APPENDIX I

POSTULATED PIPE FAILURE ANALYSIS OUTSIDE OF CONTAINMENT

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APPENDIX I – POSTULATED PIPE FAILURE ANALYSIS OUTSIDE OF CONTAINMENT

INTRODUCTION

In an Atomic Energy Commission (A Giambusso) letter to Northern States Power (AV Dienhart) dated December 12, 1972 [Ref. 1], the AEC stated that Prairie Island "...should be designed so that the reactor can be shutdown and maintained in a safe shutdown condition in the event of a postulated rupture, outside of containment, of a pipe carrying high energy fluid, including the rupture of the largest pipe in the main steam and feedwater systems". This letter requested information on how the plant design would be revised to accommodate the postulated pipe ruptures and how any proposed modifications would address the guidelines and criteria contained in the attachment to the letter. Additional requests for information and clarification of AEC criteria are contained in AEC (A Giambusso) letters to NSP (AV Dienhart) dated January 11, 1973 [Ref. 2] and February 9, 1973 [Ref. 3].

Although the Giambusso letters were only applicable to high energy line breaks outside containment, a conservative engineering judgement was made to perform a similar review of the main steam and feedwater lines inside containment utilizing the criteria from the Giambusso letters. This review resulted in installation of impingement barriers on portions of these lines. This information was not included in the FSAR, but was added to this Appendix for completeness.

Nuclear Regulatory Commission (NRC) Generic Letter 87-11 (GL 87-11) [Ref. 4] relaxed the requirements for postulating arbitrary intermediate breaks and leakage cracks in high energy piping systems. This Appendix includes information on NSP's response to the Giambusso letters and NSP's subsequent application of GL 87-11 criteria. When adopting the relief offered by Generic Letter 87-11, PINGP eliminated arbitrary breaks and utilized the applicable stress equations for break selection in the attached MEB 3-1 and nothing more. 01367047

In addition, high energy lines in the Turbine Building were reviewed utilizing the criteria from the Giambusso letters. This review resulted in installation of steam exclusion dampers, impingement barriers and pipe whip restraints on portions of these lines. This information was not discussed in FSAR Appendix I, but was added to USAR Appendix I for completeness.

I.1 HIGH ENERGY PIPING SYSTEMS AND REQUIRED EQUIPMENT

I.1.1 Definition of High Energy Piping Systems

A piping system is defined as having pressure retaining components consisting of straight or curved pipe and pipe fittings such as elbows, tees and reducers. The boundaries of a system are defined in terms of a piping run. A piping run interconnects components such as pressure vessels, pumps and rigidly fixed valves or structural anchors that may act to restrain pipe movement beyond that required for design thermal displacement. A branch run differs from a main piping run only in that it originates at a piping intersection as a branch of the main pipe run.

High energy piping systems are defined as those having a service temperature of 200°F and above and a design pressure above 275 psig. The plant operational conditions under which this definition applies, including normal reactor operation and upset conditions (e.g., anticipated operational occurrences). [Ref. 1, 2, 3, 24, 25, and 28]

There is no ASME Section III, Code Class 1 piping outside containment for the Prairie Island Nuclear Generating Plant. Therefore, the criteria used for determining design basis break and leakage crack locations is ASME Section III, Code Class 2 and 3.

I.1.2 Identification of High Energy Piping Systems

The piping systems, or portions thereof, of the Prairie Island Nuclear Generating Plant which meet the definition of high energy are [Ref. 9.5]:

<u>Auxiliary Building</u>

- Main Steam
- Feedwater
- Chemical and Volume Control Letdown
- Steam Generator Blowdown
- Steam Supply to Auxiliary Feedwater Pump Turbine

<u>Turbine Building</u>

- Main Steam
- Feedwater
- Steam Supply to Auxiliary Feedwater Pump Turbine
- Condensate
- Heater Drain Pump Discharge
- Turbine Bleed Steam to Feedwater Heaters
- Feedwater Heater and Moisture Separator / Reheater Drains

I.1.3 Selection of Break and Crack Locations

The December 12, 1972 AEC letter [Ref 1] provided the criteria that was originally used at Prairie Island to select break and crack locations. The break location criteria required selecting the terminal ends of the piping run, any location along the pipe where the combined stress exceeded 0.8 (S_h + S_A) or expansion stress exceeded 0.8 S_A plus a minimum of two arbitrary intermediate locations based on high stress. The break size was defined to be twice the inside pipe diameter in length and a width that would yield a break area equal to the effective cross-sectional flow area upstream of the break location. The crack criteria required selecting any location along the length of the pipe. The crack was defined to be one-half the pipe diameter in length and one-half the pipe wall thickness in width.

Longitudinal breaks were to be postulated in piping runs of 4″ nominal diameter and larger and would be parallel to the pipe axis oriented anywhere around the pipe circumference. Circumferential breaks were to be postulated in piping runs exceeding a nominal 1″ diameter and oriented perpendicular to the pipe axis. Cracks could occur anywhere along the length of pipe. The most adverse locations and orientations were selected after considering potential jet impingement and environmental impact on nearby plant equipment.

GL 87-11 [Ref. 4] provided a relaxation in the criteria for selecting arbitrary intermediate pipe break and leakage crack locations as well as deleted the expansion stress criteria. This new criteria selected breaks at any location along the pipe where the combined stress exceeded 0.8 (1.8 S_h + S_A) and leakage cracks at any location where the combined stress exceeded 0.4 (1.8 S_h + S_A). GL 87-11 did not revise the break and crack criteria for type, size and orientation or the terminal ends.

The GL 87-11 crack criteria are less strict than the original licensing basis crack criteria of assuming a crack at any location along the pipe. NRC Information Notice 2000-20 clarified that locations selected based on stress analysis alone may not be sufficient to ensure that the most adverse locations are described. Therefore, cracks at the most adverse locations are assumed in the break location selection.

GL 87-11 [Ref. 4] also requires that breaks should be postulated at the piping welds to each fitting, valve, or welded attachment for piping systems that do not have pipe stress calculations. This requirement applies to the high energy piping systems in the Turbine Building. Breaks were assumed at any point along high energy piping without detailed break selection due to the large number of fittings, welded attachments, valves, and terminal ends.

I.1.4 Selection of Required Equipment

The equipment required to detect and mitigate the consequences of a high energy line design basis break or leakage crack is selected to accomplish the following functions:

- Reactor trip
- Reactivity control
- Reactor coolant system pressure control
- Reactor coolant system inventory control
- Event monitoring

Operability of this equipment provides the capability to achieve Mode 3, Hot Standby, either by operator actions or by automatic reactor protection functions. This equipment also provides the capability for ultimately achieving Mode 5, Cold Shutdown.

The rupture of high energy piping systems is discussed in various sections of the USAR and identifies the assumptions made for those postulated events. Main steam is discussed in Section 14.5, feedwater in Section 14.4, CVCS letdown in Section 10.2, steam generator blowdown in Section 9.2 and steam supply to the auxiliary feedwater pump turbine is considered a small main steam line break.

For the purposes of this Appendix, these assumptions can be summarized as follows:

a. The methodology used to determine compartment pressure and temperature profiles is described in USAR Appendix I.5.3 (Compartment Pressure and Temperature). Peak pressures and temperatures in principal compartments are identified, and referenced calculations provide peak values in other compartments as well as long-term pressure and temperature time histories.

b. After a postulated accident in one unit, the other unit is brought to Mode 3 (Hot Standby).

c. A single active failure is assumed in the short term.

d. Any rupture in the secondary side main steam system is not isolatable (i.e., the rupture is upstream of an MSIV or the assumed single failure is one MSIV does not close) and the entire inventory of one steam generator blows down.

e. For peak compartment temperature calculations, the main steam released becomes increasingly superheated as steam generator tubes are uncovered.

f. All required equipment is operable from the Control Room or is accessible for manual operation.

g. The postulated pipe rupture occurs at the following plant operating conditions:

- Main Steam – Mode 3 (Hot Standby) for peak compartment pressure calculations and Mode 1 (Power Operation) full NSSS power plus uncertainty (1690 MWt) for peak temperature calculations.
- Feedwater – Mode 1 (Power Operation) full NSSS power plus uncertainty (1690 MWt) for peak compartment pressure calculations and 25% full power plus uncertainty (1690 MWt) for flooding evaluations.
- CVCS Letdown – Mode 3 (Hot Standby)
- Steam Generator Blowdown – Mode 3 (Hot Standby)
- Condensate – Mode 1 (Power Operation)
- Heater drain pump discharge – Mode 1 (Power Operation)
- Turbine bleed steam – Mode 1 (Power Operation)
- Feedwater heater drains – Mode 1 (Power Operation)

h. A loss of offsite power (LOOP) is assumed to occur at reactor protection system (RPS) actuation or turbine trip, whichever results in a more conservative analysis result, and independent of whether the RPS actuation was automatically or manually initiated.

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I.2 FEATURES FOR PROTECTION AGAINST THE EFFECTS OF HELB EVENTS

I.2.1 Pipe Rupture Induced Loads

Pipe Whip

The analysis of reaction loads resulting from pipe ruptures took into consideration the duration, initial conditions, jet stream dynamics and system pressure characteristics.

The location of breaks for pipe whip considerations was originally defined by the criteria in the Giambusso letter [Ref. 1]. Application of the GL 87-11 criteria [Ref. 4] eliminated all of the arbitrary intermediate break locations to be considered for pipe whip analysis, except for those piping systems in the Turbine Building without combined stress analysis.

The loads induced from the pipe rupture include the effects of any line restrictions, such as flow limiters, between the pressure source and the break location. The effect of break opening geometry on the magnitude of reaction load is incorporated in the analysis by the application of an appropriate, but conservative, discharge coefficient. For circumferential breaks, the discharge coefficient has a value of 1.0. For longitudinal breaks, the discharge coefficient is determined by the postulated break opening geometry for each case and is not greater than 0.85.

If a whipping pipe was capable of impacting adjacent pipes of equal or greater nominal pipe size and equal or heavier wall thickness, the adjacent pipe was considered to be free from rupture. Protection from pipe wall whip was not provided if pipe rupture occurred in such manner that 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 required to survive the accident.

Piping that is physically separated or isolated from safety related structures, systems or components was excluded from the analysis. The physical separation or isolation may take the form of distance, protective barriers or pipe restraints designed specifically for pipe whip.

The restraints installed on the high energy piping systems preclude any functional damage to required equipment in the Shield Building Annulus, Auxiliary Building, and other structures.

Compartment Pressure Loading

Compartment differential pressure loading from design basis breaks is determined from the mass-energy flow rates, from either a single ended or double ended break, the building compartment characteristics (volumes, heat sink surface areas, vent paths, etc.) and the postulated break locations.

To evaluate the capability of the compartment (walls, floors, etc.) to withstand pipe rupture pressures, methods of analysis described in USAR Section 12 were used.

Jet Impingement

Jet Impingement loading on structures, systems or components required for design basis breaks or leakage cracks is determined from the magnitude and area of influence of the jet for each break based on the break size, orientation and fluid conditions. The jet forces at the point of rupture are consistent with those used in the pipe whip analysis and are based on the fluid pressure and temperature conditions occurring during normal plant operating modes. Jet loadings are not considered to vary with time, but are conservatively based on the initial conditions at the time of rupture.

Concrete (Punching) Shear Stress

The allowable stresses for shear, bond, etc., are determined from the accident/normal stress ratios associated with the compressive and tensile allowables. The accident/normal stress ratio for A615 reinforcing steel [Ref. 16] is $0.9f_y/0.5f_y = 1.8$ and the accident/normal allowable stress ratio for concrete is $0.86f_y/0.45f_c' = 1.89$. Using 1.8 as the ratio for both concrete and steel maintains ductility within the concrete element, since steel is the governing material. The allowable accident stress for (punching) shear during a pipe rupture is therefore 1.8 times the normal provisions of ACI 318-63 Section 1207 [Ref. 15].

The dynamic forces associated with the jets are evaluated with respect to their distance and spread from the pipe separation or crack. The jet geometry, where it impacts a concrete wall, is normally ellipsoidal and its perimeter defines the (punching) shear area. The magnitude of the jet force and area of loading is compared to the (punching) shear capacity. Where shear is found to be adequate, the concrete element is checked for other possible modes of stress or failure.

Jet Erosion of Concrete

The erosion of concrete by fluid jets is evaluated in WCAP-7391, “Pressurized Water and Steam Jet Effects on Concrete” by Westinghouse Atomic Power Division [Ref. 12]. To summarize the tests, five reinforced concrete beams were subjected to steam jets with nozzle diameters of 1, 2 and 4 inches. The distances investigated between nozzles and beams were 1 foot and 4 feet and the initial system pressure was 2250 psi. The results are as follows:

The erosion under all beam tests was observed to be (at most) 30 mils of surface paste removal, with no significant loss of either fine or coarse aggregate. The resultant surfaces showed the same appearance as would be present after light sandblasting. It is concluded that short term erosion of concrete surfaces as a result of a high energy line break is not a design consideration.

I.2.2 Mitigating Consequences of Pipe Rupture

Pipe Restraints

Piping restraints are installed on high energy piping systems based on the identification of break locations selected in accordance with the criteria in the Giambusso letter [Ref. 1]. The piping restraints are designed to accommodate the loading induced by the reaction or whipping forces from the postulated design basis breaks. For a specific break location the pipe restraint accommodates a longitudinal break extending one pipe diameter on each side of the identified pipe stress node location or a circumferential break at the identified pipe stress node location.

Application of the GL 87-11 [Ref. 4] break selection criteria eliminated all high energy line design basis break locations outside containment except the terminal ends, intermediate anchors and identified branch connections.

Structural Components

Design Class I structures are reviewed for their adequacy to withstand the effects of postulated high energy pipe breaks. This analysis considers the effects of pressure and temperature transients and the static, thermal and dynamic reactions of the pipe in conjunction with the applicable loads listed in USAR Section 12.

Load combinations for structures used to mitigate a HELB event are in accordance with USAR Table 12.2-4 utilizing the DBE load combination with “other” loading as appropriate. Allowable stresses are based upon USAR Table 12.2-5 condition 5.

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Load combinations for components used to mitigate HELB event are in accordance with USAR Table 12.2-11 condition 5. Allowable stresses are based upon faulted condition allowances.

Design Class I structural elements, such as floors, interior walls, exterior walls, building penetrations and the building as a whole, are analyzed for eventual reversal of loads due to a postulated design basis break.

Guard Pipes

Two types of “guard pipes” are used:

1. Encapsulation sleeves are installed to reduce the mass-energy released by the postulated break to limit the pressure build-up in the various Auxiliary Building compartments.

The inside diameter of a main steam encapsulation sleeve is designed to be 3/4″ greater than the outside diameter of the process pipe yielding an annular gap of 3/8″ circumferentially. This produces an escape vent area of 36 in^2 per open end for the 30″ main steam line. Due to the internal geometry of the encapsulation sleeve at the tee to the safety valve riser (three open ends), the effective annular vent area is the same as an encapsulated sleeve with two open ends [Ref. 9.1]. Application of GL 87-11 criteria eliminated these tees as break locations.

Peak containment pressure from a main steam line break is below the containment design rating, therefore, no encapsulation sleeves are installed in Containment. Since the mass-energy release from the postulated main steam breaks (selection based on the Giambusso letter) was significantly larger than the other high energy lines, encapsulation sleeves were only installed on main steam piping.

Application of the GL 87-11 [Ref. 4] break selection criteria eliminated all high energy line design basis break locations outside containment except the terminal ends, intermediate anchors and identified branch connections. None of the branch connections required installation of an encapsulation sleeve [Ref. 9.4].

The following requirements [Ref. 10] are applicable to the design and support of encapsulation sleeves at design basis break locations:

a. The encapsulation sleeve is designed to fit closely around the process pipe in a manner that does not introduce significant strain concentrations on the encapsulated portion of the process pipe. The weight of the encapsulation sleeve is added to the mass of the process pipe in the pipe stress analysis and is supported by the process pipe's support system.

b. The encapsulation sleeve is designed, constructed and tested in accordance with the requirements of ASME Section III, for Code Class 2 components [Ref. 13] with the added requirement that every other pass of the final assembly welds are non-destructively examined by surface examination techniques (i.e., liquid penetrant or magnetic particle). The stresses imposed are limited to those associated with "emergency conditions."

c. The encapsulation sleeve is designed to withstand the dynamic forces of internal pressurization resulting from the escape of high energy fluid at the postulated pipe break location assuming complete pipe severance and axial separation to the extend permitted by the pipe restraints or a longitudinal break as defined in Section I.2.1.

d. The piping beyond the encapsulation sleeve is provided with pipe whip restraints (or anchors) which restrict its axial displacement and motion within the sleeve following a postulated circumferential pipe break.

e. The encapsulation sleeve extends for a minimum distance of two pipe diameters on either side of the design basis break location.

f. The encapsulation sleeve is designed to allow normal thread expansion movement of the process pipe and is not welded to the process pipe.

g. The materials are ASTM A-516 Grade 70 plate, A-106 Grade B pipe and A-234 Grade WPB fittings [Ref. 16].

h. The encapsulation sleeve is provided with open vent and drain pipe nipples which extend beyond the pipe insulation as a means of monitoring the encapsulated process pipe section for any leaks that might develop in service.

i. The design of the encapsulation sleeve permits either its removal by machining or flame cutting for the replacement of the encapsulated process pipe section in the event leaks develop.

2. <u>Impingement barriers</u> are installed to protect a structure, system or component by deflecting the high energy fluid jet generated by the postulated break or crack. Application of the GL 87-11 leakage crack location selection criteria eliminated the need for most of these installations.

   The following requirements [Ref. 11] are applicable to the design and support of impingement barriers at design basis break and crack locations:

   a. The impingement barrier is designed in a manner which does not introduce significant strain concentrations on the process pipe and is supported independently of the process pipe.

   b. The impingement barrier is designed, constructed and tested as a Design Class I structure in accordance with the rules and practices set forth in the following codes:

      Code For Welding In Building Construction, AWS D1.1-72, American Welding Society [Ref. 17].

      Specification For The Design, Fabrication And Erection Of Structural Steel For Buildings, American Institute Of Steel Construction [Ref. 18].

c. The impingement barrier is designed to normal working loads and internal pressurization resulting from the escape of high energy fluid at the postulated pipe break location assuming complete pipe severance and axial separation to the extent permitted by the pipe restraints or a longitudinal break/crack as defined in Section I.2.1.

d. The stresses imposed on the impingement barrier during dynamic pressurization are limited to:

   Membrane stresses produced by pressure existing in the impingement barrier are $\leq 0.90\ f_y$ and

   Membrane stresses and peak bending stresses of short duration in the initial stage of pressurization $\leq 1.5 \times 0.9\ f_y$.

e. The piping beyond the impingement barrier is provided with pipe restraints which restrict its axial displacement and motion within the impingement barrier following a postulated pipe break.

f. The impingement barrier is a Design Class I structure and the materials are ASTM A-572 (various type/grades), A-516 Grade 70 plate, A-106 Grade B pipe and A-234 Grade WPB fittings [Ref. 16].

Steam Exclusion Boundary

To protect the systems and components required to detect and mitigate the consequences of a high energy line break, steam exclusion boundaries are created to isolate this equipment from those areas containing high energy piping systems or are connected to their potentially harsh environment. These boundaries include the walls, floors, ceilings and doors plus any penetrations of these barriers, such as ventilation systems, cables, cable trays and piping systems.

Areas that house required equipment, but do not contain high energy piping systems and are not connected to areas that might contain a harsh environment are not provided with steam exclusion boundary functions, although they are considered to be steam exclusion areas.

The steam exclusion boundaries are designed for the peak pressure and temperature conditions they are expected to encounter and limit the harsh environment intrusion into the steam exclusion area.

Pre-Service and In-Service Inspection

Pipe welds located within an encapsulation sleeve or impingement barrier and, therefore, not accessible for subsequent in-service inspection were non-destructively examined and satisfy the acceptance criteria of ASME Section XI [Ref. 13].

Pipe welds which are not located within an encapsulation sleeve or impingement barrier and are in the piping runs traversing the Auxiliary Building are subjected to periodic in-service examination in accordance with the ASME Section XI (edition currently invoked by the Prairie Island In-Service Inspection Program) requirements for Code Class 2 piping welds. The inaccessible welds are included in the total number of welds in determining the number of welds to be inspected in each inspection interval.

I.2.3 Plant Operability

Control Room Habitability

The Control Room is maintained habitable and the equipment required for a specific high energy line break remains functional for all high energy line design basis breaks or leakage cracks with the capability to bring the reactor to a cold shutdown condition from there.

Operation of Required Equipment

Electrical equipment that is required for a high energy line design basis break or leakage crack and can be affected by the harsh environment is qualified to perform their intended function in that environment.

Electrical equipment that is not qualified to operate in a harsh environment is located in a steam exclusion area created for that purpose.

Redundancy and Separation

Redundancy of required equipment for a specific high energy line design basis break or leakage crack is maintained in the mechanical components, protection systems (Protection Systems are defined in IEEE-279 [Ref. 19]) and Class 1E electrical systems (Class 1E electrical systems are defined in IEEE-308 [Ref. 20]).

The design considers environmentally induced failures caused by a break or leak which would not in itself result in protective action, but may disable a protective function. In this regard, a loss of redundancy is permitted, but a loss of function is not. The capability to bring the plant to cold shutdown is maintained.

The separation criteria for cables associated with the required equipment is identical to that described in USAR Section 8.7.

Operating Procedures

Operating procedures allow for evaluation of the specific high energy line break conditions and determination of appropriate actions to be taken to achieve Mode 5, Cold Shutdown. Prompt achievement and maintenance of Mode 3, Hot Standby, is assured by automatic reactor protection functions or by operator action. The operator will determine which specific plant procedure will be used for placing the reactor in Mode 5, Cold Shutdown, based on the equipment available.

I.2.4 Equipment Operability

Operability requirements for equipment listed in Table I.1.4-1 are primarily contained within Tech Specs except for the steam exclusion system components, which are included in the Technical Requirements Manual.

Additional requirements for equipment beyond those listed in Tech Specs or the TRM are contained within this section. These additional requirements are used to enhance existing equipment requirements to account for HELB events.

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I.2.4.1 Cooling Water System

To ensure that the cooling water system will perform its mitigating function in a HELB, 3 safeguards cooling water pumps (pumps 12, 21, and 121) shall be AVAILABLE in Modes 1,2,3, and 4. This requirement does not apply when both reactors are in Modes 5,6, or no mode or Tech Spec LCO 3.7.8 is in effect.

Condition	Required Action	Completion Time
A. One safeguards CL pump not AVAILABLE	A.1 Restore the 3rd pump to AVAILABLE status or A.2. Split the cooling water header into two separate trains	7 days

Background: Availability requirements for a third cooling water pump are based on the need to maintain sufficient system pressure after a HELB with a consequential failure of a large CL pipe. HELB licensing basis requires consequential failures caused by the HELB to be assumed along with a single active failure and a loss of offsite power. Certain HELB events in the Turbine Building can result in pipe whip that has the potential to break large CL pipes. The added system demand caused by the large CL pipe break, combined with a single failure of one of the two normal safeguards pumps results in exceeding the remaining pump capacity if a third pump is not available.

Description: The purpose of this requirement is to enhance the out of service time and procedural limitations normally under the scope of Maintenance Rule (10CFR50.65) for the safeguards CL pumps.

Availability of the CL system can be ensured in two ways. Required action A.1 maintains this by ensuring that the 3rd pump is available, resulting in at least two pumps after all potential single-failure scenarios are considered. Required action A.2 provides equivalent assurance of availability by splitting the normal ring-header configuration of the CL system into two separate trains. With only two pumps available and the system in two separate trains a single failure of a pump will not result in loss of system function, even with the large consequential failure of a CL pipe. 01292179

The completion time for condition A is based on comparison to Tech Spec 3.7.8 condition A. This completion time was utilized to provide a conservative but reasonable time to allow for normal maintenance of the 3rd cooling water pump without requiring that the CL system be split into two trains.

Two considerations are required to be able to call the third safeguards CL pump AVAILABLE. The first is the pump itself must be capable of performing is function in the HELB event. The second is that all pump power, actuation, and instrumentation supplies must be electrically independent for all three pumps (12, 21, and 121).

I.3 SYSTEM ROUTING AND RUPTURE EVALUATION OUTSIDE CONTAINMENT

I.3.1 Structures

I.3.1.1 Description of Auxiliary Building

The part of the Auxiliary Building through which the high energy piping systems pass is a Design Class I seismic, concrete structure with tornado resistant outer walls and internal shielding walls. The Auxiliary Building is structurally divided into compartments by the walls and floors required to accommodate the equipment and components of various systems. With the exception of the compartments on elevation 695′, the relay room, control room and mechanical equipment rooms, these volumes are vented to each other through corridors, grating openings, stairways, etc. Figures I.3.1-2 through 01204043
I.3.1-6 describe the boundaries of the individual compartments. The important parameters for the major compartments are provided in Table I.3.1-1.

I.3.1.2 Description of Turbine Building

The Turbine Building is a structure with mixed design classification. The Design Class I* steel structure provides a weather-proof enclosure for the turbine-generator and secondary plant auxiliary equipment. Also included within the steel structure is a Design Class I concrete structure (the Class I aisle) that houses safety related components. There are no high energy piping systems within the Class I aisle and it is designed as a steam exclusion area. The remainder of the Turbine Building areas are vented to each other through corridors, grating openings, stairways, etc. Figures I.3.1-7 01204043
through I.3.1-10 describe the boundaries of the individual compartments.

I.3.2 High Energy Piping Systems

I.3.2.1 Main Steam

Routing

The main steam piping from steam generator 11 (21) exits the top of the steam generator and runs horizontally through a flow limiter. It then drops vertically to an anchor elbow before exiting Containment. The main steam line exits from the southwest (southeast) quadrant of Containment on Auxiliary Building elevation 715′ (compartment Y) and enters the main steam isolation valve (MSIV) stop check - check valve assembly and concrete anchor block. The pipe then rises to elevation 735′ (compartment X) where it turns northward and runs horizontally through the Auxiliary Building into the Turbine Building. It then drops vertically to elevation 715′, turns northward before rising vertically back to elevation 735′ and connects to the turbine nozzle. The main steam piping from steam generator 12 (22) exits the top of the steam generator and runs horizontally through a flow limiter. It then drops vertically to an anchor elbow before exiting Containment. The main steam line exits from the northwest (northeast) quadrant of Containment on Auxiliary Building elevation 715′ (compartment C) and rises vertically to elevation 735′ (compartment B) where the MSIV assembly and concrete anchor block are located. The pipe then turns northward and runs horizontally parallel to steam line 11 (21) through the Auxiliary Building into the Turbine Building following a path similar to steam line 11 (21) to the turbine. At no point do any of the main steam lines enter the Design Class I portion of the Turbine Building.

These routings are shown isometrically on Figures I.3.2-1 (Unit 1) and I.3.2-2 (Unit 2), which also show connections to the safety valve header, steam dump to atmosphere header and equalizing line. Additional high energy Main Steam piping is present in the turbine building, such as branch piping to the MSRs and steam dumps to the condenser. This piping is not shown on Figures I.3.2-1 and I.3.2-2. 01204043

Pipe Rupture Evaluation

The original selection of break and branch connection locations based on the Giambusso letters is shown on FSAR Figures I.3-2 and I.3-3 (Unit 1 only). Cracks were assumed to occur at any location along the pipe. The stresses for the main steam piping were calculated as described in FSAR Section I.9 and depicted on Figures I.9-1 through I.9-4 and I.9-10 through I.9-14.

Postulated break and branch connection locations [Ref. 9.4], selected based on the GL 87-11 criteria, are shown on USAR Figures I.3.2-1 (Unit 1) and I.3.2-2 (Unit 2). 01222109 The stresses for portions of the main steam piping were calculated as described in Sections I.5.1 and are depicted on Figures I.5.1-1 through I.5.1-4. Portions of main steam piping within the Turbine Building do not have detailed break selection based on combined stress analysis. These portions of the system have breaks assumed at any point on the piping. 01204043

At no point does the stress exceed the design basis break criteria. Leakage cracks are postulated at any point on the piping. Branch connections, which are considered the terminal end of the branch runs, exist at the steam supply to the auxiliary feedwater pump turbine, power operated relief valves and steam supply to the moisture separator reheaters, and trap and drain connections. The risers to the safety valve header and steam dump headers are not considered branch connections in accordance with the GL 87-11 criteria (MEB 3-1, B.1.c.(1).(a)). The main steam line terminal ends are the steam generator nozzle connections, anchor elbows in Containment and the turbine nozzle connections. In accordance with GL 87-11 criteria only circumferential breaks are postulated at the terminal ends. A summary of the break, crack, intermediate anchor and terminal end locations is included as Table I.3.2-1. In addition, a summary of the bounding breaks for each HELB compartment is included as Tables I.3.2-3 and I.3.2-4. 01204043 01222109 01204043

I.3.2.2 Feedwater

Routing

The discharge of each main feedwater pump (Turbine Building elevation 695′) is routed through a check valve, motor operated valve and feedwater heater (elevation 715′) before joining in the Turbine Building into a single line. Before entering the Auxiliary Building, the common feedwater line bifurcates into two lines - one for each steam generator. At no point do any of the feedwater lines enter the Design Class I portion of the Turbine Building. The line to steam generator 11 (21) enters the Auxiliary Building on elevation 735′ (compartment B) running in a southerly direction parallel to main steam line 11 (21) (to compartment X), before entering Containment in the southwest (southeast) quadrant. The feedwater line runs horizontally to an anchor elbow and then rises vertically through an expansion loop and check valve before turning horizontal to connect to the steam generator. The line to steam generator 12 (22) enters the Auxiliary Building on elevation 735′ (compartment B) running in a southerly direction parallel to main steam line 12 (22), before entering Containment in the northwest (northeast) quadrant. The feedwater line runs horizontally to an anchor elbow and check valve before turning horizontal to connect to the steam generator. Each line is provided with a flow nozzle, control valves, concrete anchor block and motor operated isolation valve before entering Containment.

The routing of the FW lines is shown isometrically on Figures I.3.2-3 and I.3.2-11 (Unit 1) and I.3.2-4 and I.3.2-12 (Unit 2). 01204043 01222109

Pipe Rupture Evaluation

The original selection of break and branch connection locations based on the Giambusso letters is shown on FSAR Figures I.4-1 and I.4-2 (Unit 1 only). Cracks were assumed to occur at any location along the pipe. The stresses for the main feedwater piping were calculated as described in FSAR Section I.9.1 and depicted on Figures I.9-5 through I.9-9.

Postulated break and branch connection locations [Ref. 9.4], based on the GL 87-11 criteria, are shown on Figures I.3.2-3 (Unit 1) and I.3.2-4 (Unit 2). The stresses for the feedwater piping were calculated as described in Section I.5.1 and depicted on Figures I.5.1-5 through I.5.1-8. 01222109 01204043

A summary of the break, crack and terminal end locations for each feedwater line is included as Table I.3.2-1. In addition, a summary of the bounding breaks for each HELB compartment is included as Tables I.3.2-3 and I.3.2-4. Leakage cracks are postulated at any point on the piping. In accordance with GL 87-11 criteria only circumferential breaks are postulated at the terminal ends. 01204043

Auxiliary Building 01222109

At no point in the Auxiliary Building does the stress exceed the design basis break criteria. No terminal ends or branch connections, which are considered the terminal ends of the branch runs, exist on the feedwater lines in the Auxiliary Building.

Turbine Building

One location in the Turbine Building exceeds the design basis break criteria. Terminal ends exist at the FW pumps, condenser dump connections, and #5 FW inlet and outlet nozzles. Branch connections exist at the downstream portion of the #5 FW heater bypass lines and at the Unit 1 condenser dump branches.

I.3.2.3 CVCS Letdown

Routing

The CVCS letdown line exits from the northwest (northeast) quadrant of containment into the Auxiliary Building through a penetration on elevation 715′ (compartment D). The line is provided with an isolation valve adjacent to its penetration as well as isolation valves inside containment. The letdown line is then routed in a northerly direction to the letdown heat exchanger (compartment L).

These routings are shown isometrically on Figures I.3.2-5 (Unit 1) and I.3.2-6 (Unit 2).

Pipe Rupture Evaluation

The original selection of break and branch connection locations based on the Giambusso letters is shown on FSAR Figures I.5-1 and I.5-2 (Unit 1 only). Cracks were assumed to occur at any location along the pipe. The stresses for the CVCS letdown piping were calculated as described in FSAR Section I.9 and depicted on Figures I.9-15 and I.9-16.

At no point does the stress exceed the design basis break criteria. Leakage cracks are postulated at any point on the piping. There are no branch connections. The CVCS letdown line terminal ends are the containment penetration and the letdown heat exchanger inlet nozzle. There is one intermediate anchor in each letdown line. In accordance with GL 87-11 criteria only circumferential breaks are postulated at the terminal ends and intermediate anchors. A summary of the break, crack and terminal end locations for each letdown line is included as Table I.3.2-1. In addition, a summary of the bounding breaks for each Auxiliary Building compartment is included as Table I.3.2-3. 01164502 01222109 01204043

Postulated terminal end break and intermediate anchor break locations based on the GL 87-11 criteria, are shown on Figures I.3.2-5 (Unit 1) and I.3.2-6 (Unit 2). The stresses for the CVCS letdown line piping were calculated as described in Sections I.5-1 and depicted on Figures I.5.1-9 and I.5.1-10. 01222109

I.3.2.4 Steam Generator Blowdown

Routing

The steam generator blowdown lines exit from the northwest (northeast) quadrant of Containment into the Auxiliary Building through a penetration on elevation 715′ (compartment D). Each line is provided with an isolation valve adjacent to its penetration as well as an isolation valve inside Containment. The blowdown line is then routed in a southerly direction to the blowdown flash tank (compartment D).

These routings are shown isometrically on Figures I.3.2-7 (Unit 1) and I.3.2-8 (Unit 2).

Pipe Rupture Evaluation

The original selection of break and branch connection locations based on the Giambusso letters is shown on FSAR Figures I.6-1 and I.6-2 (Unit 1 only). Cracks were assumed to occur at any location along the pipe. The stresses for the steam generator blowdown piping were calculated as described in FSAR Section I.9 and depicted on Figures I.9-21 through I.9-24.

At no point does the stress exceed the break criteria. Leakage cracks are postulated at any point on the piping. There are no branch connections. The steam generator blowdown line terminal ends are the containment penetration and the steam generator blowdown flash tank inlet nozzles. There are two intermediate anchors in the #11 and #12 blowdown lines, one intermediate anchor in the #21 blowdown line and no intermediate anchor in the #22 blowdown line. In accordance with GL 87-11 criteria only circumferential breaks are postulated at the terminal ends and intermediate anchors. A summary of the break, crack and terminal end locations for each steam generator blowdown line is included as Table I.3.2-1. In addition, a summary of the bounding breaks for each Auxiliary Building compartment is included as Table I.3.2-3. 01222109 01204043

Postulated terminal end break and intermediate anchor break locations, based on the GL 87-11 criteria, are shown on Figures I.3.2-7 (Unit 1) and I.3.2-8 (Unit 2). The stresses for the steam generator blowdown line piping were calculated as described in Section I.5.1 and depicted on Figures I.5.1-11 through I.5.1-14.

I.3.2.5 Steam Supply to Auxiliary Feedwater Pump Turbine

Routing

The steam supply line to the auxiliary feedwater pump turbine from steam generator 11 (21) originates on elevation 735′ (compartment X) at branch connection from the safety valve header upstream of the main steam isolation valves. The line is routed in a northerly direction through the Auxiliary Building and joins the supply line from steam generator 12 (22) (compartment B). The common supply line proceeds down to elevation 695′ (compartment E) and into the Turbine Building. The steam supply line from steam generator 12 (22) originates on elevation 735′ (compartment B) at a branch connection from the main steam line upstream of the main steam isolation valves. The stop valves in the steam supply line to the auxiliary feedwater pump turbine were relocated outside of the auxiliary feedwater pump room. These valves are normally closed and receive a signal to open when the pumps are started. The piping in the room is normally depressurized and the room is considered to be a mild environment for the equipment contained therein [Ref. 6 & 7].

These routings are shown isometrically on Figures I.3.2-9 (Unit 1) and I.3.2-10 (Unit 2).

Pipe Rupture Evaluation

The original selection of break and branch connection locations based on the Giambusso letters is shown on FSAR Figures I.7-1 and I.7-2 (Unit 1 only). Cracks were assumed to occur at any location along the pipe. The stresses for the steam supply to the auxiliary feedwater pump turbine piping were calculated as described in FSAR Section I.9 and depicted on Figures I.9-17 through I.9-20.

At no point does the stress exceed the design basis break criteria. Leakage cracks are postulated at any point on the piping. 01222109 There are no branch connections. The steam supply to the auxiliary feedwater pump turbine line terminal ends are the branch connections from the main steam lines and safety valve headers and an anchor in the Turbine Building down stream of the control valves. There is one intermediate anchor in the line from #11 steam generator and no intermediate anchors in the lines from #12, #21 and #22 steam generators. In accordance with GL 87-11 criteria only circumferential breaks are postulated at the terminal ends and intermediate anchor. A summary of the break, crack and terminal end locations for each supply line is included as Table I.3.2-1. In addition, a summary of the bounding breaks for each HELB compartment is included as Tables I.3.2-3 and I.3.2-4. 01204043

Postulated terminal end break and intermediate anchor break locations, based on the GL 87-11 criteria, are shown on Figures I.3.2-9 (Unit 1) and I.3.2-10 (Unit 2). The stresses for the steam supply to the auxiliary feedwater pump turbine line piping were calculated as described in Section I.5.1 and depicted on Figures I.5.1-15 through I.5.1-18.

I.3.2.6 Condensate and Heater Drain Pump Discharge

Routing

The Condensate system meets the definition of high energy at the #2 FW Heater discharge. The entire system is located within the turbine building. The discharge from the #2 FW heaters originates on the north side of the condenser at the 715' elevation and loops into the #3 FW heaters. The discharge of the two #3 FW heaters combine together to form one common pipe on the 695' level, is routed south around the condenser, and splits into two lines that rise back up to the 715' elevation to the inlet of the two #4 FW heaters. The discharge of the two #4 FW heaters joins into a common line on the 715' elevation before splitting into two lines again prior to the suction of the FW pumps on the 695' elevation.

The Heater Drain system meets the definition of high energy at the discharge of the three Heater Drain Tank Pumps on the 679' elevation. The discharge from the three pumps joins into a common line, passes through the 695' elevation, and connects to the Condensate piping just after the discharge of the #4 FW heaters.

These routings are shown isometrically on Figures I.3.2-13 (Unit 1) and I.3.2-14 (Unit 2). 01204043 01222109

Pipe Rupture Evaluation

The Condensate and Heater Drain systems were not included in the original selection of break and crack locations per the Giambusso letters. Additional discussion of the Turbine Building piping is contained in Section I.7.

Postulated break and branch connection locations [Ref 9.4], based on the GL 87-11 criteria, are shown on Figures I.3.2-13 (Unit 1) and I.3.2-14 (Unit 2). The stresses for the Condensate and Heater Drain piping were calculated as described in Section I.5.1.

I.3.2.7 Heater Drain Tank Pump Discharge

Routing

The heater drain pump discharge lines connect directly to the condensate system piping just prior to the feedwater pump suction. All heater drain tank pump discharge piping is routed within the non-safety related portion of the Turbine Building.

Pipe Rupture Evaluation

The heater drain tank pump discharge piping does not have the benefit of combined stress analysis. As specified previously for high energy piping without combined stress analysis, breaks are assumed at any point along the piping.

I.3.2.8 Bleed (Extraction) Steam

Routing

The only bleed steam lines that meet the definition of high energy are those originating at an intermediate extraction stage of the high pressure turbine and supply steam to the 15 (25) feedwater heaters. All of this bleed steam piping is routed within the non-safety related portion of the Turbine Building.

Pipe Rupture Evaluation

The bleed steam piping does not have the benefit of combined stress analysis. As specified previously for high energy piping without combined stress analysis, breaks are assumed at any point along the piping.

I.3.2.9 Feedwater Heater and MSR Drains

Routing

The only drain piping that meets the definition of high energy are those from the 15 (25) feedwater heaters to the 14 (24) feedwater heaters and from the reheater section of the MSRs to the 15 (25) feedwater heaters. All of this drain piping is routed within the non-safety related portion of the Turbine Building.

Pipe Rupture Evaluation

The drain piping does not have the benefit of combined stress analysis. As specified previously for high energy piping without combined stress analysis, breaks are assumed at any point along the piping.

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I.4 FEATURES PROVIDED FOR PIPE RUPTURE EVENTS

I.4.1 Required Equipment

The equipment required to detect and mitigate the consequences of a high energy line design basis break or leakage crack and accomplish those functions identified in Section I.1.4 is summarized in Table I.1.4-1 [Ref. 9.6].

I.4.2 Steam Exclusion Boundaries

The various steam exclusion areas created include the Auxiliary Building elevation 695′, Relay Room, Control Room, Control Room Ventilation Equipment Rooms, Unit 1 480v Bus and Events Monitoring Rooms, Control Rod Drive Equipment Rooms, Design Class I portion of the Turbine Building and Diesel Generator Rooms. Areas that do not contain high energy piping systems and are not connected to areas that might contain a harsh environment, such as the Screenhouse, are not provided with steam exclusion functions.

<u>Walls, Floors and Ceilings</u>

The steam exclusion areas are bounded by concrete (or masonry) walls, floors and ceilings. All penetrations are sealed to prevent intrusion of a harsh environment. The Auxiliary Building stairwells connecting elevation 715′ to 695′ are enclosed in masonry structures. All boundaries are designed to accommodate the maximum differential pressure expected.

<u>Doors</u>

Doors that form part of the steam exclusion boundary in either the Auxiliary Building or Turbine Building are provided with seals to preclude entry of a harsh environment. With the exception of the Control Room Ventilation Equipment Room doors, all of these doors are oriented such that they close against bar stops under the harsh environment pressure.

The Control Room Ventilation Equipment Room doors are held closed by their latch mechanisms. Four sets of doors between the Auxiliary Building (elevations 720′, 735′ and 755′) to the Fuel Handling Building have breakaway ceramic latch pins that permit the doors to open at 0.2 psid during a high energy line break and provide a vent path for Auxiliary Building pressure relief [Ref. 8, 9.11]. Typical door seals are shown on Figure I.4.3-2.

<u>Ventilation</u>

The ventilation systems serving the Relay Room, Control Room, Control Room Ventilation Equipment Rooms, Auxiliary Building elevation 695′ and Design Class I portion of the Turbine Building are provided with redundant dampers that are closed by resistance temperature detectors (RTDs) located in their respective ductwork. The RTDs for these dampers are set at less than 120°F.

The ventilation system Steam Exclusion Actuation System consists of redundant RTDs, resistance to current converter, trip unit with isolation amplifiers plus indicators and recorders. Any one RTD will close the dampers in that train for the associated building.

There are 14 control and 14 check dampers located in the Auxiliary Building and Control Room ventilation systems plus 12 control and 12 check dampers in the Turbine Building ventilation system. 01389226 The steam exclusion dampers and the ductwork between the wall and outermost damper are seismic Design Class I. The dampers originally installed were tested to a static pressure of 5 psi without the loss of functional operation. The maximum leakage acceptable, when procured, on these dampers is 50 cfm at 0.5 psi. 01394987 All dampers were originally procured at a differential pressure of 0.5 psi and the maximum leakage measured by the manufacturer was 30 cfm. These pressure values were based on preliminary compartment “X” and “Y” pressure analysis prior to installation of the flow limiting encapsulation sleeves. Subsequent compartment pressure analysis is contained in Reference 9.11. Control and check dampers are checked for functionality and the mating surfaces are visually inspected as required by the plant’s Technical Requirements Manual. 01394987

The Control Room has its own independent outside make-up air supply. Air is supplied through the Auxiliary Building roof at column rows G-6 (Unit 1) and H-14 (Unit 2) into elevation 755′ (compartment A) and ducted to the Control Room Ventilation Equipment Room through redundant steam exclusion dampers. The air is cooled, if necessary, filtered, humidified and ducted through the floor into the Control Room. This system is described in more detail in Section 10.3.3. 01367047

The Control Room is automatically isolated from any adverse environment created by a high energy line break or crack by closure of the redundant steam exclusion dampers. Redundant fans and air conditioning systems maintain the Control Room habitable with regard to temperature, humidity* and airborne radioactivity.

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An analysis [Ref. 9.13] was performed to determine the environmental conditions on Auxiliary Building elevation 695¢ in the unlikely event that both sets of steam exclusion control dampers in the ventilation supply duct failed to close or the entering steam-air mixture temperature was below the steam exclusion actuation setpoint. The steam exclusion check dampers in the ventilation return ducts would prevent backflow into elevation 695′ from the other Auxiliary Building compartments. This analysis demonstrated that the resultant temperatures on elevation 695′ remained below the environmental qualification of the required equipment.

Shield Building Seals

Bellows (similar to those used on the penetrations from the Auxiliary Building to the Shield Building annulus) have been tested [Ref. 22] at the Kewaunee Nuclear Power Plant. These tests showed that, with differential pressures of up to 20 psi internally, no rupture occurred. Tests with external pressurization equal to 50% of the internal differential pressure loadings were also conducted without any failure. The maximum calculated external pressure difference these bellows would be required to withstand is less than 0.3 psi for less than 2 minutes. The maximum calculated temperature these bellows would be exposed to during this time period is 300°F. The typical tensile strength of this material is 1443 psi with a temperature capability up to 325°F.

I.4.3 Encapsulation Sleeves and Impingement Barriers

Based on the break location and size criteria in the Giambusso letters, design basis breaks and leakage cracks were postulated in the Containment, Auxiliary Building and Turbine Building. An analysis revealed that the Auxiliary Building did not have the capability to withstand the pressure resulting from a design basis main steam line break. Encapsulation sleeves were installed at all postulated design basis break locations in the Auxiliary Building to reduce the peak compartment pressure. The criteria for the design of the encapsulation sleeves is contained in Section I.2.2 and their location was described in FSAR Figure I.3-3 for Unit 1. Although not described in the FSAR, encapsulation sleeves were installed at the same locations on Unit 2. No encapsulation sleeves were required on the other high energy piping systems. Typical encapsulation sleeves are shown on Figure I.4.3-1.

Impingement barriers were installed to protect required equipment from the effects of high energy fluid jets. Those impingement barriers that were installed around the various high energy piping systems are identified on Figures I.3.2-1 through I.3.2-10. Other impingement barrier designs were used for local protection, such as flat steel plates, steel shapes, etc. Typical impingement barriers are shown on Figure I.4.3-1.

Application of the GL 87-11 break selection criteria eliminated all main steam and feedwater design basis breaks except those at the terminal ends and greatly reduced the locations for leakage cracks. This process eliminated the need for most of these encapsulation sleeves and impingement barriers. Therefore, many of the modifications previously installed may be removed or abandoned in place.

I.4.4 Rupture Restraints

Based on the pipe rupture analysis discussed in FSAR Section I.10 rupture restraints were added to the main steam and feedwater system piping. No new rupture restraints were required on the other high energy systems. Typical tie rod restraints are shown on Figure I.4.3-1.

Application of the GL 87-11 break selection criteria eliminated all main steam and feedwater design basis breaks except those at the terminal ends, thereby eliminating the need for all other of these restraints. However, they may be removed or abandoned in place.

I.4.5 Flooding Protection

Based on the HELB flooding analysis discussed in USAR Section 1.5, changes to the facility were made to ensure adequate flooding protection. The following flood mitigating features are credited in the analysis:

- Flood barriers to protect the D1, D2, D5, and D6 diesel generators
- Access covers in the AFW rooms were fastened to prevent differential pressure from opening them
- Roll-up doors at the east and west ends of the turbine building were blocked open
- Security barriers at each roll-up door were opened or modified 01507184
- Safeguards battery room doors and door seals were credited to minimize flow into the rooms around door gaps on the HELB unit and allow flow out on the non-HELB unit.
- AFW pump room doors and door seals were credited to prevent water flow into the room around door gaps.

I.4.6 Equipment Environmental Qualification

<u>Location of Required Equipment</u>

The location of the equipment required to bring the reactors to a safe shutdown condition, after a high energy line break event, is described in Table I.1.4-1.

The safety injection and component cooling pumps for both units are located in a steam exclusion area on Auxiliary Building elevation 695′ (compartment E). The auxiliary feedwater pumps and batteries for both units plus the Unit 1 4160/480v switchgear are located in a steam exclusion area in the Turbine Building Class I corridor. Diesel generators D1 and D2 (Unit 1), D5 and D6 (Unit 2), the Unit 2 4160/480v switchgear and the cooling water pumps for both units are located in compartments separated from those containing high energy piping systems. The control room/relay room ventilation system is located in a steam exclusion area on Auxiliary Building elevation 755′ (compartment A). The reactor trip breakers for both units are located in steam exclusion areas on Auxiliary Building elevation 735′ (Compartment B). The motor control centers/motor starters for all identified motor operated valves are located in one of the steam exclusion areas of the plant.

Equipment Qualification

All instrumentation and electrical equipment required for high energy line break events, that are located in a post-accident harsh environment, are qualified in accordance with the Equipment Qualification Final Rule, 10CFR50.49. The establishment, documentation, maintenance and guidance for these components is contained within the plant's Equipment Qualification (EQ) Program.

Ancillary equipment (e.g., cable, fuses, splices, terminations, etc.), associated with any required equipment, that is located in an area where a harsh environment might exist are qualified and configured for that environment in accordance with the plant's EQ program.

I.4.7 Operating Procedures

The operating procedures discussed below are general in nature since it is appropriate to allow the operator to assess the incident and determine the equipment available prior to initiating any action. The plant can achieve and maintain Mode 3, Hot Standby, for an extended time by automatic reactor protection functions or operator action. Following the high energy line break, the operator would have alternate systems (residual heat removal, chemical and volume control, component cooling, etc.) available to facilitate an orderly shutdown of the reactor. The methods presented use equipment determined to be available following a high energy line break event. The operator would determine the appropriate methods for achieving Mode 5, Cold Shutdown based on the systems and components available.

Main Steam Design Basis Break

For a design basis break, safety injection would be initiated by either low pressurizer pressure or low steam line pressure in either steam line. The main steam isolation valves are designed to close on the coincidence of a safety injection signal with either high-high steam flow or high steam flow coincident with low-low T_{avg}. The safety injection signal would cause a reactor trip, isolate the main feedwater system, initiate containment isolation and start the auxiliary feedwater pumps.

Following initiation of safety injection, the safety injection pumps deliver borated water from the refueling water storage tank.

The following equipment will accomplish the required safety functions:

1. Safety injection to pump borated water into the core, thereby limiting the core power transient following the break and bringing the reactor to a subcritical condition.

2. Closure of the main steam isolation valves to limit the reactor coolant system cooldown.

3. Isolation of the main feedwater system: Sustained feedwater flow would cause additional cooldown and mass-energy release to the Auxiliary Building. A safety injection signal would close the main feedwater control valves, close the feedwater containment isolation valves and trip the main feedwater pumps, which closes the feedwater pump discharge valves.

4. Following a reactor trip, auxiliary feedwater is required in approximately 10 minutes to dissipate decay heat. At least one auxiliary feedwater pump is available to supply the intact steam generator. After the affected steam generator has emptied or the break has been isolated, the auxiliary feedwater system and main steam power operated relief valves provide heat removal capability for maintaining Mode 3, Hot Standby, conditions.

<u>Main Steam Leakage Crack</u>

For a leakage crack in the main steam piping system (7.3 in^2) steam release for the Mode 3, Hot Standby, condition is approximately 100 lbs/sec and for the full power condition, 80 lbs/sec or five percent and four percent of full load turbine steam flow, respectively. This would not be sufficient to cause an overpower reactor trip.

A leakage crack would result in a loss of water inventory in the secondary plant that would lower the level in the condenser hotwell from the normal operating level to the low level alarm setpoint. Should the operator fail to take action at this point, the loss of secondary inventory would continue until the condensate pumps tripped. The following table provides the times involved if the leakage crack occurred at either Mode 3, Hot Standby, or full power [Ref. 9.3]:

	Time in Minutes	
Hotwell Level	**Hot Shutdown**	**Full Power**
Normal operating level	0	0
Low alarm setpoint	9	11
Condensate pump trip	64	85

The following automatic actions occur following the condensate pump trip:

1. main feedwater pump trip on loss of condensate pumps or low feedwater pump suction pressure,

2. turbine trip on loss of main feedwater pumps if turbine latched,

3. reactor trip due to low-low steam generator level or turbine trip if power greater than 10% power,

4. auxiliary feedwater pump start on loss of main feedwater pumps or low-low steam generator level.

The auxiliary feedwater pumps would deliver water to the steam generators from the condensate storage tank or cooling water system. After the reactor trip, continued steam release from the crack would cool the reactor coolant system down slower than if the largest relief valve were open. If the steam leak were not isolated by manual main steam isolation valve closure cooldown would continue resulting in safety injection being initiated by low pressurizer pressure or low steam line pressure. The safety injection pumps deliver boric acid from the refueling water storage tank to insert sufficient reactivity to bring the reactor to Mode 5, Cold Shutdown boron concentration.

In the event of a leakage crack, the auxiliary feedwater system and steam dump system (power operated relief, atmospheric or condenser, depending on component availability) would be used to dissipate reactor decay heat and cool the plant to 350°F. The residual heat removal system would then normally be used to cool the plant to Mode 5, Cold Shutdown.

<u>Feedwater</u>

For a feedwater line design basis break, the reactor is automatically tripped due to low-low steam generator level. The auxiliary feedwater system in conjunction with the steam generator safety valves and power operated relief valves provide the ultimate heat sink for the reactor coolant system for maintaining Mode 3, Hot Standby, conditions. In order to take the reactor from Mode 3, Hot Standby, to Mode 5, Cold Shutdown conditions, boron is added to achieve Mode 5, Cold Shutdown concentration. Additional water is added to replace the volume lost due to shrinkage during cooldown. This can be accomplished by opening the pressurizer power operated relief valves to temporarily reduce reactor coolant system pressure below the safety injection pump shutoff head. After re-closing the pressurizer power operated relief valves, the auxiliary feedwater system and main steam power operated relief valves provide heat removal capability for maintaining Mode 3, Hot Standby, conditions and cooling the reactor coolant system to 350°F (Mode 4, Hot Shutdown).

If a rupture should occur in the feedwater line that would not directly cause a reactor trip, the operator has numerous devices (steam generator pressure, steam generator level, etc.) to detect such an event. The operator would assess the plant conditions (location of break, ability to isolate, equipment available, etc.) and determine actions to be taken. If necessary, the reactor could be shutdown by manually tripping the reactor or initiating safety injection which would trip the reactor, start the safety injection and auxiliary feedwater pumps and initiate containment isolation. The plant would remain in Mode 3, Hot Standby, conditions until the appropriate method for going to Mode 5, Cold Shutdown was determined.

A feedwater system leakage crack would result in a loss of water inventory in the secondary plant in a manner similar to a main steam leakage crack.

Chemical & Volume Control System Letdown

For a design basis break or leakage crack in a CVCS letdown line the operator has numerous devices (pressurizer level, pressurizer pressure, area radiation monitors, etc.) to detect such an event. The break or crack would be terminated by closing the inside containment letdown isolation valve in the affected line. This isolation could also be accomplished by closing all of the letdown orifice isolation valves.

Steam Generator Blowdown

For a design basis break or leakage crack in a steam generator blowdown line the operator has numerous devices (steam generator level, feedwater flow, steam/feedwater flow deviation, etc.) to detect such an event. The break or crack would be terminated by closing one of the redundant motor operated containment isolation valves in the affected line.

Steam Supply To Auxiliary Feedwater Pump Turbine

A design basis break or leakage crack in the steam supply line to the auxiliary feedwater pump turbine would be similar to an unisolatable main steam line leakage crack if the steam supply isolation valve could not isolate the break.

Condensate

A design basis break in the condensate line would reduce the supply to the feedwater pumps causing them to trip on low suction pressure. The condensate pumps would trip on low condenser hotwell level. This sequence would lead to a reactor trip on low-low steam generator level.

A condensate system leakage crack would result in a loss of water inventory in the secondary plant in a manner similar to a main steam or feedwater leakage crack.

Heater Drain Tank Pump Discharge

A design basis break in the heater drain tank pump discharge line would reduce the supply to the feedwater pumps causing them to trip on low suction pressure. The heater drain tank pumps would trip on low heater drain tank level or turbine stop valve closure. This sequence would lead to a reactor trip on low-low steam generator level.

A heater drain tank pump discharge line leakage crack would result in a loss of water inventory in the secondary plant in a manner similar to a main steam or feedwater leakage crack.

Bleed (Extraction) Steam

A design basis break in bleed steam line to the 15 (25) feedwater heater would result in significant imbalance in the distribution of turbine steam flow and loss of feedwater heating to the 14 (24) and 15 (25) feedwater heaters. The ensuing turbine trip (manual or automatic) would cause a reactor trip.

A bleed steam line leakage crack would result in a loss of water inventory in the secondary plant in a manner similar to a main steam or feedwater leakage crack.

Feedwater Heater and MSR Drains

A design basis break or leakage crack in a feedwater heater or MSR drain line would result in a loss of water inventory in the secondary plant in a manner similar to a main steam or feedwater leakage crack.

Cold Shutdown

The plant is designed to achieve Mode 3, Hot Standby, (automatically or by operator action) and maintain that condition for an extended time using the auxiliary feedwater system and main steam power operated relief valves for decay heat removal. The safety injection system provides the boric acid for reactivity control and reactor control inventory make-up. After assessment of the event and evaluation of the equipment available, the operator would determine the most appropriate method and procedure for achieving cold shutdown. The auxiliary feedwater system and main steam power operated relief valves would be used to cool the plant to 350°F.

The residual heat removal system would normally (and preferentially) be used to reduce the reactor coolant system temperature to Mode 5, Cold Shutdown. If the residual heat removal systems are not available, the auxiliary feedwater system and plant secondary side systems can be used to bring the reactor coolant system to Mode 5, Cold Shutdown. However, this process would require a much longer time. This could be accomplished by converting a steam generator into a water to water heat exchanger by filling it with cold water from the auxiliary feedwater pumps. The warmer water could be discharged through a combination of the steam generator blowdown flash tank, main steam line traps and drains, main steam line power operated relief valve, steam dump to condenser, etc.

I.5 TOPICAL ANALYSIS

I.5.1 Pipe Stress

Stress analysis was performed on the five identified high energy piping systems in the Auxiliary Building using a computer program with the capability to analyze piping systems subjected to thermal expansion, pressure, weight, static seismic and dynamic seismic loading conditions. These analyses were performed in accordance with the requirements of the Power Piping Code (ANSI B31.1 - 1967). The program incorporated special conditions such as anchor movements, intermediate point forced movements, limit stops, external forces, rigid supports, restraints, etc. The combination of stresses due to pressure, thermal, weight and seismic loading conditions was also determined.

These stress analyses were utilized to determine the design basis break locations in accordance with the criteria contained in the Giambusso letters. They were presented graphically as FSAR Figures I.9-1 through 24. Based on these analyses, modifications (encapsulation sleeves, impingement barriers, etc.) were made to the plant.

Generic Letter 87-11 relaxed the requirements for selecting arbitrary intermediate break locations by utilizing threshold stress criteria based on the ASME Section III Code. The most recent analysis of record for the high energy piping systems was retrieved and the combined stresses recalculated by using the ASME stress indices instead of the ANSI stress intensification factors. The new combined stress was compared to the GL 87-11 criteria for selecting design basis break and leakage crack locations.

Initial application of the GL 87-11 selection criteria to high energy lines outside containment eliminated all arbitrary intermediate design basis breaks and reduced the number of leakage cracks to a few locations. Therefore, many of the modifications previously installed may be removed or abandoned in place.

Combined stress analysis using the ASME Section III code has not been performed for some of the high energy piping systems in the Turbine Building. Therefore, breaks are assumed at any point along the piping as specified previously.

Several piping stress analyses have subsequently been re-performed using the applicable design code requirements for the piping. Additional combined stress analysis was performed for the purposes of high energy line break selection using the ASME Section III Code equations specified in GL 87-11 in lieu of manually recalculating the stress indices.

I.5.2 Pipe Whip

Restraints are provided to prevent pipe whip where there is a possibility that whip following a pipe rupture would damage structures, systems or components that are required to mitigate the consequences of that pipe rupture.

A nonlinear elastic-plastic analysis [Ref. 21] is performed to evaluate the adequacy of the pipe rupture restraint system to provide protection following postulated circumferential and longitudinal pipe breaks. The coupled nonlinear dynamic analysis of the restraint-piping system accounts for the dynamic nature of the rupture force, the elastic-plastic deformation of the pipe restraint system and the impact between the restraint and pipe.

The results of the analysis include identification of plastic hinges formed in the pipe, strain in the hinges and restraint status, including gap closure, elastic or plastic deformation and reacting loads.

<u>Blowdown Forces</u>

Blowdown forces resulting from pipe rupture were originally determined using a computer program [Ref. 21] based on RELAP-3, the loss of coolant accident program accepted by the AEC at that time. The approved method of evaluation was subsequently changed from RELAP-3 to RELAP-5/MOD 2 - B&W in Reference 40. The program computes and plots the force-time history curve of the reaction loads resulting from a circumferential or longitudinal pipe break subcooled liquid, flashing liquid and steam systems.

The system of interest is modeled as an assembly of volumes connected by flow paths. In a flow path there can be inserted a valve, check valve or pump. The program solves the transient energy, momentum and state equations for the volumes and flow paths. The program can also solve the state equation for subcooled water, two phase steam-water mixtures and superheated steam. The ASME Steam Tables are tabulated within the program and table lookup methods are used to determine the state within each volume. An optional bubble separation model can be used to represent a vapor phase above the liquid phase (e.g., steam generator). The program calculates the flow in each junction using both an inertial model (nonchoking) and a flow model (choking). The lower of the flows calculated from the two models is limiting and thus taken as the actual flow.

The program allows for special component characteristics as applicable in different systems. Leaks can open instantaneously or as a function of time. Pumps can continue to operate or coast down. Valves can be opened or closed and check valves follow a prescribed pressure loss, flow characteristic.

The break force is calculated using the one dimensional momentum equation. The resultant force on the broken piping is the algebraic sum of the following three forces:

Momentum flux

$$\rho \frac{AV_2}{g}$$

Momentum change (zero for steady state)

$$\frac{\Delta(mV)}{\Delta tg}$$

Pressure force (zero for non-choking flow)

$$(P_t - P_e)A$$

Where:
- P_t = throat pressure
- P_e = exit pressure
- A = break area
- ρ = density
- V = velocity
- g = acceleration of gravity
- m = mass
- t = time

The results of the analysis for the main steam and feedwater systems are presented in four Nuclear Services Corporation Topical Reports [Ref. 21].

Computation of piping system response to pipe rupture forces is determined with a computer program using an adaptation of the finite element method to the specific requirements of pipe rupture analysis. A dynamic response time history of the piping system is determined which includes elastic-plastic pipe behavior and nonlinear effects of pipe rupture restraints.

The piping system is modeled as an assemblage of straight and curved beams (elbows) connecting discrete nodal points. Weight of the piping system (including offset weights of valve operators) is “lumped” at selected nodal points. The blowdown force versus time history as developed by the previously discussed transient flow analysis computer program is then applied as an excitation force to the appropriate piping node point. Dynamic response of the piping system is computed at iterative increments of time and includes forces, moments, deflections and rotations at each node. The resulting bending and torsional moments at each node are used to predict both initial yielding (at which time the elastic modulus at the affected point is replaced by the strain hardening modulus) and ultimate load (i.e., formation of a plastic hinge, after which the modulus is set to a very low value). In situations where stress reversal occurs, an isotopic strain hardening model is used. The strain in plastic hinges and deflections of node points are used to identify the pipe trajectory.

Pipe rupture restraints are modeled with initial design gaps and then both elastic and plastic moduli. At each time step, the programs determine gap closure, elastic or plastic deformation and the resulting impact load.

A model of a typical main steam line is shown in Figure I.5.1-19.

I.5.3 Compartment Pressure and Temperature

The GOTHIC code (Version 7.2a) was used to predict the pressure and temperature response of compartments to a high energy line break [Ref. 9.15, 9.17, 9.22, and 9.23]. Separate models were developed to represent the Auxiliary Building and Turbine Building [Ref. 9.18 and 9.19]. The original FSAR pressure and temperature analysis was performed using the CONTEMPT computer code. Use of GOTHIC was approved in Ref 41. Use of GOTHIC version 7.2a was approved via Ref 42. 01400725

The analysis assumes that a high energy line break event can be separated into phases such that the result of the analysis of one phase serves as the conditions of the time dependent input to the next phase. The calculation accounts for the description of the high energy line blowdown characteristics, including the effects of steam superheating addressed in NRC Information Notice 84-90 [Ref. 5].

The blowdown rate and duration depend on the system operating conditions and break size. Heat sinks are included in the model to absorb energy. No credit is taken for heat removal capability of individual unit coolers or ventilation systems.

The building compartments are separated into a liquid and vapor region. Each region is assumed to have a uniform temperature, but the temperatures of the two regions may be different. The Auxiliary Building is represented as a multi-compartment structure whose behavior can be described by the one dimensional, multi-region, heat conduction equation.

The calculation proceeds as follows: The initial compartment conditions are determined from ambient pressure, temperature and relative humidity. Heat sinks are initialized at the initial temperature of the compartment. Time advancement is started by evaluating the fluid mass and energy input rates at the midpoint of a time interval, multiplying by the time interval and adding these increments to the current amounts in the compartment. Heat losses or gains to the heat conducting surfaces are estimated by using the heat transfer rates from the previous time step or the steady state conditions for the initial time step. Pressure and temperature of the liquid and vapor regions are then calculated from the mass, volume and energy balance equations. These new temperatures are used for the boundary conditions for the heat conduction solution. The resulting heat transfer rates for the end of the time step are averaged with the heat transfer rates at the beginning of the time step to correct the previous estimate of the energy in the compartment volume. Mass, momentum and energy equations are then solved for the second time for the pressure and temperatures within the compartment volume. These conditions are then used as the initial conditions for the next time step.

Calculations are performed for selected break sizes and locations at Mode 3, Hot Standby, main steam conditions to obtain the peak compartment pressure and at full power main steam conditions to obtain the peak compartment temperature.

Auxiliary Building Model:

The GOTHIC code considers the opening of four sets of steam exclusion boundary doors from the Auxiliary Building (elevations 720′, 735′ and 755′) to the Fuel Handling Building to provide a vent path for pressure relief. The pressure outside the Auxiliary Building remains at atmospheric pressure.

The peak pressure and temperature for some of the compartments are as follows [Ref. 9.15]:

Compartment	**Elevation**	**Peak Temp. °F**	**Peak Press. psig**
A	755′	337	0.34
B	735′	353	0.26
C	715′	258	0.25
D	715′	317	0.51
X	735′	412	0.54
Y	720′	410	0.54

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Elevation 695′ of the Auxiliary Building and selected areas of the plant such as the Control Room, Relay Room and Mechanical Equipment Room are isolated from the effects of the high energy line break environment.

Turbine Building Model:

In the Turbine Building model, the GOTHIC code considers the opening of blow off panels and failure of portions of the turbine building siding for pressure relief. The code also considers the automatic opening of smoke hatch vents for exhaust of high temperature air. Various flowpaths are available to account for cases with normally open or normally closed doors. Pressure and temperature outside the Turbine Building remain at initial atmospheric conditions throughout the transient.

The peak pressure and temperature for areas of interest in the Turbine Building are as follows [Ref 9.22 & 9.23].

Area (See Note)	**Peak Temp. (°F)**	**Peak Pressure (psig)**
Unit 1, 679′ elevation	361	0.47
Unit 1, 695′ elevation	309	0.52
Unit 1, 715′ elevation	287	0.48
Unit 2, 679′ elevation	386	0.47
Unit 2, 695′ elevation	310	0.51
Unit 2, 715′ elevation	293	0.46
Turbine Deck, 735′ elevation	211	0.47

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Note: Each level of the building is made up of several compartments. The highest value from all compartments in the area stated in the table is given.

I.5.4 Jet Impingement [Ref. 9.7]

Jet-impingement load is defined as the force exerted on a component or structure from an undeflected fluid resulting from an instantaneous break or crack in a high-energy pipe.

Maximum impingement pressure along the jet centerline is determined in Reference 9.7 using a combination of several methodologies including; original FSAR, ANSI/ANS-58.2-1988, and the Moody critical flow method. Due to the complexity of the equations involved, the required method of evaluation is explained in detail within the calculation and will not be restated here. Several assumptions are utilized in the methodology as follows:

1. Jet loadings due not vary with time and are conservatively based on the initial conditions at the time of rupture.
2. The jet discharge coefficient is equal to 1 and piping frictional effects are ignored. Transient pressure changes are not considered. 01362721
3. The impinging jet proceeds along a straight path.
4. The jet cross section is an elliptical shape with axes proportional to the width and length of the original break or crack.
5. After the fluid in the jet has undergone free expansion to ambient pressure, the jet area expands uniformly at a divergence half angle of 10 degrees.
6. Ideal gas critical isentropic flow is assumed.
7. Ambient pressure outside the jet is atmospheric pressure.

The methodology models jet-impingement load by dividing the expansion of the jet into three regions.

Region 1: Near the jet discharge there is a conical jet core region. The maximum impingement pressure and temperature along the jet centerline within this jet core are the system pressure and temperature, respectively, prior to pipe rupture.

Region 2: In the second region, the jet outside the conical jet core undergoes free expansion to a static jet pressure, which is related to jet stagnation quality and pressure and the ambient pressure in the subsonic portion of the jet. The area of the jet at the point in which static jet pressure is reached is called the asymptotic plane. Since depressurization out to the asymptotic plane is almost equal to the axial and radial directions, the jet expands with a jet half angle of 45 degrees out to the asymptotic plane.

Region 3: In the third region the jet continues to expand after passing the asymptotic plane with a jet half angle of 10 degrees.

Jet centerline temperature outside the jet core region is taken as the saturation temperature at pressure P.

The average jet pressure at a distant target is:

$$P_l = P\,C_{ave}$$

where:

C_{ave} = averaging factor based on experimental velocity profiles (use 1.0, which is the worst case)

The effective load on a distant target is:

$$F_e = f\,P_i\,A_t$$

where:

A_t = projected area of the target object
f = shape factor to account for deflection, rather than stagnation, of the jet. The only value used is unity.

Typical targets are walls, cables, cable trays and instrumentation. Jet impingement loads on these potential targets are determined and, if necessary, barriers or other protection is installed to reduce the forces on the targets. Calculations show that the functions of cables and cable trays are not affected by jet forces of 2 psi or less (Reference 9.14). The instrumentation and cables associated with the equipment required to bring the reactor to cold shutdown after a high energy line break are qualified for the resultant environment in accordance with the plant's EQ program. When the temperature of a high energy jet exceeds their qualification, jet impingement barriers are installed to protect them or they are relocated.

For each of the five identified high energy piping systems, pressure and temperature were calculated at various distances from postulated pipe breaks and cracks. Examples of the resulting curves appear in Figures I.5.4-1 through I.5.4-20.

I.5.5 Flooding

In support of original plant licensing, PINGP was required to review the effects of flooding for two types of pipe failure events. These event types are: 1) breaks and leakage cracks in high energy piping systems, and 2) leakage cracks in non-high energy, non-Class I systems that are capable of providing high flooding rates or which have an unlimited water supply.

For convenience, the results of flooding reviews for non-HELB events in the auxiliary building were included in Appendix I of the original FSAR. Results for non-HELB flooding reviews now reside in USAR Section 6.1.2.8.

I.5.5.1 HELB Flooding Review Basis

The original licensing basis for HELB related flooding was contained in Reference 1. Flooding was discussed in paragraph 9.29.15 (below). 01367047

> "9.29.15
> A discussion should be provided of the potential for flooding safety related equipment in the event of failure of a feedwater line or any other high energy fluid line."

AEC/NSP meetings were held on January 4, 1973, to clarify requirements of the Giambusso letter. The meeting minutes and clarifications were provided by AEC in a letter dated January 11, 1973 (Reference 2).

NSP addressed the requirements of the Giambusso letter in FSAR Amendment 28 (Reference 33).

The AEC performed a review of FSAR Amendment 28 and responded to NSP through a letter dated February 9, 1973 (Reference 3). The AEC concluded that NSP's response was not complete for several of the items requested in the Giambusso letter. One of those items was response to paragraph 9.29.15 (flooding).

NSP addressed flooding with regard to the Giambusso letter in FSAR Amendment 31, Section I.4-4, on March 17, 1973 (Reference 34). This section is specific to the Auxiliary Building, but it establishes a basis for NSP evaluation of high energy line break flooding. One of the systems evaluated for flooding potential was the feedwater system. The system was described as having a volume of 200,000 gallons at a flow rate of 28,000 gpm.

The evaluation states, "The total water volume of the feedwater system would not flood the Class I areas of the Auxiliary Building to a level sufficient to endanger any equipment required for safe reactor shut down."

This indicates that the flooding associated with high energy line break was confined to the contents of the line itself and did not include flooding from any other sources that may have been impacted and damaged from the whipping feedwater line.

The AEC approved the NSP response to the Giambusso letter through SER Supplement 1 dated March 21, 1973 (Reference 35).

As stated above, the original interpretation of the flooding requirements by NSP was that flooding due to the line break was the only water required to be considered. The NRC later provided clarification of the flooding analysis requirements in TIA 2011-007 (Reference 36). This TIA concluded the following:

> "The NRR staff concludes that if a ruptured high energy line can whip and strike another fluid-filled line which meets the criteria for being ruptured by a whipping high energy line, the second (target) pipe must also be assumed to rupture. There is no basis for not including the water contribution from the target pipe rupture in the facility's flooding analysis. Therefore, the NRR staffs position is that the fluid from the target pipe must also be included in the flooding analysis at PINGP. Further, if the HELB can also result in actuation of the fire sprinkler system, then the water from that system must also be included in the flooding analysis at PINGP."

PINGP's later commitment to implementing the high energy pipe break and leakage crack criteria in NRC Branch Technical Position MEB 3-1, as attached to NRC Generic Letter 87-11, Relaxation in Arbitrary Intermediate Pipe Rupture Requirements, (Ref. 4) is discussed in Sections I.1 and I.2. When adopting the relief offered by Generic Letter 87-11, PINGP used only the applicable equations in MEB 3-1 and nothing more.

I.5.5.2 Deleted

I.5.5.3 Auxiliary Building Flooding Review Results (Ref. 9.12)

The Design Class I area of the Auxiliary Building was reviewed for the effects of flooding due to HELB events. Failures in main steam, feedwater, and blowdown, were selected for analysis.

The analysis determined the times flooding would reach critical flood levels in the Auxiliary Building for each of the postulated pipe failures. Due to the high flow rates from a pipe break in the steam generator blowdown system, the shortest of the required response times for any HELB event was 52.7 minutes. The required response times from failures in any other non-Class I piping system are bounded by these results.

In addition, the auxiliary building was evaluated for potential damage to required equipment due to cascading water as it passes through floor openings (stairwells, pipe chases, floor drains, etc.) on its way to elevation 695′ and for damage due to water spray. Most of the required equipment is located on elevation 695', which is a steam exclusion area; all penetrations from elevation 715' are sealed. Water from the upper elevations would be directed through the floor drain system and not cascade on required equipment located on elevation 695'. Due to the physical separation of the opposite-trained equipment, water spray from any leakage crack can only affect the operability of one train of any required equipment. This satisfies the required review criteria of Reference 1.

The routing and pipe rupture evaluation of the feedwater line, as described in Section I.3.2.2, revealed no design basis break or leakage crack locations in the main piping in the Auxiliary Building. The Unit 2 feedwater flow control by-pass lines (4″) have several leakage crack locations as identified on Figure I.3.2-4.

The routing and pipe rupture evaluation of the steam generator blowdown line is described in Section I.3.2.4. Each 2″ line has terminal end design basis break locations in the Auxiliary Building. These locations are identified on Figures I.3.2-7 and I.3.2-8.

For #21 feedwater flow control valve by-pass line leakage cracks, the water would flow down to elevation 723′-4″ and spill over the fuel transfer canal into the steam generator blowdown flash tank and filter/demineralizer areas. Fire doors separating these areas from the remainder of the Auxiliary Building were conservatively assumed closed and any leakage was contained inside these areas before flowing through the floor drain system to the building sump. For #22 feedwater flow control by-pass line leakage cracks, the water would flow through floor openings and floor drains to the building sump.

Steam generator blowdown line design basis breaks occur in areas similar to those feedwater flow control by-pass line leakage cracks discussed above and flow to the building sump in a similar manner.

I.5.5.4 Turbine Building Flooding Review Results

The Design Class 1 area of the Turbine Building was reviewed for the effects of flooding due to HELB events. No high energy piping is present in the Design Class 1 area of the Turbine Building so no evaluations of high energy line breaks in this area were required.

Additional flooding evaluations were performed outside of the Design Class 1 area of the Turbine Building to determine the potential effects on engineered safety systems due to flooding from the broken high energy pipe, consequential piping ruptures due to the HELB, and sprinkler flow due to the HELB environment. Water spray effects were determined to be not applicable because all engineered safety system components in the turbine building are enclosed in rooms in the Design Class 1 area.

Walkdowns were performed in the Turbine Building to determine HELB piping breaks and cracks which could cause consequential failures of piping systems with unlimited water sources such as fire protection, cooling water, and circulating water (Ref 9.20). These results showed that numerous potential interactions were present between these systems and high energy piping that required additional evaluation.

An analysis was performed to determine the steady state flow rate of water into the Turbine Building that could be tolerated without causing failure of engineered safety systems with the mitigating features previously discussed in section I.4.5 (Ref 9.21). The results of the flooding analysis were compared to the expected flow rates from each interaction found during the walkdowns. The evaluation of expected flow rates showed that flooding caused directly or indirectly by a HELB in the turbine building will not result in flow rates high enough to cause engineered safety system failure with the flooding mitigating features in place.

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I.6 MAIN STEAM AND FEEDWATER INSIDE CONTAINMENT

Although the December 1972 Giambusso letter only requested information concerning high energy line breaks outside Containment, a conservative engineering judgement was made to perform a similar review of the main steam and feedwater lines inside Containment utilizing the criteria from the Giambusso letters. However, the results of that review were not incorporated into the FSAR/USAR or addressed by the AEC Safety Evaluation Report.

The Containment is designed for the peak pressure resulting from the rupture of a main steam or feedwater line, therefore, no encapsulation sleeves to limit mass-energy release are required. To avoid jet impingement damage to required equipment, some instrumentation on the 11 (21) steam generator was relocated. Guard pipes were installed on portions of the main steam and feedwater lines associated with the 12 (22) steam generator. This was done to protect the cables in the electrical penetration area from the crack that was assumed to occur anywhere along the pipe and the arbitrary intermediate break locations. Application of the criteria contained in GL 87-11 eliminated all arbitrary intermediate break and leakage crack locations on the main steam lines and the need for the guard pipes and it eliminated most arbitrary intermediate breaks and leakage cracks on the feedwater lines. However, one intermediate break location on #22 steam generator feedwater line and some leakage crack locations on each feedwater line were identified. These break and crack locations and impingement barrier installations are depicted on Figures I.3.2-3 & 4 and Table I.3.2-2.

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I.7 HIGH ENERGY LINES IN THE TURBINE BUILDING

Although the December 1972 Giambusso letter requested information concerning high energy line breaks outside the Containment, only the effects on the Auxiliary Building were described in the FSAR. However, high energy lines in the Turbine Building were evaluated also as demonstrated by the installation of steam exclusion dampers, impingement barriers, rupture restraints, etc. to protect the safety related equipment in the Class I aisle. It was assumed that the large net free volume, extensive metal and concrete heat sinks plus leakage to the atmosphere would prevent any significant pressure or temperature conditions in the Turbine Building. The ventilation systems for the safety related areas of the Class I aisle are equipped with steam exclusion dampers as described in Section I.4.2 to prevent creation of a harsh environment in those areas.

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7. Letter from D Musolf to Director, NRR, Resolution of Environmental Qualification of Equipment in the Auxiliary Feedwater Pump Room, November 28, 1984. (19897/2439)

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9. Calculations

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9.9 ENG-CS-127, Rev. 1, Auxiliary Building HELB Compartment Volumes, May 18, 2004.

9.10 ENG-CS-141, Rev. 1, Auxiliary Building HELB Surface Areas and Flow Paths, May 18, 2004.

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9.13 NSPNAD 00007P, Gothic Results for High Energy Line Breaks in Prairie Island Auxiliary Building (Elev. 695′-0″), Rev. 0, October, 2000.

9.14 ENG-CS-238, Structural Integrity Evaluation of Cable Trays for Jet Impingement, Rev. 0, September 20, 2001. (3941/1509)

9.15 AES PI-P602232-400, Revised Auxiliary Building HELB Analysis.

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9.17 ENG-ME-767, GOTHIC Results for Turbine Building After Main Steam HELB Scenarios that Cause Flooding. 01400725

9.18 ENG-ME-696, Inputs to Auxiliary Building GOTHIC Model for HELB Analysis.

9.19 ENG-ME-708, Inputs to Turbine Building GOTHIC Model for HELB Analysis.

9.20 ENG-ME-732, Determination of HELB / Flooding Interactions in the Turbine Building

9.21 ENG-ME-759, GOTHIC Internal Flooding Calculation for the Turbine Building

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37. Deleted

38. Deleted

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TABLE I.1.4-1 REQUIRED EQUIPMENT LIST

	DESCRIPTION	LOCATION Note 1	MS	FW	VC	SB	AF
MECHANICAL							
034-011, 034-021	D1/D2 diesel generator	*	X	X	X	X	X
234-031, 234-032	D5/D6 diesel generator	*	X	X	X	X	X
045-591, 045-592	Chilled water pump	*	X	X	X	X	X
145-071, 145-072	Safety injection pump	*	X	X	X	X	X
245-071, 245-072	Safety injection pump	*	X	X	X	X	X
145-201, 145-331	Auxiliary feedwater pump	*	X	X	X	X	X
245-201, 245-331	Auxiliary feedwater pump	*	X	X	X	X	X
045-091	Cooling water pump	*	X	X	X	X	X
145-392, 245-392	Cooling water pump	*	X	X	X	X	X
145-121, 145-122	Component cooling pump	*	X	X	X	X	X
245-121, 245-122	Component cooling pump	*	X	X	X	X	X
145-261, 145-262	Feedwater pump	TB	X	X	X	X	X
245-261, 245-262	Feedwater pump	TB	X	X	X	X	X
045-271, 045-272	D1/2 fuel oil transfer pump	*	X	X	X	X	X
045-273, 045-274	D1/2 fuel oil transfer pump	*	X	X	X	X	X
045-301, 045-302	DDCLP fuel oil transfer pump	*	X	X	X	X	X
245-881, 245-882	D5/6 fuel oil transfer pump	*	X	X	X	X	X
245-883, 245-884	D5/6 fuel oil transfer pump	*	X	X	X	X	X
067-011, 067-012	Safeguard traveling screen	*	X	X	X	X	X
146-011, 246-011	DDCLP starting air receiver	*	X	X	X	X	X

Note 1:

Code	Location
*	Outside areas that experience a harsh environment following a break.
TB	Located in the Turbine Building in an area that experiences a harsh environment.
Other Codes	Refer to Auxiliary Building compartment codes as shown on Figures I.3.1-2 thru I.3.1-6.

TABLE I.1.4-1 REQUIRED EQUIPMENT LIST

	DESCRIPTION	LOCATION Note 1	MS	FW	VC	SB	AF
MECHANICAL							
046-031, 046-032	D1/2 starting air receiver	*	X	X	X	X	X
246-031, 246-032	D5 starting air receiver	*	X	X	X	X	X
246-033, 246-034	D5 starting air receiver	*	X	X	X	X	X
246-035, 246-036	D6 starting air receiver	*	X	X	X	X	X
246-037, 246-038	D6 starting air receiver	*	X	X	X	X	X
158-011, 158-012	Cooling water strainer	*	X	X	X	X	X
258-011, 258-012	Cooling water strainer	*	X	X	X	X	X
032-041, 032-042	D1/D2 room supply fan	*	X	X	X	X	X
032-011, 032-012	D1/D2 room exhaust fan	*	X	X	X	X	X
032-291, 032-292	Control room clean-up fan	*	X	X	X	X	X
132-281, 232-281	DDCLP roof exhaust fan	*	X	X	X	X	X
076-021, 076-022	Control room air handler	*	X	X	X	X	X
232-441, 232-442	D5/D6 building supply fan	*	X	X	X	X	X
232-443, 232-444	D5/D6 building supply fan	*	X	X	X	X	X
232-451, 232-452	D5/D6 building exhaust fan	*	X	X	X	X	X
232-453, 232-454	D5/D5 building exhaust fan	*	X	X	X	X	X
232-421, 232-422	D5/D6 room cooling fan	*	X	X	X	X	X
074-031, 074-032	Relay room unit cooler	*	X	X	X	X	X
074-033, 074-034	Relay room unit cooler	*	X	X	X	X	X
174-031, 174-032	Bus 15/16 room unit cooler	*	X	X	X	X	X
274-031, 274-032	Bus 111/121 room unit cooler	*	X	X	X	X	X
174-161, 274-161	Bus 112/122 room unit cooler	*	X	X	X	X	X

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TABLE I.1.4-1 REQUIRED EQUIPMENT LIST

	DESCRIPTION	LOCATION Note 1	MS	FW	VC	SB	AF
MECHANICAL							
174-162, 274-162	EMA/B room unit cooler	*	X	X	X	X	X
174-163	EMA room unit cooler	*	X	X	X	X	X
075-011, 075-012	Control room chiller	*	X	X	X	X	X
CONTROL VALVE (CV-)							
31127, 31128	Feedwater flow - main	B/X	X	X	X	X	X
31135, 31136	Feedwater flow - main	B/X	X	X	X	X	X
31369, 31370	Feedwater flow - bypass	B/X	X	X	X	X	X
31371, 31372	Feedwater flow - bypass	B/X	X	X	X	X	X
31245, 31246	RCP thermal barrier return	*	X	X	X	X	X
31247, 31248	RCP thermal barrier return	*	X	X	X	X	X
31381, 31411	CC Hx cooling water outlet	*	X	X	X	X	X
31383, 31384	CC Hx cooling water outlet	*	X	X	X	X	X
31231, 31232	Pressurizer PORV	*	X	X	X	X	X
31233, 31234	Pressurizer PORV	*	X	X	X	X	X
31084, 31089	Steam generator PORV	A/X	X	X	X	X	X
31102, 31107	Steam generator PORV	A/X	X	X	X	X	X
31998, 31999	Steam supply to AFWPT	TB	X	X	X	X	X
31059, 31060	AFW Pump trip throttle	*	X	X	X	X	X
31153, 31154	AFW pump oil cooler	*	X	X	X	X	X
31418, 31419	AFW pump oil cooler	*	X	X	X	X	X

TABLE I.1.4-1 REQUIRED EQUIPMENT LIST

	DESCRIPTION	LOCATION Note 1	MS	FW	VC	SB	AF
CONTROL VALVE (CV-)							
31423, 31457	DDCLP jacket water cooler	*	X	X	X	X	X
31505, 31506	D1/D2 heat exchanger	*	X	X	X	X	X
31769, 31785	Control room chiller	*	X	X	X	X	X
31786, 31768	Control room air handler	*	X	X	X	X	X
31755, 31756	Bus 111/112 room unit cooler	*	X	X	X	X	X
31759, 31760	Relay room unit cooler	*	X	X	X	X	X
31761, 31762	Relay room unit cooler	*	X	X	X	X	X
31757, 31758	Bus 15/16 room unit cooler	*	X	X	X	X	X
31764, 31765	Bus 112/122 room unit cooler	*	X	X	X	X	X
31766, 31767	EMA/B room unit cooler	*	X	X	X	X	X
31788	EMA room unit cooler	*	X	X	X	X	X
31953, 31954	D1 starting air	*	X	X	X	X	X
31955, 31956	D2 starting air	*	X	X	X	X	X
31098, 31099	Containment isolation – MS	B/Y	X	X	X	X	X
31116, 31117	Containment isolation – MS	B/Y	X	X	X	X	X
31339, 31430	Containment isolation – VC	D	X	X	X	X	X
31325, 31347	Containment isolation – VC	*	X	X	X	X	X
31326, 31348	Containment isolation – VC	*	X	X	X	X	X
31327, 31349	Containment isolation – VC	*	X	X	X	X	X
31255, 31279	LTDN Line Isol – VC	*	X	X	X	X	X

TABLE I.1.4-1 REQUIRED EQUIPMENT LIST

	DESCRIPTION	LOCATION Note 1	MS	FW	VC	SB	AF
SOLENOID VALVE (SV-)							
37903, 37904	D5 starting air	*	X	X	X	X	X
37906, 37907	D5 starting air	*	X	X	X	X	X
37933, 37934	D6 starting air	*	X	X	X	X	X
37936, 37937	D6 starting air	*	X	X	X	X	X
33464, 33465	12 DDCLP starting air	*	X	X	X	X	X
33466, 33467	22 DDCLP starting air	*	X	X	X	X	X
MOTOR VALVE (MV-)							
32016, 32017	Steam supply to AFWPT	B/X	X	X	X	X	X
32019, 32020	Steam supply to AFWPT	B/X	X	X	X	X	X
32025, 32027	AFW pump suction - CL	*	X	X	X	X	X
32026, 32030	AFW pump suction - CL	*	X	X	X	X	X
32031, 32033	CL header to Turb Bldg	*	X	X	X	X	X
32034, 32035	CL pump header isolation	*	X	X	X	X	X
32036, 32037	CL pump header isolation	*	X	X	X	X	X
32045, 32047	MSIV bypass	B/Y	X	X	X	X	X
32048, 32050	MSIV bypass	B/Y	X	X	X	X	X
32068, 32070	SI cold leg injection	*	X	X	X	X	X
32073, 32176	SI cold leg injection	*	X	X	X	X	X
32171, 32173	SI cold leg injection	*	X	X	X	X	X
32079, 32080	SI pump suction from RWST	*	X	X	X	X	X
32182, 32183	SI pump suction from RWST	*	X	X	X	X	X

TABLE I.1.4-1 REQUIRED EQUIPMENT LIST
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MOTOR VALVE (MV-)	**DESCRIPTION**	**LOCATION Note 1**	**MS**	**FW**	**VC**	**SB**	**AF**
32083, 32186	SI pump suction from BAST	*	X	X	X	X	X
32089, 32091	RCP CC inlet	C	X	X	X	X	X
32124, 32126	RCP CC inlet	C	X	X	X	X	X
32090, 32092	RCP CC outlet	C	X	X	X	X	X
32125, 32127	RCP CC outlet	C	X	X	X	X	X
32120, 32121	CC Hx outlet crossover	*	X	X	X	X	X
32122, 32123	CC Hx outlet crossover	*	X	X	X	X	X
32145, 32146	Cooling water to CC Hx	*	X	X	X	X	X
32160, 32161	Cooling water to CC Hx	*	X	X	X	X	X
32144, 32159	Cooling water header crossover	*	X	X	X	X	X
32162, 32163	SI pump suction	*	X	X	X	X	X
32190, 32191	SI pump suction	*	X	X	X	X	X
32195, 32196	Pressurizer PORV isolation	*	X	X	X	X	X
32197, 32198	Pressurizer PORV isolation	*	X	X	X	X	X
32200, 32201	CC surge tank to pump	*	X	X	X	X	X
32211, 32212	CC surge tank to pump	*	X	X	X	X	X
32238, 32381	AFW to steam generator	*	X	X	X	X	X
32246, 32383	AFW to steam generator	*	X	X	X	X	X
32239, 32382	AFW to steam generator	*	X	X	X	X	X
32247, 32384	AFW to steam generator	*	X	X	X	X	X

TABLE I.1.4-1 REQUIRED EQUIPMENT LIST

	DESCRIPTION	LOCATION Note 1	MS	FW	VC	SB	AF
MOTOR VALVE (MV-)							
32266, 32267	CC to RCP	*	X	X	X	X	X
32268, 32269	CC to RCP	*	X	X	X	X	X
32323, 32324	Feedwater pump discharge	TB	X	X	X	X	X
32325, 32326	Feedwater pump discharge	TB	X	X	X	X	X
32332, 32334	Cooling water return header	*	X	X	X	X	X
32023, 32024	Containment isolation - FW	B/X	X	X	X	X	X
32028, 32029	Containment isolation - FW	B/X	X	X	X	X	X
32040, 32043	Containment isolation - SB	*	X	X	X	X	X
32046, 32049	Containment isolation - SB	*	X	X	X	X	X
32044, 32058	Containment isolation - SB	C	X	X	X	X	X
32051, 32059	Containment isolation - SB	C	X	X	X	X	X
32073, 32176	Containment isolation - SI	*	X	X	X	X	X
32242, 32243	Containment isolation - AF	B/X	X	X	X	X	X
32248, 32249	Containment isolation - AF	B/X	X	X	X	X	X
DAMPER (CD- OR MD-)							
34177, 34176	Control room outside air	A/*	X	X	X	X	X
34142, 34145	Control room outside air	*	X	X	X	X	X
34143, 34144	Air handler discharge	*	X	X	X	X	X
34146, 34147	Control room exhaust	*	X	X	X	X	X
34179, 34181	Control Room PAC filter inlet	*	X	X	X	X	X
34178, 34180	Control Room PAC filter outside air	*	X	X	X	X	X

TABLE I.1.4-1 REQUIRED EQUIPMENT LIST

	DESCRIPTION	LOCATION Note 1	MS	FW	VC	SB	AF
DAMPER (CD- OR MD-)							
34182, 34183	Control Room PAC filter outlet	*	X	X	X	X	X
34185, 34186	Waste gas storage area	FH	X	X	X	X	X
34187, 34188	Supply to elevation 695′	C	X	X	X	X	X
34189, 34190	Supply to elevation 695′	*	X	X	X	X	X
34191, 34192	480V Bus Room return	*	X	X			X
34193, 34194	480V Bus Room return	*	X	X			X
34195, 34196	Battery room supply	TB	X	X			X
34197, 34198	Battery room supply	TB	X	X			X
34199, 34200	4kv bus room supply	*	X	X			X
34201, 34202	480v bus room supply	*	X	X			X
34049	D1/D2 outside air supply	*	X	X	X	X	X
34136, 34139	DDCLP air supply	*	X	X	X	X	X
34137, 34138	DDCLP roof exhaust	*	X	X	X	X	X
32420, 32426	D5/D6 room outside air	*	X	X	X	X	X
32421, 32427	D5/D5 room exhaust	*	X	X	X	X	X
32422, 32428	D5/D6 room recirc	*	X	X	X	X	X
32423, 32429	D5/D6 outside air	*	X	X	X	X	X
32424, 32430	D5/D6 building exhaust	*	X	X	X	X	X
32425, 32431	D5/D6 building recirc	*	X	X	X	X	X

TABLE I.1.4-1 REQUIRED EQUIPMENT LIST

	DESCRIPTION	LOCATION Note 1	MS	FW	VC	SB	AF
INSTRUMENTATION (Unit 1, 2 or Common Prefix)							
NM-51, 52	Nuclear Instrumentation	*	X	X	X	X	X
PT-429, 430	Pressurizer pressure	*	X	X	X	X	X
PT-431, 449	Pressurizer pressure	*	X	X	X	X	X
PT-709, 710	RCS wide range pressure	*	X	X	X	X	X
PT-468, 469, 482	Steam generator pressure	X/Y	X	X	X	X	X
PT-378, 479, 483	Steam generator pressure	C	X	X	X	X	X
PT-751, 761	RVLIS wide range pressure	B	X	X	X	X	X
LT-723, 724	Condensate tank level	TB	X	X	X	X	X
LT-426, 427, 428	Pressurizer level	*	X	X	X	X	X
LT-751, 752, 753	RVLIS level	B	X	X	X	X	X
LT-761, 762, 763	RVLIS level	B	X	X	X	X	X
LT-461, 462, 463	Steam generator level	*	X	X	X	X	X
LT-471, 472, 473	Steam generator level	*	X	X	X	X	X
LT-460, 470	Steam generator level	*	X	X	X	X	X
LT-487, 488	Steam generator level	*	X	X	X	X	X
LT-920, 921	RWST level	*	X	X	X	X	X
FT-464, 465	Main steam line flow	*	X				
FT-474, 475	Main steam line flow	*	X				
13234, 13235	Core exit thermocouple	*	X	X	X	X	X

TABLE I.1.4-1 REQUIRED EQUIPMENT LIST

INSTRUMENTATION (Unit 1, 2 or Common Prefix)	DESCRIPTION	LOCATION Note 1	MS	FW	VC	SB	AF
13237, 13238	Core exit thermocouple	*	X	X	X	X	X
13239, 13240	Core exit thermocouple	*	X	X	X	X	X
13241, 13242	Core exit thermocouple	*	X	X	X	X	X
13243, 13245	Core exit thermocouple	*	X	X	X	X	X
13246, 13247	Core exit thermocouple	*	X	X	X	X	X
13248, 13249	Core exit thermocouple	*	X	X	X	X	X
13250, 13251	Core exit thermocouple	*	X	X	X	X	X
13252, 13253	Core exit thermocouple	*	X	X	X	X	X
13255, 13256	Core exit thermocouple	*	X	X	X	X	X
13258, 13259	Core exit thermocouple	*	X	X	X	X	X
13260, 13261	Core exit thermocouple	*	X	X	X	X	X
13262, 13263	Core exit thermocouple	*	X	X	X	X	X
13264, 13265	Core exit thermocouple	*	X	X	X	X	X
13266, 13267	Core exit thermocouple	*	X	X	X	X	X
13268, 13269	Core exit thermocouple	*	X	X	X	X	X
13270, 13271	Core exit thermocouple	*	X	X	X	X	X
13272, 12407	Core exit thermocouple	*	X	X	X	X	X
13408, 13410	Core exit thermocouple	*	X	X	X	X	X
13411, 13412	Core exit thermocouple	*	X	X	X	X	X
13413, 13414	Core exit thermocouple	*	X	X	X	X	X
13415, 13416	Core exit thermocouple	*	X	X	X	X	X
13418, 13419	Core exit thermocouple	*	X	X	X	X	X

TABLE I.1.4-1 REQUIRED EQUIPMENT LIST

INSTRUMENTATION (Unit 1, 2 or Common Prefix)	**DESCRIPTION**	**LOCATION Note 1**	**MS**	**FW**	**VC**	**SB**	**AF**
13420, 13421	Core exit thermocouple	*	X	X	X	X	X
13422, 13423	Core exit thermocouple	*	X	X	X	X	X
13424, 13425	Core exit thermocouple	*	X	X	X	X	X
13426, 13428	Core exit thermocouple	*	X	X	X	X	X
13429, 13431	Core exit thermocouple	*	X	X	X	X	X
13432, 13433	Core exit thermocouple	*	X	X	X	X	X
13434, 13435	Core exit thermocouple	*	X	X	X	X	X
13436, 13437	Core exit thermocouple	*	X	X	X	X	X
13438, 13439	Core exit thermocouple	*	X	X	X	X	X
13440, 13441	Core exit thermocouple	*	X	X	X	X	X
13442, 13443	Core exit thermocouple	*	X	X	X	X	X
13444, 13445	Core exit thermocouple	*	X	X	X	X	X
TE-401, 402	RCS hot/cold leg temperature	*	X				
TE-403, 404	RCS hot/cold leg temperature	*	X				
TE-450, 451	RCS hot/cold leg temperature	*	X	X	X	X	X
15297, 15407	Waste gas storage area	FH	X	X	X	X	X
15298, 15408	Supply to elevation 695′	*	X	X	X	X	X
15299, 15409	Supply to elevation 695′	*	X	X	X	X	X
15300, 15415	Control room exhaust	A	X	X	X	X	X
15301, 15421	Control room outside air	*	X	X	X	X	X
15302, 15422	Control room outside air	*	X	X	X	X	X
15684, 15690	480V Bus room return	TB	X	X			X

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TABLE I.1.4-1 REQUIRED EQUIPMENT LIST

	DESCRIPTION	LOCATION Note 1	MS	FW	VC	SB	AF
INSTRUMENTATION (Unit 1, 2 or Common Prefix)							
15685, 15691	480V Bus room return	TB	X	X			X
15686, 15692	Battery room supply	TB	X	X			X
15687, 15693	Battery room supply	*	X	X			X
15688, 15694	4 kv bus room supply	TB	X	X			X
15689, 15695	480v bus room supply	TB	X	X			X
CS46331, 46450	Reactor trip breaker	*	X	X	X	X	X
CS49629, 49562	Reactor trip breaker	*	X	X	X	X	X
CS46180, 49610	SI actuation	*	X	X	X	X	X
CS46408, 49545	SI actuation	*	X	X	X	X	X
CS46158, 46159	MSIV closure	*	X	X	X	X	X
CS49620, 49621	MSIV closure	*	X	X	X	X	X
FT-924, 925	Safety injection flow	*	X	X	X	X	X
23122, 23127	Auxiliary feedwater flow	*	X	X	X	X	X
23128, 23219	Auxiliary feedwater flow	*	X	X	X	X	X
PZ-HTRA/XD	Przr heater watts	*	X	X	X	X	X
PZ-HTRB/XD	Przr heater watts	*	X	X	X	X	X
XE-443, 444, 445	Przr safety valve flow	*	X	X	X	X	X
RE-01	Control room rad monitor	*	X	X	X	X	X
4190201, 4190202	Electrical bus status	*	X	X	X	X	X
4190203, 4190204	Electrical bus status	*	X	X	X	X	X
4190205, 4190206	Electrical bus status	*	X	X	X	X	X
4190301, 4190302	Electrical bus status	*	X	X	X	X	X

TABLE I.1.4-1 REQUIRED EQUIPMENT LIST

	DESCRIPTION	LOCATION Note 1	MS	FW	VC	SB	AF
INSTRUMENTATION (Unit 1, 2 or Common Prefix)							
4190303, 4190304	Electrical bus status	*	X	X	X	X	X
4190305, 4190306	Electrical bus status	*	X	X	X	X	X
4190401, 4190402	Electrical bus status	*	X	X	X	X	X
4190403, 4190501	Electrical bus status	*	X	X	X	X	X
4190502, 4190503	Electrical bus status	*	X	X	X	X	X
4190504, 4190505	Electrical bus status	*	X	X	X	X	X
4190506, 4190701	Electrical bus status	*	X	X	X	X	X
4190702, 4190703	Electrical bus status	*	X	X	X	X	X
4190704, 4190705	Electrical bus status	*	X	X	X	X	X
4190706, 4192401	Electrical bus status	*	X	X	X	X	X
4192402, 4192403	Electrical bus status	*	X	X	X	X	X
4191801, 4191802	Electrical bus status	*	X	X	X	X	X
4191803, 4192301	Electrical bus status	*	X	X	X	X	X
4192302, 4192303	Electrical bus status	*	X	X	X	X	X
ELECTRICAL							
1-52/RTA, 1-52/RTB	Reactor trip breaker	*	X	X	X	X	X
1-52/BYA, 1-52/BYB	Reactor trip breaker	*	X	X	X	X	X
2-52/RTA, 2-52/RTB	Reactor trip breaker	*	X	X	X	X	X
2-52/BYA, 2-52/BYB	Reactor trip breaker	*	X	X	X	X	X
11 Batt, 12 Batt	Battery	*	X	X	X	X	X
21 Batt, 22 Batt	Battery	*	X	X	X	X	X

TABLE I.1.4-1 REQUIRED EQUIPMENT LIST

	DESCRIPTION	LOCATION Note 1	MS	FW	VC	SB	AF
ELECTRICAL							
Bus 15, 16	4160 volt switchgear	*	X	X	X	X	X
Bus 25, 26, 27	4160 volt switchgear	*	X	X	X	X	X
Bus 111, 112	480 volt switchgear	*	X	X	X	X	X
Bus 211, 212	480 volt switchgear	*	X	X	X	X	X
Bus 121, 122	480 volt switchgear	*	X	X	X	X	X
Bus 221, 222	480 volt switchgear	*	X	X	X	X	X
MCC 1S, 2S	Pressurizer heater group A	*	X	X	X	X	X
MCC 1R, 2R	Pressurizer heater group B	*	X	X	X	X	X
DOORS							
Door 133, 182	Aux Bldg to Fuel Handling	X2	X	X	X	X	X
Door 134, 184	Aux Bldg to Fuel Handling	X1	X	X	X	X	X
Door 147, 273	Aux Bldg to Fuel Handling	A0	X	X	X	X	X
Door 155, 177	Aux Bldg to Fuel Handling	Y1	X	X	X	X	X

TABLE I.3.1-1 AUXILIARY BUILDING – COMPARTMENT DATA

	A1	**A0**	**A2**
Gross Volume (ft^3)	146,034	37,411	149,207
Equipment	(20,603)	(4,047)	(15,574)
Net Volume (ft^3)	125,431	33,364	133,633
Surface Area (ft^2)	50997	12,421	49,996

	B1	**B0**	**B2**
Gross Volume (ft^3)	101,128	38,727	114,851
Equipment	(23,036)	(6,806)	(26,652)
Net Volume (ft^3)	78,092	31,921	88,199
Surface Area (ft^2)	36,492	13,699	43,057

	X1		**X2**
Gross Volume (ft^3)	23,456		23,269
Equipment	(2,019)		(2,171)
Net Volume (ft^3)	21,437		21,098
Surface Area (ft^2)	8,281		8,755

	C1	**C0**	**C2**
Gross Volume (ft^3)	171,616	44,612	171,806
Equipment	(50,119)	(20,915)	(21,379)
Net Volume (ft^3)	121,497	23,697	150,427
Surface Area (ft^2)	57,399	20,289	61,489

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TABLE I.3.1-1 AUXILIARY BUILDING – COMPARTMENT DATA

	D1	D0	D2
Gross Volume (ft^3)	11,932	86,163	11,932
Equipment	(1,393)	(32,770)	(1,268)
Net Volume (ft^3)	10,539	53,393	10,664
Surface Area (ft^2)	4,650	39,306	4,600

	Y1		Y2
Gross Volume (ft^3)	15,806		11,975
Equipment	(3,317)		(2,384)
Net Volume (ft^3)	12,489		9,591
Surface Area (ft^2)	7,321		7,041

NOTE: Surface areas include concrete and metal.

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Volume For Compartment	Includes Volume For Compartment
B1	F1 & G1
B2	F2 & G2
D0	H0, M0, N0, N1 & N2
C1	K1 & L1
C2	K2 & L2
Y2	O2

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TABLE I.3.2-1 HIGH ENERGY LINE BREAK (B) AND CRACK (C) LOCATIONS OUTSIDE CONTAINMENT

Main Steam from Steam Generator #11				
Break ID No.	Description	Building	HELB Comp.	
MS1-B3	30″ nozzle @ HP Turbine	Turbine Bldg	3A1	
MS1-B4	10″ branch connection to MSRs	Turbine Bldg	2D1	01204043 01222109
MS1-B5	6″ branch connection to PORV	Aux Bldg	X_1	
MS1-B6	6″ branch connection to AFWP	Aux Bldg	X_1	
MS1-B7	1 1/2″ drain line from CV-31098	Aux Bldg	Y_1	
MS1-B8	1 1/2″ drain line from valve RS-19-1	Aux Bldg	Y_1	
MS1-B9	1 1/2″ drain line at drip pocket after RS-19-1	Aux Bldg	Y_1	
MS1-B10	1 1/2″ drain line at pipe 12-MS-3	Turbine Bldg	2D4	01222109
MS1-B11	Drain line from turbine stop valve	Turbine Bldg	3A1	

Main Steam from Steam Generator #12				
Break ID No.	Description	Building	HELB Comp.	
MS1-B14	30″ nozzle @ HP Turbine	Turbine Bldg	3A1	01222109
MS1-B15	16″ branch connection to MSRs	Turbine Bldg	2D4	
MS1-B16	6″ branch connection to PORV	Aux Bldg	A_1	
MS1-B17	6″ branch connection to AFWP	Aux Bldg	B_1	
MS1-B18	1 1/2″ drain line from CV-31099	Aux Bldg	B_1	
MS1-B19	1 1/2″ drain line from valve RS-19-2	Aux Bldg	B_1	
MS1-B20	1 1/2″ drain line at drip pocket after RS-19-2	Aux Bldg	B_1	
MS1-B21	1 1/2″ drain line at pipe 12-MS-4	Turbine Bldg	2D4	
MS1-B22	Drain line from turbine stop valve	Turbine Bldg	3A1	01222109
MS1-B23	Drain line upstream of CV-31099	Aux Bldg	B_1	

TABLE I.3.2-1 HIGH ENERGY LINE BREAK (B) AND CRACK (C) LOCATIONS OUTSIDE CONTAINMENT

Main Steam from Steam Generator #21			
Break ID No.	Description	Building	HELB Comp.
MS2-B3	30″ nozzle @ HP Turbine	Turbine Bldg	3A1
MS2-B4	10″ branch connection to MSRs	Turbine Bldg	2H1
MS2-B5	6″ branch connection to PORV	Aux Bldg	X_2
MS2-B6	6″ branch connection to AFWP	Aux Bldg	X_2
MS2-B7	1 1/2″ drain line from CV-31116	Aux Bldg	Y_2
MS2-B8	1 1/2″ drain line from valve RS-19-3	Aux Bldg	Y_2
MS2-B9	2″ drain line at drip pocket after RS-19-3	Aux Bldg	Y_2
MS2-B10	1 1/2″ drain line at pipe 12-2MS-3	Turbine Bldg	2H4
MS2-B11	Drain line from turbine stop valve	Turbine Bldg	3A1

Main Steam from Steam Generator #22			
Break ID No.	Description	Building	HELB Comp.
MS2-B14	30″ nozzle @ HP Turbine	Turbine Bldg	3A1
MS2-B15	16″ branch connection to MSRs	Turbine Bldg	2H4
MS2-B16	6″ branch connection to PORV	Aux Bldg	A_2
MS2-B17	6″ branch connection to AFWP	Aux Bldg	B_2
MS2-B18	1 1/2″ drain line from CV-31117	Aux Bldg	B_2
MS2-B19	1 1/2″ drain line from valve RS-19-4	Aux Bldg	B_2
MS2-B20	1 1/2″ drain line at drip pocket after RS-19-4	Aux Bldg	B_2
MS2-B21	1 1/2″ drain line at pipe 12-2MS-4	Turbine Bldg	2H4
MS2-B22	Drain line from turbine stop valve	Turbine Bldg	3A1
MS2-B23	Drain line upstream of CV-31117	Aux Bldg	B_2

Feedwater from #15A/B FW Heaters to Steam Generators #11 & #12			
Break ID No.	Description	Building	HELB Comp.
FW1-B1	16″ Nozzle @ 15B FW Heater	Turbine Bldg	2D4
FW1-B4	16″ Nozzle @ 15A FW Heater	Turbine Bldg	2D4

Feedwater from #15A/B FW Heaters to Steam Generators #21 & #22			
Break ID No.	Description	Building	HELB Comp.
FW2-B1	16″ Nozzle @ 25B FW Heater	Turbine Bldg	2H4
FW2-B4	16″ Nozzle @ 25A FW Heater	Turbine Bldg	2H4

TABLE I.3.2-1 HIGH ENERGY LINE BREAK (B) AND CRACK (C) LOCATIONS OUTSIDE CONTAINMENT

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Feedwater from FW Pumps #11 & #12 to #15A/B FW Heaters			
Break ID No.	Description	Building	HELB Comp.
FW1-B7	16″ outlet nozzle @ #11 FW pump	Turbine Bldg	1D1
FW1-B8	16″ outlet nozzle @ #12 FW pump	Turbine Bldg	1D1
FW1-B9	20″ nozzle @ 15A FW heater inlet	Turbine Bldg	2D4
FW1-B10	20″ nozzle @ 15B FW heater inlet	Turbine Bldg	2D4
FW1-B11	10″ condenser dump (#11 FW pump)	Turbine Bldg	1D3
FW1-B12	10″ condenser dump (#12 FW pump)	Turbine Bldg	1D3
FW1-B13	14″ branch (15A FW heater bypass)	Turbine Bldg	2D4
FW1-B14	14″ branch (15B FW heater bypass)	Turbine Bldg	2D4
FW1-B15	6″ branch to condenser (#11 pump)	Turbine Bldg	1D1
FW1-B16	6″ branch to condenser (#12 pump)	Turbine Bldg	1D1

Feedwater from FW Pumps #21 & #22 to #15A/B FW Heaters			
Break ID No.	Description	Building	HELB Comp.
FW2-B8	16″ outlet nozzle @ #21 FW pump	Turbine Bldg	1J1
FW2-B9	16″ outlet nozzle @ #22 FW pump	Turbine Bldg	1J1
FW2-B10	20″ nozzle @ 25A FW heater inlet	Turbine Bldg	2H4
FW2-B11	20″ nozzle @ 25B FW heater inlet	Turbine Bldg	2H4
FW2-B12	10″ condenser dump (#21 FW pump)	Turbine Bldg	1J3
FW2-B13	10″ condenser dump (#22 FW pump)	Turbine Bldg	1J3
FW2-B14	14″ branch (25A FW heater bypass)	Turbine Bldg	2H4
FW2-B15	14″ branch (25B FW heater bypass)	Turbine Bldg	2H4
FW2-B16	10″ branch to condenser (#21 pump)	Turbine Bldg	1J1

TABLE I.3.2-1 HIGH ENERGY LINE BREAK (B) AND CRACK (C) LOCATIONS OUTSIDE CONTAINMENT

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Condensate from #12A/B FW Heaters to FW Pumps #11 & #12			
Break ID No.	Description	Building	HELB Comp.
CD1-B1	16″ nozzle @ 12A FW heater outlet	Turbine Bldg	2D2
CD1-B2	16″ nozzle @ 12B FW heater outlet	Turbine Bldg	2D2
CD1-B3	16″ nozzle @ 13A FW heater inlet	Turbine Bldg	1D1
CD1-B4	16″ nozzle @ 13B FW heater inlet	Turbine Bldg	1D1
CD1-B5	16″ nozzle @ 13A FW heater outlet	Turbine Bldg	2D2
CD1-B6	16″ nozzle @ 13B FW heater outlet	Turbine Bldg	2D2
CD1-B7	16″ nozzle @ 14A FW heater inlet	Turbine Bldg	2D4
CD1-B8	16″ nozzle @ 14B FW heater inlet	Turbine Bldg	2D4
CD1-B9	16″ nozzle @ 14A FW heater outlet	Turbine Bldg	2D4
CD1-B10	16″ nozzle @ 14B FW heater outlet	Turbine Bldg	2D4
CD1-B11	12″ nozzle @ #11 HD pump outlet	Turbine Bldg	1D3
CD1-B12	12″ nozzle @ #12 HD pump outlet	Turbine Bldg	1D3
CD1-B13	12″ nozzle @ #13 HD pump outlet	Turbine Bldg	1D3
CD1-B14	16″ inlet nozzle @ #11 FW pump	Turbine Bldg	1D1
CD1-B15	16″ inlet nozzle @ #12 FW pump	Turbine Bldg	1D1
CD1-B16	Bypass line tee at 14B FW htr inlet	Turbine Bldg	2D4
CD1-B17	20″ Tee at branch to #11 FW pump	Turbine Bldg	2D4
CD1-B18	Second elbow upstream of 14A FW heater inlet	Turbine Bldg	2D4
CD1-B19	Tee upstream of 14B FW heater inlet	Turbine Bldg	1D1
CD1-B20	Tee downstream of Valve C-5-1	Turbine Bldg	1D1
CD1-B21	Tee downstream of 13A FW Htr outlet	Turbine Bldg	1D1
CD1-B22	Third elbow downstream of 13A FW heater outlet	Turbine Bldg	1D1
CD1-B23	Second elbow downstream of 13A FW heater outlet	Turbine Bldg	2D2
CD1-B24	Second elbow upstream of 14B FW heater inlet	Turbine Bldg	2D4
CD1-B25	Third elbow upstream of 14B FW heater inlet	Turbine Bldg	1D1
CD1-B26	Second elbow downstream of 13B FW heater outlet	Turbine Bldg	2D2
CD1-B27	Elbow downstream of Valve C-5-1	Turbine Bldg	1D1

TABLE I.3.2-1 HIGH ENERGY LINE BREAK (B) AND CRACK (C) LOCATIONS OUTSIDE CONTAINMENT

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Condensate from #22A/B FW Heaters to FW Pumps #21 & #22			
Break ID No.	Description	Building	HELB Comp.
CD2-B1	16″ nozzle @ 22A FW heater outlet	Turbine Bldg	2H2
CD2-B2	16″ nozzle @ 22B FW heater outlet	Turbine Bldg	2H2
CD2-B3	16″ nozzle @ 23A FW heater inlet	Turbine Bldg	1J1
CD2-B4	16″ nozzle @ 23B FW heater inlet	Turbine Bldg	1J1
CD2-B5	16″ nozzle @ 23A FW heater outlet	Turbine Bldg	2H2
CD2-B6	16″ nozzle @ 23B FW heater outlet	Turbine Bldg	2H2
CD2-B7	16″ nozzle @ 24A FW heater inlet	Turbine Bldg	2H4
CD2-B8	16″ nozzle @ 24B FW heater inlet	Turbine Bldg	2H4
CD2-B9	16″ nozzle @ 24A FW heater outlet	Turbine Bldg	2H4
CD2-B10	16″ nozzle @ 24B FW heater outlet	Turbine Bldg	2H4
CD2-B11	12″ nozzle @ #21 HD pump outlet	Turbine Bldg	1J3
CD2-B12	12″ nozzle @ #22 HD pump outlet	Turbine Bldg	1J3
CD2-B13	12″ nozzle @ #23 HD pump outlet	Turbine Bldg	1J3
CD2-B14	16″ inlet nozzle @ #21 FW pump	Turbine Bldg	1J1
CD2-B15	16″ inlet nozzle @ #22 FW pump	Turbine Bldg	1J1
CD2-B16	Elbow downstream of valve 2CD-5-1	Turbine Bldg	1J1
CD2-B17	Tee downstream of valve 2CD-5-1	Turbine Bldg	1J1
CD2-B18	Tee downstream of 23A FW Htr outlet	Turbine Bldg	1J1
CD2-B19	Second elbow downstream of 24B FW heater outlet	Turbine Bldg	2H2
CD2-B20	Second elbow downstream of 24A FW heater outlet	Turbine Bldg	2H2
CD2-B21	Tee to 24B FW heater inlet	Turbine Bldg	1J1
CD2-B22	Third elbow upstream of 24B FW heater inlet	Turbine Bldg	1J1
CD2-B23	Second elbow upstream of 24B FW heater inlet	Turbine Bldg	2H4
CD2-B24	Bypass line tee at 24B FW htr inlet	Turbine Bldg	2H4
CD2-B25	Third elbow upstream of 24A FW heater inlet	Turbine Bldg	1J1
CD2-B26	Second elbow upstream of 24A FW heater inlet	Turbine Bldg	2H4
CD2-B27	Bypass line tee at 24A FW htr inlet	Turbine Bldg	1J1
CD2-B28	20″ Tee at branch from #22 FW pump	Turbine Bldg	2H4

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TABLE I.3.2-1 HIGH ENERGY LINE BREAK (B) AND CRACK (C) LOCATIONS OUTSIDE CONTAINMENT

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CVCS Letdown line – Unit 1			
Break ID No.	Description	Building	HELB Comp.
VC1-B1	2″ Containment penetration	Aux Bldg	D_1
VC1-B2	2″ Intermediate anchor	Aux Bldg	D_1
VC1-B3	2″ Letdown heat exchanger nozzle	Aux Bldg	L_1

CVCS Letdown line – Unit 2			
Break ID No.	Description	Building	HELB Comp.
VC2-B1	2″ Containment penetration	Aux Bldg	D_2
VC2-B2	2″ Intermediate anchor	Aux Bldg	H_0
VC2-B3	2″ Letdown heat exchanger nozzle	Aux Bldg	L_2

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Unit 1 Steam Generator Blowdown			
Break ID No.	Description	Building	HELB Comp.
SB1-B1	2″ Containment penetration	Aux Bldg	C_1
SB1-B2	2″ Intermediate anchor	Aux Bldg	C_1
SB1-B3	2″ Intermediate anchor	Aux Bldg	D_1
SB1-B4	2″ Flash tank nozzle	Aux Bldg	D_1
SB1-B6	2″ Containment penetration	Aux Bldg	C_1
SB1-B7	2″ Intermediate anchor	Aux Bldg	C_1
SB1-B8	2″ Intermediate anchor	Aux Bldg	D_1
SB1-B9	2″ Flash tank nozzle	Aux Bldg	D_1

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Unit 2 Steam Generator Blowdown			
Break ID No.	Description	Building	HELB Comp.
SB2-B1	2″ Containment penetration	Aux Bldg	C_2
SB2-B2	2″ Intermediate anchor	Aux Bldg	C_2
SB2-B4	2″ Flash tank nozzle	Aux Bldg	D_2
SB2-B5	2″ Containment penetration	Aux Bldg	C_2
SB2-B7	2″ Flash tank nozzle	Aux Bldg	D_2

Unit 1 Steam Supply to Aux Feedwater Pump			
Break ID No.	Description	Building	HELB Comp.
AF1-B1	3″ Intermediate anchor	Aux Bldg	X_1

Unit 2 Steam Supply to Aux Feedwater Pump			
Break ID No.	Description	Building	HELB Comp.
	No breaks present		

TABLE I.3.2-2 HIGH ENERGY LINE BREAK (B) AND CRACK (C) LOCATIONS INSIDE CONTAINMENT

Main Steam from Steam Generator #11			
Break ID No.	Description	Building	HELB Comp.
MS1-B1	32″ nozzle @ Steam Generator	Containment	N/A
MS1-B2	31″ Intermediate anchor elbow	Containment	N/A

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Main Steam from Steam Generator #12			
Break ID No.	Description	Building	HELB Comp.
MS1-B12	32″ nozzle @ Steam Generator	Containment	N/A
MS1-B13	31″ Intermediate anchor elbow	Containment	N/A

Main Steam from Steam Generator #21			
Break ID No.	Description	Building	HELB Comp.
MS2-B1	32″ nozzle @ Steam Generator	Containment	N/A
MS2-B2	31″ Intermediate anchor elbow	Containment	N/A

Main Steam from Steam Generator #22			
Break ID No.	Description	Building	HELB Comp.
MS2-B12	32″ nozzle @ Steam Generator	Containment	N/A
MS2-B13	31″ Intermediate anchor elbow	Containment	N/A

Feedwater to Steam Generator #11			
Break ID No.	Description	Building	HELB Comp.
FW1-B2	16″ Intermediate anchor elbow	Containment	N/A
FW1-B3	16″ nozzle @ steam generator	Containment	N/A

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TABLE I.3.2-2 HIGH ENERGY LINE BREAK (B) AND CRACK (C) LOCATIONS INSIDE CONTAINMENT

Feedwater to Steam Generator #12			
Break ID No.	Description	Building	HELB Comp.
FW1-B5	16″ Intermediate anchor elbow	Containment	N/A
FW1-B6	16″ nozzle @ steam generator	Containment	N/A

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Feedwater to Steam Generator #21			
Break ID No.	Description	Building	HELB Comp.
FW2-B2	16″ Intermediate anchor elbow	Containment	N/A
FW2-B3	16″ Nozzle @ steam generator	Containment	N/A

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Feedwater to Steam Generator #22			
Break ID No.	Description	Building	HELB Comp.
FW2-B5	16″ Intermediate anchor elbow	Containment	N/A
FW2-B6	16″ at Aux feedwater nozzle	Containment	N/A
FW2-B7	16″ Nozzle @ steam generator	Containment	N/A

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TABLE I.3.2-3 BOUNDING HIGH ENERGY LINE BREAK (B) AND CRACK (C) LOCATIONS AUXILIARY BUILDING COMPARTMENTS

A summary of the bounding break and crack locations within the Auxiliary Building and sorted by compartment is as follows. Bounding breaks are selected based on break size and analysis type. The two major analysis types are temperature (T) and flooding (F).

Other analyses may result in different bounding breaks or cracks depending on the SSC being evaluated. Use caution when utilizing this table for analyses other than temperature.

<table>
<tr><td colspan="4">755′ Level</td></tr>
<tr><td>Comp. A_2</td><td colspan="2">Comp. A_0</td><td>Comp. A_1</td></tr>
<tr><td>MS2-B16 (T)</td><td colspan="2">None</td><td>MS1-B16 (T)</td></tr>
<tr><td colspan="4">735′ Level</td></tr>
<tr><td>Comp. B_2</td><td colspan="2">Comp. B_0</td><td>Comp. B_1</td></tr>
<tr><td>MS2-B17 (T)

16″ FW Pipe (F)
(crack in most adverse location)</td><td colspan="2">None</td><td>MS1-B17 (T)

16″ FW Pipe (F)
(crack in most adverse location)</td></tr>
<tr><td>Comp. X_2</td><td colspan="2" rowspan="2"></td><td>Comp. X_1</td></tr>
<tr><td>MS2-B5 / MS2-B6 (T)

16″ FW Pipe (F)
(crack in most adverse location)</td><td>MS1-B5 / MS1-B6 (T)

16″ FW Pipe (F)
(crack in most adverse location)</td></tr>
<tr><td colspan="4">715′ Level</td></tr>
<tr><td>Comp. C_2</td><td>Comp. L_2</td><td>Comp. L_1</td><td>Comp. C_1</td></tr>
<tr><td>31″ MS Pipe (T)
(crack in most adverse location)

SB2-B1 / SB2-B2 / SB2-B5 (F)</td><td>VC2-B3
(T) (F)</td><td>VC1-B3
(T) (F)</td><td>31″ MS Pipe (T)
(crack in most adverse location)

SB1-B1 / SB1-B2 /
SB1-B6 / SB1-B7 (F)</td></tr>
<tr><td>Comp. D_2</td><td>Comp. H_0</td><td>Comp D_0</td><td>Comp. D_1</td></tr>
<tr><td>VC2-B1
SB2-B4 / SB2-B7</td><td rowspan="3">VC2-B2
(T) (F)</td><td rowspan="3">2″ SB Pipe
(T) (F)
(crack in most adverse location)</td><td>VC1-B1 / VC1-B2

SB1-B3 / SB1-B8 / SB1-B9</td></tr>
<tr><td>Comp. Y_2</td><td>Comp. Y_1</td></tr>
<tr><td>31″ MS Pipe (T)
(crack in most adverse location)</td><td>31″ MS Pipe (T)
(crack in most adverse location)</td></tr>
<tr><td colspan="4">695′ Level</td></tr>
</table>

Notes:

(1) AFW piping on the 695′ level of the Aux Bldg is encapsulated and will not release energy into the steam exclusion area. Therefore, no adverse crack is listed for this piping.

(2) Cracks in the most adverse location are shown where the crack bounds all breaks or cracks in the compartment selected using the GL 87-11 criteria or if no other breaks are present.

TABLE I.3.2-4 BOUNDING HIGH ENERGY LINE BREAK (B) AND CRACK (C) LOCATIONS TURBINE BUILDING COMPARTMENTS

A summary of the bounding break and crack locations within the Turbine Building and sorted by compartment is as follows. Bounding breaks are selected based on break size and energy level for peak temperature purposes.

Other analyses may result in different bounding breaks or cracks depending on the SSC being evaluated. Use caution when utilizing this table for analyses other than temperature. 01222109

735′ Level					
Comp. 3A1					
MS1-B3 / MS1-B14 / MS2-B3 / MS2-B14[(1)] 6″ MS Pipe (T) (arbitrary break)					
715′ Level					
Comp. 2H4	Comp. 2H2	Comp. 2H1	Comp. 2D1	Comp. 2D2	Comp. 2D4
MS2-B15 (T)	8″ MS Pipe (arbitrary break)	MS2-B4	MS1-B4	8″ MS Pipe (arbitrary break)	MS1-B15
695′ Level					
Comp. 1J1			Comp. 1D1		
12″ MS Pipe (arbitrary break)			12″ MS Pipe (arbitrary break)		
679′ Level					
Comp 1J3			Comp 1D3		
12″ MS Pipe (arbitrary break)			12″ MS Pipe (arbitrary break)		

Notes:

(1) These breaks will not be evaluated for HELB effects due to their effect on the Turbine Building roof.

(2) Arbitrary circumferential breaks are shown where no detailed break selection has been performed or if the arbitrary break bounds breaks selected with the GL 87-11 criteria.

Figure I.3.1-1 has been Deleted

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Figure I.3.I-2 withheld from public disclosure under 10 CFR 2.390

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Figure I.3.I-3 withheld from public disclosure under 10 CFR 2.390

01521968

Figure I.3.I-4 withheld from public disclosure under 10 CFR 2.390

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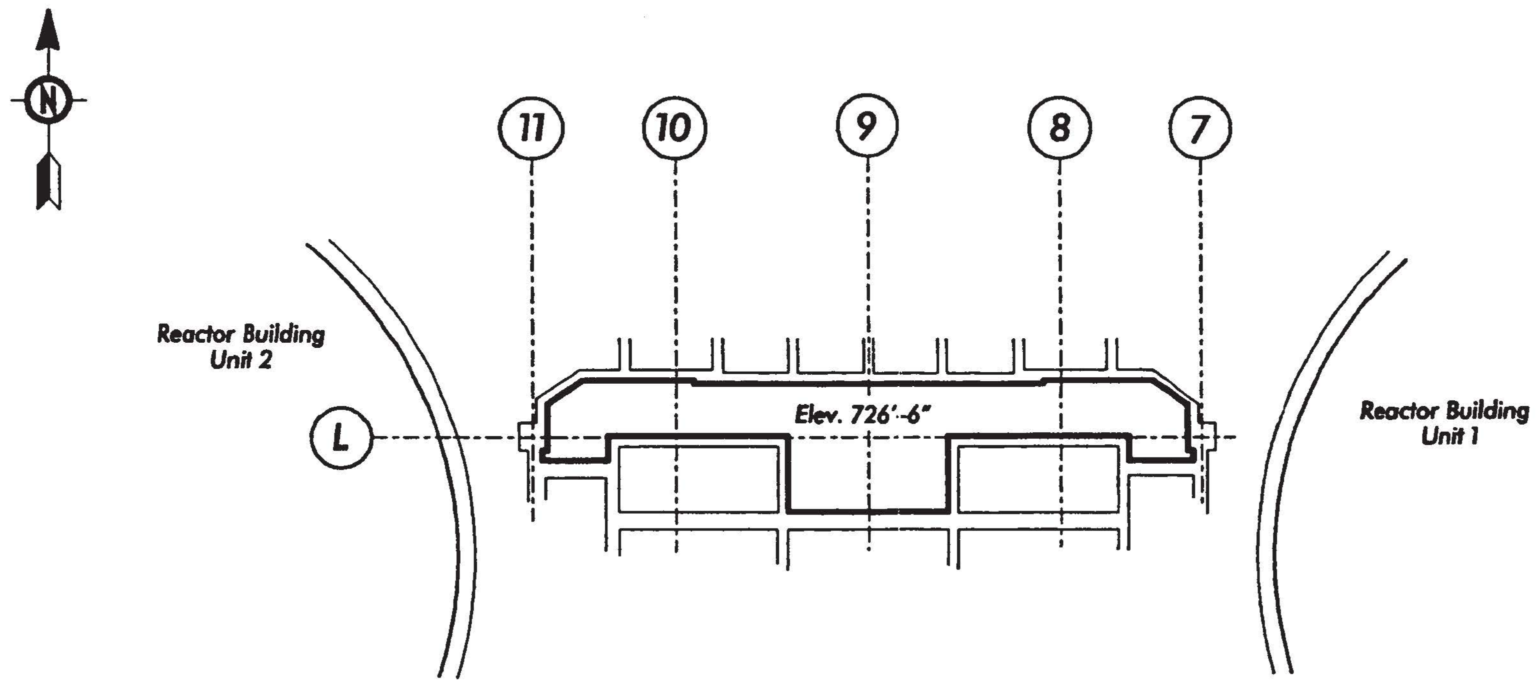
NH-172997-5

REVISIONS

AS BUILT PER SAFETY EVALUATION

DWN.
CHK'D.
MOD.
FILMED



Aux. Bldg. 726'-6"
Area H0

Note:

This Simplified Floor Plan Is Only Intended To Identify Those Compartments Utilized In The Building Computer Model (Calc. NSPNAD–99006–P) And Does Not Depict All Installed Components.

DWN TAM	DATE 6-23-99			750	1&2	A100	3	1100
CHECKED			1	2	3	4	5	6
PROJECT NO. ETNSUR		AUXILIARY BUILDING ELEV. 726'-6" AREA H0						
APP'D & CERT.								
FILMED								

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT

SCALE NONE

NH-172997-5

FIGURE I.3.1-5 REV. 22

Figure I.3.I-6 withheld from public disclosure under 10 CFR 2.390 01521968

Figure I.3.I-7 withheld from public disclosure under 10 CFR 2.390

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Figure I.3.I-8 withheld from public disclosure under 10 CFR 2.390

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Figure I.3.I-9 withheld from public disclosure under 10 CFR 2.390

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TURBINE BUILDING COMPARTMENT PLAN – ELEVATION 679'

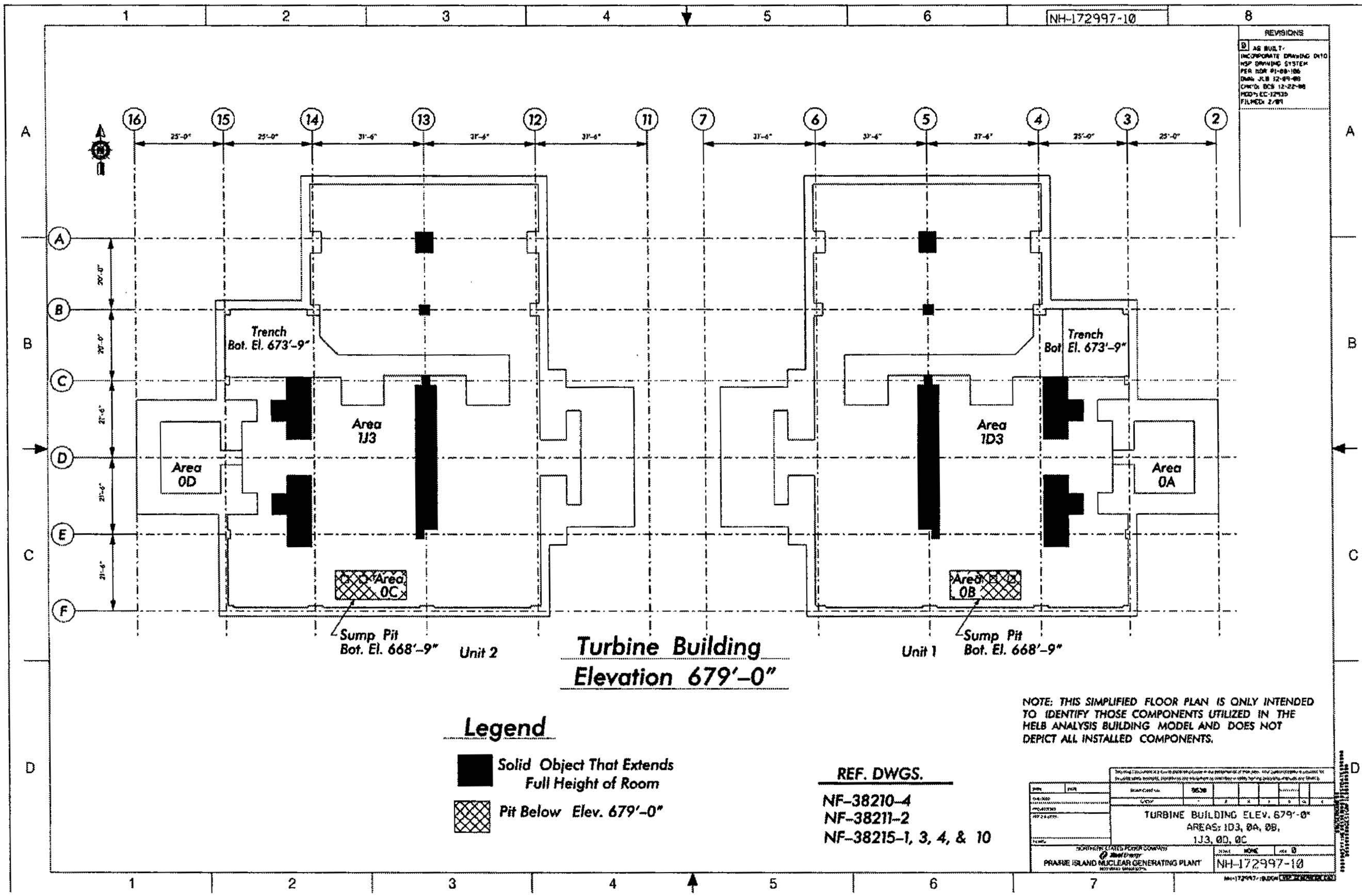

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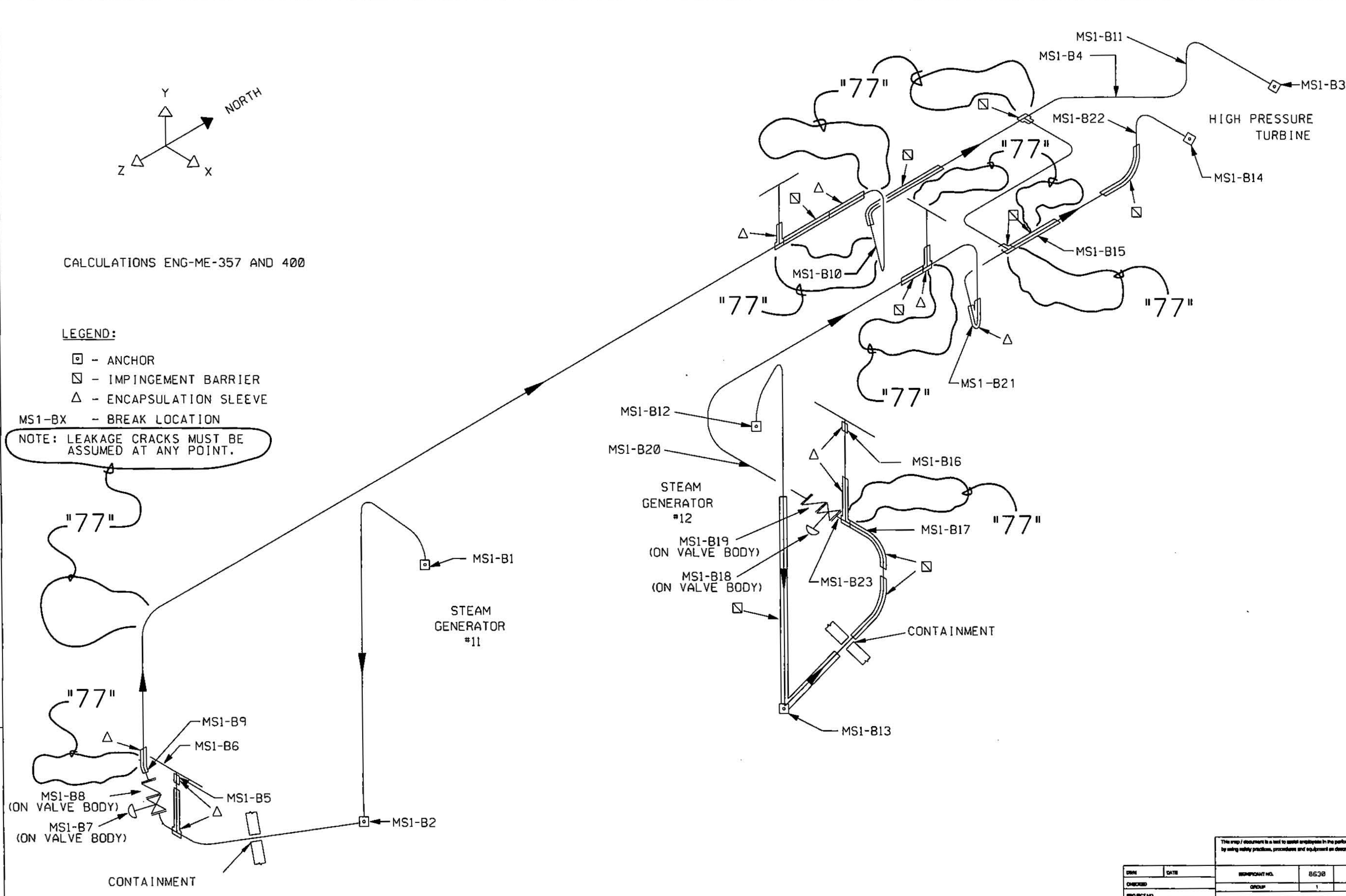
FIGURE FI.3.1-10



NH-172998-1

REVISIONS

B	AS BUILT- PER SAFETY EVALUATION 478-AI-03. PER DRR P1-00-56 DWN: DJP 7-20-00 CHK'D: CMR 8-9-00 MOD#: FILMED 8-00
76	AS BUILT- REVISE PER ENG-ME-357 REVISION 2 PER DRR P1-09-213 DWN: DMN 10-30-09 CHK'D: BCS 11-3-09 MOD#: EC-12552 APP'D: CMR 11-3-09
77	AS BUILT- UPDATED HELB LOCATIONS AND REMOVED SPECIFIC CRACK LOCATIONS. PER DRR P1-10-045 DWN: KJF 3-26-10 CHK'D: BCS 4-5-10 MOD#: EC-15549 APP'D: CMR 4-5-10

01248495

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SIGNIFICANT NO.	8630		750	1&2	6900 A100 4200	3	1100
GROUP	1	2	3	4	5	CL	6

DWN | DATE
CHECKED
PROJECT NO.
APP'D & CERT.
FILMED

MAIN STEAM ISOMETRIC

NORTHERN STATES POWER COMPANY
Xcel Energy
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING, MINNESOTA

SCALE NONE | REV 77

NH-172998-1

NH-172998-1.DGN NSP GENERATION CAD

FIGURE 1.3.2-1 REV. 31

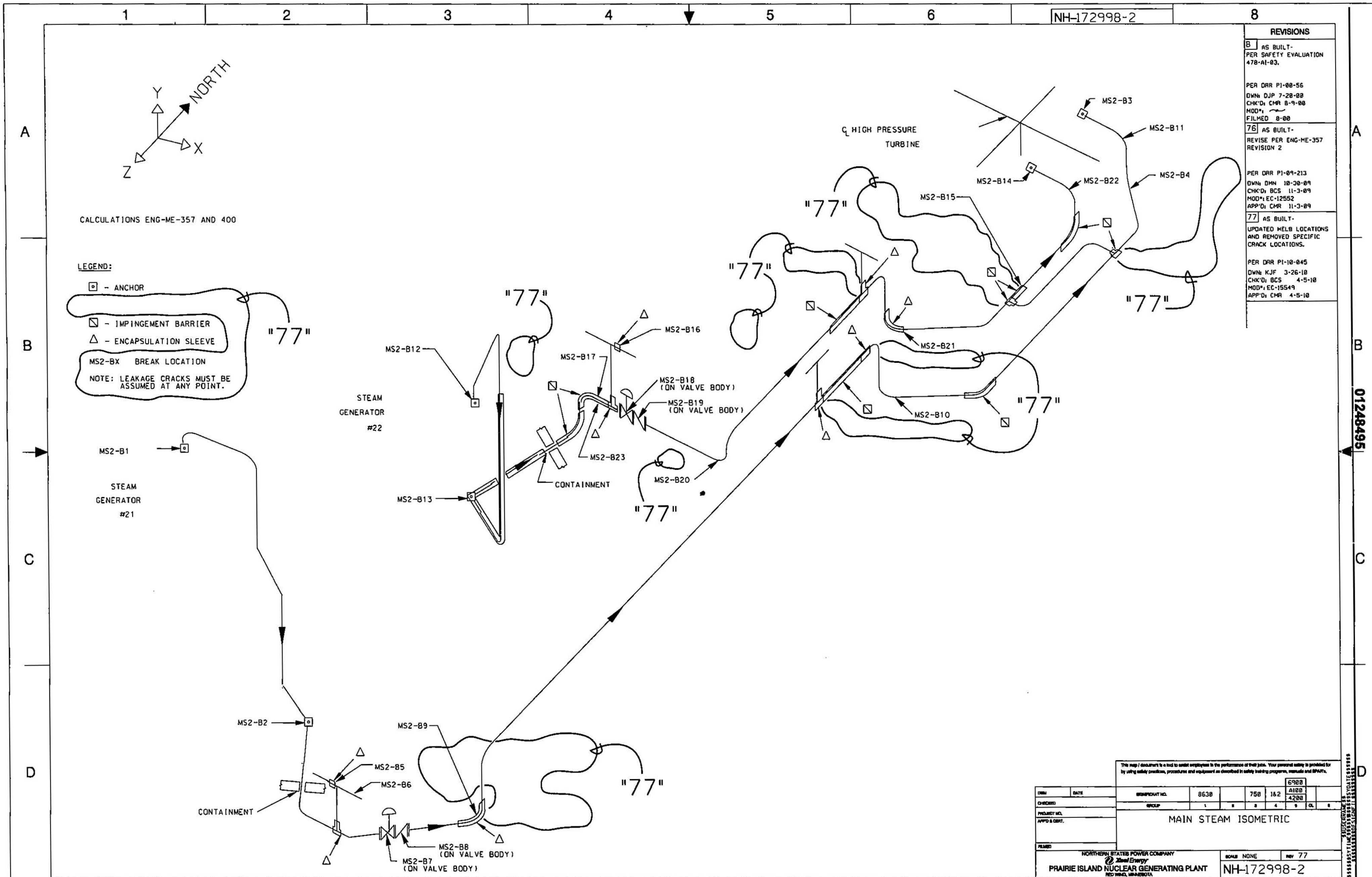
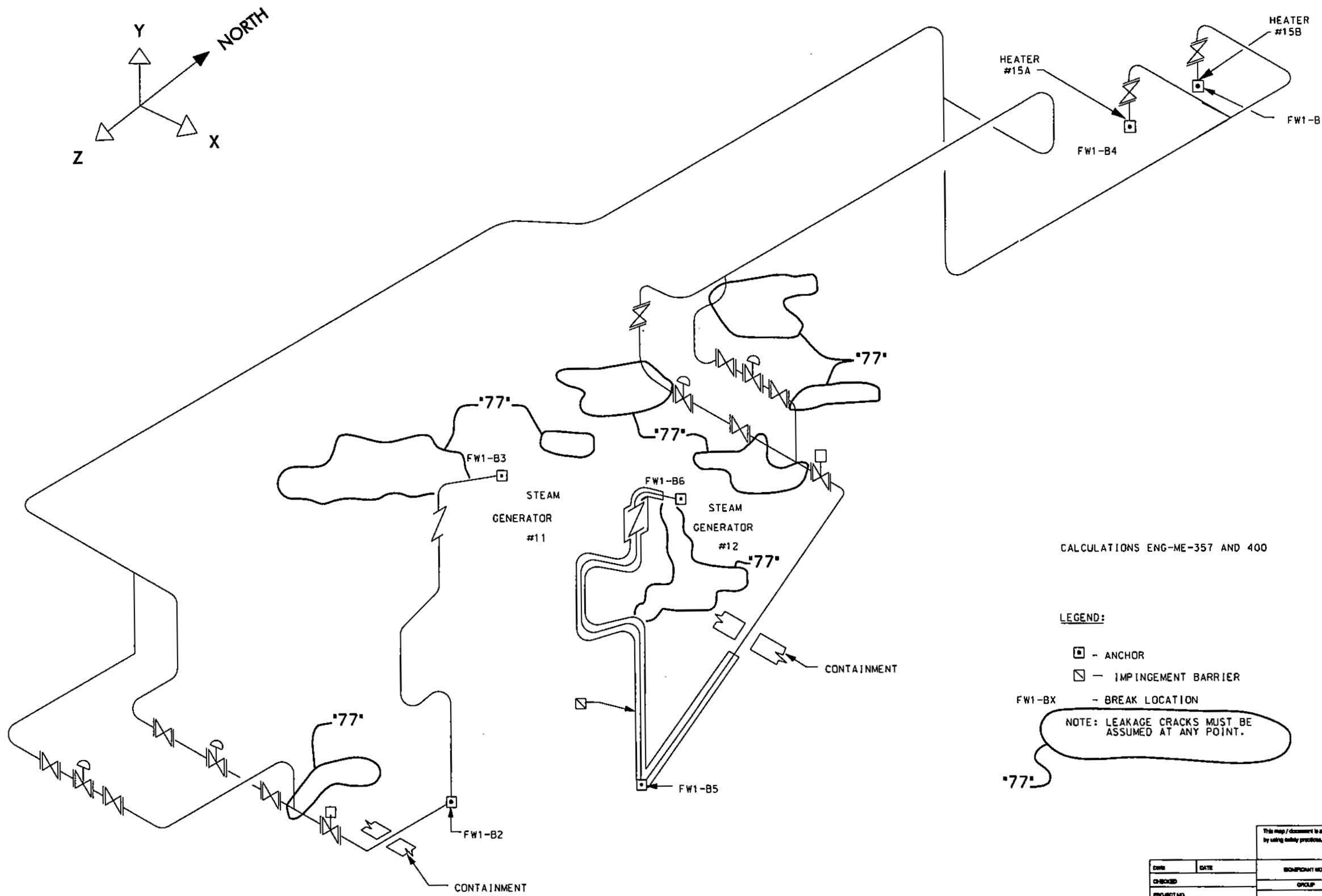


FIGURE 1.3.2-2 REV. 31

NH-172998-3



REVISIONS

B AS BUILT-
PER SAFETY EVALUATION 478-AI-03.
PER DRR PI-00-56
DWN: DJP 7-10-00
CHK'D: CMR 8-9-00
MOD#:
FILMED 8-00

C AS BUILT-
PER SAFETY EVACUATION 478-AI-03, REV.1, APP.
PER DRR PI-00-168
DWN: JES 3-2-1
CHK'D: CMS 3-8-01
MOD#:
FILMED 4-01

76 AS BUILT-
REVISE PER ENG-ME-357 REVISION 2
PER DRR PI-09-213
DWN: DMN 10-30-09
CHK'D: BCS 11-7-09
MOD#: EC-12552
APP'D: CMR 11-7-09

77 AS BUILT-
UPDATED HELB LOCATIONS AND REMOVED SPECIFIC CRACK LOCATIONS.
PER DRR PI-10-045
DWN: KJF 3-26-10
CHK'D: BCS 4-5-10
MOD#: EC-15549
APP'D: CMR 4-5-10

01248495

SIGNIFICANT NO.	8630		750	1&2	6900 A100 4200	3	1100
GROUP	1	2	3	4	5	CL	6

DWN | DATE
CHECKED
PROJECT NO.
APP'D & CERT.
FILMED

FEEDWATER ISOMETRIC

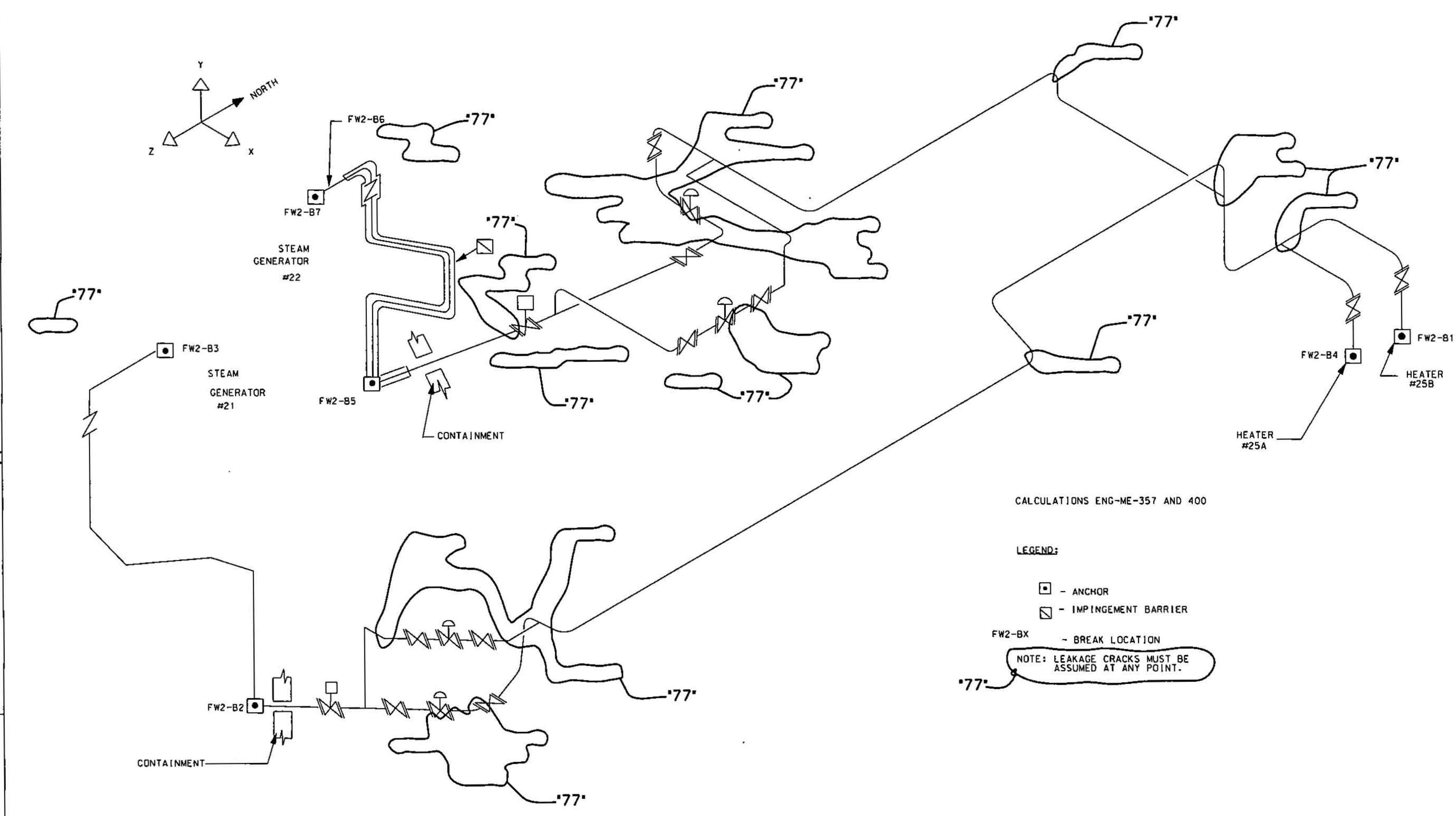
NORTHERN STATES POWER COMPANY
Xcel Energy
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING, MINNESOTA

SCALE NONE
REV 77
NH-172998-3

NH-172998-3.DGN NSP GENERATION CAD

FIGURE 1.3.2-3 REV. 31

NH-172998-4



REVISIONS

B AS BUILT-
PER SAFETY EVALUATION 478-AI-03 .
PER ORR PI-00-56
DWN: DJP 7-21-00
CHK'D: CMR 8-9-00
MOD#:
FILMED 8-00

C AS BUILT-
PER SAFETY EVALUATION 478-AI-03, REV. 1 , APP
PER ORR PI-00-169
DWN: JES 3-2-01
CHK'D:
MOD#:
FILMED 4-01

76 AS BUILT-
REVISE PER ENG-ME-357 REVISION 2
PER ORR PI-09-213
DWN: DMN 10-30-09
CHK'D: BCS 11-7-09
MOD#: EC-12552
APP'D: CMR 11-7-09

77 AS BUILT-
UPDATED HELB LOCATIONS AND REMOVED SPECIFIC CRACK LOCATIONS.
PER ORR PI-10-045
DWN: KJF 3-26-10
CHK'D: BCS 4-5-10
MOD#: EC-15549
APP'D: CMR 4-5-10

01248495

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SIGNIFICANT NO.	8630		750	1&2	6900 A100 4200	3	1100
GROUP	1	2	3	4	5	CL	6

DWN TAM | DATE 6-23-99
CHECKED
PROJECT NO. ETNSUR
APP'D & CERT.
FILMED

FEEDWATER ISOMETRIC

NORTHERN STATES POWER COMPANY
Xcel Energy
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING, MINNESOTA

SCALE NONE | REV 77

NH-172998-4

172998-4.DGN NSP GENERATION CAD

FIGURE 1.3.2-4 REV. 31

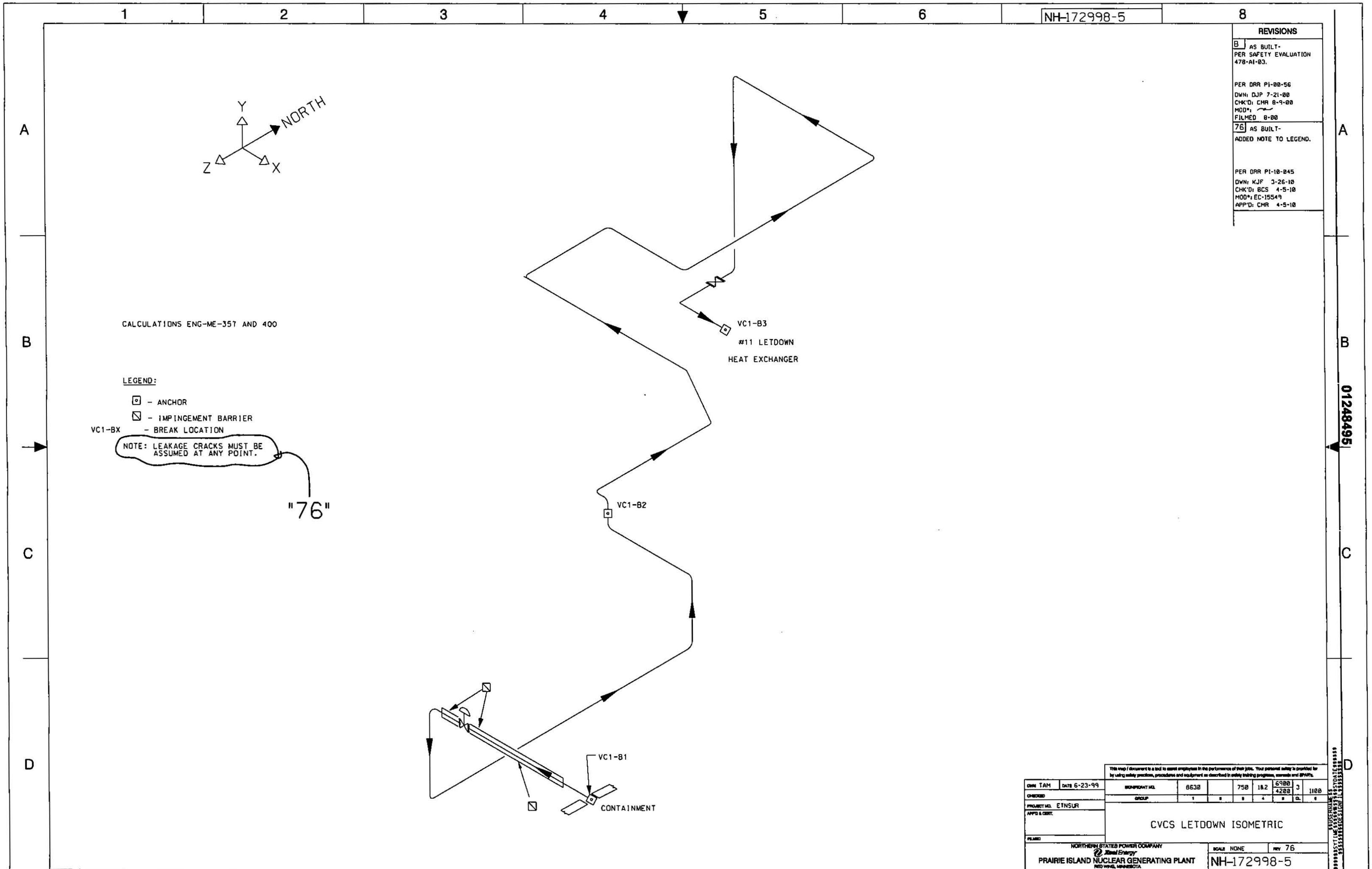


FIGURE 1.3.2-5 REV. 31

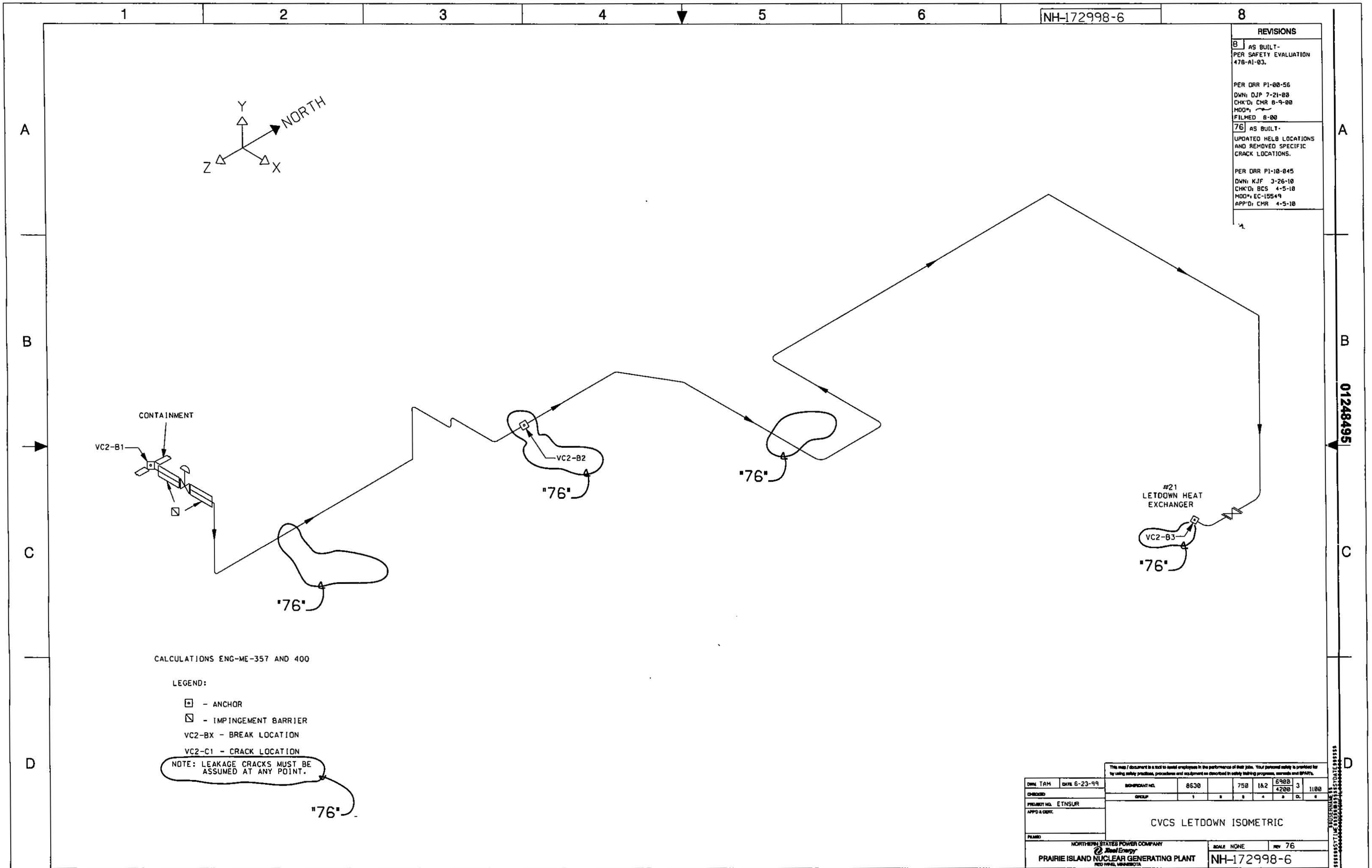


FIGURE 1.3.2-6 REV. 31

NH-172998-7

REVISIONS

B	AS BUILT- PER SAFETY EVALUATION 478-A1-03. PER DRR PI-00-56 DWN: DJP 7-21-00 CHK'D: CMR 8-9-00 MOD#: FILMED 8-00
76	AS BUILT- REVISE PER ENG-ME-357 REVISION 2 PER DRR PI-09-213 DWN: DMN 10-30-09 CHK'D: BCS 11-7-09 MOD#: EC-12552 APP'D: CMR 11-7-09
77	AS BUILT- ADDED NOTE TO LEGEND. PER DRR PI-10-045 DWN: KJF 3-26-10 CHK'D: BCS 4-5-10 MOD#: EC-15549 APP'D: CMR 4-5-10

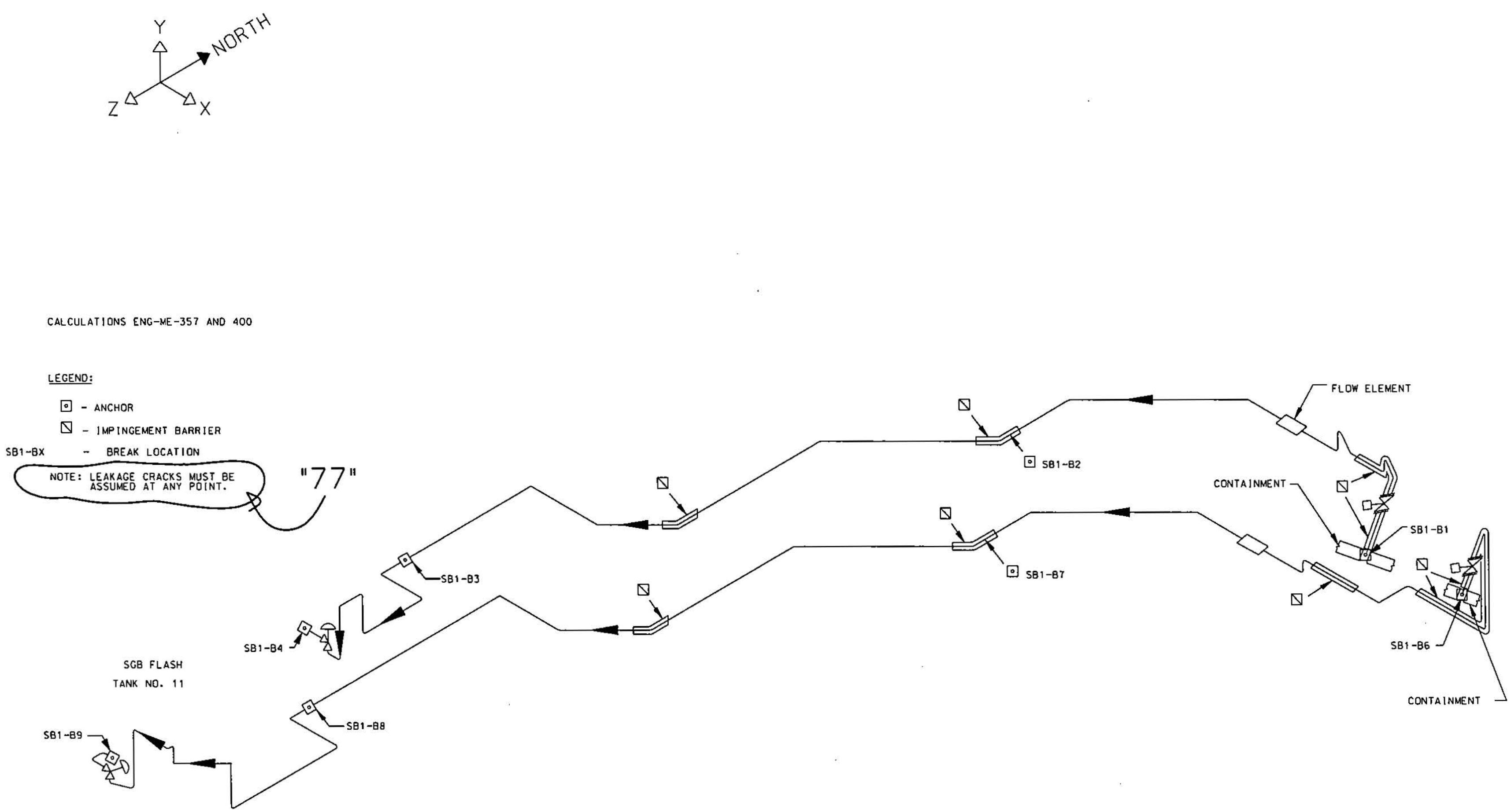
CALCULATIONS ENG-ME-357 AND 400

LEGEND:

- ANCHOR
- IMPINGEMENT BARRIER

SB1-BX - BREAK LOCATION

NOTE: LEAKAGE CRACKS MUST BE ASSUMED AT ANY POINT. "77"



01248495

SIGNIFICANT NO.	8630		750	1&2	6900 / 4200	3	1100
GROUP	1	2	3	4	5	CL	6

DWN TAM DATE 6-23-99

CHECKED

PROJECT NO. ETNSUR

APP'D & CERT.

FILMED

STEAM GENERATOR BLOWDOWN ISOMETRIC

NORTHERN STATES POWER COMPANY
Xcel Energy
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING, MINNESOTA

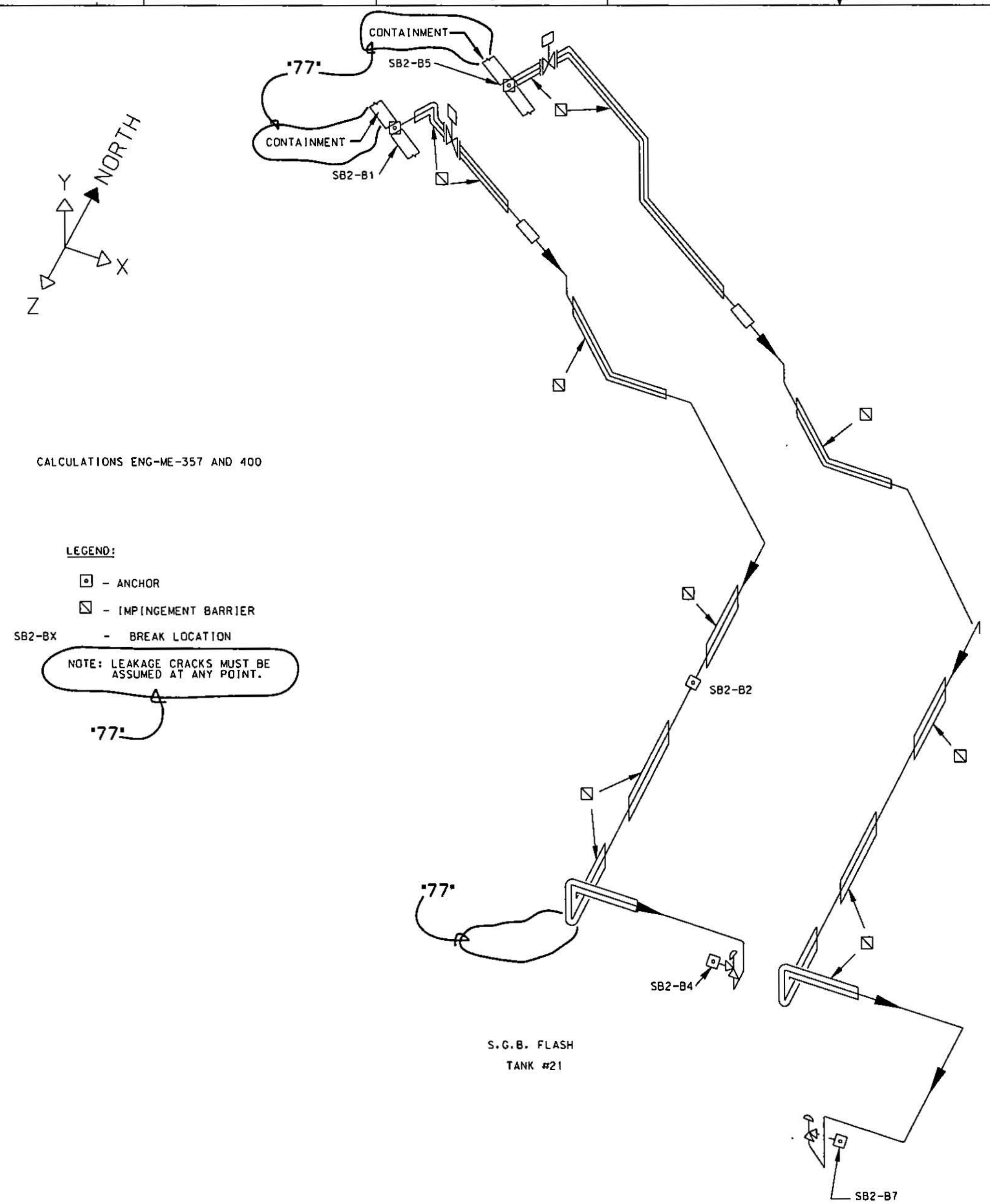
SCALE NONE REV 77

NH-172998-7

NH-172998-7.DGN NSP GENERATION CAD

FIGURE 1.3.2-7 REV. 31

NH-172998-8



REVISIONS

B AS BUILT-
PER SAFETY EVALUATION 478-AI-03.

PER DRR PI-00-56
DWN: OJP 7-21-00
CHK'D: CMR 8-9-00
MOD#:
FILMED 8-00

76 AS BUILT-
REVISE PER ENG-ME-357 REVISION 2

PER DRR PI-09-213
DWN: DMN 11-30-09
CHK'D: BCS 11-3-09
MOD#: EC-12552
APP'D: CMR 11-3-09

77 AS BUILT-
UPDATED HELB LOCATIONS. REMOVED SPECIFIC CRACK LOCATIONS AND ADDED NOTE TO LEGEND.
PER DRR PI-10-045
DWN: KJF 3-26-10
CHK'D: BCS 4-5-10
MOD#: EC-15549
APP'D: CMR 4-5-10

01248495

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DWN TAM	DATE 6-23-99	SIGNIFICANT NO.	8630		750	1&2	A100 / 4200	3	6900 / 1100
CHECKED		GROUP	1	2	3	4	5	CL.	6

PROJECT NO. ETNSUR
APP'D & CERT.
FILMED

STEAM GENERATOR BLOWNDOWN ISOMETRIC

NORTHERN STATES POWER COMPANY
Xcel Energy
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING, MINNESOTA

SCALE NONE
REV 77
NH-172998-8

NH-172998-8.DGN NSP GENERATION CAD

FIGURE 1.3.2-8 REV. 31

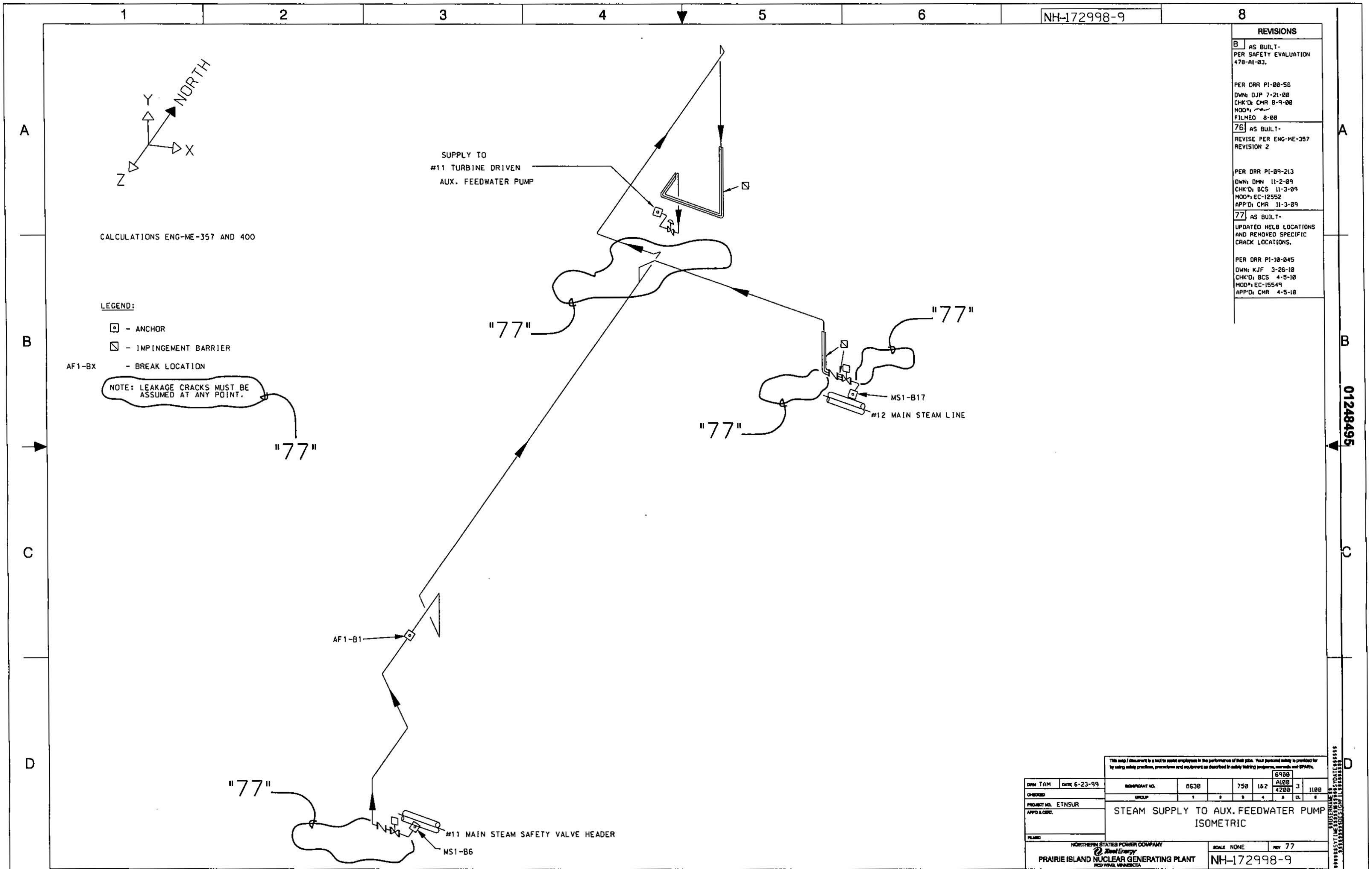


FIGURE 1.3.2-9 REV. 31

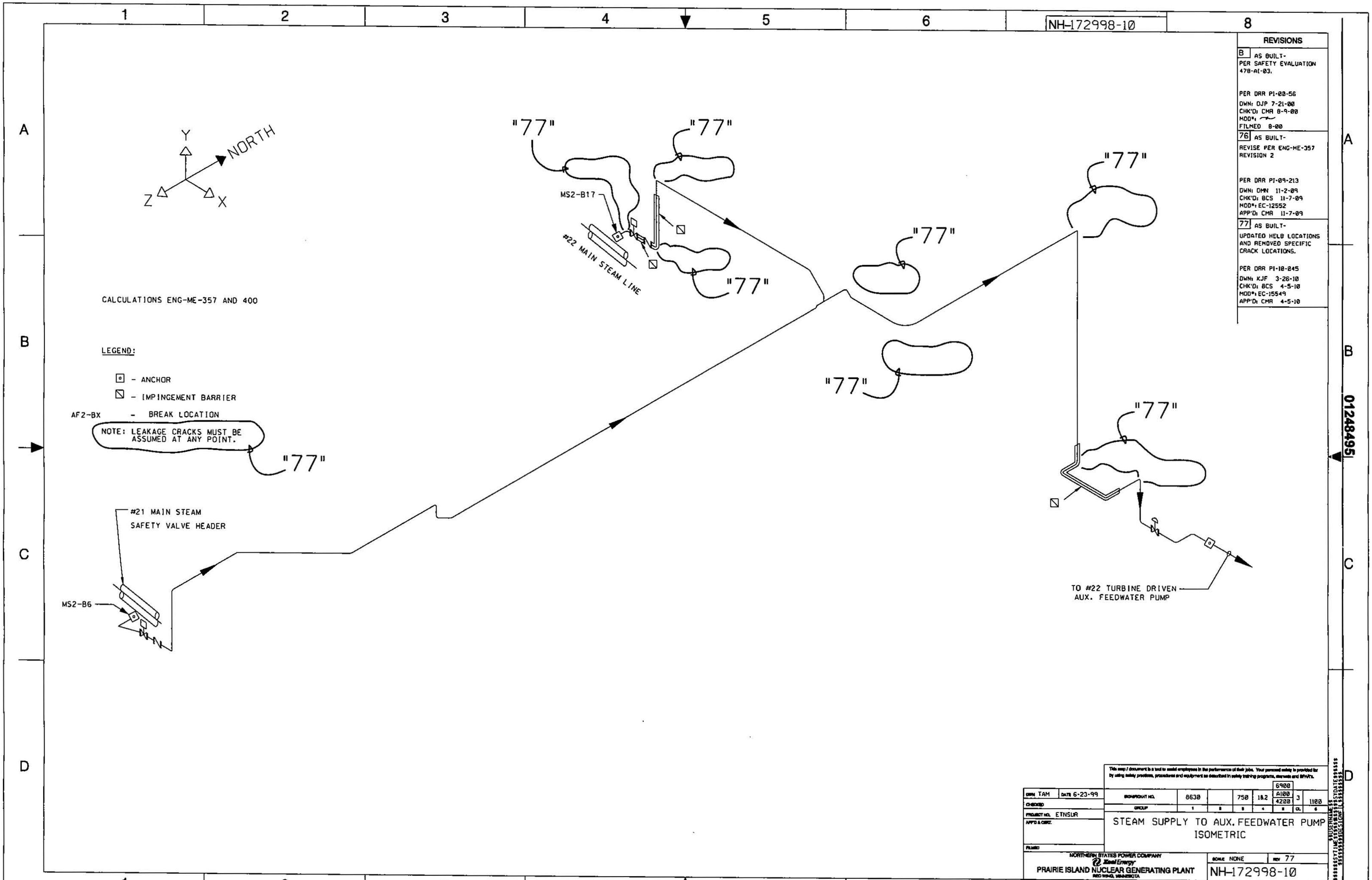
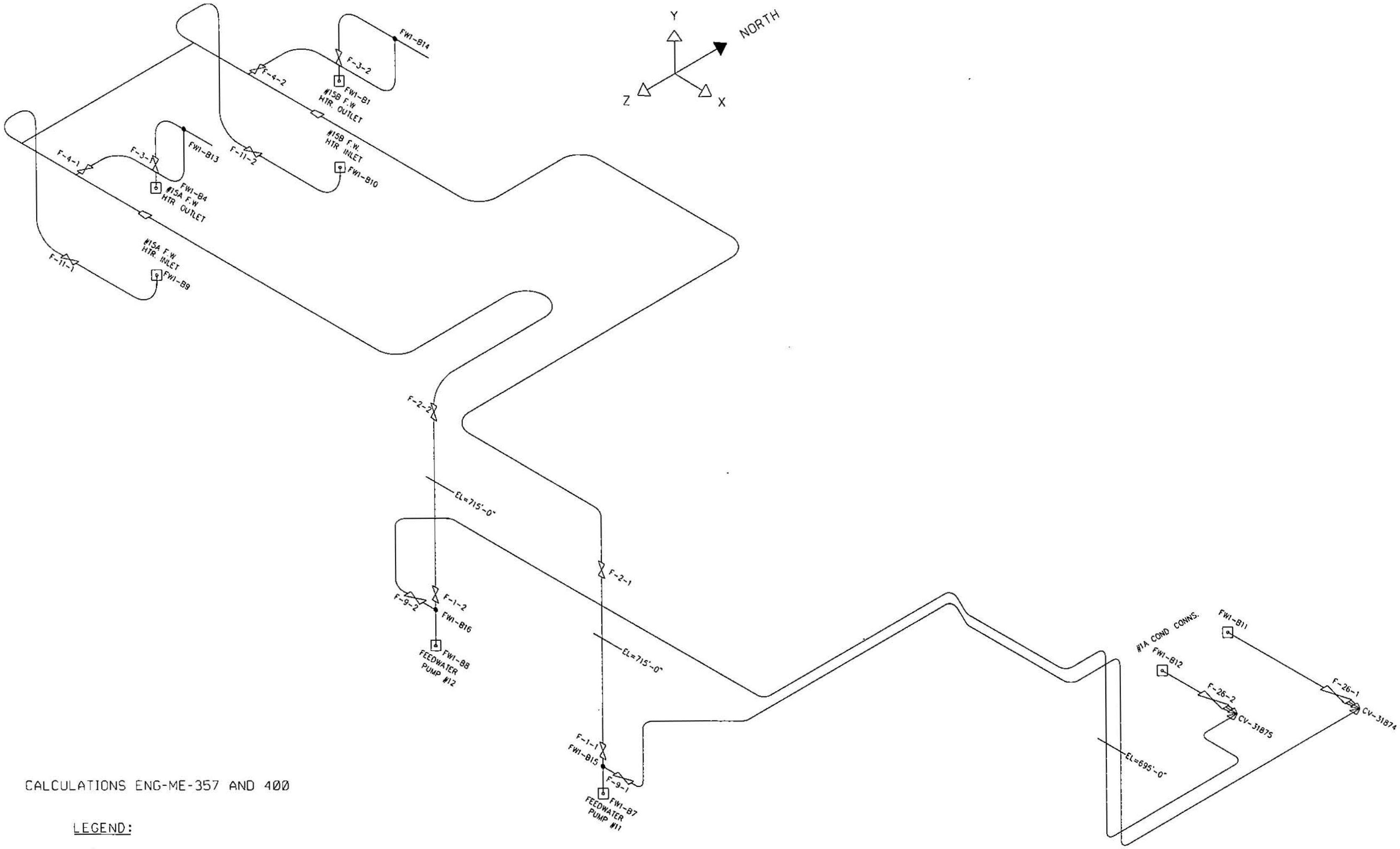


FIGURE 1.3.2-10 REV. 31

NH-172998-11

REVISIONS
0 AS BUILT- INCORPORATE DRAWING INTO NSP DRAWING SYSTEM PER NOR PI-10-046 DWN: KJF 3-25-10 CHK'D: BCS 4-5-10 MOD#: EC-15549 APP'D: CMR 4-5-10



CALCULATIONS ENG-ME-357 AND 400

LEGEND:

⊡ - ANCHOR

⧅ - IMPINGEMENT BARRIER

△ - ENCAPSULATION SLEEVE

FW1-BX - BREAK LOCATION

NOTE: LEAKAGE CRACKS MUST BE ASSUMED AT ANY POINT

01222109

DWN KJF	DATE 3-25-10
CHECKED	
PROJECT NO.	
APP'D & CERT.	
FILMED	

SIGNIFICANT NO.	8630						
GROUP	1	2	3	4	5	CL	6

TURBINE BUILDING FEEDWATER
ISOMETRIC
UNIT 1

NORTHERN STATES POWER COMPANY
Xcel Energy
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING, MINNESOTA

SCALE NONE | REV 0

NH-172998-11

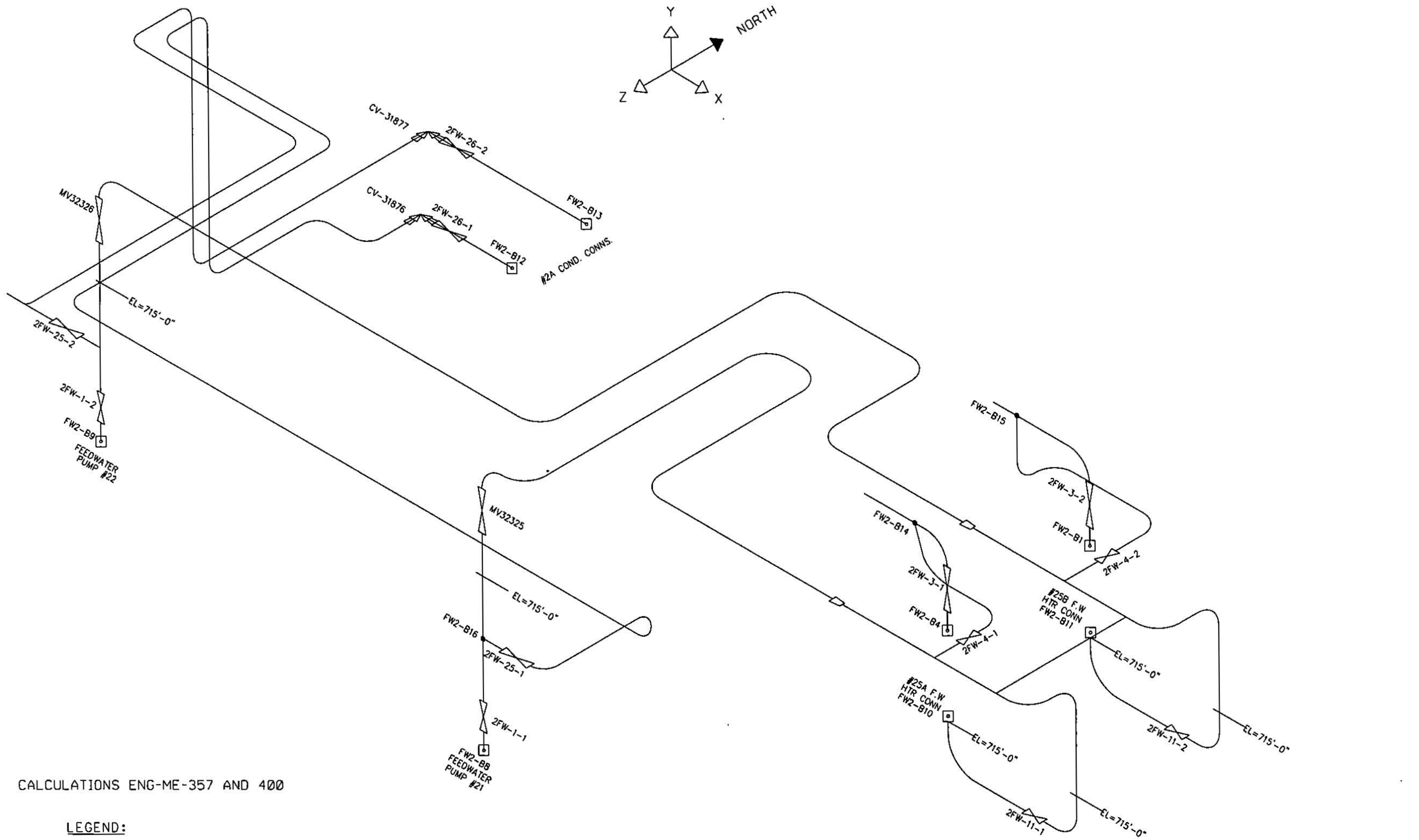
NH-172998-11.DGN NSP GENERATION CAD

FIGURE 1.3.2-11 REV.31

NH-172998-12

REVISIONS

0	AS BUILT- INCORPORATE DRAWING INTO NSP DRAWING SYSTEM PER NDR PI-10-046 DWN: KJF 3-25-10 CHK'D: BCS 4-5-10 MOD#: EC-15549 APP'D: CMR 4-5-10



CALCULATIONS ENG-ME-357 AND 400

LEGEND:

⊡ - ANCHOR

⧅ - IMPINGEMENT BARRIER

△ - ENCAPSULATION SLEEVE

FW2-BX - BREAK LOCATION

NOTE: LEAKAGE CRACKS MUST BE ASSUMED AT ANY POINT.

DRN KJF	DATE 3-25-10
CHECKED	
PROJECT NO.	
APP'D & CERT.	
FILMED	

SIGNIFICANT NO.	8630						
GROUP	1	2	3	4	5	QL	6

TURBINE BUILDING FEEDWATER
ISOMETRIC
UNIT 2

NORTHERN STATES POWER COMPANY
Xcel Energy
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING, MINNESOTA

SCALE NONE | REV 0

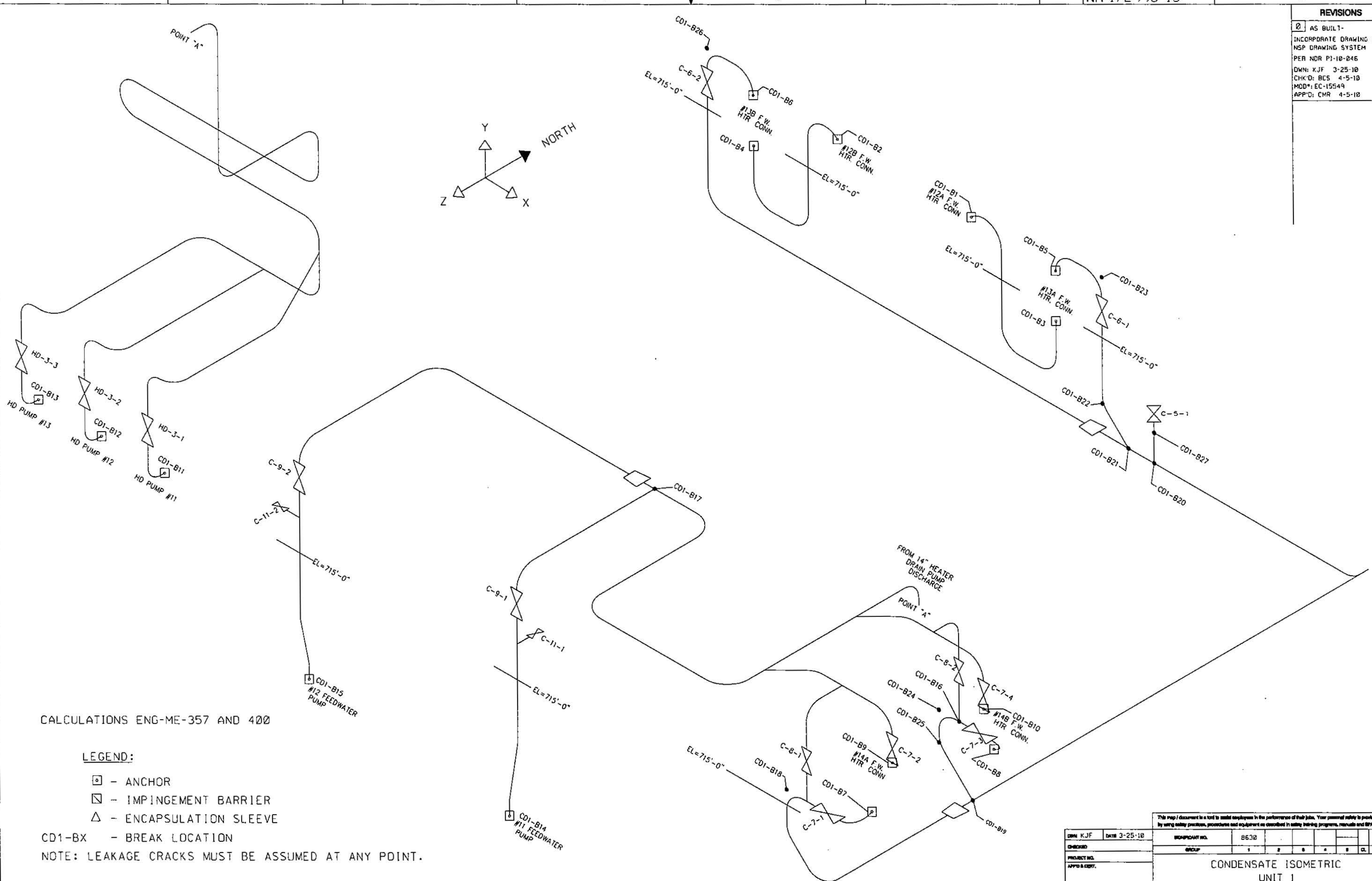
NH-172998-12

NH-172998-12.DGN NSP GENERATION CAD

01222109

FIGURE I.3.2-12 REV.31

NH-172998-13



CALCULATIONS ENG-ME-357 AND 400

LEGEND:

⊡ - ANCHOR

⧅ - IMPINGEMENT BARRIER

△ - ENCAPSULATION SLEEVE

CD1-BX - BREAK LOCATION

NOTE: LEAKAGE CRACKS MUST BE ASSUMED AT ANY POINT.

REVISIONS

0 AS BUILT-
INCORPORATE DRAWING INTO NSP DRAWING SYSTEM
PER NDR PI-10-046
DWN: KJF 3-25-10
CHK'D: BCS 4-5-10
MOD#: EC-15549
APP'D: CMR 4-5-10

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DWN KJF	DATE 3-25-10	SIGNIFICANT NO.	8630					
CHECKED		GROUP	1	2	3	4	5	CL	8
PROJECT NO.								
APP'D & CERT.								
FILMED								

CONDENSATE ISOMETRIC
UNIT 1

NORTHERN STATES POWER COMPANY
Xcel Energy
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING, MINNESOTA

SCALE NONE | REV 0

NH-172998-13

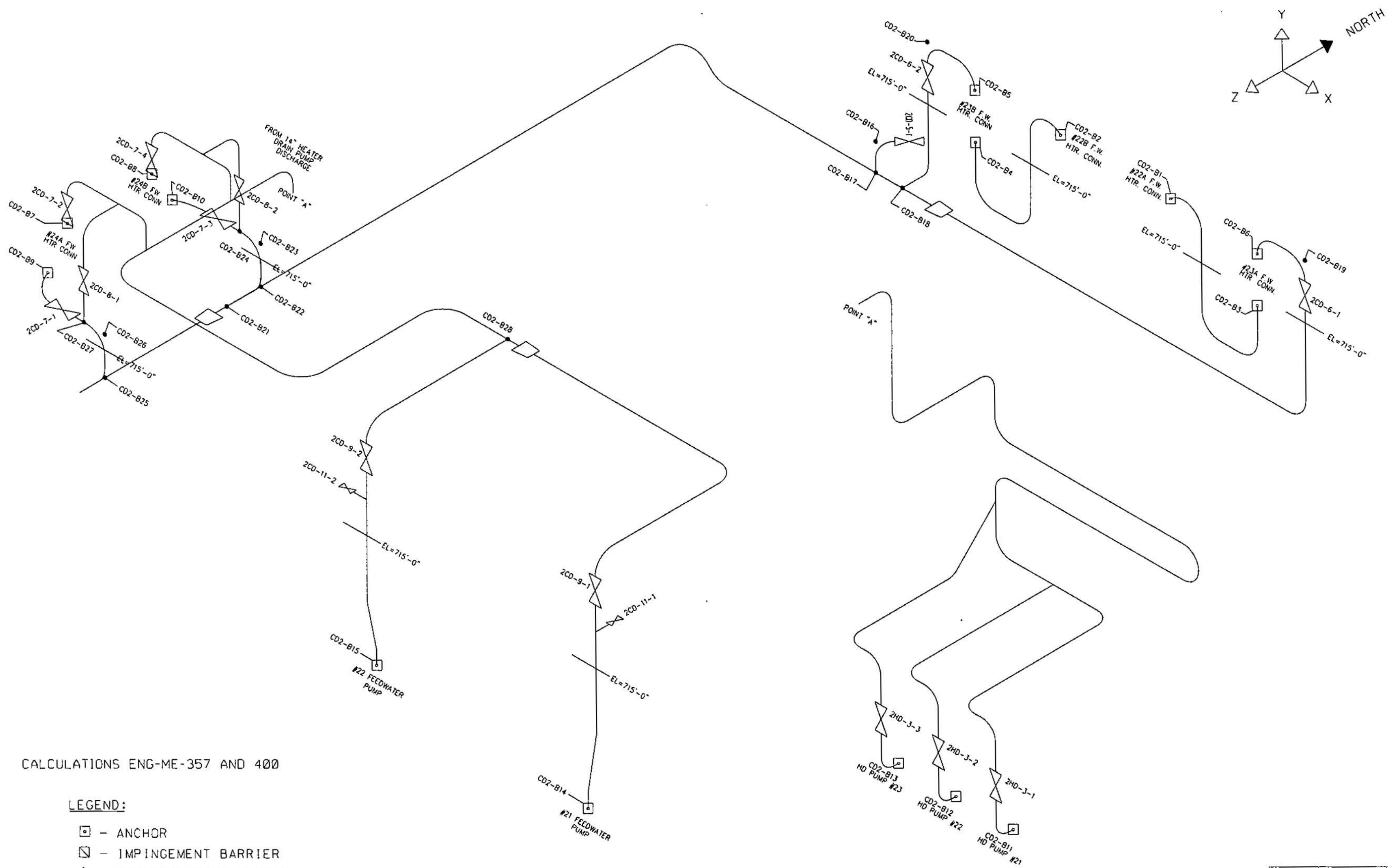
NH-172998-13.DGN NSP GENERATION CAD

01222109

FIGURE 1.3.2-13 REV.31

NH-172998-14

REVISIONS
0 AS BUILT- INCORPORATE DRAWING INTO NSP DRAWING SYSTEM PER NDR PI-10-046 DWN: KJF 3-25-10 CHK'D: BCS 4-5-10 MOD#: EC-15549 APP'D: CMR 4-5-10



CALCULATIONS ENG-ME-357 AND 400

LEGEND:

- ⊡ - ANCHOR
- ⧄ - IMPINGEMENT BARRIER
- △ - ENCAPSULATION SLEEVE

CD2-BX - BREAK LOCATION

NOTE: LEAKAGE CRACKS MUST BE ASSUMED AT ANY POINT

01222109R

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DWN KJF	DATE 3-25-10	SIGNIFICANT NO.	8630						
CHECKED		GROUP	1	2	3	4	5	CL	6
PROJECT NO.									
APP'D & CERT.		CONDENSATE ISOMETRIC UNIT 2							
FILMED									

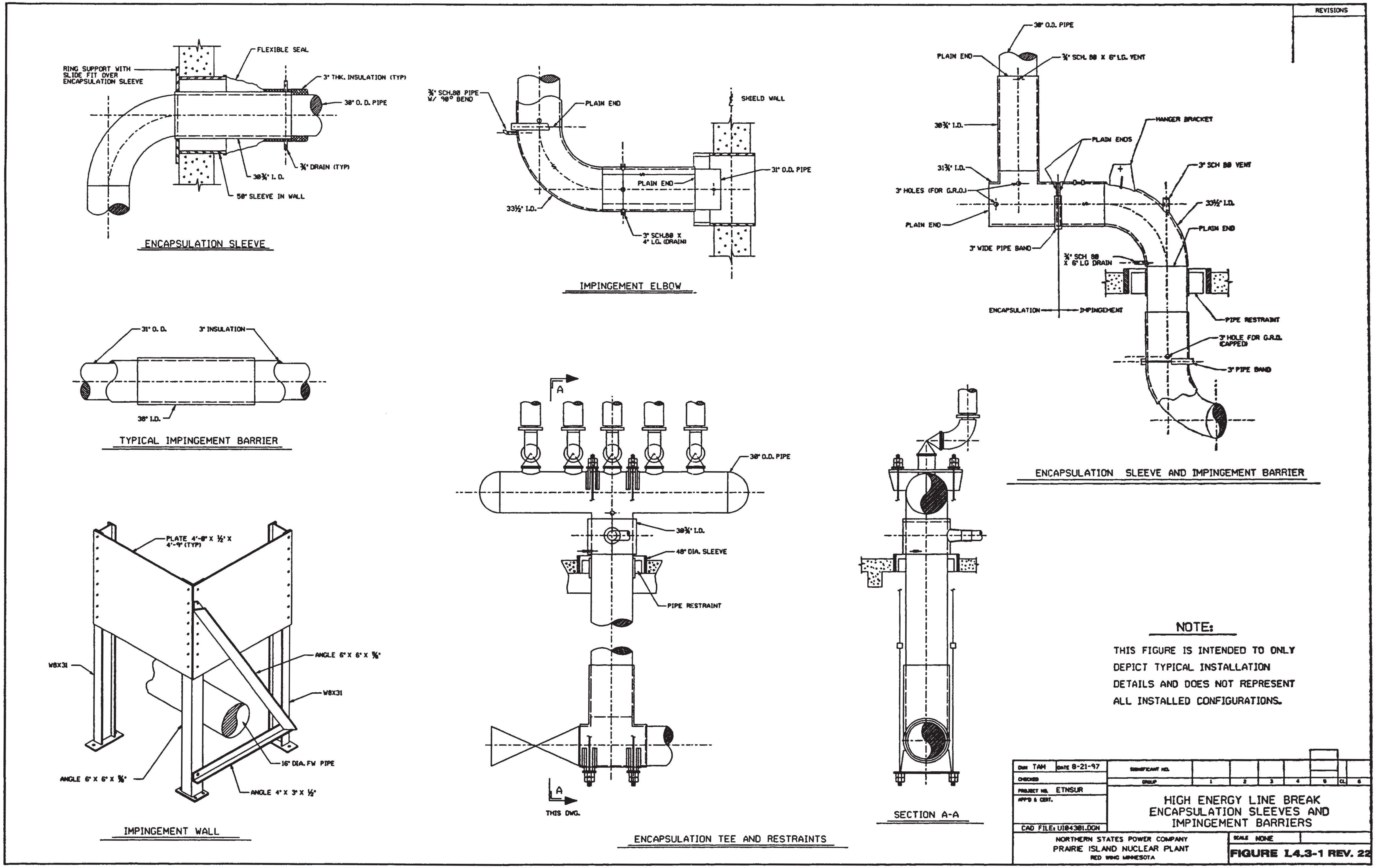
NORTHERN STATES POWER COMPANY
Xcel Energy
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING, MINNESOTA

SCALE NONE | REV 0

NH-172998-14

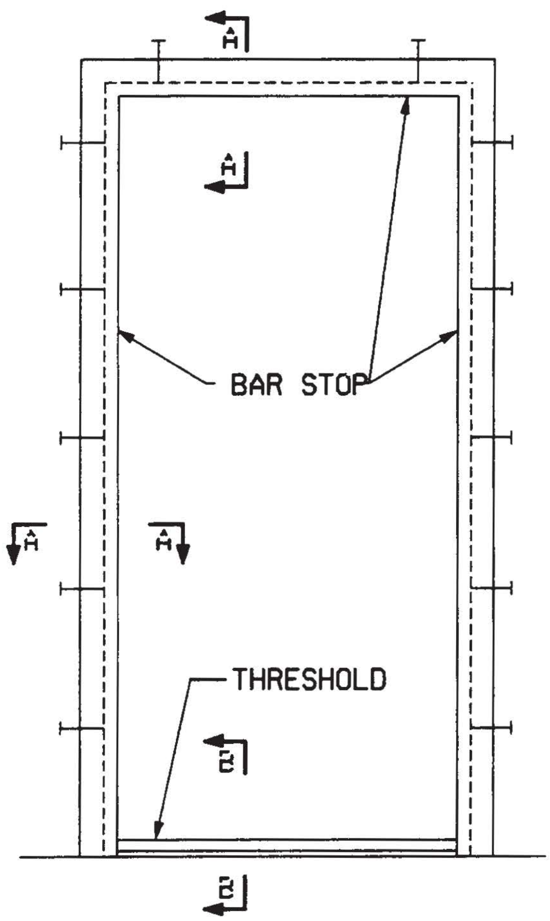
NH-172998-14.DGN NSP GENERATION CAD

FIGURE 1.3.2-14 REV.31

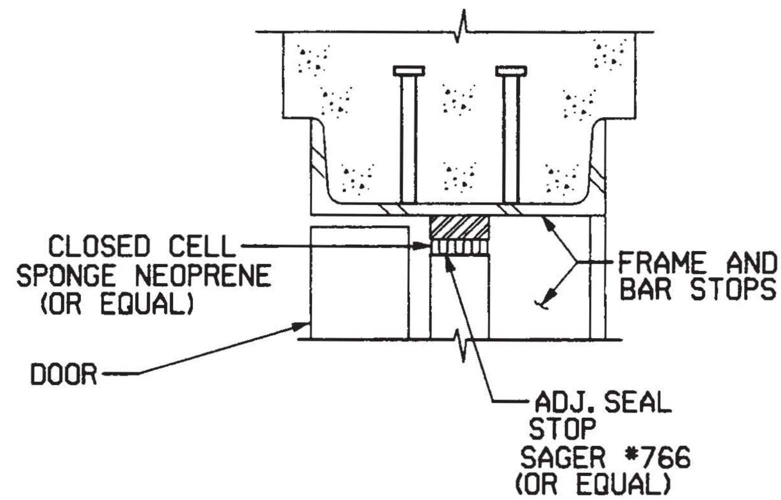


REVISIONS
RING SUPPORT WITH SLIDE FIT OVER ENCAPSULATION SLEEVE
FLEXIBLE SEAL
3" THK. INSULATION (TYP)
38" O. D. PIPE
3/4" DRAIN (TYP)
38 3/4" I. D.
50" SLEEVE IN WALL
ENCAPSULATION SLEEVE
3/4" SCH.80 PIPE W/ 90° BEND
PLAIN END
SHIELD WALL
31" O.D. PIPE
PLAIN END
33 1/2" I.D.
3" SCH.80 X 4" LG. (DRAIN)
IMPINGEMENT ELBOW
38" O.D. PIPE
PLAIN END
3/4" SCH. 80 X 6" LG. VENT
38 3/4" I.D.
HANGER BRACKET
PLAIN ENDS
31 3/4" I.D.
3" SCH 80 VENT
3" HOLES (FOR G.R.O.)
33 1/2" I.D.
PLAIN END
PLAIN END
3" WIDE PIPE BAND
3/4" SCH 80 X 6" LG DRAIN
ENCAPSULATION
IMPINGEMENT
PIPE RESTRAINT
3" HOLE FOR G.R.O. (CAPPED)
3" PIPE BAND
ENCAPSULATION SLEEVE AND IMPINGEMENT BARRIER
31" O. D.
3" INSULATION
38" I.D.
TYPICAL IMPINGEMENT BARRIER
A
38" O.D. PIPE
38 3/4" I.D.
48" DIA. SLEEVE
PIPE RESTRAINT
A
THIS DWG.
ENCAPSULATION TEE AND RESTRAINTS
SECTION A-A
PLATE 4'-0" X 1/2" X 4'-9" (TYP)
ANGLE 6" X 6" X 5/8"
W8X31
W8X31
16" DIA. FW PIPE
ANGLE 6" X 6" X 5/8"
ANGLE 4" X 3" X 1/2"
IMPINGEMENT WALL
NOTE:
THIS FIGURE IS INTENDED TO ONLY DEPICT TYPICAL INSTALLATION DETAILS AND DOES NOT REPRESENT ALL INSTALLED CONFIGURATIONS.
DWN TAM DATE 8-21-97
CHECKED
PROJECT NO. ETNSUR
APP'D & CERT.
CAD FILE: UI84301.DGN
SIGNIFICANT NO.
GROUP 1 2 3 4 5 CL 6
HIGH ENERGY LINE BREAK ENCAPSULATION SLEEVES AND IMPINGEMENT BARRIERS
NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR PLANT
RED WING MINNESOTA
SCALE NONE
FIGURE I.4.3-1 REV. 22

REVISIONS

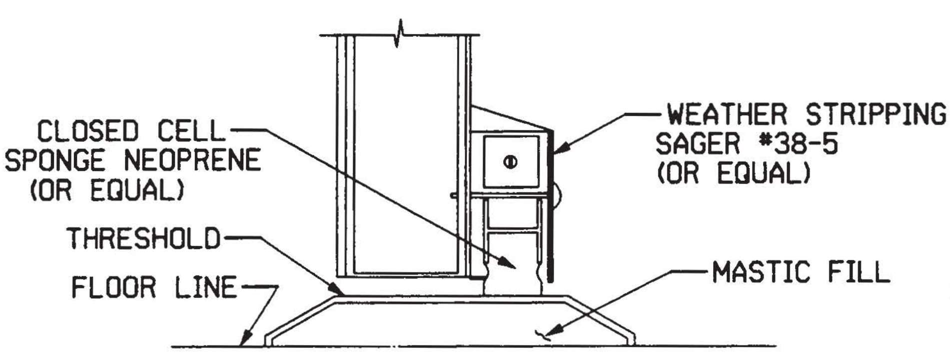


TYPICAL DOOR FRAME



SECTION A-A

HEAD-JAMB DETAIL



SECTION B-B

SILL DETAIL

NOTE:

THIS FIGURE IS INTENDED TO ONLY DEPICT TYPICAL INSTALLATION DETAILS AND DOES NOT REPRESENT ALL INSTALLED CONFIGURATIONS.

DWN T.M. DATE 6-23-99
CHECKED
PROJECT NO. ETNSUR
APPD & CERT.
CAD FILE: UI04302.DGN

SIGNIFICANT NO.
GROUP 1 2 3 4 5 C1 6

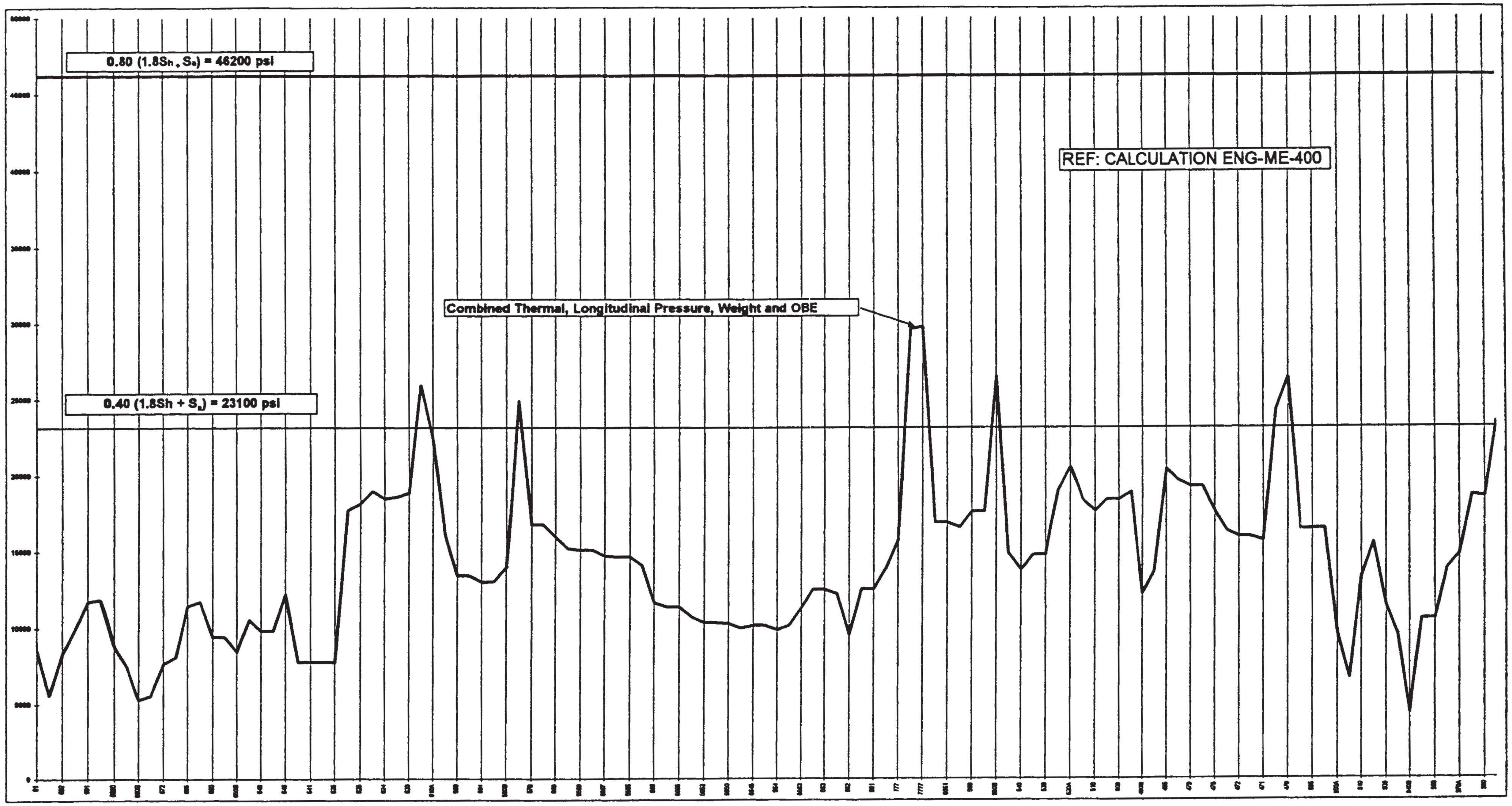
HIGH ENERGY LINE BREAK
DOOR SEALS

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING MINNESOTA

SCALE NONE

FIGURE I.4.3-2 REV.22

REVISIONS



DWN TAM DATE 11-23-99

SIGNIFICANT NO.

CHECKED

GROUP 1 2 3 4 5 CL 6

PROJECT NO. ETNSUR

APP'D & CERT.

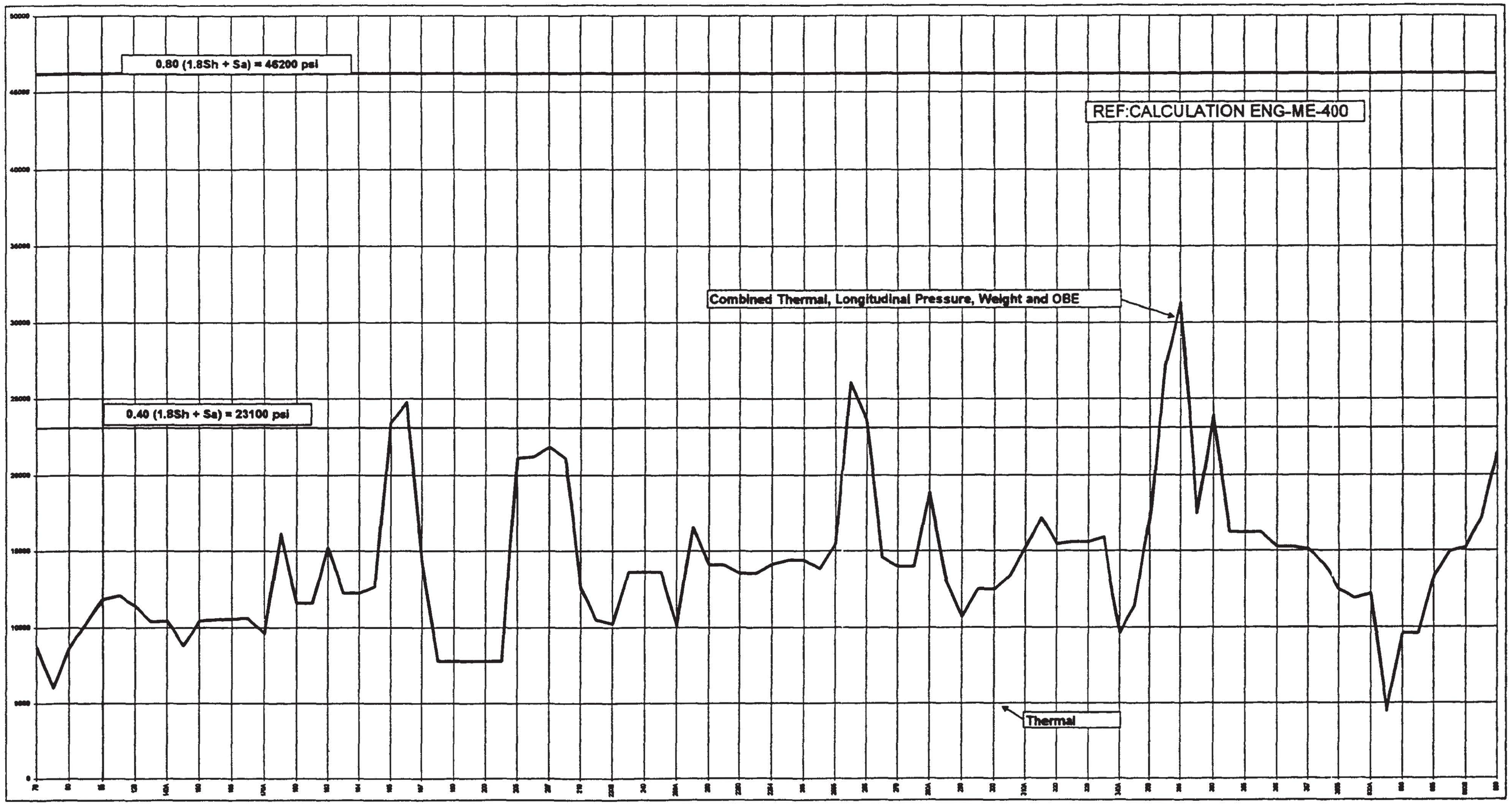
CAD FILE: UI5101.DGN

MAIN STEAM, #11 STEAM GENERATOR

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING, MINNESOTA

SCALE NONE

FIGURE I.5.1-1 REV.22



REVISIONS

DWN TAM	DATE 11-23-99	SIGNIFICANT NO.	
CHECKED		GROUP	1 2 3 4 5 CL 6
PROJECT NO. ETNSUR			
APP'D & CERT.		MAIN STEAM, #12 STEAM GENERATOR	
CAD FILE: UI5102.DGN			
NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING, MINNESOTA		SCALE NONE	
		FIGURE I.5.1-2 REV. 22	

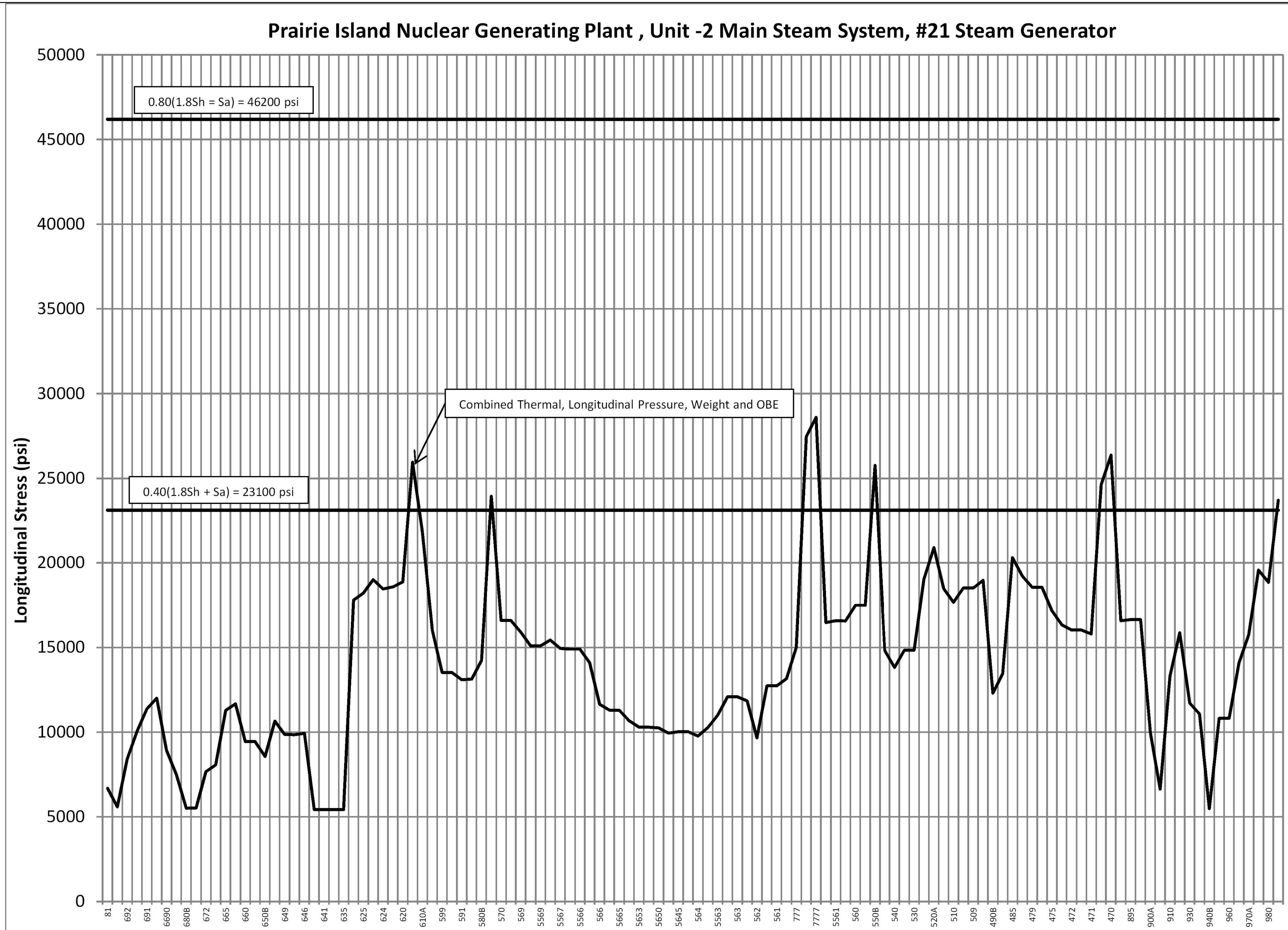
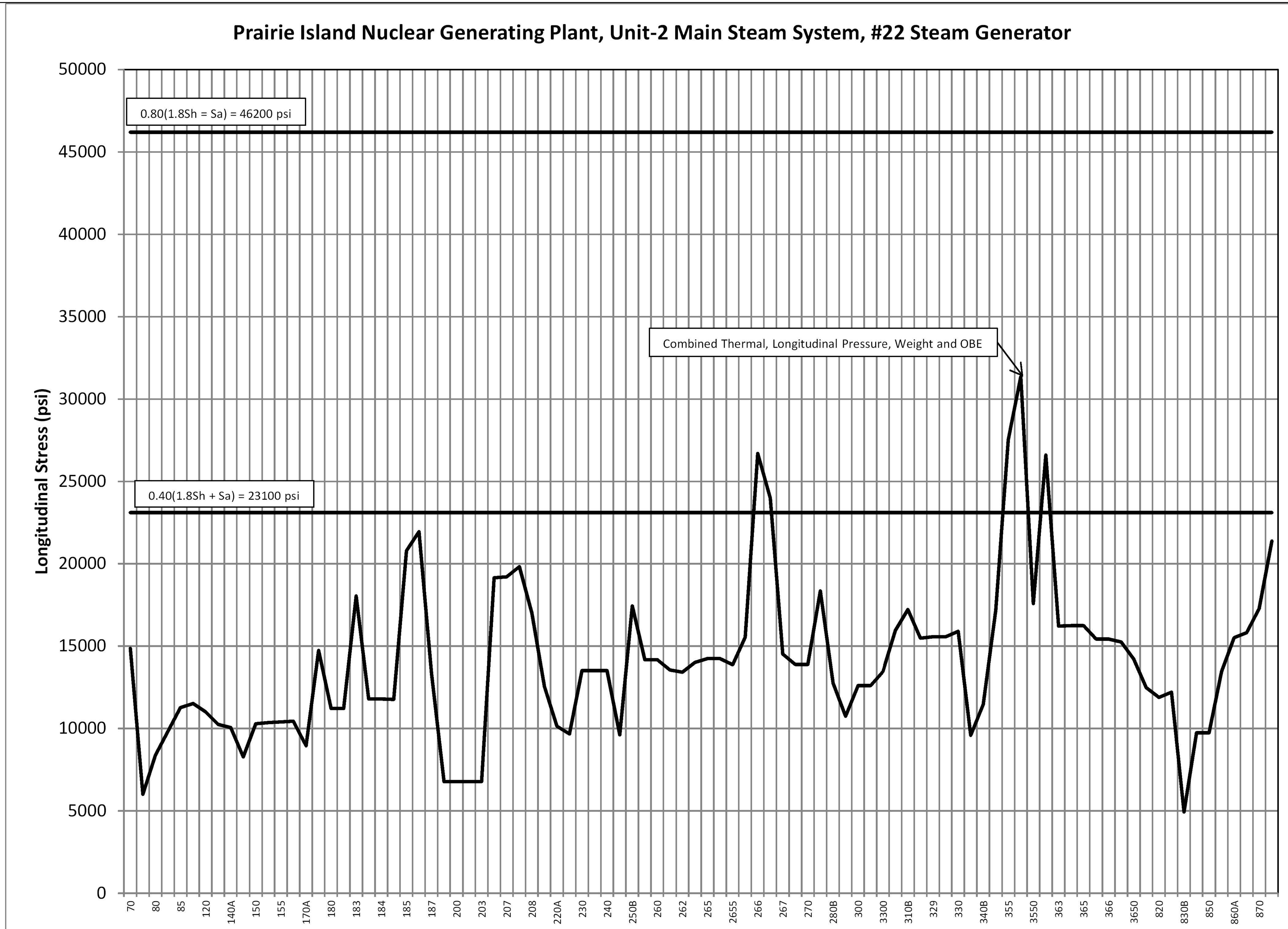


FIGURE I.5.1-3 REV. 33

CAD FILE: UI5103.DGN

01406858



01406858

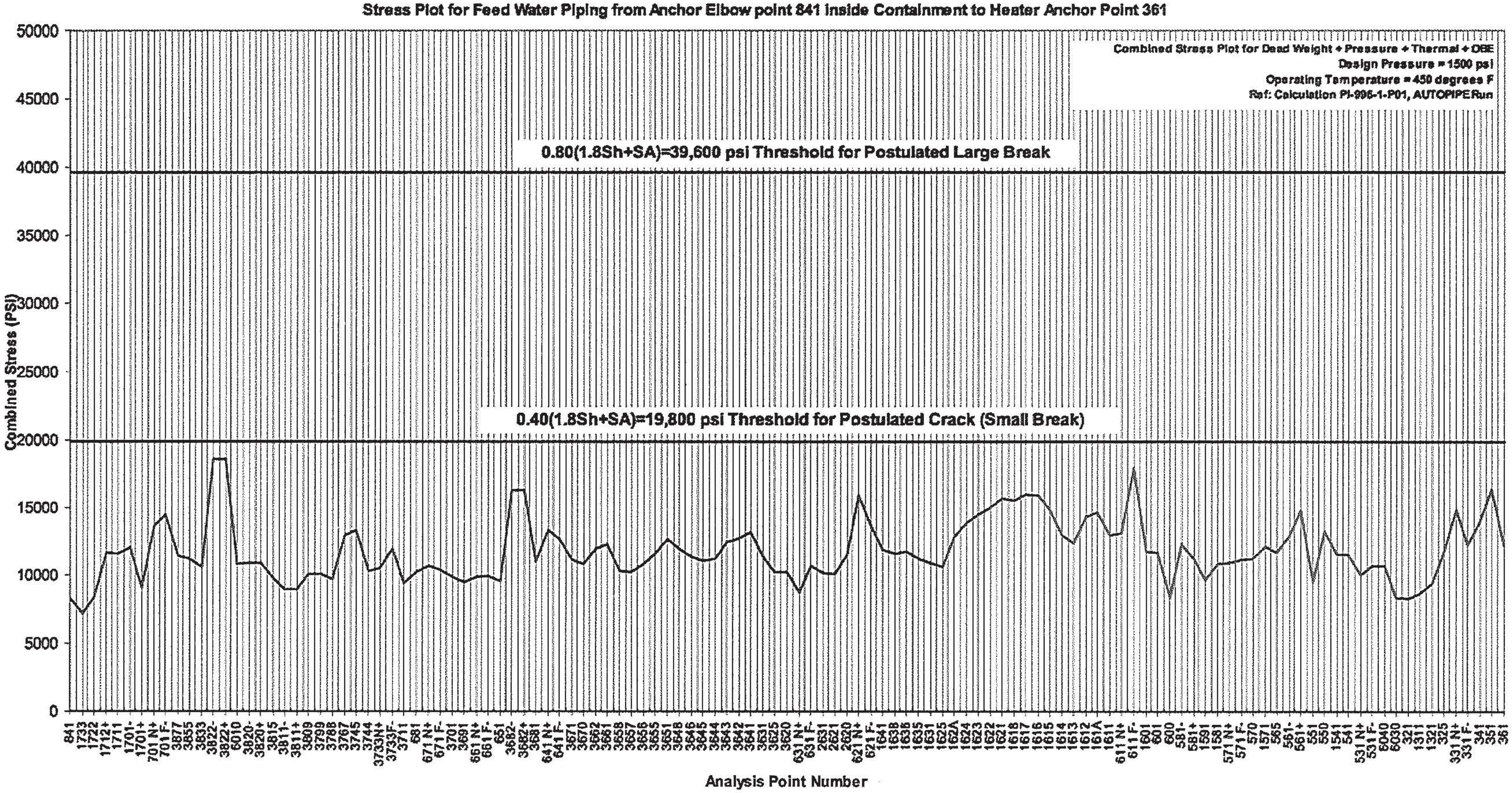
FIGURE I.5.1-4 REV. 33

CAD FILE: UI5104.DGN

PINGP CALCULATION

NUMBER:	ENG-ME-400	REVISION:	2	ADDENDUM:	0	SHEET NO:	Attachment 3 Sheet 5 OF 8
TITLE:	STRESS PLOTS FOR HIGH ENERGY PIPING SYSTEMS					DATE:	5/13/2008
						COMP. BY:	BCS

Stress Plot for Feed Water Piping from Anchor Elbow point 841 inside Containment to Heater Anchor Point 361

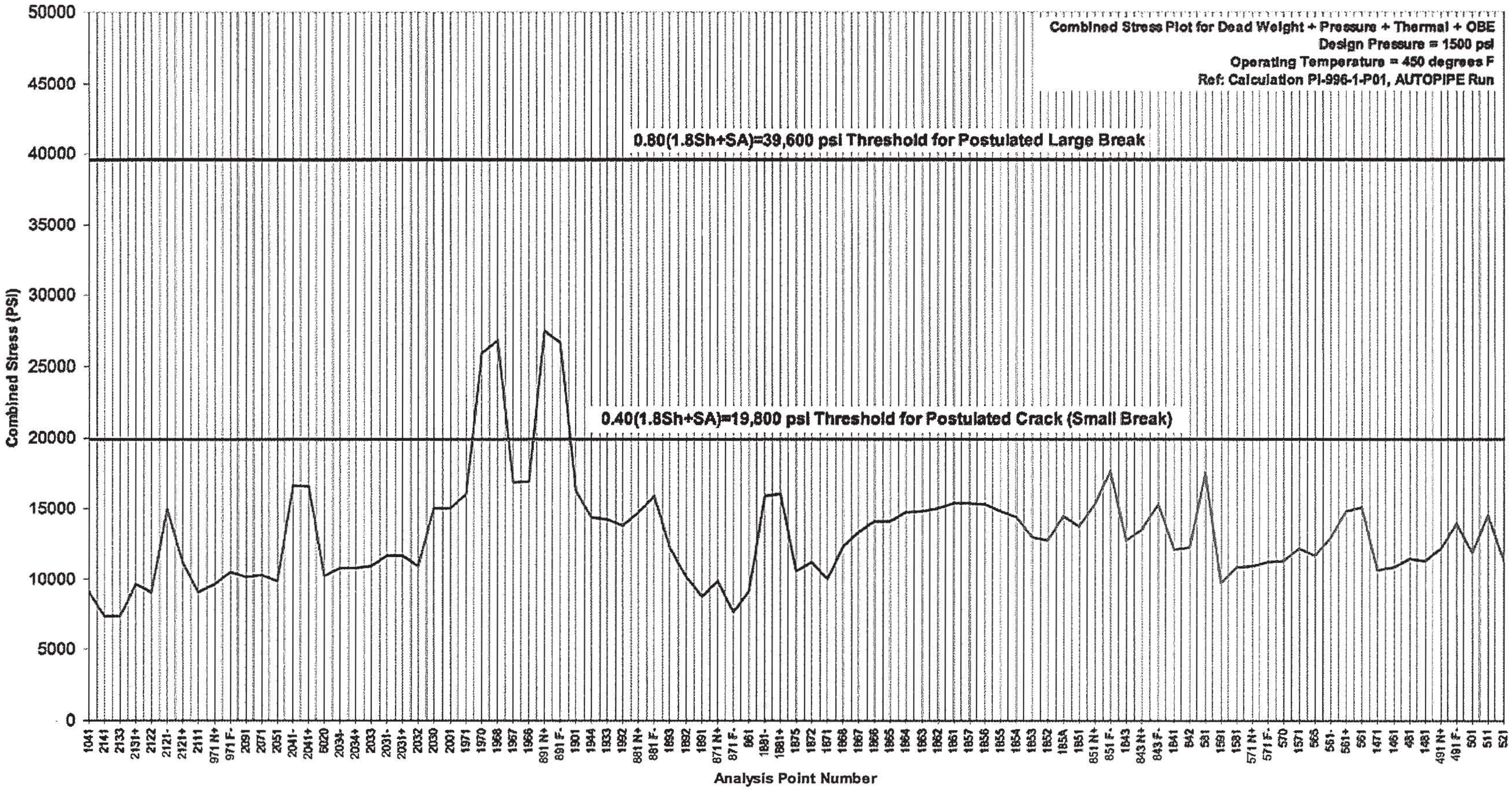


PINGP USAR
Figure FI.5.1-5
Stress Plot-Feedwater, Unit 1
REV 33

PINGP CALCULATION

NUMBER:	ENG-ME-400	REVISION:	2	ADDENDUM:	0	SHEET NO:	Attachment 3 Sheet 6 OF 8
TITLE:	STRESS PLOTS FOR HIGH ENERGY PIPING SYSTEMS					DATE:	5/13/2008
						COMP. BY:	BCS

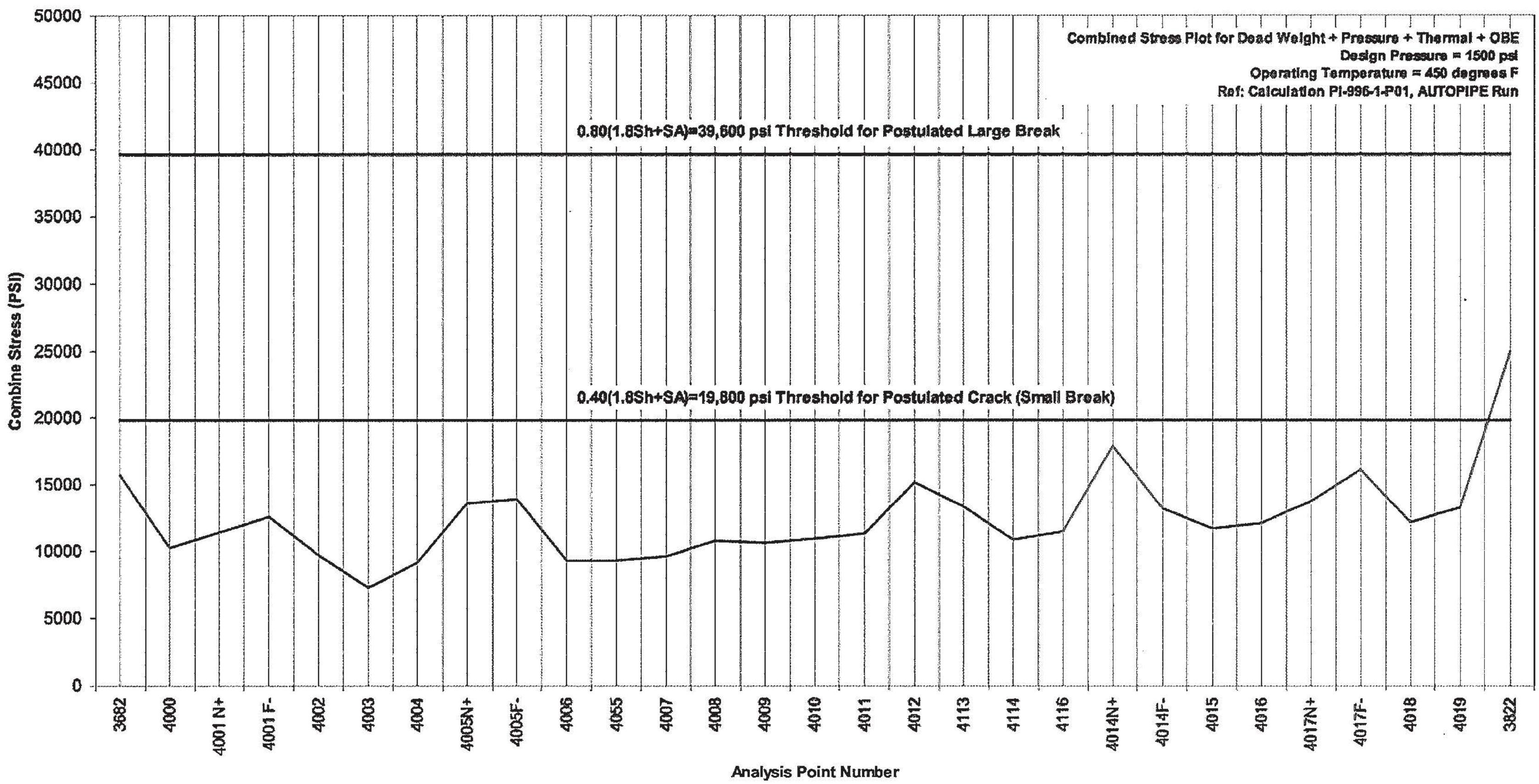
Stress Plot for Feed Water Piping from Anchor Elbow point 1041 Inside Containment to Heater Anchor Point 521



PINGP CALCULATION

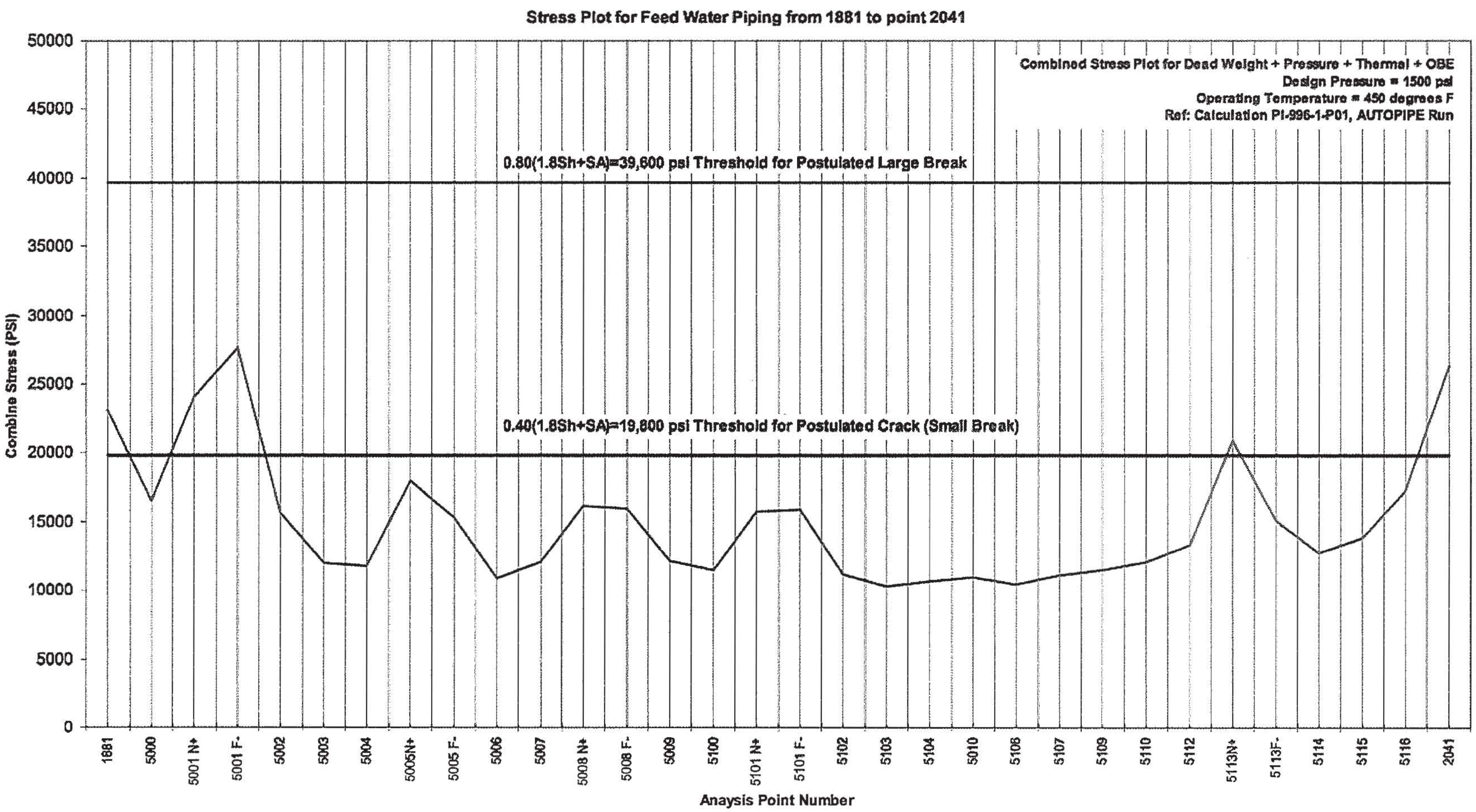
NUMBER:	ENG-ME-400	REVISION:	2	ADDENDUM:	0	SHEET NO:	Attachment 3 Sheet 7 OF 8
TITLE:	STRESS PLOTS FOR HIGH ENERGY PIPING SYSTEMS					DATE:	5/13/2008
						COMP. BY:	BCS

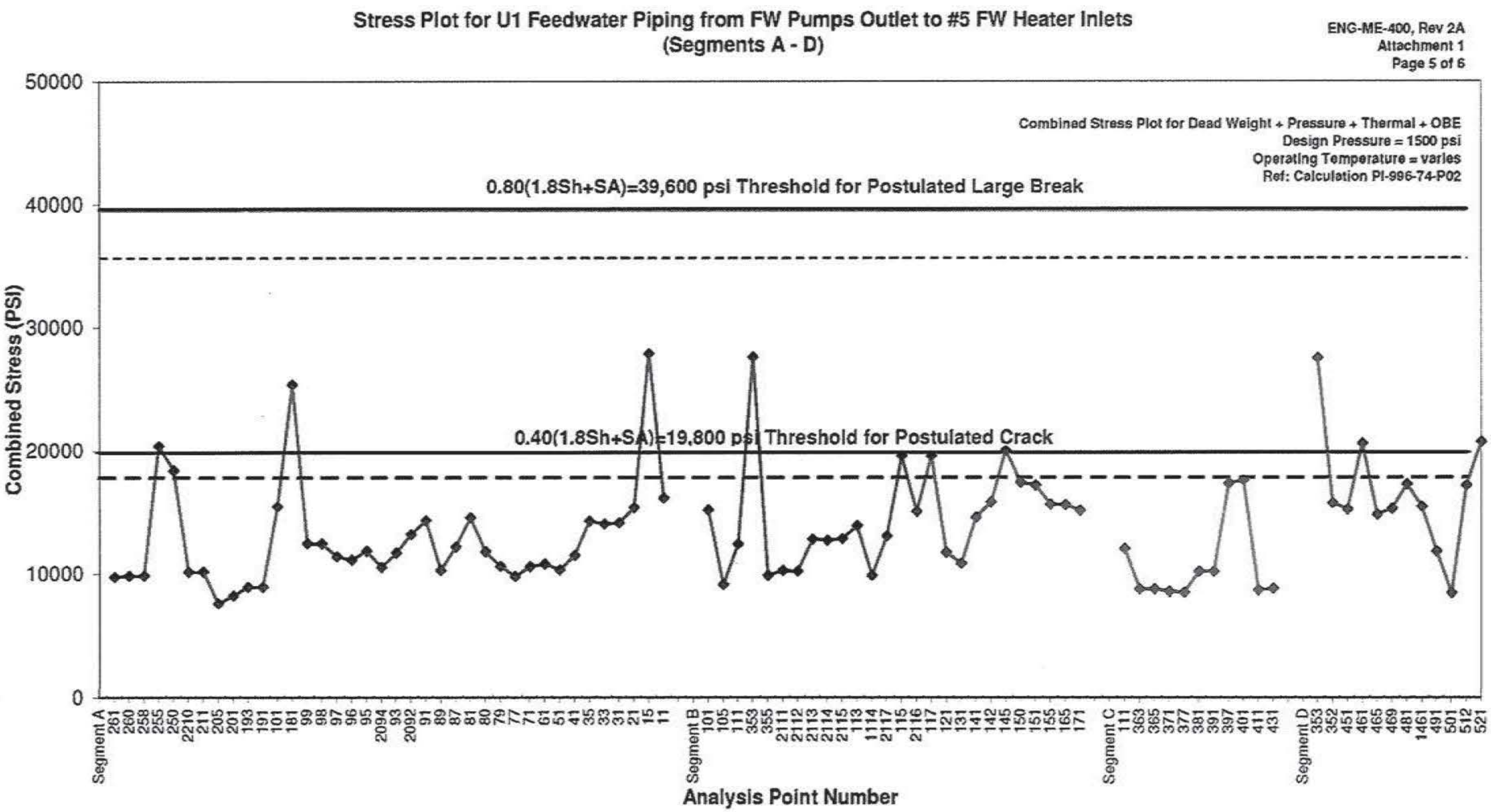
Stress Plot for Feed Water Piping from 3682 to point 3822



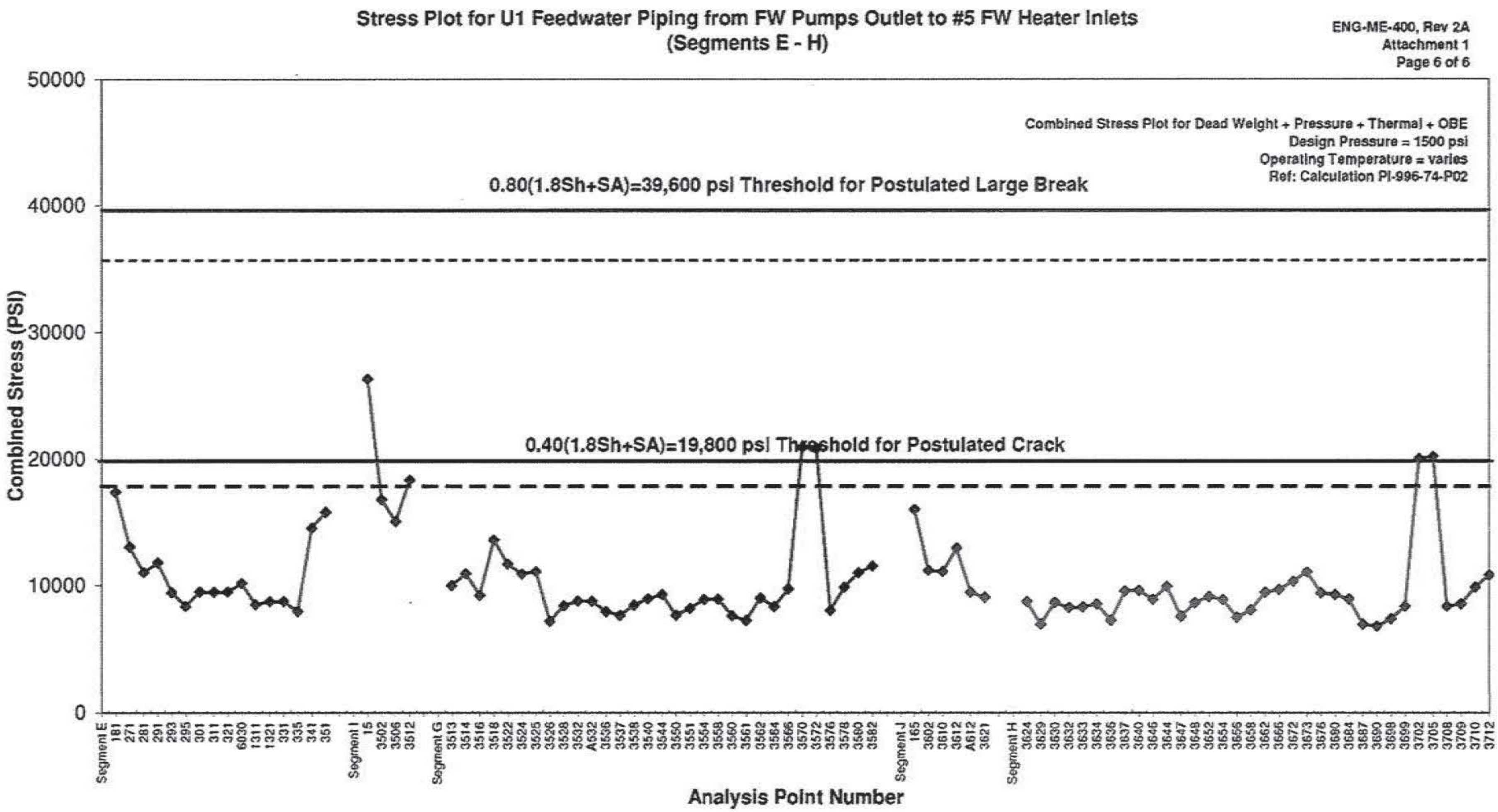
PINGP CALCULATION

NUMBER:	ENG-ME-400	REVISION:	2	ADDENDUM:	0	SHEET NO:	Attachment 3 Sheet 8 OF 8
TITLE:	STRESS PLOTS FOR HIGH ENERGY PIPING SYSTEMS					DATE:	5/13/2008
						COMP. BY:	BCS




Stress Plot for U1 Feedwater Piping from FW Pumps Outlet to #5 FW Heater Inlets
(Segments A - D)
ENG-ME-400, Rev 2A
Attachment 1
Page 5 of 6
Combined Stress Plot for Dead Weight + Pressure + Thermal + OBE
Design Pressure = 1500 psi
Operating Temperature = varies
Ref: Calculation PI-996-74-P02
0.80(1.8Sh+SA)=39,600 psi Threshold for Postulated Large Break
0.40(1.8Sh+SA)=19,800 psi Threshold for Postulated Crack
Combined Stress (PSI)
50000
40000
30000
20000
10000
0
Segment A
261
260
258
255
250
2210
211
205
201
193
191
101
181
99
98
97
96
95
2094
93
2092
91
89
87
81
80
79
77
71
61
51
41
35
33
31
21
15
11
Segment B
101
105
111
353
355
2111
2112
2113
2114
2115
113
1114
2117
115
2116
117
121
131
141
142
145
150
151
155
165
171
Segment C
111
363
365
371
377
381
391
397
401
411
431
Segment D
353
352
451
461
465
469
481
1461
491
501
512
521
Analysis Point Number

01373340

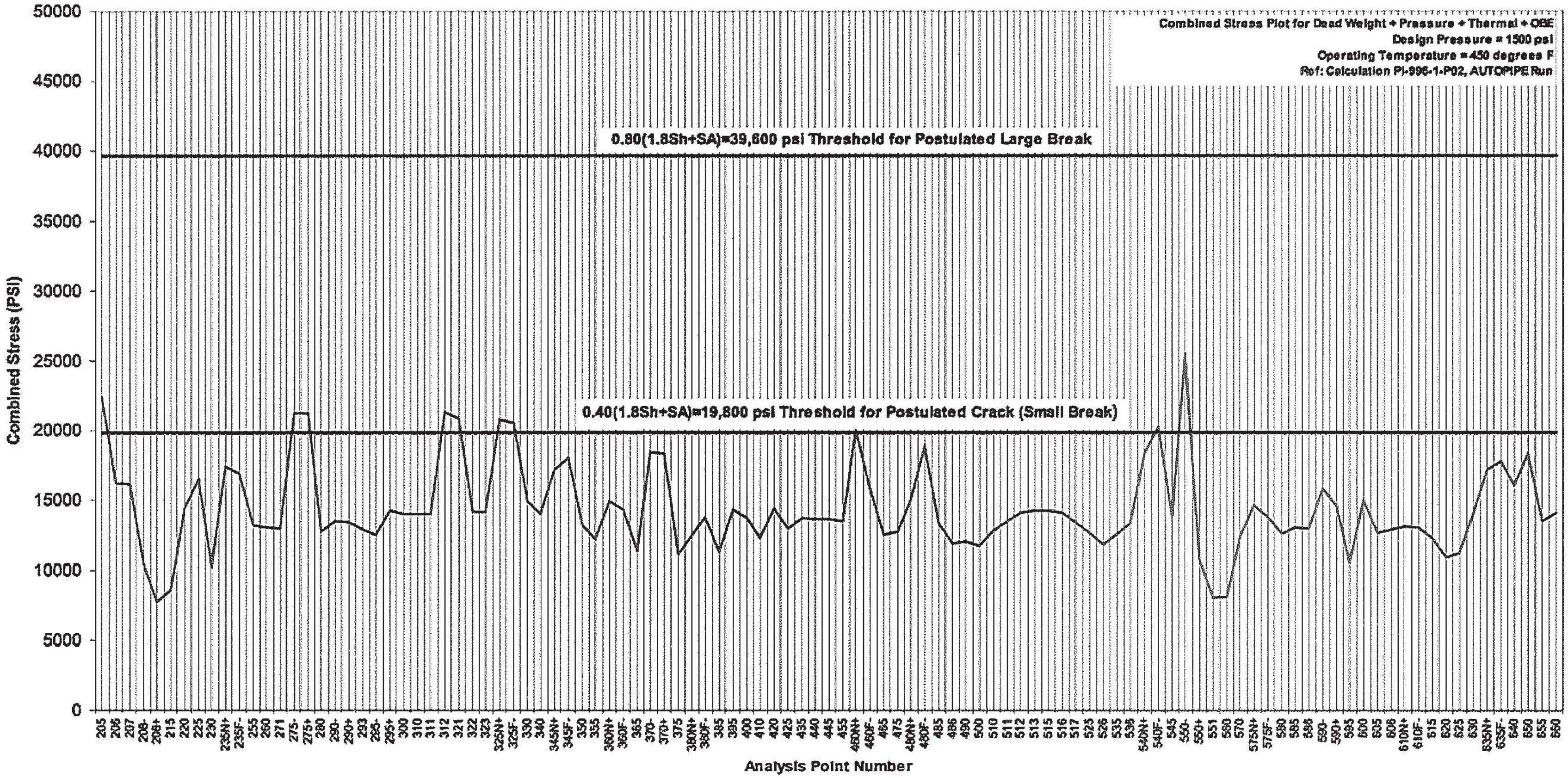

Stress Plot for U1 Feedwater Piping from FW Pumps Outlet to #5 FW Heater Inlets
(Segments E - H)
ENG-ME-400, Rev 2A
Attachment 1
Page 6 of 6
Combined Stress Plot for Dead Weight + Pressure + Thermal + OBE
Design Pressure = 1500 psi
Operating Temperature = varies
Ref: Calculation PI-996-74-P02
0.80(1.8Sh+SA)=39,600 psi Threshold for Postulated Large Break
0.40(1.8Sh+SA)=19,800 psi Threshold for Postulated Crack
Combined Stress (PSI)
Analysis Point Number

01373340

PINGP CALCULATION

NUMBER:	ENG-ME-400	REVISION:	2	ADDENDUM:	0	SHEET NO:	Attachment 4 Sheet 5 OF 8
TITLE:	STRESS PLOTS FOR HIGH ENERGY PIPING SYSTEMS					DATE:	5/13/2008
						COMP. BY:	BCS

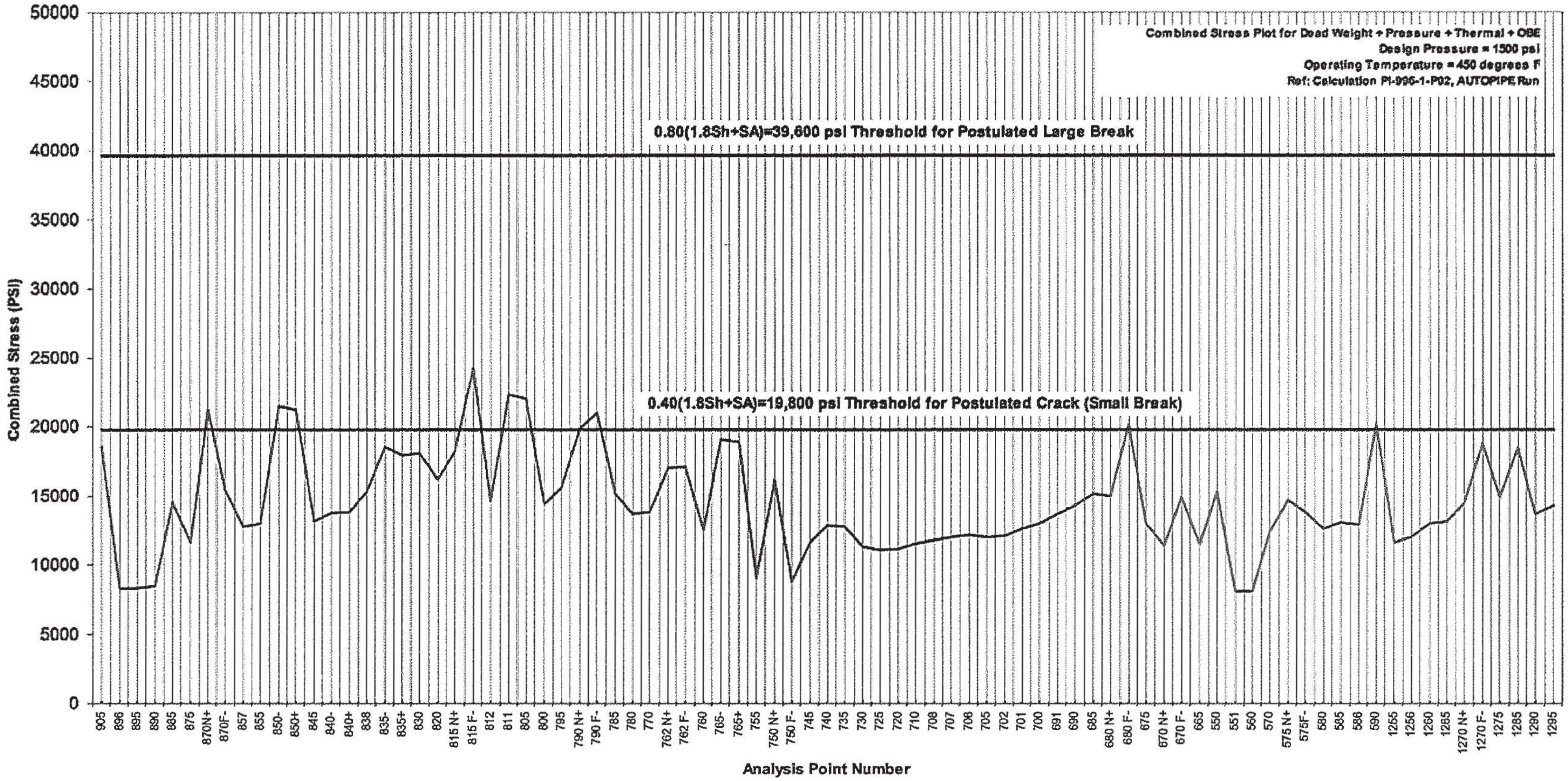
Stress Plot for Feed Water Piping from Anchor Elbow point 205 Inside Containment to Heater Anchor Point 660



PINGP CALCULATION

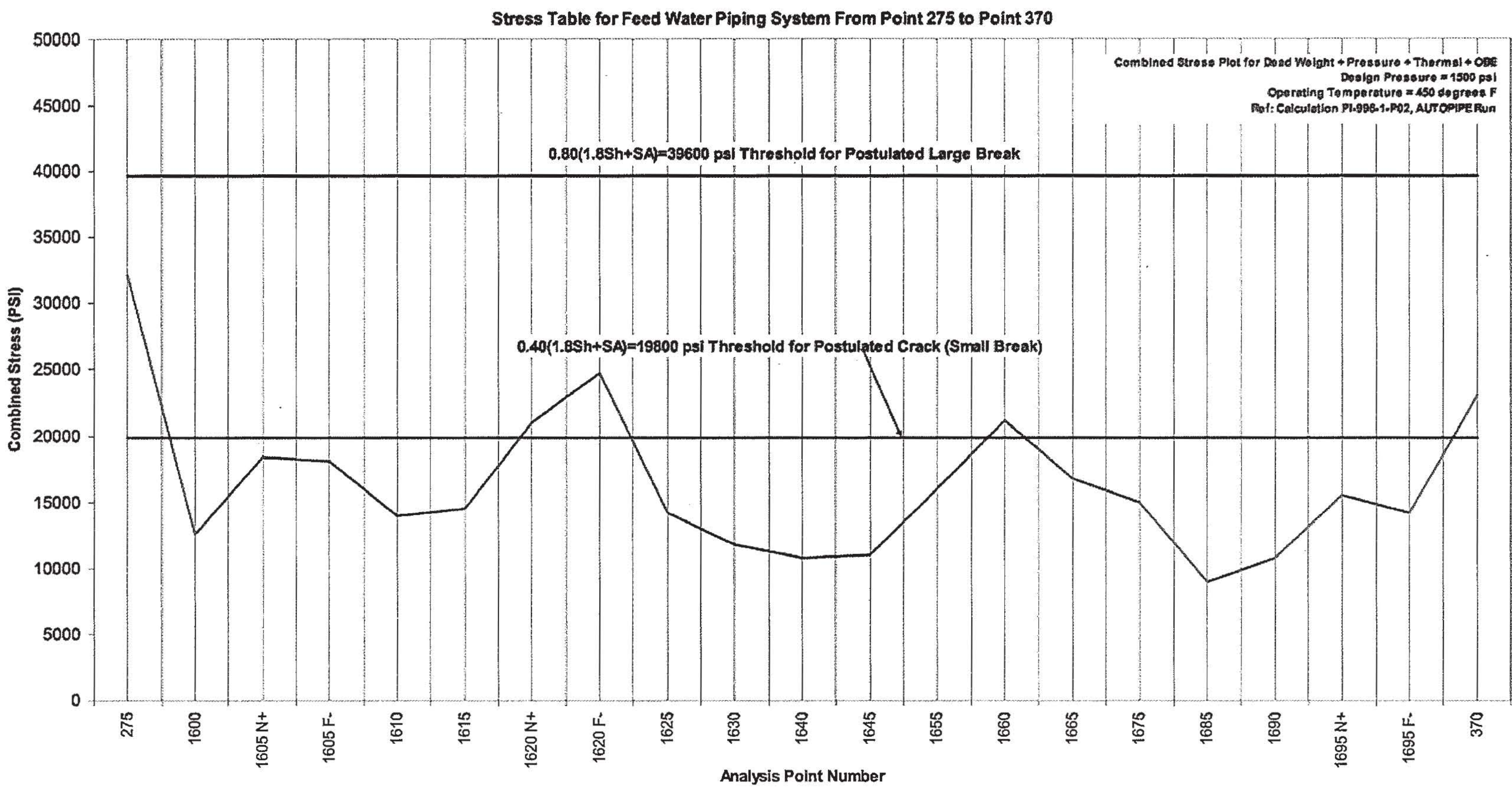
NUMBER:	ENG-ME-400	REVISION:	2	ADDENDUM:	0	SHEET NO:	Attachment 4 Sheet 6 OF 8
TITLE:	STRESS PLOTS FOR HIGH ENERGY PIPING SYSTEMS					DATE:	5/13/2008
						COMP. BY:	BCS

Stress Table for Feed Water Piping System From Anchored Elbow Point 905 to Heater #25A Point 1295



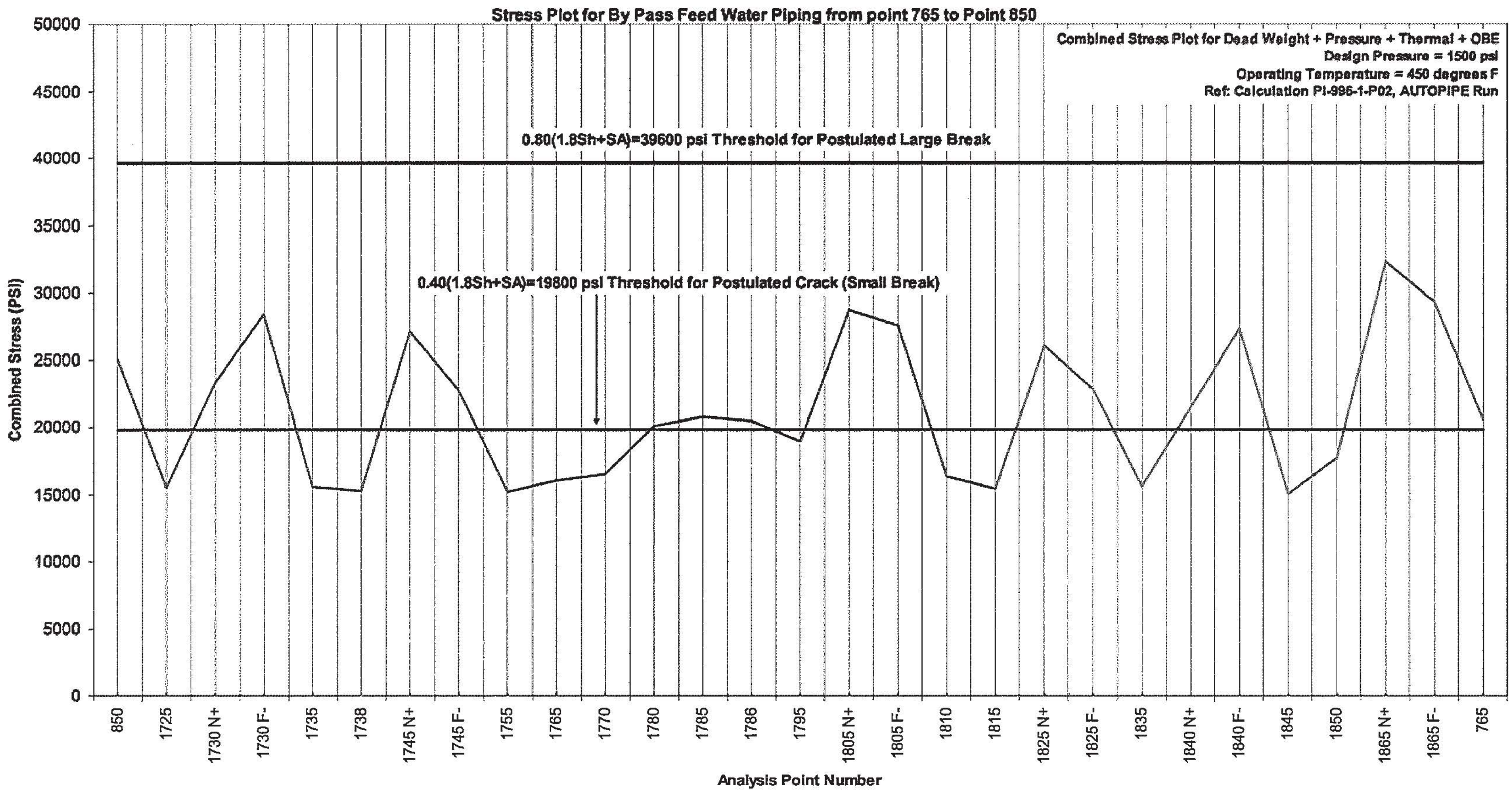
PINGP CALCULATION

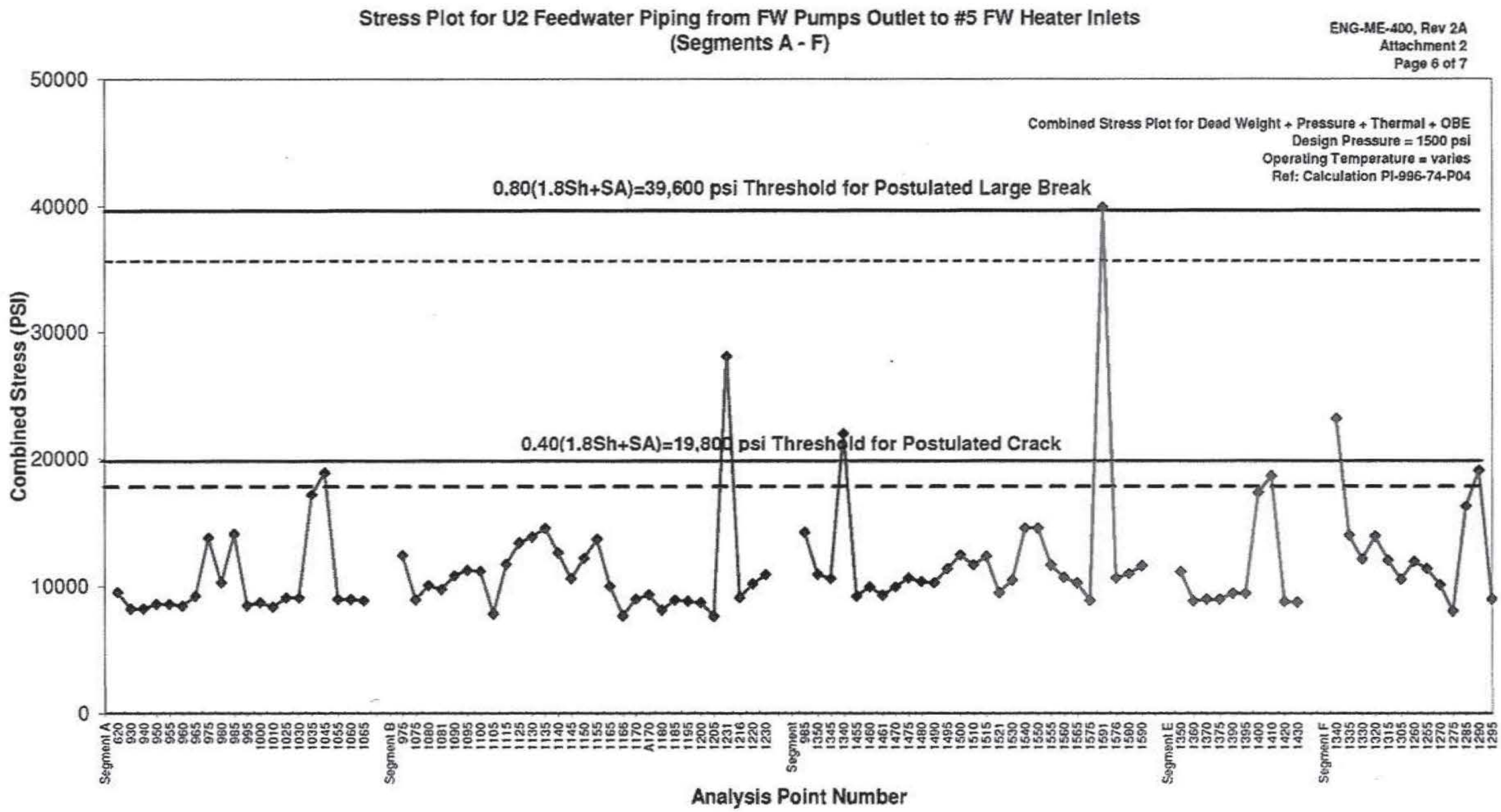
NUMBER:	ENG-ME-400	REVISION:	2	ADDENDUM:	0	SHEET NO:	Attachment 4 Sheet 7 OF 8
TITLE:	STRESS PLOTS FOR HIGH ENERGY PIPING SYSTEMS					DATE:	5/13/2008
						COMP. BY:	BCS



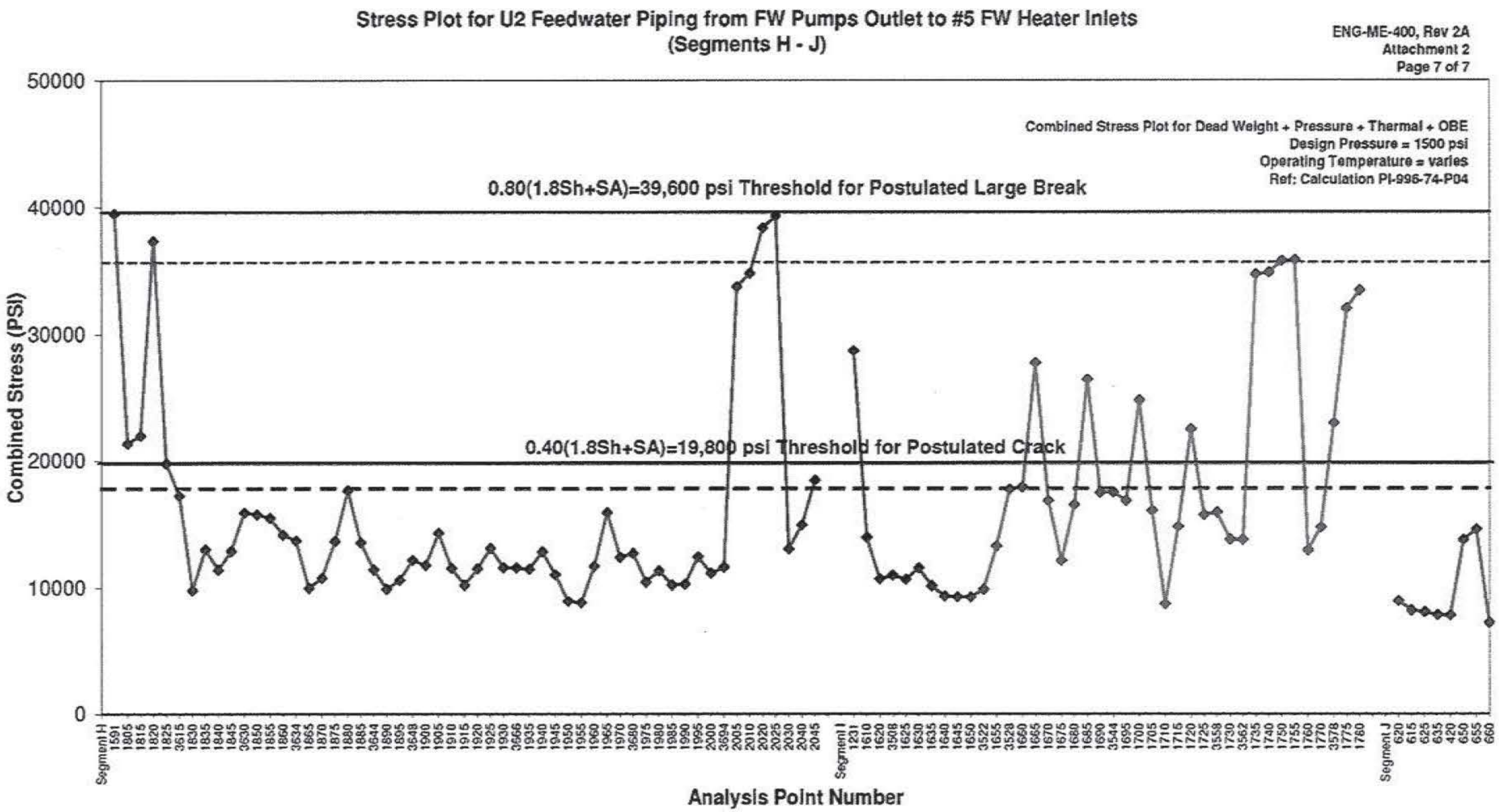
PINGP CALCULATION

NUMBER:	ENG-ME-400	REVISION:	2	ADDENDUM:	0	SHEET NO:	Attachment 4 Sheet 8 OF 8
TITLE:	STRESS PLOTS FOR HIGH ENERGY PIPING SYSTEMS					DATE:	5/13/2008
						COMP. BY:	BCS




Stress Plot for U2 Feedwater Piping from FW Pumps Outlet to #5 FW Heater Inlets
(Segments A - F)
ENG-ME-400, Rev 2A
Attachment 2
Page 6 of 7
Combined Stress Plot for Dead Weight + Pressure + Thermal + OBE
Design Pressure = 1500 psi
Operating Temperature = varies
Ref: Calculation PI-996-74-P04
0.80(1.8Sh+SA)=39,600 psi Threshold for Postulated Large Break
0.40(1.8Sh+SA)=19,800 psi Threshold for Postulated Crack
Combined Stress (PSI)
50000
40000
30000
20000
10000
0
Analysis Point Number

PINGP USAR
Figure FI.5.1-6
Stress Plot-Feedwater, Unit 2
REV 33



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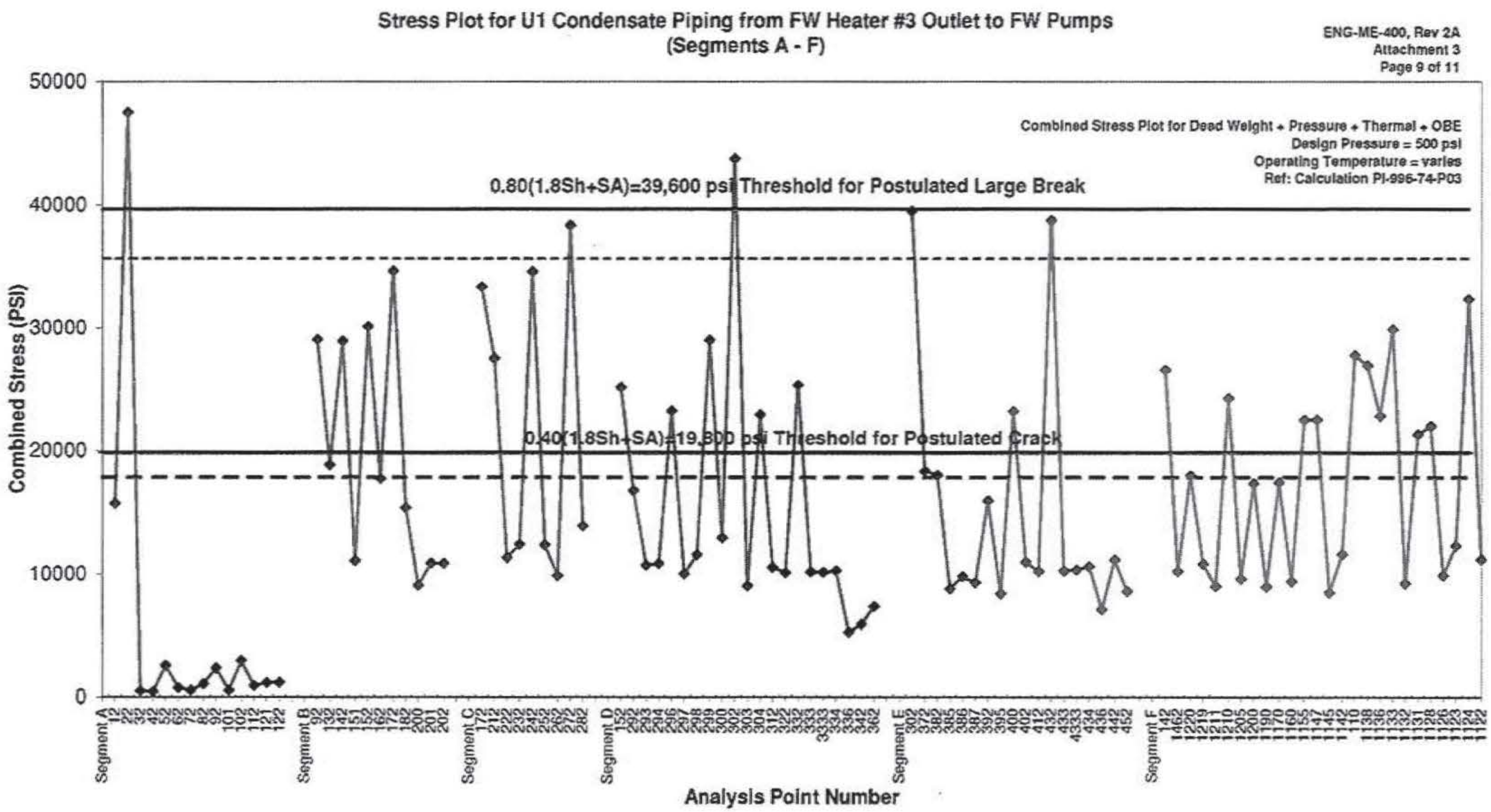
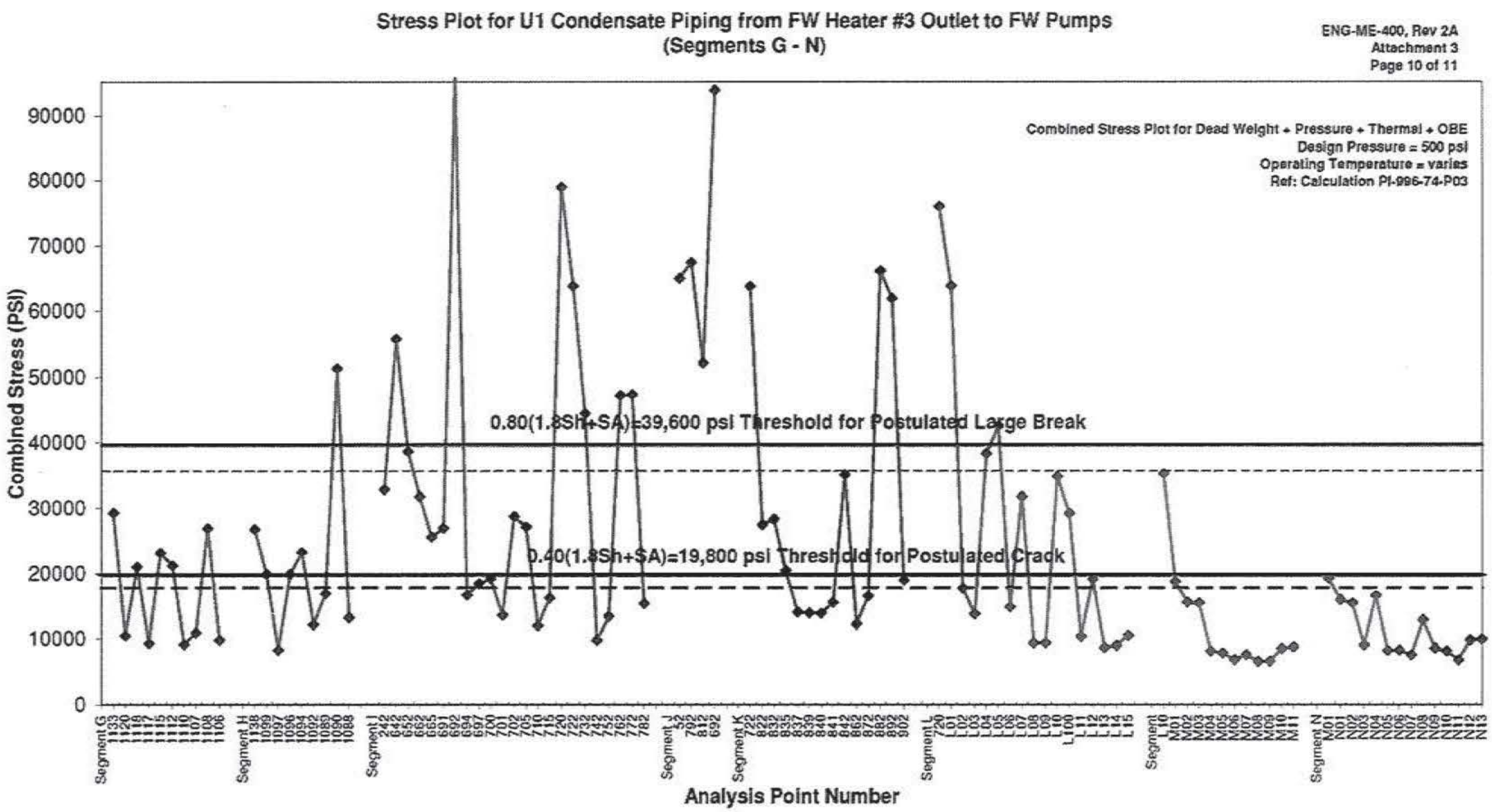
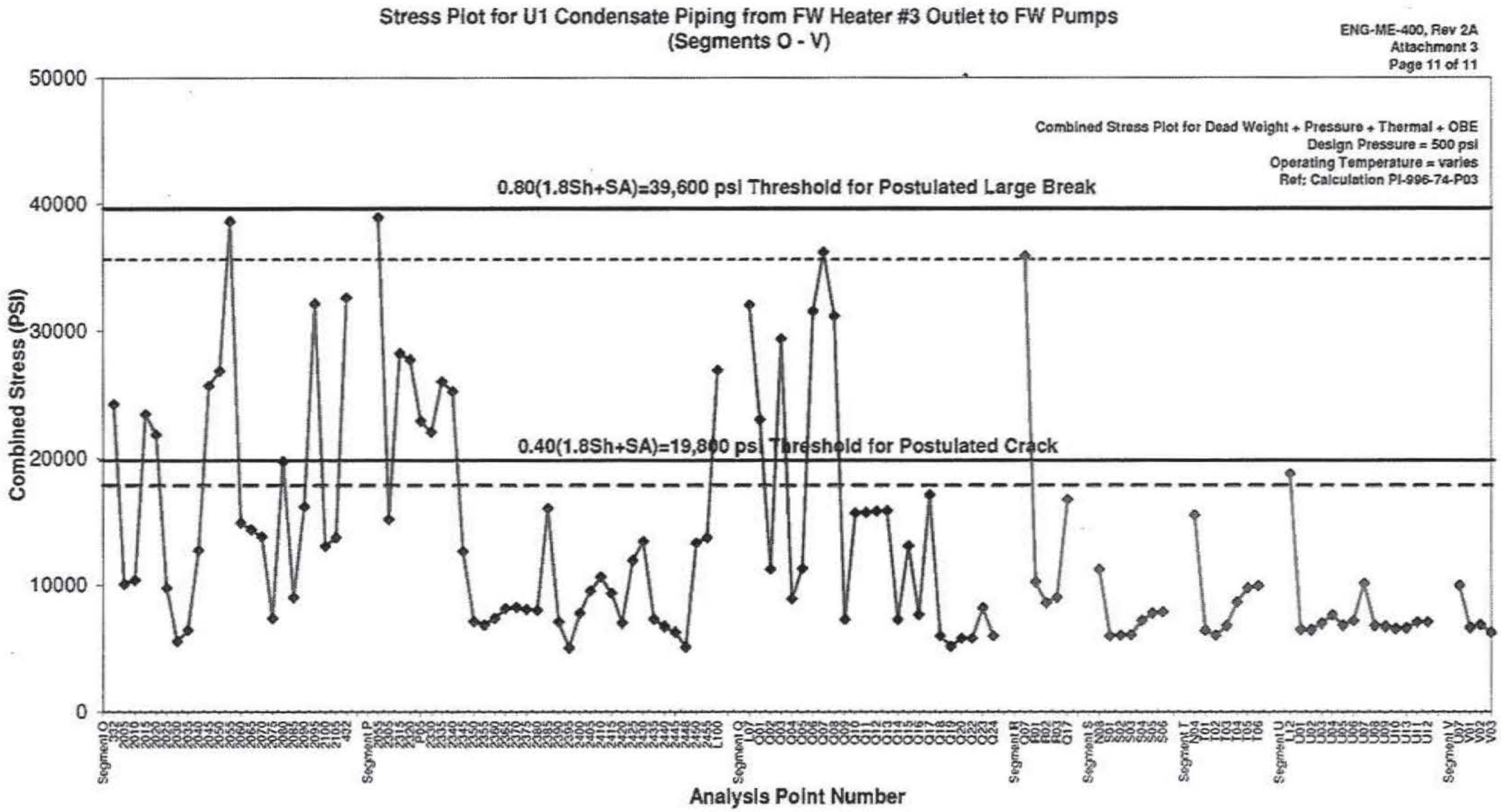

Stress Plot for U1 Condensate Piping from FW Heater #3 Outlet to FW Pumps
(Segments A - F)
ENG-ME-400, Rev 2A
Attachment 3
Page 9 of 11
Combined Stress Plot for Dead Weight + Pressure + Thermal + OBE
Design Pressure = 500 psi
Operating Temperature = varies
Ref: Calculation PI-996-74-P03
0.80(1.8Sh+SA)=39,600 psi Threshold for Postulated Large Break
0.40(1.8Sh+SA)=19,800 psi Threshold for Postulated Crack
Combined Stress (PSI)
Analysis Point Number
50000
40000
30000
20000
10000
0
Segment A
Segment B
Segment C
Segment D
Segment E
Segment F

01373340


Stress Plot for U1 Condensate Piping from FW Heater #3 Outlet to FW Pumps
(Segments G - N)
ENG-ME-400, Rev 2A
Attachment 3
Page 10 of 11
Combined Stress Plot for Dead Weight + Pressure + Thermal + OBE
Design Pressure = 500 psi
Operating Temperature = varies
Ref: Calculation PI-996-74-P03
0.80(1.8Sh+SA)=39,600 psi Threshold for Postulated Large Break
0.40(1.8Sh+SA)=19,800 psi Threshold for Postulated Crack
Combined Stress (PSI)
Analysis Point Number
90000
80000
70000
60000
50000
40000
30000
20000
10000
0

01373340

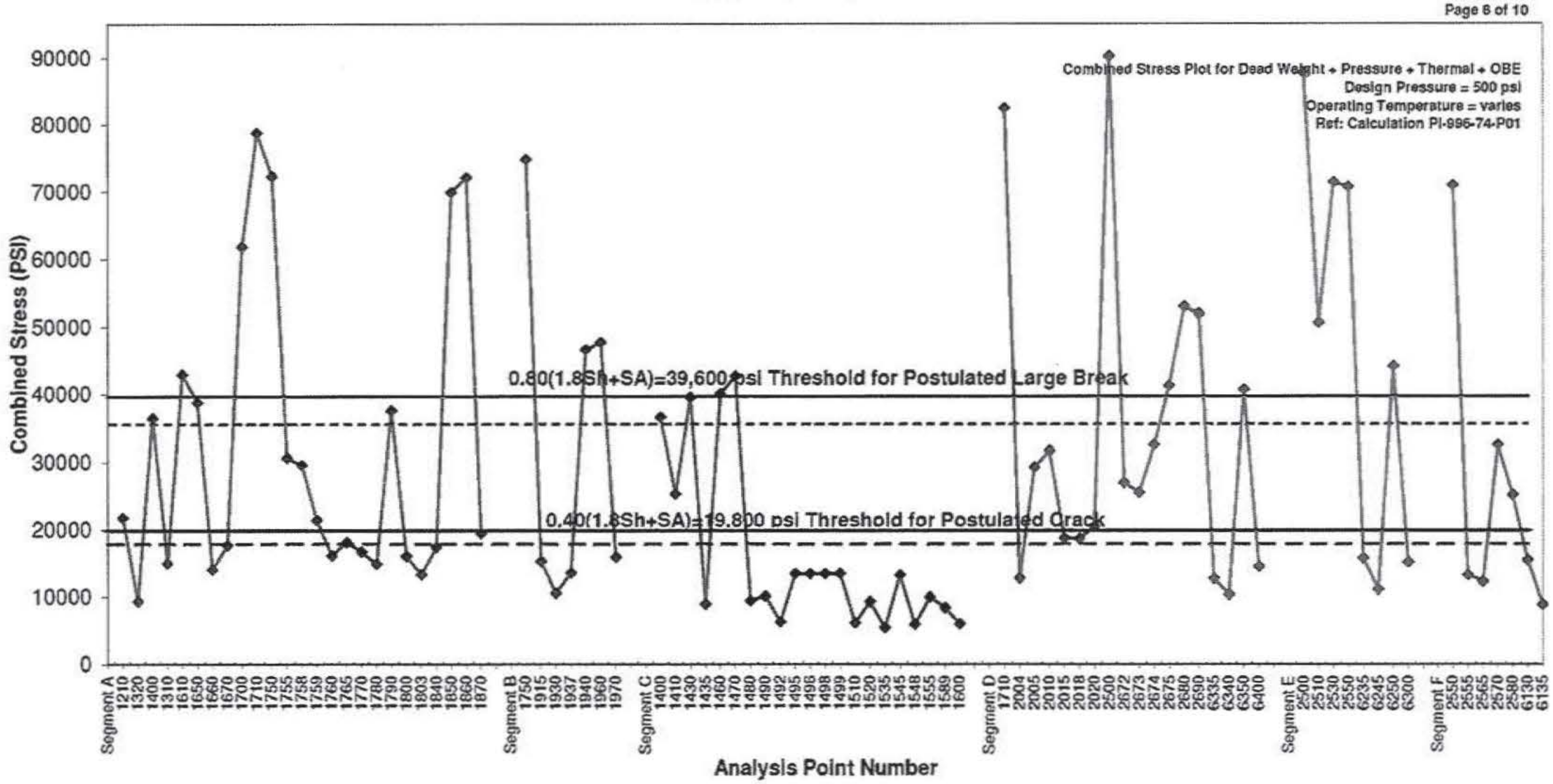

Stress Plot for U1 Condensate Piping from FW Heater #3 Outlet to FW Pumps
(Segments O - V)
ENG-ME-400, Rev 2A
Attachment 3
Page 11 of 11
Combined Stress Plot for Dead Weight + Pressure + Thermal + OBE
Design Pressure = 500 psi
Operating Temperature = varies
Ref: Calculation PI-996-74-P03
0.80(1.8Sh+SA)=39,600 psi Threshold for Postulated Large Break
0.40(1.8Sh+SA)=19,800 psi Threshold for Postulated Crack
Combined Stress (PSI)
50000
40000
30000
20000
10000
0
Analysis Point Number

01373340

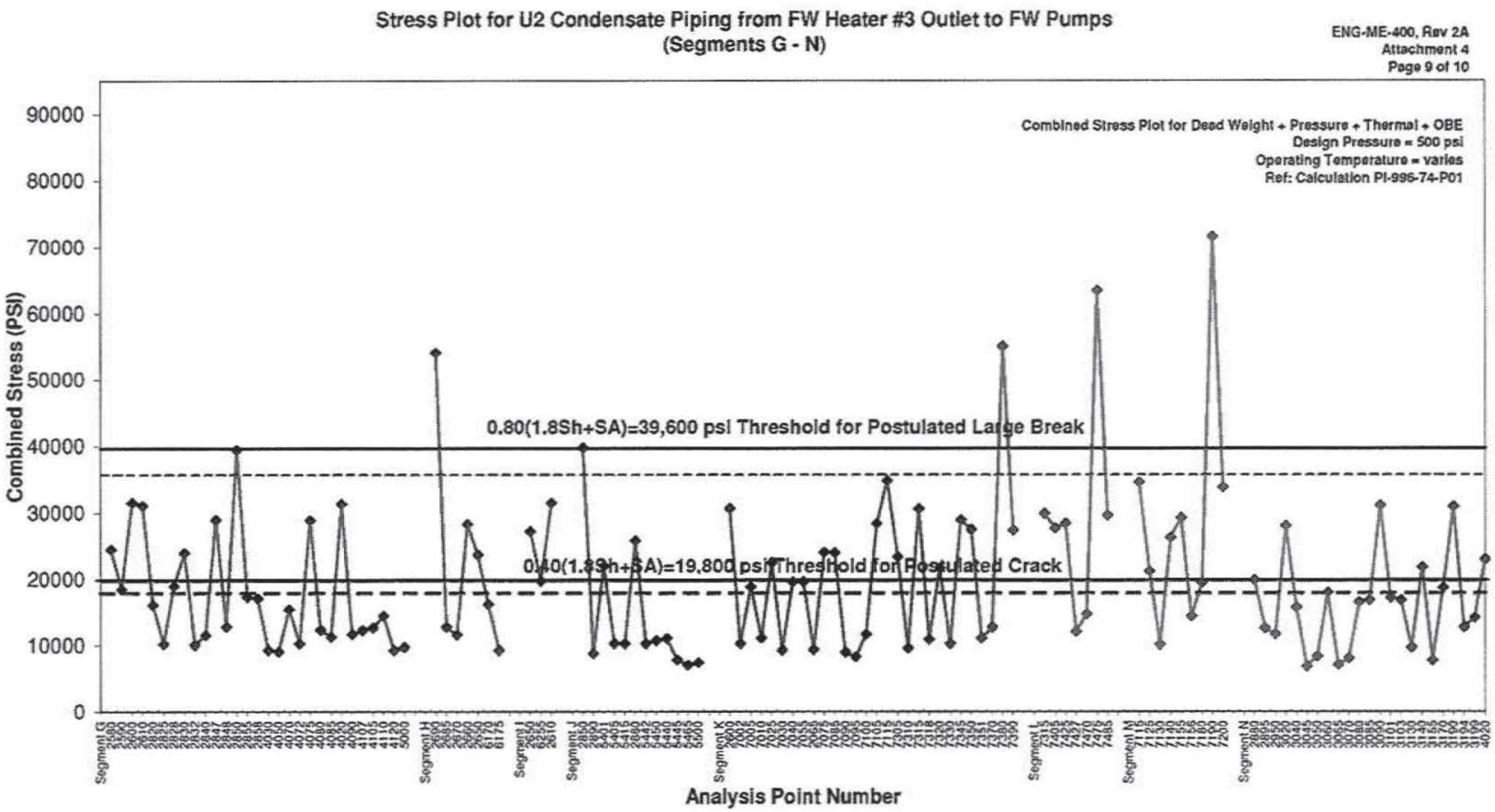
01373340

Stress Plot for U2 Condensate Piping from FW Heater #3 Outlet to FW Pumps
(Segments A - F)

ENG-ME-400, Rev 2A
Attachment 4
Page 8 of 10



PINGP USAR
Figure FI.5.1-8
CD Piping Stress Plots, Unit 2
REV 33
Page 2 of 4



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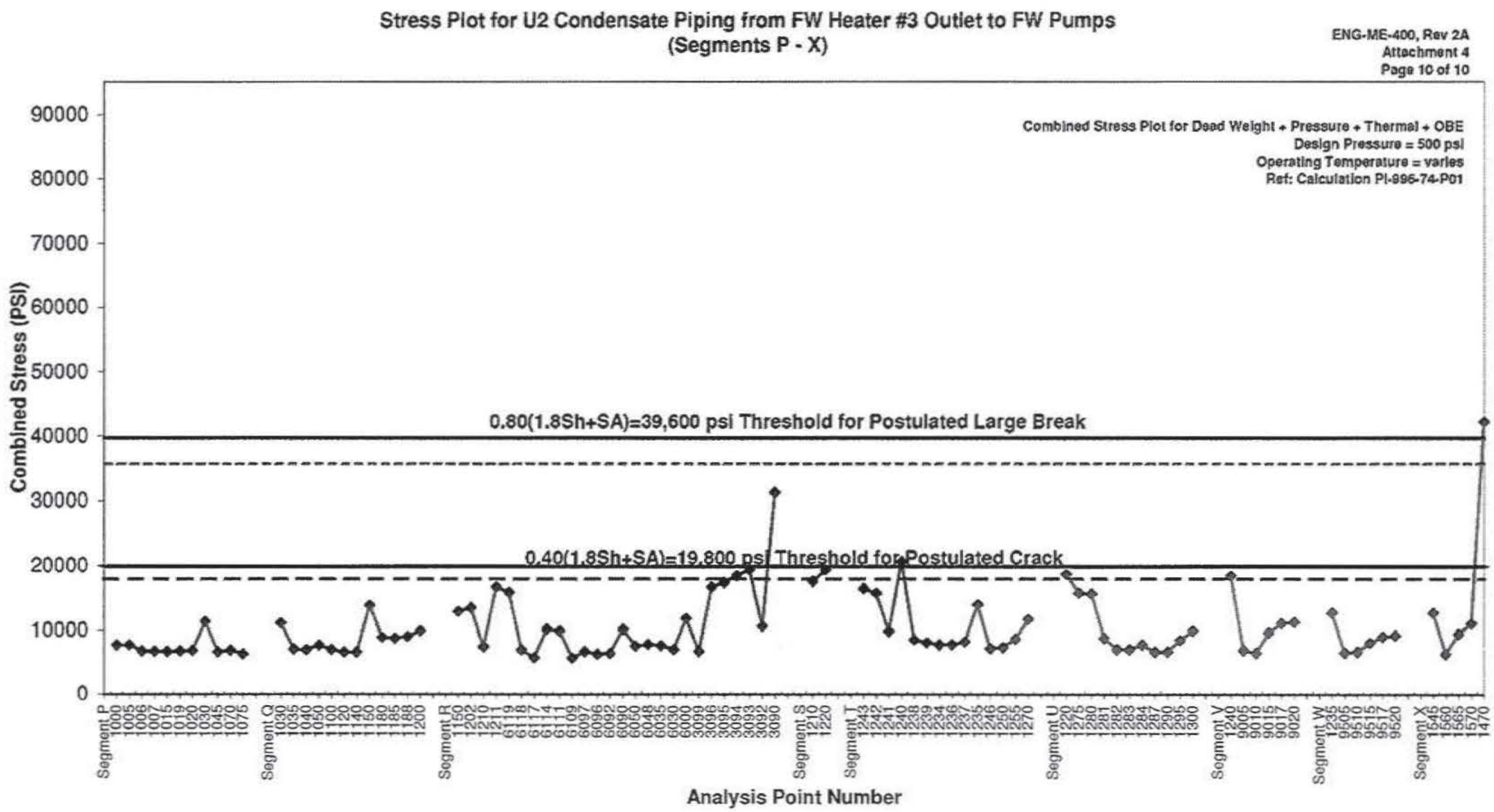
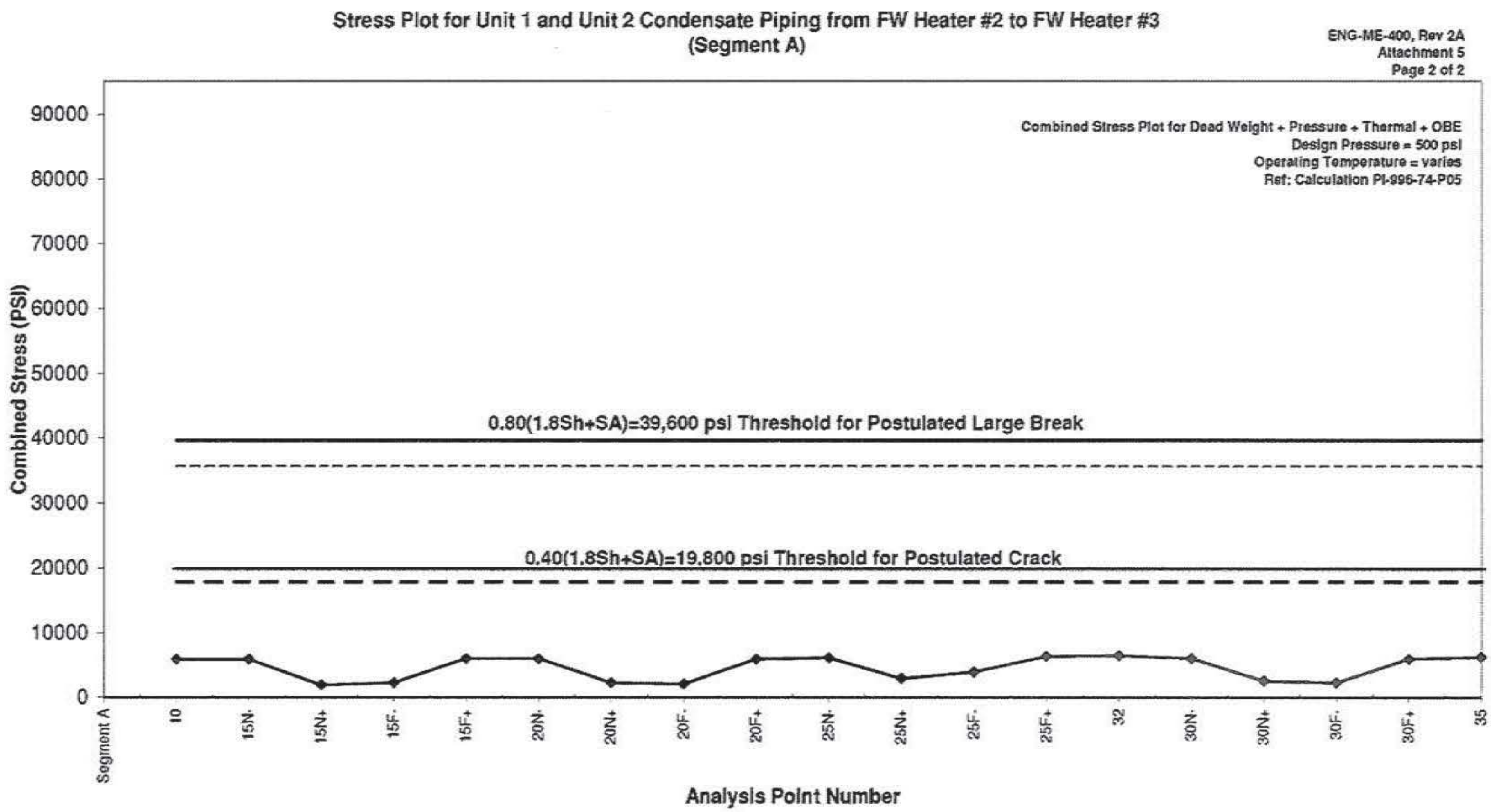

Stress Plot for U2 Condensate Piping from FW Heater #3 Outlet to FW Pumps
(Segments P - X)
ENG-ME-400, Rev 2A
Attachment 4
Page 10 of 10
Combined Stress Plot for Dead Weight + Pressure + Thermal + OBE
Design Pressure = 500 psi
Operating Temperature = varies
Ref: Calculation PI-996-74-P01
0.80(1.8Sh+SA)=39,600 psi Threshold for Postulated Large Break
0.40(1.8Sh+SA)=19,800 psi Threshold for Postulated Crack
Combined Stress (PSI)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
Segment P
Segment Q
Segment R
Segment S
Segment T
Segment U
Segment V
Segment W
Segment X
Analysis Point Number

01373340


Stress Plot for Unit 1 and Unit 2 Condensate Piping from FW Heater #2 to FW Heater #3
(Segment A)
ENG-ME-400, Rev 2A
Attachment 5
Page 2 of 2
Combined Stress Plot for Dead Weight + Pressure + Thermal + OBE
Design Pressure = 500 psi
Operating Temperature = varies
Ref: Calculation PI-996-74-P05
0.80(1.8Sh+SA)=39,600 psi Threshold for Postulated Large Break
0.40(1.8Sh+SA)=19,800 psi Threshold for Postulated Crack
Combined Stress (PSI)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
Segment A
10
15N-
15N+
15F-
15F+
20N-
20N+
20F-
20F+
25N-
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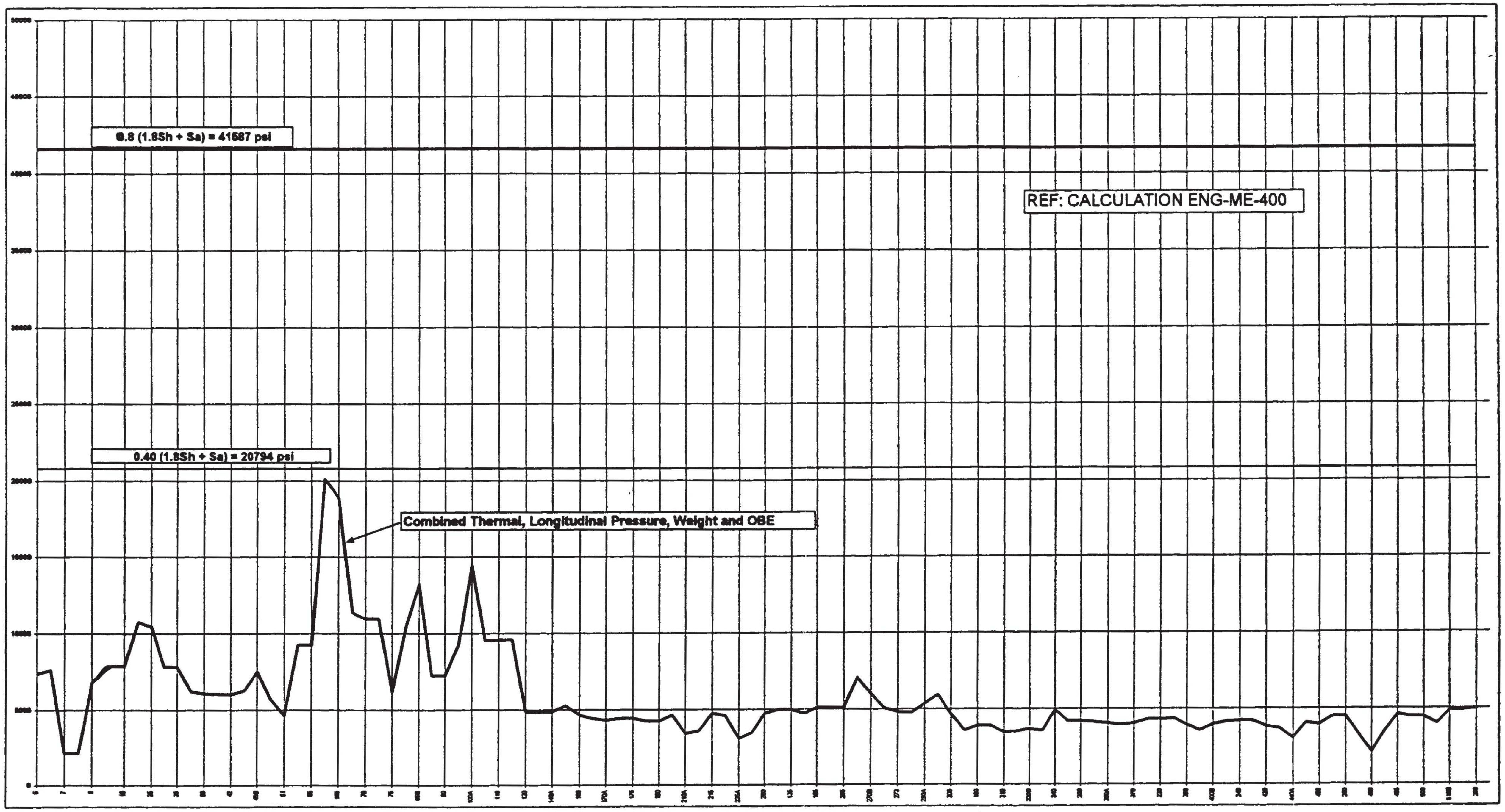
Analysis Point Number

01373340

REVISIONS



DWN TAM	DATE 11-23-99	SIGNIFICANT NO.						
CHECKED		GROUP	1	2	3	4	5	CL 6
PROJECT NO. ETNSUR								
APP'D & CERT.								
CAD FILE: UI5109.DGN								

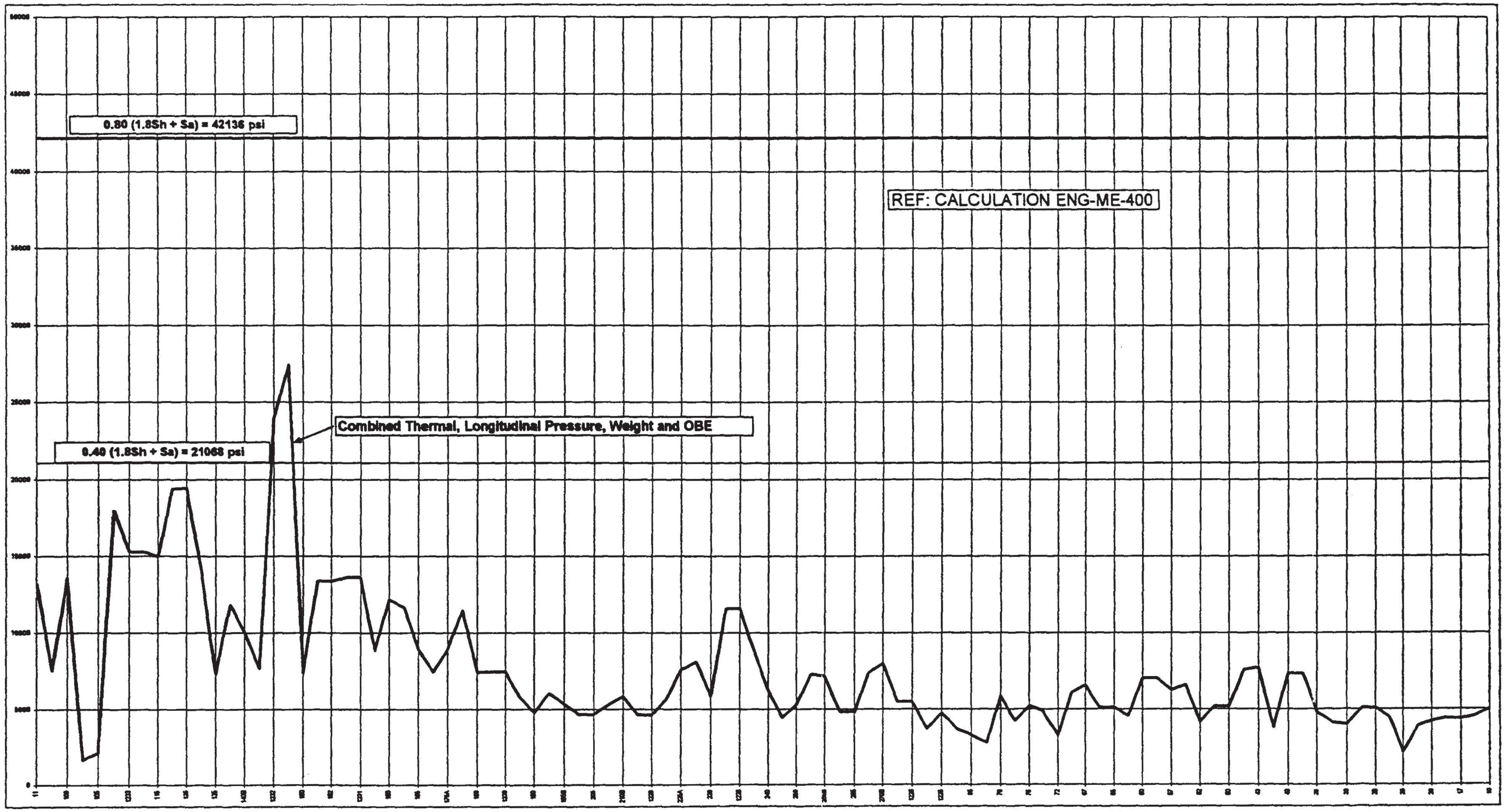
CVCS LETDOWN, UNIT 1

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING, MINNESOTA

SCALE NONE

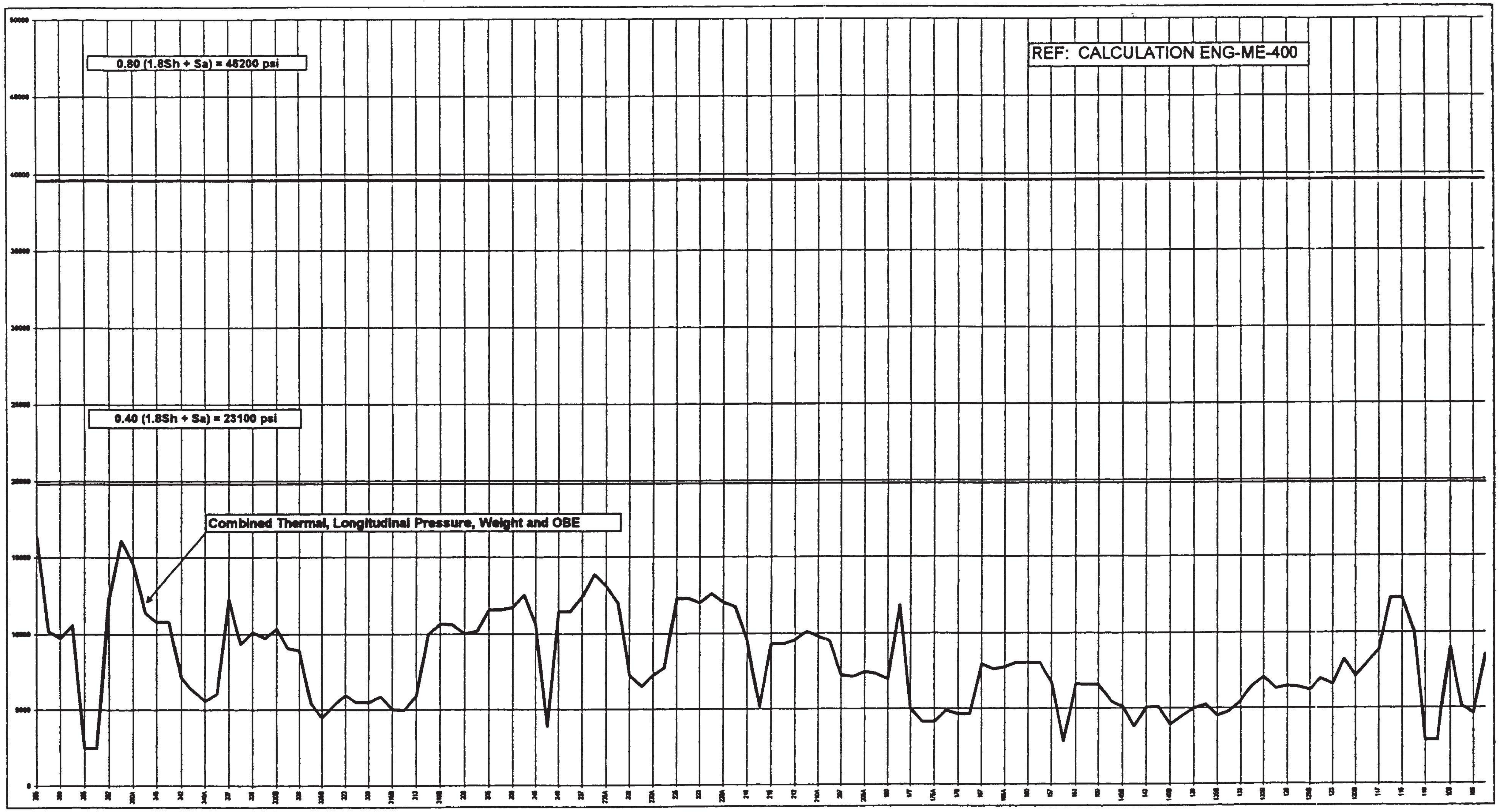
FIGURE I.5.1-9 REV. 22

REVISIONS



DWN TAM	DATE 11-23-99	SIGNIFICANT NO.	
CHECKED		GROUP	1 2 3 4 5 CL 6
PROJECT NO. ETNSUR			
APP'D & CERT.		CVCS LETDOWN, UNIT 2	
CAD FILE: UI5110.DGN			
NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING, MINNESOTA		SCALE NONE	
		FIGURE I.5.1-10 REV. 22	

REVISIONS



DWN TAM DATE 11-23-99
CHECKED
PROJECT NO. ETNSUR
APP'D & CERT.
CAD FILE: UI5111.DGN

SIGNIFICANT NO.
GROUP 1 2 3 4 5 CL 6

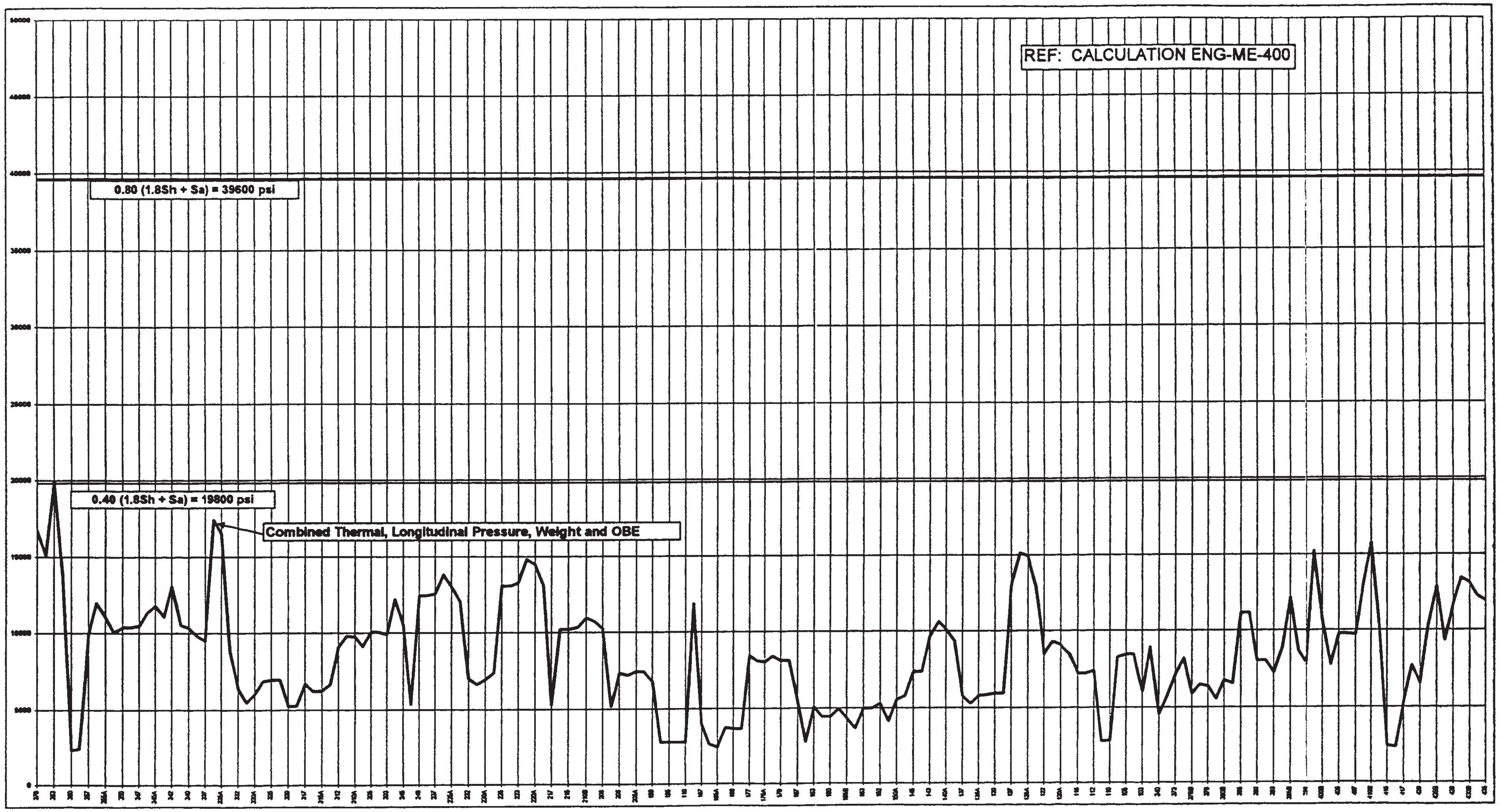
#11 STEAM GENERATOR BLOWDOWN

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING, MINNESOTA

SCALE NONE

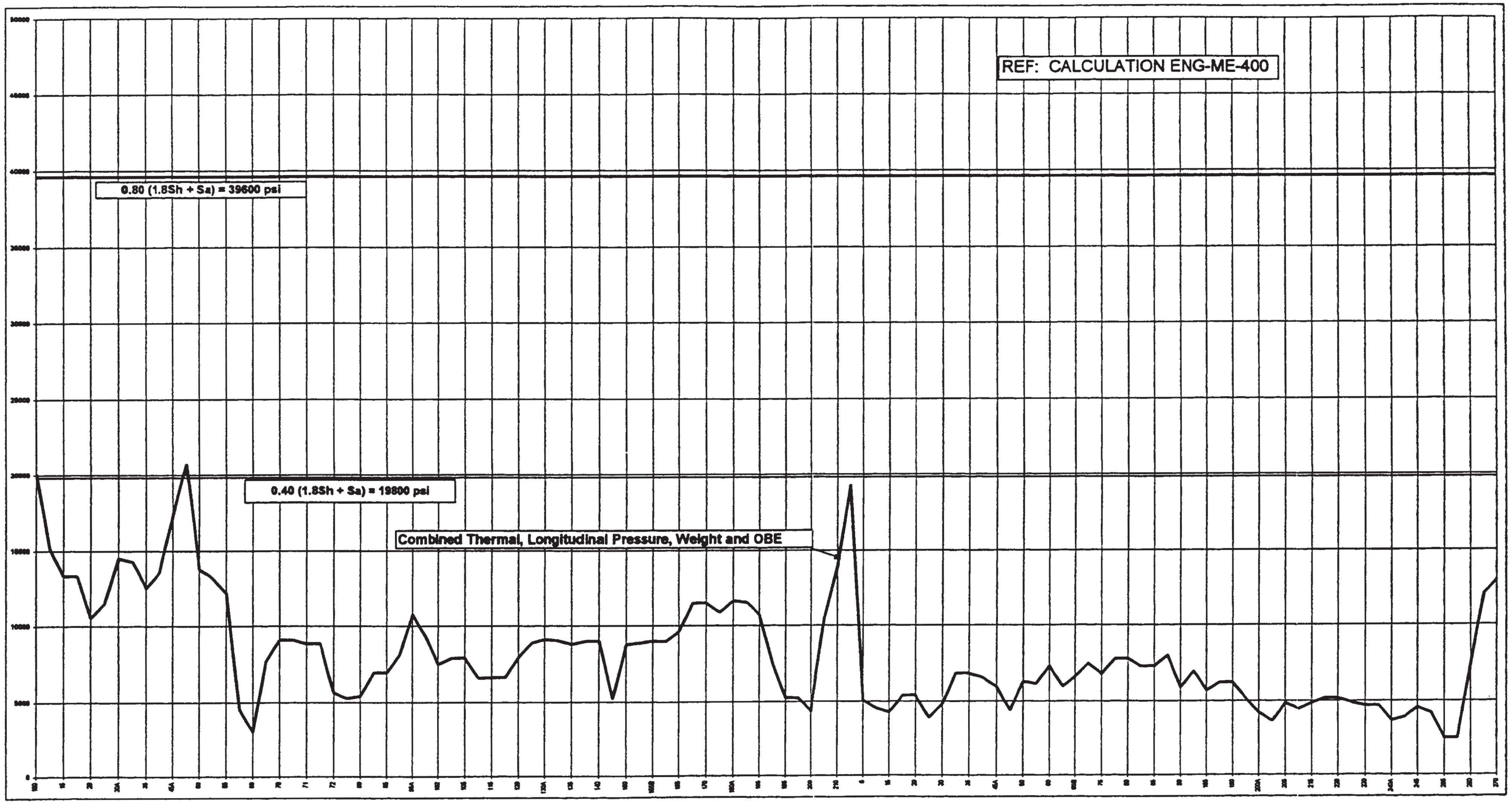
FIGURE I.5.1-11 REV. 22

REVISIONS



DWN TAM	DATE 11-23-99	SIGNIFICANT NO.	
CHECKED		GROUP	1 2 3 4 5 CL 6
PROJECT NO. ETNSUR			
APP'D & CERT.		#12 STEAM GENERATOR BLOWDOWN	
CAD FILE: UI5112.DGN			
NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING, MINNESOTA		SCALE NONE	
		FIGURE 1.8.1-12 REV. 22	

REVISIONS



DWN TAM DATE 11-23-99

CHECKED

PROJECT NO. ETNSUR

APP'D & CERT.

CAD FILE: UI5113.DGN

SIGNIFICANT NO.

GROUP 1 2 3 4 5 CL 6

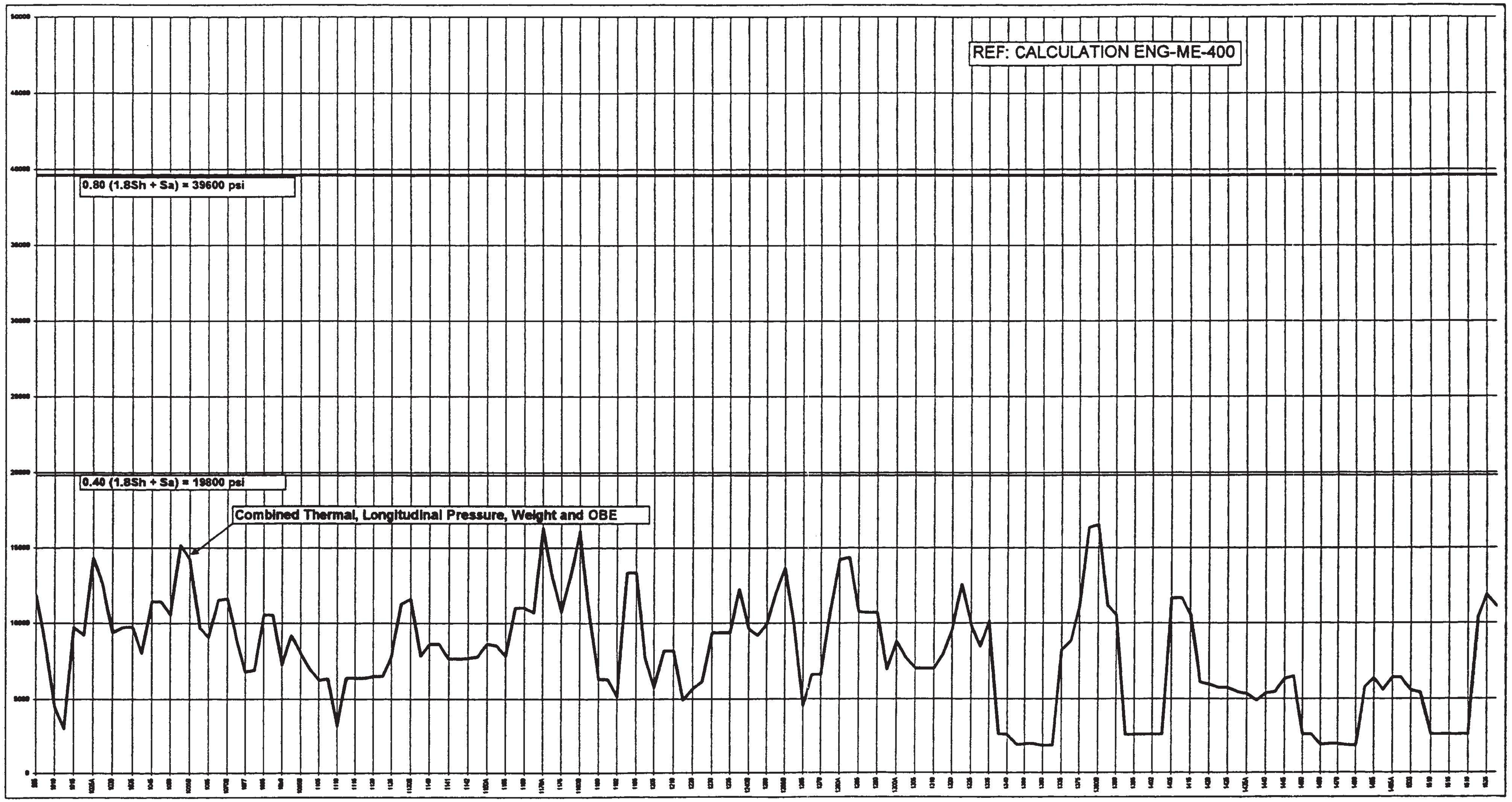
*21 STEAM GENERATOR BLOWDOWN

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING, MINNESOTA

SCALE NONE

FIGURE I.5.1-13 REV. 22

REVISIONS



DWN TAM	DATE 11-23-99	SIGNIFICANT NO.						
CHECKED		GROUP	1	2	3	4	5	CL 6
PROJECT NO. ETNSUR								
APP'D & CERT.								
CAD FILE: UI5114.DGN								

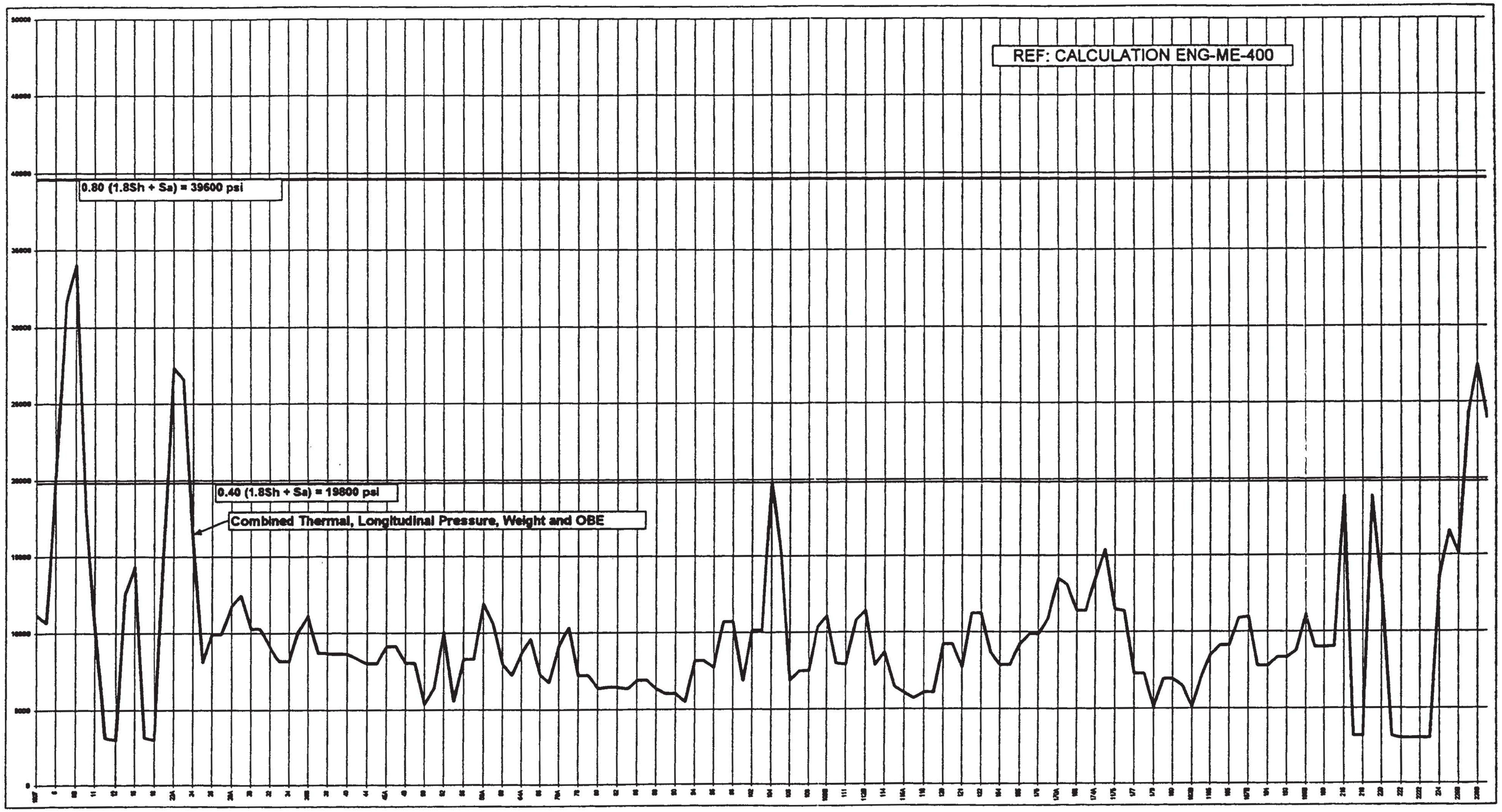
#22 STEAM GENERATOR BLOWDOWN

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING, MINNESOTA

SCALE NONE

FIGURE I.5.1-14 REV. 22

REVISIONS



DWN TAM DATE 11-23-99
CHECKED
PROJECT NO. ETNSUR
APP'D & CERT.
CAD FILE: UI5115.DGN

SIGNIFICANT NO.
GROUP 1 2 3 4 5 CL 6

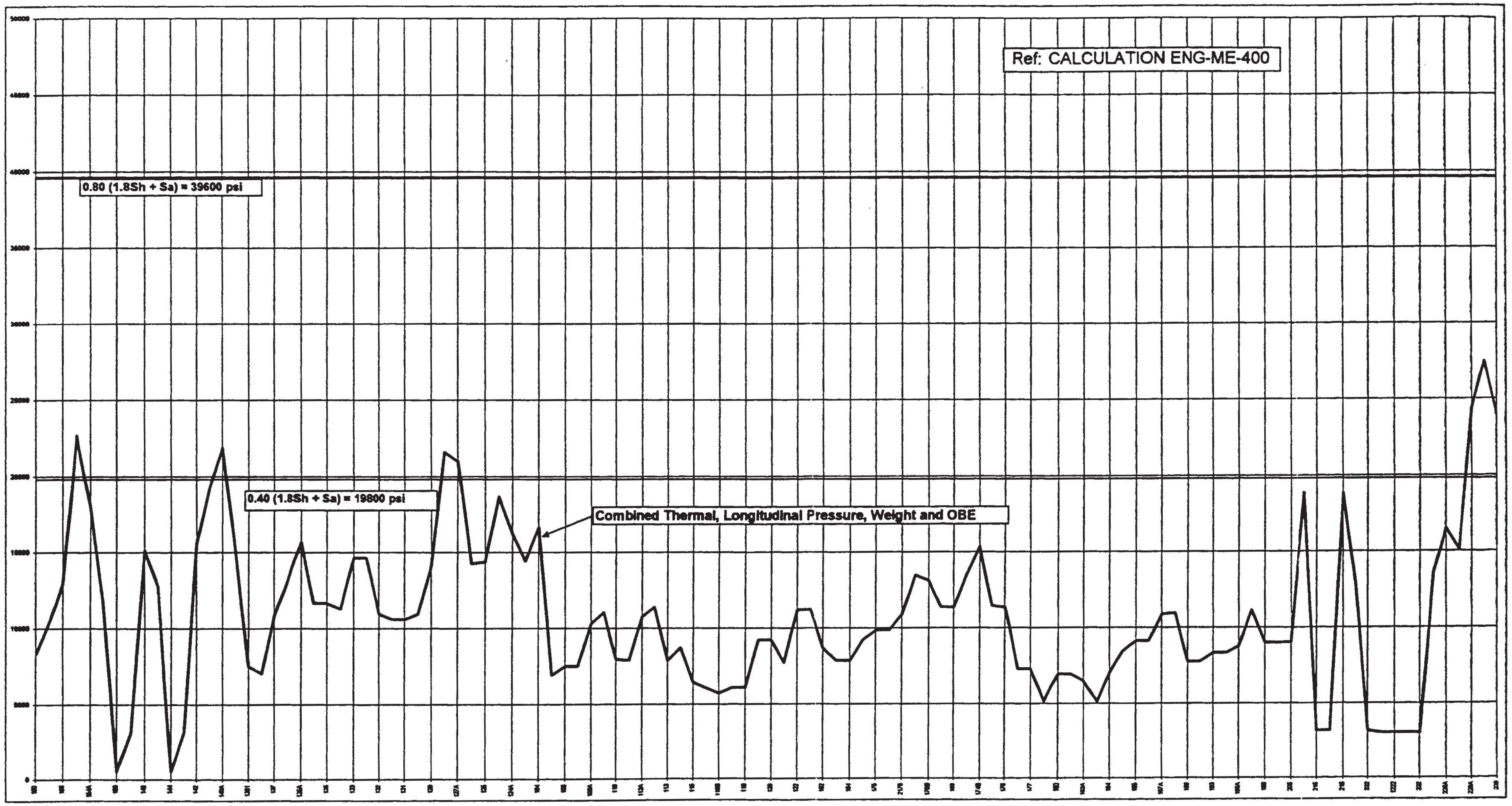
#11 STEAM GENERATOR SUPPLY TO AUX FEEDWATER PUMP

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING, MINNESOTA

SCALE NONE

FIGURE I.5.1-15 REV. 22

REVISIONS



DWN TAM	DATE 11-23-99	SIGNIFICANT NO.
CHECKED		GROUP
PROJECT NO. ETNSUR		
APP'D & CERT.		
CAD FILE: UI5116.DGN		

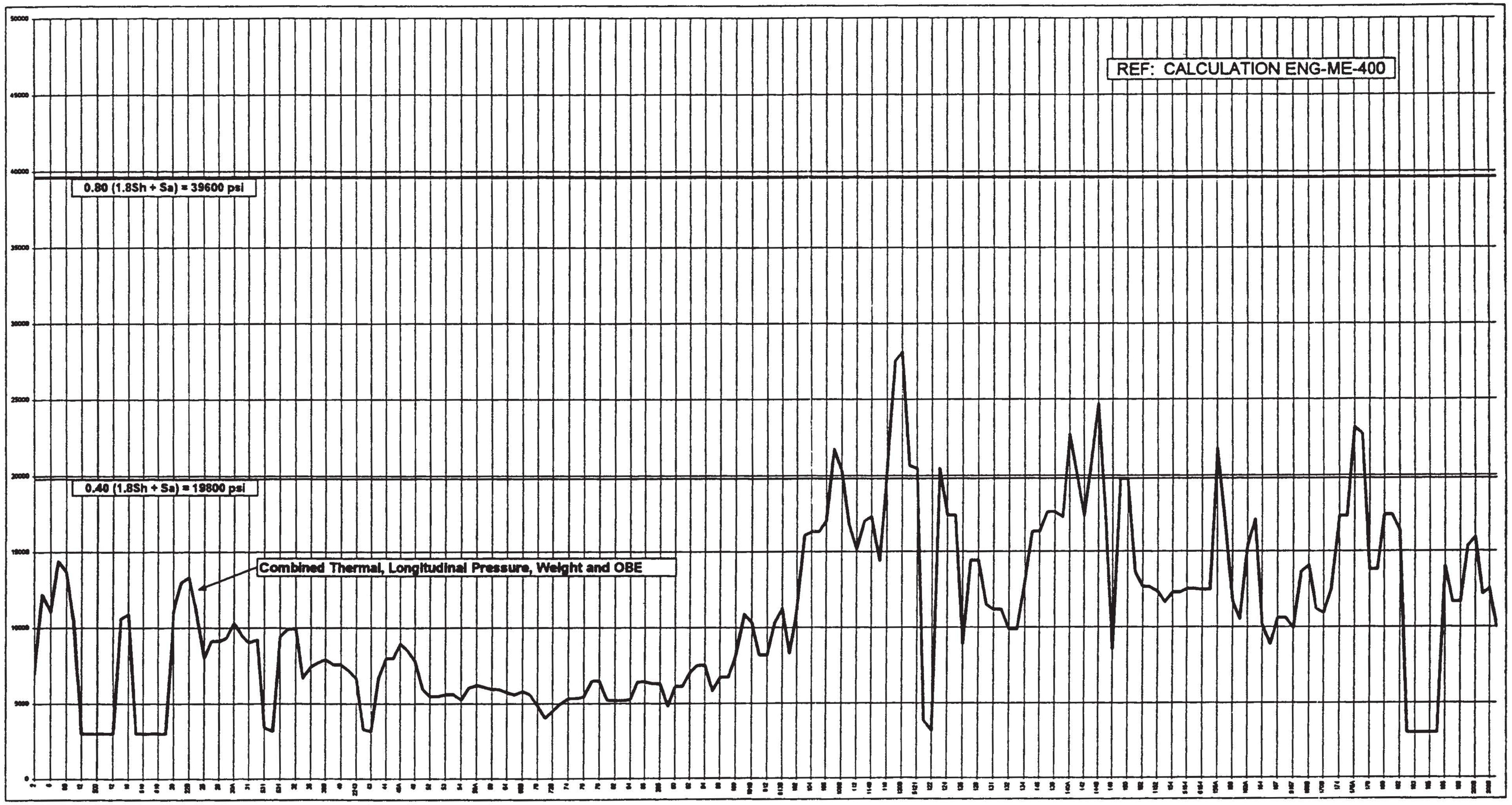
#12 STEAM GENERATOR
SUPPLY TO AUX FEEDWATER PUMP

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING, MINNESOTA

SCALE NONE

FIGURE I.5.1-16 REV. 22

REVISIONS



DWN TAM	DATE 11-23-99	SIGNIFICANT NO.						
CHECKED		GROUP	1	2	3	4	5	CL 6
PROJECT NO. ETNSUR								
APP'D & CERT.								
CAD FILE: UI5117.DGN								

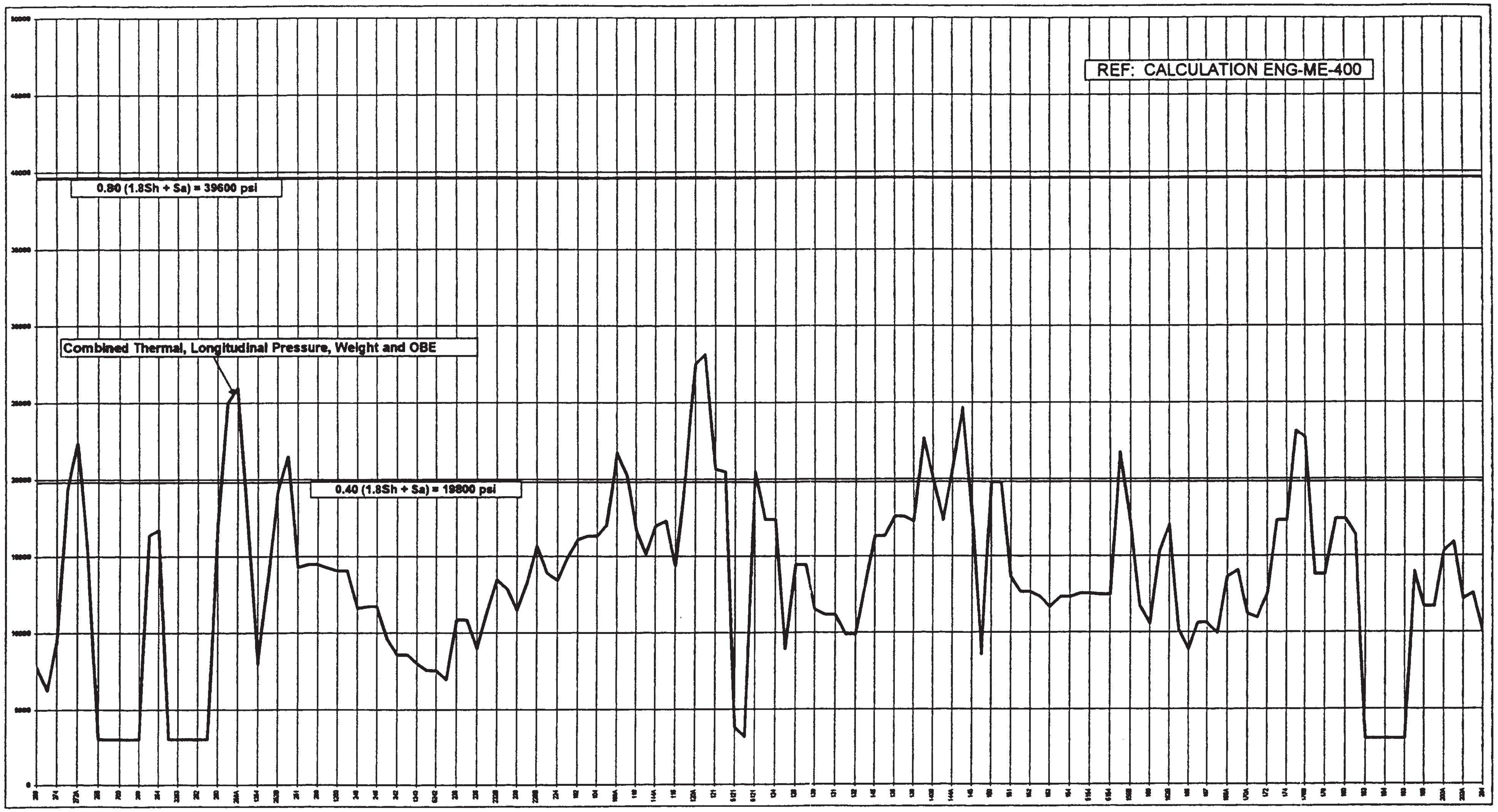
*21 STEAM GENERATOR SUPPLY TO AUX FEEDWATER PUMP

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING, MINNESOTA

SCALE NONE

FIGURE I.5.1-17 REV. 22

REVISIONS



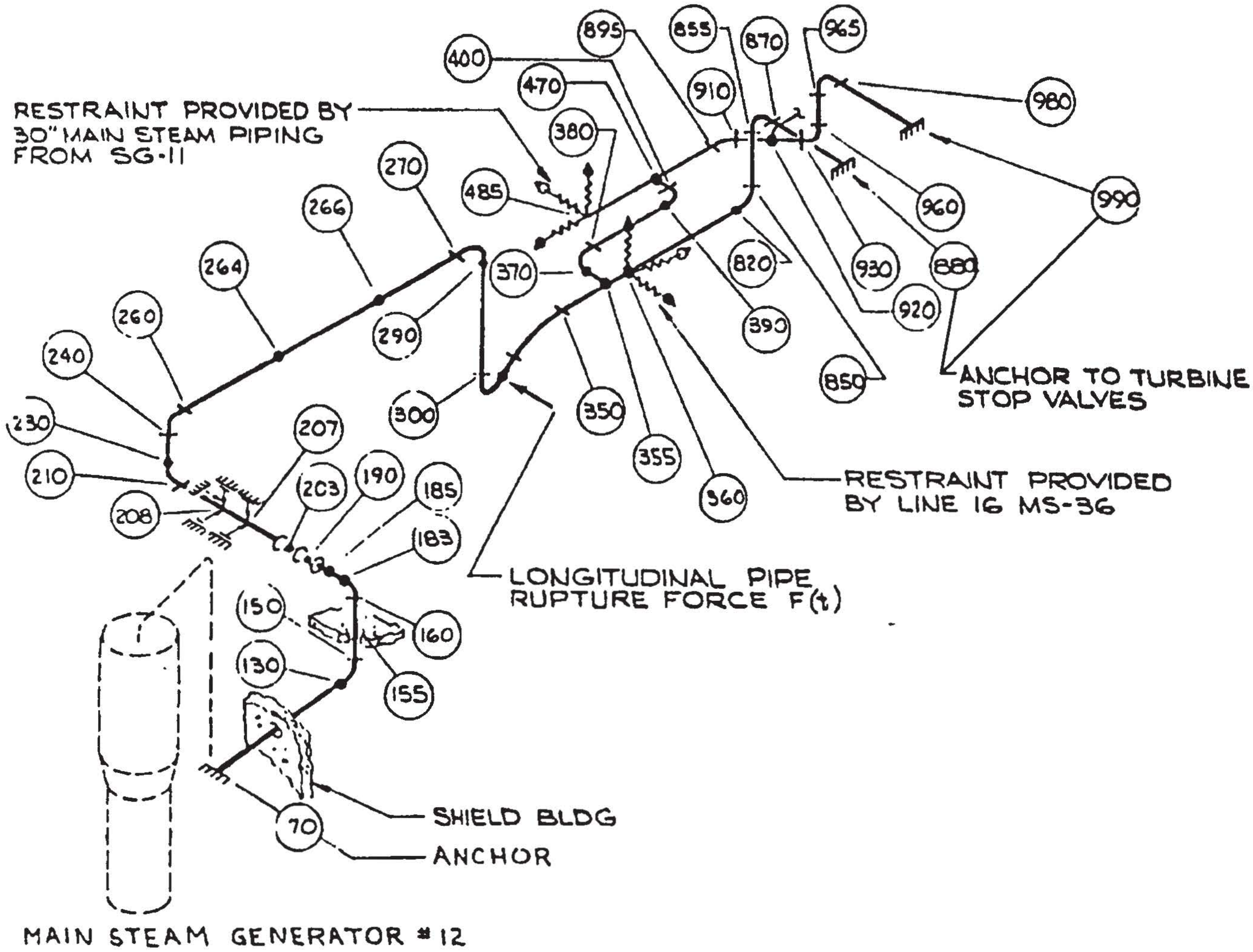
DWN TAM	DATE 11-23-99	SIGNIFICANT NO.						
CHECKED		GROUP	1	2	3	4	5	CL 6
PROJECT NO. ETNSUR								
APP'D & CERT.								
CAD FILE: UI5118.DGN								

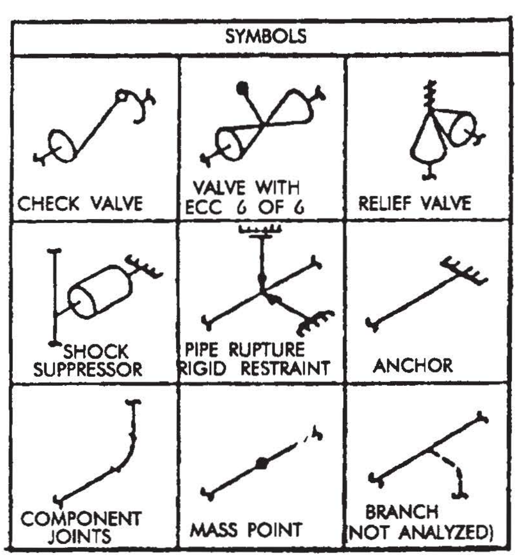
#22 STEAM GENERATOR
SUPPLY TO AUX FEEDWATER PUMP

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING, MINNESOTA

SCALE NONE

FIGURE I.5.1-18 REV. 22



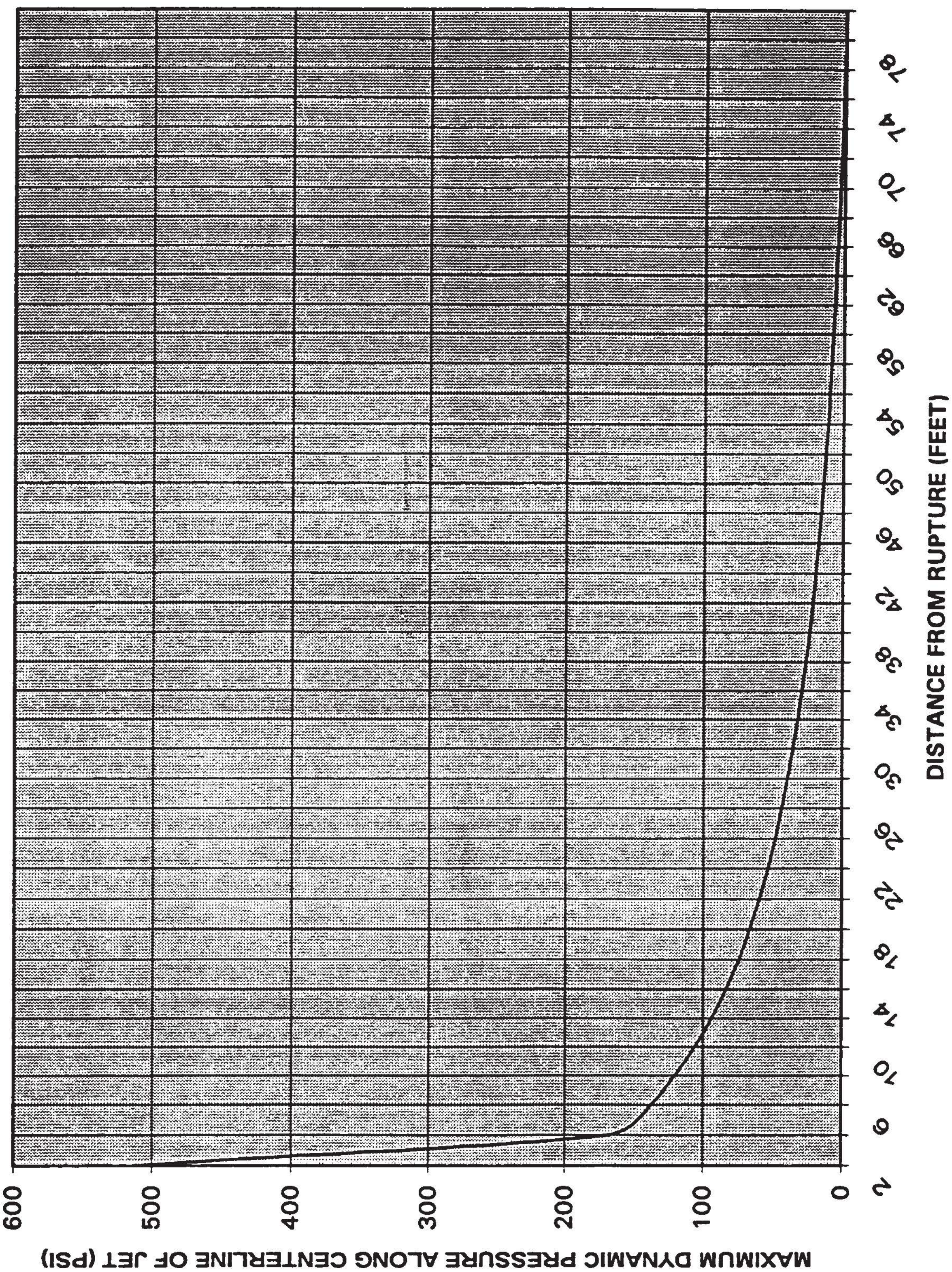


NOTE:

THIS FIGURE IS INTENDED TO ONLY DEPICT TYPICAL INSTALLATION DETAILS AND DOES NOT REPRESENT ALL INSTALLED CONFIGURATIONS.

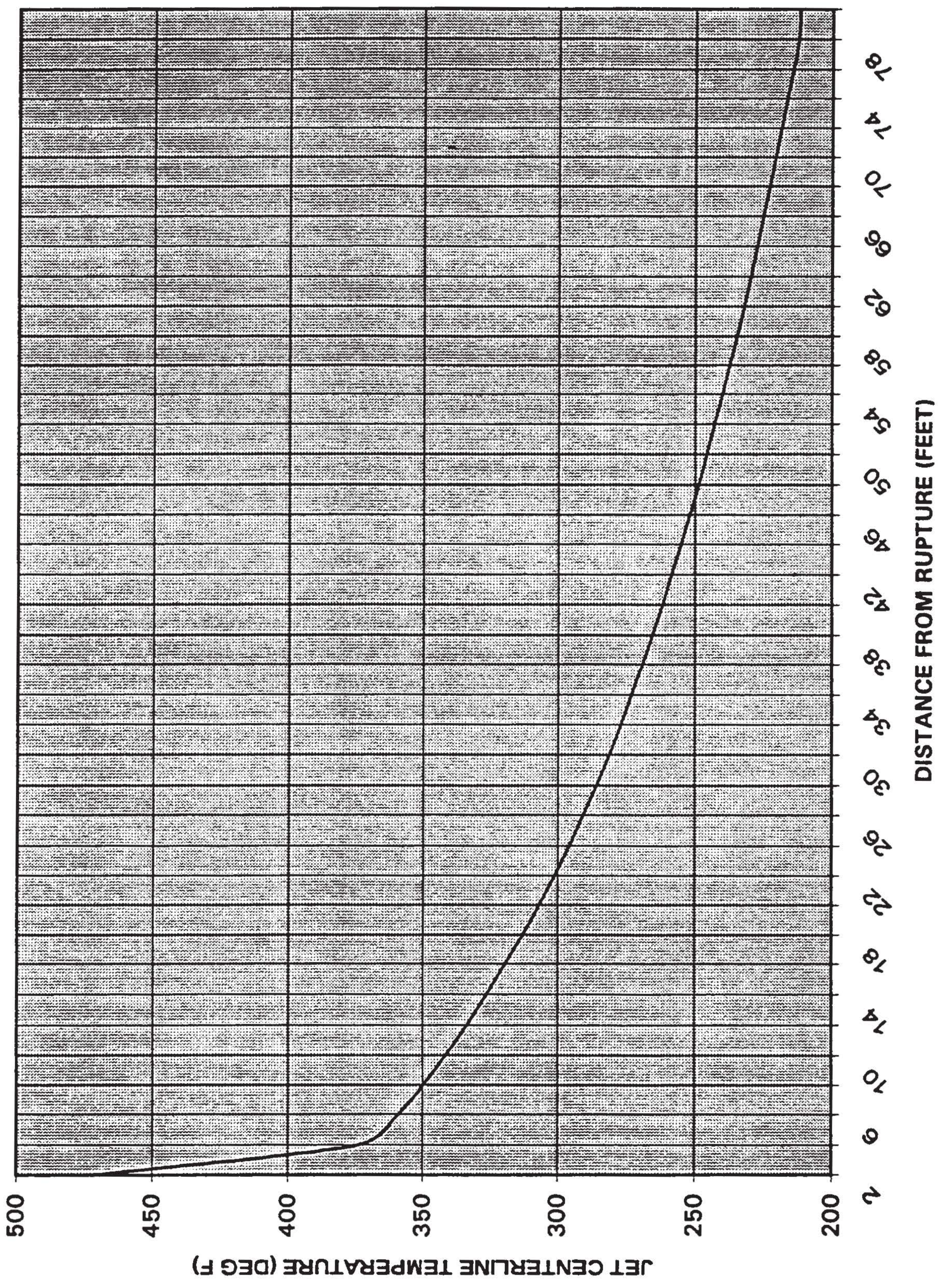
DYNAMIC ANALYSIS MATHEMATICAL MODEL
MAIN STEAM UNIT 1

DWN T. MILLER	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE
CHECKED	CAD FILE UI05119.DGN		FIGURE I.5.1-19 REV.22



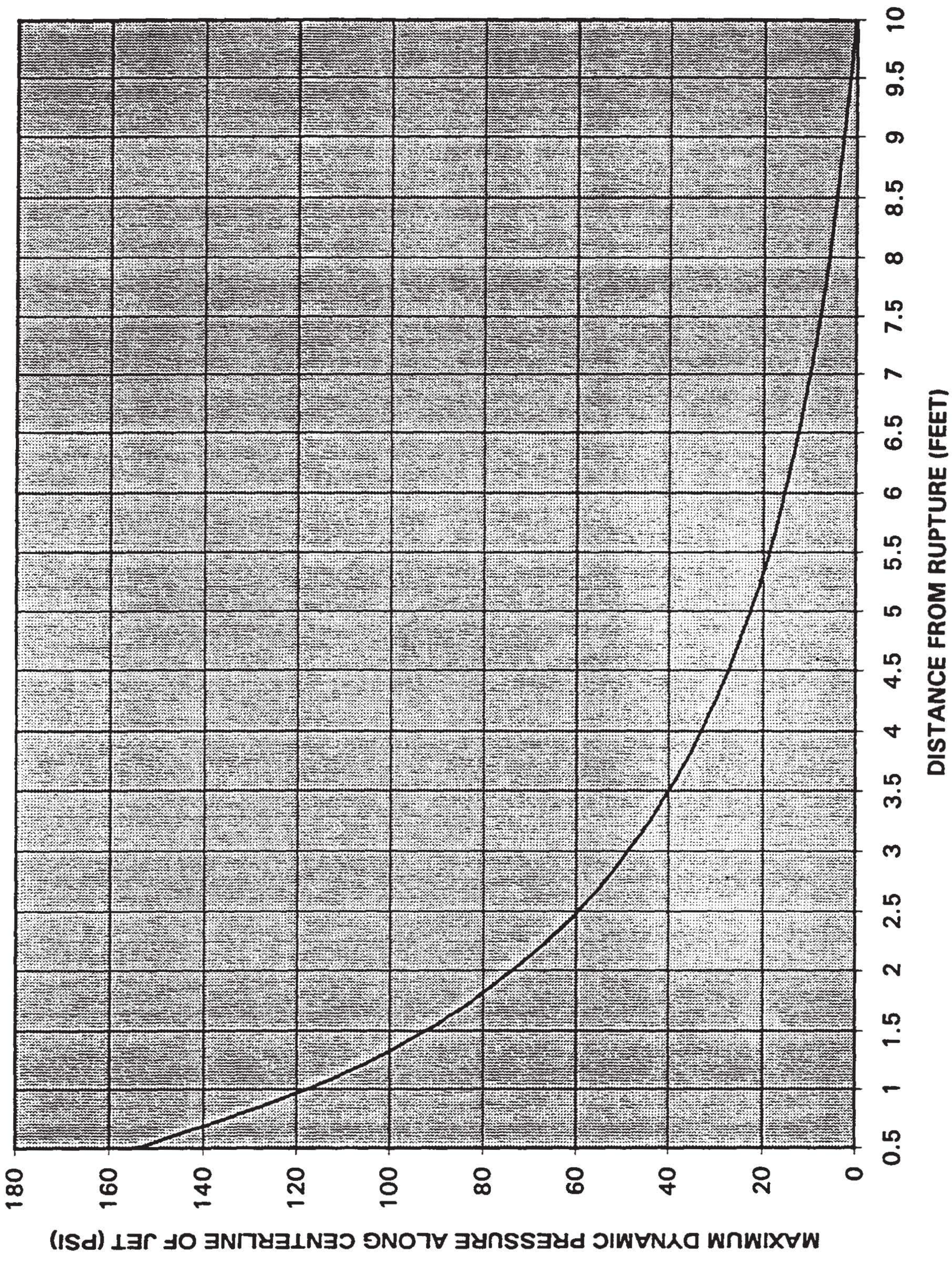
IMPINGEMENT PRESSURE 31" MAIN STEAM, DESIGN BASIS BREAK

DWN GLD	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE
CHECKED	CAD FILE UI5.4-1.DGN		**FIGURE I.5.4-1 REV. 22**



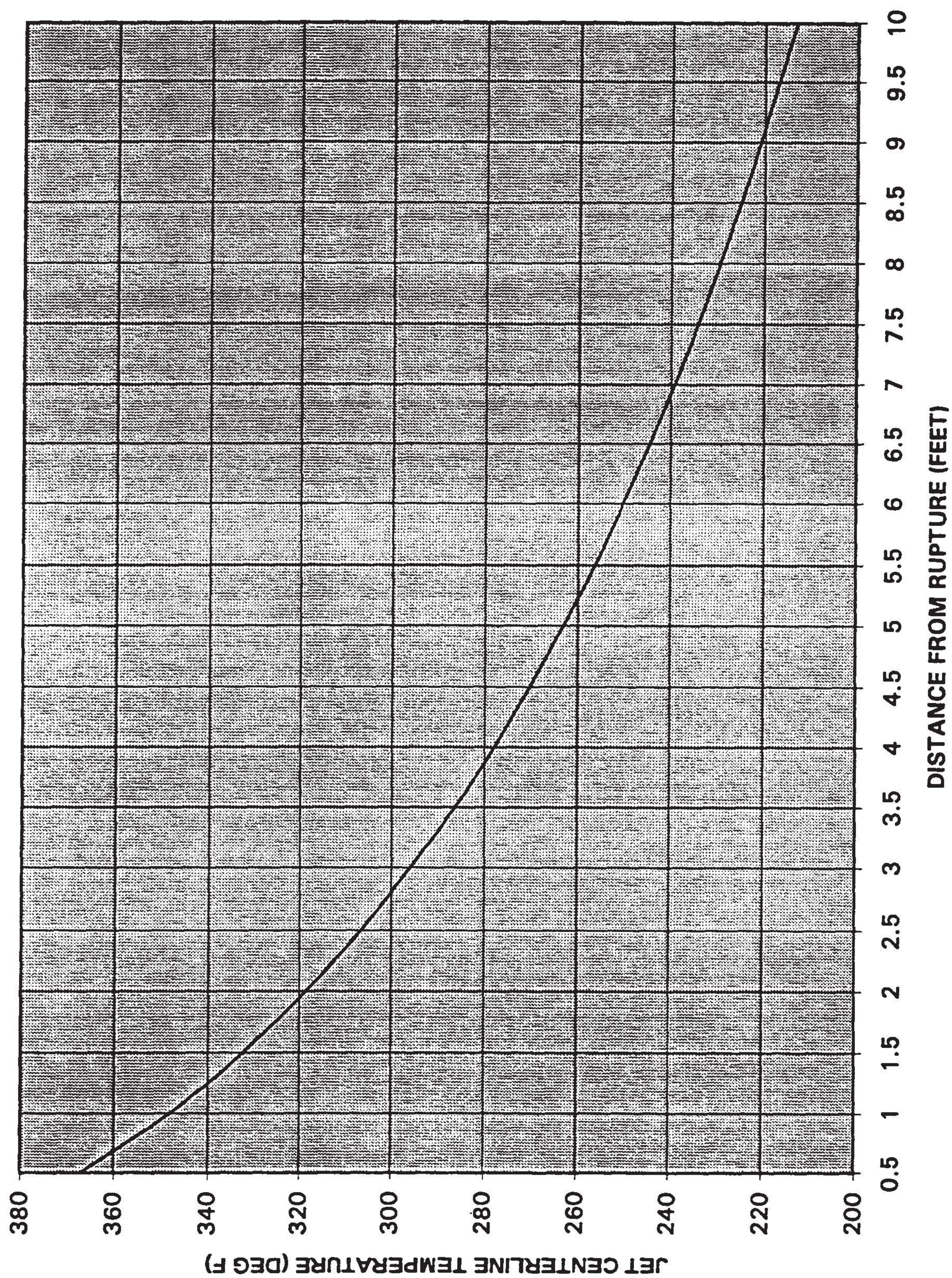
IMPINGEMENT TEMPERATURE 31" MAIN STEAM, DESIGN BASIS BREAK

DWN TAM	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE
CHECKED	CAD FILE UI5.4-2.DGN		FIGURE I.5.4-2 REV. 22



IMPINGEMENT PRESSURE 31" MAIN STEAM, DESIGN BASIS CRACK

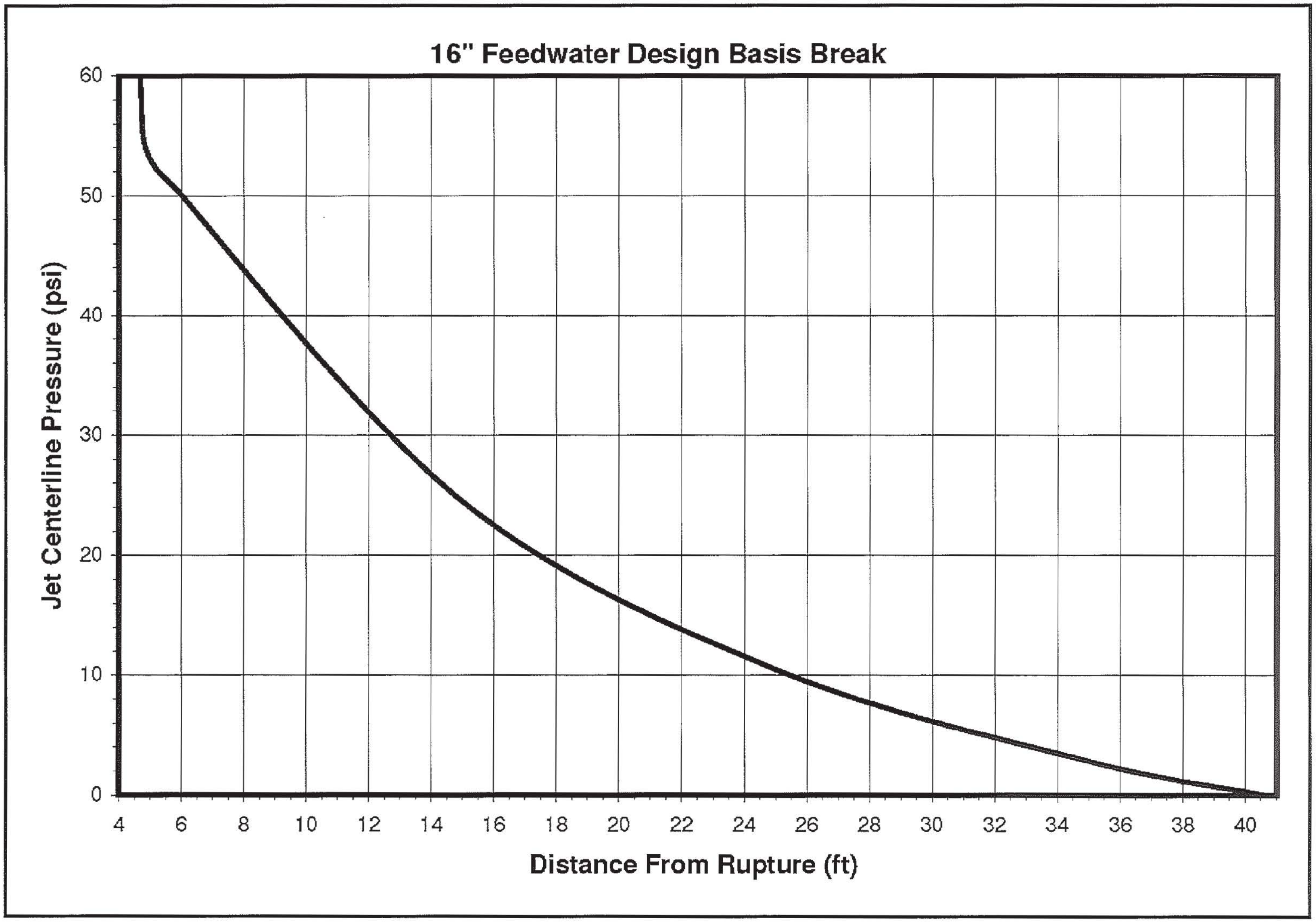
DWN TAM	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE
CHECKED	CAD FILE UI5.4-3.DGN		FIGURE I.5.4-3 REV. 22



IMPINGEMENT TEMPERATURE 31" MAIN STEAM, DESIGN BASIS CRACK

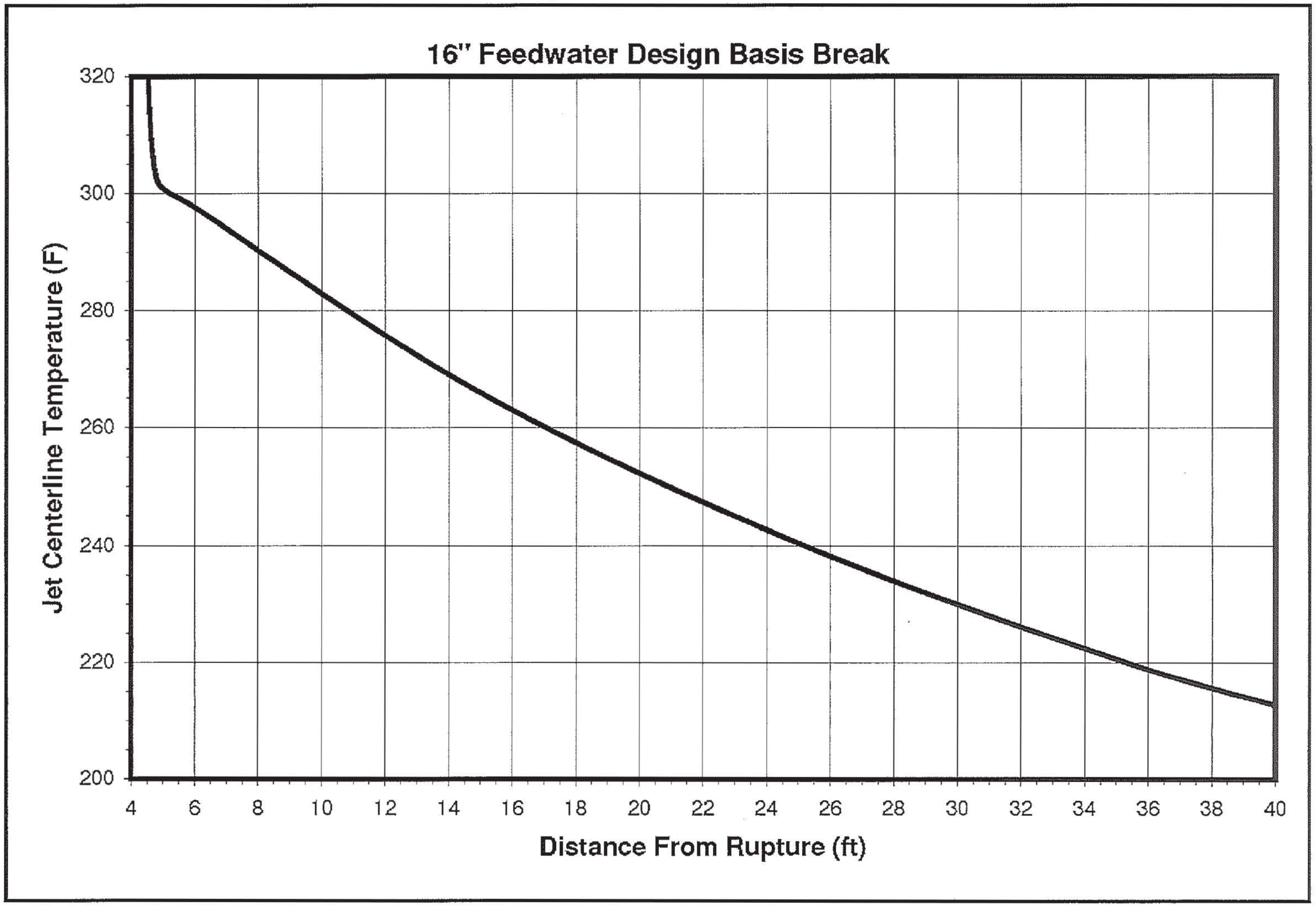
DWN TAM	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE
CHECKED	CAD FILE UI5.4-4.DGN		**FIGURE I.5.4-4 REV. 22**

16" Feedwater Design Basis Break - Pressure



16" Feedwater Design Basis Break - Pressure

16" Feedwater Design Basis Break - Temperature



16" Feedwater Design Basis Break - Temperature

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FIGURE I.5.4-6
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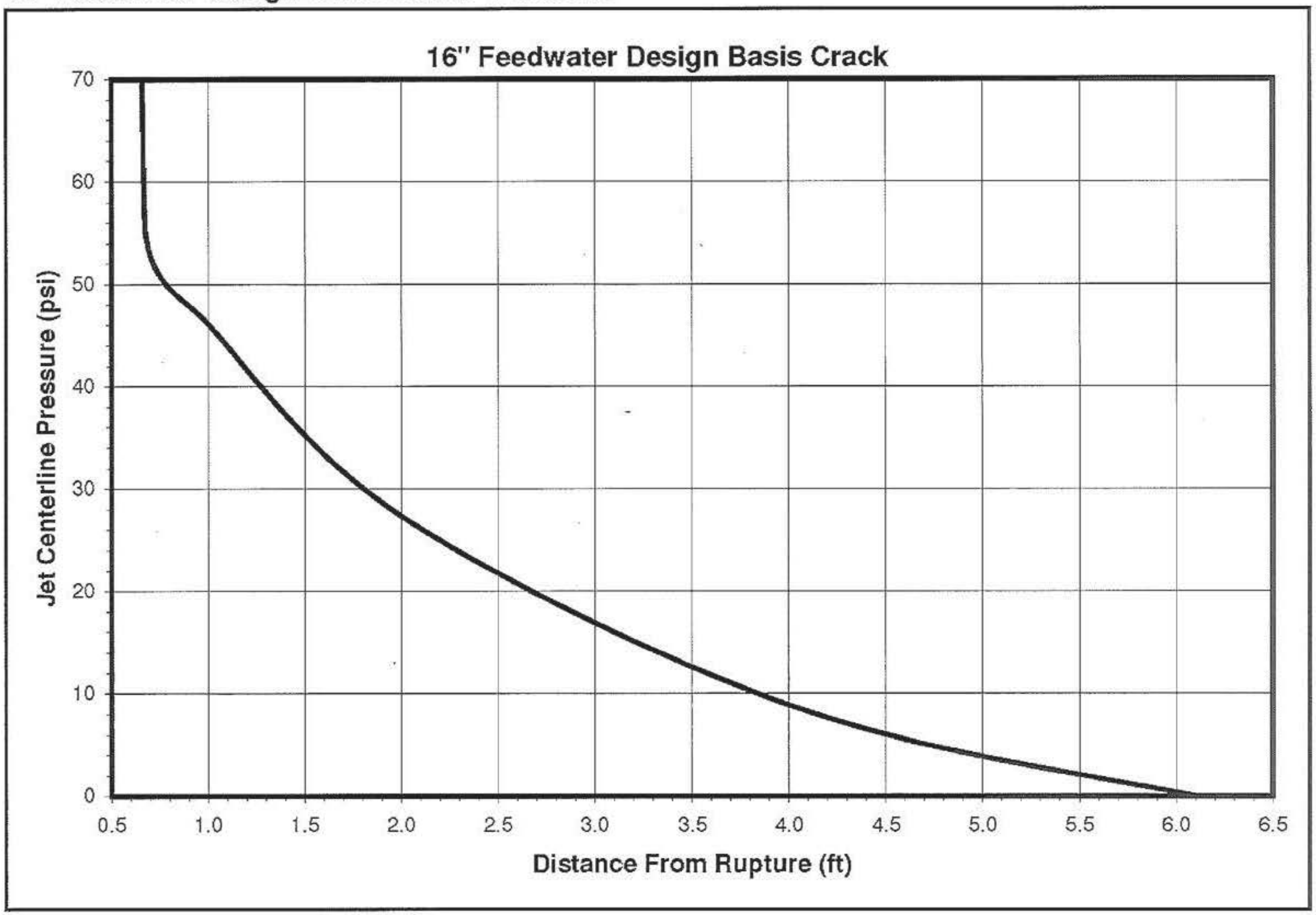
16" Feedwater Design Basis Crack - Pressure



16" Feedwater Design Basis Crack - Pressure

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FIGURE I.5.4-7
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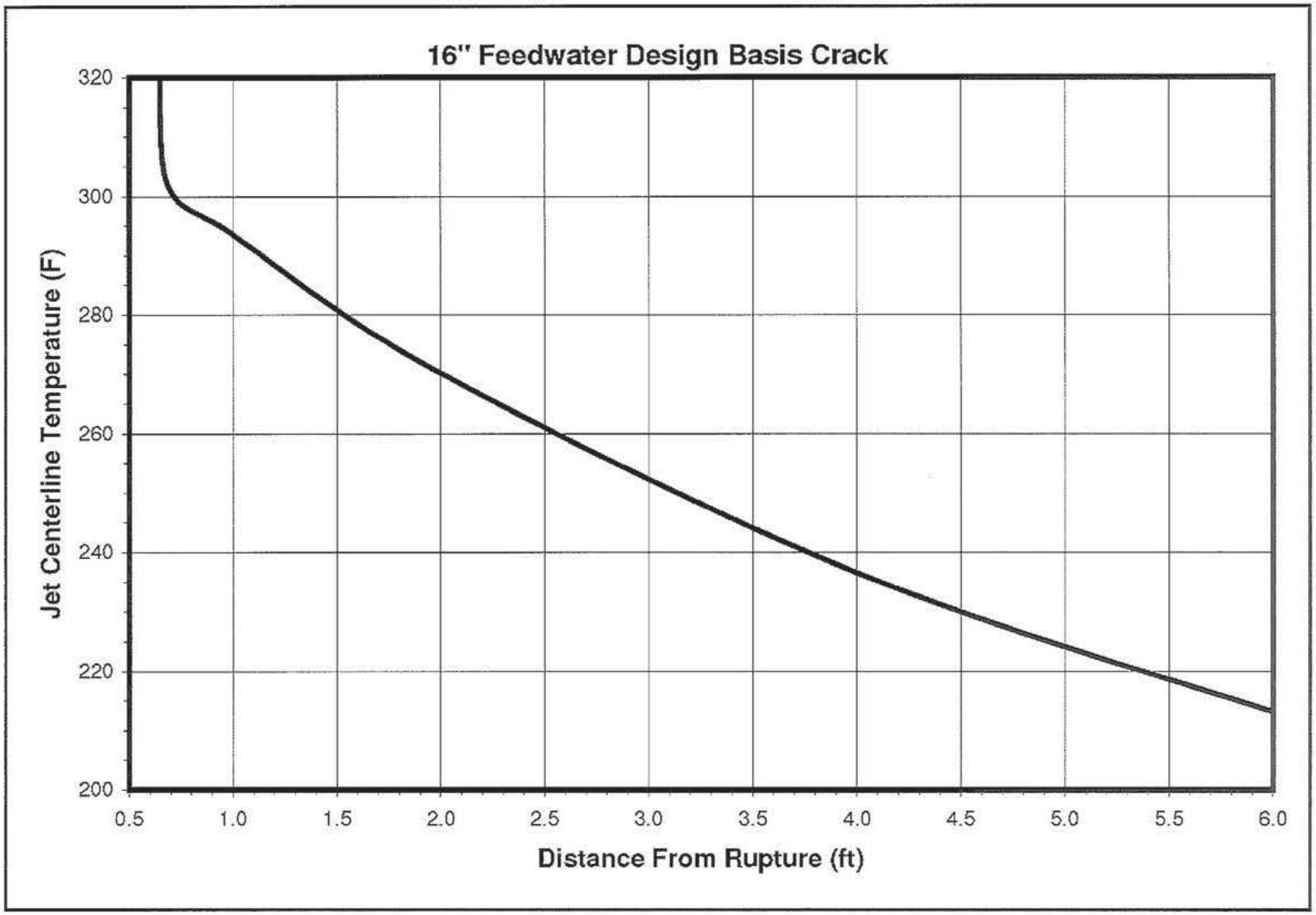
16" Feedwater Design Basis Crack - Temperature



16" Feedwater Design Basis Crack - Temperature

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FIGURE I.5.4-8
Revision 33

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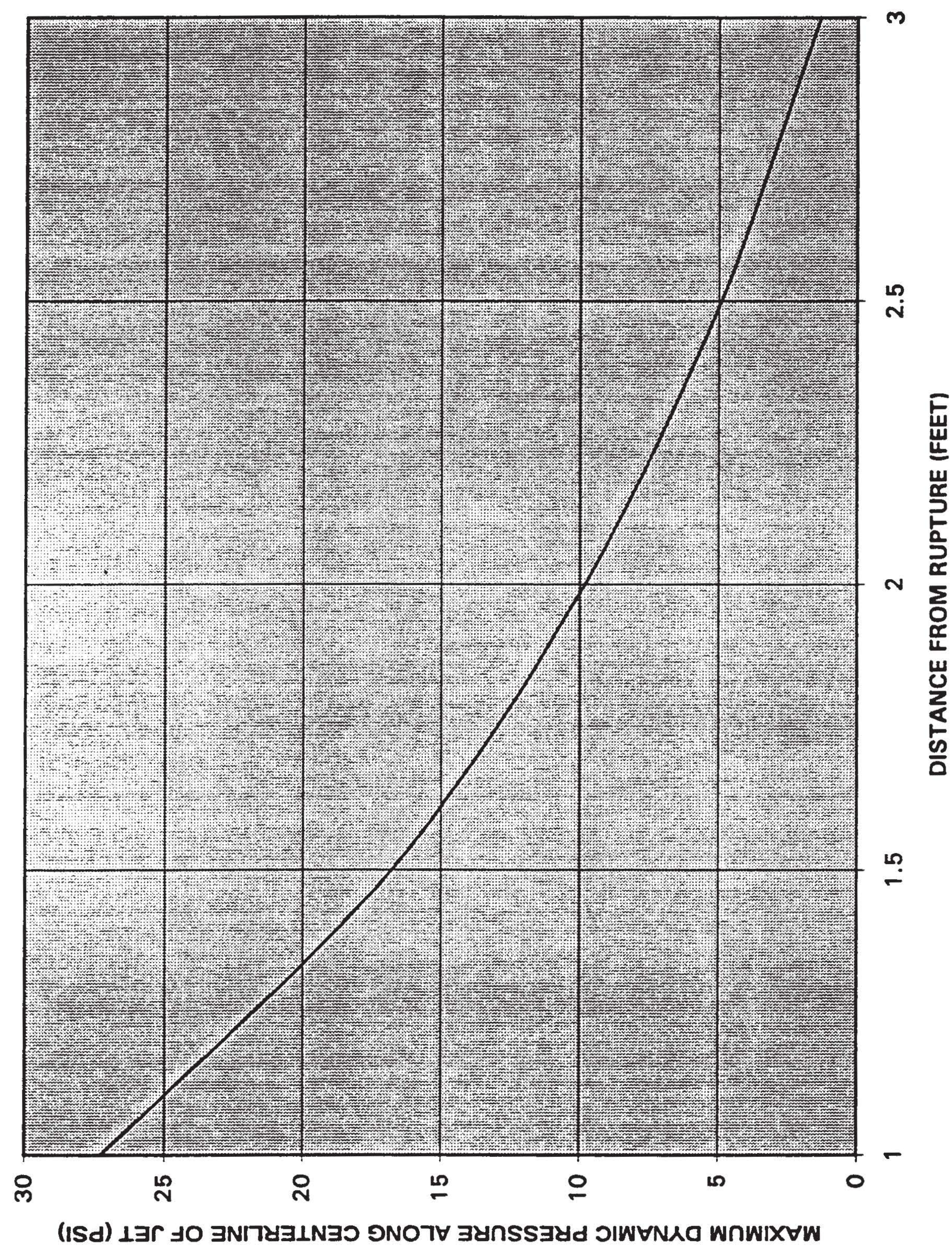
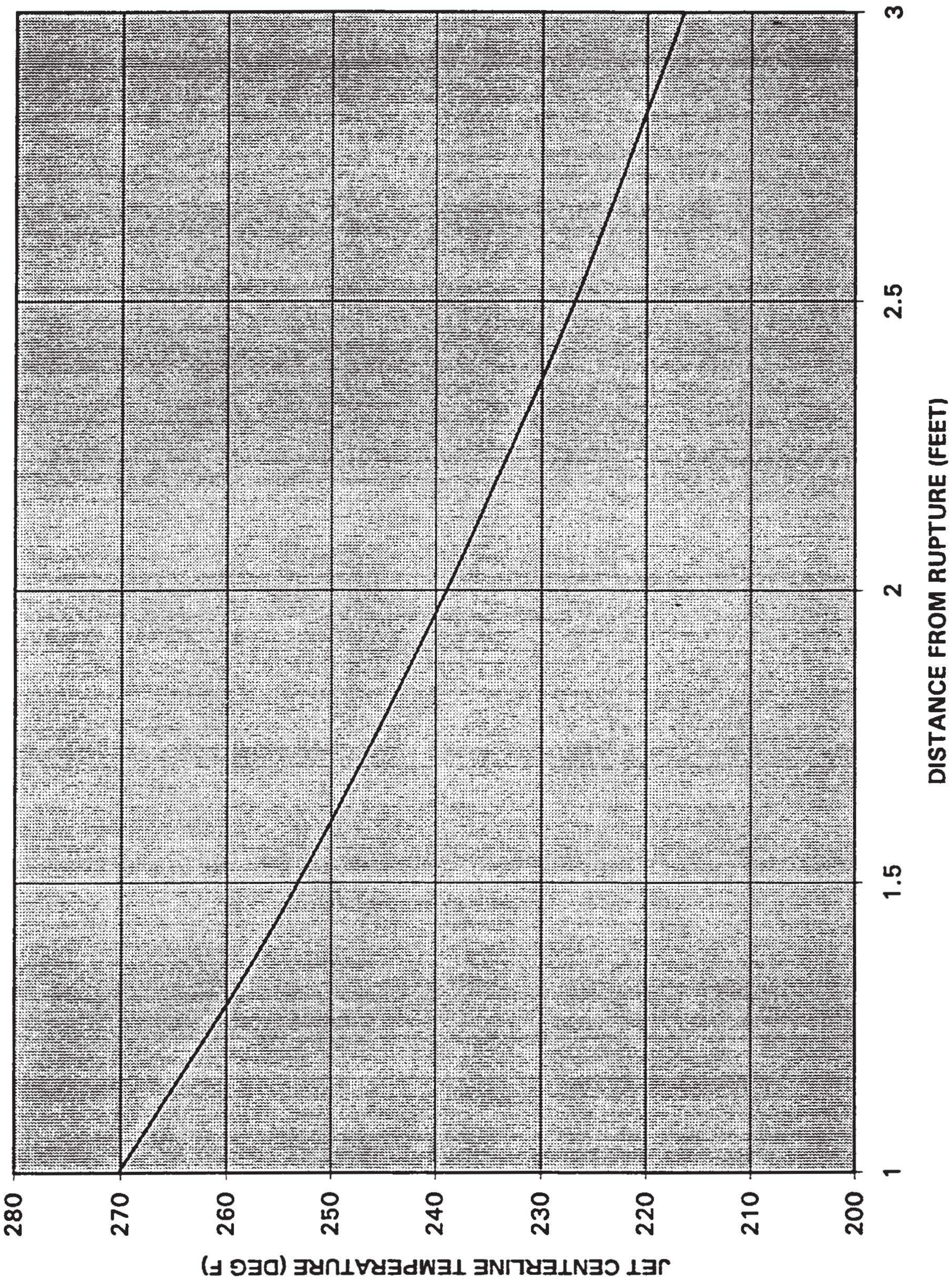


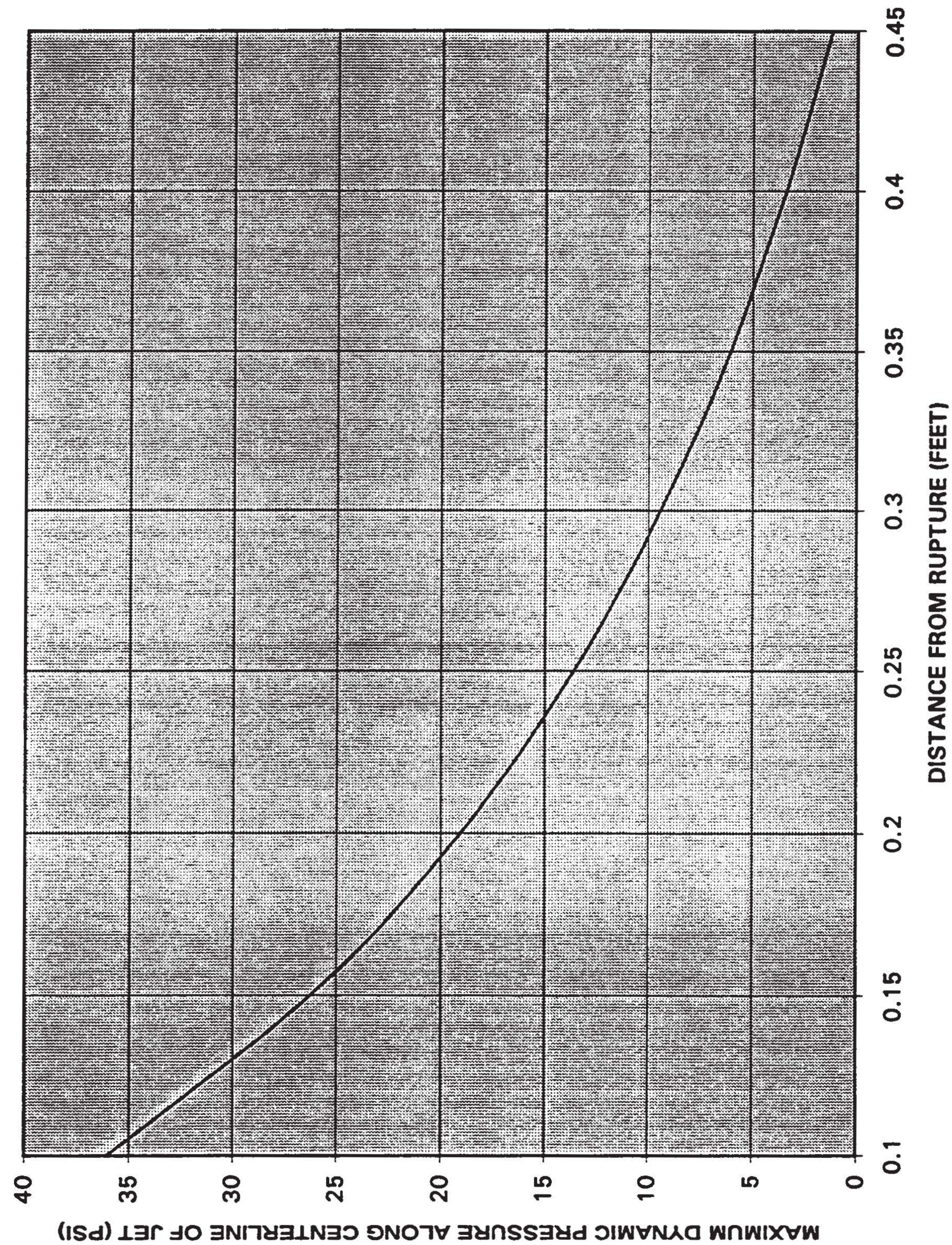
IMPINGEMENT PRESSURE 2" CVCS LETDOWN, DESIGN BASIS BREAK

DWN TAM	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE
CHECKED	CAD FILE UI5.4-9.DGN		FIGURE I.5.4-9 REV. 22



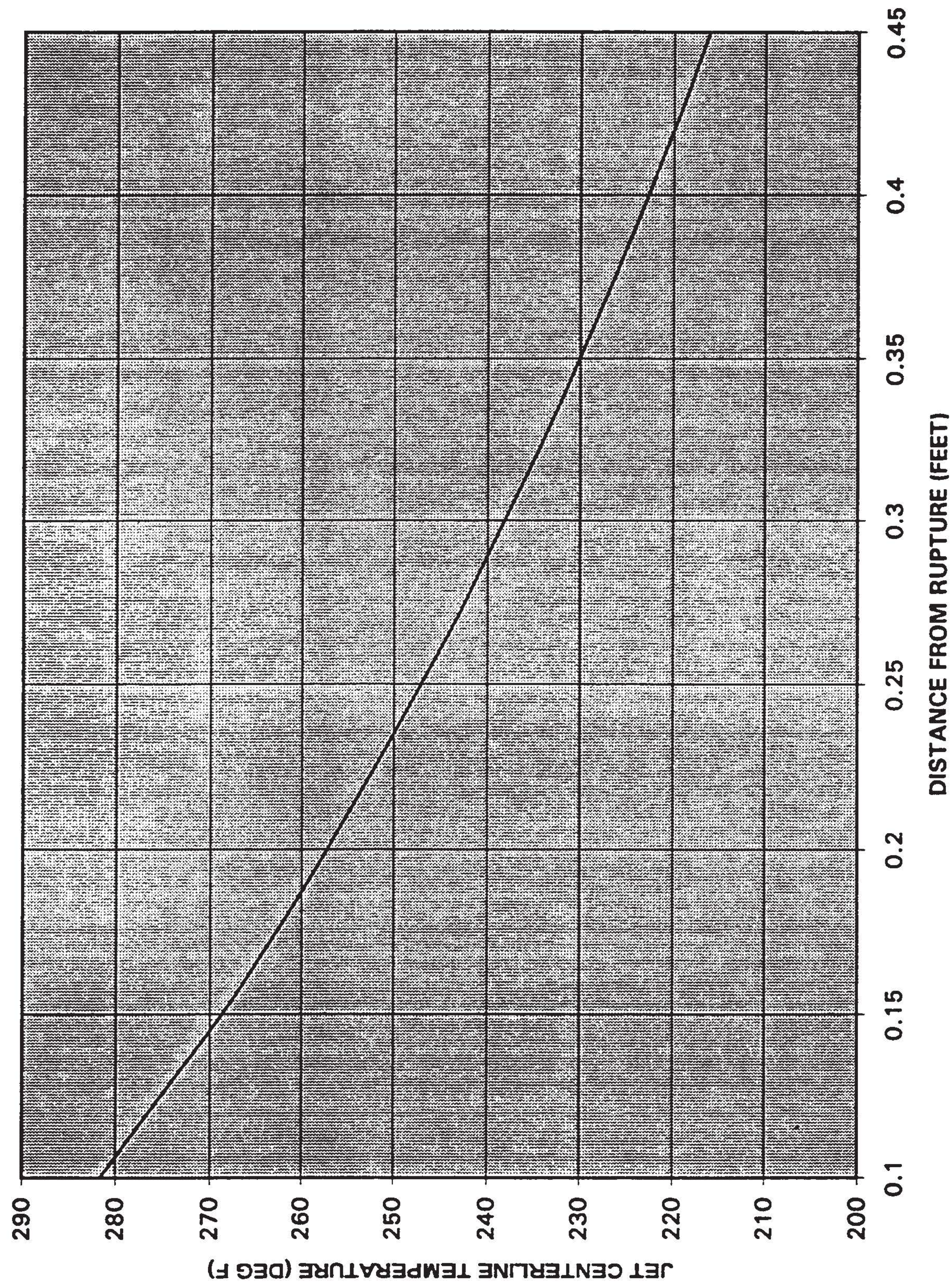
IMPINGEMENT TEMPERATURE 2" CVCS LETDOWN, DESIGN BASIS BREAK

DWN TAM	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE	
CHECKED	CAD FILE UI5.4-10.DGN		FIGURE I.5.4-10 REV. 22	



IMPINGEMENT PRESSURE 2" CVCS LETDOWN, DESIGN BASIS CRACK

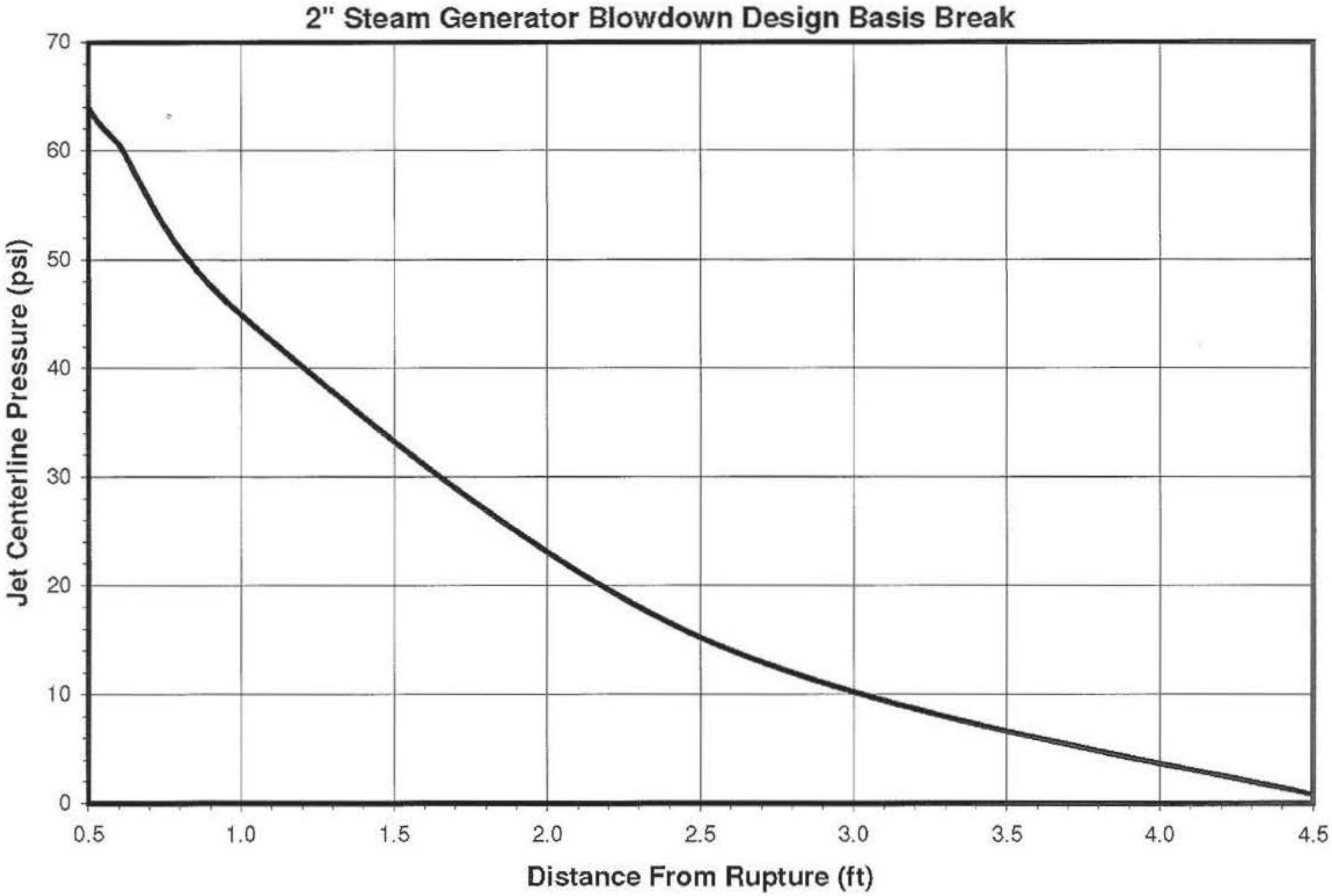
DWN TAM	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE
CHECKED	CAD FILE UI5.4-11.DGN		**FIGURE I.5.4-11 REV. 22**



IMPINGEMENT TEMPERATURE 2" CVCS LETDOWN, DESIGN BASIS CRACK

DWN TAM	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE	
CHECKED	CAD FILE UI5.4-12.DGN		FIGURE I.5.4-12 REV. 22	

2" Steam Generator Blowdown Design Basis Break - Pressure



2" Steam Generator Blowdown Design Basis Break - Pressure

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FIGURE I.5.4-13
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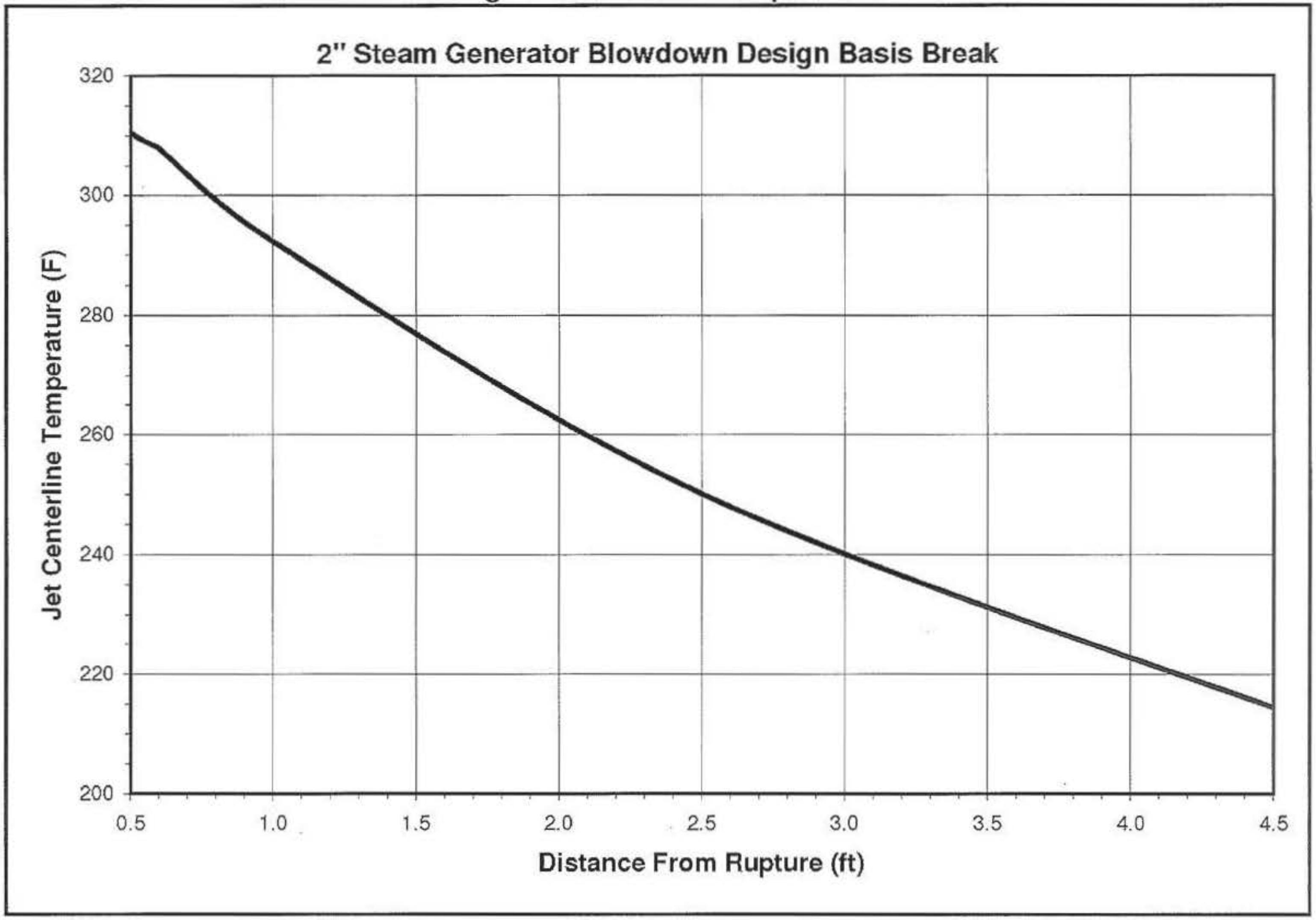
2" Steam Generator Blowdown Design Basis Break - Temperature



2" Steam Generator Blowdown Design Basis Break - Temperature

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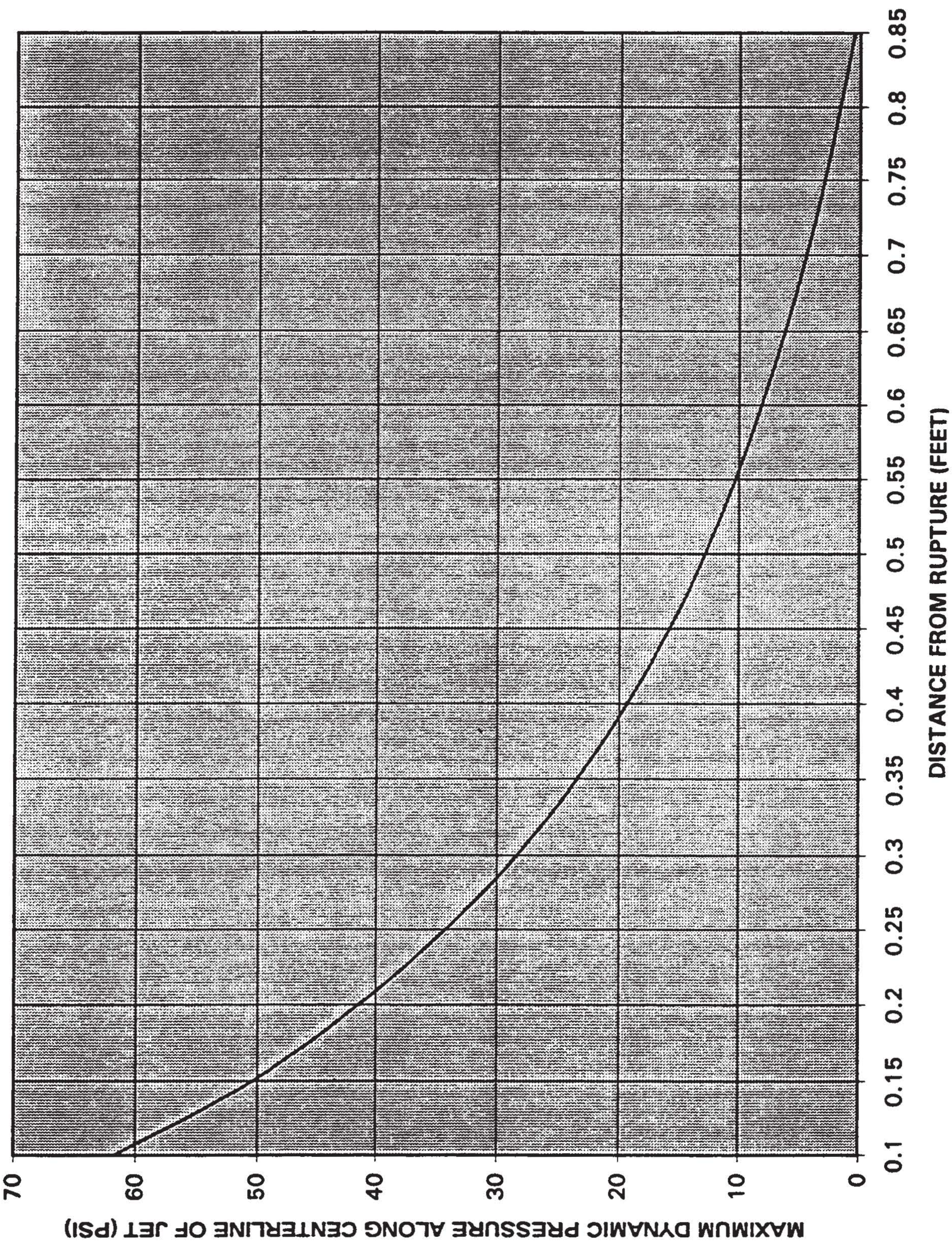
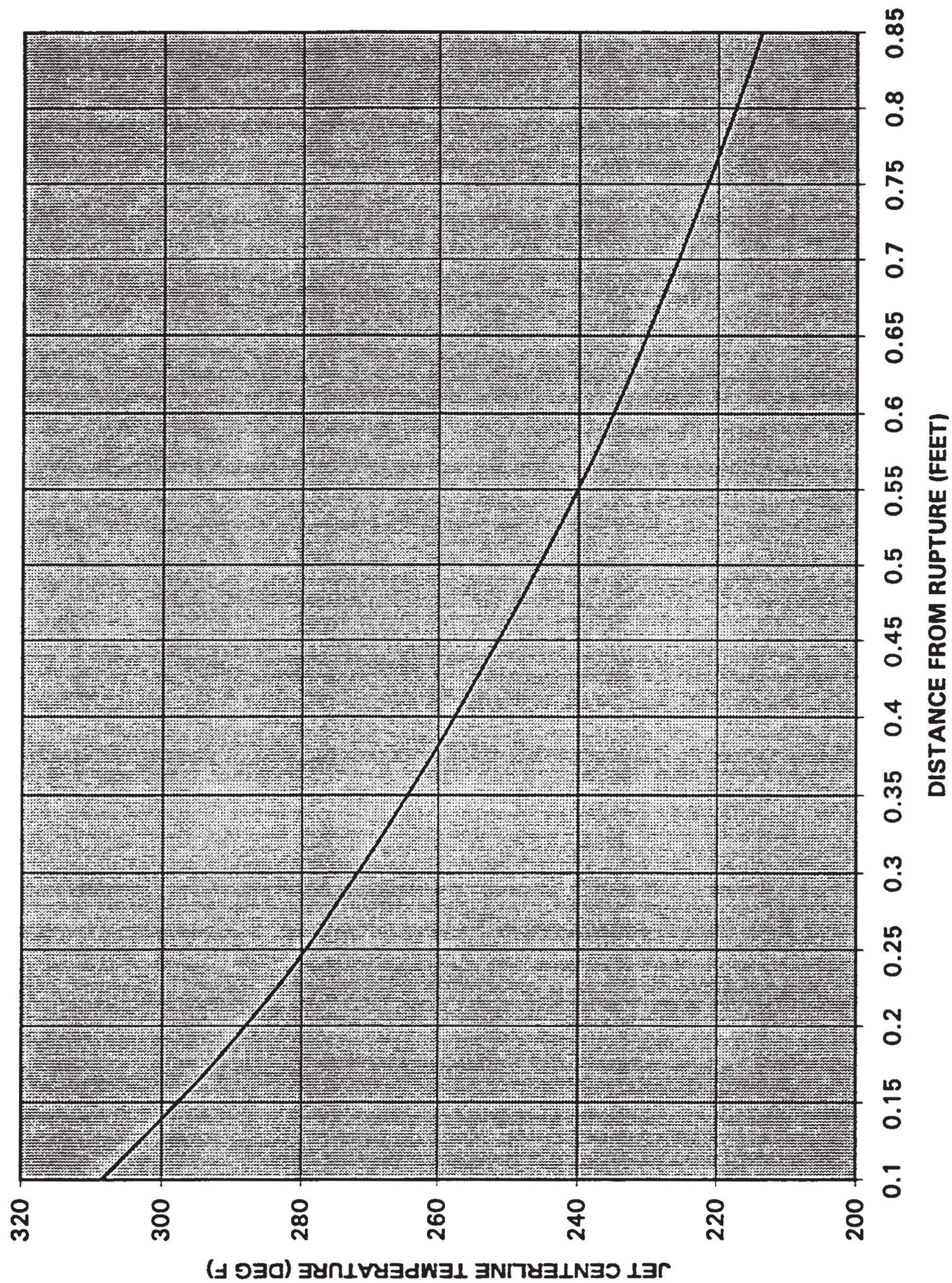
FIGURE I.5.4-14
Revision 33



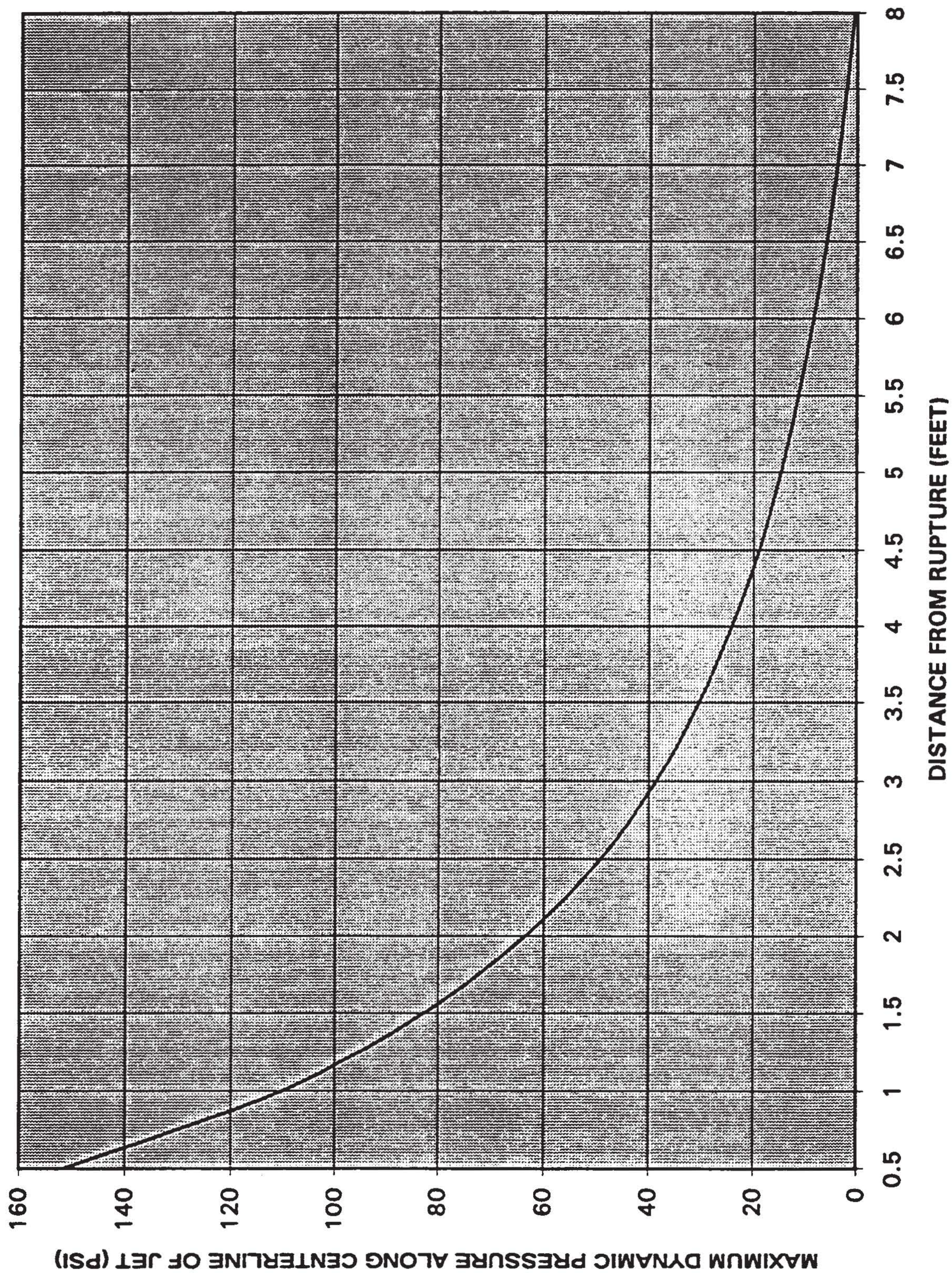
IMPINGEMENT PRESSURE 2" STEAM GENERATOR BLOWDOWN, DESIGN BASIS CRACK

DWN TAM	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE
CHECKED	CAD FILE UI5.4-15.DGN		**FIGURE I.5.4-15 REV. 22**



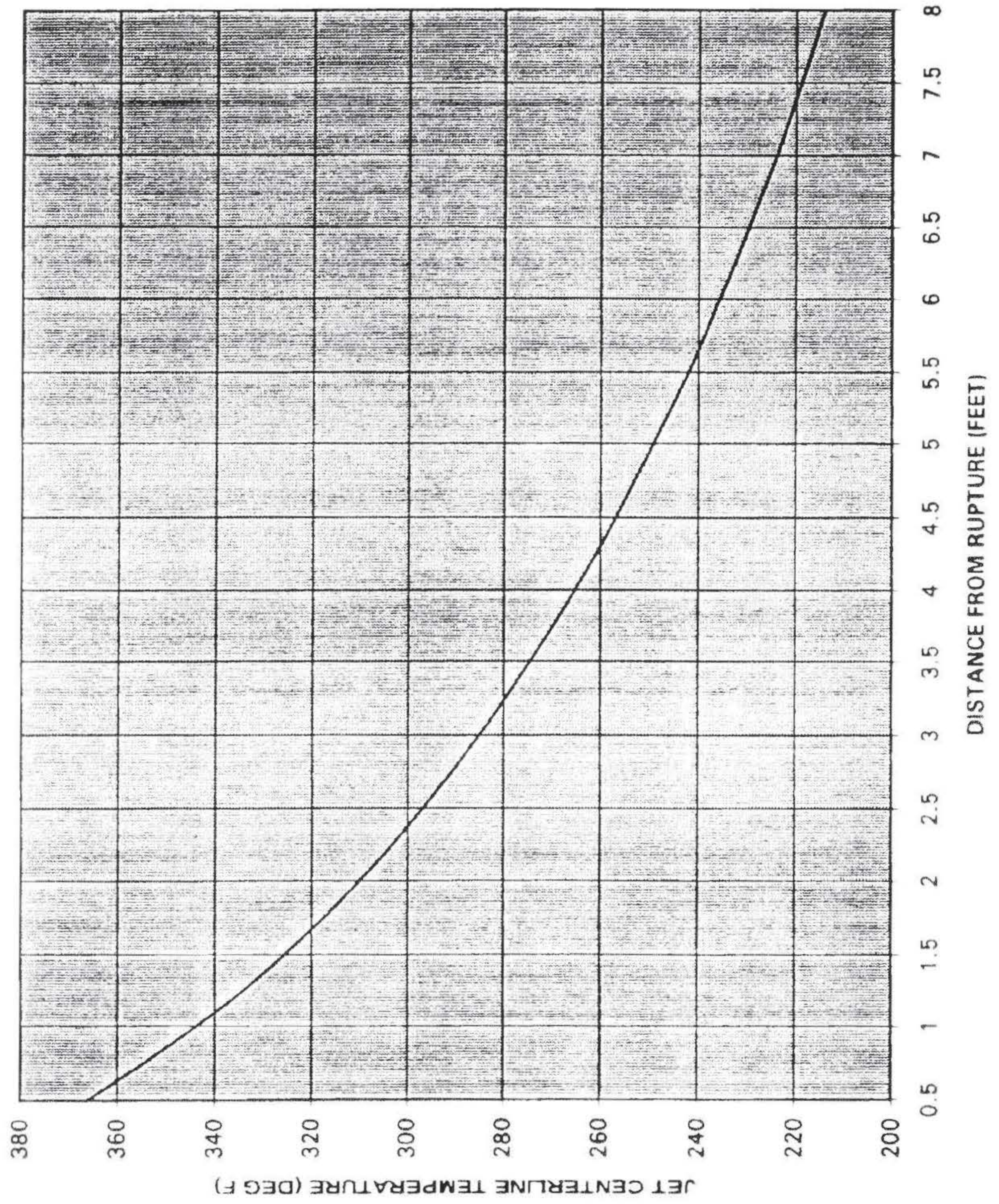
IMPINGEMENT TEMPERATURE 2" STEAM GENERATOR BLOWDOWN, DESIGN BASIS CRACK

DWN TAM	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE
CHECKED	CAD FILE UI5.4-16.DGN		FIGURE I.5.4-16 REV. 22



IMPINGEMENT PRESSURE 3" STEAM SUPPLY TO AUXILIARY FEEDWATER PUMP, DESIGN BASIS BREAK

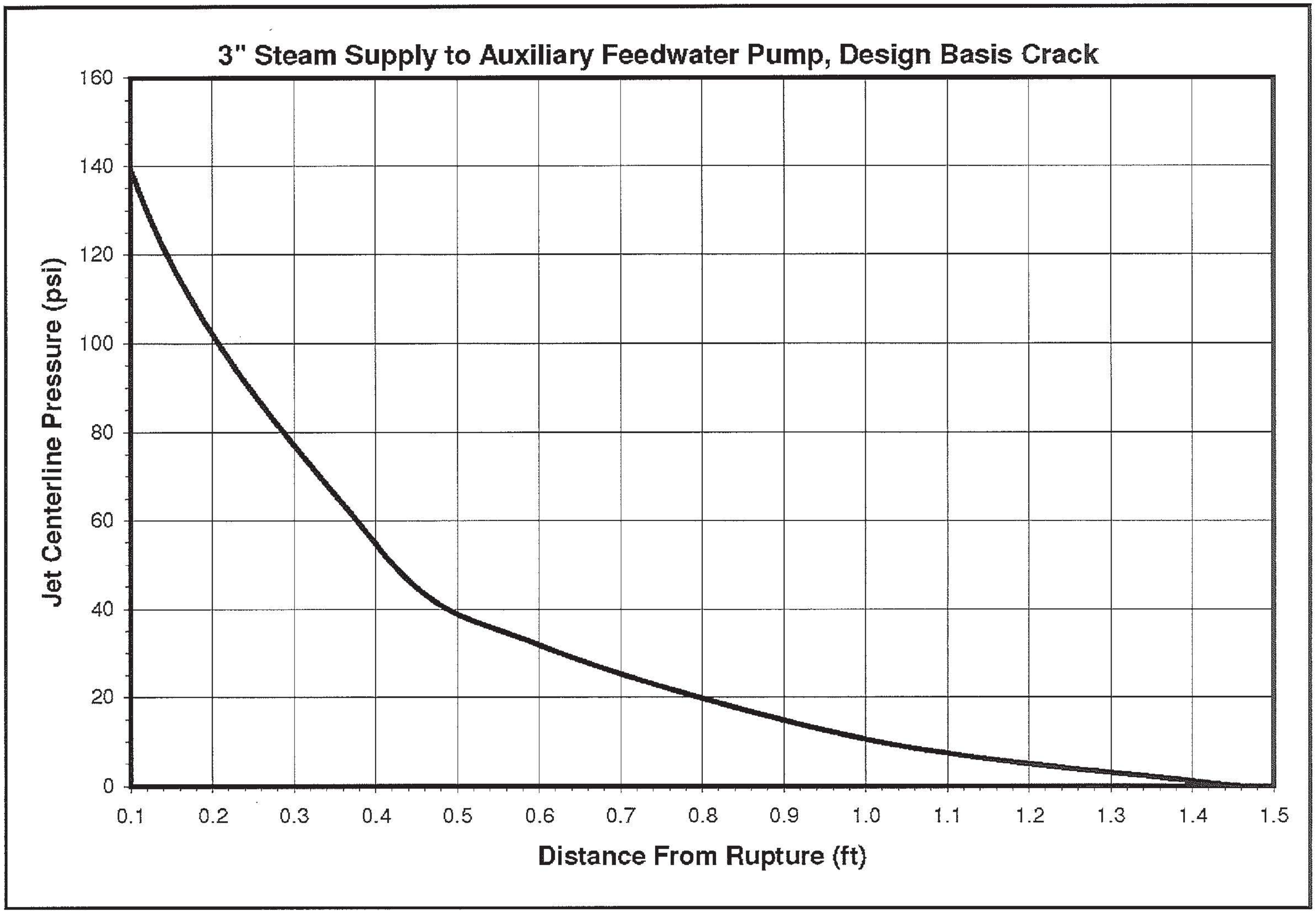
DWN TAM	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE
CHECKED	CAD FILE UI5.4-17.DGN		FIGURE I.5.4-17 REV. 22



IMPINGEMENT TEMPERATURE 3" STEAM SUPPLY TO AUXILIARY FEEDWATER PUMP, DESIGN BASIS BREAK

DWN TAM	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE
CHECKED	CAD FILE UI5.4-18.DGN		FIGURE I.5.4-18 REV.22

3" Steam Supply to Auxiliary Feedwater Pump, Design Basis Crack - Pressure



3" Steam Supply to Auxiliary Feedwater Pump, Design Basis Crack - Pressure

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FIGURE I.5.4-19
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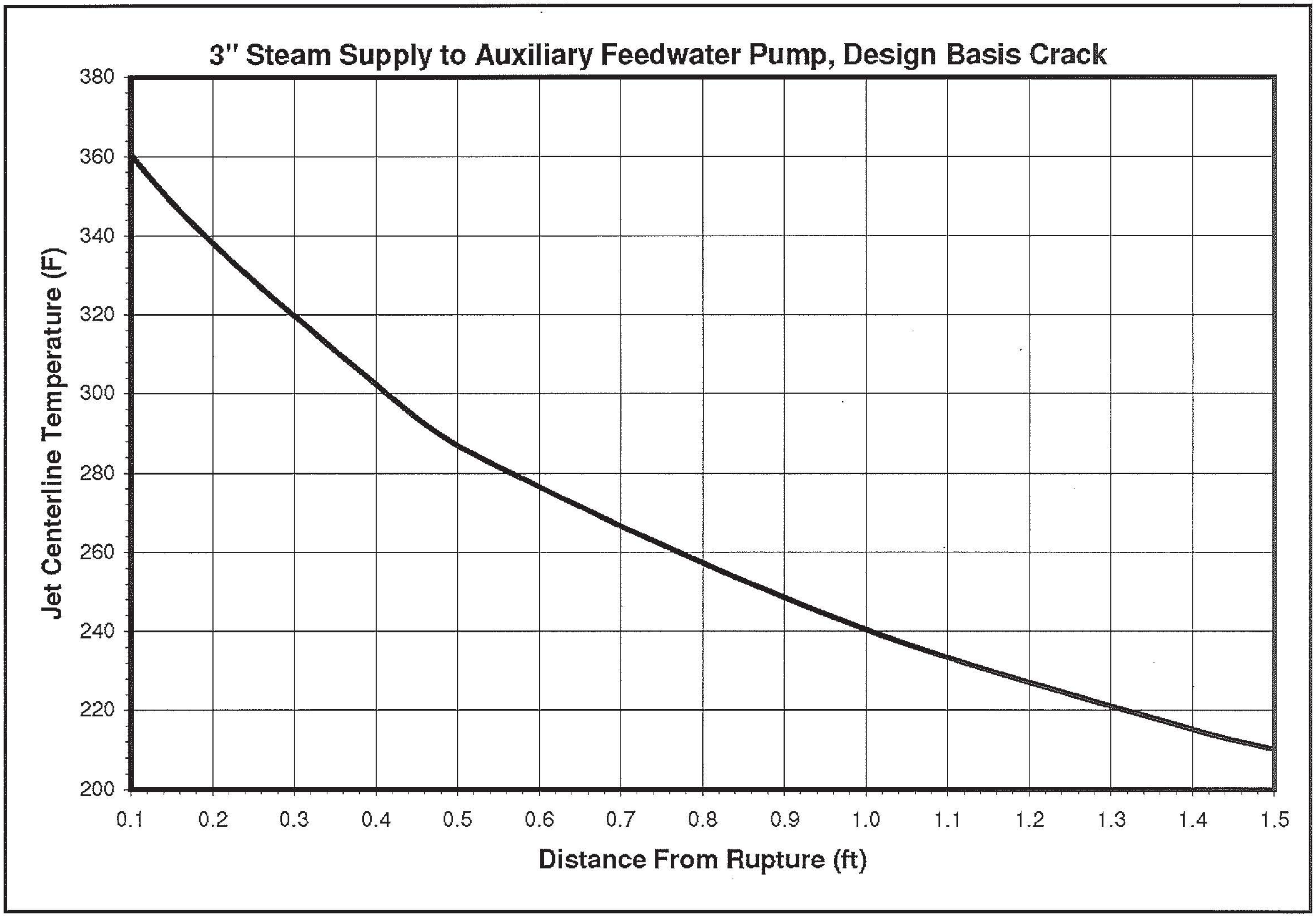
3" Steam Supply to Auxiliary Feedwater Pump, Design Basis Crack - Temperature



3" Steam Supply to Auxiliary Feedwater Pump, Design Basis Crack - Temperature

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FIGURE I.5.4-20
Revision 33

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