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IRM/APRM OVERLAP IMPROVEMENT FOR NINE MILE POINT NUCLEAR STATION UNIT ONE

PREPARED FOR
NIAGARA MOHAWK POWER CORPORATION

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1.0 ABSTRACT

GE Nuclear Energy (GENE) supports the Niagara Mohawk Power Corporation's (NMPC's) submittal for the Nine Mile Point Unit 1 (NMP1) Technical Specification amendment to operate in the Intermediate Range Monitor (IRM) Range 10 during "STARTUP" with the Reactor Protection System (RPS) low pressure trip for main steam line isolation valve closure unbypassed.

2.0 BACKGROUND

The inability to achieve IRM/Average Power Range Monitor (APRM) overlap calibration at NMP1 became known to GENE in May 1992. A Potential Safety Concern (PSC) evaluation was conducted by GENE Licensing who has concluded that no Potential Reportable Condition (PRC) evaluation was required. Results of the engineering study showed that the operational inconvenience is intrinsic, pertaining to the design of the plant. In 1982, Oyster Creek Nuclear Generating Station, a sister plant of NMP1, had the same operational problem; but decided, with GENE's help, to modify its RPS isolation logic such that proper IRM/APRM overlap calibration would be allowed. With the intention to solve the same problem, NMPC requested GENE to perform a plant specific analysis for NMP1 in April 1993. The results, which were documented in the GENE Report Numbers GE-NE-909-16-0295 (Reference 10.4), which recommended a similar solution to this problem for NMP1.

3.0 SCOPE

GENE will provide a non-proprietary version of the engineering report, GENE-909-39-1093, which is to assist NMPC to justify IRM operation in Range 10 during the "STARTUP" mode and the RPS low pressure isolation trip unbypassed, and to review the NRC submittal proposed by NMPC to confirm the proper implementation of the GENE's Recommendation 11.2 of Reference 10.4.

4.0 OBJECTIVE

The principal objective of this analysis is to provide engineering support to NMPC for preparing the NRC submittal of a NMP1 Technical Specification change. These Technical Specification changes are the result of implementing (1) the use of IRM Range 10 in the "STARTUP" mode of plant operation and (2) the deletion of the APRM downscale scram. Both implementations have been justified by analyses performed by GENE, consistent with recommendations from a study performed by GENE for NMPC on IRM/APRM overlap problem. (References 10.4 and 10.5)

5.0 EVALUATION OF EXPANDED OPERATION IN STARTUP USING IRM RANGE 10

Current operating procedures at NMP1 during "STARTUP" and "SHUTDOWN" are to switch the reactor mode switch between "STARTUP" and "RUN" when the IRMs are in Range 9. This causes significant system adjustment and operational difficulties because of the narrow IRM/APRM overlap when switching reactor modes in IRM Range 9. This is detailed further in Reference 10.4. Current Technical Specifications are commensurate with these operational procedures.

To greatly reduce the operational difficulties, the IRM Range 10 is used to increase the IRM/APRM overlap.

During startup for low reactor pressures, less than 800 psia, or low core flows, less than 10 percent of rated, the protection against the fuel cladding integrity safety limit is provided by the Safety Limit 2.1.1b through the Limiting Safety System Setting (LS^3) 2.1.2b. Ideally, the IRM Range 9 high flux scram corresponds approximately to 12 percent rated neutron flux. This provides compliance with LS^3 2.1.2b and conservatively protects against Safety Limit 2.1.1b. An expanded discussion of technical specification applicability and basis for operation in "STARTUP" mode IRM Range 9 is provided in Section 7 of Reference 10.4.

After the core flow exceeds 10 percent of rated and the reactor pressure exceeds 800 psia, the IRMs are allowable to be switched to Range 10, and the protection against the fuel cladding safety limit is now provided by the Safety Limit 2.1.1a.

5.0 EVALUATION OF EXPANDED OPERATION IN STARTUP USING IRM RANGE 10 (continued)

For operation in IRM Range 10, power can be increased in the "STARTUP" mode until such time when all APRMs are on scale (calibrated per standard surveillance procedure), and without overlap difficulties, the mode switch can be readily switched from "STARTUP" to "RUN". For operation in IRM Range 10, protection against reactivity transients would be provided by the IRM high flux scram and rod block trips since the reactor scrams from reactivity insertion transients occurring while in IRM Range 10 will occur well before transients initiated under similar conditions in the "RUN" mode.

The potential reactivity insertion transients necessary to be considered for reactor operation while in IRM Range are the Control Rod Drop Accident (CRDA), the Rod Withdrawal Error (RWE) transient, and cold water injection events.

Protection against the CRDA are provided by the Rod Worth Minimizer(RWM), which ensures through group rod withdrawal sequencing that the effects of a CRDA will be within the peak fuel enthalpy design limit. NMP1's Technical Specification limit for RWM operation is conservatively set at 20 percent rated power.

This study shows that, during operation in IRM Range 10, the IRM upscale rod block and the IRM upscale scram and the minimum recirculation flow requirement of greater than 30 percent, ensure that a complete rod withdrawal transient to full out position will not result in violating the fuel cladding safety limit. These restrictions bound the uncertainty associated with the IRM's ability to terminate a rod withdrawal transient due to the limited number and location of the detectors compared with the APRM system.

The application of these generic analyses supporting the above are valid for NMP1 for the current reload using GE fuel designs up through GE11, based on the current cycle rod withdrawal error analysis as non limiting for an unblocked full rod withdrawal (reference 10.10). The validity of these generic analyses, which have been used to qualify the RWE transient in IRM Range 10, must be confirmed for new core/fuel designs if the RWE analysis takes credit for a blocked rod withdrawal from the APRM system to mitigate the delta CPR.

5.0 EVALUATION OF EXPANDED OPERATION IN STARTUP USING IRM RANGE 10 (continued)

The third power increasing transients are cold water injection transients, such as inadvertent High Pressure Coolant Injection (HPCI), Loss of Feedwater Heater (LOFH) events, and improper startup of an idle recirculation loop. Analysis of these events assume maximum injection of cold water into the reactor (Reference 10.18). The separate analysis and calculations supporting these three transients were based on the reactor scramming from the 120 percent of rated neutron flux trip; no credit was taken for the IRM scram or the flow biased flux scram. All calculations demonstrated significant margin towards the licensing basis failure criterion of 170 cal/g total energy deposition. On an MCPR basis, the acceptability of cold water injection transients at low powers is supported by the Reload 12 engineering analysis (Reference 10.10). Therefore, cold water injection transients occurring during IRM Range 10 operation will not result in violating the fuel cladding safety limit.

Because the capability exists for operation in IRM Range 10 above 25 percent core thermal power (CTP), protection is necessary against a depressurization transient which could drop pressure below 800 psia violating Safety Limit 2.1.1b. To provide automatic protection against this, the RPS low pressure isolation trip could be unbypassed for operation in IRM Range 10. With the modification of the RPS logic to include low pressure isolation trip in the IRM Range 10, no degradation in plant safety would exist from operating in IRM Range 10 during "STARTUP".

6.0 DELETION OF COINCIDENT APRM DOWNSCALE/IRM UPSCALE SCRAM TRIP

6.1 NMP1 Design Basis

Based on the NMP1 Technical Specification, NMP1 has the coincident logic which enforces a scram trip whenever an IRM upscale scram trip occurs and the corresponding APRM is downscale as the reactor mode switch is in the "RUN" position. The trip logic allows the APRM downscale trip to automatically reactivate the IRM upscale scram trip when the IRM is fully inserted in the core and considered operable.

The coincident APRM downscale/IRM upscale scram trip design basis is to ensure that the reactor is operated with continuous neutron monitoring instrumentation. The coincident logic is intended to enforce adequate overlap with a scram trip, and as long as the Neutron Monitoring System is operating properly with the required overlap between the two NMS subsystems (IRM's and APRM's), the scram trip would not be reactivated

6.0 DELETION OF COINCIDENT APRM DOWNSCALE/IRM UPSCALE SCRAM TRIP (Continued)

The IRM's are required to be inserted in the core whenever the mode switch is in "REFUEL", "STARTUP", and "RUN". When the IRM's are fully inserted in the core and monitoring core neutron flux levels, the IRM's are considered operable and performing the design basis function. However, the IRM's are only required to be inserted in "RUN" mode until the APRM downscales have cleared with sufficient margin such that transients would not cause the power level to decrease resulting in APRM downscale trips. Operating procedures ensure that the IRM's remain inserted until the reactor power is stabilized in the "RUN" mode at power levels such that the APRM downscale's are not challenged.

After the transition to "RUN" is complete, the IRM's are no longer required and are withdrawn from the core. The design of the IRM's requires withdrawal at this point in order to prevent premature burnup. The coincident APRM downscale/IRM upscale scram function no longer applies. The protection of the core is now provided by the APRM upscale trips and the APRM downscale protective function is provided by the APRM rod block trip.

6.2 Basis for Deletion

The proposed IRM Range 10 modification expands the operating region for the IRM's to correspond with a range from 0 percent to 40 percent rated neutron flux. Through the expansion of the IRM operating region, the ability of the APRM subsystem to overlap with the IRM subsystem is greatly improved such that the coincident scram function can be replaced with an overlap surveillance similar to that for the later generation BWR's.

This is consistent with the basis employed to eliminate the coincident scram trip from the Reactor Protection System (RPS) design of the later generation BWR's. This change was achieved by incorporating the following improvements over the earlier APRM system design like the one at NMP1.

a. The later generation BWR's improved monitoring of the average flux in the low power region such that the APRM could provide the core wide transient protection in "STARTUP" mode.

b. In addition to the above design improvement of the APRM subsystem and the RPS protective logic, an overlap surveillance requirement was imposed between the IRM's and APRM's. This surveillance required that, during a controlled shutdown, the IRM's be verified to be onscale with at least 1/2 decade in neutron flux indication prior to reaching the APRM downscale setpoint and prior to changing the operating mode from "RUN" to "STARTUP".

c. Plant operation procedures established to provide the operator with corrective actions required in response to a APRM downscale rod block in the overlap region.

6.0 DELETION OF COINCIDENT APRM DOWNSCALE/IRM UPSCALE SCRAM TRIP (Continued)

6.3 Safety Analysis Basis

As discussed previously the basis for the deletion of the coincident scram function is that the IRM system operation band has been expanded and protective functions improved such that the IRM/APRM overlap problem is no longer a concern. The addition of the surveillance provides adequate assurance the overlap capabilities will be maintained.

The current safety basis is that the IRM's are considered operable in the run mode when the IRM's are fully inserted and monitoring core flux levels in the overlap region and, if a corresponding RPS trip channel APRM is downscale, the APRM is considered inoperable and the IRM trip is reactivated.

If, because of prematurely entering the "RUN" mode during startup, the minimum number of operable APRM's is not met, a rod block would be initiated and the existing technical specification LCO would be applied. The LCO requires corrective action within one hour. The basis of this LCO time period is that the probability of an accident or transient requiring a scram from the APRM system is minimized.

The existing LCO is based on operation in the power range after the IRM's have been determined to be not required and withdrawn from the core wherein no credible failure exists which would cause more than one APRM channel to be downscale. The only credible failure is loss of power and in this case the RPS system would automatically initiate a scram trip. The expansion of the IRM operating range and the IRM/APRM overlap surveillance ensure that the probabilities associated with multiple APRM channel downscales occurring is eliminated. Therefore, the Technical Specification LCO for this occurrence is applicable.

Plant operating procedures place strict controls on changing from one operating condition to another (e.g. "STARTUP" to "RUN"), and therefore, the APRM's can be relied upon to satisfy their respective operability requirements (e.g. minimum number of channels above downscale setpoint) prior to entering the "RUN" mode. If the procedure minimum requirements are not met the operator will not be allowed to switch from the "STARTUP" mode to the "RUN" mode.

The APRM system is designed to meet the single failure criteria and during this short period of time (1 hour), the APRM channels may read downscale but should still be responsive to the neutron flux. The 120 percent APRM upscale trip will provide the necessary protection against all associated design basis accidents previously evaluated in the NMP1 FSAR: Rod Drop Accident and Rod Withdrawal Error event (References 10.8, 10.14, 10.15, & 10.16). This is the same design basis which is the basis for requiring the APRM system to be operable in "REFUEL", and "STARTUP" even though the channels indicate downscale.

During power descent, the possible operator error would be to delay changing the reactor mode switch to the "STARTUP" mode, thus bypassing the IRM's for a longer period of time and to a lower power level. The consequences of this error would be no different than those described above for power ascension.

6.0 DELETION OF COINCIDENT APRM DOWNSCALE/IRM UPSCALE SCRAM TRIP (Continued)

6.4 Conclusion

As discussed above, the operator errors of prematurely going to the "RUN" mode during startup or delaying shifting from "RUN" mode during shutdown (resulting in too many APRM channels having downscale) do not result in a significantly degraded APRM safety function. The APRM downscale rod block trip will continue to both prohibit control rod withdrawal errors and power ascension during the time period needed to take corrective action required by plant technical specification. The 120 percent APRM upscale trip will provide the necessary protection against design basis events previously evaluated in the Final Safety Analysis Report (FSAR). It is for these reasons, together with the extensive surveillance required for the function, that the coincident APRM downscale/IRM upscale scram trip is recommended to be deleted from the NMP1 Technical Specification.

7.0 PROPOSED TECHNICAL SPECIFICATION CHANGES

The following Technical Specification changes required for implementing the modifications are proposed by NMPC and concurred by GENE.

LS[3] 2.1.2b — IRM scram trip setting shall not exceed 12 percent of rated neutron flux for IRM range 9 or less. (safety limit 2.1.1b)

IRM scram trip setting shall not exceed 38.4 percent of rated neutron flux for IRM range 10 and reactor pressure greater than or equal to 850 psig. (safety limit 2. 1. la)

Basis 2.1.2b — For operation in the startup mode while the reactor is at low pressure, the IRM Range 9 High Flux scram setting of 12 percent of the rated neutron flux provides adequate thermal margin between the maximum neutron flux and the safety limit of 25 percent of rated power to accommodate anticipated maneuvers associated with power plant startup. There are a few possible sources of rapid reactivity input to the system in the low power/low flow condition. Effects of increasing pressure at zero or low void content are minor, because cold water from sources available during the startup is not much colder than that already in the system, temperature coefficients are small, and control rod sequences are constrained by operating procedures backed up by the rod worth minimizer. Worth of individual rods is very low in a constrained rod pattern. In a sequenced rod withdrawal approach to the scram level, the rate of power rise is no more than 5 percent of the rated per minute, and the IRM system would be more than adequate to assure a scram before the power could exceed the safety limit.

7.0 PROPOSED TECHNICAL SPECIFICATION CHANGES (Continued)

To continue operation beyond 12 percent of rated neutron flux, the IRMs must be transferred into Range 10. The Reactor Protection System is designed such that reactor pressure must be above 850 psig to successfully transfer the IRMs into Range 10, thus assuring added protection for the fuel cladding safety limit. The IRM scram remains active until the mode switch is placed in the "RUN" position at which time the scram function is transferred to APRMs.

The adequacy of the IRM scram was determined by comparing the scram level on the IRM Range 10 to the minimum APRM scram level. The IRM scram is at approximately 40 percent of rated power while the minimum flow biased APRM scram which occurs at zero recirculation flow is at 65 percent of rated power. Therefore, transients requiring a scram based on flux excursion will be terminated sooner with an IRM Range 10 scram than with an APRM scram.

Above the (RWM) low power setpoint (20 percent of rated power, the ability of the IRMs to terminate a rod withdrawal transient is limited due to the number and location of IRM detectors. An evaluation was performed that showed by maintaining a minimum core flow of $20.25 x 10^6$ lb/hr in Range 10 a complete rod withdrawal to full-out position initiated below 40 percent of rated power or less would not result in violating the fuel cladding safety limit. Therefore, the IRM rod block and scram in Range 10 provide adequate protection against a rod withdrawal error transient.

LS[3] 2.1.2g — The reactor low pressure setting for main-steam line isolation valve closure shall be ≥850 psig when the reactor mode switch is in the run position or IRM's are on Range 10. (safety limit 2.1.1a)

Basis 2.1.2g-h (1st paragraph) — The low pressure isolation of the main steam lines at 850 psia was provided to give protection against fast reactor depressurization and the resulting rapid cooldown of the vessel. Advantage was taken of the scram feature which occurs when the main steam line isolation valves are closed, to provide for reactor shutdown so that high power operation at low reactor pressure does not occur, thus providing protection for the fuel cladding integrity safety limit. Operation of the reactor at pressures lower than 850 psig requires that the reactor mode switch be in the startup position and the IRMs on Range 9 or lower, where protection of the fuel cladding integrity safety limit is provided by the IRM high neutron flux scram. Thus, the combination of main steam line isolation on reactor low pressure and isolation valve closure scram assures the availability

7.0 PROPOSED TECHNICAL SPECIFICATION CHANGES (Continued)

of neutron flux scram protection over the entire range of applicability of the fuel cladding integrity safety limit. In addition, the isolation valve closure scram anticipates the pressure and flux transients which occur during normal or inadvertent isolation valve closure. With the scrams set at $\leq$10 percent valve closure, there is no increase in neutron flux and peak pressure if the vessel dome is limited to 1141 psig.(8,9,10)

References for Bases 2.1.1 & 2.1.2	(16) GE-NE-909-16-0393, "NMP1 IRM/APRM Overlap Modification."

LCO 3.1.7(g) Required Minimum Recirculation Flow Rate for Operation in IRM Range 10

During "STARTUP" mode operation, 30 percent of rated core flow is the minimum flow rate necessary to perform control rod movement during operation in IRM Range 10. This flow rate is consistent with the minimum flow rate conservatively established by the RWE analysis. Control rod movement is prohibited during operation in IRM Range 10 if the core flow is less than 30 percent of rated.

Basis LCO 3.1.7g

During operation above the low power setpoint of 20 percent power and less than 40 percent power when in IRM Range 10 with the mode switch in "STARTUP", the RWE analysis established the minimum core flow to be greater than 30 percent to ensure protection against the SLMCPR for a RWE to the full-out position. To ensure compliance with this analysis, the LCO prohibits control rod movement in IRM Range 10 if the core flow is less than 30 percent. This is procedurally controlled. This minimum flow restriction does not apply in the "RUN" mode.

Table 3.6.2(a)	Item 9ai:	Delete the IRM upscale from run. Replace Note g with "x" for startup and refuel
	Item 9biii:	Delete the APRM downscale scram from the table.

Note (f) for Table 4.6.2a

Perform Instrument Channel Test once per week, not required to be performed when entering startup from "RUN" until 12 hours after entering "STARTUP". Verify the source range monitor (SRM) and intermediate range monitor (IRM) channels overlap during startup. Verify the IRM and APRM channels overlap at least 1/2 decade during entry into "STARTUP" from "RUN". Perform Instrument Channel Calibration once per operating cycle (neutron detectors are excluded).

7.0 PROPOSED TECHNICAL SPECIFICATION CHANGES (Continued)

Note (g) Table 3.6.2a	Deleted.
Table 3.6.2b	Item (5) Add Note h to the startup mode.
Note (h) for Table 3.6.2b	Only applicable during "STARTUP" mode while operating in IRM Range 10.
Note (g) for Tables 4.6.2g	Perform Instrument Channel Test once per week, not required to be performed until 12 hours after IRMs are on Range 2 or below. Perform Instrument Channel Calibration once per operating cycle (neutron detectors are excluded).
Note (j) for Tables 4.6.2g	Perform Instrument Channel Test once per week, not required to be performed when entering "STARTUP" from "RUN" until 12 hours after entering "STARTUP". Perform Instrument Channel Calibration once per operating cycle (neutron detectors are excluded).

8.0 PROCEDURES

NMP1 IRM calibration/test surveillance procedures should be updated in order to implement the GENEs' recommendations of References 10.4 and 10.5, and this report.

9.0 CONCLUSION

GENE has reviewed the existing overlap between the IRM's and the APRM's at NMP1 and is in concurrence that expanded overlap is required. This report provides the engineering evaluation of the design changes proposed by NMPC and supports expanding the IRM monitoring range to include Range 10 to allow better IRM/APRM overlap. These conclusions are based on IRM Range 9 being calibrated such that the Range 9 upscale ensures compliance with the LS^3 setpoint of 12 percent of rated neutron flux, when the reactor dome pressure is less than 800 psia. Operation in IRM Range 10 is automatically prohibited below a reactor pressure of 800 psia. GENE has reviewed the need for the coincident APRM downscale/IRM upscale scram trip assuming that the IRM Range 10 modification is implemented and concurs that this scram trip is not required. If the IRM Range 10 modification is implemented, then this coincident scram trip can be replaced with an overlap surveillance which requires that a minimum of 1/2 decade in neutron flux overlap between the IRM and the APRM's be demonstrated during planned shutdowns to

9.0 CONCLUSION (continued)

assure a smooth transition from "STARTUP" to "RUN" mode during next plant startup. The Range 10 modification and the corresponding procedural controls governing transfer between "STARTUP" and "RUN" assure adequate overlap between the IRM and APRM and meet the 1/2 decade overlap requirement without incurring any safety degradation.

10.0 REFERENCES

10.1 Deleted.

10.2 Deleted.

10.3 Deleted.

10.4 GENE-909-16-0295, "IRM/APRM Overlap Analysis for Nine Mile Point Nuclear Station Unit One," February, 1995.

10.5 EMCL9348, draft letter from EM Chu to G. Inch, "APRM Downscale Scram Trip," October 1, 1993.

10.6 Deleted.

10.7 Deleted.

10.8 G.A. Watford, "Continuous Control Rod Withdrawal Transient in the Startup Range with IRM Failure, MDE-88-0786, September 1986.

10.9 Deleted.

10.10 J.L. Embley, "Engineering Report for Application of GE11 to Nine Mile Point Nuclear Station Unit 1 - Reload 12, Revision 1" GENE-770-31-1292, April 1993.

10.11 Deleted.

10.12 Deleted.

10.13 Deleted.

10.14 R.C. Stirn, et al, "Rod Drop Accident Analysis for Large Boiling Water Reactors," NEDO-10527, March 1972.

10.15 R.C. Stirn, et al, "Rod Drop Accident Analysis for Large Boiling Water Reactors," NEDO-10527, Supplement 1, July 1972.

10.16 R.C. Stirn, et al, "Rod Drop Accident Analysis for Large Boiling Water Reactors," NEDO-10527, Supplement 2, January 1973.

10.0 REFERENCES (continued)

10.17 Deleted.

10.18. Deleted.

10.19 NMP1 Technical Specification Table 3.6.2a, Amendment No. 142.

10.20 Deleted.

10.21 Deleted.