UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
SUPPORTING AMENDMENT NO. 51 TO LICENSE NO. DPR-20
CONSUMERS POWER COMPANY
PALISADES PLANT
DOCKET NO. 50-255

1.0 Introduction

By letter dated January 3, 1978, Consumers Power Company (CPC) requested changes to the Technical Specifications for the Palisades Plant. The proposed changes would establish requirements related to prevention of low temperature overpressurization events. Supporting information was submitted by letters dated March 8, 1977, June 24, 1977, and November 28, 1977. The CPC submittals are in response to NRC requests related to the generic issue of PWR overpressure protection.

2.0 Background

The history of the generic low temperature overpressure protection issue is described in NUREG-0138 (Reference 1). Briefly, a series of over thirty incidents had occurred in pressurized water reactors (PWRs) since 1972 in which the Appendix G pressure-temperature limits had been exceeded at temperatures less than normal operating temperature.

These incidents consisted of two varieties of pressure transients: a mass input type from charging pumps, safety injection pumps, or safety injection accumulators, and an energy input type caused by thermal feedback when a reactor coolant pump (RCP) sweeps cooler primary system water through a steam generator with a hot secondary side. These incidents usually occurred in a water solid system during startup or shutdown operations.

Pressure transients which could occur at normal operating temperature, approximately 570°F, are mitigated in most plants by large code safety valves located on the pressurizer. These are mechanical valves which open against a spring pressure of about 2400 psia. The code safety valves are quite simple, having no electrical components, and as such are considered passive, failure free components. These code safety valves are tested in accordance with ASME Code, Section XI requirements.

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Prior to the introduction of an overpressure protection system (OPS), pressure transients initiated while operating at lower temperatures were not protected against and there were no pressure relief devices in the reactor coolant system to prevent these transients from exceeding the Appendix G pressure-temperature limits. Nuclear reactors such as Palisades, which have a pressure limit in excess of 2500 psia at 570°F, have only a 700 psia limit at 200°F. The code safety valves with settings in the 2400 psia range would not be able to relieve a pressure transient at low reactor coolant system (RCS) temperature without the limits of 10 CFR Part 50 Appendix G being violated by a large amount.

The Appendix G pressure limit drops off rapidly at lower temperatures because the reactor vessel material and welds have significantly less toughness at lower temperatures and are therefore more susceptible to flaw induced failure. In addition, factors such as copper content in welds and neutron fluence levels affect the material toughness and contribute to the reduction in safety margin to vessel failure at low temperature conditions.

In a series of meetings and through correspondence with PWR vendors and licensees, the staff developed a set of criteria, which if adhered to, would produce an acceptable OPS. These criteria are:

a. Operator Action - No credit can be taken for operator action until ten minutes after the operator is aware, through an action alarm, that a pressure transient is in progress.

b. Single Failure Criterion - The low temperature overpressure protection system should be designed to protect the reactor vessel given a single failure in addition to the event that initiated the pressure transient.

c. Testability - The system must be testable on a periodic basis on a schedule consistent with the frequency that the system is relied upon for low temperature overpressure protection.

d. Seismic and IEEE 270 Criteria - The system should meet both seismic Category I and IEEE 279 criteria. The basic objective is that the system should not be vulnerable to a failure mode that would both initiate a pressure transient and disable the overpressure mitigating system. Such events as loss of instrument air and loss of offsite power must be considered.

In addition to the four formally stated criteria mentioned above, a number of additional criteria were established in the process of the staff review of generic submittals from the various vendors and in the exchange of information between the staff and the licensees.

Foremost among these was the requirement that the licensees show protection for the limiting mass addition transient regardless of the administrative procedures proposed to eliminate that potential scenario. Each licensee, therefore, was required to analyze the effects of the single pump start which would produce the most limiting mass addition transient and most severely challenge the Appendix G limits.

For the worst case energy addition transient the licensees were allowed to limit the severity of the transient in their analyses by assuming a maximum ΔT across the steam generator. By maximum ΔT we mean the maximum difference in the temperature between the primary loop coolant and the secondary loop water in the steam generator. For this case and for other scenarios the licensees were required to develop Technical Specifications which delineated the actions required to limit the severity of these scenarios and also provide justification for their action.

Another criterion for the design of the OPS was that the electrical instrumentation and control system provide a variety of alarms to alert the operator to 1) properly enable the low temperature OPS at the proper temperature during cooldown, and 2) indicate if a pressure transient was occurring. Additionally the electrical system had to provide positive assurance that the isolation valve upstream of each PORV was open when the system was enabled by wiring its position into the enable alarm. The enable alarm would not be permitted to clear until the OPS mode selector switch for each PORV system was placed in the low pressure setpoint position <u>and</u> the isolation valve was opened.

The Combustion Engineering Owner's Group, comprised of five utilities, submitted a generic overpressurization protection report prepared by Combustion Engineering (CE) (Reference 2). The generic report provided information on RCS response to postulated pressure transients that occur at low temperatures during heatup and cooldown, and provided a general description of design modifications which could be used to prevent overpressurization of CE designed Nuclear Steam Supply Systems (NSSS). In Reference 3 CPC pointed out the difference between the Palisades plant and the 2560 MWt class of plants covered in the generic report in terms of equipment and operating procedures. The staff, in conjunction with its review of the CE generic report, requested that CPC commit to a schedule for implementing a permanent or interim version of the OPS by December 31, 1977, and requested additional information related to the application of the generic aspect of the OPS as pertinent to the Palisades plant (Reference 4). In References 4 through 8 the licensee submitted additional information to the staff on equipment and procedural improvements as well as a schedule for implementation of the proposed system.

The system proposed by CPC for Palisades incorporates a defense in depth concept for overpressure protection, utilizing operator training, administrative procedures, Technical Specifications, and hardware improvements to meet the criteria established by the staff. The objective of the OPS is, first, to ensure that pressure transients while operating at low RCS temperatures become and remain unlikely events, and second, to mitigate the consequences of a pressure transient should one occur. The proposed mitigating system includes sensors, actuating mechanisms, and valves to prevent a RCS pressure transient from exceeding the pressure-temperature limits included in the Palisades Technical Specifications as required by Appendix G to Chapter 10, Code of Federal Regulations, Part 50 (10 CFR 50).

The Palisades final OPS was installed during the 1978 refueling. This conformed to the staff's requirement to install a final version of OPS at least by the first refueling outage after December 31, 1977.

This Safety Evaluation Report presents the results of the staff's review of the installed OPS, administrative controls and proposed changes to the Technical Specifications.

3.0 Low Temperature Overpressure Protection System

The licensee identified pressurizer power operated relief valves (PORV's) and the shutdown cooling system (SDC) safety valves as being capable of providing pressure relief during low temperature operations.

The PORV's are located on the pressurizer and are normally available for overpressure protection during normal plant operations. These valves usually have a single pressure setpoint just below the opening pressure of the mechanical code safety valves and are designed to relieve small pressure transients without requiring the code safety valves to lift. The licensee proposed to provide the PORV's with a low pressure setpoint to which they could be switched as the plant cooled down. If a pressure transient would occur at these lower temperatures and the lower setpoint had been selected, there would then be a pathway to relieve system pressure.

The PORV's are significantly more complicated than the code safety valves since the PORV's require electrical circuitry to sense pressure, transmit a signal to the valve, and actuate the solenoid to open the valve. Thus it is desirable to insure redundancy and separability in the circuitry to preclude a single failure from disabling the entire OPS system.

The SDC safety valves, in addition to the PORV's, are also available for overpressure protection during low temperature operation because the SDC system is aligned and operational. The Palisades SDC system does not have autoclosure and would, therefore, not be isolated because of a pressure transient. There is no electrical circuitry associated with the SDC safety valves and they are considered passive, failure free components.

3.1 System Description and Evaluation

3.1.1 OPS Functioning

Acceptable performance of OPS depends on the proper functioning and adequate relief capacity of the two pressurizer PORV's and a SDC safety relief valve. The two PORV OPS trains are enabled at 300°F during a cooldown and have a setpoint of 415 psia. The SDC system is placed in operation at 225°F. Although the SDC system has two safety relief valves, only one falls into the range of pressures expected during an overpressure transient. These SDC valves have setpoints of 300 psia and 500 psia and are on the suction and discharge sides of the SDC system. The maximum transient pressure for an overpressure event would be less than 500 psia. The NSSS vendor and the licensee demonstrated that with two PORV's and the SDC safety relief valve functioning all postulated mass and energy addition transients could be mitigated. If one PORV is assumed to fail, administrative procedures must be relied upon to limit the severity of the limiting transients in both the energy and mass addition cases to insure that Appendix G limits are not violated.

3.1.2 Energy Addition Transients

The temperature difference across the steam generators must be maintained less than 70°F to prevent a RCP start energy addition transient from violating Appendix G limits. This is accomplished by the careful method by which the plant is cooled down.

Energy Incorporated performed the overpressurization analyses for CPC using the RETRAN computer code, a modified version of RELAP 4, Mod 03, Update 95. RETRAN provides the capability to analyze light water reactor plant transients. Energy Incorporated used a number of CE overpressurization analysis results for comparison with the RETRAN results. In all cases the RETRAN results agreed with the CE results or were more conservative. The following conservatisms were inherent in these RETRAN analyses:

a. The RCS was assumed to be water solid.

b. Metal masses did not act as heat sinks.

c. Pump starts were assumed to be instantaneous.

With one PORV disabled the analysis showed that one PORV and the SDC safety relief valve would limit the maximum pressure to 450 psia for a ΔT of 85°F. For a ΔT of 70°F, a single PORV can relieve the pressure transient which results with a maximum pressure of 470 psia. The initial conditions for these analyses were a primary temperature of 120°F, primary pressure of 270 psia, and secondary temperature of 190°F for the 70°F ΔT case and 205°F for the 85°F ΔT case. The corresponding Appendix G limit at 120°F is 475 psia.

We conclude that the licensee and vendor have demonstrated that the OPS can protect the RCS from exceeding Appendix G limits for an energy addition transient even with the additional single failure of a PORV.

3.1.3 Mass Addition Transients

Protection from the effects of the limiting mass addition transient was afforded by the licensee by assuring that components of the ECCS system would be disabled by procedure and Technical Specification during cooldown. This is accomplished at a pressurizer pressure of 1400 psia by valving out the Safety Injection Tanks and physically removing the control system fuses for the high pressure safety injection pumps. This provides assurance that Appendix G limits will not be violated should a single PORV fail prior to or during a mass addition transient. As noted previously, the overpressurization transients were analyzed using the RETRAN computer code along with appropriately conservative assumptions.

The staff guidance to the licensee for analyzing the mass addition transient was to show that Appendix G limits were not violated assuming that the safety injection pump which could produce the worst case transient inadvertantly started, regardless of administrative procedures calling for disabling the pumps at various stages. For the Palisades plant the worst pump start would be a HPSI pump. The licensee demonstrated that a single HPSI pump start would produce a peak pressure of ~460 psia assuming the failure of a single PORV and the SDC safety relief valve. The PORV opens at 415 psia, the OPS setpoint, and the pressure continues to rise until the OPS relief rate equals the HPSI input rate at 460 psia. The initial conditions for this transient were a RCS temperature of 120°F and a pressure of 270 psia. The Appendix G limit for a RCS temperature of 120°F is 475 psia.

We conclude that the licensee has demonstrated that the OPS will prevent overpressurization of the RCS due to mass addition transients, assuming the single failure of a PORV.

3.1.4 System Electrical Design

The low temperature overpressure protection system is comprised of two redundant and independent channels designed to comply with the above criteria. Each channel will automatically provide a relief path from the RCS pressurizer to the relief tank should a pressure in excess of 400 psi coexist with a temperature below 250°F. Each channel consists of a power operated relief valve (PORV), a PORV isolation valve, related instrumentation and controls, and other ancillary equipment. The low temperature overpressure protection system is manually enabled by the operator any time the RCS temperature is below 300°F. If, at any time, the RCS temperature is below 300°F amd either overpressure protection system channel is not enabled, a control room annynciator alarm, "NO PCS PROTECTION," will be activated (a single annunciator alarm is provided for both channels). Each channel is enabled by closing a key-operated switch in the control room and by opening the associated isolation valve (also with a switch in the control room). Once enabled, the PORVs will open automatically in response to pressure transients. Annunciators are also provided to alert the operator of an approaching high pressure condition ("PCS PRESSURE 375 PSI") and of pressure grater than 430 psig coincident with temperature less than 250°F ("PORV OPEN"). Single annunciators are provided for both channels. In addition to the above annunciators, control room indicator lights in each channel will inform the operator that (1) the PORV isolation valve is open, (2) the channel is enabled, and (3) the PORV is open. The "PORV OPEN" light will remain 'on' until it is reset by the operator.

The overpressure protection system design as submitted by CPC and described above is in accordance with the criteria in Section II, and therefore is acceptable to the staff.

3.1.5 Inadvertent Operation of SIS Components

The staff position with regard to inadvertent operation of safety injection system (SIS) components during cold shutdown operations requires the deenergization of SIS pumps and closure of safety injection header/discharge valves.

The licensee has agreed to valve out the safety injection tanks and to remove control power from the high pressure safety injection pumps when the RCS pressure is reduced to 1400 psi during cooldown. We find this acceptable.

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3.1.6 Testability

The OPS components will be tested at appropriate intervals. A channel functional test will be performed on the electrical circuitry during each refueling. The PORV's are pilot-operated and therefore cannot be tested unless a differential pressure exists across the valve. Also, these valves are physically inaccessible during operation and cooldown. CPC proposes, therefore, to test the valves in accordance with the applicable requirements of ASME Code Section XI, Subsection IWV. We find this acceptable.

4.0 Procedures and Technical Specifications

One cornerstone of the Palisades OPS is the use of operating procedures and Technical Specifications to limit the probability of initiating pressure transients at low temperatures (<250°F) and to insure the enabling, disabling, and proper functioning of the OPS. Procedures and Technical Specifications described and submitted by the licensee are described in the following two sections.

4.1 Procedures

The licensee will make extensive use of operating procedures to provide a large measure of the administrative protection against overpressure transients. Among these operating procedures for low temperature operating conditions are the following:

a. When RCS temperature, pressure, and other operating conditions permit, a pressurizer steam volume of about 60% of the pressurizer volume will be maintained.

b. The licensee will conduct the Palisades plant cooldown in such a manner that the ΔT across the steam generator will be no more than 70°F. This will insure that a RCP start would not be capable of overpressurizing the RCS. The cooldown from hot conditions will be conducted by steaming to the condenser via the turbine bypass valve. Cooling of the primary side continues to 325°F at which point the low head safety injection pumps are realigned for the SDC mode. The RCP's continue to run until the cooldown reaches 160°F to 180°F at which time the system goes solid and the RCP's are stopped. At this stage the secondary side is also in the 160°F to 180°F range Cooldown via SDC continues to 120°F at which time the primary side is reduced to atmospheric pressure. Therefore the ΔT across the steam generator will not be greater than 70°F during the cooldown.

c. ECCS component testing will be conducted with a steam bubble or with the reactor vessel head removed. Operational testing of the Safety Injection and CVCS components (i.e., pumps, valves, automatic signals, etc.) will be accomplished with a non-solid RCS.

We conclude that these operating procedures significantly contribute to plant protection from low temperature overpressure transients and are acceptable. We also conclude that the licensee's method of insuring a maximum ΔT is acceptable.

4.2 Technical Specifications

The following are suggested Technical Specifications submitted by the licensee for implementation as part of the Palisades OPS.

a. The OPS will be enabled prior to reaching 250°F during cooldown.

b. ECCS components which could cause overpressure transients and which are not necessary during low temperature operations will be disabled in stages.

c. OPS components will be tested at appropriate intervals. For Palisades a channel functional test will be conducted during each refueling. Valve functioning will be tested in accordance with ASME Code, Section XI, Subsection IWV.

In addition to the Technical Specifications submitted by the licensee, a Technical Specification concerning inoperability of OPS is required as follows: Both PORV's must be operable whenever the RCS temperature is less than the minimum pressurization temperature, except one PORV may be inoperable for seven days. If these conditions are not met, the primary system must be depressurized and vented to the atmosphere or to the pressurizer relief tank within eight hours. We have revised the Technical Specifications to include these requirements and to conform the Technical Specifications to the staff's model Standard Technical Specifications. We have discussed these revisions with representatives of CPC and they have informed us that they find our revisions acceptable.

We conclude that the Technical Specifications submitted by the licensee and as modified by the staff, will provide assurance that pressure transients at low temperatures will be unlikely and that the system will function to prevent overpressure transients from exceeding Appendix G limits. We further conclude that the Technical Specifications as modified by the staff meet the criteria established by the staff and are acceptable.

5.0 Environmental Considerations

We have determined that the amendment does not authorize a change in effluent types, an increase in total amounts of effluents or an increase in power level and therefore will not result in any significant environmental impact. Having made this determination, we have concluded, pursuant to 10 CFR 51.5(d)(4), that an environmental impact statement or negative declaration and environmental impact appraisal need not be prepared in connection with the issuance of this amendment.

6.0 Conclusions

The system presented by the Consumers Power Company to provide protection for the Palisades plant from low temperature overpressure transients provides assurance that these transients will be unlikely events and that, should they occur, the plant will be protected.

We conclude, therefore, that the Palisades OPS meets the criteria established by the staff for overpressure protection and is acceptable as a low temperature overpressure protection system. We further conclude that the suggested Technical Specifications submitted with the OPS design as modified by us are in consonance with the OPS criteria and are therefore acceptable.

We have concluded, based on the considerations discussed above, that: (1) because the amendment does not involve a significant increase in the probability or consequences of accidents previously considered and does not involve a significant decrease in a safety margin, the amendment does not involve a significant hazards consideration, (2) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, and (3) such activities will be conducted in compliance with the Commission's regulations and the issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public.

Dated: September 10, 1979

7.0 REFERENCES

1. U. S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation "Staff Discussion of Fifteen Technical Issues Listed in Attachment to November 3, 1976 Memorandum from Director, NRR to NRR Staff," NUREG-0138, November 1976.

2. Combustion Engineering Owner's Group, "Generic Report Overpressure Protection for Operating CE NSSS".

3. Letter, Sewell to Director, Nuclear Reactor Regulation, Docket No. 50-255, December 6, 1976.

4. Letter, Schwencer to Sewell, Docket No. 50-255, January 10, 1977.

5. Letter, Hoffman to Schwencer, Docket No. 50-255, March 8, 1977.

6. Letter, Hoffman to Schwencer, Docket No. 50-255, June 24, 1977, forwarding "Palisades Plant Overpressurization Analysis", prepared by Energy Incorporated.

7. Letter, Hoffman to Schwencer, Docket No. 50-255, November 28, 1977.

8. Letter, Hoffman to Schwencer, Docket No. 50-255, January 3, 1978.