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SUBJECT: Forwards response to NRC 820311 request for addl info re low temp overpressure protection.

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July 6, 1982

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. J. F. Stolz, Chief
Operating Reactors Branch No. 4

Subject: Oconee Nuclear Station
Docket Nos. 50-269, -270, -287

Dear Sir:

By letter dated March 11, 1982, the Staff requested responses to several questions related to the concern of low temperature overpressure protection. My letter of April 9, 1982 addressed delays associated with the preparation of the response. Attached please find our responses to the Staff's request for information.

Following review and acceptance of these responses by the Staff, appropriate Technical Specifications will be proposed.

Very truly yours,

William O Parker Jr

William O. Parker, Jr.

RLG/php
Attachment

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Duke Power Company
Oconee Nuclear Station

Response to NRC Request for Additional Information
Low Temperature Overpressure Protection

I. Introduction

By letter dated August 11, 1976, the NRC initially requested Duke Power Company (DPC) to evaluate the Oconee Units 1, 2, and 3 "overpressure protection system designs to determine their susceptibility to overpressurization events," and their ability to mitigate the consequences of these events. It was also requested that operating procedures be examined and administrative controls be implemented to guard against initiating overpressure events at temperatures below the Nil Ductility Transition Temperature (NDTT).

For nearly six years, Duke has submitted information to the Staff and the Staff has requested additional information. This culminated in 1981 with the issuance of a Technical Evaluation Report by the Staff. A Duke response was provided by letter dated July 24, 1981. Because of the significant time lag from the first analyses, Duke has reevaluated both the systems response for the limiting postulated transient and the reactor vessel Appendix G limits. The following sections provide discussions on the expected plant response, the Appendix G limits, and a summary section providing specific answers to the Staff requests.

II. Operational Considerations

The potential for a low temperature overprotection event at Oconee is extremely remote. This is principally due to the fact that during startup and shutdown, the plant is operated with a steam bubble in the pressurizer. Analyses have been performed that show that only the spurious opening of the safety injection valve will cause a rapid repressurization of the primary coolant system. The following is a discussion of the events important to low temperature overpressure protection during the plant startup and shutdown.

Startup Sequence

Prior to plant startup, pertinent initial system conditions are as follow:

PORV opening setpoint is 550 psig.

HPI system valves HP-26, -27, -409, and -410 are closed and power is removed from the valve operators.

Prior to exceeding 45 psi in the Reactor Coolant System (RCS) the PORV operability test is performed.

Prior to reaching 100 psig in the RCS, one High Pressure Injection (HPI) pump (either A or B) is started to provide RC pump seal flow.

When the RC system pressure reaches 300 psig, one RC pump is started.

After Low Pressure Injection (LPI) system has been removed from service and above 325^{o}F and prior to 350^{o}F white tags are removed from HP-26, -27, -409, -410 and from their motor operators. Power is restored to the motor operators. HPI check valve functional test is completed prior to exceeding 350^{o}F.

(Oconee Technical Specification 3.3.1 requires that the HPI system be fully operational above 350^{o}F.)

Two more RC pumps are started.

When RC temperature is greater than 325^{o}F and the RC pressure is less than 550 psi, the PORV selector switch is positioned to NORMAL.

Throughout this sequence, pressurizer level is being controlled by makeup and letdown flow.

Shutdown Sequence

When the RC pressure decreases to 1750 psig the HPI automatic actuation feature is bypassed.

Prior to RC temperature less than 325^{o}F, and with the RC pressure less than 550 psi, the PORV selector switch is positioned to LOW.

When RC temperature is less than 350^{o}F but greater than 325^{o}F, HP-26, -27, -409, -410 are closed or check closed; power is removed by opening the motor operator breakers. Valves and breakers are tagged to assure inadvertent operation does not occur.

Two RC pumps remain in operation until LPI is in service and temperatures have stabilized. After the last RC pump is secured, the HPI pump operating either A or B is secured.

The vulnerability of the plant to a low temperature overpressurization sequence is from the time the HPI system is operational ($\sim$325^{o}F) to the minimum pressurization temperature. Per Technical Specification 3.1.2, this is about 408^{o}F, but recent calculations described in Section III provide a more realistic value for the minimum pressurization temperature of 325^{o}F. Thus, protection above 325^{o}F is provided by the pressurizer safety valves while protection below 325^{o}F is provided by the PORV. Only if the PORV fails or the PORV block valve is closed, could system overpressurization occur.

This sequence of system pressurization caused by a safety injection valve opening has been evaluated. Automatic actuation of HPI by Engineered Safeguards signal is bypassed below 1750 psi. Thus, under low pressure, temperature conditions, the safety injection valve can only be postulated to be:

1) by opening of an HPI valve from the Control Room and closing the valve operator breaker from the Equipment Room, or

2) by local manual opening of the valve in the East Penetration Room.

Except during the performance of a required surveillance test when the Control Room Operator is in direct control of the valve, and closely monitoring and controlling RCS parameters such as pressure, pressurizer level, and HP flow, it is not considered credible to assume that a safety injection valve would be opened.

Oconee Specification 4.0.4 requires, as part of the Inservice Testing requirements of ASME Section XI, that the check valves of both HPI trains be stroke tested each startup. This is accomplished on train B by cracking open HP-27 with HP-C pump operating, then closing HP-27 after flow has been confirmed through the check valves. In order to minimize the thermal shock to the associated HP injection nozzles, this is done at a low temperature but, in any case, prior to 350°F when the HPI system must be operable. On train A, this testing is accomplished by using the makeup valve HP-120. In both instances, the Control Operator is in direct control of the plant to assure that overpressurization does not occur.

III. Appendix G Limits

Pressure and temperature (P-T) limitations imposed by the overpressure protection measures currently in effect at the Oconee Nuclear Station are based on fracture analyses performed in accordance with 10 CFR 50 Appendix G and Appendix G of the ASME Code, Section III. These limitations were calculated by conservatively combining portions of the three operating limit curves for normal plant heatup, normal plant cooldown and hydrotest and inservice leak test. These three operating limit curves are intended to impose P-T limits during actual plant evolutions.

Because occasional minor violations of such limits are anticipated, Appendix G of the Code requires that an additional safety factor be used in the calculation of such curves: 2.0 for normal plant heatup and cooldown and 1.5 for hydrotest and inservice leak test.

However, the overpressure protection measures are not intended to provide for normal operation. Instead, they provide a backup designed to prevent overpressurization in the unlikely event that normal procedures and administrative controls fail to prevent such occurrences. Thus, unlike the operating limits, the overpressure protection limits are not subject to inadvertent violation, and the use of the additional safety factor in their calculation is not appropriate.

A more appropriate P-T limit curve for the low temperature overpressure protection issue has been calculated and is shown in Figure 1. This curve was calculated using the limiting Oconee reactor vessel and the assumed heatup and cooldown rates in Table 1. The curve is a composite formed by combining the most limiting portions (lowest pressure, greatest temperature) of three constituent curves: (1) A P-T limit curve for normal plant heatup; (2) a P-T limit curve for normal plant cooldown; and (3) a P-T limit curve for hydrotest and inservice leak test. With one exception, the development of these constituent curves follows the method used to obtain Technical Specification curves in accordance with Appendix G of the Code. However, instead of safety factors of 2.0 and 1.5, development of the constituent curves for Figure 1 assumed a safety factor of 1.0.

The use of the safety factor of 1.0 and new heatup and cooldown rates result in a reduction of the minimum pressurization temperature to 325°F at 15 EFPY. This is well below the current value of 408°F at 6 EFPY which is based on safety factors of 2.0 and 1.5 and assumes much greater heatup and cooldown rates (100°F/hr.).

It should be emphasized that removal of this safety factor does not eliminate conservatism from the analyses. The overall safety factor applied to the fracture analysis in Appendix G is quite large. Moreover, safety factors inherent in the code are not easily recognizable. However, they exist as follow:

1. The assumed reference flaw is very large compared with defects which would either be undetected or not repaired under Section III standards. The safety factor in assumed initial flaw size is greater than a factor of 10, resulting in a safety factor of $\sqrt{10}$ on stress.

2. The use of lower bound fracture toughness data measured from both dynamic and crack arrest tests as a design curve for static initiation K_{IC} values imposes a safety factor of K_{IC} curve. This safety factor varies with temperature because the shape of the dynamic and crack arrest curve differs from the static K_{IC} curve. At $(T - RT_{NDT}) = 100°F$, the safety factor is approximately 2.4 while at $(T - RT_{NDT}) = 0°F$, the factor is about 1.4.

3. The method of determining stress intensity values is conservative. The magnitude of this varies depending on the stress gradient and the method used to determine K_I values in a gradient stress field. However, the minimum safety factor inherent in this method is the factor of 2 (or 1.5) which the NRC has added and which is recommended for removal for calculation of overpressure protection limitations.

Based on the above, the combined factor of safety on stress at $(T - RT_{NDT}) = 100°F$ and for a membrane loading case is:

$\sqrt{10}$ due to flaw size estimate
x 2.4 due to K_{IR} versus K_{IC}
x 2 due to safety factor applied in determination of K_I
15.7 total applied to allowable stress

While at $(T - RT_{NDT}) = 0°F$, the combined safety factor would be:

$\sqrt{10}$ due to flaw size
x 1.4 due to K_{IR} versus K_{IC}
x 2 due to safety factors applied in determination of K_I
8.85 total applied to allowable stress

Elimination of the factor of 2 used in determination of K_I still leaves overall safety factors of about 8 and 4.4, respectively, in the two cases illustrated.

In conclusion, therefore, the additional safety factor assumed in calculation of the operational P-T limits is not justified for inclusion in the analysis of limitations for overpressure protection measures. But, elimination of this safety factor still leaves a very conservative limit to assure safety.

Table 1

Assumed Heatup and Cooldown Rates

RC Temperature (°F)	Heatup Rate (°F/hr)	Cooldown Rate (°F/hr)
> 280	100	100
280 to 150	50	50
< 150	50	10

COMPOSITE P-T CURVE FOR HEATUP,
COOLDOWN AND INSERVICE LEAK
AND HYDROTEST FOR 15 EFPY

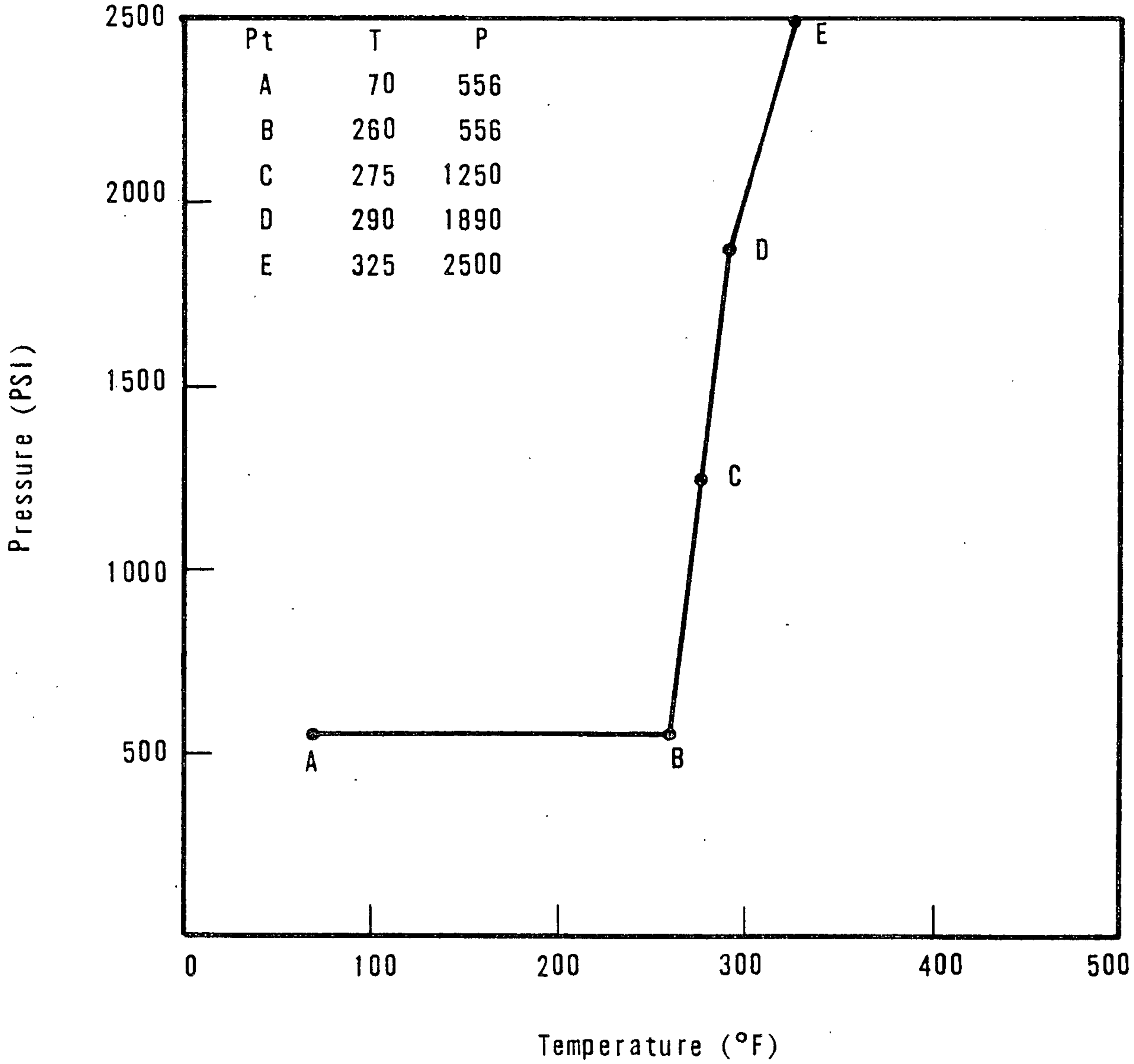

Figure 1

IV. Responses to NRC Requests for Information

1. The Branch Technical Position (SRP 5.2.2/RSB 5-2) requires the Oconee Units 1, 2, and 3 overpressure protection systems (OPS) to prevent exceeding the applicable Technical Specifications and 10 CFR 50 Appendix G limits. In your analysis and system description, you use 550 psig as the low temperature PORV setpoint and as the value that RCS pressure is allowed to reach prior to any credited operator action. Does the 550 psig setpoint provide adequate assurance that the Appendix G curve limits will not be exceeded for all temperatures below 408°F (the minimum pressurization temperature)?

Response

As discussed in the Staff evaluation contained in the NRC letter dated April 24, 1981, Duke analyzed seven low temperature overpressure events. Based on this analysis, erroneous actuation of HP-26 was identified as the limiting transient. Current operating procedures require that HP-26 be disabled below 325°F which is the minimum temperature at which full pressurization is allowed.

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2. The OPS is required to function assuming any single active component failure. The Oconee overpressure protection system does not meet this criterion for the case of inadvertent actuation of the high pressure injection (HPI) system with the PORV failing closed. You mentioned in your submittals a proposed system to trip the HPI pumps during a pressure transient and several administrative controls that are used to prevent an inadvertent HPI injection. In its February 2, 1978 letter, the staff stated that this concept is acceptable provided the system meets the design criteria, and adequate controls to prevent the event are included in the plant Technical Specifications.

   a. Provide a copy of all Technical Specifications (TSs) that deal with this subject or propose appropriate revisions.

   b. List all procedural and administrative controls used during HPI system tests and RCS hydrostatic tests to prevent violating Appendix G limits.

   c. Could the HPI isolation valves HP-26 and HP-27 be manually opened locally? Would the control room operators have any indication of this?

   d. What is the status of the installation of the proposed system mentioned above?

Response

In view of the reanalysis of both the response of reactor coolant system pressure and the pressure-temperature limits, the system previously offered as a conceptual design to trip HPI pumps is no longer considered necessary to prevent inadvertent overpressurization. The current overprotection system is the PORV with an opening setpoint less than 550 psig and control of the only source of high pressure water, the HPI system and HP-26. The valve is closed with power removed and appropriately tagged prior to cooling down below 325°F. Above this temperature, spurious activation of HP-26, though not likely to occur, will not result in violation of the appropriate P-T limits. During heatup, valve HP-26 is functionally inoperable until RCS temperature is above 325°F, and spurious activation of this valve, likewise, will not result in violation of the appropriate P-T limits.

a. The only proposed Technical Specification considered appropriate is to add the requirement that either valves HP-26, -27, -409, -410 be closed with power removed and tagged or all HP injection pumps be secured with power removed and tagged when the RCS temperature is below 325°F.

b. HPI system leakage tests and RCS hydrostatic tests are conducted by procedures PT/0/A/150/23 and PT/0/A/200/46, respectively. HPI check valve stroke testing is conducted by PT/0/A/251/6.

   Copies of these procedures are attached.

c. HPI isolation valves HP-26, -27 could be manually opened locally; however, with power available to the valve, the operators would have indication in the Control Room. Power is removed by operator action to open breakers and tag valve and breaker appropriately. This is consistent with the regulatory branch position and is thus not considered to be credible to assume the valve is opened.

   Valve HP-27 opening is of no concern because pump HP-C is off. HP-26, if opened, could provide a flow path of high pressure fluid as either pump HP-A, or -B is on providing makeup and RC pump seal injection flows.

d. The conceptual system to trip HPI pumps will not be installed.

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3. Relative to the OPS testing, please respond to the following:

   a. How is the PORV and its control circuitry functionally tested?

   b. At what frequency are these tests performed?

   c. How do you ensure that these valves actually open during testing?

   d. Provide a copy of all TSs that deal with this subject or propose appropriate revisions.

Response

a. PT/0/A/201/04 PORV Operability Test is used to test the PORV. A copy of the new procedure is attached.

b. These tests are performed during every startup.

c. The operator monitors downstream indications including the acoustic monitors installed per NUREG-0737, Item II.D.3.

d. The existing Technical Specifications and procedures are considered adequate. Any change to Technical Specifications would reflect actions currently in existing procedures.

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4. The Reactor Systems Branch position RSB 5-2 requires an alarm to alert the operator to properly enable the overpressure protection system at the correct plant condition during cooldown. If the system is not properly enabled, with the PORV isolation valve open and the PORV low setpoint selected by the correct position of the key-lock switch, it will not function to mitigate an overpressure event. How does Duke Power Company meet this requirement at Oconee Units 1, 2, and 3?

Response

Currently, administrative procedures require the operator to enable the low temperature overpressure protection system prior to 325°F. It is considered that the existing administrative controls are adequate to assure that the overpressure protection system is properly enabled. It is proposed that this be reviewed again during the Control Room design review, required by TMI Action Plan Item I.D.1, and that any changes identified as being necessary be implemented following conduct of such review.

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5. RSB 5-2 requires that an alarm must be provided to alert the operator that a pressure transient is occurring. You take credit for operator action to mitigate a pressure transient for all analyzed events when a failed-closed PORV is considered. No credit can be taken for operator action until 10 minutes after the operator is aware that a pressure transient is in progress. For the most severe event that you analyzed, what audible alarm will alert the operators that a pressure transient is occurring (alarms associated with the PORV cannot be used because it is assumed failed closed)? We require that acceptable technical specification changes or system modifications be proposed to increase your calculated operator time from 4.4 minutes to at least 10 minutes.

Response

The postulated severe event is considered to be spurious opening of HP-26. This can only be postulated to occur at RC temperature conditions above 325°F. The operator has several indications that a pressurization transient is in progress. These include:

1. HP-26 not closed;
2. Pressurizer level high alarm (260");
3. HP flow in excess of normal 40-80 gpm (An actual alarm would occur if flow was in excess of 500 gpm.);
4. RC pressure increasing (Alarmed at 2255 psig).

As can be seen with Figure 1, full system pressure is allowed for fluid temperatures above 325°F.

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6. What training has been conducted at Oconee to make the operating personnel aware of overpressure incidents at other facilities and possible overpressure situations at Oconee? How do you ensure that an emphasis is placed on this problem during your licensing and retraining programs?

Response

Licensed personnel at Oconee are trained in accordance with the Operator Licensing Program and Requalification Program for NRC Licensed Personnel as approved by the NRC and required by 10 CFR 55. Some of the lessons included in the Licensing Program that are related to this issue include Reactor Coolant System, High Pressure Injection System, Pressurizer, Operating Procedures, Emergency Procedures, and Operating Experiences (Industry and Station).

Similarly, in the Requalification Program, this issue is addressed by lessons such as Procedures and Technical Specifications, Safety and Emergency Systems, Operating Characteristics, and Design Characteristics.

The Licensing Program is conducted on a continuing basis as the need for replacement training demands. This program includes the use of lectures, on-the-job training, simulator training and audit examinations. The Requalification Program is designed to maintain and demonstrate the competence of all licensed operators and senior operators. This program is conducted on an annual basis and includes a comprehensive exam, formal requalification lectures, on-the-job training and simulator operation. It is considered that the program as presently structured emphasizes all aspects of safe plant operation, including the particular concern related to low temperature overpressurization.

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7. Provide current P&IDs of the overpressure protection system.

Response

The installed overpressure protection system is the PORV. Duke drawing OEE-150-7 is attached.

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8. The administrative controls you use to ensure against the inadvertent opening of an HPI valve are not put into use until RCS temperature drops to 250°F during cooldown and they are removed once temperatures reach 250°F during system heatup. This leaves the time spent between 250°F and 408°F (the minimum pressurization temperature) where an inadvertent valve opening or a valve malfunction could result in a pressure transient that could exceed Appendix G curve limit. Address this issue.

Response

The administrative controls have been revised to disable the HP valves by 325°F on cooldown and to maintain them disabled until above 325°F during heatup. This action takes into account the appropriate pressure-temperature limits as well as consideration that Technical Specification 3.3 requires HP injection to be operable at 350°F. The pressure-temperature limits are valid through 15 EFPY.

It is recognized that to assure safe operation throughout the lifetime of the plant, additional changes are necessary. Currently an evaluation is being made to determine the basis of the Technical Specification limit that requires full HPI system operability above 350°F. One option available is to require both trains to be operable above about 410°F with only one train necessary between 350°F and 410°F. This and any other options will be fully evaluated and the necessary licensing actions will be taken to demonstrate safe operation beyond 15 EFPY.

Duke Power Company
Oconee Nuclear Station

Response to NRC Request for Additional Information
Low Temperature Overpressure Protection

Documents

PT/0/A/150/23

PT/0/A/200/46

PT/0/A/201/04

OEE-150-7

PT/0/A/251/6