

3M Intersystem Loss Of Coolant Accident For Lungmen NPS

3M.1 Introduction

An intersystem loss of coolant accident (ISLOCA) is postulated to occur when a series of failures or inadvertent actions occur that allow the high pressure from one system to be applied to the low design pressure of another system, which could potentially rupture the pipe and release coolant from the reactor system pressure boundary. This may also occur within the high and low pressure portions of a single system. The Lungmen NPS systems will be designed to reduce the possibility of a LOCA outside the containment by designing to the extent practicable all piping systems, major system components (pumps and valves), and subsystems connected to the reactor coolant pressure boundary (RCPB) to an ultimate rupture strength (URS) at least equal to the full RCPB pressure.

3M.2 Lungmen NPS Requirements

The ISLOCA issue has been resolved for the Lungmen NPS by requiring that low-pressure piping systems that interface with the RCPB be designed to withstand reactor pressure to the extent practicable. For some low-pressure systems attached to the RCPB, it may not be practical or necessary to provide a higher system ultimate pressure capability for the entire low-pressure connected system. If the RCPB interfacing piping is not designed to the URS pressure, the piping should be designed to provide (1) the capability for leak testing the pressure isolation valves, (2) valve position indication that is available in the control room when isolation valve operators are de-energized and (3) high-pressure alarms to warn main control room operators when rising reactor pressure approaches the design pressure of attached low-pressure systems or when both isolation valves are not closed. Evaluations of such exceptions should be performed on a case-by-case basis during specific design certification reviews.

The URS design pressure for the low-pressure piping systems that interface with the RCPB is equal to 0.4 times the normal operating RCPB pressure of 7.07 MPaG ($0.4 \times 7.07 \text{ MPaG} = 2.82 \text{ MPaG}$). The minimum wall thickness of the low-pressure piping designed for URS will be no less than that of a standard weight pipe and valves will be designed to Class 300 as a minimum. The design of the low-pressure piping systems will be in accordance with the ASME Boiler and Pressure Vessel Code, Section III, Subarticle NC/ND-3600. Periodic surveillance and leak rate testing of the low pressure system isolation valves will be required in accordance with the Technical Specification requirements as a part of the ISI program.

Piping systems designed as described above will provide an ultimate rupture strength (URS) equal to or greater than the normal operating RCPB pressure of 7.07 MPaG. For the purpose of this Appendix, a low-pressure piping system is defined as any piping system that could be designed to pressures below the URS design pressure of 2.82 MPaG if ISLOCA was not considered.

3M.3 Boundary Limits of URS

The following items form the basis of what constitutes practicality and set forth the test of practicality used to establish the boundary limits of URS for the Lungmen NPS:

- (1) It is impractical to consider a disruptive open flow path from reactor pressure to a low pressure sink. A key assumption to understanding the establishment of the boundary limits from this practicality basis is that only static pressure conditions are considered. Static conditions are assumed when the valve adjacent to a low pressure sink remains closed. Thus, the dynamic pressurization effects accompanied by violent high flow transients and temperature escalations are precluded that would occur if the full RCPB pressure was connected directly to the low pressure sink. As a consequence, the furthest downstream valve in such a path is assumed closed so that essentially all of the static reactor pressure is contained by the URS upgraded region.
- (2) It is impractical to design or construct large tank structures to the URS design pressure that are vented to atmosphere and have a low design pressure. Tanks included in this category are:
 - (a) Condensate storage tank,
 - (b) Standby Liquid Control System (SLC) main tank,
 - (c) Radwaste Sumps (SUMP) low conductivity waste (LCW) receiving tank,
 - (d) SUMP high conductivity waste (HCW) receiving tank,
 - (e) Fuel Pool Cooling and Cleanup System (FPCU) skimmer surge tank,
 - (f) FPCU spent-fuel storage pool and cask pit, and
 - (g) Condensate hotwell

These are termed low pressure sinks for the purposes of this report. See Table 3M-1 for approximate sizes of these tanks as an indication of the impracticality of increasing the design pressure. The size of these tanks would result in an unnecessary dollar cost burden to increase their design pressure to the URS value. The small tanks in Table 3M-1 are greater than 3 meters in height and diameter. The large condensate storage tank, if constructed with its height equal to the diameter, is approximately as tall as a four story building. The FPCU tank, pool, and pit (Table 3M-1) have no top cover and are open to the large refueling floor (bay), so that their pressure can not be increased above the static head for which they are designed.

- (3) It is impractical to design piping systems that are connected to low pressure sink features to the URS design pressure when the piping is always locked open to a low pressure sink by locked open valves. These piping sections are extensions of the low pressure sink and need no greater design pressure than the low pressure sink to which they are connected.

In summary, the following low pressure sinks are protected by an adjacent closed valve and are impractical to design to the URS design pressure.

Suppression Pool — Provides a normal low pressure sink, approximately 4.9 kPaG above atmospheric for its interfacing systems and the first closed valve will have at least a 2.82 MPaG rating. The suppression pool is designed to Seismic Category I.

Condensate Storage Tank— Vented to atmosphere and its locked open valves insure it is a low pressure sink for its interfacing systems. The first closed valve of each interfacing system with RCPB will have at least a 2.82 MPaG rating.

SLC main tank—Vented to atmosphere with the first closed valve having at least a 2.82 MPaG rating. The SLC main tank is designed to Seismic Category I.

LCW Receiving Tank - Vented to atmosphere, and the first closed valve will have at least a 2.82 MPaG rating and one of the dual tank's inlet valves will be locked open.

HCW Receiving Tank— Vented to atmosphere, and the first closed valve will have at least a 2.82 MPaG rating and one of the dual tank's inlet valves will be locked open.

FPCU Skimmer Surge Tank— The FPCU skimmer surge tank is open to the near atmospheric pressure of the refueling floor. The first closed valve will have at least a 2.82 MPaG rating. The FPCU skimmer surge tank is designed to Seismic Category I.

FPCU Spent Fuel Storage Pool and Cask Pit— The FPCU spent-fuel storage pool and cask pit is open to the near atmospheric pressure of the refueling floor. The first closed valve will have at least a 2.82 MPaG rating. The FPCU spent-fuel storage pool and cask pit is designed to Seismic Category I.

Condensate Hotwell— During reactor high pressure operation, the hotwell operates at a vacuum pressure.

3M.4 Piping System Evaluation

The pressure of each piping system on all of the Lungmen NPS piping and instrument diagrams (P&IDs) has been reviewed to ensure that all piping which interfaces with RCPB piping, except for the piping described in Section 3M.3, will have a minimum design pressure of 2.82 MPaG (See 3M.2). All piping systems that have been designed to the above requirements are outlined in Section 3M.5.

3M.5 Systems Evaluated

The following fifteen systems, which have been determined to interface directly or indirectly with the RCPB, have been evaluated.

	SSAR Figure No.
(1) Residual Heat Removal System (RHR)	5.4-10
(2) High Pressure Core Flooder System (HPCF)	6.3-7
(3) Reactor Core Isolation Cooling System (RCIC)	5.4-8
(4) Control Rod Drive System (CRD)	4.6-8
(5) Standby Liquid Control System (SLC)	9.3-1
(6) Reactor Water Cleanup System (RWCU)	5.4-12
(7) Fuel Pool Cooling Cleanup System (FPCU)	9.1-1
(8) Main Steam System (MS)	5.1-3
(9) Reactor Recirculation System (RCIR)	5.4-4
(10) Condensate Storage and Transfer System (CSTF)	9.2-4
(11) Makeup Water System (MW)	9.2-5
(12) Radwaste Systems (SUMP and Other systems)	11.2-2
(13) Condensate System (COND)	10.4-6
(14) Sampling Systems (RBS and TBS)	_____

Attachment 3MA contains a system-by-system evaluation of the application of ISLOCA and URS boundary conditions to piping segments within each system listed above. The piping segments are represented by pipeline codes (e.g., 1E11 - L-D) shown on the system P&IDs (See Figures listed above). Each pipeline code contains all piping and attached components within the pipeline code boundaries as shown on the P&ID.

3M.6 Piping Design Pressure for URS Compliance

The following Guidelines for URS compliance are used in designing the piping systems for the Lungmen NPS:

- (1) The design pressure for the low-pressure piping systems that interface with the RCPB pressure boundary should be equal to 0.4 times the normal operating RCPB pressure of 7.07 MPaG ($0.4 \times 7.07 \text{ MPaG} = 2.82 \text{ MPaG}$), and
- (2) The minimum wall thickness of the low-pressure piping should be no less than that of a standard weight pipe.

3M.7 Applicability of URS Non-piping Components

The following guidelines should be followed to determine the applicability of URS to non-piping components:

- (1) The remaining components in the low-pressure systems should also be designed to a design pressure of 0.4 times the normal operating reactor pressure. If the component is shown within the boundaries of a pipeline code which is designed to the URS design pressure, then the component will also be designed to the URS design pressure. A stated parameter (e.g., design pressure) of a pipeline code on the P&ID applies to all the piping and components on the P&ID that extend away from the pipeline code flag symbol, including along any branch line, until another pipeline code flag symbol occurs on the P&ID. The components include flanges, and pump seals, etc. as shown on the P&ID.

Lungmen NPS heat exchangers are not affected by ISLOCA and will not be designed to the URS design pressure. The following heat exchangers are within the systems evaluated for ISLOCA, but will not be designed for the URS design pressure.

- (a) The Reactor Water Cleanup System (RWCU) heat exchangers are designed for the high reactor pressure already above the URS.
- (b) The Residual Heat Removal System (RHR) heat exchangers are designed for 3.43 MPaG on the tube side which exceeds the 2.82 MPaG URS design pressure. The heat exchanger's tube side carries the reactor water. The shell side, which carries the Reactor Building Cooling Water System's (RBCW) cooling water, has a design pressure of 1.37 MPaG which is the same as the RBCW design pressure. Since the heat exchanger's tube side is designed well above the URS design pressure, an overpressurization failure was not assumed that would apply reactor pressure to the shell side.
- (c) The Fuel Pool Cooling and Cleanup System (FPCU) heat exchangers are isolated from a potential exposure to reactor pressure so that no upgrade was applicable.

- (2) A Class 300 valve is adequate for ensuring the pressure of the low-pressure piping system under full reactor pressure. The rated working pressure for Class 300 valves varies widely depending on material and temperature (ASME/ANSI B16.34). However, as a lower limit bounding condition, within the material group that includes the stainless steels, the lowest working pressure is 2.86 MPaG at 204 °C, which exceeds the URS of 2.82 MPaG. For lower temperatures the working pressure increases. The material group that includes the carbon steels has working pressures above this value. More typical working pressure values at 93°C range between 4.12 MPaG to 4.81 MPaG.

3M.8 Results

See Attachment 3MA for results.

3M.9 Valve Misalignment Due To Operator Error

The Lungmen NPS design with the ISLOCA URS applied for the boundary described by this appendix and its attachment, extends the increased design pressure (URS) over the full extent of regions that could potentially experience reactor pressure, so that operator misaligned valves will not expose piping, which is not designed to URS pressure, to reactor pressure.

3M.10 Additional Operational Considerations

The periodic surveillance testing of the ECCS injection valves that interface with the reactor coolant system might lead to ISLOCA conditions if their associated testable check valve was stuck open. To avoid this occurrence, the RHR, HPCF, and RCIC motor operated injection valves will only be tested during low pressure shutdown operation.

The RHR shutdown cooling suction line containment isolation valves are also only tested during shutdown operation. These valves are interlocked against opening for reactor pressure greater than the shutdown cooling setpoint of approximately 0.93 MPaG.

3M.11 Summary

The Lungmen NPS is in full compliance with the requirements provided in this Section. For ISLOCA considerations, a design pressure of 2.82 MPaG and pipe having a minimum wall thickness equal to standard grade has been provided as an adequate margin with respect to the full reactor operating pressure of 7.07 MPaG. This design pressure was applied to the low pressure piping at the pipeline code flag symbols shown on the P&IDs, and therefore, imposes the requirement on the associated piping, valves, pumps, tanks, instrumentation and all other equipment shown between the pipeline code flag symbols.

Table 3M-1 Low Pressure Sink Component Sizes

Tank Name	Volume m³	Diameter m	Height m	Length m	Width m	Design Pressure MPaG	Note
Condensate storage tank	2110	13.9	13.9			1.37	(1)
SLC main tank	32	3.44	3.44			SWH	(1)
LCW receiving tank	430	8.18	8.18			0.98	(1)
HCW receiving tank	45	3.85	3.85			0.98	(1)
FPC skimmer surge tank	30	2.3	7.2			SWH	
FPC spent fuel storage pool	2960		11.8	17.9	14.0	SWH	
FPC cask pit	121		11.8	3.2	3.2	SWH	
Condensate hotwell	7800		20	30	13		

Notes:

(1) Diameter and height calculated from volume based on diameter = height.

SWH = Static water head