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

September 2, 1988

NRC INFORMATION NOTICE NO. 88-72: INADEQUACIES IN THE DESIGN OF DC MOTOR-OPERATED VALVES

Addressees:

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

Purpose:

This information notice is being provided to alert addressees to potential problems in the design specifications of dc motor-operated valves, especially for conditions that may involve reduced or degraded dc voltage and/or elevated temperatures. 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 do not constitute NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances:

On July 1, 1988, a high pressure coolant injection (HPCI) steam admission valve failed to open during a post-maintenance test at the Brunswick nuclear power plant, Unit 1. The same valve had failed in December 1987 and on May 28, 1988. The licensee, Carolina Power and Light Company, established a team to investigate the cause of failure, and the team identified the most probable cause as a dc motor failure due to a shunt-winding to series-winding short circuit. The team believed that this condition was precipitated by thermal binding of the valve internals. The previous failure in May was also diagnosed as having been caused by thermal binding. As a result of these failures, the licensee reviewed the design of the dc motor-operated valves for both the HPCI and the reactor core isolation cooling (RCIC) systems. This review identified a number of significant design deficiencies going well beyond the problems with thermal binding. The deficiencies constitute a potential common cause failure mechanism for safety system valves. Unit 1 was shut down on July 14, 1988 to replace the failed HPCI valve motor and to implement design modifications to other motor-operated valves.

Discussion:

Pressure locking and thermal binding of gate valves were identified as potentially important valve failure mechanisms within the nuclear industry several

years ago. Pressure locking occurs when a gate valve is closed under full system pressure and fluid is trapped in either the bonnet cavity or between the disks of a double disk valve. When the valve is subsequently heated, the trapped fluid expands or flashes to steam and causes pressure to increase in the valve bonnet area and between the wedges of the valve disk. The pressure increase inhibits opening of the valve by causing the wedges to press tightly against the valve seats, resulting in binding of the valve. This phenomenon contributed to the May 1988 HPCI valve failure. To prevent recurrence of this failure, the licensee drilled a small drain hole in the upstream disk to provide a pressure relief path. This remedy was only partially successful because the valve also underwent thermal binding, which was not recognized at that time.

Thermal binding occurs when a valve is seated in a hot condition and, during subsequent temperature changes, the valve body contracts a proportionally greater amount than the valve internals because of the different expansion and contraction characteristics of the valve body and the disk. This is particularly true for valves with internals which have reduced clearances due to improper maintenance or alterations. Several potential remedies have been suggested to alleviate this situation, including slightly opening and reclosing a valve during cooldown, limiting valve actuator closing forces, and using compensating spring packs to reduce valve inertial closing forces. In general, neither ac nor dc valve motor operator sizing analyses account for the extra torque needed to unseat a valve when it is thermally bound. It should be noted that certain valves may become functionally inoperable when conditions induce thermal binding.

The dc motor operator design problems discovered at Brunswick as a result of the review following the July 1 HPCI valve failure were attributed by the licensee to a lack of design coordination and inadequate consideration of the valves' functional operability requirements by the architect engineering firm, United Engineers and Constructors. The licensee found that inadequate torque was available to open the valves, particularly under reduced dc bus voltage conditions, and when MOVs were installed in locations that are normally at elevated ambient temperatures. Reduced or degraded dc bus voltage conditions could occur during accidents in which battery charging capability is lost (for example, during a station blackout or failure of the chargers). Four design flaws were identified in the licensee's review.

(1) The specified motor operator torque was found to be deficient. Also, the design temperatures used for sizing the motors were found to be below the actual ambient temperature in which some valves were operating. Thus, the motors were unable to develop the torque required to unseat (open) the valves under reduced dc voltage conditions. Additionally, the operability of some of the valves during accident conditions, such as high-energy line breaks, was questionable.

(2) The presence of starting resistors and their impact on starting torque were not considered in motor sizing. The resistors were installed to limit the dc current until the motor starts and accelerates toward rated speed. However, they were found to reduce the "hammer blow" effect needed to ensure valve opening. They also increased the potential for motor stalling against a seated valve.

(3) Cable resistance contributed to reduced motor terminal voltage and starting current. As a result, actual torque supplied by the motor was further reduced.

(4) High-voltage transients were induced in the dc motor's shunt windings whenever the motor's power supply circuit breaker was opened. (In some cases, high voltage transients may also result when motor starter contacts are opened in installations in which the shunt field is set up for intermittent service; i.e. energized only when the armature is energized.) This process led to degradation of the insulation on the shunt and field windings.

These dc motor-related design flaws were not uncovered during routine surveillance testing nor during post-maintenance testing. In part, this was because dc voltage was normally maintained at or above nominal values by battery chargers operating "in float" with the batteries when the tests were conducted. Thus, design flaws related to reduced dc voltage performance would not be readily detected.

Additionally, Motor Actuator Characterizer (MAC) traces were made from valve tests performed during certain maintenance testing activities. These MAC traces indicated anomalies in valve performance. However, the deviations from expected performance were subtle. Careful engineering review was necessary to properly interpret these traces.

The corrective actions taken by the licensee included removal of starting resistors, replacement of certain motors and cable, and the addition of metal oxide varistors to dissipate induced voltage transients during power supply interruptions. (Discussions with Limitorque have revealed that, for the past five years, the company has recognized the need to control voltage transients in their motor operators. Therefore, they have included depictions of voltage surge suppression devices in their electrical drawings for their motor-operated valves.)

It is important to note that the removal of dc motor operator starting resistors may cause a significant increase in the 1-minute load on the station's batteries. A battery performance assessment was conducted by the Brunswick licensee to ensure that the dc power system continued to meet plant safety analysis requirements following removal of the resistors.

No specific action or written response is required by this information notice. If you have any questions about this matter, please contact one of the technical contacts listed below or the Regional Administrator of the appropriate regional office.

Charles E Rossi

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

Technical Contacts: P. W. Baranowsky, NRR
(301) 492-1157

E. N. Fields, NRR
(301) 492-1173

Attachment: List of Recently Issued NRC Information Notices

LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
88-71	Possible Environmental Effect of the Reentry of COSMOS 1900 and Request for Collection of Licensee Radioactivity Measurements Attributed to That Event	9/1/88	All holders of OLs or CPs for nuclear power reactors, fuel cycle licensees, and Priority 1 material licensees.
88-70	Check Valve Inservice Testing Program Deficiencies	8/29/88	All holders of OLs or CPs for nuclear power reactors.
88-69	Movable Contact Finger Binding in HFA Relays Manufactured by General Electric (GE)	8/19/88	All holders of OLs or CPs for nuclear power reactors.
88-48, Supplement 1	Licensee Report of Defective Refurbished Valves	8/24/88	All holders of OLs or CPs for nuclear power reactors.
88-68	Setpoint Testing of Pressurizer Safety Valves with Filled Loop Seals Using Hydraulic Assist Devices	8/22/88	All holders of OLs or CPs for nuclear power reactors.
88-67	PWR Auxiliary Feedwater Pump Turbine Overspeed Trip Failure	8/22/88	All holders of OLs or CPs for nuclear power reactors.
88-66	Industrial Radiography Inspection and Enforcement	8/22/88	All NRC industrial radiography licensees.
88-65	Inadvertent Drainages of Spent Fuel Pools	8/18/88	All holders of OLs or CPs for nuclear power reactors and fuel storage facilities.
88-64	Reporting Fires in Nuclear Process Systems at Nuclear Power Plants	8/18/88	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit

No specific action or written response is required by this information notice. If you have any questions about this matter, please contact one of the technical contacts listed below or the Regional Administrator of the appropriate regional office.

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

Technical Contacts: P. W. Baranowsky, NRR
(301) 492-1157

E. N. Fields, NRR
(301) 492-1173

Attachment: List of Recently Issued NRC Information Notices

* see previous concurrence

*OEAB:NRR	*OEAB:NRR	*RPB:ARM	*C:OEAB:NRR	*D:DEST:NRR	*C:OGCB:NRR	D:DOEA:NRR
PBaranowsky	NFields	TechEd	WLanning	LShao	CHBerlinger	CERossi
8/12/88	8/12/88	8/04/88	8/12/88	8/17/88	8/25/88	8/31/88

(In some cases, high voltage transients may also result when motor starter contacts are opened in installations in which the shunt field is set up for intermittent service, i.e. energized only when the armature is energized.) This process led to degradation of the insulation on the shunt and field windings.

These dc motor-related design flaws were not uncovered during routine surveillance testing nor during post-maintenance testing. In part this was because dc voltage was normally maintained at or above nominal values by battery chargers operating "in float" with the batteries when the tests were conducted. Thus, design flaws related to reduced dc voltage performance would not be readily detected.

Additionally, Motor Actuator Characterizer (MAC) traces were made from valve tests performed during certain maintenance testing activities. These MAC traces indicated anomalies in valve performance. However, the deviations from expected performance were subtle. Careful engineering review was necessary to properly interpret these traces.

The corrective actions taken by the licensee included removal of starting resistors, replacement of certain motors and cable, and the addition of metal oxide varistors to dissipate induced voltage transients during power supply interruptions. (Discussions with Limitorque have revealed that, for the past five years, the company has recognized the need to control voltage transients in their motor operators. Therefore they have included depictions of voltage surge suppression devices in their electrical drawings for their motor operated valves.

It is important to note that the removal of dc motor operator starting resistors may cause a significant increase in the 1-minute load on the station's batteries. A battery performance assessment was conducted to ensure that the dc power system continued to meet plant safety analysis requirements following removal of the resistors.

No specific action or written response is required by this information notice. If you have any questions about this matter, please contact the technical contact listed below or the Regional Administrator of the appropriate regional office.

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

Technical Contact: P.W. Baranowsky
(301) 492-1157

E.N. Fields
(301) 492-1173

Attachment: List of Recently Issued NRC Information Notices

CHB as corrected

* see previous concurrence

*OEAB:NRR	*OEAB:NRR	*RPB:ARM	C:OEAB:NRR	D:DEST:NRR	C:OGCB:NRR	D:DOEA:NRR
PBaranowsky	NFields	TechEd	WLanning	LShao	CHBerlinger	CERossi
/ /88	/ /88	/ /88	/ /88	/ /88	8/25/88	/ /88

(In some cases, high voltage transients may also result when motor starter contacts are opened in installations in which the shunt field is set up for intermittant service, i.e. energized only when the armature is energized.) This process led to degradation of the insulation on the shunt and field windings.

These dc motor-related design flaws were not uncovered during routine surveillance testing nor during post-maintenance testing. In part this was because dc voltage was normally maintained at or above nominal values by battery chargers operating in float with the batteries when the tests were conducted. Thus, design flaws related to reduced dc voltage performance would not be readily detected.

Additionally, Motor actuator characterizer (MAC) traces were made from valve tests performed during certain maintenance testing activities. These MAC traces indicated anomalies in valve performance. However, the deviations from expected performance were subtle. Careful engineering review was necessary to properly detect and interpret these traces. The corrective actions taken by the licensee included removal of starting resistors, replacement of certain motors and cable, and the addition of metal oxide varistors to dissipate induced voltage transients during power supply interruptions. (Discussions with Limitorque have revealed that for the past five years the company has recognized the need to control voltage transients in their MOVs. Therefore they have included depictions of voltage surge suppression devices in their electrical drawings for their MOVs.)

It is important to note that the removal of dc motor operator starting resistors may cause a significant increase in the 1-minute load on batteries. A battery performance assessment was required to ensure that the dc power system continued to meet plant safety analysis requirements following removal of the resistors.

No specific action or written response is required by this information notice. If you have any questions about this matter, please contact the technical contact listed below or the Regional Administrator of the appropriate regional office.

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

Technical Contact: P.W. Baranowsky
(301) 492-1157

E.N. Fields
(301) 492-1173

Attachment: List of Recently Issued NRC Information Notices

*See previous concurrence

*OEAB:NRR	*OEAB:NRR	*RPB:ARM	C:OEAB:NRR	D:DEST:NRR	C:OGCB:NRR	D:DOEA:NRR
PBaranowsky	NFields	Tech.Ed.	WLanning	LShao	CHBerlinger	CERossi
8/12/88	8/12/88	/ /88	8/12/88	8/17/88	/ /88	/ /88

New P ? or should this be part of previous ?

MAC

Motor actuator characterizer (MAC) traces were made from valve tests performed during certain maintenance testing activities. These traces indicated anomalies in valve performance. However, the deviations from expected performance were subtle. Careful engineering review was necessary to properly detect and interpret these traces. The corrective actions taken by the licensee included removal of starting resistors, replacement of certain motors and cable, and the addition of metal oxide varistors to dissipate induced voltage transients during power supply interruptions.

It is important to note that the removal of dc motor operator starting resistors may cause a significant increase in the 1-minute load on batteries. A battery performance assessment was required to ensure that the dc power system continued to meet plant safety analysis requirements following removal of the resistors.

No specific action or written response is required by this information notice. If you have any questions about this matter, please contact the technical contact listed below or the regional administrator of the appropriate regional office.

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

Technical Contact: P.W. Baranowsky
(301) 492-1157

E.N. Fields
(301) 492-1173

Attachment: List of Recently Issued NRC Information Notices

See PREVIOUS CONCURRENCE

*OEAB:NRR	*OEAB:NRR	*RPB:ARM TECHED	C:EAB:NRR	D:DEST:NRR	C:OGCB:NRR	D:DOEA:NRR
PBaranowsky:db	NFields		WLanning	LShao	CHBerlinger	CERossi
8/05/88	8/05/88	8/04/88	/ /88	/ /88	/ /88	/ /88