# Accident Sequence Precursor Program Event Analysis

LER No: 346/88-007 R1 Event Description: Component cooling values drift closed on loss of air Date of Event: March 4, 1988 Plant: Davis Besse

### Summary

During maintenance, it was discovered that a prolonged loss of instrument air would cause three service water valves to close. This closure results in isolation of service water to the component cooling water heat exchangers, which faults the heat removal capability of this system. This event has been modeled as a potential unavailability of CCW during a long-term loss of instrument air. The conditional probability of core damage associated with the event is estimated to be  $1.6 \times 10^{-6}$ . The relative significance of this event compared with other potential events at Davis Besse is shown below.



### Event Description

During troubleshooting, operations personnel isolated instrument air from service water air-operated valve SW1434 (service water heat exchanger temperature control valve) with the understanding that the valve would remain in its fail-safe full open position. Approximately 1.5 h after the valve was isolated from instrument air, a control room alarm indicated that the valve was not fully open. The valve drifted closed due to air leakage of its accumulator system. Further investigation revealed five other valves with similar problems. The valves were the temperature control valves (SW1424 and SW1429) for the other two component cooling water heat exchangers, the temperature control valves

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(CC1467 and CC1469) for the decay heat removal heat exchangers, and the component cooling nonessential header isolation valve CC 1495.

Upon discovery of the potential failure mode of valves CC1467 and CC1469, valve CC1469 was placed in the open position by engaging its manual operator. There was, however, no corrective action immediately identified for the remaining valves. Long-term corrective action was identified to modify the valves' actuator design and implement the modifications during the sixth refueling outage.

## Event-Related Plant Design Information

The air-operated values impacted by this event utilize two safety-grade accumulators as a backup pneumatic supply source. One accumulator allows the value to open on demand by providing pressurized air to the bottom of the value's actuator piston, forcing the value open as air is vented from above the piston. Similarly, when closing the value, the other accumulator provides pressurized air to the top of the value's actuator piston, forcing the value to close as air is vented from below the piston.

Valves SW1424, SW1429, and SW1434 are the service water heat exchanger temperature control valves to the respective E22-1, E22-2, and E22-3 component cooling water heat exchangers. The component cooling water loops serviced by these heat exchangers provide cooling to many components, some of which are shown below:

(1) the high-pressure-injection-bearing oil coolers

(2) the decay-heat-pump-bearing housing coolers

(3) the emergency diesel generator jacket heat exchangers

(4) the make-up pump gear and pump lube oil coolers

- (5) the seal return coolers
- (6) the letdown coolers
- (7) the control rod drive coolers

If the three values close, component cooling water will be able to circulate; however, heat removal capability for the system would be lost and would eventually render the above components inoperable if not corrected.

Valves CC1467 and CC1469 are the temperature control valves for the respective E27-1 and E27-2 decay heat removal heat exchangers. Closure of these valves would render both trains of decay heat removal inoperable. However, closure of the CCW heat exchanger valves results in the same impact.

## ASP Modeling Assumptions and Approach

This event has been modeled a long-term unavailability of instrument air. Loss of instrument air results in a loss of feedwater due to unavailability of air to the feedwater control valves. The frequency of loss of instrument air was assumed to be 0.01/yr (this is consistent with valves assumed in plant-specific PRAs). The probability of not recovering instrument air prior to depletion of the individual valve accumulators at ~1.5 h was assumed to be 0.34. In addition, operator action to restore service water to the heat exchangers [p(nonrecovery) = 0.34] has been included in the analysis.

# Analysis Results

The core damage frequency estimated for the event is  $1.6 \times 10^{-6}$ . This value was developed from the probability of loss of instrument air over a 1-year period (p = 0.01), failure to recover instrument air before 1.5 h (p = 0.34), failure to recover CCW once the valves have closed on loss of instrument air (p = 0.34, included in transient calculation), and p(core damage | LOFW and loss of HPI, feed and bleed, and HPR). The dominant sequence (highlighted on the following event tree) involves loss of secondary-side cooling and failure of feed and bleed. Note that this assessment may be conservative in that relaxed system success criteria resulting from 1.5 h of successful decay heat removal has not been factored into the analysis.



Dominant Core Damage Sequence for LER 346/88-007 R1

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

| Event  | Identifier:  | 346/88-007 |         |        |       |       |    |      |    |     |
|--------|--------------|------------|---------|--------|-------|-------|----|------|----|-----|
| Event  | Description: | Component  | cooling | valves | drift | close | on | loss | of | air |
| Event  | Date:        | 03/04/88   |         |        |       |       |    |      |    |     |
| Plant; |              | Davis-Bess | e       |        |       |       |    |      |    |     |

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

| TRAN | 15                                 | 3.4E-01     |
|------|------------------------------------|-------------|
| SEQU | JENCE CONDITIONAL PROBABILITY SUMS |             |
|      | End State/Initiator                | Probability |
| CD   |                                    |             |
|      | TRANS                              | 4.6E-04     |
|      | Total                              | 4.6E-04     |
| ATWS |                                    |             |
|      | TRANS                              | 1.1E-05     |
|      | Total                              | 1.1E-05     |

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

|       |              |           | Sequence    | End State | Prob    | N Rec** |
|-------|--------------|-----------|-------------|-----------|---------|---------|
| 17    | TRANS -rt    | afw MFW   | HPI(F/B)    | CD        | 4.6E-04 | 9.2E-02 |
| 18    | TRANS rt     |           |             | ATWS      | 1.1E-05 | 4.1E-02 |
| ** no | n-recovery c | redit for | edited case |           |         |         |

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

|    |                   | Sequence   | End State | Prob    | N Rec** |
|----|-------------------|------------|-----------|---------|---------|
| 17 | TRANS -rt afw MFN | N HPI(F/B) | CD        | 4.6E-04 | 9.2E-02 |
| 18 | TRANS rt          |            | ATWS      | 1.1E-05 | 4.1E-02 |

\*\* non-recovery credit for edited case

| SEQUENCE MODEL:   | c:\asp\sealmod\pwrbseal.cmp |
|-------------------|-----------------------------|
| BRANCH MODEL:     | c:\asp\sealmod\davis.sll    |
| PROBABILITY FILE: | c:\asp\sealmod\pwr bsl1.pro |

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

| Branch               | System                | Non-Recov         | Opr Fail |
|----------------------|-----------------------|-------------------|----------|
| TRANS                | 6.3E-04 > 1.0E+00     | 1.0E+00 > 3.4E-01 |          |
| Branch Model: INITOR |                       |                   |          |
| Initiator Freq:      | 6.3E - 04 > 1.0E + 00 |                   |          |
| loop                 | 1.6E-05               | 2.4E-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                  | 5.0E-03               | 2.7E-01           |          |
| afw/emerg.power      | 5.0E-03               | 2.7E-01           |          |
| MFW                  | 2.0E-01 > 1.0E+00     | 3.4E-01 > 1.0E+00 |          |
| Branch Model: 1.OF.1 |                       |                   |          |
| Train 1 Cond Prob:   | 2.0E-01 > Unavailable |                   |          |

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| 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                      | 0.0E+00               | 1.0E+00           |         |
| ep.rec(sl)                     | 0.0E+00               | 1.0E+00           |         |
| ep.rec                         | 4.5E-01               | 1.0E+00           |         |
| HPI                            | 1.0E-03 > 1.0E+00     | 8.4E-01 > 1.0E+00 |         |
| Branch Model: 1.0F.2           |                       |                   |         |
| Train 1 Cond Prob:             | 1.0E-02 > Unavailable |                   |         |
| Train 2 Cond Prob:             | 1.0E-01 > Unavailable |                   |         |
| HPI(F/B)                       | 1.0E~03 > 1.0E+00     | 8.4E-01 > 1.0E+00 | 1.0E-02 |
| Branch Model: 1.OF.2+opr       |                       |                   |         |
| Train 1 Cond Prob:             | 1.0E-02 > Unavailable | •                 |         |
| Train 2 Cond Prob:             | 1.0E-01 > Unavailable |                   |         |
| HPR/-HPI                       | 1.5E-04 > 1.0E+00     | 1.0E+00           | 1.0E-03 |
| Branch Model: 1.0F.2+opr       |                       |                   |         |
| Train 1 Cond Prob:             | 1.0E-02 > Unavailable |                   |         |
| Train 2 Cond Prob:             | 1.5E-02 > Unavailable |                   |         |
| porv.open                      | 1.0E-02               | 1.0E+00           | 4.0E-04 |
| * branch model file            |                       |                   |         |
|                                |                       |                   |         |

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