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Director
Office of Nuclear Reactor Regulation
U S Nuclear Regulatory Commission
Washington, DC 20555

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
Docket Nos. 50-282 License Nos. DPR-42
Docket Nos. 50-306 License Nos. DPR-60

Request for Schedule Relief from the
Requirements of 10 CFR Part 50, Section 50.49

On September 19, 1984 a meeting was held with the NRC staff relating to the environmental qualification of electrical equipment in the auxiliary feedwater pump room at the Prairie Island Nuclear Generating Plant. By letter, dated November 28, 1984, we committed to relocate the turbine stop valves for the steam-driven auxiliary feedwater pumps outside of the auxiliary feedwater pump rooms.

Since the September 19, 1984 meeting we have been working, on a high priority schedule, with the Prairie Island architect-engineer to complete design and procurement for this modification. The installation of this modification requires that the Auxiliary Feedwater Pump be out of service for an extended period of time with the plant at cold shutdown. We are now working to complete this work for Unit 1 during the ten-year refueling and inspections outage which started January 12, 1985. We anticipate completing the modification for Unit 1 prior to March 31, 1985, which is the currently specified deadline for both units.

Attachment 1 details the construction schedule for the Unit 2 Auxiliary Feedwater Pump modificiation. This schedule provides for the Unit 2 modifications to be completed during the ten-year refueling scheduled to start in August, 1985. Additional schedule relief from the Commission is being sought since this schedule cannot realistically be improved upon.

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As noted in our letter dated November 28, 1984, to justify continued operation of the plant prior to the completion of this modification, Impell Corporation performed a fracture mechanics evaluation of the steam supply piping in the auxiliary feedwater pump room. This analysis concluded:

1. The double-ended guillotine breaks that were previously postulated to cause harsh steam environments in the auxiliary feedwater pump room need not be postulated

2. There is significant margin on crack initiation for postulated cracks in the steam supply lines

3. The leakage from small, stable cracks is detectable

4. The leakage from larger cracks will not impact the function of safety related equipment

We believe that operation of Unit No. 2 may safely continue until the work is completed later this year and that premature shutdown of the unit is not necessary. The Impell analysis is provided in Attachment 2.

Therefore, based on the above information, an exemption is requested from the schedule specified in 10 CFR Part 50, Section 50.49, to relocate the Unit 2 turbine-driven auxiliary feedwater pump stop valve. The ten-year outage is expected to begin in August, 1985. Uncertainties in outage scheduling make it impossible to precisely fix this date, however. For this reason, schedule relief until the next refueling outage of Unit 2, but in no case later than November 30, 1985, is requested.

All other modifications required to comply with Section 50.49, that have been identified to date, will be completed by March 31, 1985. We believe this reflects the good faith effort being made by Northern States Power Company to achieve full compliance with the Commission's environmental qualification requirements.

A check in the amount of $150.00 is included as the review application fee requried by 10 CFR Part 170. Please contact us if you have any questions related to our request.

David Musolf
Manager-Nuclear Support Services

DMM/le

c: Regional Administrator-III, NRC
NRR Project Manager, NRC
Resident Inspector, NRC
G Charnoff

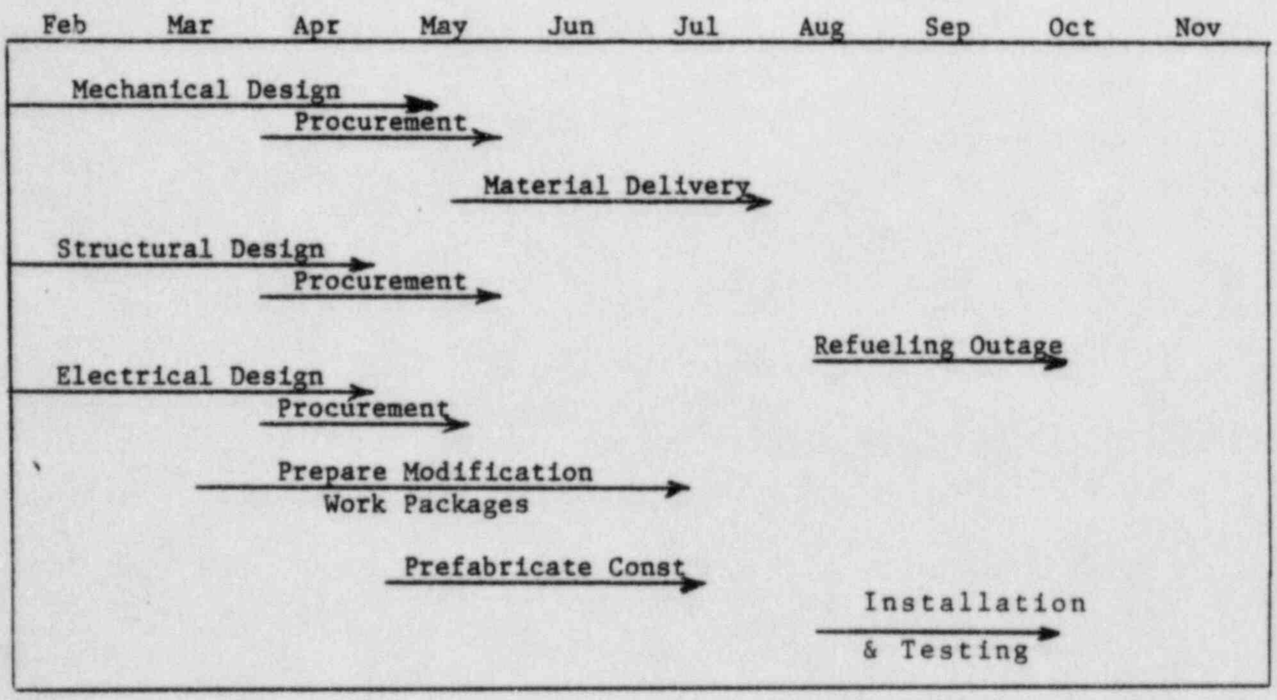
Attachments

Director of NRR
January 25, 1985
Attachment 1

Relocate Steam Inlet Valves
to Unit 2 Turbine Driven
Auxiliary Feedwater Pump

<u>Project Milestones</u>

1985



Leak-Before Break Evaluation for Auxiliary Feedwater Pump Room

Prairie Island Nuclear Generating Plant Units 1 and 2

1.0 Introduction

As part of the environmental qualification effort initiated in response to IE Bulletin 79-01B, abnormal environments outside containment due to postulated double-ended pipe ruptures were determined. Included in this review was an evaluation of the potential double-ended rupture of the steam supply line to the turbine-driven auxiliary feedwater pump (TDAFWP). A rupture of the steam supply line to the TDAFWP could potentially affect safety-related electrical equipment in the pump rooms, including the electric motor control centers (MCCs). A general arrangement diagram of the auxiliary feedwater (AFW) pump rooms is provided in Figure 1. A complete equipment list of safety-related electrical equipment in the AFW pump room is shown in Table 1. The AFW pumps are arranged by train. The redundant motor driven pump serving each unit is located in an adjacent room separated by an automatic fire door.

Initially, it was determined that a rupture of the steam supply line to the TDAFWP would not result in an increased temperature, pressure, or humidity in the AFW pump room because the piping was encapsulated with guard piping. This guard piping was installed in 1972 as part of an effort to mitigate the consequences of a High Energy Line Break (HELB) outside containment. It was believed that the guard piping would maintain the escaping steam within the annular area between the steam supply line and the guard pipe and that the steam would exit from this annular area through an opening in the guard pipe located outside of the AFW pump room. Thus, the environment in the AFW pump room would not be different than that existing during normal operating conditions.

Subsequently, it has been determined that the guard piping is not welded to the TDAFWP control valve at the terminal end of the high-pressure portion of the piping in the AFW pump room. Thus, there is a possibility that in the event of pipe rupture, steam could escape from the annular area between the guard pipe and the steam supply line and exit to the AFW pump room. In this case, steam entering the AFW pump room could create an adverse environment.

Several options were explored to resolve this issue, including:

- o backfit welding of the guard piping to the control valve to eliminate the postulated steam environment;
- o modification of the AFW pump room to a configuration that would ensure isolation of the redundant motor driven AFW pump from the adverse environment;

- o environmental qualification of the safety-related equipment in the room to the conditions that would exist following a postulated double-ended break of the steam supply line;
- o relocation of safety-related equipment to an isolated post-accident environment; and
- o replacement of safety-related equipment with equipment qualified to the postulated environments.

In each case, the options for resolution proved to be unacceptable. Backfit physical modification is not feasible since welding the guard pipe to the control valve body to close the gap between them would produce unacceptably high stresses in the valve body due to differential thermal expension. A data search was performed to evaluate the potential for qualifying the existing equipment and it was determined that qualification data was not available. Relocation and replacement of equipment would require significant plant modifications, including new Class 1 facilities designed to meet Appendix R and environmental qualification requirements and extensive relocation of safety-related control and power equipment. Modifications to this extent would negatively affect plant safety and performance.

Accordingly, the only approach that was technically justified was a fracture mechanics approach to realistically determine the failure mode of the pipe break and the subsequent post-accident environment. The technical approach used and the results of this evaluation are reported below. In summary, the evaluation determined that the leak that would develop from a crack in the steam supply line results in an environment that will not lead to any damage to the safety-related equipment in the room.

2.0 Technical Evaluation

A leak-before-break evaluation was performed to define the potential harsh environment that could develop in the AFW pump room due to failure of the steam supply lines. The approach is based on demonstrating that the steam supply lines to the TDAFWP would develop stable, detectable cracks rather than suddenly breaking in a double-ended guillotine fashion, as has been previously postulated. The approach used three analyses to provide a realistic determination of the steam and temperature conditions resulting from a crack in the pipe. First, linear elastic and elastic-plastic fracture mechanics are used to define crack growth potential and to evaluate the stability of a through-wall crack. Second, two-phase fluid flow computations define the leakage of high-energy fluid from the pipe into the room. Third, thermal/hydraulic energy and mass balances are used to determine the environment in the room due to the leakage from the pipe. The capability of the safety-related equipment to sustain this calculated AFW pump room environment was then evaluated.

The fracture mechanics and fluid flow analyses are described in Section 2.2. The thermal/hydraulic analysis is similar to those standardly used to define environments and is not described in detail here.

2.1 Description of Piping

The portions of two TDAFW steam supply lines inside the AFW pump room were covered by the evaluation and are shown in Figures 2 and 3. The following is a description of the piping system:

Design Class: I
Design Pressure: 1085 PSI
Operating Pressure: 1005 PSI
Design Temperature: 600°F
Operating Temperature: 560°F
Pipe Size and Schedule: 3", Schedule 80
Pipe Material: A106, Grade B

The portions of the steam supply lines inside the rooms are fairly short. The line to turbine number 11 is approximately 36 feet in length, and the line to turbine number 22 is approximately 19 feet in length. The piping is enclosed by a guard pipe which is covered by 2-1/2"-thick insulation. As mentioned in Section 1, the guard pipe does not completely encapsulate the piping in the room.

2.2 Methodology

For conservatism, several locations were evaluated in addition to the one break in the room on each line required by the guidelines of SRP 3.6.1. A total of twelve locations (six on each line) were selected. The terminal ends of the high energy portion of the piping at the valves were evaluated. The pipe/turbine junctions, although not normally pressurized, were included using a broad interpretation of the terminal end of a piping system. On each line, four additional locations of peak normal operating loads and peak seismic loads were evaluated.

A defense-in-depth approach was used to demonstrate that small surface flaws will not grow significantly over the design life of the plant and that if a through-wall crack were to develop, it would be stable and could be detected and repaired. The following evaluations were performed:

- o The maximum allowable in-service flaw, according to the ASME BPVC, Section XI, was postulated and the crack growth was shown to be acceptable throughout the life of the plant.

- o The leakage through a crack twice the wall thickness (2t) in both longitudinal and circumferential direction was shown to be detectable under normal conditions (Level A).

- o A crack four times the wall thickness (4t) in both longitudinal and circumferential directions was shown to be locally and globally stable under faulted conditions (Level D). The safety margin against instability was determined.

- o The flow through the 2t crack was calculated and the resulting environment was shown to have no impact on the safety-related equipment in the room.

These evaluations are described in the following sections.

2.2.1 Crack Growth Analysis

A fatigue crack growth was performed in accordance with ASME B&PV Code, 1983, Section XI. A maximum flaw size was assumed, and the method in Appendix A was used to show that this maximum crack will not grow significantly over the life of the plant.

A semi-elliptical circumferential surface flaw size was assumed with dimensions taken from Table IWB-3514-1. The greatest value of the aspect ratio (a/t = 14.4%) was used to define the initial flaw.

The crack depth at the end of the design life of the plant was calculated to be 16.67% of the wall thickness using conservative definitions of transient loads. The acceptance criteria for stress intensity from Section IWB-3612 were met. The evaluaton clearly showed that small flaws will not grow through the pipe wall under design conditions.

2.2.2 Flow Through a Postulated 2t Crack

Two analyses were performed to determine the leak rate through a postulated 2t crack. The first analysis was performed using minimum Level A loads (pressure + thermal + gravity). The second analysis used maximum Level D loads (pressure + gravity + thermal + SSE SAM + SSE) to determine a postulated worst case leak rate. This upper bound leak rate was used to determine the severity of the environemnt that would result in the AFW pump room.

The crack opening area was calculated using the computer program CRACK and the leak rate was calculated using the program IMLEAK. CRACK is based on the methodology of Reference 1. Stress intensity factors based on methods of linear elastic fracture mechanics, including corrections for plastic zones at the crack tips, are used. Internal pressure, axial forces, and bending moments are considered. IMLEAK is based on Reference 2. IMLEAK evaluates flow rate through cracks in piping given the upstream thermodynamic conditions and the geometric configurations of the crack. The model used accounts for two-phase flow and includes pressure drops due to entrance, friction, acceleration, and area changes.

Under Level A loads, the 2t crack leak rate is 0.001 gpm, which results in a leakage of approximately 0.5 gallons of water in eight hours. The maximum leakage through a 2t crack under Level D is 0.018 gpm.

2.2.3 Local and Global Stability of a 4t Crack

To establish that a crack in the pipe is stable and would not extend even under the most severe loading conditions, the local and global stability of the cracked pipe was evaluated. For conservatism, a 4t crack and maximum Level D loads (pressure + gravity + thermal + SSE SAM + SSE) were used. The stress intensity, K_I, was determined using the CRACK program, and J_I was calculated from K_I. Local stability was established by showing J_{IC}/J_I. A minimum margin of 29 on local stability was determined.

The global plastic stability of the piping section with a 4t crack under Level D loadings was demonstrated. The fully plastic moment capacity (M_p) of the section was shown to be greater than the actual applied moment, M, and the margin on global stability (M_p/M) was established. A minimum margin of 3.77 for global stability was determined.

These results indicate a wide margin of safety against both local and global stability for a crack twice the size of the postulated 2t crack.

2.2.4 Leak Detectability

Operating personnel are required by plant procedures to enter and inspect the AFW pump room at least twice each 8-hour shift. This inspection includes visual examination for steam leaks and unusual water accumulation. A leak or degrading environment would be detected. The motor-operated isolation valves for the steam supply lines are controlled from the control room. The motor-operated isolation valves are not affected by environmental changes in the AFW pump room.

To provide additional assurance that the postulated leak would be detected, a dedicated leak detection system will be installed. This system will annunciate in the control room.

2.2.5 Environmental Conditions Resulting from a 2t Crack

A thermal/hydraulic analysis was performed to determine the environment that would develop in the room due to the leakage from the cracked pipe under Level D conditions.

The analysis conservatively assumes that the entire leakage from the pipe exits into the AFW pump room and none exits from openings in the guard pipe outside the room. The HVAC system is redundant; there are four supply fans and two exhaust fans. In addition, the maximum leak rate is based upon steady application of Level D loads and does not account for crack closure that would occur when the Level D loads cease to act. This is a significant conservatism in the leak rate calculation. Thus,

there is considerable conservatism in the derivation of the post-accident temperature and relative humidity.

The thermal hydraulic analysis shows that for initial room conditions of 80°F and 70% RH and HVAC flow at 4,000 cfm at 80°F and 70% RH, the steady state conditions for the room are below 95% RH and 105°F for leakage under Level D conditions. The analysis shows insignificant change due to leakage under Level A conditions.

2.2.6 Environmental Response of Equipment

The maximum environmental conditions calculated (105°F, 95% RH) represent a relatively small incremental increase from the normal ambient conditions. Based on our environmental equipment qualification experience to date, we have not identified any plant equipment unqualified to this environment. In fact, this environment does not differ significantly from the normal environment and could be considered a mild environment.

The safety-related electrical equipment of primary concern in the room are electric motors for the motor-driven AFW pumps and several MCCs. Power for the motor-driven AFW pumps is provided from a source outside the affected room.

The electric motors are of Class B insulation, which is capable of 90°C temperature rise at a service factor of 1.15. Operability of the motors is assured based on the high industrial quality of the motors, the fact that they are manufactured in accordance with IEEE and NEMA Motor standards, and the general capabilities of other similar Class B insulated motors installed at Prairie Island and other nuclear facilities.

The MCCs with safety-related loads are manufactured by General Electric (GE-7700 series). These MCCs can be expected to perform in the postulated post-accident environment based on testing of these and other similar MCCs. The GE-7700 series MCCs have been tested to 122°F and 95% RH. A new version of MCC, GE-8800 series, is qualifiable to approximately 135°F based on information obtained from the 7700 series testing. In addition, an owners group has been formed, of which NSP is a participant, to extend the qualification of the GE-7700 series MCCs to an excess of 160°F at 100% RH. Phase I of that program has been completed and there is assurance that the MCCs could operate, if so required, for the duration of the post-accident increase in environment.

3.0 Leak Detection

As discussed in Section 2.2.4, visual leak detection provides assurance that the leakage or a degrading environment from a through-wall crack would be detected. Additional assurance of leak detection will be provided by installation of a dedicated leak detection system annunciating in the control room.

4.0 Summary

The discussion provided above has outlined the specific application for which a fracture mechanics evaluation was used to determine post-accident environments to be used in equipment qualification. A defense-in-depth approach was used to show that small cracks are stable and detectable. There is significant margin against both local and global instability to ensure that the harsh environment resulting from a double-ended guillotine break will not occur. The technical basis upon which the fracture mechanics evaluation was performed is conservative. Based on the design and available testing on the safety-related equipment installed in the AFW pump room, adequate assurance of equipment operability exists under these conditions.

We believe that this approach to justify environmental equipment qualification for this one isolated case is technically justifiable and conservative. In addition, alternative solutions have been determined to require significant plant modification and negatively affect plant safety and performance. Accordingly, NRC acceptance of this specific application of fracture mechanics methodology is requested.

References:

1. H. Tada and P. Paris, "Estimation of Stress Intensity Factors and the Crack Opening Area of a Circumferential and a Longitudinal Through-Crack in a Pipe", Del Research Corporation, St. Louis, Missouri.

2. R.P. Collier, et. al., "Study of Critical Two-Phase Flow Through Simulated Cracks", Interim Report BCL-EPRI-80-1, Battelle Columbus Laboratories, 1980.

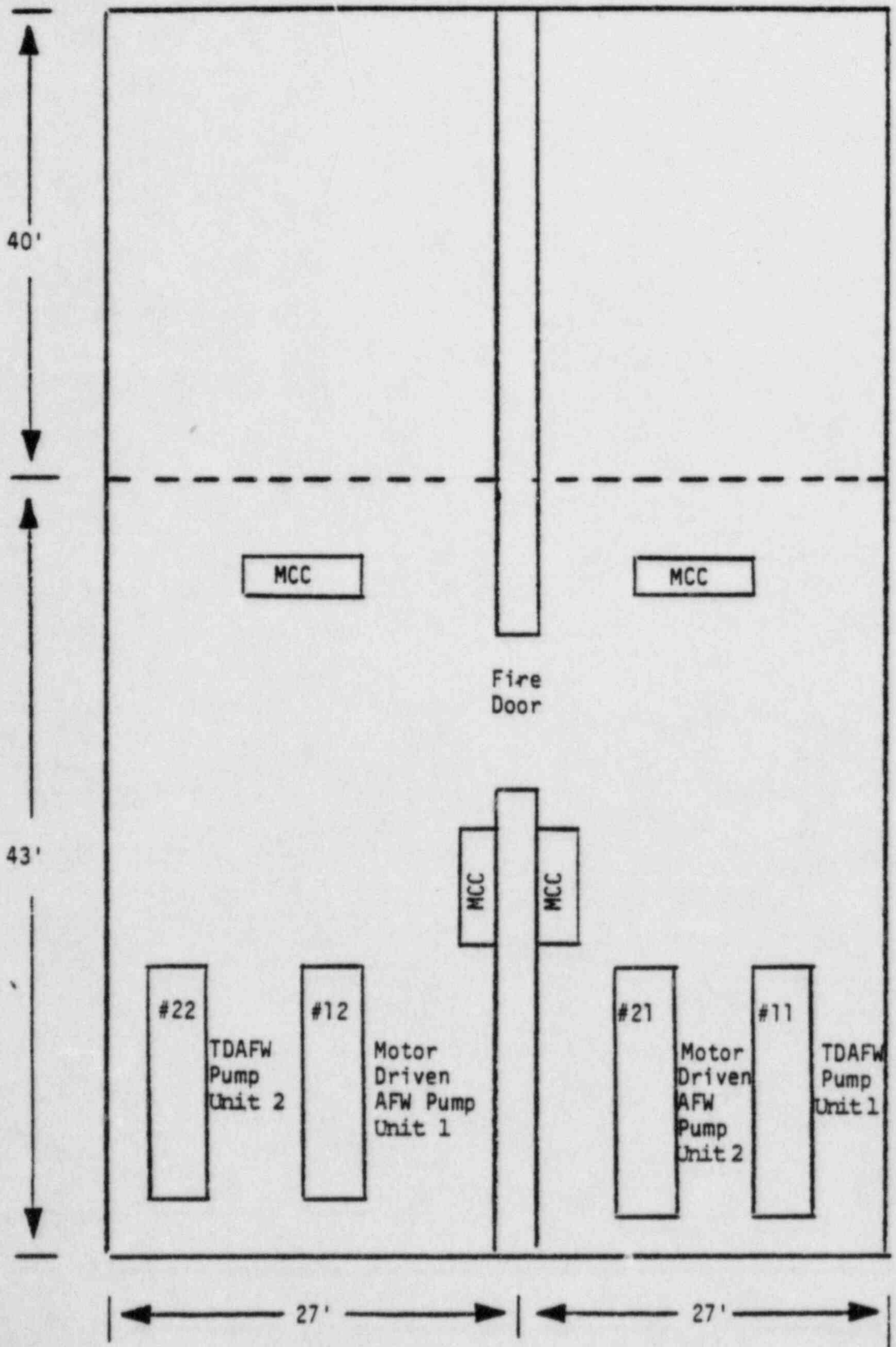


FIGURE 1 - General Arrangement of the AFW Pump Room

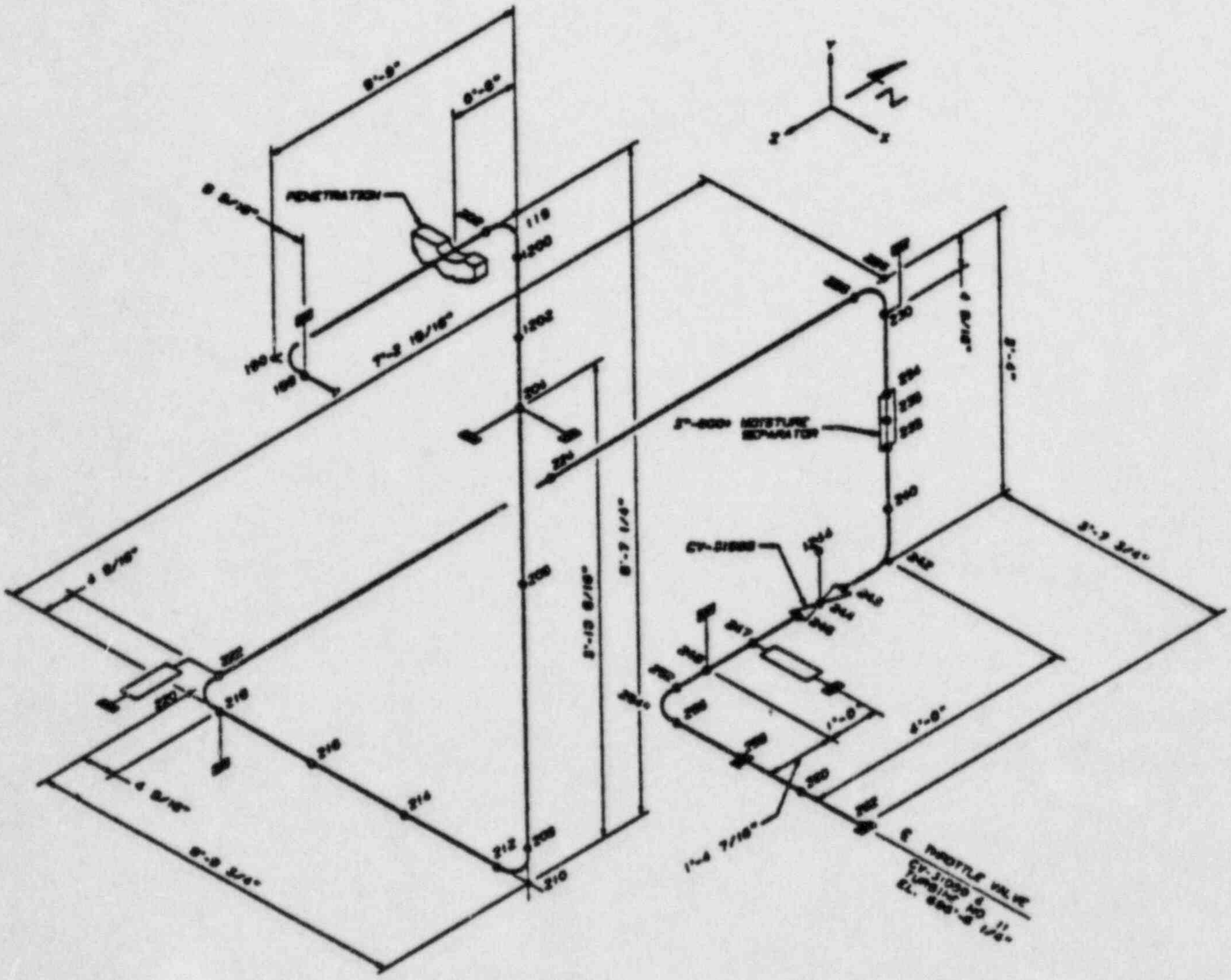


FIGURE 2 - Piping Isometric of Auxiliary Feedwater
Steam Line to Turbine Pump No. 11, Unit 1

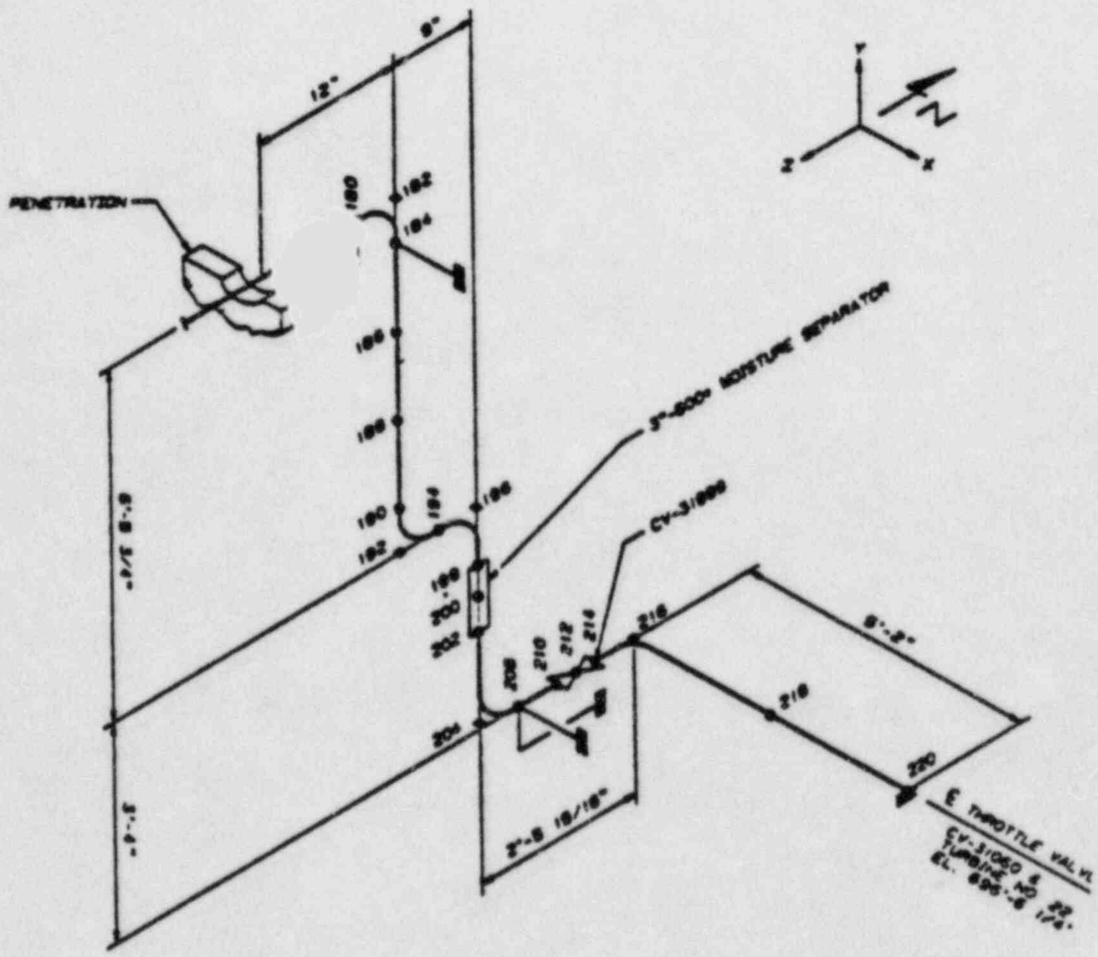


FIGURE 3 - Piping Isometric of Auxiliary Feedwater
Steam Line to Turbine Pump No. 22, Unit 2