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U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Monticello Nuclear Generating Plant
Docket No. 50-263
Renewed Facility Operating License No. DPR-22

Response to an Apparent Violation Regarding NRC Inspection Report 05000263/2016010 (EA-16-175)

Reference: 1) Letter from Nuclear Regulatory Commission (NRC) to Mr. Peter A. Gardner, "Monticello Nuclear Generating Plant, NRC Inspection Report 05000263/2016010 and Preliminary White Finding," dated September 15, 2016

2) Letter from Northern States Power – Minnesota to NRC, "Notification of Intention Regarding NRC Inspection Report 05000263/2016010 (EA-16-175), dated September 26, 2016

In Reference 1, the NRC identified a preliminary White finding resulting from an event at Monticello Nuclear Generating Plant (MNGP) on March 22, 2016 when a sudden increase in oil leakage extended the unavailability of the High Pressure Coolant Injection (HPCI) system during a maintenance window causing a loss of safety function. Subsequent engineering evaluation determined that a long-standing crack in an oil pipe nipple had propagated creating an oil leak of approximately 1/3 gallons per minute (gpm) which would have rendered HPCI inoperable had maintenance not been in progress.

Reference 1 provided Xcel Energy Northern States Power Company – (NSPM) an opportunity to present our perspective on the facts and assumptions used by the NRC to arrive at the finding and its significance at either a Regulatory Conference or in a written response to the NRC. In a telephone call between Mr. Peter Gardner (NSPM) and Mr. Kenneth Riemer on

September 23, 2016, NSPM notified the NRC of our intent to provide a written response on the finding.

This letter submits additional information for the NRC's consideration in its final determination of the significance of the apparent violation.

NRC Finding Summary

A self-revealing finding preliminarily determined to be of low to moderate safety significance (White) and an associated apparent violation of Technical Specification 5.4.1.a were identified for the licensee's failure to plan and perform maintenance affecting the safety-related HPCI system in accordance with written documents appropriate to the circumstance. Specifically, improperly planned and performed pre-April 2005 maintenance initiated a crack in a safety related HPCI oil pipe and, for numerous years, the licensee failed to perform maintenance to resolve repeated identification of HPCI oil leakage. These failures resulted in a sudden increase in oil leakage on March 22, 2016, extending the unavailability of HPCI during a maintenance window and causing a loss of safety function.

The inspectors determined that the licensee's failure to pre-plan and perform maintenance on safety-related equipment was a performance deficiency; the cause was reasonably within the licensee's ability to foresee and correct; and should have been prevented. Specifically, improperly planned and performed 2005 maintenance initiated a crack in a safety-related HPCI oil pipe and, for numerous years, the licensee failed to perform maintenance to resolve repeated identification of HPCI oil leakage.

NSPM Response

MNGP agrees that a performance deficiency occurred. MNGP takes the significance of this event and the shortfalls in station behaviors around this event very seriously and has internalized lessons learned to improve station performance. The station root cause identified the specific shortfalls in behaviors as failure to escalate the potentially degrading condition to a Prompt Operability Determination (POD), not entering station Tiered Decision-Making process, and failure to recognize the potential for the condition to degrade further over time. The common theme among these behavior shortfalls was a failure to recognize that existing thresholds for action were unclear which enabled a tolerance of small leaks on the HPCI system. Corrective actions have been implemented to address these behavior shortfalls and are summarized below.

- The identified HPCI leak was repaired
- POD and Operational Decision Making (ODMI) entry conditions were reinforced with Operations Managers and the Engineering Department
- Operations and engineering improved behaviors around review of degraded conditions identified in Action Request (AR) packages for any needed ODMIs, PODs, ACMPs

- Extent of condition walk-down of HPCI leaks was performed and the impact of any remaining oil leaks was evaluated for needed ODMI or inclusion in the Adverse Condition Monitoring Program (ACMP). All active leaks (i.e., dripping) have been repaired
- Aggregate review of HPCI system health was performed
- Fluid leak management procedural guidance was developed based on industry best practices. The guidance established objective criteria for prioritization of resolution of fluid leaks on the following systems: HPCI, Reactor Core Isolation Cooling (RCIC), Residual Heat Removal (RHR), RHR Service Water, Core Spray (CSP), Diesel Generators, and Diesel Fuel Oil. The guidance includes objective trigger thresholds that drive timely repair and entry into POD, ODMI, or ACMP processes as appropriate
- Various procedures were revised to specifically control and provide guidance for monitoring low-level deficiencies on critical equipment including triggers for entry into the process.

MNGP appreciates the opportunity to present our perspective on the facts and assumptions used by the NRC to arrive at the significance level of the finding. As such, MNGP respectfully requests that the NRC consider the three aspects discussed below during their discussions on finding significance: 1) the characterization of the performance deficiency, 2) the point of inception for the performance deficiency and 3) crediting short-term operation of HPCI with transition to a CRDH pump in the risk assessment.

Performance Deficiency Characterization

MNGP agrees that a performance deficiency occurred. MNGP does not agree with the characterization of the performance deficiency. Specifically, MNGP disagrees that maintenance was improperly planned in 2005 and disagrees that it was within our ability to foresee and correct a condition that may have been a result of maintenance in 2005 that would, a decade later, result in a loss of safety function of the HPCI system. However, during system operation on January 9, 2016, the oil leakage rate changed which should have prompted more thorough evaluation by the station. Therefore, the station believes that the performance deficiency was a failure to adequately assess and act on a potentially degrading condition when the first noticeable change in leakage was identified on January 9, 2016. The basis for this conclusion is provided below.

Preplanning Maintenance

The preliminary significance letter (Reference 1) identified that MNGP's failure to pre-plan and perform maintenance on safety-related equipment was a performance deficiency. However, MNGP does not agree that maintenance was improperly planned because it is generally understood that standard maintenance practices to address nuisance leaks as were observed in the HPCI system in the 2005 timeframe could have relied upon 'skill of the craft' for repair. Regulatory Guide 1.33 Revision 2, which MNGP is committed to via the Xcel Energy Quality

Assurance Topical Report (QATR), states that maintenance activities that can affect the performance of safety-related equipment should be properly preplanned and performed in accordance with written procedures appropriate to the circumstances. The Regulatory Guide also states that skills normally possessed by qualified maintenance personnel may not require detailed step-by-step delineation in a procedure. The Regulatory Guide gives an example of this type of ‘skill of the craft’ activity as gasket replacement. At MNGP as defined in the maintenance training program, gasket replacement is a task that requires minimal classroom or on-the-job training but is covered during initial and continuing training, and is performed relatively frequently by maintenance personnel (every 3-7months). Similarly, assembling threaded joints requires minimal classroom or on-the-job training but is covered during initial and continuing training, and is performed relatively frequently by maintenance personnel (every 6-12 months). Since minimal training is required to perform joint assembly to the required standard as defined in the maintenance training program, evolutions relying on ‘skill of the craft’ may not have necessitated a planned maintenance work package and may not have been improperly planned as described in the performance deficiency.

Ability to Foresee the Cause

The preliminary significance letter (Reference 1) states “From April 2005 until March 22, 2016, the licensee repeatedly identified HPCI oil leakage near the pipe crack; however maintenance was not performed to resolve the issue.” The first known leak on the pipe elbow near HPO-13 at Pilot Cylinder port D was documented on August 26, 2005. The leak was characterized as minor leakage of “1 drop every 20 seconds while the auxiliary oil (aux) pump is running” and without impact on the system’s ability to meet its safety function. Although Reference 1 states there was repeated leakage near HPO-13 for which maintenance was not performed, MNGP’s root cause investigation documented there were no additional ARs written during the intervening years identifying either continuing or degrading leakage from this specific area (HPO-13). The root cause investigation identified only one other oil leak AR from March 2006 titled “S-201, HPCI Drive Turbine minor oil leaks” which did not address HPO-13. An additional search of the Corrective Action system for HPCI oil leak ARs between 2005 and January 9, 2016 identified six ARs for oil leaks on various components but no additional ARs were found identifying leakage on or near HPO-13. All identified oil leaks were evaluated as minor and not impacting system operability. Therefore, Work Orders (WOs) were generated as appropriate and prioritized for resolution relative to other work. These facts do not support the conclusion that MNGP repeatedly identified oil leakage near the pipe crack but failed to resolve the issue. Additionally, subsequent engineering analysis of the pipe crack showed that following initiation, the crack would have propagated very slowly for many years due to low cycle fatigue and therefore an increase in oil leakage may not be become apparent for a significant period of time.

Notwithstanding that station standards should not have allowed an oil leak to exist for such an extended period of time, the fact that no additional ARs were written and the leak was not

known to be degrading between 2005 and January 2016 led MNGP to believe the problem was threaded joint leakage which can be a common challenge with threaded pipe fittings. The non-degrading nature of the leak obscured the station's ability to foresee the cause to be more significant than thread leakage until January 9.

Additionally, during the period from 2005 until January 9, 2016 a significant number of hours of HPCI run time were accumulated without a loss of safety function due to oil leakage near HPO-13 as demonstrated by the repeated successful completion of Technical Specification surveillance testing during those years. Most recently, on November 23, 2015 HPCI was operated for approximately 15.33 consecutive hours without noted increase in oil leakage in the area of HPO-13 or loss of system function. The continued demonstration of HPCI to perform its safety function between August 2005 and January 2016 gave MNGP confidence that a more serious issue did not exist and precluded the station's ability to foresee a more significant condition needing correction.

On January 9, 2016, an AR was written documenting an oil leak on the pipe inlet to valve HPO-13 and quantified the leakage as 1 drop every 4 seconds. The AR identified that the leaks were minor but would require constant housekeeping while HPCI Auxiliary Oil Pump or Turbine Driven Oil Pump were in service. This AR stated that the cause could be thread loosening or pipe cracking and recommended the fitting be investigated and repaired as necessary. This condition represented a change from previous system condition and should have prompted the station to enter the appropriate decision-making processes. Although station personnel assessed the leakage, including performing in-situ observation of the piping integrity, the station incorrectly concluded the leak would not challenge HPCI turbine function because there was "no evidence of looseness, cracking, damage or any other challenge to the integrity which would result in failure during operation." Had the station taken the actions at this point to enter appropriate decision-making processes and acted on the change in leakage, the subsequent extended out-of-service window could have been prevented.

Conclusion

Standard maintenance practices to address nuisance leaks have relied upon 'skill of the craft' for repair. Regulatory Guide 1.33 acknowledges skills normally possessed by qualified maintenance personnel may not require detailed step-by-step delineation in a procedure. Therefore, the characterization of the performance deficiency as MNGP's failure to pre-plan maintenance does not accurately reflect the intent of the maintenance performed in the 2005 timeframe.

Information available to the station regarding the condition of the oil piping prior to January 9, 2016 was not sufficient for the station to foresee the condition as other than threaded joint leakage and take action to correct the crack in HPCI oil pipe. A change in leakage conditions

on January 9, 2016 provided new information that should have prompted the station to take appropriate actions that would have identified the more significant issue.

Therefore, the performance deficiency was a failure to adequately assess and act on a potentially degrading condition when the first noticeable change in leakage was identified on January 9, 2016. Only upon the change in leakage was the cause of this performance deficiency reasonably within the station's ability to foresee and correct.

Inception Time of Deficiency

The NRC inspectors screened the HPCI oil leak using IMC 0609, Attachment A, Exhibit 2, Section A for "Mitigating Systems" and determined a detailed risk evaluation was required because the finding represented a loss of system and/or function. The NRC Senior Risk Analyst (SRA) subsequently used the MNGP Standardized Plant Analysis Risk (SPAR) model, version 8.24 for the detailed risk evaluation. The model contains both internal and external event sequences. The risk contribution from internal events for an exposure period of 121 days was estimated to be a delta core damage frequency (ΔCDF) of 1.6E-6/yr. The internal flooding risk contribution for an exposure period of 121 days is estimated to be a ΔCDF of 6.3E-7/yr. The external events including fire risk contribution for 121 day exposure period is 1.6E-6/yr. The SRA concluded that the total ΔCDF for the 121 day portion of the exposure period is 3.8E-6/yr., which is a finding of low to moderate safety significance (White).

The SRA's risk assessment is predicated on the stated performance deficiency that the station failed to pre-plan and perform maintenance on safety-related equipment in 2005 and therefore the system was degraded for over 10 years. As a result, the SRA began with an applicable exposure time of 10 months (based on when HPCI was last capable of completing PRA mission time) in accordance with Risk Assessment of Operational Events (RASP) Handbook) and then reduced the exposure time based on the demonstrated substantial capability for HPCI to run in November 2015.

However, MNGP contends that it was not reasonably within our ability to foresee and correct the condition until January 9, 2016 as discussed in the previous section above. Specifically, the lack of additional ARs identifying degrading leakage and the continued successful completion of Technical Specification surveillance testing between 2005 and 2016 indicate the starting point (or inception time) for the performance deficiency should be January 9, 2016. In accordance with Section 2.5 of the RASP Handbook, for a deficiency where the inception of the condition is known, the exposure time should be measured from point of inception to system return-to-service. This results in an exposure time of 75 days from January 9, 2016 to March 24, 2016.

Crediting Short-Term HPCI Operation

Engineering analysis has determined that the HPCI system had 1.5 hours of capability remaining on January 9, 2016 following the 57 minute surveillance testing conducted on that date. Crediting this remaining HPCI capability in the risk analysis has a significant impact on the assessment of safety significance when combined with the 75 day exposure time discussed above. Specifically, if short-term HPCI operation is credited along with an exposure period of 75 days the ΔCDF would be 8.28E-07/yr or Green. A discussion of MNGP's conclusion that the significance of the issue is Green follows.

Based on a review of the applicable design and operational documentation, the license-basis mission time for HPCI was determined to be the following:

1. 4 hours of intermittent HPCI water injection into the vessel to include at most 17 minutes of HPCI injection time and 4 HPCI starts for a Station Blackout (SBO)
2. 2¼ continuous hours of operation (135 minutes) in Reactor Pressure Vessel makeup and pressure control mode for a small break loss-of-coolant accident or loss of feed water transient.

Engineering evaluation concluded HPCI was last capable of meeting the licensing basis on January 9, 2016 prior to the performance of the surveillance run. HPCI was successfully run for 57 minutes on January 9, 2016 and analysis demonstrated an additional 1.5 hours of capability when it was removed from service on March 20, 2016. The MNGP license basis mission time is significantly shorter than the PRA mission time for this system.

Because 90 minutes is a significant portion of the bounding license-basis mission time, MNGP executed Modular Accident Analysis Program (MAAP) analysis cases in order to determine if Control Rod Drive Hydraulic (CRDH) flow, by itself is adequate to prevent core damage starting with normal water level at 1.5 hours into a transient. The MAAP case was run starting with normal reactor water level and a loss of HPCI at 1.5 hours into the transient. At this time, a single CRDH pump was operated at post-scram flow rates, as would be the case where no operator action occurs to increase CRDH flow by starting an additional pump or enhancing flow by manipulating valves out in the plant. Two additional cases were run to determine the effect of a stuck open relief valve, and a reactor cool down initiated early in the transient. The thermal hydraulic analysis demonstrates that a successful 1.5 hour operation of HPCI and transition to a normally running single CRDH pump at post-SCRAM flow rates (no operator action required) will provide sufficient core cooling for a 24 hour PRA mission time (Enclosure 1).

The risk of this condition was calculated by failing HPCI top gates TE_HPCI-SBO and TE_HPCI-L plus the following changes were made to more accurately portray a 1.5 hour run of HPCI:

1. The order of two operator actions in the MNGP Revision 3.3 Internal Events PRA model was altered, specifically moving a flood isolation (110-ISOL-COND-Y) as the first action in a flood scenario. This issue was captured in the PRA Change Database as MT-16-0053 and will be incorporated into MNGP's next model update.

2. The mission times of HPCI running basic events were changed to reflect the established forensics analysis run time of 1.5 hours:

		Rev 3.3 model	**New model**
Basic Event	Basic Event Description	TIME (hrs)	TIME (hrs)
HPTP209XXT12	HPCI TURBINE DRIVEN PUMP P-209 FAILS TO RUN FOR 1st HOUR	1	1
HPTP209XXR12-S	HPCI TURBINE DRIVEN PUMP P-209 FAILS TO RUN FOR 4 HOURS	4	0.5
HPTP209XXR12-L	HPCI TURBINE DRIVEN PUMP P-209 FAILS TO RUN (LONG TERM)	18.5	22.5

3. The CRDH pump success criterion was changed from two to one CRDH pump in the long term HPCI in the transient tree. This no longer requires the operator action to start the second CRDH pump from the control room (J2NDPHRS-Y). This criterion was confirmed by performing new MAAP analysis and reviewing previously produced MAAP analysis for all modeled accident types including: Transients, SORV, all LOCA sizes and break locations, and ATWS.

The MNGP internal events PRA model was quantified assuming random HPCI failures for short term (1.5 hours) HPCI operation, followed by long term (past 1.5 hours) HPCI failure. CDF increased by 2.53E-06/yr from its baseline value of 6.88E-06/yr. Similarly, the MNGP Fire PRA model was run with a CDF increase of 1.50E-06/yr over the baseline frequency of 4.11E-05/yr. Combining Fire and Internal Events, results in a CDF increase of 4.03E-06/yr from a baseline value of 4.80E-05/yr. Operation at this increased risk frequency for greater than 91 days would be required to exceed a threshold of 1.0E-06 probability of core damage risk. Quantification of LERF was found to be less restrictive than the core damage metric.

The results of the analysis are shown below:

Model	Normal IE	Fail Event	Result (/yr)	% Change	Risk Change
Rev 3.3 Internal Events Model with listed changes	Baseline	CDF	6.88E-06		
		LERF	9.06E-07		
	TE_HPCI-L, SBO failed	CDF	9.41E-06	37%	2.53E-06
		LERF	9.86E-07	9%	8.04E-08
Rev 3.0 Fire Model with listed changes	Baseline	CDF	4.11E-05		
		LERF	5.26E-06		
	TE_HPCI-L, SBO failed	CDF	4.26E-05	4%	1.50E-06
		LERF	5.35E-06	2%	9.34E-08
Fire + Internal Events Models	Baseline	CDF	4.80E-05		
		LERF	6.17E-06		
	TE_HPCI-L, SBO failed	CDF	5.20E-05	8%	4.03E-06
		LERF	6.34E-06	3%	1.74E-07

Lastly, defense-in-depth exists with respect to the ability to repair the leak and/or add oil to the HPCI oil reservoir. Although not credited in the above PRA analysis, guidance provided in the RASP Handbook, does indicate there may be exceptions to requirements and considerations of recovery/repair actions. It is reasonable to consider repair to the oil leak on the HPCI system or addition of oil as a credible method to prolong the operation of HPCI, and thus reduce the risk impact from this issue. Detection of an excessive oil leak is likely via normal operational system monitoring or via receipt of low oil pressure annunciators. Although core damage would be averted through the short-term operation of HPCI and use of a CRDH pump as discussed above, restricting the oil leakage rate, and/or adding oil to the HPCI oil reservoir, are simple actions that could be taken in a reasonable timeframe and could be performed without the need for detailed procedures to allow extended use or restoration of the HPCI system.

In conclusion, crediting short-term HPCI operation with continued CRDH pump operation following HPCI failure is sufficient to prevent core damage. This, combined with an exposure period of 75 days as described above, results in a total ΔCDF of 8.28E-07/yr. This total ΔCDF equates to very low safety significance (Green).

Summary

NSPM respectfully requests that the NRC consider the information discussed above in its final significance determination for the finding. Notwithstanding our assessment of the significance of the finding, NSPM clearly understands our performance shortcomings concerning sensitivity to degrading conditions and their impact on safety. Corrective actions have already been completed to address the condition and its Root Cause including ensuring lessons learned from this finding are applied more broadly to overall performance.

Summary of Commitments

This letter contains no new commitments and no revisions to existing commitments.

Peter A. Gardner
Site Vice President, Monticello Nuclear Generating Plant
Northern States Power Company – Minnesota

cc: Regional Administrator, Region III, USNRC
Project Manager, MNGP, USNRC
Resident Inspector, MNGP, USNRC

Enclosure 1: PRA-CAL-16-002

ENCLOSURE 1

MONTICELLO NUCLEAR GENERATING PLANT

PRA-CAL-16-002

(17 pages follow)

PRA Document Signature Sheet

Document Information	
PRA Document No: PRA-CALC-16-002	Revision: 0
Title: Risk Assessment for HPCI Oil leak discovered on March 22-24, 2016	
Facility: ☒ MT ☐ PI	Applicable Unit: ☒ 1 ☐ 2

NOTE:	Print **and** sign name in signature blocks, as required.

Review Information		
☐ Vendor Calc	Vendor Doc No: n/a	
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Prepared by: (sign) [signature]	/ (print) Adam Stein	Date: 8/1/2016
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Revision History

Rev.	Description	Preparer	Reviewer	Date
0	Initial Revision	ABS	TPW	8/4/2016

Table of Contents

1. Purpose

The purpose of this calculation is to evaluate the risk significance of the Monticello HPCI oil leak discovered on March 22, 2016. This event resulted in a preliminary greater than green finding from the NRC.

2. Background

Below is a chronological list of events related to the HPCI oil system and this calculation.

- November 23rd, 2015 – HPCI pump ran for 15 straight hours after Group 1 signal and consequential SCRAM.
- January 9th, 2016 – HPCI runs for approximately one hour. HCPI oil leaks (1 drop per 6 seconds) are identified and entered into the CAP process (AR 01508130).
- March 16th, 2016 – Increase in oil leak rate to 4 drops/sec (AR 01515945).
- March 22nd, 2016 – HPCI runs for approximately one hour. HPCI oil leak suddenly increases from 4 drops per second to a steady stream (AR 01516361).
- March 24, 2016 at 4:49 – HPCI oil leak is repaired and pump is returned to operable.

After the events on March 22-24, a forensic analysis was performed to determine the extent of degradation of the HPCI oil system. The following describes the conclusions of the forensics analysis:

- During a postulated event, the HPCI turbine control valve would have eventually failed in the closed position due to loss of oil/hydraulic pressure.
- HPCI was determined to be able to run for 90 minutes straight in the condition present on March 22nd. 45 minutes with a 4 drops per second leak, then 45 minutes with a larger leak (approx. 1/3gpm).
- The HPCI oil leak was limited to 1/3 gpm due to pipe restraint considerations.
- It was determined that HPCI would have been able to start and stop 4 separate times for a 17 minute total run time over 4 hours.

3. Inputs and Assumptions

The following items are assumptions to this calculation:

1. On January 9th, 2016 this condition was first discovered and entered into the CAP process (AR #1508130). This is assumed to be when this condition of HPCI began. Therefore the exposure time is 75 days.

Thermal hydraulic analysis were performed using the MAAP software that demonstrate for transient and SORV accidents, that a successful 1.5 hour operation of HPCI, followed by transition to a normally running single CRDH pump at post-SCRAM flow rates (no operator action required), will provide sufficient core cooling for a 24 hour mission time. All other accident types were dispositioned by reviewing previously performed MAAP analysis. The risk of this condition was calculated by failing HPCI top gates TE_HPCI-SBO and TE_HPCI-L (HPCI SBO and long term) while leaving TE_HPCI-S (HPCI short term) successful. During this calculation a model error was found where the order of two human error events was corrected in the HEP dependency analysis. The order had restoration of plant loads occurring before the loads were lost from failure of a flood isolation. The HEP order was fixed by placing HEP 110-ISOL-COND-Y (Failure to isolate condensate leak by tripping condensate pumps from the MCR in) before C4H-EASY-Y (Fail to restore loads (simple CR action) after LOSP and ECCS load shed) in the HRA Calculator using a -1 minute Tdelay. This evaluation includes this model correction. This issue is tracked in PRA Change Database form MT-16-0053.

The following changes were made to the PRA model to more accurately portray a 1.5 hour run of HPCI:

1. The mission times of HPCI running basic events were changed to reflect the established forensics analysis run time of 1.5 hours verses the 5.5 hour run time previously credited based on HPCI battery duration assumptions:

		Rev 3.3 model		New model	
Basic Event	Basic Event Description	TIME (hrs)	Probability	TIME (hrs)	Probability
HPTP209XXT12	HPCI TURBINE DRIVEN PUMP P-209 FAILS TO RUN FOR 1st HOUR	1	2.03E-03	1	2.03E-03
HPTP209XXR12-S	HPCI TURBINE DRIVEN PUMP P-209 FAILS TO RUN (SHORT TERM)	4	3.24E-04	0.5	3.59E-05
HPTP209XXR12-L	HPCI TURBINE DRIVEN PUMP P-209 FAILS TO RUN (LONG TERM)	18.5	1.33E-03	22.5	1.62E-03

The HPCI short term top gate (TE_HPCI-S) has basic events HPTP209XXT12 and HPTP209XXR12-S underneath it while HPCI long term and SBO have all three HPCI basic events.

2. The CRDH pump success criterion was changed from two to one CRDH pump success, in the long term high pressure injection gate in the transient tree. This no longer requires operator action to start the second CRDH pump from the control room (J2NDPHRS-Y). This criterion was confirmed by performing new MAAP analysis and reviewing previously produced MAAP analysis for all modeled accident types including Transients, SORV, all LOCA sizes and break locations, and ATWS. The MAAP analysis and review is discussed in further detail in Section 4.

4. Methodology

This section will document the new MAAP analysis performed and the previous MAAP analysis that was reviewed to confirm that successful operation of HPCI for 1.5 hours is correctly modeled by HPCI short term success and long term failure as described in Section 2. Three new MAAP cases were created to determine if a successful 1.5 hour run of HPCI, and a single CRDH pump at post-SCRAM flow rates, would be sufficient for a transient or SORV event. A detailed pipe flow analysis for the CRDH system under varying configurations (number of pumps and enhanced versus post-SCRAM flows) was documented in PRA-CALC-10-002 [1]. The following assumptions were used to develop three new MAAP runs to determine viability of HPCI short term (1.5 hour) success:

1. All MAAP runs were initiated by a loss of Feedwater event with a delayed closure of the MSIVs since this gives the least inventory above top of active fuel.
2. A maximum leakage rate of 165gpm was included for each Transient MAAP case. This is assumed, based on complete loss of both recirc pump seals (70gpm each) [2], and an assumed maximum Tech Spec reactor leakage of 25gpm [3]. The leaks are assumed to occur at the elevation of the recirc pump, therefore it is modeled as a water break.
3. Core damage was assumed to occur if the hottest reactor core temperature (TCRHOT) reached 1800 degrees Fahrenheit per the EPRI Technical Report 1016750 [4].
4. The only difference between the two transient cases, was if the operators performed a procedurally directed cooldown of 90F/hr, which was assumed to start 15 minutes into the scenario. The cooldown rate and start time were determined based on procedure review [5] and conversations with the Monticello Senior Reactor Operators.
5. HPCI was assumed to be available to inject for the first 1.5 hours of the scenario. All other injection sources (Feedwater, RCIC, LPCI, Core Spray, etc) excluding CRDH at post-SCRAM flow rates were assumed failed.
6. HPCI flow was assumed to be throttled by operators, to maintain a desired reactor level.
7. Decay heat removal was not included in any of the MAAP cases, since it is not the success criteria being evaluated, nor does it impact a 1.5 hour operation of HPCI or CRDH operation. Drywell and wetwell parameters are given for information only.
8. The Drywell Coolers are assumed failed at time zero since they are not credited in the PRA model.
9. Each MAAP case was run for 24 hours to ensure that HPCI short and 1 CRDH pump at post-SCRAM flow rates would be sufficient for the full PRA mission time.
10. A separate MAAP review was performed and verified that the unchanged success criteria of RCIC short term of 5.5hours with 1 CRDH pump at post-SCRAM flow rates was still successful.

11. Each new MAAP case utilized an include file (MO_FLEX_INCLUDE.inc) that ensures that these MAAP cases use validated inputs originally intended for the Monticello FLEX/Fukushima Submittal. This data validation was documented in PRA-CALC-14-002 [6] which illustrates compliance with the NRC letter dated October 3, 2013 from Jack R. Davis to Joseph Pollock (NEI) endorsing MAAP for post-Fukushima applications [7]. This NRC letter discusses the endorsement of the MAAP code based on the EPRI Technical Report 3002001785 “Use of Modular Accident Analysis Program (MAAP) in Support of Post-Fukushima Applications” [8].

For all three new cases, hpci_only_1_5hrs_1crdh_scram_leakage, hpci_1_5hrs_only_cooldown_1crdh_scram_leakage, and hpci_only_1_5hrs_1crdh_scram_sorv, core damage did not occur, as reactor core maximum temperature remained well below 1800F. Figures 1, 2, and 3 give the critical parameters for each of the MAAP cases. The figures illustrate that cooldown and consequential depressurization of the reactor is beneficial, since it allows a higher injection rate for the CRDH pump.

The MAAP run without cooldown, hpci_only_1_5hrs_1crdh_scram_leakage, gets close (1650F) to the established core damage criteria but avoids it due to steam cooling of the reactor. This case also illustrates that shroud water level (core height as viewed by operators (XWSH-39.79)*12) gets very low due to the assumed leakage path through the recirc seals. But since the flow path with CRDH injection is through the lower plenum forcing water into the core, adequate cooling via steam cooling is achieved. Figure 4 illustrates the actual reactor core level for hpci_only_1_5hrs_1crdh_scram_leakage. This figure shows that actual reactor core level does dip below 2/3 core height at the time when core temperature is at its highest but level rebounds from then on to eventually above 2/3 height. Top of Active Fuel (TAF) and 2/3 Core height were determined using NX-7831-197-1: RPV Internal Dimensions [9]. Reactor level issue would not be an issue in this case if operators depressurized the reactor per procedure as illustrated in MAAP case hpci_1_5hrs_only_cooldown_1crdh_scram_leakage.

As is shown in Figure 2, the assumed leak is not large enough to depressurize the reactor. The input files (.inp) used to create these MAAP cases are presented in Appendix A. The transient with recirc pump leakage, is likely more significant (higher reactor core temperature) than the SORV because the recirc seal leakage is a water break and the SORV is a steam break, therefore more inventory is lost.

Figure 1: Critical Parameter Plots for hpci_1_5hrs_only_cooldown_1crdh_scram_leakage

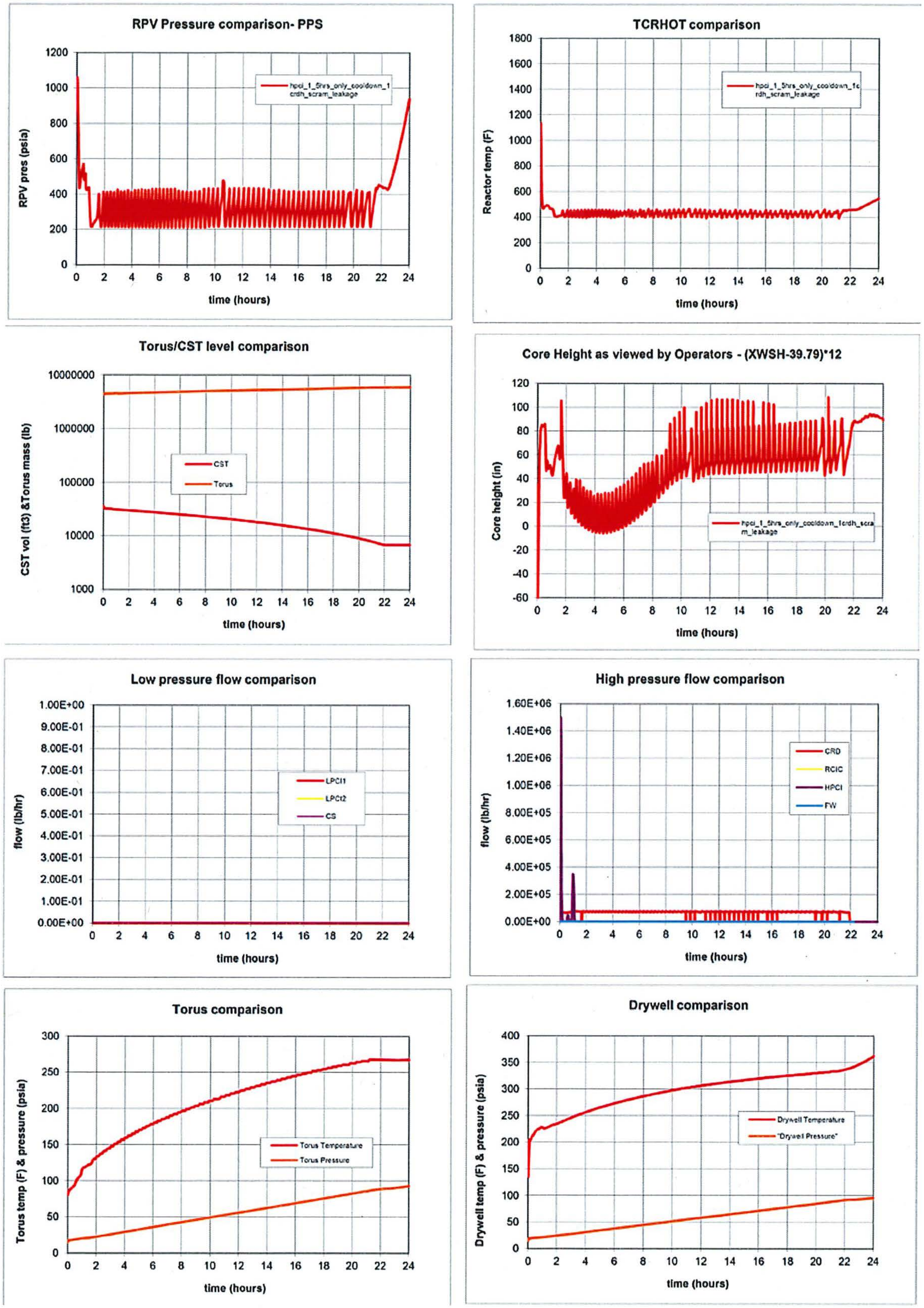

Figure 2: Critical Parameter Plots for hpci_only_1_5hrs_1crdh_scram_leakage

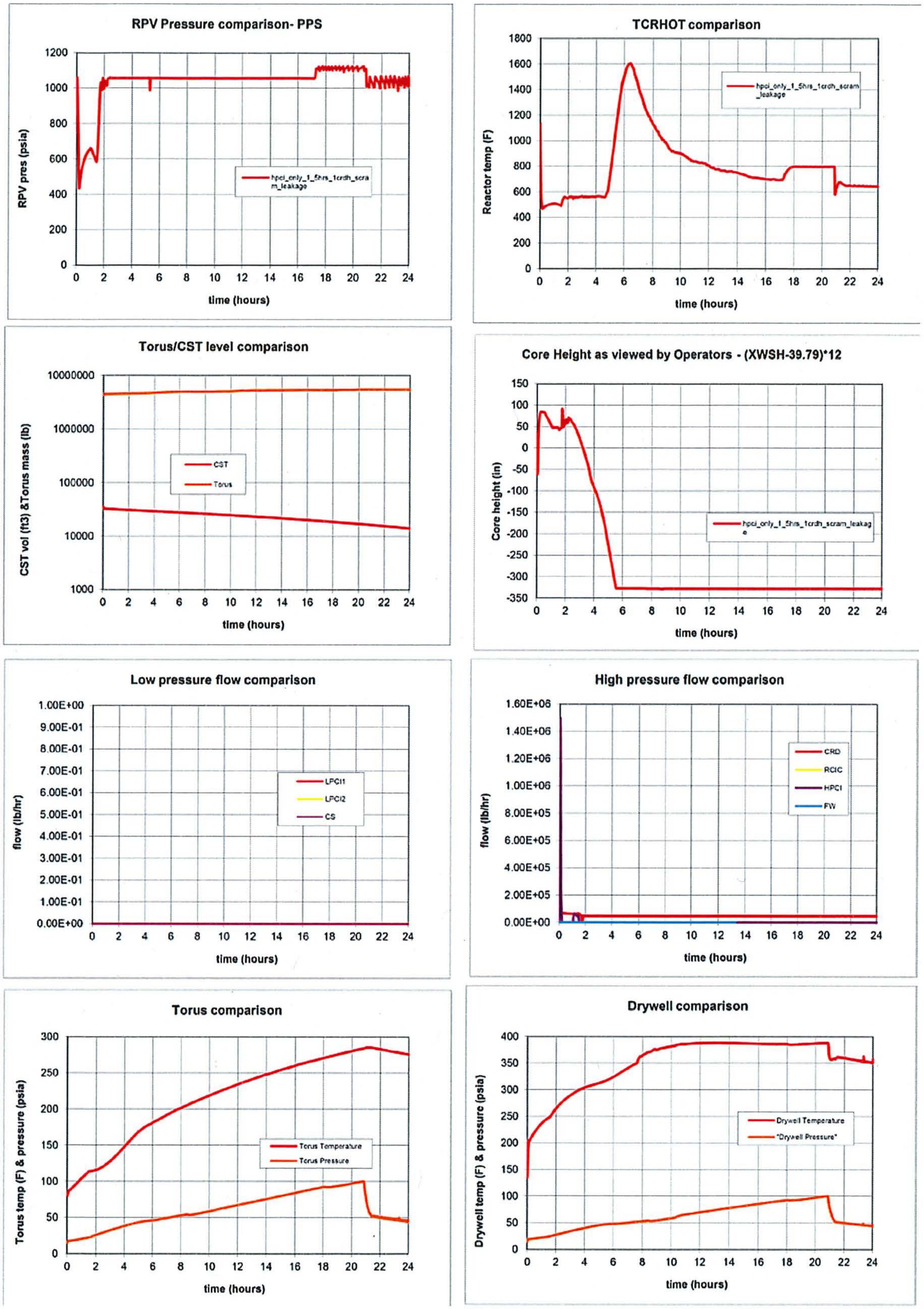

Figure 3: Critical Parameter Plots for hpci_only_1_5hrs_1crdh_scram_sorv

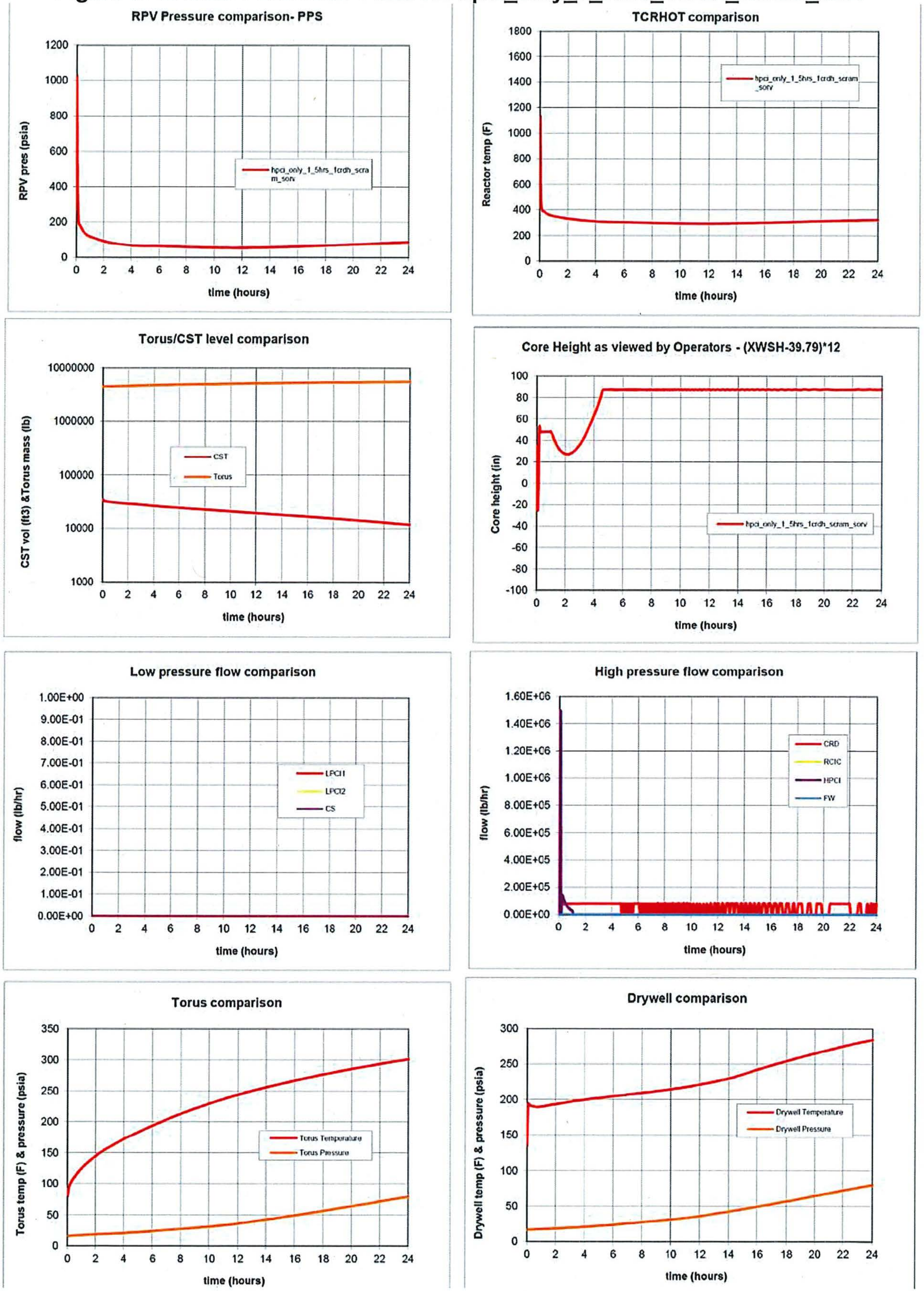

Figure 4: Reactor Core Level (XWCOR) for case hpci_only_1_5hrs_1crdh_scram_leakage

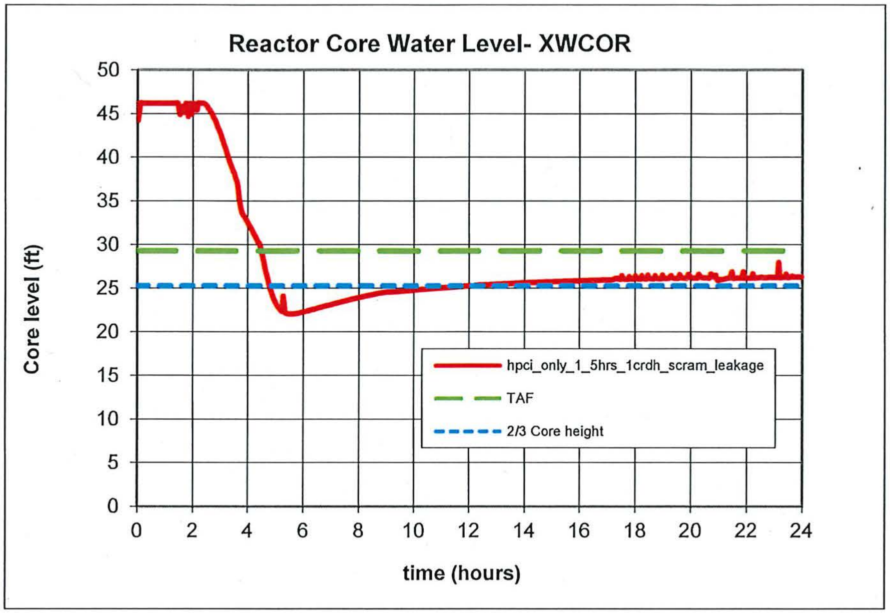

Table 2 discusses the MAAP analysis that was reviewed for all of the modeled accident sequences. Fire, internal flooding, LOOP, and SBO events all propegate through the Transient event tree.

Accident	MAAP Case(s)	Reason why HPCI for 1.5 hours correctly models HPCI short term
Transient	hpci_only_1_5hrs_1crdh_scram_leakage and hpci_1_5hrs_only_cooldown_1crdh_scram_leakage	HPCI for 1.5 hours and 1 CRDH pump at SCRAM flow prevented core damage
ATWS	MPB0011-95	The smallest flow credited late in the ATWS event tree is 2 CRDH pumps at enhanced flow rates which needs to be established within 22 minutes. This requires a short term injection of HPCI and SBLC injection within 5.6 minutes. The referenced MAAP scenario was mitigated successfully with RCIC alone which has a smaller flow rate than 2 CRDH pumps at enhanced flow therefore this case is bounding.
SORV	hpci_only_1_5hrs_1crdh_scram_sorv	HPCI operates for only 1 hour and 9 minutes before it is lost due to depressurization
SLOCA	sloca-hpci-5_5hr	
MLOCA	mloca-no-inj	The Group 4 isolation signal of less than 100psig reactor pressure is reached within 1 hour of the accident.
LLOCA	n/a	HPCI is not credited to mitigate these events
XLOCA	n/a	
ISLOCA	n/a	

5. Conclusion

The convergence truncation used for the internal events quantification is 1E-12 for CDF and LERF, and was documented in PRA-CALC-15-005: MNGP Model Rev. 3.3 [10]. Internal floods that fail the lower 4kV room and cause a LOOP event are the most significant in the IE model. The HPCI top gates TE_HPCI-SBO and TE_HPCI-L were failed by setting a newly created basic event, HPCI_OIL_LEAK, to one in the internal events model. In the Fire PRA model, a new failed flag text file was created that failed the HPCI top gates TE_HPCI-SBO and TE_HPCI-L directly.

Software used for the fire quantification was FRANX 4.2 and FTREX 1.8. Fire PRA truncation was 1E-11 for CDF and 1E-12 for LERF per PRA-MT-FQ, Rev 3.0 [11]. The fire PRA model does not perform detailed fire analysis on the HCPI room (zone 1E) and its fire risk is still very low (~0.2%) for CDF and LERF.

Seismic and high winds are expected to be much less significant than IE and fire. Table 2 displays the results for CDF and LERF for internal Events and Fire.

Table 2: Risk Results

Model	Normal IE	Failed Event	Truncation	Result (/yr)	% Change	Risk Change
Rev 3.3 Internal Events Model w/ HEP Combo Change	**Baseline**	CDF	1.00E-12	6.88E-06		
		LERF	1.00E-12	9.06E-07		
	TE_HPCI-L failed	CDF	1.00E-12	9.41E-06	37%	2.53E-06
		LERF	1.00E-12	9.86E-07	9%	8.04E-08
Rev 3.0 Fire Model	**Baseline**	CDF	1.00E-11	4.11E-05		
		LERF	1.00E-12	5.26E-06		
	TE_HPCI-L failed	CDF	1.00E-11	4.26E-05	4%	1.50E-06
		LERF	1.00E-12	5.35E-06	2%	9.34E-08
Fire + Internal Events Models	**Baseline**	CDF	1.00E-12	4.80E-05		
		LERF	1.00E-12	6.17E-06		
	TE_HPCI-L failed	CDF	1.00E-12	5.20E-05	8%	4.03E-06
		LERF	1.00E-12	6.34E-06	3%	1.77E-07

6. References

[1] "PRA-CALC-10-002, CRDH Flow Model Assessment, Rev 1.".

[2] "B.01.04-02, OPERATIONS MANUAL SECTION: Reactor Recirculating System, Rev 20.".

[3] "Monticello Technical Specifications, Section 3.4.4: RCS Operational LEAKAGE, Rev 188.".

[4] "6. EPRI Technical Report 1016750, MAAP4 Application Guidance, Revision 1, November 2008.".

[5] "C.5-1100, RPV Control, Rev 20.".

[6] "PRA-CALC-14-002, MAAP Parameter file review in support FLEX-Fukushima, Rev 0.".

[7] "Jack R. Davis to Joseph E. Pollock, October 3, 2013, U.S. NRC, ADAMS Accession No.: ML13275A318.".

[8] "Use of Modular Accident Analysis Program (MAAP) in Support of Post-Fukushima Applications. EPRI, Palo Alto, CA: 2013. 1020236.".

[9] " NX-7831-197-1, RPV Internal Dimensions, Rev 78.".

[10] "PRA-CALC-15-005, MNGP Model Rev 3.3".

[11] "PRA-MT-FQ, Monticello Fire PRA Quantification, Rev 3.0".

7. Appendix A: MAAP Input files

hpci_1_5hrs_only_cooldown_1crdh_scram_leakage Input file

```
Sensitivity on

Title
 Transient, 165gpm leakage, HPCI un-throttled only for 1.5 hours and cooldown starting at 15 minutes
 , 1 CRDH pump at SCRAM rate at 1.5 hours
End

 PARAMETER FILE MO406_040412.par
 INCLUDE FILE MO_Include_R1.inc
 INCLUDE FILE MO_GESIL636.inc
 INCLUDE FILE MO_FLEX_INCLUDE.inc

PARAMETER CHANGE

 TDMAX = 1.0 S     // DECREASE THE MAXIMUM ALLOWED TIME STEP TO 1 SEC
 ICRBAL = 2        // CORE ENERGY BALANCE
 FQUEN = 0.        // NO WATER INGRESSION INTO DEBRIS POOL IN LOWER PLENUM
 IPLT1 = 4         // Change to Plot file

 ZLOCA = 961.9        // ZLOCA = ELEV OF LOCA (= RCP SUCTION LINE)
 ALOCA = 0.0014 FT**2 // ALOCA = AREA OF LOCA (=0.2 IN2= .0014 FT2)

END

START TIME IS          0 HR
END TIME IS           24 HR
PRINT INTERVAL IS      1 HR

INITIATORS
  BREAK IN PRIMARY SYSTEM (LOCA) // RCP Seals Leak
  FEEDWATER MAN OFF
C  HPCI LOCKED OFF              // Turn off HPCI
  HPCI & RCIC FLOW THROTTLED TO MAINTAIN DESIRED LEVEL  // HPCI throttled to maintain level see
B.03.02-05, Section G.1
  RCIC LOCKED OFF               // Turn off RCIC
  LPCI LOOP 1 LOCKED OFF        // Turn off LPCI
  LPCI LOOP 2 LOCKED OFF
  LPCI LOOP 3 LOCKED OFF
  LPCS LOCKED OFF
C  CRD PUMP LOCKED OFF          // Turn off CRDH
  IEVNT(292) = 1                // DW Coolers manually turned OFF
END

WHEN TIM > 1.5 HR // At 1.5 HPCI fails due to oil leak and 1 CRDH pump at SCRAM flow rate on
  HPCI LOCKED OFF
END

******************************************************************
** MANUAL COOLDOWN 90F/HR
******************************************************************
PARAMETER CHANGE // initialize user-defined variables for plotting
COOLRATE = 90/1.8    // arbitrary value
TARGET_T_K = 560 // arbitrary value
TARGET_T_F = 550
END
```

```
C BEGIN COOLDOWN AT 0.25 HR
WHEN TIM  > 900. S // sequence specific condition to start the cooldown
  SET TIMER #40
C 90 DEGREES F/HR COOLDOWN RATE
  COOLRATE = 90/1.8 // the 1.8 factor adjusts for F to Kelvin
  TARGET_T_K = TWCR-(COOLRATE/20) // using 1/20 of an
  // hour as the time increment in the next block so need
  // 1/20 of the temperature change during that time
  TARGET_T_F = (TARGET_T_K * 1.8)-459.6 // convert to F for output
  PSETRV(8) = MAX(PSAT(TARGET_T_K),1480304.)+1378951.
C ADD 200 PSI TO ACCOUNT FOR DEADBAND
C  80 PSI EQUALS 551581 PA
C 100 PSI EQUALS 689476 PA
C 150 PSI EQUALS 1034214 PA
C 200 PSI EQUALS 1378951 PA
C 214.7 PSI EQUALS 1480304 PA
C 250 PSI EQUALS 1723689 PA
END

WHEN PPS < 400. PSI
  PDRV(8) = 200. PSI
END

WHEN TIMER #40 >= 0.05 HR AND TIMD < 12.0 HR // 1/20 of an hour
// increment and sequence specific end of cooldown conditions (150 psi)
C  TARGET_T_K = TWCR-(COOLRATE/20)
  TARGET_T_K = TARGET_T_K-COOLRATE/20
C Or use TARGET_T_K = TARGET_T_K-COOLRATE/20; might improve precision
  TARGET_T_F = (TARGET_T_K * 1.8)-459.6
  PSETRV(8) = MAX(PSAT(TARGET_T_K),1480304.)+1378951.
C ADD 200 PSI TO ACCOUNT FOR DEADBAND
C  80 PSI EQUALS 551581 PA
C 100 PSI EQUALS 689476 PA
C 150 PSI EQUALS 1034214 PA
C 200 PSI EQUALS 1378951 PA
C 214.7 PSI EQUALS 1480304 PA
C 250 PSI EQUALS 1723689 PA
  RESET TIMER #40
  REPEAT
END
```

hpci_only_1_5hrs_1crdh_scram_leakage Input file

```
Sensitivity on

Title
 Transient, 165gpm leakage, HPCI un-throttled only for 1.5 hours, 1 CRDH pump at SCRAM rate at 1.5 hours
End

 PARAMETER FILE MO406_040412.par
 INCLUDE FILE MO_Include_R1.inc
 INCLUDE FILE MO_GESIL636.inc
 INCLUDE FILE MO_FLEX_INCLUDE.inc

PARAMETER CHANGE

 TDMAX = 1.0 S     // DECREASE THE MAXIMUM ALLOWED TIME STEP TO 1 SEC
 ICRBAL = 2        // CORE ENERGY BALANCE
 FQUEN = 0.        // NO WATER INGRESSION INTO DEBRIS POOL IN LOWER PLENUM
 IPLT1 = 4         // Change to Plot file

 ZLOCA = 961.9       // ZLOCA = ELEV OF LOCA (= RCP SUCTION LINE)
 ALOCA = 0.0014 FT**2 // ALOCA = AREA OF LOCA (=0.2 IN2= .0014 FT2)

END

START TIME IS          0 HR
END TIME IS           24 HR
PRINT INTERVAL IS      1 HR

INITIATORS
  BREAK IN PRIMARY SYSTEM (LOCA) // RCP Seals Leak
  FEEDWATER MAN OFF
C  HPCI LOCKED OFF              // Turn off HPCI
  HPCI & RCIC FLOW THROTTLED TO MAINTAIN DESIRED LEVEL  // HPCI throttled to maintain level see
B.03.02-05, Section G.1
  RCIC LOCKED OFF               // Turn off RCIC
  LPCI LOOP 1 LOCKED OFF        // Turn off LPCI
  LPCI LOOP 2 LOCKED OFF
  LPCI LOOP 3 LOCKED OFF
  LPCS LOCKED OFF
C  CRD PUMP LOCKED OFF           // Turn off CRDH
  IEVNT(292) = 1                // DW Coolers manually turned OFF
END

WHEN TIM > 1.5 HR // At 1.5 HPCI fails due to oil leak and 1 CRDH pump at SCRAM flow rate on
  HPCI LOCKED OFF
END
```

hpci_only_1_5hrs_1crdh_scram_sorv

```
Sensitivity on

Title
 SORV, no leakage, HPCI throttled only for 1.5 hours, 1 CRDH pump at SCRAM rate at 1.5 hours
End

 PARAMETER FILE MO406_040412.par
 INCLUDE FILE MO_Include_R1.inc
 INCLUDE FILE MO_GESIL636.inc
 INCLUDE FILE MO_FLEX_INCLUDE.inc

PARAMETER CHANGE

 TDMAX = 1.0 S     // DECREASE THE MAXIMUM ALLOWED TIME STEP TO 1 SEC
 ICRBAL = 2        // CORE ENERGY BALANCE
 FQUEN = 0.        // NO WATER INGRESSION INTO DEBRIS POOL IN LOWER PLENUM
 IPLT1 = 4         // Change to Plot file

END

START TIME IS        0 HR
END TIME IS         24 HR
PRINT INTERVAL IS    1 HR

INITIATORS
  PSETRV(3) = 0                // SORV
  FEEDWATER MAN OFF
C  HPCI LOCKED OFF             // Turn off HPCI
  HPCI & RCIC FLOW THROTTLED TO MAINTAIN DESIRED LEVEL  // HPCI throttled to maintain level see
B.03.02-05, Section G.1
  RCIC LOCKED OFF              // Turn off RCIC
  LPCI LOOP 1 LOCKED OFF       // Turn off LPCI
  LPCI LOOP 2 LOCKED OFF
  LPCI LOOP 3 LOCKED OFF
  LPCS LOCKED OFF
C  CRD PUMP LOCKED OFF         // Turn off CRDH
  IEVNT(292) = 1               // DW Coolers manually turned OFF
END

WHEN TIM > 1.5 HR // At 1.5 HPCI fails due to oil leak and 1 CRDH pump at SCRAM flow rate on
  HPCI LOCKED OFF
END
```