TECHNICAL EVALUATION

ELECTRICAL, INSTRUMENTATION, AND CONTROL

LOW TEMPERATURE OVERPRESSURE MITIGATING SYSTEM

FOR

CRYSTAL RIVER UNIT 3

50-302

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1.0 INTRODUCTION

By letter dated October 1, 1976 (Reference 7), the NRC requested that the Florida Power Corporation (FPC) design and install plant systems to mitigate the consequences of pressure transients at low temperatures at the Crystal River Unit 3 (CR-3) nuclear power station. It was also requested that operating procedures be examined and administrative changes be made to minimize initiating overpressure events.

By letter dated December 2, 1976 (Reference 1), FPC submitted a plant-specific analysis in support of their reactor vessel overpressure mitigating system (OMS) for CR-3. The analysis was supplemented by letter dated February 7, 1979 (Reference 2) and other documentation submitted by FPC (Rferences 3, 4, 5). FPC has installed the equipment and incorporated the procedures described in this report.

Additional NRC concerns were expressed in letters to FPC, dated November 19, 1976, January 7, 1977, and November 11, 1977 (Rferences 8, 9, 10). FPC responded to these concerns in References 2 and 4. The correspondence focused on system design criteria.

The electrical, instrumentation, and control systems aspects of the FPC proposal have been reviewed in this report. Section 2 discusses events which are most likely to cause overpressure transients; Section 3 describes precautionary measures taken at CR-3 to minimize the occurrence of these events; and Section 4 describes the system designed to mitigate an overpressure event should it occur.

2.0 DESIGN BASIS EVENTS (DBE)

An "Evaluation of Potential Reactor Vessel Overpressurization" has been provided by FPC by letter dated February 17, 1977. Of the seven design basis events evaluated, FPC found four credible overpressure events. The events are:

(1) Erroneous actuation of a High Pressure Injection (HPI) train - The time from initiation of one HPI train to required operation (550 psig) of the Pilot Actuated Relief Valve (PARV) varies between 4.9 and 8.4 minutes with the initial reactor coolant system (RCS) pressure between 250 and 100 psig, and the pressurizer level between 220 (High Level Alarm) and 180 inches, respectively.

The actuation of an HPI train requires a makeup pump to be running and one of four HPI motor-operated valves to be open.

The CR-3 design has three makeup pumps. Two of these are normally aligned to provide HPI should it be required, while the remaining pump is used to provide makeup to the RCS as well as seal water to the RC pumps. Prior to going below 280°F, the circuit breakers for the four HPI motor-operated valves are "locked out" with the valves closed. Between 280°F and 150°F, the Decay Heat Removal System is placed in operation, the remaining RC pumps and the operating makeup pump are shut down. This transition period, from the time the RCS temperature drops below 280°F until the operating makeup pump is shut down, is approximately 1-1/2 hours.

When the RC temperature is below 280°F, the PARV out-of-service alarm will be actuated if any of the four HPI valve circuit breakers is energized. In addition to this alarm, the operator will have indicating lights when the breakers are locked out. Other alarms and indications available to the operator indicating the actuation of a HPI train include the HPI actuation alarm and HPI valve position indication lights.

(2) Makeup control valve (makeup to the RCS) fails full open - The time from initiation of the transient to required operation of the PARV (550 psig) varies between 10.4 and 10.5 minutes with the initial RC pressure between 250 and 100 psig, and pressurizer level 220 (High Level Alarm) and 180 inches, respectively.

This transient occurs when one makeup pump is running and the makeup control valve fails open. The makeup valve is controlled by the pressurizer level controller.

The operator can identify this event by either the full-open indicating light for the makeup valve, the low makeup pump discharge pressure indication, or the makeup line flow indication.

(3) All pressurizer heaters erroneously energized - The time from the initiation of the event to the required operation of the PARV (550 psig) is about 53 minutes with the initial RCS pressure at 250 psig.

The operator can identify this type of event by the "on" indicating lights for the pressurizer heater banks groups. Other indications would be abnormal flow rates for the makeup tank and letdown lines due to the increasing RCS pressure.

(4) Temporary loss of the Decay Heat Removal System's capability to remove decay heat from the RCS - The time from the initiation of the event to the required operation of the PARV (550 psig) is about 29.5 minutes with the initial RCS pressure at 250 psig.

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Loss of decay heat removal capability could only be caused by loss of flow in the Decay Heat Removal (DHR) system or in the cooling water system serving the DHR system.

Loss of flow in either system would immediately actuate low-flow alarms, thus alerting the operator.

3.0 PROCEDURAL PRECAUTIONS

The staff position with regard to the inadvertent operation of components capable of causing a low temperature overpressurization during cold shutdown and startup requires the deenergization and lockout of equipment capable of causing the overpressurization, and equipment not necessary for shutdown and startup.

3.1 DESCRIPTION

The CR-3 procedural steps requiring the removal of equipment from operation or the locking-out of pump and valve breakers are performed in accordance with Procedure CP-115, "In-Plant Equipment Clearance and Switching Orders."

The FPC CR-3 plant has the following procedural precautions to prevent DBEs during cold shutdown and startup:

1. Erroneous action of a HPI train - The circuit breakers for the four normally closed HPI motor-operated valves are "locked out" with the valves closed during plant cooldown and prior to startup of the DHR system. This is accomplished by opening the breaker and tagging their associates selector switches in the Control Room by racking out, locking out, and tagging the valve circuit breakers at the Motor Control Center. The operator has indication that power has been removed as the status lights in the Control Room will be off. The energization of any one of the four circuit breakers will activate the PARV low-temperature out-of-service alarm.

2. All pressurizer heaters erroneously energized - As part of the FPC cooldown procedure, the pressurizer heater banks are placed in the 'off' position during cooldown to prevent erroneous energizing of the heaters. This function is performed by the operator from the Control Room. Position indicator lights in the Control Room provide the operator continuous status of the heaters.

3.2 EVALUATION

The CR-3 procedural precautions are in agreement with the staff position except that the circuit breakers supplying the pressurizer heaters should be opened, locked out, and tagged.

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4.0 OVERPRESSURE MITIGATING SYSTEM (OMS)

4.1 SYSTEM DESCRIPTION

The design of the Crystal River reactor differs from that of Westinghouse in that the RCS is never planned to be in a water solid condition. The B&W RCS is operated at all times with either a steam or nitrogen bubble in the pressurizer. This bubble prevents a rapid overpressure transient from occurring in the RCS. The FPC report, "Evaluation of Potential Reactor Vessel Overpressurization" (Reference 1) has analyzed the events which could potentially cause a reactor vessel low temperature overpressurization. With the initial water level in the pressurizer at 220 inches (High Alarm), the FPC analysis has determined the time required for a pressure transient to reach 550 psig (required relief setting) after initiation varies between 4.9 and 52 minutes, depending on the transient source. Only a pressure transient caused by the actuation of a HPI train will reach the required relief setting in less than ten minutes.

The Crystal River plant has a single existing pilot actuated relief valve (PARV) located on the pressurizer. The cost for the addition of a second valve has been estimated by FPC to be between $200-400K. The decay heat removal system can provide no additional relief protection from overpressure transients since it is isolated from the RCS when the RCS pressure exceeds 284 psig.

Therefore, FPC proposes two separate methods for low temperature overpressure protection. They are:

<u>Operator Action</u> - Since the operation of the RCS with a steam or nitrogen bubble in the pressurizer provides a minimum 4.9 minutes from the initiation of the transient until overpressurization, FPC has proposed that operator action be credited as a redundant action to the automatic pressure relief system (dual setpoint PARV). The operator action necessary to prevent vessel overpressurization is to determine the cause of the transient and to deenergize or control the responsible equipment before the RCS pressure reaches the PARV setpoint.

Alarms and indications which give direct indication that a transient is in progress include pressurizer level alarms, RCS pressure indication and pressurizer level indication. The operator also has other system indicators and alarms to indicate that the systems and equipment as described in Section 2.0 are in abnormal conditions.

<u>Dual Setpoint PARV</u> - The automatic low temperature overpressure mitigating system is a modification of the actuation circuit for the existing PARV to provide alternate relief setpoints. The high pressure setpoint is 2255 psig for reactor operation and the low temperature pressure setpoint is 550 psig. A manually operated switch is provided to change the PARV

setpoint. Control power is provided from a 125 VDC battery supply. Also, the system is testable.

An alarm is actuated when the RCS temperature is below 280°F and either the PARV setpoint enable switch is not in the low-range position, the PARV isolation valve is closed, or any of the four HPI valve circuit breakers is energized. An indicating light is provided to indicate that the OMS enable switch is in the low range.

Alarms and indication are provided to indicate that the PARV has operated and include the PARV indication lights, the PARV operation alarm, and the PARV discharge line high temperature alarm. There is no alarm indicating the failure of the PARV to operate at 550 psig.

4.2 DESIGN COMPLIANCE

On November 11, 1977, the NRC granted approval to FPC for their low temperature overpressurization mitigating system for all postulated transients with the exception of an inadvertent initiation of safety injection by the high pressure injection (HPI) train. The OMS, as it is designed to respond to HPI transients, is evaluated relative to the following staff requirements:

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

   The CR-3 proposal does not satisfy the staff requirements since the overpressure mitigation system relies both on operator action and the PARV. The PARV is designed to respond to HPI transients, but requires operator action. During a HPI caused transient, the operator must detect the transient and act to prevent RCS overpressure within 4.9 minutes after the transient has been initiated.

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

   The CR-3 does not satisfy all of the IEEE Std-279 and Seismic criteria.

The FPC has proposed to utilize only one low temperature overpressure protection channel for CR-3, with the use of operator action as a backup method of overpressure protection. The single channel utilizes a seismic qualified PARV with the control power provided by 125 VDC.

3. Single Failure - "The system must be designed to relieve the pressure transient given a single failure in addition to the failure that initiated the pressure transient.

   The CR-3 design has only one low temperature over-pressure protection channel. As such, there is no channel redundancy. It does not satisfy the single failure criterion.

4. Testability - "The system shall include provisions for testing on a schedule consistent with the frequency that the system is relied upon for pressure protection."

   The single CR-3 OMS is designed to allow testing prior to any reliance on the system.

The licensee was also required to provide alarms to alert the operator to (a) manually enable the OMS during cooldown, (b) indicate closure of a PARV isolation valve, and (c) indicate the occurrence of an overpressure transient.

The CR-3 design provides an alarm which indicates to the operator that the PARV must be enabled and/or that the PARV isolation valve is closed. This design feature meets the staff requirements.

The CR-3 design also provides an alarm to indicate that the PARV has operated. However, there is no direct pressure alarm to indicate that overpressure transient is in progress. As such, we recommend that pressure alarms indicating that an overpressure transient is in progress be installed by the licensee.

5.0 TECHNICAL SPECIFICATIONS

It is the NRC position that, when administrative controls are used to limit overpressure scenarios, that administrative controls appear in the Technical Specifications as Limiting Conditions for Operation. Therefore, it is recommended that the licensee Technical Specifications required changes be consistent with the following:

1. Any operation or failure of the PARV to operate to relieve pressure transients must be reported to the NRC.

2. The OMS and alarms must be operable (in operation) when the RCS temperature is below 280^{o}F. If these conditions are not met, the reactor coolant system must be depressurized and vented to the atmosphere within eight hours.

3. The four HPI motor-operated valves must be closed and the supplying circuit breakers opened, racked out, locked out, and tagged when the RCS temperature is below 280^{o}F and the reactor coolant is not vented to the atmosphere.

4. The pressurizer water level will be maintained below 220 inches when the reactor coolant temperature is below 280^{o}F and the reactor vessel is not vented to the atmosphere.

5. The low temperature overpressure mitigating system (dual setpoint PARV) and the low temperature over-pressure alarms must be tested on a periodic basis consistent with the need for its use. A system functional test and a setpoint verification test shall be performed prior to enabling the overpressure protection system during cooldown and startup. The system shall be calibrated and the PARV operationally tested at refueling intervals.

6. When the RCS temperature is below 280^{o}F, the operation of makeup water to the pressurizer shall be manually controlled (see 4 above).

7. The pressurizer heater banks will be deenergized and the breakers locked out and tagged when not required during cooldown and startup.

6.0 CONCLUSIONS

The Florida Power Corporation's proposal for a low temperature overpressure mitigation system for Crystal River Unit 3 does not satisfy all of the NRC criteria in the areas of electrical, instrumentation, and controls. It does not satisfy the criteria on the basis that (a) operator action will be required within ten minutes after detection of one specific transient (HP safety injection), (b) the system does not have redundant channels, and may be susceptable to a single failure, and (c) the system does not satisfy the IEEE-Std-279 and seismic requirements.

Although the CR-3 plant does not satisfy all of the original criteria, there are other factors which we considered to be compensatory. The criteria for an OMS were originated for PWR's that may be operated with the RCS in a water solid condition during cooldown and startup. The B&W-designed plant plan never operates with a water solid condition. A steam or nitrogen bubble is maintained in the reactor pressurizer. Of the 44 overpressure transients to date, there has been only one low temperature overpressure transient at the B&W-designed plants.

In order that the OMS be found acceptable from the EI&CS standpoint, it is recommended that the following additional changes be made by the licensee at the next refueling outage.

1. Pressure alarms should be installed to give the operator direct indication that a low temperature pressure transient is in progress and that the RCS pressure is on a trend to the exceeding the 550 psig relief setpoint.

2. The RCS pressure and temperature should be continuously recorded to provide a permanent record of all low temperature pressure transients. The recorder should have the capability to record 100 psig per second overpressure transients.

7.0 REFERENCES

1. J. T. Rodgers, "Interim Response to Overpressurization at Shutdown Conditions," December 2, 1976, FPC letter.
2. J. T. Rodgers, "Response to NRC Request for Additional Information," February 17, 1977, FPC letter.
3. J. T. Rodgers, Status Report to John Stolz, NRC, June 3, 1977, FPC letter.
4. W. P. Stuart, "Response to NRC Request for Additional Information," January 5, 1978, FPC letter.
5. W. P. Stuart, "Technical Specification Change Request N 17," January 23, 1978, FPC letter.
6. "Staff Discussion of Fifteen Technical Issues Listed in Attachment G, November 3, 1976 Memorandum from Director NRR to NRR Staff," NUREG-0138, November 1976.
7. J. F. Stolz, "Verification for Compliance with Appendix G Pressure-Temperature Limits During Startup and Shutdown," NRC letter, October 1, 1976.
8. J. F. Stolz, NRC letter to FPC in regard to overpressure protection system, NRC letter, November 19, 1976.
9. J. F. Stolz, "Verification of Compliance with Appendix G Pressure-Temperature Limits During Startup and Shutdown (Crystal River Unit 3 Nuclear Generating Plant)", NRC letter, January 7, 1977.
10. R. W. Reid, NRC letter to FPC in regard to overpressure protection system, November 11, 1977.