures of pipes other than a steam line, such as the rupture of pipes causing a steam or water leak too small to cause a reactor accident but large enough to cause electrical failure.~~

12. Assurance should be provided that the control room will be habitable and its equipment functional after a steam line or feedwater line break or that the capability for shutdown and cooldown of the unit(s) will be available in another habitable area.

13. Environmental qualification should be demonstrated by test for that electrical equipment required to function in the steam-air environment resulting from a high energy ~~steam line or feedwater~~ line break. The information required for our review should include the following:

(a) Identification of all electrical equipment necessary to meet requirements of 11 above. The time after the accident in which they are required to operate should be given.

(b) The test conditions and the results of test data showing that the systems will perform their intended function in the environment resulting from the postulated accident and time interval of the accident. Environmental conditions used for the tests should be selected from a conservative evaluation of accident conditions.

(c) The results of a study of steam systems identifying locations where barriers will be required to prevent steam jet impingment from disabling a protection system. The design criteria for the barriers should be stated and the capability of the equipment to survive within the protected environment should be described.

(d) An evaluation of the capability for safety related electrical equipment in the control room to function in the environment that may exist following a pipe break accident should be provided. Environmental conditions used for the evaluation should be selected from conservative calculations of accident conditions.

(e) An evaluation to assure that the onsite power distribution system and onsite sources (diesels and batteries) will remain operable throughout the event.

14. Design diagrams and drawings of the steam and feedwater lines including branch lines showing the routing from containment to the turbine building should be provided. The drawings should show elevations and include the location relative to the piping runs of safety related equipment including ventilation equipment, intakes, and ducts.

15. A discussion should be provided of the potential for flooding of safety related equipment in the event of failure of a feedwater line or any other line carrying high energy fluid.

16. A description should be provided of the quality control and inspection programs that will be required or have been utilized for piping systems outside containment.

17. If leak detection equipment is to be used in the proposed modifications, a discussion of its capabilities should be provided.

18. A summary should be provided of the emergency procedures that would be followed after a pipe break accident, including the automatic and manual operations required to place the reactor unit(s) in a cold shutdown condition. The estimated times following the accident for all equipment and personnel operational actions should be included in the procedure summary.

19. A description should be provided of the seismic and quality classification of the high energy fluid piping systems including the steam and feedwater piping that run near structures, systems, or components important to safety.

20. A description should be provided of the assumptions, methods, and results of analyses, including steam generator blowdown, used to calculate the pressure and temperature transients in compartments, pipe tunnels, intermediate buildings, and the turbine building following a pipe rupture in these areas. The equipment assumed to function in the analyses should be identified and the capability of systems required to function to meet a single active component failure should be described.

21. A description should be provided of the methods or analyses performed to demonstrate that there will be no adverse effects on the primary and/or secondary containment structures due to a pipe rupture outside these structures.

ENCLOSURE 3

DRAFT

BREAK LOCATION

Design basis break locations should be selected in accordance with the AEC pipe whip protection criteria; however, where pipes carrying high energy fluid are routed in the vicinity of structures and systems necessary for safe shutdown of the nuclear plant, supplemental protection of those structures and systems shall be provided to cope with the environmental effects (including the effects of jet impingement) of a single postulated open crack at the most adverse location with regard to those essential structures and systems, the length of the crack being chosen not to exceed the critical crack size.

(The critical crack size is taken to be 1/2 the pipe diameter in length and 1/2 the wall thickness in width.)

ENCLOSURE NO. 4

ATTENDANCE LIST

Kewaunee Steam Line Meeting

January 5, 1973

Pioneer Service & Engineering Company

D. Sahlin
I. Nelson
L. Newhart
R. Hollmeier
W. Lowry, Jr.
E. U. Claeson
Pai L. Lin
A. F. Kitz
M. M. DeLong
H. S. Drerer
C. E. Agan
W. M. Gelszinnus

Wisconsin Public Service Corporation

G. Giesler

Shaw, Pittman, Potts, Trowbridge & Madden

G. Charnoff

Atomic Energy Commission

L. Crocker
R. Maccary
R. W. Klecker
J. C. Glynn
D. C. Fischer
T. J. Carter
W. F. Anderson
R. Tedesco
C. G. Long
R. R. Renfrow