YANKEE ATOMIC ELECTRIC COMPANY

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United States Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. Dennis M. Crutchfield, Chief
Operating Reactors Branch #5
Division of Licensing

Reference: (a) License No. DPR-3 (Docket No. 50-29)

Subject: SEP Topic Assessment Completion

Dear Sir:

Enclosed please find our assessment of the following topic:

III-5.B Effects of High Energy Piping System Breaks Outside Containment

We trust this information is satisfactory; however, if you have any questions, please contact us.

Very truly yours,

YANKEE ATOMIC ELECTRIC COMPANY

J. A. Kay

J. A. Kay
Senior Engineer - Licensing

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Docket No. 50-29

SEP TOPIC III-5.B

REPORT ON EFFECTS OF

HIGH ENERGY PIPING SYSTEM BREAKS

OUTSIDE CONTAINMENT

AT

YANKEE ATOMIC POWER STATION

ROWE, MASSACHUSETTS

TABLE OF CONTENTS

I. INTRODUCTION

The safety objective of Systematic Evaluation Program (SEP) Topic III-5.B, "Pipe Break Outside Containment", is to ensure that pipe breaks would not cause the loss of needed functions of safety-related systems, structures, and components and to ensure that the plant can be safely shut down in the event of such breaks. The needed functions of safety-related systems are those functions required to mitigate the effects of the pipe break and safely shut down the reactor plant.

II. REVIEW CRITERIA

The current criteria for review of pipe breaks outside containment are contained in Standard Review Plan, Sections 3.6.1 and 3.6.2 including their attached Branch Technical Positions.

III. RELATED SAFETY TOPICS AND INTERFACES

a. SEP Topic III-4.C, "Internally Generated Missiles (outside containment)".

b. SEP Topic III-6, "Seismic Design Consideration".

c. SEP Topic III-12, "Environmental Qualification of Safety-Related Equipment".

d. SEP Topic VII-3, "Systems Required for Safe Shutdown".

IV. REVIEW GUIDELINES

In D. K. Davis letter to KMC, Inc., dated July 20, 1978 (Re: Assessment of Postulated Pipe Breaks Inside Containment for SEP Plants), the Staff outlined acceptable criteria to be used for SEP Topic III-5.A, "High Energy Pipe Break Inside Containment". The Staff has indicated that the criteria are acceptable for use in evaluating Topic III-5.B.

Three basic approaches for postulating pipe break locations were outlined in the referenced letter. They are:

1. Fully Mechanistic Approach - This approach uses stress analysis for postulating break locations and is an evolution of the criteria outlined in Regulatory Guide 1.46 and Branch Technical Position (BTP) MEB 3-1. However, it does not significantly deviate from these criteria. The criteria for this approach are based on the current Mechanical Engineering Branch's (MEB) practice and are extracted from the revised Standard Review Plan (SRP) 3.6.2.

2. Effects-Oriented Approach - This approach does not require stress analysis for postulating break locations. Its main objective is to provide a basis for protecting safety-related equipment from a break anywhere in the piping system. This approach is based on the Auxiliary Systems Branch's (ASB) practice for postulating break locations in the main steam and feedwater lines outside containment as an alternative to separation. The criteria for this approach are partially extracted from BTP ASB 3-1.

3. Simplified Mechanistic Approach - This approach does not require stress analysis. It is also extracted from SRP 3.6.2. This approach will result in a large number of break locations as a trade-off for not performing stress analysis.

High energy piping systems are defined as those systems where temperature is $\geq$200°F or pressure is $\geq$275 psig.

The referenced criteria require that breaks be postulated at the following locations in high energy piping systems:

1. At the terminal ends of the run; and

2. At effect-oriented intermediate locations chosen in accordance with the following:

   a. A longitudinal pipe break at the point which produces the greatest jet impingement loading on each component of each essential system (typically this would be the point of closest approach); and

   b. A circumferential pipe break at the point whch produces the greatest pipe whip loading on each component of each essential system.

Circumferential pipe breaks must be assumed to occur in lines >1" and longitudinal breaks in piping $\geq$4".

V. DISCUSSION

A. Background

High energy line break (HELB) analyses for piping systems outside containment at the Yankee Nuclear Power Station at Rowe, Massachusetts was furnished in "Report on Effects of a Piping System Break Outside Containment", dated July 1973, and "Report on Effects of a Piping System Break Outside Containment Supplemental Information", dated September, 1973. The effects-oriented approach was used as the basis for the report. The investigation was carried out in accordance with the criteria provided in the attachments to the letter sent by A. Giambusso in December 1972. These attachments are Appendix B of Standard Review Plan 3.6.1.

The general procedure utilized in conducting the original investigation was as follows:

1. A determination was made of all those systems, components and areas whose integrity must be maintained in order to conduct a safe plant shutdown for any postulated pipe rupture outside containment.

2. All plant systems outside containment were then categorized in one of three categories:

a. High energy system where circumferential and/or equivalent area longitudinal pipe breaks were postulated as required. These lines required that pipe whip, jet impingement force, and environmental effects be considered.

b. A system where the energy level required evaluation of small breaks where environmental effects were the primary concern.

c. A system where the energy level was insignificant and no failures were of concern.

3. The interaction between the systems, components and areas listed under the criteria of items No. 1 and 2 above was then determined. This determination was made by actually walking the lines and determining any area where a category 2.a or 2.b line could interfere with safe plant shutdown. This review included determining contents of cable trays.

The inspection of plant systems was conducted while the facility was shut down for reactor internals modifications; thus, there was free and unimpeded access to all necessary areas.

B. Analysis Assumptions

The following assumptions were made by Yankee Atomic:

1. High energy fluid systems are systems with operating temperature $\geq 200^{o}F$ or operating pressure ≥ 275 psig. In accordance with Branch Technical Position (BTP) MEB 3-1, breaks are not postulated in piping of systems that qualify as high energy systems for only short operational periods (i.e., less than 2% of the time the system operates as a moderate energy system or less than 1% of the time that the plant operates).

2. The worst, unrelated, single active failure occurs simultaneously with the pipe break. Unrelated passive failures are not considered in the short-term.

3. A simultaneous, unrelated, pipe failure is not postulated with the high energy pipe break.

4. The effects of pipe whip or jet impingement will not damage equal diameter or larger piping with equal or greater wall thickness.

5. The piping boundary is taken as the first normally closed valve, check valve, relief/safety valve or first valve capable of remote or automatic closure.

6. Effects of pipe whip and jet impingement from rupture of piping 1" nominal pipe size and smaller are not required to be analyzed.

7. The effects of pipe whip, impingement, or leakage from moderate energy pipe systems are not required.

C. Identification of High Energy Systems

Service temperature and pressure exceed 200°F and 275 psig, respectively.

1. Main steam lines.

2. Feedwater lines from discharge of feed pumps.

3. Auxiliary steam lines from main steam header to:

   a. Turbine bypass valve

   b. Steam to No. 1 feedwater heater control valve

   c. Air ejector inlet

   d. Building heat regulation valve

   e. Inlet valves to primary jets

4. Heater drain system from heater drain pump discharge to connection in condensate system near feed pump suction.

5. Steam generator blowdown piping from vapor container to isolation valves in primary auxiliary building.

Service temperature or service pressure in excess of 200°F and 275 psig, respectively.

1. Feedwater system from outlet of No. 3 feedwater heater to suction of boiler feed pumps.

2. Auxiliary steam lines from regulation valve to:

   a. Plant building heating steam

   b. Plant tank heating system

   c. Waste disposal evaporator

   d. Primary drain tank eductor

3. Extraction steam lines from extraction at turbine to feedwater heaters.

4. Heater vents from heaters to condenser.

5. Main steam from high pressure turbine exhaust to low pressure turbine inlet.

6. Drain lines from No. 1 and No. 2 feedwater heaters to condenser.

7. Waste disposal from evaporator to evaporator condenser.

8. Charging system from charging pump discharge to vapor container.

9. Turbine oil systems.

10. Moisture separator inlet and outlet lines to heater drain tank.

11. Drain lines from No. 3 feedwater heater to heater drain cooler.

D. Safety-Related Equipment

Safety-related equipment includes systems needed to mitigate the effects of the line breaks and to bring the reactor to safe shutdown.

Of first concern when evaluating the effects of high energy pipe breaks is to identify the lines, equipment, and instrumentation required to safely shut down the plant. These systems and equipment perform the following functions: (1) insert negative reactivity into the reactor core, (2) maintain reactor coolant system (RCS) and/or secondary side water inventory, (3) control RCS overpressure, and (4) remove decay heat and control cooldown of the RCS. Where possible, Yankee has made use of previously docketed information, as well as information developed in the NRC's "SEP Review of Safe Shutdown Systems for the Yankee Rowe Nuclear Power Plant" document. Page B-12 of that document lists the minimum required components and systems required for safe shutdown coincident with a loss of total off-site power and the most limiting single failure without a design basis event (DBE). This list is as follows:

1. Main Steam Safety Valves (MSSV) and Main Steam Piping

2. Atmospheric Dump Valves (ADVs) and Other Steam Relieving Paths

3. Emergency Feed Pump's (EFPs) and Feedwater Piping

4. Demineralized Water Storage Tank (DWST) and Primary Water Storage Tank (PWST)

5. Shutdown Cooling System (SCS) and Piping

6. Component Cooling System (CCS)

7. Service Water System (SWS)

8. Emergency Power System

9. 125V dc Power System

10. Chemical and Volume Control System (CVCS) and Piping Inside the Vapor Container

11. Pressure Control and Relief System

12. Instrumentation for Shutdown and Cooldown

VI. EVALUATION

A. Approach and Criteria

Using an effects-oriented approach, the piping and equipment required for safe shutdown were surveyed to determine if the breaking of any high energy lines would prevent safe shutdown of the plant.

Yankee has reviewed the original analysis and has compared the criteria in effect during 1973 with present day criteria. It is Yankee's position that there are negligible differences in the criteria when an effects-oriented approach is used.

With the modifications described in Section VI.C, Yankee has greatly improved its ability to handle any break outside the vapor container. The plant now has the capability of providing feed to the steam generators from pumps and piping located in the primary auxiliary building (PAB) which is physically separate from the main steam or main feed piping. The steam generators can be fed from the following:

1. Main feed and condensate pump - assuming off-site power available.

2. Steam-driven emergency feedwater pump located in the turbine building.

3. Two motor-driven emergency feedwater pumps located in the PAB.

4. Charging pumps located in the PAB.

5. Three trains of safety injection pumps located in the PAB.

The plant now has the capability of limiting blowdown from a main steam line rupture to only one steam generator.

Information provided in Topic III-12, "Environmental Qualification of Safety-Related Equipment", shows that the instrumentation required for high energy line breaks outside containment are not affected by high energy line breaks.

B. Interaction Studies

For each of the postulated break locations, the licensee evaluated the effects on the needed equipment. In addition, the effects on other impacted equipment were considered to ensure that failure of such equipment would not affect the plant's ability to safely shut down.

The results of these interaction studies show that the failure of high energy pipes outside containment will not prevent safe shutdown of the plant. A high energy line is assumed to break impacted lines which are smaller. If this impacted line is also a high energy line, the potential dynamic effects of that break were concurrently considered.

The original analysis determined that there were basically two categories of pipe rupture, each requiring different methods of heat removal and core cooling. The two basic categories were:

1. A rupture in the main feed system which completely eliminates the ability to feed the steam generators as a means of core cooling, including the emergency feed pump.

2. A rupture in a major steam line which eliminates the ability to utilize the closed-cycle steam system as part of a core cooling process.

YAEC still believes that the main steam line and main feedwater line breaks are the most severe breaks which could occur outside the vapor container. However, with the modifications installed, assuming a single failure, Yankee will not lose the ability to feed the generators and will not blowdown all four steam generators.

As part of this topic, Yankee has done an effects-oriented analysis of high energy piping systems which were added since the original report. Yankee has concluded that these additions have resulted in increased ability to safely shut down the plant. However, there are two areas where potential problems arose. They are:

1. A main steam line break in the vicinity of the non-return valve hydraulic operators may cause jet impingement on the adjacent operator. This may result in the blowdown of more than one steam generator, and will require further evaluation.

2. A break in the No. 4 main steam line will cause jet impingement on the V.C. safety injection recirculation piping and could result in violation of containment integrity and loss of ECCS function during the recirculation phase of a LOCA. This break will not cause jet impingement on the non-return valve hydraulic operators. It is Yankee's position that this is acceptable because there is no need for recirculating safety injection fluid, and Yankee believes that the off-site dose rates will be much lower than 10CFR100 limits.

Yankee has also reviewed the analysis performed in the original report. Based on this review, there is one additional area where a modification may be necessary; however, further evaluation is required. A break in the No. 2 feedwater heater extraction steam line on the mezzanine level of the turbine building results in jet impingement on the switchgear room block wall. A jet impingement shield plate similar to those installed as part of the initial report modifications could be added in this area.

C. Modifications

As a result of the original investigation, modifications were made to alleviate the following problem areas:

1. Switchgear Room Floor (Turbine Hall Ground Floor Area)

   a. Impact of ruptured feedwater lines on floor.

   b. Feedwater line fluid jet impingement on floor.

   c. Impact of ruptured feedwater lines on essential cable conduits feeding switchgear room (opposite feed pumps).

   d. Feedwater line fluid jet impingement on essential cable conduits feeding switchgear room.

2. Switchgear Room Hollow Concrete Block Wall on Turbine Hall Mezzanine Level

   a. Impact of ruptured feedwater lines on wall.

   b. Feedwater line fluid jet impingement on wall.

3. Turbine Hall Operating Floor

   a. Extraction steam line fluid jet impingement on control room windows.

4. All Levels in Turbine Hall and Primary Auxiliary Building

   a. Effects of steam environment, as a result of high energy line ruptures, on personnel and equipment.

These modifications are described in the original report and have been completed.

Yankee has made several major modifications since 1975 which provide additional assurance that the plant can be safely shut down in the event of a pipe break outside containment. The most significant modifications are:

1. Addition of two full capacity motor-driven emergency feedwater pumps located on the ground level in the primary auxiliary building. These pumps can be backfed from the emergency diesel-generators.

2. The addition of piping and valves which enables the operators to supply feedwater to the steam generators via the blowdown piping and feedwater piping inside containment. This provides a piping path which is outside the turbine building. Additional valves are provided which allow the operators tc feed the steam generators with the safety injection pumps.

3. Automatic, fast closing, hydraulic operators have been added to each of the four main steam non-return valves. Now, assuming the worst single failure, only one steam generator can completely blowdown rather than all four.

4. A local, manual, atmospheric steam dump consisting of two valves in series has been added to each of the four m in steamlines upstream of the automatic non-return valves. Each dump is capable of handling 1/2 of the decay heat load.

5. The steam supply to the turbine-driven emergency feed pump has been moved upstream of the non-return valves. Supply is from two steam generators, so that in the event of a steam line rupture, a steam supply is always available.

6. The emergency core cooling system has been upgraded so that the safety injection pumps are used in the recirculation phase of a LOCA rather than the purification pumps.

VII. CONCLUSIONS

The conclusions reached in the previous submittals on high energy line breaks outside containment are still valid. Based on these conclusions, Yankee can safely shut down assuming a high energy line break concurrent with a single active failure. This information was furnished in "Report on Effects of a Piping System Break Outside Containment", dated July 1973, and "Report on Effects of a Piping System Break Outside Containment Supplemental Information", dated September 1973.

The effects of a main steam line rupture on the non-return valve operators still requires further evaluation. Also, the need for a jet impingement shield to be added to the switchgear room wall in the area of the No. 2 feedwater heater extraction steam line must be further evaluated.