

## A.3 LER No. 289/93-002

Event Description: Both Residual Heat Removal Heat Exchangers Unavailable

Date of Event: January 29, 1993

Plant: Three Mile Island 1

### A.3.1 Summary

Three Mile Island 1 (TMI-1) was operating at 100% power on January 29, 1993, when an operator aligned river water system valves to bypass both decay heat service (DHS) coolers. The coolers remained unavailable for about 3 h. With the DHS coolers unavailable, it would not have been possible to remove heat from several safety-related systems had they been demanded. The conditional core damage probability estimated for this event is  $3.1 \times 10^{-6}$ . The relative significance of this event compared to other postulated events at Three Mile Island 1 is shown in Fig. A.3.1.

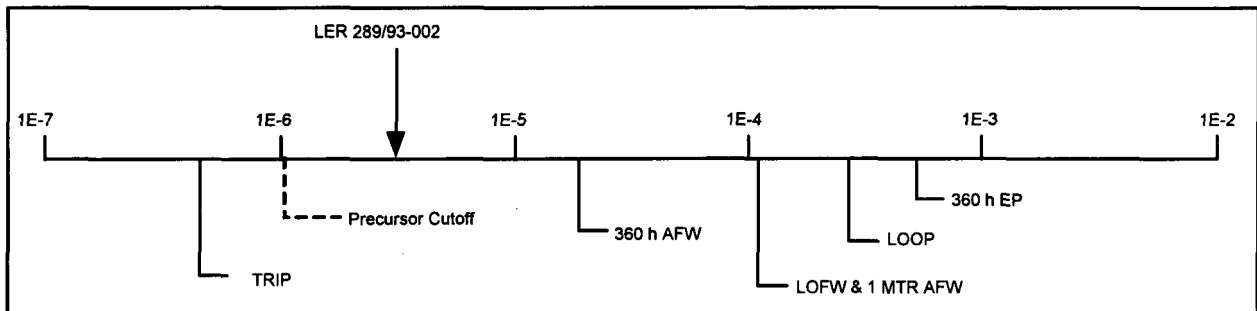


Fig. A.3.1 Relative event significance of LER 289/93-002 compared with other potential events at Three Mile Island 1

### A.3.2 Event Description

During execution of a surveillance instruction involving operation of decay heat river water (DHRW) pumps, an auxiliary operator simultaneously bypassed DHS coolers DC-C-2A and DC-C-2B. The DHS coolers serve as the heat sink for the decay heat closed cooling water (DCCW) system. Loads on the DCCW system include decay heat removal (DHR) coolers, DHR pump motor and bearing coolers, DCCW pump bearing coolers, reactor building spray (BS) pump motor and bearing coolers, and two of three makeup [charging/high-pressure injection (HPI)] pump motor, bearing, and gear reducer coolers.

After ~2.5 h, a control room operator discovered the error while evaluating the steps taken for the surveillance instruction. The DHS coolers were returned to service ~0.5 h later.

In the LER, the licensee discussed the potential plant response to a large-break loss-of-coolant accident (LOCA) with the DHS coolers isolated. They concluded that core and containment response would be unaffected before sump recirculation. Following initiation of sump recirculation, DHR would be provided by the reactor building emergency cooling fan coolers in conjunction with the recirculation flow from the low-pressure injection (LPI) and reactor BS pumps. They also concluded, based on the licensee's engineering judgement, that at least 30 min was available to restore cooling to the LPI and spray pumps. The impact of the isolated DHS coolers on sump recirculation following a small-break LOCA was not discussed in the LER.

### A.3.3 Modeling Assumptions

In the sump-recirculation phase following a small-break LOCA, flow from the discharge of the DHR coolers is directed to the suction of the makeup HPI pumps to provide adequate net positive suction head for HPI pump operation. This water is cooled to prevent damaging the makeup pumps (the TMI-1 final safety analysis report indicates that the design temperature of the makeup pumps is 200°F). With the DHS coolers isolated, makeup and LPI pump cooling water temperatures would exceed design temperatures during sump recirculation following a small-break LOCA, resulting in failure of high-pressure recirculation (HPR). The time to pump failure cannot be accurately estimated based on available data, although it may be as long as several hours.

The event was modeled as a 3-h unavailability of HPR. Because of the uncertainty in the available time before pump damage and the potential radiological conditions at the closed valves following initiation of HPR, recovery of the isolated DHS coolers (through operation of the two 18-in. manual valves in each train) was assumed not to be possible in the analysis. The low temperature of the borated water storage tank (BWST) fluid before sump recirculation was assumed not to impact HPI pump operation in the injection phase.

### A.3.4 Analysis Results

The conditional core damage probability estimated for this event is  $3.1 \times 10^{-6}$ . The dominant sequence, highlighted on the event tree in Fig. A.3.3, involves a postulated small-break LOCA, success of reactor trip, auxiliary feedwater, and HPI functions followed by failure of HPR.

The core damage probability estimated for this event is strongly influenced by the probability of not recovering the DHR service coolers used in the analysis. For example, if a nonrecovery probability of 0.34 (ASP Recovery Class R2, the failure appeared recoverable in the required period at the failed equipment, and the equipment was accessible; recovery from the central room did not appear possible) is assumed, the conditional core damage probability is reduced to  $1.1 \times 10^{-6}$ .

# A.3-3

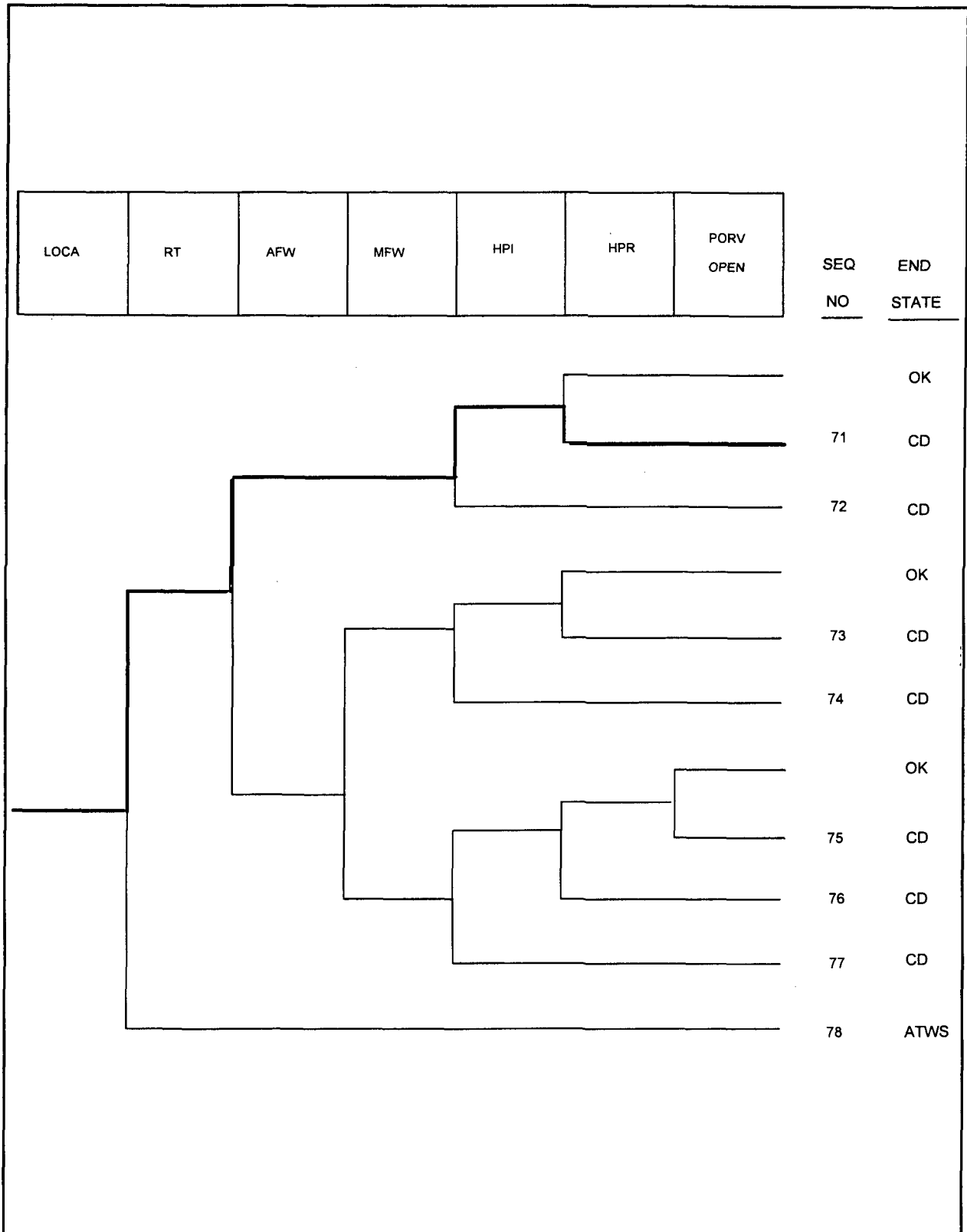


Fig. A.3.2 Dominant core damage sequence for LER 289/93-002

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**CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS**


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Event Identifier: 289/93-002  
 Event Description: Both RHR heat exchangers unavailable  
 Event Date: January 29, 1993  
 Plant: Three Mile Island 1

UNAVAILABILITY, DURATION= 3

**NONRECOVERABLE INITIATING EVENT PROBABILITIES**

TRANS	3.9E-04
LOOP	2.6E-05
LOCA	3.1E-06

**SEQUENCE CONDITIONAL PROBABILITY SUMS**

End State/Initiator	Probability
CD	
TRANS	1.9E-08
LOOP	1.7E-08
LOCA	3.1E-06
Total	3.1E-06
ATWS	
TRANS	0.0E+00
LOOP	0.0E+00
LOCA	0.0E+00
Total	0.0E+00

**SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)**

Sequence	End State	Prob	N Rec**
71 loca -rt -afw -hpi HPR/-HPI	CD	3.1E-06	4.3E-01
16 trans -rt afw mfw -hpi(f/b) HPR/-HPI	CD	1.5E-08	8.8E-02
44 loop -rt/loop -emerg.power afw -hpi(f/b) HPR/-HPI	CD	1.5E-08	1.4E-01
11 trans -rt -afw porv.or.srv.chall porv.or.srv.reseat -hpi HPR/-HPI	CD	3.4E-09	1.1E-02
73 loca -rt afw -mfw -hpi HPR/-HPI	CD	1.7E-09	1.1E-01
51 loop -rt/loop emerg.power -afw/emerg.power -porv.or.srv.chall seal.loc -ep.rec(sl) -hpi HPR/-HPI	CD	1.1E-09	4.2E-01
41 loop -rt/loop -emerg.power -afw porv.or.srv.chall porv.or.srv.reseat -hpi HPR/-HPI	CD	2.3E-10	5.8E-03
76 loca -rt afw mfw -hpi HPR/-HPI	CD	1.2E-10	3.8E-02
46 loop -rt/loop emerg.power -afw/emerg.power power.or.srv.chall porv.or.srv.reseat/emerg.power seal.loc -ep.rec(sl) -hpi HPR/-HPI	CD	9.1E-11	4.2E-01
13 trans -rt afw -mfw porv.or.srv.chall porv.or.srv.reseat-hpi HPR/-HPI	CD	1.9E-12	2.7E-03

**SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)**

Sequence	End State	Prob	N Rec**
11 trans -rt -afw porv.or.srv.chall porv.or.srv.reseat -hpi HPR/-HPI	CD	3.4E-09	1.1E-02
13 trans -rt afw -mfw porv.or.srv.chall porv.or.srv.reseat -hpi HPR/-HPI	CD	1.9E-12	2.7E-03
16 trans -rt afw mfw -hpi(f/b) HPR/-HPI	CD	1.5E-08	8.8E-02
41 loop -rt/loop -emerg.power -afw porv.or.srv.chall porv.or.srv.reseat -hpi HPR/-HPI	CD	2.3E-10	5.8E-03
44 loop -rt/loop -emerg.power afw -hpi(f/b) HPR/-HPI	CD	1.5E-08	1.4E-01
46 loop -rt/loop emerg.power -afw/emerg.power porv.or.srv.chall -porv.or.srv.reseat/emerg.power seal.loc -ep.rec(sl) -hpi HPR/-HPI	CD	9.1E-11	4.2E-01
51 loop -rt/loop emerg.power -afw/emerg.power -porv.or.srv.chall seal.loc -ep.rec(sl) -hpi HPR/-HPI	CD	1.1E-09	4.2E-01
71 loca -rt -afw -hpi HPR/-HPI	CD	3.1E-06	4.3E-01
73 loca -rt afw -mfw -hpi HPR/-HPI	CD	1.7E-09	1.1E-01

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76	loca -rt afw mfw -hpi HPR/-HPI	CD	1.2E-10	3.8E-02
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\*\* nonrecovery credit for edited case

Note: For unavailabilities, conditional probability values are differential values which reflect the added risk due to failures associated with an event. Parenthetical values indicate a reduction in risk compared to a similar period without the existing failures.

SEQUENCE MODEL: s:\asp\prog\models\pwrdsal.cmp  
 BRANCH MODEL: s:\asp\prog\models\tmi1.sl1  
 PROBABILITY FILE: s:\asp\prog\models\pwr\_bsl1.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Nonrecov	Opr Fail
trans	1.3E-04	1.0E+00	
loop	1.6E-05	5.3E-01	
loca	2.4E-06	4.3E-01	
rt	2.8E-04	1.2E-01	
rt/loop	0.0E+00	1.0E+00	
emerg.power	2.9E-03	8.0E-01	
afw	2.3E-03	2.6E-01	
afw/emerg.power	5.0E-02	3.4E-01	
mfw	2.0E-01	3.4E-01	
porv.or.srv.chall	8.0E-02	1.0E+00	
porv.or.srv.reseat	1.0E-02	1.1E-02	
porv.or.srv.reseat/emerg.power	1.0E-02	1.0E+00	
seal.loca	4.6E-02	1.0E+00	
ep.rec(sl)	5.7E-01	1.0E+00	
ep.rec	1.6E-01	1.0E+00	
hpi	1.0E-03	8.4E-01	
hpi(f/b)	1.0E-03	8.4E-01	1.0E-02
HPR/-HPI	1.5E-04 > 1.0E+00 **	1.0E+00	1.0E-03
Branch Model: 1.0F.2+opr			
Train 1 Cond Prob:			
Train 2 Cond Prob:			
* branch model file			
** forced			