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LOFT TECHNICAL REPORT

Title: Failure Mode Effect and Consequence Analysis on the LOFT Pressurizer Relief Line Modification and the Small Break Valves for L3-5	LTR No. LO-20-80-138
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ABSTRACT

This report documents a failure mode effects and consequence analysis (FMECA) on the LOFT Pressurizer Relief Line Modification and on the L3-5 Small Break Modification.

FAILURE MODE EFFECT AND CONSEQUENCE ANALYSIS ON THE LOFT PRESSURIZER RELIEF LINE MODIFICATION AND THE SMALL BREAK VALVES FOR L3-5

1. INTRODUCTION

This report presents the results of a failure mode effects and consequence analysis (FMECA) on the LOFT Pressurizer Relief Line Modification and on the L3-5 Small Break Modification. The purpose of this analysis was to identify component failure modes that could result in damage to the facility or preclude successful completion of a LOCE.

2.0 METHOD OF ANALYSIS

The methodology used during the course of this analysis consisted of examining the functional failure modes for each component, assigning a relative failure likelihood for each failure mode, and then evaluating the effect of each failure mode on plant operations prior to and/or during a loss-of-coolant experiment (LOCE).

2.1 Failure Likelihood Ranking

A numerical value of 1, 2, or 3 was assigned to each component failure mode to indicate its relative likelihood of occurrence. The failure likelihood statements of (1) anticipated, (2) unlikely, and (3) extremely unlikely are to be thought of only in a relative sense; that is, those assigned a "1" are more likely to occur than those assigned a "2" or "3". The implication that they will frequently occur in the operation of LOFT is not intended. There was no attempt made to quantify the results. A description of the likelihood rating system as it pertains to active component failure modes is given in Table I of LTR-10-60.

2.2 Failure Effects Ranking

The following are the three failure effect categories used in the analysis:

A. Failure will result in costly equipment damage, extensive plant downtime (two weeks or greater delay in obtaining the intended test results) and/or fuel meltdown.

B. Failure will delay or disrupt normal plant operations (greater than one day but less than two weeks) but will not result in fuel meltdown.

c. Failure will not significantly affect system operations or cause a significant delay (less than one day) of the experiment.

2.3 FMECA Table

The FMECA for the Pressurizer Relief Line Modification is contained in Table I. The FMECA for the L3-5 Small Break Modification is contained in Table II. Each component is listed in the first column followed in each subsequent column by the component of system function, its effect on the system or plant operation, and the assigned failure effect and failure likelihood categories.

3.0 CONCLUSIONS

For the Pressurizer Relief Line Modification nearly all components are passive and therefore have a very low likelihood of failure. The most likely fault to occur is failure of valve CV-P139-5-4 (the PORV) to actuate when required. During Technical Specification Mode 7 operation (normal power operation), the code safety valves will provide backup protection to prevent exceeding primary coolant system pressure limits.

The next most likely undesired occurrence is inadvertent actuation of the PORV. During Mode 7 operation, the PORV can be isolated or if the operator fails to isolate the PORV, a SCRAM will occur and the ECCS will protect the core. For the L3-5 Pre-LOCE case, important test data may be lost and the test may need to be repeated.

For the L3-5 Small Break Modification the most likely fault to occur is failure of valve CV-P139-57 or valve CV-P139-58 to open in order to initiate the L3-5 Test. This failure mode for either valve will preclude performance of the experiment.

The next most likely fault is inadvertent opening of valve CV-P139-57 three minutes before To. In this case, valve CV-P139-58 is opened three minutes before the L3-5 LOCE is initiated. If valve CV-P139-57 inadvertently opens before To, some Pre-LOCE operations may not be completed and important test data may be lost if the DAVDS system is not ready.

Inadvertent opening of valve CV-P139-57 or valve CV-P139-58 during Mode 7 operations should not be a problem as long as both valves are kept normally closed.

SYSTEM Pressurizes Relief Line Modification — FAILURE MODE EFFECTS AND CRITICALITY ANALYSIS

COMPONENT	COMPONENT FUNCTION	COMPONENT FAILURE MODE	EFFECT ON REACTOR SYSTEM	CRITICALITY: EFFECT CATEGORY	CRITICALITY: FAILURE LIKELIHOOD
1. Valve CV-P139-5-4 (PORV)	Pressure relief	(a) Fails to open	Mode 7: Code safety valves will provide backup protection to prevent exceeding primary coolant system pressure limits.	C	1
			Pre-LOCE: (PORV LOCE) Valve required to open to initiate small break PORV LOCE. Failure would preclude performance of the experiment (Effect Category assumes valve needs repair).	B	1
			(Pre-LOCE) (L3-5 LOCE) Same as Mode 7 (a).	C	1
		(b) Inadvertent actuation or operator error	Mode 7: Decrease in primary system pressure. Valve CV-P139-18 can be shut to isolate the PORV. If the operator does not isolate the PORV, SCRAM and the ECCS will protect the core.	B	1
			Pre-LOCE: (PORV and L3-5 LOCE) Loss of data if the DAVDS system is not ready. May necessitate repeating the experiment. Same as Mode 7 (b).	B	1
		(c) Rupture	Mode 7 and LOCE: (PORV and L3-5 LOCE) Small LOCA and potential damage to facility due to primary secondary projectiles and/or pipe whip.	B	3

SYSTEM Pressurizer Relief Line Modification — FAILURE MODE EFFECTS AND CRITICALITY ANALYSIS

COMPONENT	COMPONENT FUNCTION	COMPONENT FAILURE MODE	EFFECT ON REACTOR SYSTEM	CRITICALITY: EFFECT CATEGORY	CRITICALITY: FAILURE LIKELIHOOD
2. Piping 1-1/2"-PCV-41-VC SCH. 160 SMLS	Flow path	(a) Plug	Mode 7: Effectively disables PORV. Code safety valves will provide backup protection.	C	3
			Pre-LOCE: (PORV-LOCE) Preclude performance of small break PORV LOCE.	B	3
			Pre-LOCE: (L3-5 LOCE) Same as Mode 7 (a).	C	3
			During LOCE: (PORV LOCE) Loss of expected experiment results code safety valves will provide backup protection.	C	3
			During LOCE: (L3-5 LOCE) Same as Mode 7 (a).	C	3
		(b) Rupture	Mode 7 and LOCE: (L3-5 LOCE) Normally no safety problem unless PORV lifts after the rupture.	C	3
			During LOCE: (PORV-LOCE) Potential damage to facility due to primary and secondary projectiles and/or pipe whip. Loss of experimental results.	B	3
3. Flange (2 each) 1-1/2" WN 2500# R. F. SCH. 160	Interface between Gamma Densitometer Spool Piece and Piping	(4) Leak (due to gasket or bolt failure)	During LOCE: (PORV-LOCE) Possible loss of experiment data depending on amount of leakage. May necessitate repeating experiment.	C	2
			During LOCE: (L3-5 LOCE) Same as #2(b), Mode 7 (L3-5 LOCE).	C	2

SYSTEM Pressurizer Relief Line Modification — FAILURE MODE EFFECTS AND CRITICALITY ANALYSIS

COMPONENT	COMPONENT FUNCTION	COMPONENT FAILURE MODE	EFFECT ON REACTOR SYSTEM	CRITICALITY	
				EFFECT CATEGORY	FAILURE LIKELIHOOD
4. Non-Instrumented Spool Piece (211323-1)	Flow path	(a) Plug (b) Rupture	Same as #2 (a) Same as #2 (b)	See #2 (a) B	3
5. Piping 1-1/4"-PVC-41-VC SCH. 160 SMLS	Flow path	(a) Plug (b) Rupture	Same as #2 (a) Same as #2 (b)	See #2 (a) B	3
6. Flange (4 each) 1-1/4" WN 2500# R. F. SCH. 160	Interface between Non-Instrumented Spool Piece (211323-2) and Piping	(a) Leak (due to gasket or bolt failure)	Same as #3 (a)	C	2
7. Non-Instrumented Spool Piece (211323-2)	Flow path	(a) Plug (b) Rupture	Same as #2 (a) Same as #2 (b)	See #2 (a) B	3
8. Second Orifice	Flow control	(a) Plug (b) Rupture	Same as #2 (a) Same as #2 (b)	See #2 (a) B	3

SYSTEM L3-5 Small Break Modification

FAILURE MODE EFFECTS AND CRITICALITY ANALYSIS

COMPONENT	COMPONENT FUNCTION	COMPONENT FAILURE MODE	EFFECT ON REACTOR SYSTEM	CRITICALITY	
				EFFECT CATEGORY	FAILURE LIKELIHOOD
1. EFD-1, Pipe	Flow path to L3-5 small break valves CV-P139-57 and CV-P139-58	(a) Plug	Mode 7 Pre-LOCE: Not detectable - no effect.	C	3
			During LOCE: Loss of some experimental results necessitating repeat of test.	B	3
		(b) Rupture	Mode 7: Small break LOCA. Possible damage due to primary and secondary projectiles.	A	3
			Pre-LOCE: Same as Mode 7 (b). Delays experiment.	A	3
			During LOCE: Same as Mode 7 (b).	A	3
2. Spool Piece (2 each) 210776-2 and 210706-2	Test section	(a) Plug	Mode 7 Pre-LOCE: Same as #1 (a).	C	3
			During LOCE: Same as #1 (a).	B	3
		(b) Rupture	Mode 7: Same as #1 (b).	A	3
			Pre-LOCE: Same as #1 (b).	A	3
			During LOCE: Same as #1 (b).	A	3

SYSTEM L3-5 Small Break Modification

FAILURE MODE EFFECTS AND CRITICALITY ANALYSIS

COMPONENT	COMPONENT FUNCTION	COMPONENT FAILURE MODE	EFFECT ON REACTOR SYSTEM	CRITICALITY	
				EFFECT CATEGORY	FAILURE LIKELIHOOD
3. Flange (4 each)	Interface between spool piece and piping	(a) Leak (due to seal or bolt failure)	Mode 7: Decrease in primary system coolant.	C	2
			Pre-LOCE: Same as Mode 7. Delays experiment.	C	2
			During LOCE: Possible loss of some experimental results depending on degree of leakage.	B	2
4. 3"-PC-85, Pipe	Flow path	(a) Plug	Mode 7		
			Pre-LOCE: Same as #1(a).	C	3
			During LOCE: Same as #1(a).	B	3
		(b) Rupture	Mode 7: Same as #1(b).	A	3
			Pre-LOCE: Same as #1(b).	A	3
			During LOCE: Same as #1(b).	A	3

SYSTEM L3-5 Small Break Modification — FAILURE MODE EFFECTS AND CRITICALITY ANALYSIS

COMPONENT	COMPONENT FUNCTION	COMPONENT FAILURE MODE	EFFECT ON REACTOR SYSTEM	CRITICALITY: EFFECT CATEGORY	CRITICALITY: FAILURE LIKELIHOOD
5. Isolation valve CV-P138-58	Isolate loop from rest of system	(a) Inadvertent opening	Mode 7 Pre-LOCE: No effect since CV-P139-57 is closed.	C	1
		(b) Failure to open	Pre-LOCE: Precludes running experiment.	B	1
		(c) Rupture	Mode 7: No effect since CV-P139-57 is closed.	C	3
			Pre-LOCE: Precludes running experiment.	B	3
			During LOCE: LOCA. Damage due to pipe whip.	A	3
6. Isolation valve CV-P139-57	Isolate small break loop from primary coolant	(a) Inadvertent opening	Mode 7 Pre-LOCE: No effect since CV-P139-58 is closed.	C	1
			Pre-LOCE 3 Min: Valve CV-P139-58 is opened 3 minutes before the LOCE is initiated. If CV-P139-57 inadvertently opens before To, some Pre-LOCE operations may not be completed and important test data may be lost.	B	1
		(b) Failure to open	Pre-LOCE: Precludes running experiment.	B	1

SYSTEM L3-5 Small Break Modification — FAILURE MODE EFFECTS AND CRITICALITY ANALYSIS

COMPONENT	COMPONENT FUNCTION	COMPONENT FAILURE MODE	EFFECT ON REACTOR SYSTEM	CRITICALITY: EFFECT CATEGORY	CRITICALITY: FAILURE LIKELIHOOD
		(c) Rupture	Mode 7 Pre-LOCE During LOCE: LOCA. Damage to facility due to pipe whip. Loss of experimental results.	A	3
7. 3"-BSD-312-VC, Pipe	Flow path	(a) Plug	Mode 7 Pre-LOCE: Same as #1(a).	C	3
			During LOCE: Loss of experimental results. This will also result in immediate pipe rupture. Damage due to pipe whip.	A	3
		(b) Rupture	Mode 7: If BST is pressurized rupture could result in loss of BST contents . May not be detected.	B	3
			Pre-LOCE: Same as Mode 7. Loss of experimental results.	B	3
			During LOCE: Same as #6(c).	A	3
8. Secondary orifice	Flow control	(a) Plug	Mode 7 Pre-LOCE: Same as #1(a).	C	3
			During LOCE: Same as #7(a).	A	3
		(b) Rupture	Mode 7: Same as #7(b).	B	3
			Pre-LOCE: Same as #7(b).	B	3
			During LOCE: Same as #6(c).	A	3

SYSTEM L3-5 Small Break Modification — FAILURE MODE EFFECTS AND CRITICALITY ANALYSIS

COMPONENT	COMPONENT FUNCTION	COMPONENT FAILURE MODE	EFFECT ON REACTOR SYSTEM	CRITICALITY: EFFECT CATEGORY	CRITICALITY: FAILURE LIKELIHOOD
9. 4" Schedule 40 Pipe 4"-BSD-312-VC	Flow path	(a) Plug	Mode 7 Pre-LOCE: Same as #1(a).	C	3
			During LOCE: Same as #7(a).	A	3
		(b) Rupture	Mode 7: Same as #7(b).	B	3
			Pre-LOCE: Same as #7(b).	B	3
			During LOCE: Same as #6(c).	A	3
10. 3"-PC-85 (between CV-P139-57 and CV-P139-53)	Flow path	(a) Rupture (due to heating of entrapped water)	Mode 7 Pre-LOCE: Possible to have water entrapped in line between isolation valves which, when heated during startup, will result in a pressure increase. A line has been installed to preclude the possibility of overpressurization.	B	2