

UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
OFFICE OF NUCLEAR REACTOR REGULATION  
WASHINGTON, D.C. 20555

December 20, 1991

NRC INFORMATION NOTICE 91-83: SOLENOID-OPERATED VALVE FAILURES RESULTED  
IN TURBINE OVERSPEED

Addressees

All holders of operating licenses or construction permits for nuclear power reactors.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to turbine overspeed problems and turbine trip failures resulting from the failures of multiple solenoid-operated valves (SOVs). It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

Background

Westinghouse turbines are tripped using a combination of electro-hydraulic control (EHC) fluid and auto-stop oil (Attachment 1). In the electro-hydraulic portion, SOVs dump the fluid to the EHC sump, causing the throttle valves, reheat stop valves, intercept valves, and the governor valves to shut, stopping the flow of steam to the turbine. Failure of the SOVs in the EHC system to open could lead to the turbine overspeeding. Several events have occurred in the industry that involved the failure of SOVs that must operate for turbine emergency trip and overspeed protection. The consequences of these failures have varied according to the initiating event and the type of SOV failure. These failures suggest that there are weaknesses in the preventive maintenance and testing of these SOVs.

Description of Circumstances

On November 9, 1991, Unit 2 of the Salem Nuclear Generating Station sustained severe damage to its turbine and generator. The event occurred while the Public Service Electric and Gas Company (the licensee) was conducting routine turbine testing at 100-percent power. The licensee bypassed the turbine's auto-stop oil trip mechanism in accordance with the test procedure. During the test, an oil pressure perturbation occurred in the auto-stop trip system, the exact cause of which is yet to be determined. This caused the interface valve to open and thereby depressurized the EHC fluid. Both the turbine and the reactor tripped and, as expected, all turbine stop valves closed. However, the emergency trip solenoid valve failed to open upon receiving the trip signal.

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When the auto-stop oil repressurized, the interface valve closed, and all turbine stop valves reopened allowing steam flow into the turbine. As designed, the generator output breakers had opened upon receiving the reactor trip signal, so the steam flow through the unloaded turbine caused the turbine to overspeed. Both overspeed protection controller (OPC) solenoid valves failed to open preventing the governor valves and intercept valves from closing properly. The turbine continued to overspeed to an estimated 160-percent of rated speed. Operators observed increasing noise and vibration from the turbine and a fire at the generator. The low pressure turbine blades penetrated the turbine shroud. The overspeed resulted in severe damage to the low pressure turbine, the generator exciter unit, the condenser, and associated support structures, systems, and components.

### Discussion

The staff sent an augmented inspection team (AIT) to the site to investigate the event. The AIT concluded that the proximate cause of the event was the failure of the emergency trip solenoid valve and both overspeed protection controller solenoid valves to open when energized. The specific failure mechanisms of the Parker-Hannifin SOVs are yet to be determined, but preliminary analysis indicated that the pilot valve assembly in each solenoid unit was mechanically bound sufficiently to prevent movement. Other previous failures of these valves in the industry have also been attributed to mechanical binding, corrosion, and worn or pinched elastomeric parts.

Several precursory factors contributed to the event. The licensee for the Salem Nuclear Generating Station has no preventive maintenance program for any of these three SOVs. The surveillance and operational testing of the turbine trip and overspeed circuits does not specifically verify the proper hydraulic functioning of each SOV independently. Further, information concerning previous SOV failures has not been well disseminated.

The licensee had two earlier indications of problems with these SOVs. Similar valves on Salem Unit 1 required replacement, yet the licensee had not effectively verified the operability of the SOVs in Unit 2. Another indication occurred during a startup in October 1991. The OPC solenoid valves failed to open when a test of the system was performed. The licensee was required to verify proper OPC operation by closing the intercept valves when the OPC test switch was activated. The intercept valves did not close, indicating a possible malfunction of both of the OPC solenoid valves. The results were apparently misinterpreted, leading management to believe a procedure problem existed, rather than an equipment problem. The licensee continued the startup without further diagnosis and resolution. The staff will include more details of this event in NRC Inspection Report 50-311/91-81 when issued.

### Previous Events

The following previous events involved failures of SOVs in the turbine trip system during reactor trip events:

On April 6, 1985, at the R. E. Ginna Nuclear Power Plant, the turbine failed to trip automatically following a reactor trip because of mechanical binding of the emergency trip solenoid valve.

On February 28, 1988, at the Crystal River Plant, Unit 3, the turbine failed to trip automatically following a reactor trip because of a faulty emergency trip solenoid valve.

On September 10, 1990, at Salem, Unit 1, the reactor tripped because of a steam generator water level transient caused by a spurious overspeed signal. Mechanical binding prevented the OPC solenoid valves from functioning.

On September 29, 1990, at Ginna, the reactor tripped because of personnel error, but mechanical binding prevented the turbine emergency trip solenoid valve from functioning.

These events indicate that proper maintenance and operability testing of both the emergency trip solenoid valve and the OPC solenoid valves is prudent.

#### Related Generic Communications

The staff issued Generic Letter 91-15, "Operating Experience Feedback Report, Solenoid-Operated Valve Problems at U.S. Reactors," to distribute NUREG-1275, Volume 6, to industry. This document provided the staff's analysis of recent U.S. light water reactor experience (primarily 1984-1989) with SOVs. Appendix A of NUREG-1275, Volume 6, cited similar SOV failures at four other plants. The staff noted the susceptibility of SOVs to common-mode failures. The staff found that most SOVs cannot tolerate contaminants, need preventative maintenance or periodic replacement, and have a propensity for rapid aging and deterioration when subjected to elevated temperatures. The staff provided recommendations to aid in preventing common-mode SOV failures.

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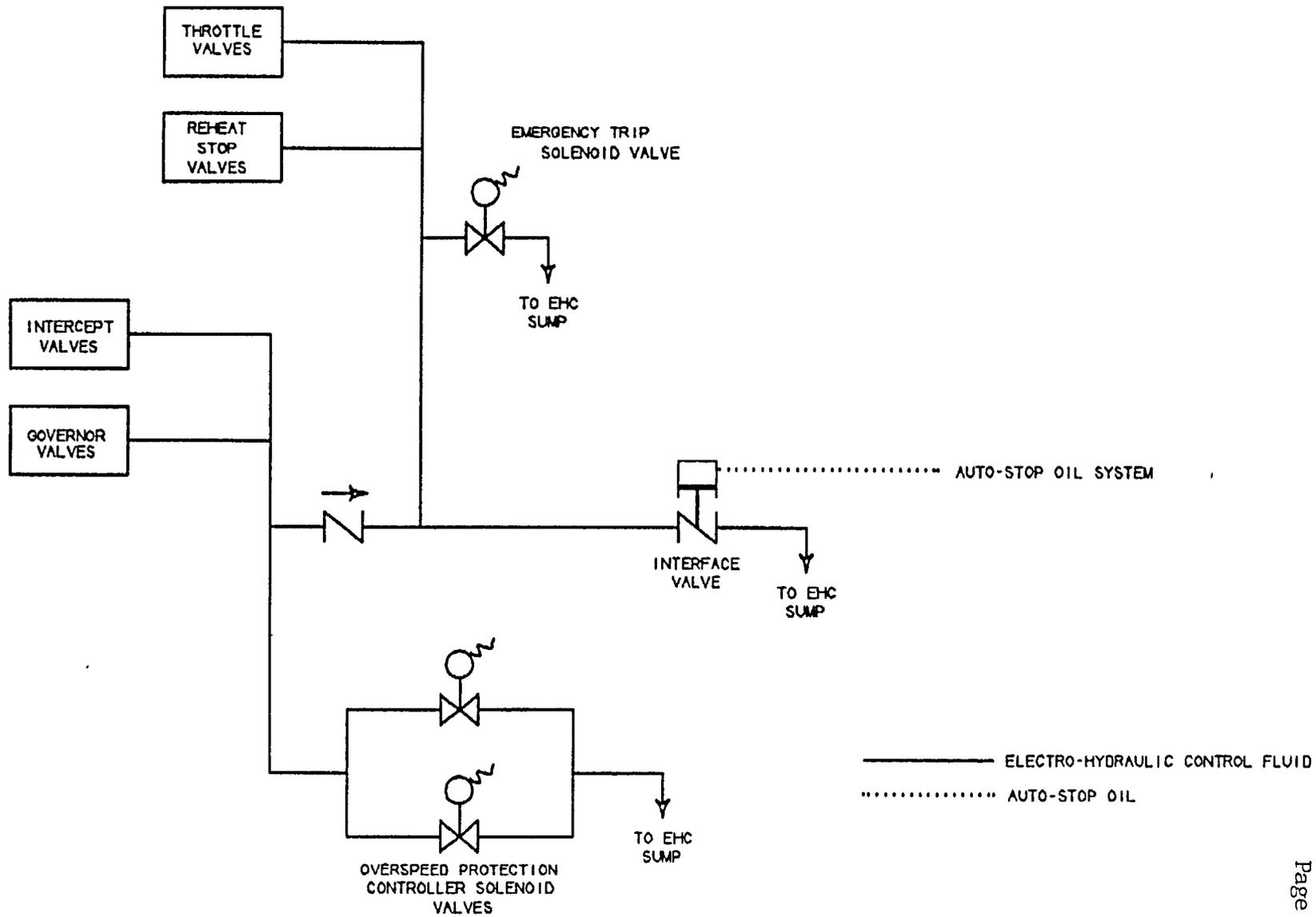
Charles E. Rossi, Director  
Division of Operational Events Assessment  
Office of Nuclear Reactor Regulation

Technical contacts: John White, Region I  
(215) 337-5114

David Gamberoni, NRR  
(301) 504-1171

#### Attachments:

1. Westinghouse Electro-Hydraulic Control System
2. List of Recently Issued NRC Information Notices



**WESTINGHOUSE ELECTRO-HYDRAULIC CONTROL SYSTEM**

LIST OF RECENTLY ISSUED  
NRC INFORMATION NOTICES

| Information Notice No. | Subject   | Date of Issuance | Issued to  |
|------------------------|---|------------------|--|
| 91-18,<br>Supp. 1      | High-Energy Piping Failures<br>Caused by Wall Thinning  | 12/18/91         | All holders of OLs or CPs<br>for nuclear power reactors. |
| 91-82                  | Problems with Diaphragms<br>in Safety-Related Tanks   | 12/18/91         | All holders of OLs or CPs<br>for nuclear power reactors. |
| 91-81                  | Switchyard Problems that<br>Contribute to Loss of<br>Offsite Power  | 12/16/91         | All holders of OLs or CPs<br>for nuclear power reactors. |
| 91-80                  | Failure of Anchor<br>Head Threads on Post-<br>Tensioning System During<br>Surveillance Inspection         | 12/11/91         | All holders of OLs or CPs<br>for nuclear power reactors. |
| 91-79                  | Deficiencies in the<br>Procedures for Instal-<br>ling Thermo-Lag Fire<br>Barrier Materials                | 12/06/91         | All holders of OLs or CPs<br>for nuclear power reactors. |
| 88-92,<br>Supp. 1      | Potential for Spent<br>Fuel Pool Draindown  | 11/29/91         | All holders of OLs or CPs<br>for nuclear power reactors. |
| 91-78                  | Status Indication of<br>Control Power for<br>Circuit Breakers Used<br>in Safety-Related Appli-<br>cations | 11/28/91         | All holders of OLs or CPs<br>for nuclear power reactors. |
| 90-57,<br>Supp. 1      | Substandard, Refur-<br>bished Potter & Brum-<br>field Relays Repre-<br>sented as New                      | 11/27/91         | All holders of OLs or CPs<br>for nuclear power reactors. |
| 91-77                  | Shift Staffing at<br>Nuclear Power Plants   | 11/26/91         | All holders of OLs or CPs<br>for nuclear power reactors. |

OL = Operating License  
CP = Construction Permit

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*Carl H. Berlinger for*

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- Westinghouse Electro-Hydraulic Control System
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Document Name: IN 91-83 \*SEE PREVIOUS CONCURRENCES

|                 |               |                  |                  |
|-----------------|---------------|------------------|------------------|
| *REGION I       | *EAB:DOEA:NRR | *SC:REGION I     | *SC:EAB:DOEA:NRR |
| IMoghissi       | DGamberoni    | JWhite           | DFischer         |
| 12/05/91        | 12/09/91      | 12/10/91         | 12/13/91         |
| *C:EAB:DOEA:NRR | *Tech Ed      | *C:OGCB:DOEA:NRR | D:DOEA:NRR       |
| ACHaffee        | 12/10/91      | CBerlinger       | CRossi           |
| 12/13/91        |               | 12/13/91         | 12/16/91         |

*CNRB*

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| OFC :  | *REGION I | : *EAB:DOEA:NRR | : *SC:REGION I | : SC:EAB:DOEA:NRR |
| NAME : | IMoghissi | : DGamberoni    | : JWhite       | : DFischer        |
| DATE : | / /91     | : / /91         | : / /91        | : 12/13/91        |

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| OFC :  | C:EAB:DOEA:NRR | : *Tech Ed | : C:OGCB:DOEA/NRR | : D:DOEA:NRR |
| NAME : | ACHaffee       | :          | : CBerlinger      | : CRossi     |
| DATE : | 12 /13/91      | : / /91    | : 12/13/91        | : / /91      |

9/10/90 At Salem, Unit 1, the reactor tripped due to a steam generator water level transient caused by a spurious overspeed signal. The OPC solenoid valves did not function due to mechanical binding.

9/29/90 At Ginna, the reactor tripped due to personnel error, but the turbine emergency trip solenoid valve failed to function due to mechanical binding.

It is apparent from these events that proper maintenance and operability testing of both the ET solenoid valve and the OPC solenoid valves is prudent.

Related Generic Communications

NUREG-1275, Operating Experience Feedback Report - Solenoid-Operated Valve Problems, which was distributed to industry via Generic Letter 91-15, analyzed recent U.S. light-water reactor experience (primarily 1984-1989) with solenoid-operated valves (SOVs). It was found that most SOVs cannot tolerate contaminants, need preventative maintenance or periodic replacement, and have a propensity for rapid aging and deterioration when subjected to elevated temperatures. Various recommendations were provided to aid in the prevention of further SOV problems.

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| NAME | :   | IMoghissi | : | DGamberoni   | : | JWhite        | : | DFischer        | : |
| DATE | :   | / /91     | : | 12/9/91      | : | / /91         | : | / /91           | : |

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| NAME | : | AChaffee       | : | JMain    | : | CBerlinger      | : | CRossi     | : |
| DATE | : | / /91          | : | 12/10/91 | : | / /91           | : | / /91      | : |

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| NAME | IMoghissi | DGamberoni   | JWhite      | DFischer        |
| DATE | / /91     | / /91        | 12/10/91    | / /91           |

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| NAME | AChaffee       |         | CBerlinger      | CROSS1     |
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| NAME | : JM IMoghissi | : DGamberoni   | : JWhite      | : DFischer        |
| DATE | : 12/15/91     | : / /91        | : / /91       | : / /91           |

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