SAFETY EVALUATION REPORT

THREE MILE ISLAND UNIT 1

OVERPRESSURE MITIGATING SYSTEM

TAC 6708

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PREPARED BY

PLANT SYSTEMS BRANCH

DIVISION OF OPERATING REACTORS

SAFETY EVALUATION REPORT

1.0 INTRODUCTION

By letter dated August 11, 1976, we requested Metropolitan Edison Company (MEC) to analyze the Three Mile Island Nuclear Plant, Unit 1 (TMI-1) for potential causes of overpressure transients at low RCS temperatures, and to design and install plant systems to mitigate the consequences of these events. We also requested that operating procedures be examined and administrative controls be implemented to guard against initiating overpressure transients at RCS temperatures below the Nil Ductility Transition Temperature (NDTT).

The electrical, instrumentation, and control system aspects of the MEC proposal have been reviewed. Discussed are the events which are most likely to cause overpressure conditions at low temperatures, precautionary measures taken at TMI-1 to minimize the occurrence of these events, and a description of the system designed to respond to an overpressure transient should it occur. A safety evaluation follows.

2.0 EVALUATION

The enclosed Technical Evaluation Report was prepared for us by EG&G Idaho, Inc., as part of our DOR technical assistance program.

3.0 SYSTEM DESCRIPTION

The design of the Three Mile Island, Unit 1 reactor differs from that of Westinghouse designed reactors in that the TMI-1 RCS is never operated in a water solid condition. The B&W designed system 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 events which could potentially cause a reactor vessel low temperature overpressurization have been analyzed. With the initial RCS conditions at NDTT and a pressure of 275 psig, the analysis has determined the time required for a pressure transient to reach 550 psig (required pressure relief setting) after initiation, varies between 3.9 and 46.6 minutes, depending on the pressure transient source. Only a pressure transient caused by the actuation of a high pressure injection (HPI) train will reach the required pressure relief setting in ten minutes or less.

The Three Mile Island, Unit 1 plant has a single existing pilot actuated relief valve (PARV), located on the pressurizer. The decay heat removal system can not provide any additional relief protection from overpressure transients since it is isolated from the RCS when the pressure exceeds 400 psig.

The low temperature overpressure mitigating system is a modification of the actuation circuit for the existing PARV and provides alternate pressure relief setpoints. The high pressure setpoint is 2255 psig for reactor operation and the low temperature pressure setpoint is 485 psig which is lower than 550 psig when the NDTT limit is reached. This gives some allowance for the operator to serve as backup. A manually operated switch is provided to change the PARV setpoint. Control power is provided from a 125V DC battery supply. The system is also testable.

An alarm is actuated when the RCS temperature is below 275°F and the PARV setpoint control switch is not in the low-range position or when the PARV isolation valve is closed.

Alarms and indication provided to indicate the PARV has operated include the PARV indication lights, the PARV operation alarm, and the PARV discharge line high temperature alarm.

In addition to the above design features, the licensee has agreed to implement the following NRC recommended changes:

(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 exceeding the 485 psig setpoint.

(2) The RCS pressure and temperature should be continuously recorded to provide a permanent record of all low temperature pressure transients.

(3) HPI valves MU-V16A/B/C/D should be alarmed in the control room when not closed and the RCS temperature is less than 275°F.

4.0 CONCLUSIONS

The Metropolitan Edison Company's proposal for a low temperature overpressure mitigation system for the Three Mile Island, Unit 1 does not meet the intent of the NRC criteria in the areas of electrical, instrumentation, and controls. It fails to meet the criteria on the basis that (a) operator action will be required within ten minutes after detection of one specific transient, (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 TMI-1 plant does not comply with the original staff criteria, there are other factors which should be considered. The staff criteria for an OMS were originated for plants that are operated with the RCS in a water solid condition during cooldown and startup. With a water solid condition, a transient can cause an overpressurization of the vessel within seconds of initiation. This step transient makes it impossible for an operator to detect a transient and act in time to prevent overpressurization. The B&W designed plant never operates with a water solid condition. A steam or nitrogen bubble is maintained in the reactor pressurizer at all times.

Of the 44 overpressure transients to date, there has only been one low temperature overpressure transient at B&W designed plants.

In order that the TMI-1 OMS be found acceptable in the areas of EI&C, the licensee will be required to implement the additional changes described in Section 3.0 prior to startup.

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TECHNICAL EVALUATION
ELECTRICAL, INSTRUMENTATION, AND CONTROL ASPECTS
LOW TEMPERATURE OVERPRESSURE MITIGATING SYSTEM
FOR
THREE MILE ISLAND, UNIT 1
50-289

A. C. Udy
EG&G Idaho, Inc.

TAC 6708

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TECHNICAL EVALUATION
ELECTRICAL, INSTRUMENTATION, AND CONTROL ASPECTS
LOW TEMPERATURE OVERPRESSURE MITIGATING SYSTEM
FOR
THREE MILE ISLAND, UNIT 1

1.0 INTRODUCTION

By letter dated August 11, 1976 (Reference 8), the NRC requested Metropolitan-Edison Company (MEC) to analyze the Three Mile Island Nuclear Plant, Unit 1 (TMI-1) for causes of pressure transients at low pressure, and to design and install plant systems 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).

By letter dated October 15, 1976 (Reference 1), MEC submitted to the NRC a plant specific analysis. The NRC questioned portions of this analysis in a letter dated December 9, 1976 (Reference 9). In responding, the MEC, in a letter dated March 22, 1977 (Reference 2), revised their analysis and answered the NRC questions. This prompted design changes documented in References 3, 4, 5, and 6).

The electrical, instrumentation, and control system aspects of the MEC proposal have been reviewed in this report. Section 2 discusses the events which are most likely to cause overpressure conditions at low temperatures; Section 3 describes precautionary measures taken at TMI-1 to minimize occurence of these events; and Section 4 describes the system designed to respond to an overpressurizing event should it occur.

2.0 DESIGN BASIS EVENTS (DBE)

MEC analyzed seven postulated events in References 1 and 2. Of these events, four were found capable of creating an overpressure event. The events are:

(1) Erroneous Action of a HPI Train – An inadvertent actuation of a single train of high pressure injection (HPI) pumps would require action of the pilot-actuated relief valve (PARV) between 3.9 and 4.9 minutes with an initial pressure of 275 psig and a pressurizer level at 260 and 220 inches, respectively. At lower initial pressures, the times are longer. MEC does not consider this event as credible because of procedural requirements on startup and cooldown that require the circuit breakers for the HPI motor-operated valves to be racked-out when the Reactor Coolant System (RCS) temperature is less than 250°F.

(2) Makeup control valve (Makeup to the RCS) Fails Full Open – The time from initiation of the overpressure transient to required action of the PARV at 550 psig varies between 10.1 and 12.1 minutes (the analysis shows that the makeup tank will be empty at 12.1 minutes) with an initial pressure of 275 psig and the initial pressurizer level at 260 and 220 inches, respectively.

This transient occurs when one makeup pump is running and the makeup control valve (which is automatically controlled by the pressurizer level controller) fails in a full-open position. The operator can identify this event before the required PARV action by a combination of pressurizer high level alarms, makeup line flow rate indicator, low makeup pump discharge pressure, makeup control valve full-open indicating light, and high RCS pressure indication.

(3) All Pressurizer Heaters Erroneously Energized – The time from initiation of the overpressure

transient to required action of the PARV is 46.6 minutes with an initial pressure of 275 psig at a pressurizer level of 90 inches (resulting in the fastest rate of pressure increase). The pressurizer level is normally under automatic control, therefore, the automatic low-level heater cutoff cannot be credited with the capability of ending the pressure transient.

The operator can identify this event before the required PARV action by a combination of RCS pressure indication, higher-than-normal letdown flow rate indication (to the makeup tank), higher-than-normal makeup flow rate indication, and the pressurizer heater bank "On" lights.

(4) Loss of Decay Heat Removal System Capability – This event could be caused by loss of flow in either the decay heat removal system (DHRS) or in the cooling water system serving the DHRS, either of which would actuate low-flow alarms. The time from the initiation of the overpressure transient to required action of the PARV is 28.2 minutes for an initial pressure of 275 psig and an initial pressurizer level of 260 inches.

By a combination of RCS pressure indicators and low-flow alarms, mentioned above, the operator is made aware of this event.

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 either lockout or alarming of equipment capable of causing the overpressurization, and equipment not necessary for shutdown and startup.

3.1 Description The TMI-1 procedural steps requiring the removal of equipment from operation or the racking-out of pump and valve circuit breakers are performed by precedure steps that require initialling to indicate that satisfactory completion (Reference 2, Appendix A). Critical steps perfcrmed under administrative control are included.

The MEC TMI-1 plant has the following procedural precautions to prevent DPEs 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 racked 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 associated selector switches in the Control Room and by racking 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. These circuit breakers are not racked-in again until startup when RCS temperature is above 250°F.

(2) All pressurizer heaters erroneously energized - As part of the TMI-1 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. Heater "on" indicator lights in the Control Room provide the operator status of the heaters when energized.

3.2 Evaluation The TMI-1 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 when not in use and the RCS temperature is below the NDTT limit.

4.0 OVERPRESSURE MITIGATING SYSTEM (OMS)

4.1 System Description The design of the Three Mile Island, Unit 1 reactor differs from those of Westinghouse design in that the RCS is never in a water solid state. The B&W designed system 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. References 1 and 2 has analyzed the events which could potentially cause a reactor vessel low temperature overpressurization. With the initial RCS conditions at NDTT and a pressure of 275 psig, the analysis has determined the time required for a pressure transient to reach 550 psig (required relief setting) after initiation varies between 3.9 and 46.6 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 ten minutes or less.

The Three Mile Island, Unit 1 plant has a single existing pilot actuated relief valve (PARV) located on the pressurizer. 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 400 psig.

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

Operator Action - Since the operation of the RCS with a steam or nitrogen bubble in the pressurizer provides a minimum 3.9 minutes from the initiation of the transient until overpressurization, MEC has proposed that operator action should 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 presssure 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.

Dual Setpoint PARV – The automatic low temperature overpressure protection 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 chosen by MEC is 485 psig (Reference 6) which is lower than 550 psig when the NDTT limit is reached. This gives some allowance for the operator to serve as backup. A manually operated switch is provided to change the PARV setpoint. Control power is provided from a 125 VDC battery supply. The system is testable.

An alarm is actuated when the RCS temperature is below 275^{o}F and the PARV setpoint control switch is not in low-range position or when the PARV isolation valve is closed.

Alarms and indication provided to indicate that the PARV has operated 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 485 psig.

4.2 Design Compliance On November 11, 1977, the NRC granted approval to MEC for their low temperature overpressurization protection for all postulated transients with the exception of an inadvertent initiation of safety injection by the high pressure injection (HPI) train (Reference 10). The OMS, as it is designed to respond to HPI transients, is evaluated relative to the following staff requirements:

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

The TMI-1 proposal does not meet the staff requirements as the methods for overpressure mitigation are operator action and the PARV system. The PARV is designed to respond to HPI transients, but the operator can't be given credit for backup response. During a HPI caused transient the operator must detect the transient and act to prevent overpressurization within 3.9 minutes after the transient has been initiated. There is no alarm that a pressure transient is in progress.

(2) Seismic and IEEE 279 Criteria - "Ideally, the 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 mitigation system. Such events as the loss of instrument air and the loss of offsite power must be considered."

The TMI-1 OMS does not comply with the IEEE 279 and Seismic criteria.

The original intent of the NRC staff was that at least two independent automatic low pressure protection channels should make up the OMS. A channel should include separate sensors, alarms, power trains, and relief valves. Each channel should have complete electrical and physical independence from each other to prevent common mode failures. The OMS should be operable upon loss of offsite power. In addition, each OMS channel should not be susceptable to seismic events that could cause a transient and fail the channel at the same time.

MEC has proposed to utilize only one automatic low pressure protection channel for TMI-1, with the use of operator action as a second method of overpressure protection. The single channel utilizes a seismic qualified PARV with the control power provided by a 125 VDC power train.

No information has been provided by MEC concerning the electrical and physical independence between the control and power systems for the transient initiating devices and the PARV channel.

(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 TMI-1 design has only one low temperature overpressure protection channel. There is no channel redundancy. It does not comply with the NRC 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 TMI-1 PARV system is designed to allow testing of the system prior to its use.

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

The licensee design provides an alarm to indicate to the operator that the PARV must be enabled or that the PARV isolation valve is closed. This meets the staff requirements.

There is no direct pressure alarm to indicate that a transient is in progress. Since the TMI-1 proposal depends on operator action as the primary method to mitigate an overpressurization, the PARV operate alarm does not meet the staff requirements.

5.0 TECHNICAL SPECIFICATIONS

It is the staff position that, when administrative controls are used to limit overpressurization scenarios, that administrative controls shall appear in the Technical Specifications as Limiting Conditions for Operation. Therefore, it is recommended that the licensee be required to submit Technical Specification changes into the Three Mile Island, Unit 1 license 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 275°F. If these conditions are not met, the primary system

must be depressurized and vented to the atmosphere within eight hours. The PARV system may be removed from service for a short period of time if all (RC) makeup pumps are out of service.

(3) The four HPI motor-operated valves must be closed and the supplying circuit breakers opened, racked out, and tagged when the temperature is below 275°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 275°F and the reactor vessel is not vented to the atmosphere.

(5) The low temperature overpressure protection system (dual setpoint PARV) and the low temperature overpressure 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 275°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 licensee should submit Technical Specifications to comply with the requirements listed in Section 5.0.

The Metropolitan Edison Company's proposal for a low temperature overpressure mitigation system for the Three Mile Island, Unit 1 does not meet the intent of the NRC criteria in regards to electrical, instrumentation, and controls. It does not meet the criteria on the basis that (a) operator action will be required within ten minutes after detection of the transient, (b) the system does not have redundant channels and will be susceptable to a single failure, and (c) the system does not meet the IEEE 279 and seismic requirements. It does not have redundant channels that are electrically and physically separated and may be susceptable to seismic or other events which could cause a transient and a common failure of the single protection channel.

The single protection channel does have the required testability and an OMS enable switch alarm as required by the staff criteria.

One acceptable method for TMI-1 to comply with the NRC staff criteria would be to install an identical, yet electrically and physically independent, protection channel.

Although the TMI-1 plant does not comply with the original staff criteria, there are other factors which should be considered. The staff criteria for an OMS was originated for plants that are operated with the RCS in a water solid condition during cooldown and startup. With a water solid condition, a transient can cause an overpressurization of the vessel within seconds of initiation. This step transient makes it impossible for an operator to detect a transient and act in time to prevent overpressurization. The B&W designed plant never operates with a water solid condition. A steam or nitrogen bubble is maintained in the reactor pressurizer at all times. This bubble does not allow step transients to occur. Instead, transients occur as a ramp function with the HPI transient reaching the overpressurization point

3.9 minutes or more after initiation and all others requiring over ten minutes. This delay allows the operator time to detect the transient and take action to prevent the RCS pressure from reaching the PARV relief point. There has been only one low temperature overpressurization at the B&W designed plants.

If the MEC proposal is accepted, it is recommended that the following be required of the licensee:

(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 has exceeded 485 psig.

(2) The RCS pressure and temperature should be continuously recorded to provide a permanent record of all low temperature pressure transients.

(3) HPI valves MU-V16A/B/C/D should be alarmed in the control room when not closed and the RCS temperature is less than 275°F.

7.0 REFERENCES

1. R. C. Arnold, "Evaluation of Potential Vessel Overpressurization," October 15, 1976, Met-Ed letter GQL 1448.

2. R. C. Arnold, "Evaluation of Potential Vessel Overpressurization," March 22, 1977, Met-Ed letter GQL 0332.

3. R. C. Arnold, letter to R. W. Reid, NRC, April 6, 1977, Met-Ed letter GQL 0464.

4. J. G. Herbein, "Overpressurization Protection Systems," January 13, 1978, Met-Ed letter GQL 0049.

5. J. G. Herbein, "RCS Overpressurization," March 13, 1978, Met-Ed letter GQL 0426.

6. J. G. Herbein, "Technical Specification Change Request No. 74," March 13, 1978, Met-Ed letter GQL 0395.

7. "Staff Discussion of Fifteen Technical Issues listed in Attachment G, November 3, 1976 Memorandum from Director NRR to NRR staff," NUREG-0138, November 1976.

8. R. W. Reid, NRC letter to Met-Ed, Re: Reactor vessel overpressurization in pressurized water reactor facilities, August 11, 1976.

9. R. W. Reid, NRC letter to Met-Ed, Re: Additional information to evaluate overpressure mitigating system, December 9, 1976.

10. R. W. Reid, NRC letter to Met-Ed, Re: Preliminary review of overpressure mitigating system, November 11, 1977.