15.8 ANTICIPATED TRANSIENTS WITHOUT SCRAM

15.8.1 Causes, Frequency Classification, Initiating Events, Acceptance Criteria, Mathematical Models, Input Parameters, and Initial Conditions

An Anticipated Transient Without Scram (ATWS) event was not part of the SSES design basis at the time SSES was designed and built. Codification of the ATWS rule in 10CFR50.62 made ATWS an event for which mitigation capability is required. Thus, ATWS is an event for which SSES structures, systems and components (SSC's) are required to function. The specific functions, ranges of values, etc. of SSC's that are required to mitigate an ATWS are considered to be within Susquehanna's "design basis". These functions, ranges of values etc., are within the Susquehanna "design basis" because they are required to comply with 10CFR50.62. Note, however, that the ATWS event it not considered to be a Design Basis Accident, but is considered to be an "other event" specifically addressed in regulation.

The specific functions, ranges of value etc. of SSC's that are required to mitigate an ATWS, however, do not necessarily relate to SSC's operability requirements as specified in SSES Technical Specifications. Operability of SSC's required to mitigate an ATWS is determined based on the requirements provided in SSES Technical Specifications.

15.8.1.1 Identification of Causes

A failure to scram event may be caused by electrical or mechanical problems. An electrical ATWS is characterized by a failure to vent the compressed gas from the scram exhaust and scram inlet valve operators so that the exhaust valve and the inlet valve do not open on demand as required for a reactor trip. The smallest number of components which must fail in order to cause an "electrical" failure to scram is four RPS relays. The RPS logic is divided so that the control rods are segregated into four electrical groups. The design of the logic system is such that there is no reasonable combination of failures, other than relays, which is expected to cause less than all four rod groups to insert. For this reason, the most probable cause of an "electrical" ATWS appears to be the simultaneous failure of four RPS relays, and the result is a full ATWS. In addition to these failures, the occurrence of an electrical ATWS requires failure of the ARI (Alternate Rod Insertion) system which is a redundant and independent set of components to vent the scram air header.

As discussed above, electrical ATWS events result in failure of the rods to insert because of excessive back pressure on the piston due to failure of the scram exhaust valve to open. In the case of the "mechanical" failure to scram, the excessive back pressure is most likely caused by inadequate exhaust volume in the SDV (Scram Discharge Volume). In order for a mechanical ATWS to occur, a source of water to the SDV must be present. This could result from valves leaking or inadequate draining from a previous scram. In addition, the SDV drain valve must fail to open or the drain line must be blocked to prevent draining of the water source. And finally, the level instrumentation and SDV level logic must fail to provide an alarm and scram signal from the high water level.

The probability of an ATWS event is very low since multiple failures are required to result in insufficient SDV capacity or failure to vent the scram air header.

15.8.1.2 Frequency Classification

The occurrence of an ATWS event is not expected in the life of the plant. The initiating event for the failure-to-scram event is an incident of moderate frequency (anticipated operational transient).

15.8.1.3 Initiating Events

In accordance with Regulatory Guide 1.70, Rev. 2, the following seven initiating events are considered:

- Inadvertent Control Rod Withdrawal,
- Loss of Feedwater,
- Loss of Normal A.C. Power,
- Loss of Electrical Load,
- Loss of Condenser Vacuum,
- Turbine Trip, and
- Closure of Main Steam Line Isolation Valves.

In addition to the seven initiating events required by Reg. Guide 1.70, the following three initiating events are included:

- Pressure Regulator Failure Open,
- Feedwater Controller Failure Open, and
- Inadvertent Opening of a S/R Valve.

These three initiating events also were examined as part of the Susquehanna ATWS evaluation for Power Uprate. Ref. 15.8-1A

15.8.1.4 Acceptance Criteria

15.8.1.4.1 Peak Clad Temperature and Vessel Pressure Associated with Initial Pressurization Transient

The most severe ATWS events are initiated by a pressurization transient (MSIV Closure or turbine trip) or by an equipment failure which leads to a pressurization transient (e.g., pressure regulator failure; loss of condenser vacuum). With scram failure, a pressurization transient can result in a large power spike which may be several hundred percent of rated power. The large increase in power exacerbates vessel pressurization. Acceptance criteria are specified in EC-PUPC-20902 (Ref. 15.8-1A) to ensure that the initial power and pressure transients do not threaten fuel and vessel integrity. Specifically, these criteria consist of

- Reactor Pressure Vessel (RPV) Integrity. The peak RPV pressure must be less than 1500 psig (Service Level C).

- Fuel Integrity. The maximum fuel cladding temperature cannot exceed 2200°F and the local cladding oxidation must be less than 17%.

The RPV Integrity acceptance criteria is verified on a cycle-specific basis starting with U2C21 and U1C23 using the AURORA-B AOO methodology (Ref. 15.8-10). The Framatome cycle-specific safety analysis report provides the results for the limiting ATWS event. ATWS for ATRIUM 11 is non-limiting relative to Fuel Integrity criteria and bounded by 10 CFR 50.46 LOCA analyses per EC-PUPC-20902.

15.8.1.4.2 Peak Suppression Pool Temperature and Containment Pressure

In an isolation ATWS, suppression pool temperature increases rapidly as steam generated by fission power is condensed within the pool. The increasing vapor pressure associated with rising pool temperature drives steam and nitrogen through the vacuum breakers to the drywell which causes an increase in drywell pressure. Suppression pool temperature and containment pressure limits are specified in EC-PUPC-20902 to ensure the effectiveness of mitigating actions (recirculation pump trip, boron injection, and reactor water level reduction) on containment thermal loading. The acceptance criteria consist of

- Suppression Pool Temperature. The peak Suppression Pool bulk temperature must remain less than 220°F.

- Containment Pressure. The peak Containment pressure must remain below the design pressure of 53 psig.

Note that if the suppression pool temperature is below 190°F, it is not necessary to explicitly evaluate the containment pressure as it will remain well below the design limit of 53 psig.

Per EC-PUPC-20902, ATRIUM 11 does not significantly impact peak Suppression Pool Temperature and Containment Pressure and the values reported in the analysis remain applicable.

15.8.1.4.3 Fuel Integrity Under Unstable Operation

An instability event at LaSalle County Nuclear Station Unit 2 in March 1988 led to an NRC and BWR Owners' Group investigation into the impact of unstable operation on fuel integrity in ATWS events (Ref. 15.8-2). The LaSalle event was initiated by an inadvertent trip of both recirculation pumps. The reduction in power and turbine steam flow caused by the pump trip led to automatic isolation of some feedwater preheaters. The decrease in core flow accompanied by a decrease in feedwater temperature led to diverging power oscillations which were terminated by the high neutron flux trip.

Because of the similarity between the LaSalle instability event and the turbine trip ATWS, which involves a trip of recirculation pumps and a complete loss of feedwater heating, calculations were performed by General Electric to investigate instabilities under ATWS conditions (Ref. 15.8-2). Results for a bounding turbine trip ATWS showed the development of severe power/flow instabilities with potential for localized cladding damage and centerline fuel melting. Owing to the localized nature of the fuel/cladding damage, the NRC has concluded that significant distortion of the fuel to impede core cooling or prevent safe shutdown is unlikely (Ref. 15.8-3). The NRC also concluded that instabilities should not change qualitatively the containment response. Therefore, the radiological conditions should be within 10CFR50.67 guidelines (Ref. 15.8-4).

Since the impact of unstable operation on fuel integrity has already been evaluated on a generic basis by considering a bounding turbine trip ATWS scenario, it is not necessary to reevaluate Susquehanna for ATWS instability on a cycle-specific basis.

In order to minimize the consequences of large-amplitude power instabilities, the NRC has proposed modifications to the Emergency Procedure Guidelines. These modifications consist of: (1) reduction of water level below the feedwater sparger immediately upon confirmation of ATWS, and (2) initiation of boron injection upon detection of oscillations during an ATWS event regardless of suppression pool conditions (Ref. 15.8-3).

Lowering RPV water level below the feedwater sparger is very effective in mitigating unstable operation because subcooled feedwater is preheated by mixing with saturated steam before it enters the core. Early boron injection also helps mitigate instabilities, but its effect is considerably slower than that of level reduction. The Susquehanna EOPs comply with the water level guidance and exceed the boron injection requirement put forth by the NRC (the ATWS EOP requires boron injection for any ATWS event where power is greater than 5%, or cannot be determined, rather than waiting for the development of power oscillations.)

Since the NRC has concluded, on a generic basis, that

- unstable operation will not significantly distort the fuel to impede core cooling or prevent safe shutdown,

- instabilities should not change qualitatively the containment response, and

- radiological conditions should be within 10CFR50.67 guidelines,

and since the Susquehanna EOPs satisfy the NRC requirements for mitigation of instabilities in ATWS events, no further analysis on ATWS instability is required as long as the assumptions used in Ref. 15.8-2 remain bounding.

15.8.1.4.4 Radiological Consequences and Long-Term Shutdown and Cooling Capability

Acceptance criteria with regard to radiological consequences and long-term shutdown and cooling capability are specified in NUREG 0460 (Ref. 15.8-5). As discussed in Section 15.8.1.4.3, unstable operation under ATWS conditions does not lead to violation of these criteria. Given this fact, it can be concluded that the radiological and long-term-shutdown and cooling-capability requirements are met as long as the criteria in Sections 15.8.1.4.1 and 15.8.1.4.2 are satisfied (Ref. 15.8-6). Therefore, only the criteria in Sections 15.8.1.4.1 and 15.8.1.4.2 need be considered in evaluating the performance of Susquehanna for ATWS events.

15.8.1.5 Mathematical Models

The analysis methods utilized in the General Electric ATWS analysis are described in EC-PUPC-20902. Cycle-specific ATWS over pressurization analyses for RPV integrity are performed by the fuel vendor using the AURORA-B AOO methodology starting with U2C21 and U1C23 (Ref. 15.8-10).

15.8.1.6 Input Parameters and Initial Conditions

Input parameters for the ATWS analysis are listed in Table 15.8-1. The Hot Shutdown Boron Concentration is based on Hot Full Power Xenon concentration.

The ATWS simulations are initiated at a core power of 100% of rated or greater, and 99 MLbm/hr and/or 108 Mlbm/hr total core flow. This power/flow condition corresponds to the Maximum extended load line limit (MELLL) and maximum rated core flow, respectively. Table 15.8-3 list the initial conditions.

15.8.2 Inadvertent Control Rod Withdrawal

In Section 3.1.16 of NEDE-24222 (Ref. 15.8-9), General Electric presents a detailed discussion of the consequences of a rod withdrawal error at full power and within the startup range. GE has concluded that the consequences of the control rod withdrawal error are such that analysis of this event is not necessary.

15.8.3 Loss of Feedwater (LOFW)

This event was analyzed for Susquehanna by GE in GENE-637-024-0893, and was found to be less severe than the MSIV Closure ATWS; therefore, it does not need to be reanalyzed.

The LOFW event is initiated by an assumed loss of all feedwater. Reactor water level drops to L2 (-38”) in about 15 seconds. At this time, an RPT occurs (with 10 second delay), and HPCI and RCIC initiate. The operator is assumed to initiate boron injection 90 seconds after Level 2 is reached.

Since the condenser remains available, no SRVs lift, and there is no significant increase in suppression pool temperature (pool temperature increases a small amount because of steam exhausted from HPCI/RCIC turbines). After the LOFW, the reactor pressure and neutron flux begin to fall. Thus, the peak values for these parameters occur at the beginning of the event.

15.8.4 Loss of Offsite Power (LOOP)

An analysis of this event was performed for Susquehanna in EC-PUPC-20902. Initially, there is a loss of power to the recirculation pumps and condensate pumps. Pressure, power, and water level begin to decline due to the loss of feedwater and the recirculation pump trip. At two seconds, the MSIVs are assumed to begin closing due to the loss of A.C. power, and this results in a rapid rise in pressure and neutron flux. HPCI and RCIC initiate on Level 2, and the operator is assumed to initiate boron injection 120 seconds after the ATWS high pressure setpoint is reached.

Peak vessel pressure and PCT for the LOOP event are bounded by the MSIV closure ATWS. Power and pressure responses are less severe because the MSIVs do not start to close until after the recirculation pumps are tripped in the LOOP event. Peak suppression pool temperature is also bounded by the MSIV closure event. The loss of feedwater at the beginning of the LOOP event leads to a substantial reduction in water level and power following the MSIV closure. In contrast, feedwater is available for 1 to 2 minutes following containment isolation in the MSIV closure ATWS. The availability of feedwater in the MSIV Closure ATWS results in higher water level and power. The higher power level, with the MSIVs closed, results in more energy deposited in the suppression pool for the MSIV closure ATWS than for the LOOP event. However, the LOOP event is the most limiting event with regard to operation of the SLC system. LOOP results in a loss of Containment Instrument Gas to the SRVs terminating the relief mode function. Therefore, the SRVs will lift at the higher safety mode setpoints, which could affect SLCS performance. SLCS is designed to inject against a reactor steam dome pressure of 1500 psig (Section 3.9.3.1.12). Therefore, SLCS design is sufficient to ensure performance in this event.

15.8.5 Loss of Electrical Load

In the loss of electrical load event, the turbine-generator lock out relays trip to initiate turbine control valve fast closure. The fast control valve closure initiates a recirculation pump trip.

This event is essentially the same as the turbine trip ATWS event which was analyzed in GENE-637-024-0893. The turbine trip initiates closure of the main stop valves which in turn initiates a recirculation pump trip. Since the events are practically the same, only the turbine trip ATWS event (Section 15.8.7) has been analyzed for Susquehanna.

15.8.6 Loss of Condenser Vacuum

The loss of condenser vacuum ATWS event was analyzed by General Electric, on a generic basis, in NEDE-24222. The transient starts with closure of all turbine stop valves when an unexpected decline in condenser vacuum reaches the turbine trip setpoint. Thus, the beginning of this event is the same as the turbine trip ATWS. Feedwater turbines also isolate on low condenser vacuum early in the event.

As condenser vacuum decays further, the MSIVs and turbine bypass valves also close. Since the recirculation pumps and feedwater turbines are already tripped at this point, the pressurization and neutron flux transients due to the MSIV closure are much less severe than those generated by the initial turbine trip.

Since feedwater is not available following MSIV closure in the loss of condenser vacuum ATWS, the suppression pool temperature response will be bounded by the MSIV closure ATWS event. In the MSIV closure event, feedwater remains operable for 1 to 2 minutes into the event. When feedwater injection is available, reactor power is much higher than it is when level is maintained with the lower-capacity HPCI/RCIC systems.

Since the beginning part of the loss-of-condenser-vacuum event is the same as the turbine trip ATWS (Section 15.8.7), and the pool heat up is bounded by the MSIV closure ATWS (Section 15.8.8), a plant specific analysis is not performed.

15.8.7 Turbine Trip

Since this event is less severe than the MSIV Closure ATWS, it does not need to be reanalyzed for any changes in plant conditions.

This transient was evaluated for Susquehanna in GENE-637-024-0893. The Turbine Trip event begins with rapid closure of the turbine stop valves and the resultant opening of the turbine bypass valves.

After the stop valves close, the pressure immediately begins to rise which results in a reduction of the core void fraction and a rapid increase in power. The pressure and power rise are mitigated by the RPT which is initiated directly from the turbine stop valve closure. Pressure continues to rise until it is halted by the opening of relief valves. In GENE-637-024-0893 it is conservatively assumed that the operator initiates boron injection after suppression pool temperature reaches the BIIT (Boron Injection Initiation Temperature). It is also assumed that the operator begins to lower RPV water level at this time.

Simulation results for suppression pool temperature and peak vessel pressure in GENE-637-024-0893 determine that the Turbine Trip ATWS is not limiting for Susquehanna. Vessel pressure and pool temperature are bounded by the MSIV closure event. The PCT due to the initial power spike was not calculated for the Turbine Trip ATWS in GENE-637-024-0893 because based on the core power response, this transient was not considered limiting.

15.8.8 Closure of Main Steam Line Isolation Valves

The Susquehanna ATWS Evaluation, determined that the MSIV Closure ATWS is one of the two limiting ATWS events (the other is the Pressure Regulator Failure - Open event). The evaluation of fuel integrity, suppression pool temperature, and containment pressure criteria was performed by GE using the computer models described in Section 15.8.1.5. Evaluation of RPV integrity is performed by Framatome on a cycle-specific basis starting with U2C21 and U1C23 using the computer model described in Section 15.8.1.5.

15.8.8.1 Sequence of Events, Systems Operation, and Operator Actions

The typical sequence of events for the MSIV Closure ATWS are listed in Table 15.8-5 and are based on GE computer models. Credit is taken for HPCI, RCIC, and CRD systems for coolant makeup to the vessel. Feedwater injects until main steamline pressure decays to the point where it is insufficient to run the feedwater turbines.

Operator actions assumed for mitigation of the ATWS event are consistent with the EOPs (Emergency Operating Procedures). These actions consist of:

- Initiate SLCS,
- Lower RPV level to within the target band specified by the EOPs,
- Maintain HPCI suction on the CST if sufficient time available for operator action,
- Inhibit ADS,
- Initiate suppression pool cooling, and
- Raise RPV water level to normal range when the HSBW (Hot Shutdown Boron Weight) has been injected.

Although the operator will bypass the RWM (Rod Worth Minimizer) using a control room keylock bypass switch and initiate MRI (manual control rod insertion) to accelerate reactor shutdown, no credit is taken for MRI in order to add conservatism to the suppression pool temperature results.

15.8.8.2 Results

Calculation results for the MSIV closure ATWS scenarios are presented in Table 15.8-7 and based on GE computer models. The peak vessel pressure, PCT, and peak suppression pool temperature remain below the applicable limits.

As discussed in Section 15.8.1.4.2, there is a large margin to the primary containment design pressure limit of 53 psig if suppression pool temperature is less than the 220°F limit. For ATWS, the increase in containment pressure is primarily driven by the vapor pressure of the suppression pool which is relatively small when pool temperatures are within the acceptance criterion.

Comparing PCTs for the MSIV Closure ATWS (Table 15.8-7) against values computed in the generic ATWS study performed by General Electric (NEDE-24222), indicates that cladding oxidation will be significantly below the accepted maximum value of 17% of cladding volume (Ref. 15.8-9, Section 4.4.2).

15.8.9 Pressure Regulator Failure - Open

The ATWS event initiated by failure of the pressure regulator to maximum demand has been found to be a limiting event (along with the MSIV Closure ATWS) for Susquehanna. The evaluation of fuel integrity, suppression pool temperature, and containment pressure criteria for the PREGO-initiated ATWS was performed by GE using the computer models described in Section 15.8.1.5. Evaluation of RPV integrity is performed by Framatome on a cycle-specific basis starting with U2C21 and U1C23 using the computer model described in Section 15.8.1.5.

15.8.9.1 Sequence of Events, Systems Operation, and Operator Actions

The typical sequence of events for the PREGO ATWS are listed in Table 15.8-9 and are based on GE computer models. Credit is taken for HPCI, RCIC and CRD systems for coolant makeup to the vessel. Feedwater injects until main steamline pressure decays to the point where it is insufficient to run the feedwater turbines.

Assumed operator actions are consistent with the EOPs, and these actions consist of:

- Initiate SLCS,
- Lower RPV level to within the target band specified in the EOPs,
- Maintain HPCI suction on the CST if sufficient time available for operator action,
- Inhibit ADS,
- Initiate suppression pool cooling, and
- Raise RPV water level to normal range when the HSBW has been injected.

As in the case of the MSIV Closure ATWS (Section 15.8.8), conservatism is added to the peak suppression pool temperature result by not taking credit for manual insertion of control rods.

15.8.9.2 Results

Table 15.8-11 list the calculation results for the PREGO ATWS event and are based on GE computer models. The peak vessel pressure, PCT, and peak suppression pool temperature remain below the applicable limits.

There is a large margin to the primary containment design pressure with pool temperature less than the 220 °F Limit. Based on the PCTs for the PREGO event (Tables 15.8-11 and 15.8-12) and the generic results reported by General Electric in Section 4.4.2 of NEDE-24222, cladding oxidation will be significantly below the accepted maximum value of 17% of cladding volume.

15.8.10 Feedwater Controller Failure—Open (FWCFO)

The Susquehanna ATWS evaluation performed by General Electric (Ref. 15.8-1) determined that the effects of the FWCFO event are bounded by the MSIV Closure ATWS and the PREGO ATWS. Therefore, the event does not need to be reanalyzed for any changes in plant conditions.

The initiating event for this transient is failure of the feedwater controller to the maximum demand position. As soon as the feedwater controller is assumed to fail, the reactor water level, pressure, and power begin to rise slowly as the higher subcooling due to increasing feedwater flow reduces the core void fraction. Water level continues to rise until the turbine and feedwater pumps trip on Level 8. RPT is initiated by turbine stop valve closure. Following the turbine trip, reactor pressure begins to rise more rapidly and the ATWS high pressure setpoint is reached. Boron is assumed to be initiated manually 90 seconds after the ATWS high pressure setpoint is reached. There is little increase in suppression pool temperature for this event because the main condenser remains available. The availability of the turbine bypass valves and the larger steam volume (more than the volume from the vessel to the MSIVs) should keep the peak vessel pressure and peak clad temperature less severe than for the MSIV closure ATWS event.

Since the time of the ATWS evaluation performed by General Electric, Susquehanna has installed a digital Integrated Control System encompassing the control of reactor feedwater level. Common mode failure of the reactor feedwater level control system to the maximum demand position will result in the described initiating event and transient.

15.8.11 Inadvertent Opening of a S/R Valve

The inadvertent opening of a relief valve (IORV) transient is initiated by an assumed failure of a relief valve in the open position. This event involves no rapid increase in reactor pressure and power, causes long-term suppression pool heatup and vessel depressurization. GENE-637-024-0893 determined that peak pool temperature is substantially below the values predicted for the MSIV Closure and PREGO events. Consequently, this event does not need to be reanalyzed for any changes in plant conditions.

15.8.12 References

15.8-1 Claassen, L. B., "Evaluation of Susquehanna ATWS Performance for Power Uprate Conditions," GENE-637-024-0893, September 1993.

15.8-1A EC-PUPC-20902, “EPU Task Report T0902 Anticipated Transient Without SCRAM”.

15.8-2 NEDO-32047-A, “ATWS Rule Issues Relative to BWR Core Thermal-Hydraulic Stability,” General Electric Company, June 1995.

15.8-3 “Safety Evaluation Report ATWS Rule Issues and Mitigative Actions in Response to ATWS with Large Power Oscillations NEDO-32047 and NEDO-32164, Revision 0,” Attachment to Letter from Ashok C. Thadani (NRC) to Les England (BWR Owner’s Group), TAC No. M79766, February 5, 1994.

15.8-4 Technical Evaluation Report on Review of the Consequences of Thermohydraulic Instability during ATWS and the Effect of Mitigative Actions, ORNL/NRC/LTR-93-04, prepared by Oak Ridge National Laboratory, April 1993.

15.8-5 NUREG 0460, “Anticipated Transients Without Scram for Light Water Reactors,” Volume 1, Section 7.1, April 1978.

15.8-6 Letter from M. M. Urioste (General Electric Nuclear Services Manager) to R. J. Poshefko (PP&L), “Susquehanna Steam Electric Station Proposed Change to Power Uprate Contract to Provide ATWS Analysis Proposal #295 - 1DKM4-KRO,” GKR-92-128 Dated November 24, 1992.

15.8-7 PLA-4480, “Susquehanna Steam Electric Station Unit 2 Cycle 9 ATWS Evaluation,” File R41-2, Docket No. 50-388, Dated July 23, 1996.

15.8-8 NRC Safety Evaluation: Modifications to the Boiling Water Reactor (BWR) Emergency Procedure Guidelines to Address Reactor Core Instabilities, June 6, 1996.

15.8-9 “Assessment of BWR Mitigation of ATWS, Volume II (NUREG 0460 Alternate No. 3),” NEDE-24222, December 1979.

15.8-10 ANP-10300P-A, Revision 1, “AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Transient and Accident Scenarios,” Framatome Inc., January 2018.

TABLE 15.8-1

INPUT PARAMETERS FOR ATWS ANALYSIS

Closure Time of MSIV (sec)	2-5
ATWS High Pressure RPT Setpoint, UAL (psig)	1170
Setpoint for Low Water Level Closure of MSIV	L1(-129”)
Setpoint for Low Steam Line Pressure Closure of MSIV (psig)	861
Relief Valve Setpoints	†
HPCI Flow Rate (gpm)	5000
HPCI Start/Stop Levels	L2(-38”) / L8(+54”)
RCIC Flow Rate (gpm)	600
RCIC Start/Stop Levels	L2(-38”) / L8(+54”)
Hot Shutdown Boron Weight (ppm)	494
SLCS Boron Injection Rate Per Pump (GPM)	40
Boron Transport Time from SLCS Pumps to Vessel (sec)	40
Condensate Storage Tank Water Temperature (^oF)	140
ATWS Low Water Level RPT Setpoint	-38”
RHR Pool Cooling Capacity (1^{st} / 2^{nd} Loop) (Btu/sec ^oF)	322.4/324.1
Service Water Temperature (^oF)	88
Number of Operating SLCS Pumps	1

† SRV set points are taken from Ref. 15.8-1A.

TABLE 15.8-3

INPUT OPERATING CONDITIONS FOR ATWS ANALYSIS

Dome Pressure (psia)	1035-1050
Total Core Flow (Mlbm/hr)	99.0
Core Thermal Power (Mwth)	3952
Narrow Range Water Level (INCHES AVZ)	562.5
Suppression Pool Liquid Volume (ft^3)	122,410
Suppression Pool Temperature (°F)	90

TABLE 15.8-5

SEQUENCE OF EVENTS FOR MSIV CLOSURE ATWS*

Event	Time (sec)
MSIV Isolation Initiates	0
MSIV Fully Closed	4.0
Peak Neutron Flux	4.02
High Pressure ATWS Setpoint	4.17
Opening of the First Relief Valve	4.34
Recirculation Pumps Tripped	4.7
Peak Heat Flux Occurs	4.81
Peak Vessel Pressure	6.84
Feedwater Reduction Initiated (feedwater stopped completely)	104
SLCS Pump Starts	124
RHR Cooling Initiated (first train/second train)	1100/1600
Peak Suppression Pool Temperature	1508
Hot Shutdown Achieved (Neutron flux remains <0.1%)	1618

* Sequence of events are based on Reference 15.8-1A. Short-term sequence of events (i.e. time to peak vessel pressure) are typical cycle results.

TABLE 15.8-7

RESULTS FOR MSIV CLOSURE ATWS EVENT

Parameter	Result*	Limit
Peak Vessel Pressure (psig)	1333	1500
Peak Clad Temperature (°F)	1247	2200
Peak Suppression Pool Temperature (°F)	206	220

* Results are based on Reference 15.8-1A. Peak vessel pressure is a typical cycle result.

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TABLE 15.8-9

SEQUENCE OF EVENTS FOR PREGO ATWS*

Event	Time (sec)
Turbine Control and Bypass Valve Start Open	0.11
MSIV Closure Initiated by Low Steamline Pressure	12.6
Peak Neutron Flux	16.6
MSIVs Fully Closed	16.6
High Pressure ATWS Setpoint	18.7
Opening of the First Relief Valve	18.9
Peak Heat Flux Occurs	19.2
Recirculation Pumps Tripped	19.2
Peak Vessel Pressure	21.3
Feedwater Reduction Initiated (feedwater stopped completely)	118
SLCS Pumps Start	139
RHR Cooling Initiated (first train/second train)	1100/1600
Peak Suppression Pool Temperature	1959
Hot Shutdown Achieved (Neutron flux remains <0.1%)	1656

* Sequence of events are based on Reference 15.8-1A. Short-term sequence of events (i.e. time to peak vessel pressure) are typical cycle results.

TABLE 15.8-11

RESULTS FOR PREGO ATWS EVENT

Parameter	Result*	Limit
Peak Vessel Pressure (psig)	1336	1500
Peak Clad Temperature (°F)	1434	2200
Peak Suppression Pool Temperature (°F)	206	220

* Results are based on Reference 15.8-1A. Peak vessel pressure is a typical cycle result.