B.1 LER No. 244/82-003 and -005

Event Description: Steam Generator Tube Rupture with One PORV Failed Open

Date of Event: January 25, 1982

Plant: Ginna

B.1.1 Summary

On January 25, 1982, while operating at 100% power, the Ginna B steam generator experienced a tube rupture. The resulting plant transient included significant primary system depressurization, actuation of the safety injection system and minor releases of radioactive materials from the plant. During the transient, a pressurizer power-operated relief valve (PORV) failed to close after being used to reduce primary and secondary pressure below the steam generator safety valve setting. The estimated conditional core damage probability for this event is 3.8×10^{-4}.

B.1.2 Event Description

On January 25, 1982, at 0925, while the plant was operating at 100% power, a tube rupture occurred in steam generator B. Multiple control room alarms alerted the operators to a reactor coolant system (RCS) rapid depressurization. The air ejector radiation monitor alarm indicated that the rupture was likely in steam generator B. The continuing pressure drop resulted in an automatic reactor trip and an automatic safety injection actuation. All three high-pressure injection (HPI) pumps started. The safety injection actuation resulted in an automatic containment isolation and trip of the operating charging pumps. All safety systems functioned properly. Both reactor coolant pumps were manually stopped, and natural circulation cooling in the RCS was verified. The pressurizer emptied, and the RCS depressurization reached a minimum of 1200 psig. A small steam bubble formed during natural circulation in the upper head, but was collapsed when safety injection flow refilled the RCS.

Initially, operators cooled down the reactor by steaming both steam generators to the main condenser. The B steam generator was isolated at 0940, and natural circulation cooling in loop B was terminated. The B steam generator water level continued to rise in spite of the termination of feedwater flow to the steam generator, due to flow through the ruptured tube. At 0955, the narrow-range water level indicator on B steam generator went off scale high, and subsequently the B main steam line started to fill.

At 0957, the safety injection actuation circuitry was reset, thus resetting the containment isolation system. Instrument air, and thus control of the air-operated valves inside containment, was restored.

At 1007, operators attempted to equalize the pressure differential between the RCS and the secondary side of the B steam generator to stop flow through the tube rupture. A pressurizer PORV was cycled three times before it stuck open. The operator attempted to close the valve, but the valve would not close. The operator then closed the block valve to prevent further RCS water loss. Steam bubbles in the reactor vessel upper head and in the top of the B steam generator tubes occurred as well. The growth of the bubbles and increased safety injection

flow resulted in the rapid filling of the pressurizer. Loop A natural circulation was not affected by the steam bubbles.

One of the B steam generator safety valves cycled three times as a result of the overpressurization caused by continued flow through the ruptured tube (apparently caused by the inappropriate isolation of the B steam generator atmospheric dump valves). At 1038, safety injection was terminated to prevent further water discharge through the safety valve. At 1040, the condensate system was secured to prevent further radioactive contamination of the condensate storage tanks and demineralizers. The operators used the steam generator (SG) PORV to relieve steam from the A steam generator.

At 1042, the pressurizer heaters were reenergized (after having tripped at 0928 on low pressurizer level) to re-establish a steam bubble in the pressurizer. At 1052, the rupture disk on the pressurizer relief tank burst due to the addition of water from the letdown line relief valve, the pressurizer PORV, and the relief valve for the reactor coolant pump (RCP) seal return line.

At 1107, one safety injection pump was started in anticipation of an RCS pressure drop due to the restart of the A RCP. At 1119, the B steam generator safety valve lifted and closed. At this time, the B steam line had flooded sufficiently to cause water, rather than steam, to be released. At 1121, the A RCP was started. The RCP flow cooled and collapsed any remaining steam bubbles in the reactor upper vessel head and the B steam generator. This addition of flow led to another cycle of the B steam generator safety valve. Safety injection was stopped, but the valve continued to leak water at approximately 100 gpm.

At 1152, the pressurizer level returned on scale, and a steam bubble was re-established. At 1202, normal letdown from the RCS to the chemical and volume control system was re-established. Due to the B steam generator safety valve leak, the RCS continued to leak through the tube rupture in steam generator B. Operators re-started one safety injection pump at 1212 in response to the continued decrease in pressurizer level. The pump was intermittently operated until 1235. The safety relief valve on steam generator B stopped leaking at approximately 1225.

At 1227, the RCS and B steam generator pressures equalized. RCS pressure was maintained at 25 psia below steam generator B pressure. At 1840, B steam generator water level returned on scale. Secondary side feed and bleed was then used to cool steam generator B.

At 0700, on January 26, 1982, the residual heat removal system was placed in operation, and the plant was declared to be in cold shutdown.

B.1.3 Additional Event-Related Information

The ruptured B steam generator tube was located at row 42, column 55 on the hot-leg side of the steam generator. The rupture was approximately 4 inches long and 0.7 inch wide at its center. The rupture was fish-mouth shaped, and pointed outward along the tube column. The tube appeared ballooned at the rupture location, and had a wall thickness of less than 5% of the nominal thickness. Markings on the exterior of the tube had the appearance of fretting wear. Damage to sixteen additional tubes that had been plugged in steam generator B was identified. Foreign objects and tube fragments were found in the steam generator. An examination of steam generator A revealed the existence of some small foreign objects as well. The most probable cause of damage to steam generator B was a piece of metal that was left inside during a 1975 repair when a large ring was

removed to increase the efficiency of the recirculation flow. The ring was cut into pieces to be removed, but one piece was left inside.

Additional information on this event is included in the *Report to Congress on Abnormal Occurrences, January - March 1982*, NUREG-0090, Vol. 5, No. 1.

B.1.4 Modeling Assumptions

This event was modeled as a steam generator tube rupture initiating event. Since a second pressurizer PORV was available and the leaking valve could have been used for depressurization during this event by opening its block valve, the model was not revised to reflect the stuck-open pressurizer PORV. The potential for the steam generator relief valve that leaked during the event to have stuck open was addressed by revising the failure probability for SG.ISO.AND.RCS.COOLDOWN to 0.1, a typical failure probability for a relief valve, once it has passed water.

B.1.5 Analysis Results

The estimated conditional core damage probability for this event is 3.8×10^{-4}. The dominant sequence, highlighted on the event tree in Figure B.1.1, involved the successful operation of auxiliary feedwater and the failure of high-pressure injection.

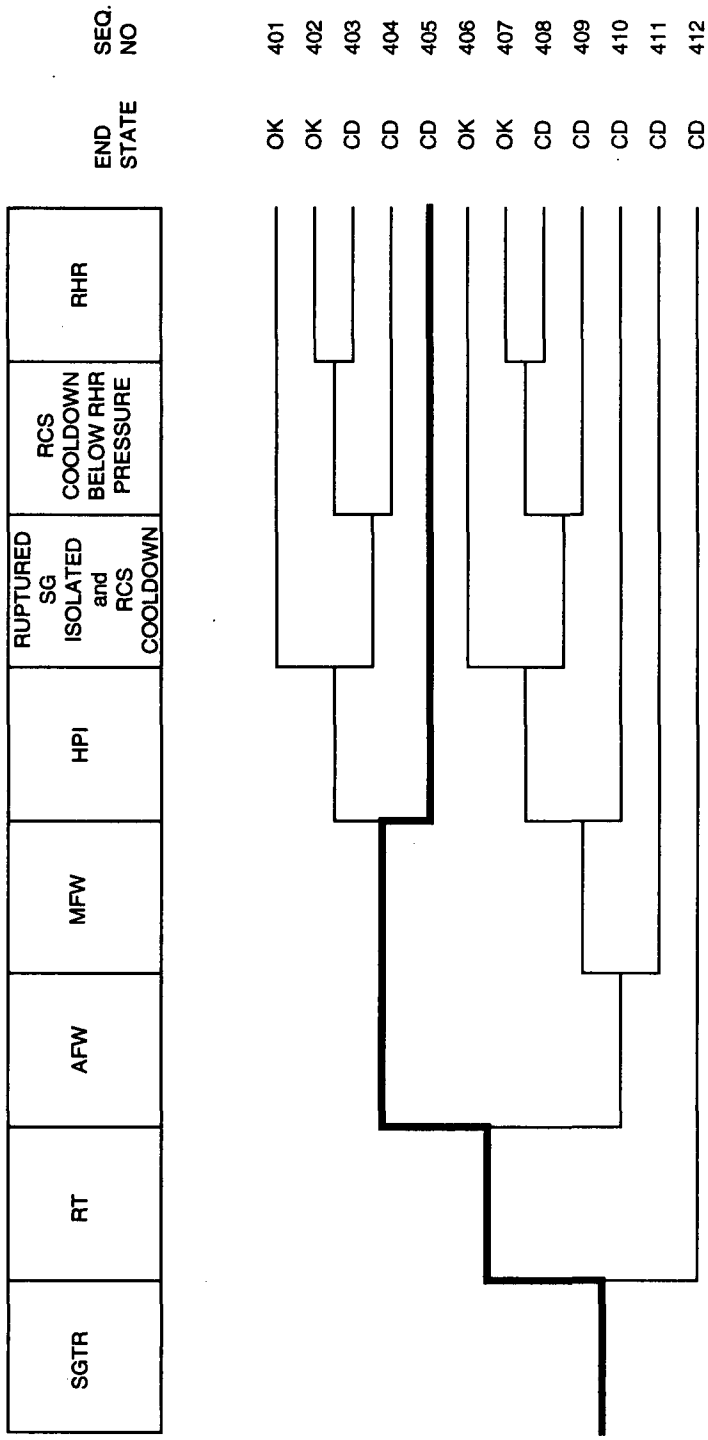

Figure B.1.1 Dominant core damage sequence for LER 244/82-003 and -005

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 244/82-003 and -005
Event Description: Steam Generator Tube Rupture
Event Date: January 25, 1982
Plant: Ginna

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

SGTR	1.0E+00

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
SGTR	3.8E-04
Total	3.8E-04

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
405	sgtr -rt -afw hpi	CD	2.7E-04	8.9E-01
404	sgtr -rt -afw -hpi SG.ISO.AND.RCS.COOLDOWN rcs.cool.below.rhr	CD	6.0E-05	1.0E-01
412	sgtr rt	CD	2.8E-05	1.0E-01
403	sgtr -rt -afw -hpi SG.ISO.AND.RCS.COOLDOWN -rcs.cool.below.rhr rhr	CD	2.2E-05	5.7E-03

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
403	sgtr -rt -afw -hpi SG.ISO.AND.RCS.COOLDOWN -rcs.cool.below.rhr rhr	CD	2.2E-05	5.7E-03
404	sgtr -rt -afw -hpi SG.ISO.AND.RCS.COOLDOWN rcs.cool.below.rhr	CD	6.0E-05	1.0E-01
405	sgtr -rt -afw hpi	CD	2.7E-04	8.9E-01
412	sgtr rt	CD	2.8E-05	1.0E-01

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1982-83\pwrb8283.cmp
BRANCH MODEL: c:\asp\1982-83\ginna.82
PROBABILITY FILE: c:\asp\1982-83\pwr8283.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail

trans	2.6E-04	1.0E+00	
loop	1.6E-05	3.6E-01	
loca	2.4E-06	5.4E-01	
sgtr	1.6E-06	1.0E+00	
rt	2.8E-04	1.0E-01	
rt(loop)	0.0E+00	1.0E+00	
afw	1.6E-05	4.5E-01	
afw/atws	4.3E-03	1.0E+00	
afw/ep	5.0E-02	3.4E-01	
mfw	1.9E-01	3.4E-01	1.0E-03
porv.chall	4.0E-02	1.0E+00	
porv.chall/afw	1.0E+00	1.0E+00	
porv.chall/loop	1.0E-01	1.0E+00	
porv.chall/sbo	1.0E+00	1.0E+00	
porv.reseat	2.0E-02	1.1E-02	
porv.reseat/ep	2.0E-02	1.0E+00	
srv.reseat(atws)	1.0E-01	1.0E+00	
hpi	3.0E-04	8.9E-01	
feed.bleed	2.0E-02	1.0E+00	1.0E-02
emrg.boration	0.0E+00	1.0E+00	1.0E-02
recov.sec.cool	2.0E-01	1.0E+00	
recov.sec.cool/offsite.pwr	3.4E-01	1.0E+00	
rcs.cooldown	3.0E-03	1.0E+00	1.0E-03
rhr	2.2E-02	5.7E-02	1.0E-03
rhr.and.hpr	1.0E-03	1.0E+00	1.0E-03
hpr	4.0E-03	1.0E+00	1.0E-03
ep	2.9E-03	8.9E-01	
seal.loca	2.3E-01	1.0E+00	
offsite.pwr.rec/-ep.and.-afw	2.1E-01	1.0E+00	
offsite.pwr.rec/-ep.and.afw	9.9E-02	1.0E+00	
offsite.pwr.rec/seal.loca	6.0E-01	1.0E+00	
offsite.pwr.rec/-seal.loca	8.2E-03	1.0E+00	
SG.ISO.AND.RCS.COOLDOWN	1.0E-02 > 1.0E-01	1.0E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	1.0E-02 > 1.0E-01		
rcs.cool.below.rhr	3.0E-03	1.0E+00	3.0E-03
prim.press.limited	8.8E-03	1.0E+00	

* branch model file
** forced