LOFT TECHNICAL REPORT LTR 1141-33

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STEAM GENERATOR SPECIFICATION DESIGN TRANSIENTS

D. H. Stevenson

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DEPARTMENT OF ENERGY

IDAHO OPERATIONS OFFICE UNDER CONTRACT EY-76-C-07-1570

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LOFT TECHNICAL REPORT LOFT PROGRAM

FORM EG&G-229
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TITLE Steam Generator Specification Design Transients		REPORT NO. LTR 1141-33
AUTHOR D. H. Stevenson <i>DBS</i> (PSE)		GWA NO.
PERFORMING ORGANIZATION LOFT		DATE May 12, 1978 <i>DR</i>
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RCSC Supvr.	PSB Mgr. SA&TSS Supvr.	P&CSB Mgr. RSB Mgr.

SUMMARY

This LTR documents LOFT Plant operational, upset, and emergency transients, and pressure and temperature conditions as generated by the LOFT Plant Dynamic analysis model of the primary system for use in steam generator specification.

The results of this LTR have been supplemented by succeeding efforts as follows:

- I. L. E. Demick, "Response of the LOFT Steam Generator to Normal Operating and Accident Transients", March 12, 1971.
- II. FSAR Analysis Cover:
 - A. Loss of load during full power operation.
 - B. Loss of primary pump electrical power.
 - C. Loss of site power.
- III. LOFT maneuvering analysis (in process) cover:
 - A. $\pm 10\%$ step change in steam flow.
 - B. Manual reactor trip.

The initial plant conditions considered in I, II, and III may differ from this LTR plant conditions. Items I, II, and III are outlined to document in this LTR other analyses which cover the same plant transients.

These documents were originally Appendix C to CDD 1.1.4.1B.

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IDAHO NUCLEAR CORPORATION

INTEROFFICE CORRESPONDENCE

July 8, 1970

Steam Generator Specification
Design Transients
DJH-5-70

D. R. Heinicke
OFFICE

Reference: (1) Ltr, D. J. Hanson to P. L. Camp, "LPDA Standard Parameter List - Revision 1", DJH-4-70, June 19, 1970

Attached are the LOFT plant transients that you requested. These transients are intended to provide you with information suitable for presentation in the steam generator specification. I have made no attempt to single out those transients which should be included in the specification since you indicated you would make the appropriate choices [a].

All the transients were run on the LOFT Plant Dynamic Analysis model of the primary system. A schematic diagram of the simulation is shown in Reference 1. The parameters used in the simulation are also included in Reference 1. Any deviation from the standard parameters is noted on each individual transient.

It has been determined that the model of the steam generator gives conservative results following a reactor trip. In particular the shell side pressure and steam flow are conservative. Modifications to the steam generator model are currently being made to reduce the amount of conservatism. Results from the modified model will be sent to you as soon as they are available, approximately July 17, 1970.

If you have any questions pertaining to the transients, please contact Duane Hanson on extension 372.

DJH:lc

[a] See Table C-I.

Duane J. Hanson
D. J. Hanson

Approved by

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#

TABLE C-I

LIST OF DESIGN TRANSIENTS FOR PRODUCT SPECIFICATION

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Description: -10% step change in steam load

Purpose: To demonstrate the effect of the pressurizer spray on the primary system pressure

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW
Main steam valve off automatic control
Pressurizer spray rate = 0 gpm
Initial pressurizer water volume = 26 ft³ (low level)

Transient Description:

The main steam valve was stepped closed 10% from its full power (65 MW) position. The main steam valve automatic controller was not functioning. No correction in steam flow due to pressure changes across the main steam valve was accounted for. Pressurizer spray was not initiated.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

Description: Loss of load during full power operation

Purpose: Investigation of pressurizer relief valve and high pressure trip set points

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW
Main steam valve closure time = 5 sec
Decay heat based on infinite run time at 65 MW
Pressurizer power operated relief valve set point = 2440 psia
Initial pressurizer water volume = 26 ft³ (low level)
High pressure trip set point = 2350 psia

Transient Description:

The main steam valve was ramped shut in 5 seconds. The primary system heated up until the high pressure trip set point was exceeded and a reactor trip occurred. The high temperature trip set point was not exceeded since the high pressure trip occurred first. The pressurizer relief valve set point was never reached due to the reactor trip. Steam was removed from the steam generator by the power operated relief valves.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

CLEVITE CORPORATION/BF

Run No. 1.1.2.1 - Loss of Load During Full Power Operation

Run No. 1.1.2.2

Date JUN 18 1970

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Description: Loss of load during full power operation

Purpose: Investigation of pressurizer relief valve and high pressure trip set points

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW
Initial primary flow = 2.0×10^6 lb/hr
Main steam valve closure time = 5 sec
Decay heat based on infinite run time at 65 MW
Initial pressurizer water volume = 26 ft³ (low level)
Pressurizer power operated relief valve set point = 2440 psia
High pressure trip set point = 2350 psia
Steam generator relief valve #2 flowrate = 27.5 lb/sec
Steam generator relief valve #3 inoperative

Transient Description:

The main steam valve was ramped shut in 5 seconds. The primary system heated up until the high pressure trip set point was exceeded and a reactor trip occurred. The high temperature trip set point was not exceeded since the high pressure trip occurred first. The pressurizer relief valve set point was never reached due to the reactor trip. Steam was removed from the steam generator by the power operated relief valves.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

Run No. 1.1.2.2 - Loss of Load During Full Power Operation - Low Flow

Run No. 1.1.2.2 - Loss of Load During Full Power Operation - Low Flow

Description: -10% step change in steam flow

Purpose: Steam generator specification design transient

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW

Main steam valve off automatic control

Initial pressurizer water volume = 26 ft³ (low level)

Transient Description:

The main steam valve was stepped closed 10 percent from its full power (65 MW) position. The main steam valve automatic controller was not functioning. No correction in steam flow due to pressure changes across the steam valve was accounted for.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

Run No. 2.1.1.2

Date III 1970

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Description: +10% step change in steam flow

Purpose: Steam generator specification design transient

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 59 MW
Main steam valve off automatic control
Initial pressurizer water volume = 26 ft³ (low level)
Initial hot leg temperature = 613°F

Transient Description:

The main steam valve was stepped open 10 percent from its initial (59 MW) position. This position was the steady state position attained by stepping the main steam valve closed from an initial power of 65 MW. The main steam valve automatic controller was not functioning. No correction in steam flow due to pressure changes across the valve was accounted for.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

Run No. 2.1.1.3

Date JUN 16 1970
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Description: Manual reactor trip

Purpose: Steam generator specification design transients

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW
Main steam valve closure time = 5 sec.
Decay heat based on infinite run time at 65 MW
Initial pressurizer water volume = 26 ft³

Transient Description:

The reactor was tripped manually. Steam was removed from the steam generator by the power operated relief valves.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

Run No. 2.1.1.4

Date JUN 16 1970

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Description: Loss of load during full power operation

Purpose: Steam generator specification design transient

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW
Main steam valve closure time = 5 sec
Decay heat based on infinite run time at 65 MW
Initial pressurizer water volume = 26 ft³ (low level)

Transient Description:

The main steam valve was ramped shut in 5 seconds. The primary system heated up until the hot leg reactor trip set point was exceeded and a reactor trip occurred. The pressurizer relief valve flow rate was large enough that the pressure never exceeded the relief valve set point and therefore never reached the high pressure trip set point. Steam was removed from the steam generator by the power operator relief valves.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

Run No. 2.1.1.4 - Loss of Load During Full Power Operation

Run No. 2.1.1.4 - Loss of Load During Full Power Operation

Run No. 2.1.1.5

Date JUN 16 1970

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Description: Loss of load during full power operation

Purpose: To indicate that the steam generator power operated relief valves can be made smaller if the high pressure reactor trip is utilized.

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW
Main steam valve closure time = 5 sec
Decay heat based on infinite run time at 65 MW
Pressurizer power operated relief valve set point = 2440 psia
Initial pressurizer water volume = 26 ft³ (low level)
High pressure trip set point = 2350 psia
Steam generator relief valve #2 flowrate = 26 lb/sec
Steam generator relief valve #3 inoperative

Transient Description:

The main steam valve was ramped shut in 5 seconds. The primary system heated up until the high pressure trip set point was exceeded and a reactor trip occurred. The high temperature trip set point was not exceeded since the high pressure trip occurred first. The pressurizer relief valve set point was never reached due to the reactor trip. Steam was removed from the steam generator by the power operated relief valves.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

Run No. 2.1.1.5 - Loss of Load During Full Power Operation

Description: Loss of load during full power operation

Purpose: Investigation of steam generator power operated relief valve sizing

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW
Main steam valve closure time = 5 sec
Decay heat based on infinite run time at 65 MW
Pressurizer power operated relief valve set point = 2440 psia
Initial pressurizer water volume = 26 ft³ (low level)
High pressure trip set point = 2350 psia
Steam generator relief valve #1 and #2 flow rate = 21 lb/sec each
Steam generator relief valve #3 inoperative

Transient Description:

The main steam valve was ramped shut in 5 seconds. The primary system heated up until the high pressure trip set point was exceeded and a reactor trip occurred. The high temperature trip set point was not exceeded since the high pressure trip occurred first. The pressurizer relief valve set point was never reached due to the reactor trip. Steam was removed from the steam generator by the power operated relief valves.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

Run No. 2.1.1.6 - Loss of Load During Full Power Operation

Description: Loss of load during full power operation

Purpose: Investigation of steam generator power operated relief valve sizing

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW
Main steam valve closure time = 5 sec
Decay heat based on infinite run time at 65 MW
Pressurizer power operated relief valve set point = 2440 psia
Initial pressurizer water volume = 26 ft³ (low level)
High pressure trip set point = 2350 psia
Steam generator relief valve #1 and #2 flowrate = 25 lb/sec each
Steam generator relief valve #3 inoperative

Transient Description:

The main steam valve was ramped shut in 5 seconds. The primary system heated up until the high pressure trip set point was exceeded and a reactor trip occurred. The high temperature trip set point was not exceeded since the high pressure trip occurred first. Steam was removed from the steam generator by the power operated relief valves.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

Run No. 2.1.1.7 - Loss of Load During Full Power Operation

Run No. 2.1.1.8

Date LTR 1141-33
Appendix C

Description: Loss of load during full power operation

Purpose: Investigation of steam generator power operated relief valve sizing

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW
Main steam valve closure time = 5 sec
Decay heat based on infinite run time at 65 MW
Pressurizer power operated relief valve set point = 2440 psia
Initial pressurizer water volume = 26 ft³ (low level)
High pressure trip set point = 2350 psia
Steam generator relief valve #1 flowrate = 12.5 lb/sec
Steam generator relief valve #2 flowrate = 15.0 lb/sec
Steam generator relief valve #3 inoperative

Transient Description:

The main steam valve was ramped shut in 5 seconds. The primary system heated up until the high pressure trip set point was exceeded and a reactor trip occurred. The high temperature trip set point was not exceeded since the high pressure trip occurred first. Steam was removed from the steam generator by the power operated relief valves.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

Description: Loss of load during full power operation with no reactor trip

Purpose: Investigation of steam generator code relief valve sizing

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW

Main steam valve closure time = 5 sec

Pressurizer power operated relief valve set point = 2440 psia

Initial pressurizer water volume = 26 ft³ (low level)

No reactor trips are operative

Steam generator relief valve #1: setpoint = 1100 psia, flowrate = 14.5 lb/sec

Steam generator relief valve #2: setpoint = 1120 psia, flowrate = 14.5 lb/sec

Steam generator relief valve #3 inoperative

Transient Description:

The main steam valve was ramped shut in 5 seconds. No reactor trips were operative. As the primary system temperature increased the reactor shut down from the doppler and the moderator reactivity coefficients. The steam generator relief valves removed steam from the steam generator. The pressurizer relief valve kept the primary system from overpressurizing.

Parameters to be Recorded:

Recorder #1

Reactor power

Steam generator mass

Steam generator T_{in}

Steam generator T_{out}

Pressurizer pressure

Steam generator pressure

Steam flowrate

Feedwater flowrate

Recorder #2

Primary system flowrate

Steam generator level

Pressurizer insurge enthalpy

Pressurizer spray enthalpy

Pressurizer level

Pressurizer water volume

Surge flowrate

Steam generator boil off rate

Description: Loss of load during full power operation with no reactor trip

Purpose: Investigation of steam generator code relief valve sizing

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW

Main steam valve closure time = 5 sec

Pressurizer power operated relief valve set point = 2440 psia

Initial pressurizer water volume = 26 ft³ (low level)

No reactor trips are operative

Steam generator relief valve #1: set point = 1100 psia, flowrate = 21.5 lb/sec

Steam generator relief valve #2: set point = 1120 psia, flowrate = 21.5 lb/sec

Steam generator relief valve #3 inoperative

Transient Description:

The main steam valve was ramped shut in 5 seconds. No reactor trips were operative. As the primary system temperature increased the reactor shut down from the doppler and the moderator reactivity coefficients. The steam generator relief valves removed steam from the steam generator. The pressurizer relief valve kept the primary system from overpressurizing.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

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Description: Loss of load during full power operation with no reactor trip

Purpose: Investigation of steam generator code relief valve sizing

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW

Main steam valve closure time = 5 sec

Pressurizer power operated relief valve set point = 2440 psia

Initial pressurizer water volume = 26 ft³ (low level)

No reactor trips are operative

Steam generator relief valve #1: setpoint = 1100 psia, flowrate = 25 lb/sec

Steam generator relief valve #2: setpoint = 1120 psia, flowrate = 25 lb/sec

Steam generator relief valve #3 inoperative

Transient Description:

The main steam valve was ramped shut in 5 seconds. No reactor trips were operative. As the primary system temperature increased the reactor shut down from the doppler and the moderator reactivity coefficients. The steam generator relief valves removed steam from the steam generator. The pressurizer relief valve kept the primary system from overpressurizing.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

Run No. 2.1.1.12

Date JUN 16 1970
LTR 1141-33
Appendix C

Description: Loss of primary pump electrical power

Purpose: Steam generator specification design transient

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW
Main steam valve closure time = 5 sec
Decay heat based on infinite run time at 65 MW
Initial pressurizer water volume = 26 ft³ (low level)
Steam generator relief valve #2 flowrate = 26.0 lb/sec
Steam generator relief valve #3 inoperative

Transient Description:

A pump coastdown was initiated. The reactor tripped on low flow (90% of nominal). The flow coasted down to 307 gpm and then held constant. Steam was removed from the steam generator by the power operated relief valves.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

Run No. 2.1.1.12 - Loss of Primary Pump Electrical Power

Appendix C

Description: Loss of site power

Purpose: Steam generator specification design transient

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW
Steam valve closure time = 5 sec
Decay heat based on infinite run time at 65 MW
Emergency feedwater flowrate = 15 gpm
Steam generator relief valve #2 flowrate = 26.0 lb/sec
Steam generator relief valve #3 inoperative
Initial pressuriser water volume = 26 ft³ (low level)

Transient Description:

At the instant of loss of site power the pump began to coast down. At that same time the safety system also detected the electrical power loss and after the appropriate safety system delay and clutch release time the rods began to drop. The main steam valve ramp was initiated by the safety system. The feedwater valve was assumed to close instantaneously thus neglecting secondary pump coastdown. As soon as the feedwater pump shut down the emergency pump was assumed to start up on a first order, ten second time constant. Steam was removed from the steam generator by the power operated relief valves. The primary flow coasted down to 307 gpm and then held constant.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

Run No. 2.1.1.14

Date JUN 16 1970

LTR 1141-33
Appendix C

Description: -10% step change in steam flow

Purpose: Steam generator specification design transient

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW
Initial primary flow = 2.0×10^6 lb/hr
Initial pressurizer water volume = 26 ft³ (low level)
Main steam valve off automatic control

Transient Description:

The main steam valve was stepped closed 10 percent from its full power (65 MW) position. The main steam valve automatic controller was not functioning. No correction in steam flow due to pressure changes across the steam valve was accounted for.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

Run No. 2.1.1.15

Date _____

LTR 1141-33
Appendix C

Description: +10% step change in steam flow

Purpose: Steam generator specification design transient

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 58.5 MW
Initial primary flow = 2.0×10^6 lb/hr
Initial pressurizer water volume = 26 ft³ (low level)
Initial hot leg temperature = 612°F
Main steam valve off automatic control

Transient Description:

The main steam valve was stepped open 10 percent from its initial (58.5 MW) position. This position was the steady state position attained by stepping the main steam valve closed from an initial power of 65 MW. The main steam valve automatic controller was not functioning. No correction in steam flow due to pressure changes across the valve was accounted for.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

Run No. 2.1.1.16

Date _____

LTR 1141-33

Appendix C

Description: Manual reactor trip

Purpose: Steam generator specification design transient

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW
Initial primary flow = 2.0×10^6 lb/hr
Main steam valve closure time = 5 sec
Decay heat based on infinite run time at 65 MW
Initial pressurizer water volume = 26 ft³ (low level)

Transient Description:

The reactor was tripped manually. Steam was removed from the steam generator by the power operated relief valves.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

Run No. 2.1.1.16 - Manual Reactor Trip - Low Flow

Run No. 2.1.1.17

Date JUN 18 1970

LTR 1141-33
Appendix C

Description: Loss of load during full power operation

Purpose: Steam generator specification design transient

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW
Initial primary flow = 2.0×10^6 lb/hr
Main steam valve closure time = 5 sec
Decay heat based on infinite run time at 65 MW
Initial pressurizer water volume = 26 ft³ (low level)
Steam generator relief valve #2 flowrate = 27.5 lb/sec
Steam generator relief valve #3 inoperative

Transient Description:

The main steam valve was ramped shut in 5 seconds. The primary system heated up until the hot leg reactor trip set point was exceeded and a reactor trip occurred. The pressurizer relief valve flow rate was large enough that the pressure never exceeded the relief valve set point and therefore never reached the high pressure trip set point. Steam was removed from the steam generator by the power operator relief valves.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

Run No. 2.1.1.18

Date _____

LTR 1141-33
Appendix C

Description: Loss of primary pump electrical power

Purpose: Steam generator specification design transient

Initial Conditions Which Differ From Standard Parameter List Rev. No. 1

Initial reactor power = 65 MW
Initial primary flow = 2.0×10^6 lb/hr
Main steam valve closure time = 5 sec
Decay heat based on infinite run time at 65 MW
Initial pressurizer water volume = 26 ft³ (low level)
Steam generator relief valve #2 flowrate = 27.5 lb/sec
Steam generator relief valve #3 inoperative

Transient Description:

A pump coastdown was initiated. The reactor tripped on low flow (90% of nominal). The flow coasted down to 307 gpm and then held constant. Steam was removed from the steam generator by the power operated relief valves.

Parameters to be Recorded:

Recorder #1

Reactor power
Steam generator mass
Steam generator T_{in}
Steam generator T_{out}
Pressurizer pressure
Steam generator pressure
Steam flowrate
Feedwater flowrate

Recorder #2

Primary system flowrate
Steam generator level
Pressurizer insurge enthalpy
Pressurizer spray enthalpy
Pressurizer level
Pressurizer water volume
Surge flowrate
Steam generator boil off rate

Run No. 2.1.1.18 - Loss of Primary Pump Electrical Power - Low Flow

IDAHO NUCLEAR CORPORATION

INTEROFFICE CORRESPONDENCE

July 1, 1970

LOFT Steam Generator
Specification
RCG-15-70

Mr. W. C. Reed
TAN-602

The requested structural dynamic loadings for inclusion in the LOFT steam generator specification are enclosed. The various loadings and the associated assumptions are listed below:

1. Steam generator base accelerations (maximum) are those previously determined for the LOFT system based on a 16 $\frac{1}{2}$ -inch top blowdown with 3 msec. opening time. These peak accelerations are expected to be conservative for the tests presently contemplated. The accelerations shown are peak values and the worst combination or combinations should be used. (For coordinate convention see Figure 1.)

<u>Component</u>	<u>Acceleration</u>
X	± 1900 inches/second ²
Y	± 2800 inches/second ²
Z	± 4400 inches/second ²
θ_x	± 95 radians/second ²
θ_y	± 20 radians/second ²
θ_z	± 28 radians/second ²

2. Limit loads should be used for piping dynamic nozzle loads.
3. The steam generator support skirt should be designed to withstand a horizontal thrust load of 2 PA resulting from a steam pipe rupture at the top of the steam generator in addition to the base accelerations listed in 1. above. This thrust load is:

$$2 \text{ PA} = 2(1100)(71.81) \\ \text{Thrust} = 158,000 \text{ lbs.}$$

It should be understood that these loads are conservative design loads and that later analysis will provide more realistic values.

RCG:ka

R. C. Guenzler
R. C. Guenzler

Attachment

cc: P. L. Camp
S. Cohen
R. C. Guenzler - 2

D. R. Heinicke
E. J. Hughes

72

J. L. Liebenthal
C. A. Moore *CAH*

Figure 1

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IDAHO NUCLEAR CORPORATION
D. R. HEINICKE

INTEROFFICE CORRESPONDENCE

June 19, 1970

LPDA Standard Parameter
List - Revision 1
DJH-4-70

P. L. Camp
TAN-602

Attached is a copy of the LOFT Plant Dynamic Analysis (LPDA) Standard Parameter List - Revision 1. This list contains the parameters currently being used in the simulation of the LOFT Primary System. A diagram of the system simulated is included on page 16A for information purposes. If the parameters listed do not define the system as currently designed, it is requested that the new parameters be forwarded to D. J. Hanson by June 29, 1970.

For any assistance or further clarification of the parameters, please contact Duane Hanson on extension 372.

DJH:le

Duane J. Hanson
Duane J. Hanson

Attachment

cc: w/attachment
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LPDA Standard Parameter List - Rev. 1

The following parametric values will be used in all LOFT Plant Dynamic Analysis work beginning June 10, 1970. Any time a revision occurs, a new standard parameter list will be issued. The source of each parameter is indicated by the reference number. A list of references appears on the last page of the Standard Parameter List.

<u>Reactor Kinetics and Control</u>		<u>Reference</u>
Core power	55 MW	1
Prompt moderator heating	3% of core power	2
Decay heat curve	Figure 1	3
Doppler reactivity coefficient		
Hot (590°F)	$-1.6 \times 10^{-5} \Delta\rho/^\circ\text{F}$	2
Cold (68°F)	$-1.3 \times 10^{-5} \Delta\rho/^\circ\text{F}$	2
Moderator temperature coefficient	$-2.8 \times 10^{-4} \Delta\rho/^\circ\text{F}$	2
Control rod worth, $\Delta\rho$		
Hot	$.230 \Delta k_{12}/k_1 k_2$	2
Cold	$.161 \Delta k_{12}/k_1 k_2$	2
See attached rod worth curves	Figures 2 and 3	2
Neutron lifetime (birth to birth), ℓ		
Hot	$20 \times 10^{-6} \text{ sec}$	2
Cold	$16 \times 10^{-6} \text{ sec}$	2
Delayed neutron fraction, β	.007	2
6 group delayed neutrons	<u>Fraction</u>	<u>Decay Constant²</u>
1	$f_1 = .0457$	$\lambda_1 = 3.01 \text{ Disintegrations/sec}$
2	$f_2 = .1273$	$\lambda_2 = 1.13$ "
3	$f_3 = .3947$	$\lambda_3 = .301$ "
4	$f_4 = .1917$	$\lambda_4 = .111$ "
5	$f_5 = .2058$	$\lambda_5 = .0305$ "
6	$f_6 = .0308$	$\lambda_6 = .0124$ "

FIGURE 1

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FIGURE 2

Worth of All Rods
vs
Rod Insertion Depth
for Hot Reactor (590°F)
with 1000 ppm Boron

Total Rod Worth = 0.230 $\Delta K/K, K_0$

Fraction of Rod Worth

1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

Fraction of Rod Insertion Depth

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Appendix C

FIGURE 3

Worth of All Rods
vs
Rod Insertion Depth
for Cold Reactor (68°F)
with 1000 ppm Boron

Total Rod Worth = 0.161 $\Delta K_{12}/K, K_2$

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<u>Reactor Kinetics and Control</u> (contd.)		<u>Reference</u>
Control rod speed	4.25 in/min	4
Control rod clutch release time on trip	200 millisecond	4
Control rod drop time (Includes clutch release)	2 seconds	4

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<u>Core Thermal-Hydraulics</u>		<u>Reference</u>
Number of fuel pins	1300	4
Fuel pin pitch	.563 in. $\square$	4
Fueled length	66 in.	4
Fuel pin O.D.	.422 in.	4
Clad thickness	.0243 in.	5
Fuel pellet O.D.	.3669 in.	5
Fuel mass per pin	2.69 lbsUO ₂ /pin	4
Clad mass per pin	.514 lbsZr-4/pin	4
Gap conductance	Variable	4
Fuel conductivity, specific heat, expansion coefficient	DRE-18-69	17
Clad conductivity, specific heat, expansion coefficient	DRE-18-69	17
Percent of flow bypassing the core	5%	4
Convective heat transfer coefficient @ 4.3×10^6 lb/hr	5745 BTU/hr ft ² °F	6
Clad surface heat transfer area	263.31 ft ²	6
Core flow area	1.7 ft ²	1

JUN 12 1970

Steam Generator

Reference

Primary side thermal hydraulics

Number of tubes	643	7
Tube O.D.	.75 in.	7
Nominal wall thickness	.060 in.	7
Average tube length	23.1 ft	7
Convective heat transfer coefficient @ 4.3×10^6 lb/hr	6880 BTU/hr ft ² °F	6
Tube material	Inconel	8

Secondary side thermal hydraulics

Feedwater enthalpy	382 BTU/lb	9
Boiling heat transfer coefficient	8000 BTU/hr ft ² °F	
Tube heat transfer area	2662 ft ²	7
Steady state recirculation ratio at 100% power	5	9
Steam generator tube mass	9.4 ft ³	6

Secondary side volumes and dimensions

Total shell volume	314 ft ³	7
Shroud plus can less tubes and baffels	164.4 ft ³	7
Total tube outside volume	41.7 ft ³	8
Baffels	2.1 ft ³	8
Total water volume (100% power)	135 ft ³	7
Inside shroud plus can (100% power)	82 ft ³	7
Downcomer	53 ft ³	7
Total steam volume (100% power)	132.2 ft ³	6
Pipe from steam generator to steam control valves	46.8 ft ³	1
Secondary side dimensions	PLC-6-70	7

Steam generator control

		<u>Reference</u>	
Main steam valve controller	Figure 4	10	
Small steam valve controller	Figure 4	10	
Feedwater control system	Figure 5	10	
Main steam valve set point	Variable	10	
Level set point (above tube sheet)	146 in.	7	
Small steam valve set point (at 100% power)	1250 psia	11	
Main steam valve closure time on reactor trip	10 sec	9	
Relief valve setpoints and flowrates		11	
	<u>On Setpoint</u>	<u>Off Setpoint</u>	<u>Flowrate</u>
Power operated #1	1050 psia	1010 psia	15%
Power operated #2 & #3	1070 psia	1030 psia	20% each

FIGURE 4

Main Steam Valve and Small Steam Valve Control Systems

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Feedwater Valve 3 Control System

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<u>Pressurizer</u>		<u>Reference</u>
Volume	46 ft ³	12
Nominal Water Volume	29 ft ³	12
Nominal steam volume	17 ft ³	12
Level dead band (about nominal)	± 3 ft ³	12
Nominal pressure	2250 psia	13
Spray flowrate	20 gpm	12
Total heater capacity		
Primary heaters	13 BTU/sec	12
Backup heaters	39 BTU/sec	12
Relief valve flowrate (prevents reactor trip)	7200 lb/hr	12
Controller set points		
Spray pressure set point, on & off	2265 psia	13
Primary heater pressure set, on & off	2235 psia	13
Backup heater pressure set point, on & off	2225 psia	13
Relief valve set point	<u>on</u> <u>off</u> 2350 2256	13

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<u>Primary Pump</u>		<u>Reference</u>
Pump characteristic curve	Figure 6	13
Pump coastdown	Figure 7	6
Pump moment of inertia (includes pump, motor, fly wheel)	5816 lb ft ²	6
Nominal flow rate	4.3 x 10 ⁶ lb/hr	13

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FIGURE 6
Pump Characteristic Curve

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<u>Primary System Volumes</u>		<u>Reference</u>
RVO to SGI	13 ft ³	14
Pressurizer liquid (nominal)	29 ft ³	12
Pressurizer vapor (nominal)	17 ft ³	12
Steam generator plenums	29.6 ft ³	7
Steam generator tubes	32.3 ft ³	7
SGO to RCPI	8.7 ft ³	14
Pump volute	7.3 ft ³	1
RCPO to RVI	9.3 ft ³	14
Core downcomer	31.0 ft ³	1
RVO lower plenum	16.0 ft ³	1
Active core region	10.8 ft ³	1
Outlet plenum (without filler)	<u>53.0 ft³</u>	1
TOTAL	257.0 ft ³	14
Primary loop pressure drop @ 4.3 x 10 ⁶ lb/hr	94 psi	13

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<u>Safety System</u>		<u>Reference</u>
Safety system response time	300 milliseconds	15
Set points		
High temperature hot leg trip	619°F	16
High primary pressure trip	2385 psia	16
Low primary pressure trip	2150 psia	16
Low primary flow trip	90% nominal	16
High flux trip	110% nominal	16

Note: Figure 8 shows the LOFT plant as now simulated. The main components of the primary system are simulated. The simulation of the secondary system includes the shell side of the steam generator and the steam and feedwater control valves.

FIGURE 8

LOFT Plant Dynamic Analysis

References

1. Appendix B, Mobile Test Assembly Parameters for All SDD 1.1 Series Documents, Revision A, April 1970.
2. Letter, M. N. Monson to H. U. Johansen, "Dynamic Analysis", MNM-6-70, May 7, 1970.
3. M. R. Killgore, "LOFT Core Post-Shutdown Heat Generation", LTR 62B02-010A, December 1968.
4. Notegram; To H. U. Johansen from E. Arbtin, April 15, 1970.
5. Personal Communication with E. Arbtin, April 22, 1970.
6. Calculated from appropriate parameters.
7. Letter, P. L. Camp to H. U. Johansen, "CDD 1.1.4.1 Steam Generator Design Parameters", PLC-6-70, June 5, 1970.
8. Personal Communication with W. C. Reed, June 4, 1970.
9. Letter, D. R. Heinicke to H. U. Johansen and S. C. Datsko, "Steam Generator CDD 1.1.4.1", DRA-6-70, April 7, 1970.
10. F. K. Hyer, et.al., "LOFT Plant Dynamic Analysis - Steam Generator and Instrumentation Model"; (Issued in rough draft form only), Jim-5-69A, March 4, 1970.
11. Letter, D. R. Heinicke to H. U. Johansen, "Steam Generator", DRH-8-70, May 22, 1970.
12. Pressure size determined by plant transients to keep the pressurizer heaters covered under worst case conditions.
13. Notegram, to H. U. Johansen from E. J. Hughes, April 10, 1970.
14. Personal communication with E. J. Hughes, June 5, 1970.
15. SDD 1.1.7, Reactor Shutdown System.
16. Initial setpoint, documented in reference 13.
17. Letter, D. R. Evans to P. R. Davis, "Common Parameters for LOCA Analyses (Task 7.0)", DRE-18-69, November 20, 1969.

IDAHO NUCLEAR CORPORATION

INTEROFFICE CORRESPONDENCE

July 9, 1970

Steam Line Break Analysis
DSO-10-70

D. R. Heinicke
TAN 602

- References: (1) D. R. Heinicke to H. U. Johansen Ltr., "Steam Generator Transient Analysis," DRH-12-70, June 18, 1970.
- (2) W. H. Rettig et al, "RELAP3 - A Computer Program for Reactor Blowdown Analysis," (Internal INC report) January 1970.

In Reference 1 you requested analysis of the steam line break accident. The results of these analyses are provided herein.

The following assumptions and input have been used for the analysis:

1. The worst-case pressure and temperature will result from an offset shear of the steam line. This will provide the most rapid depressurization and cooldown of the shell-side fluid.
2. The fluid temperature and pressure on the secondary side of the steam generator during steady state operation was 526°F and 856 psia, respectively. These were chosen to provide the worst thermal gradient during ECC injection and correspond to primary coolant system high flow conditions (4.3×10^6 lb/hr) and a hot leg temperature of 610°F. Analyses have also been performed for the low temperature case of 460°F. These correspond to low flow conditions in the primary coolant system of 2.0×10^6 lb/sec and a hot leg temperature of 610°F.
3. Heat transfer between the primary and secondary coolant system was neglected (ie, adiabatic expansion of the secondary fluid was assumed).
4. Only that portion of the secondary system within the containment shell was analyzed. The fluid was modeled as two volumes. One volume (276 ft³) modeled the steam generator and feedwater line and the other (65 ft³) modeled the steam pipe.
5. A discharge coefficient of 1.0 was used at the break.

D. R. Heinicke
DSO-10-70
Page 2

In our discussions with you, it has been agreed that these analyses are to be used as input for stress analyses. The output which is available from the blowdown analyses which is pertinent to stress analyses is the temperature and pressure transient results for the fluid on the shell side of the steam generator. The blowdown analyses have been performed with RELAP3(2). The results are shown in Figures 1 through 4. Figures 1 and 2 show the temperature and pressure response, respectively, for the high temperature case (526°F). Figures 3 and 4 show the same data for the low temperature case (460°F).

In performing stress analyses, it is recommended that the assumption be made that the pressure and temperature of the primary coolant remains constant throughout the blowdown. This should provide a conservatively high stress evaluation when compared to the actual behavior expected from the primary coolant system during the blowdown.

If you need further data concerning the blowdown response, we will be happy to supply that data which is available from our analysis. The detailed PSAR analysis of the steam line break is scheduled to be completed on August 31, 1970. However, if there is a need for more detailed analysis prior to that time, please contact us.

DES:lh

GLE
for D. E. Solberg

Approved by

H. U. Johansen

H. U. Johansen, Manager
Analytical Systems Design Branch, LOFT

cc: Director, LOFT Project Division, ID - 3

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LO-025-DJJ:C LOFT SECONDARY SYSTEM BLOWDOWN 526 DEG F, HIGH FLOW, 100PCT

LO-025-DJJ>C LOFT SECONDARY SYSTEM BLOWDOWN 526 DEG F, HIGH FLOW, 100PCT

LO-026-DJJ>C LOFT SECONDARY SYSTEM BLOWDOWN 461 DEG F, LOW FLOW, 100PCT

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Figure 3. 100% steam line break, shell-side water temperature response, LOFT low flow.

LO-026-DJJ:C LOFT SECONDARY SYSTEM BLOWDOWN 461 DEG F, LOW FLOW, 100PCT

IDAHO NUCLEAR CORPORATION

INTEROFFICE CORRESPONDENCE

October 30, 1970

CDD-1.1.4.1
Steam Generator Blowdown Transients
DSO-19-70

To: Distribution

The transient response of the LOFT Steam Generator have been analyzed for the worst case LOCA and a Davis-Bessel equivalent outlet break (LOCE). The results are reported in the attached LTR.

DES:tms

D. E. Solberg

Attachment

Distribution

w/Attach

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LOFT TECHNICAL REPORT
LOFT PROJECT DIVISION

IDAHO NUCLEAR CORPORATION

TITLE		REPORT NO.	
STEAM GENERATOR BLOWDOWN TRANSIENTS		1141-4	
AUTHOR	D. E. Solberg <i>DES ja</i>	GWA NO.	ACCOUNT NO.
SECTION	Experimental Analysis	51470-612-220	51470
BRANCH	Test Assembly <i>MCamp</i>	DATE October 30, 1970	

STEAM GENERATOR BLOWDOWN TRANSIENTS

1. PURPOSE

The purpose of this study is to obtain pressure and temperature transient in the primary coolant system portion of the steam generator for a loss-of-coolant (LOCA) accident and a loss-of-coolant experiment (LOCE). Of particular concern was to determine if quenching of the steam generator with ECC would occur.

2. CONCLUSIONS

Rapid cooling of the steam generator by quenching with ECC does not occur. The environment described by the curves supplied herein are applicable as worst case LOCA and LOCE environments for the steam generator.

3. METHODS AND ASSUMPTIONS

Analyses presented herein were performed on RELAP3 (Reference 1). The data obtained is applicable to the saturated blowdown, core heatup and ECC injection portions of the loss-of-coolant sequence. Subcooled blowdown loads must be obtained from other codes.

The LOFT Primary Coolant System was modeled on RELAP3 using 15 volumes. These volumes are as identified in Figure 1 with the following exceptions:

1. The steam generator, volume 5, was divided into four discrete volumes representing the inlet plenum, half the tubes with $600^{\circ}\text{F} \geq T \geq 593.5^{\circ}\text{F}$, half the tubes with $593.5^{\circ}\text{F} \geq T \geq 577^{\circ}\text{F}$, and an outlet plenum.
2. The hot leg piping, volume 4, was divided into two equal parts so that the offset shear can be modeled.

Assumptions used in the analyses, shown in Table 1, were chosen to provide the worst case steam generator transient. The following justification is provided for the values shown in Table 1. Scram, pump coastdown and void coefficient values were best estimates for LOFT. ECC operation is modeled to give maximum flooding rates for LOCE and LOCA. Discharge coefficients of .6 provide the best comparison of experimental and analytical results. Largest available break areas were chosen to provide the most rapid depressurization and thus the earliest possible ECC injection. Outlet breaks were chosen so that flow of ECC from the assumed cold leg injection locations would have the highest probability of flowing to the steam generator. For the LOCA an offset shear of the hot leg in the circulating loop was assumed. For the LOCE, the orifices in the LOFT blowdown system were chosen to model the relative flow rates at the reactor vessel nozzles determined for an offset shear in the Davis-Besse plant (Appendix 1) which provides the most rapid depressurization rate that has been analyzed thus far. High flow conditions (high T_{ave}) were assumed since they provide the highest initial temperature for the steam generator hardware and therefore the greatest potential for high ΔT during the blowdown and ECC flooding.

4. DISCUSSION OF RESULTS

4.1 LOCA

The LOCA was analyzed for 9.6 seconds of the transient. At that time all accumulator coolant had been emptied into the primary coolant system. Primary system pressures in the region of the steam generator were at about the assumed containment pressure and the pressure differential from steam generator inlet nozzle to outlet nozzle had been reduced to 0.01 psid. At the end of the transient a negligible amount of ECC had managed to get into the piping between the pump and steam generator (400 pounds liquid, total inventory) and the steam generator had no liquid remaining. Because the pressure differential across the steam generator is so small at the end of blowdown, the potential for forcing emergency coolant into the steam generator, which is at a higher elevation than the break, no longer exists and flooding of the steam generator with ECC is not expected to occur. Transient pressure, temperature, flow and quality data obtained from the analysis which are applicable to steam generator analyses, are shown in Figures 2 through 19 for the 9.6 seconds of transient analyzed. The erratic behavior of the quality after 8 seconds in Figures 16 through 19 are inconsequential since the flow rate at this time is less than .3 lb/sec. It is suggested that if the quality data is to be used in additional analyses that the data be averaged during those periods of erratic behavior.

The RELAP3 results for this LOCA may be examined for further information by obtaining Run #R3B-LO-63.

4.2 LOCE

The LOCE was analyzed for 15.5 seconds of the transient. At that time, all accumulator coolant had been emptied into the primary coolant system and the primary system pressures were at the assumed containment pressure. The pressure differential from nozzle to nozzle on the steam generator had been reduced to 0.05 psid. At the end of the transient, no ECC had flowed into the piping between the pump and the steam generator and the steam generator was devoid of liquid. Because the pressure differential across the steam generator is small at the end of the transient analysis, the potential for forcing emergency coolant into the steam generator no longer exists and flooding of the steam generator with ECC is not expected to occur. Applicable transient pressure, temperature, flow and quality data for the LOCE analysis is presented in Figures 20 through 37. The RELAP3 results for this LOCE may be examined for further information by obtaining Run #R3B-LO-61.

5. REFERENCE

1. W. H. Rettig, et al., "RELAP3 --- A Computer Program for Reactor Blowdown Analysis", IN-1321, June 1970.

ANALYSIS ASSUMPTIONS

<u>Parameter</u>	<u>LOCA Assumption</u>	<u>LOCE Assumption</u>
1. Scram	\$0 at 0.5 sec to -\$30 at 2.0 sec	\$0 at 0.5 sec to -\$30 at 2.0 sec
2. Pump Coastdown	Full ΔP at 0 sec to zero ΔP at 100 sec	Full ΔP at 0 sec to zero ΔP at 100 sec
3. ECC operation	2 accumulators initiate at 600 psig, 50 ft ³ coolant each	1 accumulator initiates at 600 psig, 50 ft ³ coolant
4. Void coefficient	\$.286/% void	\$.286/% void
5. Discharge coefficient	.60	.60
6. Break area/location	1.36 ft ² /hot leg	.339 ft ² /blowdown system
7. Steady state mass flowrate, primary system	4.3 x 10 ⁶ lb/hr	4.3 x 10 ⁶ lb/hr
8. Hot leg temperature, steady state	610°F	610°F
9. Cold leg temperature, steady state	577°F	577°F

FIGURE 1

LOFT MODEL ON RELAP

Volume Identification

<u>Vol#</u>	<u>Component</u>
1	Core
2	Core bypass
3	Outlet plenum
4	Hot leg piping
5	Steam generator
6	Cold leg piping, steam generator to pump
7	Cold leg piping, pump to reactor vessel
8	Downcomer
9	Inlet plenum
10	Pressurizer
11	Blowdown system, hot leg
12	Blowdown system, cold leg

Elevation View, Reactor Vessel

Plan View of Primary Coolant System

R3-L0-63 STEAM GEN. STUDY - LOCA

R3-L0-63 STEAM GEN. STUDY - LOCA

FIGURE 4

PRESSURE HISTORY FOR THE COLD SIDE TUBES OF THE
LOFT STEAM GENERATOR FOR LOCA WITH ECC

601
AVG PRESS PSIA V16

LTR 1141-33
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R3-LO-63 STEAM GEN. STUDY - LOCA

FIGURE 6

TEMPERATURE HISTORY FOR THE INLET PLENUM OF THE LOFT
STEAM GENERATOR FOR LOCA WITH ECC

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FIGURE 7

TEMPERATURE HISTORY FOR THE HOT SIDE TUBES OF THE LOFT
STEAM GENERATOR FOR LOCA WITH ECC

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R3-L0-63 STEAM GEN. STUDY - LOCA

FIGURE 8

TEMPERATURE HISTORY FOR THE COLD SIDE TUBES OF THE STEAM
GENERATOR FOR LOCA WITH ECC

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FIGURE 9

TEMPERATURE HISTORY IN THE OUTLET PLENUM OF THE LOFT
STEAM GENERATOR FOR LOCA WITH ECC

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R3-L0-63 STEAM GEN. STUDY - LOCA

R3-L0-63 STEAM GEN. STUDY - LOCA

R3-LG-63 STEAM GEN. STUDY - LOCA

R3-L0-63 STEAM GEN. STUDY - LOCA

Figure 14

Flow History Between the Tubes and the Outlet Plenum of the LOFT
Steam Generator for LOCA with ECC

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FIGURE 15

QUALITY BEHAVIOR AT THE INLET NOZZLE OF THE LOFT
STEAM GENERATOR FOR LOCA WITH ECC

QUALITY J2

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R3-L0-63 STEAM GEN. STUDY - LOCA

FIGURE 16

QUALITY BEHAVIOR AT THE OUTLET NOZZLE OF THE LOFT
STEAM GENERATOR FOR LOCA WITH ECC

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FIGURE 17

QUALITY BEHAVIOR BETWEEN THE INLET PLENUM AND THE TUBES
OF THE LOFT STEAM GENERATOR FOR LOCA WITH ECC

QUALITY J18

R3-L0-63 STEAM GEN. STUDY - LOCA

FIGURE 18

QUALITY BEHAVIOR BETWEEN THE HOT AND COLD SIDE OF THE TUBES
OF THE LOFT STEAM GENERATOR FOR LOCA WITH ECC

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FIGURE 19

QUALITY BEHAVIOR BETWEEN THE TUBES AND THE OUTLET PLENUM OF THE
LOFT STEAM GENERATOR FOR LOCA WITH ECC

QUALITY J20

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Appendix C

FIGURE 20

PRESSURE HISTORY IN THE INLET PLENUM OF THE LOFT
STEAM GENERATOR FOR LOCE WITH ECC

FIGURE 21

PRESSURE HISTORY FOR THE HOT SIDE TUBES OF THE LOFT
STEAM GENERATOR FOR LOCE WITH ECC

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FIGURE 22

PRESSURE HISTORY FOR THE COLD SIDE TUBES OF THE LOFT
STEAM GENERATOR FOR LOCE WITH ECC

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Appendix C

AVG PRESS PSIA V17

FIGURE 23

PRESSURE HISTORY IN THE OUTLET PLENUM OF THE LOFT
STEAM GENERATOR FOR LOCE WITH ECC LTR 1141-33
Appendix C

FIGURE 24

TEMPERATURE HISTORY FOR THE INLET PLENUM OF THE LOFT
STEAM GENERATOR FOR LOCE WITH ECC

FIGURE 25

TEMPERATURE HISTORY FOR THE HOT SIDE TUBES OF THE LOFT
STEAM GENERATOR FOR LOCE WITH ECC

WATER TEMP F V15

LTR 1141-33
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FIGURE 26

TEMPERATURE HISTORY FOR THE COLD SIDE TUBES OF THE
STEAM GENERATOR FOR LOCE WITH ECC

FIGURE 27

TEMPERATURE HISTORY IN THE OUTLET PLENUM OF THE LOFT
STEAM GENERATOR FOR LOCE WITH ECC

LTR 1141-33
Appendix C

FIGURE 28

FLOW HISTORY FOR THE INLET NOZZLE OF THE LOFT STEAM
GENERATOR FOR LOCE WITH ECC

FIGURE 29

FLOW HISTORY FOR THE OUTLET NOZZLE OF THE LOFT
STEAM GENERATOR FOR LOCE WITH ECC

LTR 1141-33
Appendix C

R3-LOFT STEAM GEN. STUDY-RERUN OF LO-34 WITH CORRECTED INPUT

LO-61

1000

FIGURE 30

FLOW HISTORY BETWEEN THE INLET PLENUM AND THE TUBES OF
THE LOFT STEAM GENERATOR FOR LOCE AND ECC

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Appendix C

R3-LOFT STEAM GEN. STUDY-RERUN OF LO-34 WITH CORRECTED INPUT

LO-61

1000

FIGURE 32

FLOW HISTORY BETWEEN THE TUBES AND THE OUTLET PLENUM
OF THE LOFT STEAM GENERATOR FOR LOCE WITH ECC

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Appendix C

FIGURE 33

QUALITY BEHAVIOR AT THE INLET NOZZLE OF THE LOFT
STEAM GENERATOR FOR LOCE WITH ECC

LTR 1141-33
Appendix C

R3-LOFT STEAM GEN. STUDY-RERUN OF LO-34 WITH CORRECTED INPUT

LO-61

1000

FIGURE 34

QUALITY BEHAVIOR AT THE OUTLET NOZZLE OF THE LOFT
STEAM GENERATOR FOR LOCE WITH ECC

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FIGURE 35

QUALITY BEHAVIOR BETWEEN THE INLET PLENUM AND THE TUBES
OF THE LOFT STEAM GENERATOR FOR LOCE WITH ECC

QUALITY
140
117
118

TIME SEC

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Appendix C

FIGURE 36

QUALITY BEHAVIOR BETWEEN THE HOT AND COLD SIDES OF THE TUBES OF THE
LOFT STEAM GENERATOR FOR LOCE WITH ECC

FIGURE 37

QUALITY BEHAVIOR BETWEEN THE TUBES AND THE OUTLET PLENUM
OF THE LOFT STEAM GENERATOR FOR LOCE WITH ECC

QUALITY J20
142

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COMPUTER SCIENCE CENTER

FLOW-CHARTING WORK SHEET

Calculation of LOFT Blowdown Nozzle Area Ratios	Effective Date 9/23/70	Revision Date	Page 1
	System I.D.	Program I.D.	Programmer D. Solberg

1. Purpose

Determine the break area ratio to be used for the orifices in the LOFT blowdown legs that will model an offset shear of the hot leg piping in the Davis-Besse plant.

2. Method

Obtain mass flow rates at the reactor vessel nozzles on the ruptured loop of the Davis-Besse plant for the LOCA described in 1. In the initial portion of the blowdown (before quality at the nozzles becomes significant and before flashing of fluid in the steam generator becomes significant) determine the ratio of mass flow rate which occurs at the vessel nozzles. To model the blowdown in LOFT, it is required that the ratio of hot and cold nozzle flows for the blowdown loop in LOFT be the same as those occurring in Davis Besse. The orifice areas required in the LOFT blowdown legs are determined as that area ratio which, under choked flow conditions for the steady state coolant temperatures existing at the nozzles, provides the necessary flow ratio and provides a total orifice area such that the total break area to coolant volume in Davis-Besse and LOFT are the same. Choked flow analyses are based on the Moody Tables and an assumed back pressure (primary system pressure) of 1600 psia.

COMPUTER SCIENCE CENTER

FLOW-CHARTING WORK SHEET

Calculation of 40FT Blowdown Nozzle
Area Ratios, cont.Effective Date
9/23/70

Revision Date

Page 2

System I.D.

Program I.D.

Programmer

D. Solberg

3. Calculations

The analyses, initially performed on July 6, 1970 for these computer runs, are presented below.

- a. Davis-Besse data for the period of $0.55 \text{ sec.} < t < 2.2 \text{ sec.}$ for Run # DB-7 indicated the vessel nozzle flow ratios were

$$\frac{m(\text{hot nozzle})}{m(\text{cold nozzle})} = 2.4$$

(note: $m(\text{cold nozzle})$ is the summed mass flow rates of the two cold leg pipes on the Davis-Besse ruptured loop)

- b. The following critical flow data was obtained from the Moody Tables (WAPD-TM-534) for the assumed 40FT coolant conditions

Temp., °F	Enthalpy, Btu/lb	G _{crit} , lbm/ft ² sec
610	631.8	9400
577	584	11,900

- c. A break area correction factor (ie. area ratio which would provide the same mass flow rate at each junction) is calculated as

$$f = \frac{A_{\text{inlet}}}{A_{\text{outlet}}} = \frac{9400}{11,900} = .79$$

- d. Area ratio is calculated as

$$\frac{A_{\text{hot leg}}}{A_{\text{cold leg}}} = \frac{m(\text{hot nozzle})}{m(\text{cold nozzle})} \cdot \frac{1}{f} = \frac{2.4}{.79} = 3.0$$

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FLOW-CHARTING WORK SHEET

Calculation of LOFT Blowdown Nozzle Ratios, cont.	Effective Date 9/23/70	Revision Date	Page 3
	System I.D.	Program I.D.	Programmer D Solberg

e. Davis-Besse Data

Area of offset shear of hot leg piping = 14.12 ft^2 Total volume of Primary Coolant System = $12,140 \text{ ft}^3$

$$\frac{\text{Area}}{\text{Volume}} \bigg|_{D/B} = \frac{14.12}{12,140} = 1.16 \times 10^{-3} \text{ ft}^{-1}$$

f. LOFT Driftage Calculation

Total break area required:

$$\begin{aligned} \text{Area} &= \text{LOFT Vol.} \times \frac{\text{Area}}{\text{Volume}} \bigg|_{D/B} \\ &= 282 \text{ ft}^3 \times 1.16 \times 10^{-3} \text{ ft}^{-1} = 0.33 \text{ ft}^2 \end{aligned}$$

$$A_{\text{Hot leg}} = .08 \text{ ft}^2$$

$$A_{\text{Cold leg}} = .25 \text{ ft}^2$$

IDAHO NUCLEAR CORPORATION

INTEROFFICE CORRESPONDENCE

October 8, 1970

Transmittal of
 Blowdown Analysis on
LOFT Steam Generator
 Cond-12-70

Mr. D. R. Heinicke
 TAN-602

- References: [1] S. Fabric, Computer Program WHAM for Calculation of Pressure, Velocity, and Force Transients in Liquid Filled Piping Networks, Kaiser Engineers Report No. 67-49-R (November 1967).
- [2] Letter, J. C. Nichols, MPR Associates, to H. L. Coplen, INC, "LOFT Project - Steam Generator Conceptual Design With Removable Steam Drum" (July 1, 1970).

Transmitted herewith are sixteen pressure vs. time curves for the inlet and outlet plenums of the LOFT steam generator as predicted by the WHAM^[1] water hammer computer code for four subcooled blowdown cases.

The curves are identified by case number and leg number as follows; where a 100% blowdown refers to each break opening equal to the area of the LOFT blowdown piping.

- Case 1 - 100% blowdown from both hot and cold legs of reactor, simultaneously.
- Case 2 - 100% blowdown from reactor cold (inlet) leg.
- Case 3 - 100% blowdown from reactor hot (outlet) leg.
- Case 4 - 100% double ended break in the primary piping immediately adjacent to the outlet nozzle of the steam generator (LOCA).
- Leg #68 Lower - Inlet plenum inlet.
- Leg #68 Upper - Top of inlet plenum adjacent to tube sheet.
- Leg #84 Lower - Top of outlet plenum adjacent to tube sheet.
- Leg #84 Upper - Outlet plenum outlet (location of break for Case 4).

The model of the steam generator was formulated from design information available as of July 1, 1970^[2]. Additional documentation of the WHAM model will be available in an Engineering "A" Report to be published by the Applied Structural Mechanics Section at a later date.

It must be noted that once the pressure in a leg drops below the saturation pressure (1661 psia in this analysis) the results shown are no longer valid and should be ignored.

KGC:ka

K. G. Condie

K. G. Condie

Attachments

cc: w/Attachments

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