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UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555-0001

March 22, 1999

NRC INFORMATION NOTICE 99-07: FAILED FIRE PROTECTION DELUGE VALVES AND POTENTIAL TESTING DEFICIENCIES IN PREACTION SPRINKLER SYSTEMS

Addressees

All NRC licensees.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to alert addressees to test methodologies for fire protection deluge valves that may not adequately demonstrate valve operability. 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

Valves for sprinkler system automatic control (SSAC) are used in fire protection systems that protect areas housing both safety-related and non-safety-related equipment used for fire safe shutdown (FSSD). Many of these systems are used to provide primary fire protection and to meet the requirements of 10 CFR Part 50, Appendix R, Section III.G. Poor design, deficient maintenance, or inadequate testing of SSAC valves and associated solenoid valves can lead to a common-mode failure of the valves to perform their design function of providing adequate and reliable fire protection. This, in turn, can result in fire damage to safe shutdown equipment in the event of a fire.

The Model A-4 Multimatic Valve manufactured by Grinnell is a deluge valve designed specifically for use in fire protection systems. It is used as a system control valve in deluge, preaction, and special types of fire protection systems and may also provide for actuation of fire alarms when the systems operate.

Preaction valves contain connections for monitoring pressure in the diaphragm chamber and in the main water supply, for providing valve drainage and for supplying water to the diaphragm chamber. All required components for these connections are typically supplied by the valve manufacturer as "trim packages" and are included as part of the Underwriters Laboratories, Inc., (UL) and Factory Mutual, Inc., (FM) certifications of the valves.

Description of Circumstances

In the week of March 4, 1996, during surveillance testing of preaction sprinkler systems in the Farley Unit 1 fire protection system, 5 of 11 SSAC valves (Grinnell Model A4 deluge valves) failed to trip open when water pressure was vented out of the diaphragm chamber. Upon additional testing, the licensee found that several other SSAC valves failed. The licensee's root-cause team, formed after the initial valve failures, concluded that the diaphragm was sticking to its retainer and push rod disk, that the push rod assembly showed wear (pits and eroded plating), and that the associated solenoid valves were not properly bleeding water pressure out of the diaphragm area.

The licensee's root-cause team found that plant personnel were using an abrasive cleaning pad to clean the chrome-plated push rod and the push rod guide in the diaphragm retainers. The team theorized that this activity may have created rust particles that caused the sticking. In like manner, abrasives used to clean the solenoid valves could cause the plunger assembly to stick. Grinnell does not recommend using any abrasives, lubricants, or solvents because they may damage metallic surfaces such as valve seats, and may also damage elastomeric seals. Grinnell recommends cleaning the push rods, guides, and solenoid valves with only soap, water, and clean cloths.

The root-cause team also found that the solenoid valves were designed for operating pressures of approximately 150 psig (UL maximum rated pressure is 175 psig), whereas the actual operating pressures often exceeded 150 psig (the licensee determined that fire protection system pressures sometimes went as high as 225 psig). The NRC staff theorizes that the valves may not be able to open against this pressure.

Although the root-cause team did not conclusively determine the root cause of the valve failures, the team recommended (1) replacing the diaphragms and solenoid valves, (2) installing new solenoid valves with a design pressure of 200 psi (and factory tested to 300 psi), (3) flushing the solenoid valve piping and diaphragm chamber when cleaning the solenoids, (4) requiring the use of only soap, water, and a clean cloth when cleaning the solenoid valves, (5) cleaning the solenoid and SSAC valves more frequently, and (6) testing the valves more often — every 12 months instead of 18 months (in the short term, the licensee increased testing to every 2, 6, and 12 months after resetting the valves to improve reliability).

In subsequent walkdowns, the team found that the piping for the deluge valve control drain lines had a 3/8-inch diameter in lieu of the ½-inch diameter line typically supplied by the manufacturer as part of the trim package listed by the independent testing laboratory (i.e., UL or FM). The use of the smaller drain line could potentially inhibit the bleedoff of water from the diaphragm chamber, resulting in increased pressure in the chamber. The staff notes that this restriction, in turn, could prevent the valve from opening.

In mid-February 1998, the licensee performed a scheduled surveillance test on several deluge valves in preaction sprinkler systems. One valve failed to trip, and its push rod had to be forced back manually after completely isolating and draining the diaphragm chamber, closing the main isolation valve, opening the main drain, and opening the valve faceplate. Inspection of the rubber diaphragm showed a "dimple" near the diaphragm chamber supply inlet. The valve had been left in the tripped condition for about 22 days in May 1997, then it was reset to the

operable, ready position until this surveillance (for about 9 months). As a result of this failure, the licensee tested a sample of six additional valves that had been left in a tripped condition for long periods.

One of these valves failed to trip electrically. Inspection of this valve indicated that the push rod appeared to be misaligned in the retainer ring slot and some corrosion had formed where the rod slides through the ring. Also, the diaphragm was stuck to the face of the push rod. In total, five of the six sample valves and one other valve failed to operate properly.

In June 1998, as part of the ongoing testing program, one of the deluge valves was manually actuated from its pull station; it failed to operate. An investigation indicated that the pull station housing had rotated and was preventing complete travel (i.e., fully open) of the valve handle. After adjusting the pull station housing, the handle was actuated again and the deluge valve successfully tripped.

The team commissioned by the licensee to study the problems with the Grinnell A-4 valves concluded that, although the cause and effect are not known, it appears that the failure occurred within a tripped open valve exposed to pressure over time. This exposure appears to cause the valve to fail after being reset. The team noted that the manufacturer does not recommend leaving the tripped-open valves pressurized for a significant length of time. The root-cause team is also exploring other potential failure mechanisms of the Grinnell A-4 valve.

The staff is continuing to monitor the licensee's investigation into the valve failures.

Discussion

The staff noted several potential problems as a result of this event. First, as discussed above, when deluge valves are left in the tripped condition for long periods, the rubber diaphragm is forced against the inlet side of the diaphragm chamber. When the valves are reset, the diaphragm may then bond to the push rod flange, or pinch between the push rod flange and retainer ring, thus keeping the valve from operating properly. In the set condition, the rubber diaphragm is held by water pressure against the flange and retainer and bonding may possibly occur then. Bonding may be more probable in systems using well water or raw river water rather than potable water supplies.

The staff also notes that it is a common practice for many plants to keep their preaction sprinkler system deluge valves in a tripped condition for long periods, usually during outages when welding or other activities are taking place, which increases the likelihood of spurious system actuation. Grinnell recommends that the valve be reset within 24 hours of any valve operation and that the internal components of valves be cleaned and inspected after any valve operation.

Second, the use of plant-supplied or plant-designed trim packages instead of the UL- or FM-certified packages and designs supplied by the valve manufacturer may result in issues such as undersized drain lines, which may restrict the bleedoff from the diaphragm chamber and further inhibit valve actuation.

Third, an evaluation by Grinnell concluded that the valve release mechanism may be jamming from the high pressure and surging conditions in the fire protection water supply system. The jamming may be related to deep indentations on the valve latch. Cleaning and inspection of the valves' internal components should reveal these potential problems.

While reviewing this event, the staff noted that the licensee performs full-flow testing. It is the staff's understanding that many plants isolate the deluge valves from the main fire protection water supply during individual system valve testing. This practice is a potential testing weakness and may mask the actuation problems discussed herein. With the deluge valve isolated, a limited volume of water is trapped in both the main line and the diaphragm chamber supply line. The water in the diaphragm chamber is slowly bled off until the valve opens. If the diaphragm has bonded to the flange, the inlet to the diaphragm chamber could be partially blocked, inhibiting (but not preventing) valve actuation. However, during normal operation with full flow from the diaphragm chamber supply line, the primary flow path would follow the supply line to the drain, thus trapping water in the diaphragm chamber and preventing valve actuation. Note the following statement in National Fire Protection Association (NFPA) Standard 25 ("Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems," 1995 edition, section 9-4.3.2.2): "Each deluge or preaction valve shall be trip tested annually at **full flow** [emphasis added] in warm weather and in accordance with the manufacturer's instructions." The valve manufacturer may also have special requirements for inservice testing. The A-4 valve manufacturer recommends partial flow testing where full-flow testing is undesirable.

Another event involving the failure of automatic deluge valves took place at Grand Gulf in 1983, and is discussed in IN 84-16, "Failure of Automatic Sprinkler System Valves to Operate." While the licensee was performing an operational test of the emergency diesel generator (EDG), a fire occurred in the diesel. The automatic deluge valve (6-inch Model C valve manufactured by the Automatic Sprinkler Company of America (ASCO)) failed to open. Approximately 3 months later, a Model C valve in a preaction sprinkler system for the EDG room at Grand Gulf failed to operate during a test. In both cases, scoring was found in the actuation weight upper guide collar and in the box that encloses the weight guide bushing.

Another instance of repeated failures of a preaction deluge valve occurred in 1997 at Limerick Unit 1. A Model "D" 6-inch deluge valve manufactured by Star Sprinkler, Inc., did not actuate during a surveillance test. The frequency of testing had been increased because of earlier failures caused by suspected mechanical problems. Continued troubleshooting of the valve failures uncovered a potential voltage mismatch between the deluge valve and the Chemetron release control panel, resulting in marginal power available to operate the valve. The Model "D" valves were subsequently replaced with Model "G" valves, also manufactured by Star Sprinkler.

Related Generic Communications

- IN 84-16, "Failure of Automatic Sprinkler System Valves to Operate," issued March 2, 1984.
- IN 92-28, "Inadequate Fire Suppression System Testing," issued April 8, 1992.
- IN 97-22, "Potential for Failure of the OMEGA Series Sprinkler Heads," issued September 22, 1997.

This information notice requires no specific action or written response. However, addressees are reminded that they are required to consider industry-wide operating experience (including NRC information notices) where practical, when setting goals and performing periodic evaluations under 10 CFR 50.65, "Requirement for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants." If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

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