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WESTERN MASSACHUSETTS ELECTRIC COMPANY
HOLYOKE WATER POWER COMPANY
NORTHEAST UTILITIES SERVICE COMPANY
NORTHEAST NUCLEAR ENERGY COMPANY

General Offices • Selden Street, Berlin, Connecticut

P.O. BOX 270
HARTFORD, CONNECTICUT 06141-0270
(203) 665-5000

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Docket No. 50-245
B11650

Director of Nuclear Reactor Regulation
Attn: Mr. Christopher I. Grimes, Chief
Systematic Evaluation Program Branch
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Gentlemen:

Millstone Nuclear Power Station, Unit No. 1
Integrated Safety Assessment Program
Summaries of Public Safety Impact Model Project Analyses

In a letter dated July 31, 1985,(1) Northeast Nuclear Energy Company was requested to provide the Staff with summaries of the public safety risk oriented analyses of a selected number of projects we are evaluating in the Integrated Safety Assessment Program (ISAP).

In response to this request, and in accordance with our understanding of the ISAP process, we are providing the Staff with summaries of the following projects we have evaluated for public safety impacts:

1) ISAP Topic No. 2.04 - "High Steam Flow Setpoint Increase"

2) ISAP Topic No. 2.08 - "Extraction Steam Piping Replacement"

3) ISAP Topic No. 2.28 - "Long-Term Cooling Study"

4) ISAP Topic No. 2.30 - "MSIV Closure Test Frequency"

It is noted that since we have not completed our analyses of the entire set of ISAP projects, the public safety impact scores are to be considered preliminary at this time. Upon completion of our analyses of the entire ISAP project set, including all five attributes, we will review our analyses and revise our public safety impact results, if necessary, to assure consistency in the ranking of the ISAP projects.

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(1) H. L. Thompson letter to J. F. Opeka, "Integrated Safety Assessment Program," July 31, 1985.

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As further public safety impact analyses are completed, we will promptly forward summaries to the Staff for review.

If you have any questions on this material, please feel free to contact my staff.

Very truly yours,

NORTHEAST NUCLEAR ENERGY COMPANY

J. F. Opeka
Senior Vice President

cc: J. A. Zwolinski

ISAP #2.04 High Steam Flow Setpoint Increase

Safety Issue

At present the existing warranty for the Main Steam Turbine at Millstone Unit 1 requires weekly surveillance testing of the Turbine Stop Valves. This weekly surveillance testing requires reducing the core power from 100% to 90% to prevent Main Steam Isolation Valve (M.S.I.V.) closure on the resultant high steam flows in the non-affected steam lines (which occurs at 120% of rated steam flow). Any time in which the plant is maneuvered in power there is an increased chance of a plant transient resulting in reactor trip. The frequency of such events was evaluated in the Millstone Unit 1 Probabilistic Safety Study. It is proposed to increase the M.S.I.V. closure setpoint from 120% to 140% of rated steam flow. This will allow turbine stop valve closure testing at full power and will eliminate one of the more frequent causes for a power reduction (the other predominant causes being backflushing the condenser and on-line condenser tube plugging).

In raising the high steam flow setpoints for M.S.I.V. closure it must also be recognized that the potential exists for certain steam line breaks (outside containment) not being automatically detected and mitigating actions taken. The increase in the M.S.I.V. closure setpoint would thus have the effect of replacing an automatic action (for a certain size break) with a manual action.

Proposed Project

No hardware modifications are required. The setpoint for M.S.I.V. closure will be increased from 120% to 140% of rated steam flow and the weekly power reduction for turbine stop valve testing will be eliminated.

Analysis of Public Safety Impact

The public safety impact of this proposed project was assessed using Method A. As discussed in the Bases Section 3.2 of the Millstone Unit 1 Technical Specifications, the primary function of M.S.I.V. closure on high steam flow is to detect and isolate a break in the steam lines downstream of the M.S.I.V.s.

(e.g.: outside primary containment). The only adverse effect of increasing the setpoint was found to be for those steam line breaks which result in a flow rate between 120% and 140% in the main steam lines. If the proposed change is implemented, these specific breaks instead of isolating automatically will require the operator to manually close the M.S.I.V.s.

The method of analysis was to determine the frequency of breaks downstream of the M.S.I.V.s with specific break areas corresponding to steam flows between 120% and 140%. These breaks can be mitigated by the operator isolating them (by closing the M.S.I.V.s). The following assumptions were made:

- The frequency of a break which results in a flow rate between 120% and 140% in the steam lines is 1/5th of frequency of break with any flow area. The main steam lines are provided with Venturi's which limit the flow rate to 200% in case of a double ended break of a steam line. In other words, the spectrum of break sizes in the steam lines will result in flow rates between 100 and 200%. The specific break sizes of interest represent 20% of the entire range.

- It is conservatively assumed that due to blowdown of steam in the reactor building, all mitigating systems in the reactor building do not operate. The feedwater system which is located in the turbine building will remain operable. A break in the turbine building is not as severe since all mitigating systems located in the reactor building will remain operable. Therefore, all breaks in the turbine building are treated like breaks in the reactor building.

There are 40 sections of the steam lines downstream of the MSIVs (10 sections per steam line). Frequency of a pipe (>3" diameter) break per section is 1×10^{-10}/hour (based on WASH-1400 data). The frequency of a break in any one of 4 steam lines with a flow area resulting in a flow rate between 120 and 140% would be 7×10^{-6}/year.

If the operator fails to isolate the break but the feedwater system continues to run, the unmitigated blowdown outside the drywell will result in a late core melt with containment by-passed. (This would be a Plant Damage State SL2, see

Section 2.2 of the Millstone Unit 1 P.S.S.). As discussed in the second assumption, the feedwater (FW) may be the only mitigating system available. Therefore, failure of the FW will result in an early core melt with the containment bypassed (i.e. the PDS SE2).

The increase in plant damage state frequencies, if the project is implemented, was calculated by the following equations:

$$\lambda_{SL2} = \lambda_{LOCA} Q_{HEP} (1 - Q_{FW})$$

$$\lambda_{SE2} = \lambda_{LOCA} Q_{FW}$$

Where: λ_{LOCA} = frequency of a LOCA, 7×10^{-6}/year.

Q_{HEP} = Human error probability of the operator failing to isolate the break, 1×10^{-2}

Q_{FW} = Unavailability of FW system post trip, 1.031×10^{-2}

Results

If the M.S.I.V. closure setpoint is increased from 120% to 140%, the frequencies of the plant damage states SE2 and SL2 are expected to increase by 7×10^{-8}/year, each. All other Plant Damage States would be unaffected. This results in a total increase in the core melt frequency of 1.4×10^{-7}/year (less than 0.02% increase) and in public risk of 15 Man-Rem even when conservative assumptions (e.g. that environmentally qualified equipment in the reactor building would fail due to a harsh environment) are utilized. This project has been assigned a score of -0.05. The negative score indicates an actual increase in the public risk.

ISAP #2.08 Extraction Steam Piping Replacement

Safety Issue

A number of operating nuclear power plants have experienced severe erosion and failures in their extraction steam piping. Such failures are a potentially severe risk to operations personnel should an extraction steam line fail while they are in close proximity. Within the last five years there have been a number of fatalities in the industry which have occurred due to these types of failures.

As the industry problem with extraction steam piping erosion became evident an extensive inspection of extraction steam piping at Millstone Unit 1 was undertaken. Results from the inspections conducted at the last Millstone Unit 1 outage showed that the 8th, 9th and 11th stage extraction steam piping from the low pressure turbine had significant erosion degradation.

In terms of plant response to such an event, an extraction steam pipe failure will most likely lead to an M.S.I.V. closure event of the type already analyzed in the Millstone Unit 1 Probabilistic Safety Study. Such events result in the isolation of the Main Condenser as a decay heat removal system.

Proposed Project

The proposed project is to replace the affected extraction steam piping to prevent further erosion which could lead to subsequent piping failure. Replacement will consist of installing new pipe and associated hardware that has been upgraded to better resist erosion than the present carbon steel piping.

Analysis of Public Safety Impact

The public safety impact of this proposed project was evaluated using Method A. Based on industry experience, severe erosion of extraction steam piping can result not only in steam leaks but pipe rupture as well. In the event of such a rupture, the M.S.I.V.'s would automatically respond by isolating the main

steam lines from the downstream pipe rupture. In doing so, the Main Condenser is lost as a decay heat removal system. This increases the initiating event frequency for M.S.I.V. closure and pipe break outside of containment. Implementation of this project thus provides two benefits:

- o the likelihood of a future steam pipe rupture outside of containment is reduced
- o the likelihood of a future M.S.I.V. closure event is reduced.

Each of these potential benefits was evaluated separately.

A. Benefits From Avoiding a Future Pipe Rupture Outside Containment

Implementation of the proposed project avoids the potential of an increase in public risk due to unisolated steam line breaks outside of the containment resulting in core melt. The potential increase in public risk due to this type of scenario was determined to be wholely insignificant due to the availability of redundant and diverse ways to isolate an extraction steam pipe rupture. The mechanisms considered include:

- o M.S.I.V.s, located both inside and outside of containment which can be closed automatically on high steam flow or manually by the operator in the unlikely event that automatic detection fails.
- o two sets of turbine stop valves which can be closed by tripping the turbine.

In view of these available options and the long time periods available for the operator to take manual action from the control room, the benefits from avoiding a potential M.S.I.V. closure are found to be much more significant.

B. Benefits From Preventing a Future M.S.I.V. Closure Event

Implementation of the proposed project also avoids an increase in the M.S.I.V. closure frequency. The public safety impact of this benefit was evaluated using the Millstone Unit 1 P.S.S. model as a base case. The sensitivity of increased M.S.I.V. closure frequency (due to extraction steam piping rupture) on the core melt frequency was then calculated. The estimated increase in M.S.I.V. closure frequency is 0.5/yr. based on the actual piping wall thickness at Millstone Unit 1 and the erosion thinning rates for extraction lines as experienced by the industry. Calculations show that 90% of the extraction steam piping weld

joints will be at the 30% minimum threshold for wall thickness (the industry standard for initiating such pipe replacement) towards the end of Millstone Unit 1's current fuel cycle. If the piping is not replaced during the refueling outage, it is assumed that field repairs will be made to areas of the piping where leaks have been observed. During the following cycle, which is assumed to last 24 calendar months, most of the unrepaired welds will be close to 0% wall thickness near the end of cycle. Again, if the piping is not replaced, it is assumed that repairs will be made during refueling. The above implies that the extraction steam piping will have degraded to a point where failure would be expected to occur at any time during an operating cycle. If it is conservatively assumed that one failure could occur during each operating cycle that the pipe is not replaced, then the frequency of such an event is 0.5/yr. (i.e. 1 failure in each 24 month operating cycle).

The Millstone Unit 1 P.S.S. model was requantified after the MSIV closure frequency was increased by 0.5/yr. to account for extraction steam pipe failure. Results of this sensitivity study are shown in Table 1, and indicate that the core melt frequency increases by ~2.7% i.e., from 8.07×10^{-4}/yr. to 8.29×10^{-4}/yr.

Results

The results of the sensitivity study indicate that the frequency of plant damage states TE1, TE2, TI1, and TL2 will increase slightly as a result of not replacing the existing extraction steam piping. The Man-Rem impact of this proposed project was evaluated assuming that the extraction steam piping will in any case be replaced within 10 years. Thus the exposure time T = 10 years is used instead of the 25 years of remaining plant life. It is concluded that the extraction steam pipe replacement would conservatively result in the savings of 709 Man-Rem to the public. Accordingly the project was given a score of 1.75 out of a possible 10.

Table 1

Impact of Not Replacing the Extraction Steam Piping at Millstone Unit 1

	Base Case (As-Is)	Without Extraction Steam Piping Replacement
M.S.I.V. Closure Frequency		
	0.435/yr	0.935/yr
Plant Damage State Frequencies		
TE1	2.57×10^{-4}	2.62×10^{-4}
TE2	1.41×10^{-5}	1.53×10^{-5}
TI1	2.26×10^{-4}	2.30×10^{-4}
TL2	8.25×10^{-5}	9.49×10^{-5}
SE1	1.54×10^{-5}	1.54×10^{-5}
SE2	2.54×10^{-7}	2.54×10^{-7}
SI1	1.85×10^{-4}	1.85×10^{-4}
SL2	8.59×10^{-6}	8.59×10^{-6}
AE1	1.37×10^{-6}	1.37×10^{-6}
AE2	2.30×10^{-9}	2.30×10^{-9}
AI1	1.60×10^{-5}	1.60×10^{-5}

ISAP #2.28 Long Term Cooling Study

Safety Study

The Millstone Unit 1 Probabilistic Safety Study (P.S.S.) modeled four long term decay heat removal systems:

- Feedwater and Main Condenser
- Isolation Condenser
- Shutdown Cooling System
- Alternate Shutdown Cooling

The results of Millstone Unit 1 Probabilistic Safety Study show that about 64% of total core melt frequency from the internal events is due to a failure to maintain adequate long term decay heat removal. In all of these sequences, RPV water level is initially recovered to its normal value either by the Feedwater system or the low pressure pumps (L.P.C.I. or Core Spray) and core decay heat is rejected into the torus. If sufficient long term decay heat removal is not available, the torus will continue to heat up. This will result in a loss of injection pump N.P.S.H. and will lead to loss of all injection and thus core melt.

The P.S.S. analysis shows that failures of Shutdown Cooling (SDC) and Alternate Shutdown Cooling are the major contributors to core melt frequency. Unavailability of the Main Condenser and Isolation Condenser systems also contribute to core melt risk, however, their calculated unavailabilities are an order of magnitude lower than those of the Shutdown Cooling System and Alternate Shutdown Cooling. By improving the plant's long term decay heat removal capability, the public risk impact of Millstone Unit 1 can be greatly reduced.

Proposed Project

The proposed project is an integrated study of the long term cooling capability at Millstone Unit 1. The study will include:

- A review of all potential decay heat removal schemes (including those not directly considered in the Millstone Unit 1 P.S.S.)
- Plant specific thermal hydraulic analyses of long term core

cooling and containment cooling utilizing systems and containment codes

- o Identification of potential operator actions to improve on the existing decay heat removal capability (such as torus flooding from external sources to prolong injection) until permanent hardware improvements are incorporated
- o Identification of decay heat removal systems requiring hardware modifications.

The study will consider all existing systems which can be used for long term cooling (examples include but are not limited to: Reactor Water Clean-Up System non-regenerative heat exchangers, torus makeup and letdown, and containment venting). The desired results will include:

- o A refinement of system success criteria
- o Recommendations on possible emergency operating procedure changes
- o Identification of weaknesses of existing long term decay heat removal systems and recommendation of possible hardware modifications.

Analysis of Public Safety Impact

The public safety impact of this proposed study was evaluated using Method A. This proposed study is intended to identify the best way to improve the plant's long term decay heat removal capability. Since failure of long term decay heat removal contributes to 64% of the total core melt frequency, the importance of this issue is self evident. To reduce public risk, it is necessary to address this issue. Therefore, the long term cooling study has been assigned a score of 10 out of 10.

ISAP #2.30 MSIV Closure Test Frequency

Safety Issue

The Millstone Unit 1 Reactor Protection System (R.P.S.) design incorporates an M.S.I.V. Closure trip function which initiates reactor trip when 1/2 taken twice coincidence logic senses M.S.I.V. closure greater than 10%, based on valve travel limit switches. This trip function is an anticipatory trip which provides for reactor trip before the reactor pressure and neutron flux respond to the collapse in reactor coolant voids that accompanies M.S.I.V. closure. The failure of this trip function is backed up by the High-High Average Power Rate Monitor (A.P.R.M.) and High Reactor Pressure trip functions.

At present, Technical Specification 4.1.A requires monthly surveillance testing of this trip function. The actual test performed requires 10% closure of the valve to ensure that a reactor trip signal is generated. Another surveillance test (performed quarterly at 60% power) determines the closure time of the M.S.I.V.s.

On two occasions, while performing the 10% M.S.I.V. closure surveillance test, at 100% power the individual valve being tested over travelled and closed causing high steam flow in the remaining three steam lines. This resulted in automatic main steam line isolation and the closure of the remaining M.S.I.V.s. There is some potential for this type of event to occur any time the test is performed while at 100% power. The Millstone Unit 1 Probabilistic Safety Study evaluated such events and concluded that they contributed to 93% of the causes of Reactor Transient Events with the Main Condenser Unavailable. Such events account for 2.44% of the predicted core melt frequency. Therefore, by reducing the frequency of 10% M.S.I.V. closure test, the frequency of such events can be reduced.

Proposed Project

No hardware modifications are required. The proposed project calls for only a change in the surveillance test procedures by requiring that the surveillance test for 10% M.S.I.V. closure be conducted in conjunction with the quarterly

M.S.I.V. closure stroke test required by Technical Specification 4.7.D.1.c. In performing this surveillance reactor power is reduced to roughly 60% to avoid the high steam flows in the unaffected steam lines.

Analysis of Public Safety Impact

The public safety impact of this proposed change was assessed using Method A. In the 12 years of plant operation considered in the initiating event data base of the Millstone Unit 1 P.S.S., there have been 5 events initiated by M.S.I.V. closure. Two of these five events were due to failures occurring during the 10% M.S.I.V. closure surveillance testing. The benefit of performing the 10% M.S.I.V. closure test in conjunction with quarterly closure-time test, was estimated by requantifying the frequency of M.S.I.V. closure events and excluding the two testing related events. The core melt frequency was then recalculated with the modified M.S.I.V. closure frequency.

The main purpose of 10% closure testing is the verification of generation of the R.P.S. trip signal on M.S.I.V. closure. Increasing the testing interval may slightly reduce the reliability of R.P.S. signal generated by the M.S.I.V. position. For almost all the dominant core melt sequences provided in Section 5 of the Millstone Unit 1 Probabilistic Safety Study, it was found that the R.P.S. signal is generated either on low RPV water level or high drywell pressure. Therefore, a slight reduction in the reliability of the R.P.S. signal being generated by the M.S.I.V. position will have an insignificant impact on core melt frequency or public risk. This effect was not considered further.

As discussed in Sections 1.1 and 1.2 of the Millstone Unit 1 P.S.S., the events initiated by M.S.I.V. closure are included in the event category of Reactor Trip with the Main Condenser System unavailable. If the 10% M.S.I.V. closure testing had never been performed, 2 of the M.S.I.V. closure events in this category would not have occurred. Excluding these 2 M.S.I.V. closure events from Millstone Unit 1 experience and updating the industry experience results in a drop in the Reactor Transient with Main Condenser System unavailable frequency from 0.435/year to 0.27/year. (Note, as discussed in Section 1.2, of the Millstone Unit 1 P.S.S., M.S.I.V. closure contributes more than 93% to this

category). Decrease in core melt frequency is calculated by requantifying all the sequences.

Results

If the 10% M.S.I.V. closure test is performed quarterly along with M.S.I.V. closure-time test, the core melt frequency is expected to decrease from 8.07 x 10^{-4}/year to 7.99 x 10^{-4}/year, or a drop of 8.0 x 10^{-6}/year (or ~1%). About 50% of this drop is in plant damage states TE1 and TI1. The remaining reduction is in plant damage state TL2 (see Section 2.2 of the Millstone Unit 1 P.S.S. for the definition of the plant damage states). The change in the test frequency proposed here will decrease the public risk by 600 person-rem over the remaining life of the plant. This results in a score of 1.5 out of 10.