UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
WASHINGTON, D.C. 20555

December 28, 1994

NRC INFORMATION NOTICE 94-89: EQUIPMENT FAILURES AT IRRADIATOR FACILITIES

Addressees

All U.S. Nuclear Regulatory Commission irradiator licensees.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to several equipment failures -- some of which have generic implications -- that involve wet source storage irradiators. It is expected that all recipients (including dry source storage irradiator licensees) 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 new NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances

The first equipment failure involved the time delay system required in 10 CFR 36.23(f). The second equipment failure involved two incidents where the control console provided false indications of irradiator condition. The final equipment failure involved a source rack that failed to return to its shielded position after the command was initiated at the control console.

1. Fault in the Operational Time Delay Reset Power Supply.

In this incident, a fault in the control console circuitry occurred at a licensee's facility when an external electrical power surge caused a fuse to blow in the operational time delay reset power supply. This circuit had been recently installed to meet the requirements of 10 CFR Part 36. The operational time delay circuit prevents the control console from activating for a preset time after being initiated by the operator in the irradiation room, thereby preventing source rack movement per 10 CFR 36.23(f). In addition, the operational time delay circuit of this irradiator must be operational for the audible and visual warning circuit and the door interlock circuit to function properly. The audible and visual warning systems are designed to activate whenever the irradiator door is opened and source movement is initiated. Nevertheless, the audible and visual warning systems did not activate when the operator left the irradiation room, until the control console was turned "ON" with the console key. The planned irradiation was performed, however, since the audible warning system did activate before irradiation, per the requirement in 10 CFR 36.31(a).

The operational time delay circuit was also designed to reset after an irradiation to prevent the control console from being re-energized and allowing additional source movement. The control console should not re-energize until the circuit is again initiated by the operator in the irradiation room. However, in this incident, the control console was able to be re-energized before the time delay circuit was initiated. The blown fuse in the reset power supply prevented the time delay circuit from resetting as designed.

To prevent reoccurrence, a surge protector was installed to protect the entire system from external power surges, and the time delay circuit was redesigned to disable the control console, audio and visual safety circuits, and the source positioning system, in case the fuse blows again. This alerts the operator to a fault and prevents source movement until the fuse is replaced.

2. False Indications of Source Rack Position.

A false indication of source rack position (rack not in the fully down position) was received at the control console of a wet source storage licensee when the wire that carries the source position signal shorted because of worn insulation. Vibration in the system caused the wire to rub against nearby metal and wore away the insulation. The short-circuit also caused an initial intermittent false indication of a collision between the source rack and the carrier. The licensee verified that the sources were in the shielded position and traced the fault to the damaged wire. The wire was replaced and rerouted through a flexible conduit to reduce the possibility of additional wear.

A second false indication of source rack position occurred at the same facility when the plunger of a source rack down-position switch failed to extend and thereby did not properly indicate the true position of the source rack. The plunger failed to extend because of corrosion between the plunger and sleeve causing increased friction. The irradiator licensee received conflicting signals when the lower position switch indicated that the source rack was not fully down, but the upper position switch indicated that the source rack was fully down. The installed radiation monitors and subsequent surveys performed outside of the cell indicated that the source rack was shielded. Further visual analysis confirmed that the source racks were in the fully shielded position.

The licensee concluded that the lower source rack position switch was malfunctioning and replaced the switch. On further analysis of the switch, it was determined that green corrosion deposits on the brass sleeve and steel plunger of the switch caused the plunger to stick in the retracted position, preventing it from springing back to the extended position. With the plunger in the retracted position, the switch indicates the source rack is not in the fully down position. The irradiator vendor, Nordion International, Inc. (NII), was notified and has issued Service Bulletin IND-93-2, which is included as Attachment 1 to this information notice. Service Bulletin IND-93-2 advises all users of NII pool type irradiators containing these plunger-type position indicators to check the switches for evidence of corrosion, clean the switches if corrosion is found, and replace the switches as soon as possible.

In addition, NII has provided replacement switches constructed of corrosion-resistant materials (porcelain sleeve and stainless steel plunger) to all users whose irradiators contain the non-corrosion-resistant switches, and has provided instructions for installation and initial testing of the new switches.

3. Failure of Source Rack to Return to the Shielded Position.

In this incident, a source rack at a licensee's facility failed to return to the shielded position. This occurred when an air solenoid valve failed to fully return to the exhaust position and stuck in an intermediate position that blocked any air passage through the valve, thereby trapping air pressure in the line between the valve and source rack hoist. During a typical irradiation, the licensee noted an irregular reading on the control console (not related to source rack position) and pressed the emergency stop button. The source rack position indication on the control console indicated that one of the two irradiator source racks failed to return to the fully down/shielded position. The installed radiation monitors, the position of the source rack cable on the roof of the irradiator building, and subsequent radiation surveys performed outside the irradiation cell confirmed that one source rack had remained in the up/unshielded position. Further investigation revealed that pressure remained in the air line to the source rack hoist, keeping the rack in the exposed position, when this pressure should have been released. The licensee cut the air line to release the pressure, and the source rack returned to the fully down/shielded position. The licensee determined that one or both of the air solenoid valves in the supply line failed to move to the exhaust position when the source down command was initiated, thereby not lowering the source rack. Both valves were replaced and the source hoist system operated normally.

The irradiator vendor, NII, was notified and both solenoid valves were returned to NII for further investigation. NII determined that the solenoid valves that were indicated to be four-way, two-position (exhaust/pressurize), five-port valves could in certain circumstances, operate as four-way, three-position (exhaust/pressurize/neutral), five-port valves. A two-position valve would exhaust pressure in the air line to the source rack hoist upon loss of supply air pressure, regardless of valve position. The neutral position of a three-position valve would maintain pressure in the air line to the source rack hoist regardless of supply air pressure. Therefore, a three-position valve would not allow for a fail-safe operation. The circumstance that allowed the valve to operate as a three-position valve was attributed to the deterioration and hardening of the seals in the valve spool, causing the valve spool to stick in the "neutral" position. NII's investigation showed that it is unlikely that the ingress of contaminants caused the valve spool to stick in the "neutral" position. However, NII did not rule that out as a contributing factor. According to NII, harding of the seals is thought to be caused by oxidation over time of the seal material. One of the spools, in use for over 5 years, showed considerable hardening of the seal material, whereas the seals of the other spool, in use for only 14 months, had become hardened, but not as hard as the first valve's seals.

As a result of this incident, NII issued Service Bulletin IND-94-1, which is included as Attachment 2 to this information notice. To preclude future failures of this nature, NII recommends that Norgren part 54237-56 valve spools no longer be used in Norgren Nugget 200 Series Source Hoist Valves, part K71EA00 KSI AECKGI, and that Norgren part 54237-58 spools be used as replacement spools in existing and all new valves of this type used in NII pool type irradiators.

The 54237-58 spools allow for the exhaust of air in all positions, thus eliminating the possibility of pressure remaining in the air line to the source rack hoist on removal of supply air pressure. In addition, NII recommended in their report to the licensee, that the spools be replaced periodically to reduce the possibility of additional failures because of seal hardening. NII's investigation revealed that detectable hardening of the seal material has occurred, in at least one case, within 14 months of use. However, the valve in that case continued to operate without failure.

In addition, NII reports that licensees who have ordered replacement valves for the original installed valves (part K71EA00 KSI AECKGI), may have received replacement valves labeled with Norgren's "off-the-shelf" part numbers. Therefore, Norgren Nugget 200 Series Source Hoist Valves with part numbers K71EA00 KS6 KQ1, K71EA00 KS6 AECKGI, and any other variants of the K71EA00 valves used for these operations should have their valve spools replaced also. NII asserts that the construction and operation of these valves are identical to the K71EA00 KSI AECKGI valves.

Discussion:

The failures of the audible and visual warning systems and operational time delay to initiate properly were caused by a blown fuse in the operational time delay reset power supply, failing to cause the timer to reset. This allowed the control console to be energized and source movement to occur before the operational time delay being re-initiated, contrary to Part 36 requirements. The redesigned circuit prevents this situation from occurring by not allowing the control console to re-energize if this fuse blows again. The control console is designed such that source movement cannot occur unless the control console is energized. Irradiator users should evaluate all possible failure modes of source positioning control circuitry and interlocks, or circuitry that supports these systems, upon installation and whenever modifications are made.

The worn insulation that caused the short in the source rack position indication circuit did not cause a situation in which the source racks were in the exposed position unintentionally. However, the licensee was required to bypass safety interlocks (using appropriate safety measures) to verify the true position of the source rack. Users should be aware of and take precautions against conditions (e.g., wear caused by vibration, excessive heat, embrittlement caused by high radiation, etc.) which could cause the failure of essential electrical components and indicators.

Users of NII pool-type irradiators containing source down-position indication switches constructed of non-corrosion-resistant materials should be aware that if the recommendations contained in NII Service Bulletin IND-93-2 are not followed, the potential for false or conflicting source rack position signals exists. If a false signal is received, the operator may be required to bypass safety interlocks (using appropriate safety measures) to verify the true position of the source rack.

The most likely cause of the corrosion was the close proximity of the switch to the water line and high humidity in the irradiation room. To date, NII is not aware of any indications of corrosion developing in the upper source position switch, which is constructed using materials similar to the original bottom source down-position switches. The upper switch is located away from the water line and is exposed to higher temperatures and lower humidity when the source rack is in the raised/exposed position. However, if conditions exist in the area around the upper switch that are favorable to corrosion (e.g., high humidity or a caustic atmosphere), this switch could corrode also.

Users of NII pool-type irradiators containing Norgren part 54237-56 valve spools used in Norgren Nugget 200 Series Source Hoist Valves, part K71EA00, should be aware that if they do not follow the NII recommendation to replace the 54237-56 spools with 54237-58 spools, the source racks may become stuck in the exposed position. Licensees may have to cut the air line to the source rack hoist to return the source rack to the shielded position. In addition, the licensees should consider NII's recommendation that the spools be replaced on a periodic basis to reduce the possibility of failure, according to their specific operation. If not replaced, the replacement valve spools could fail because of seal material hardening, although such failure would not cause pressure to remain trapped in the air line.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact the technical contact listed below or the appropriate regional office.

Carl J. Paperiello

Carl J. Paperiello, Director
Division of Industrial and
Medical Nuclear Safety
Office of Nuclear Materials Safety
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Technical contact: Douglas Broaddus, NMSS
(301) 415-5847

Attachments:
1. Nordion International Inc., Service Bulletin IND-93-2
2. Nordion International Inc., Service Bulletin IND-94-1
3. List of Recently issued NMSS Information Notices
4. List of Recently issued NRC Information Notices

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The most likely cause of the corrosion was the close proximity of the switch to the water line and high humidity in the irradiation room. To date, NII is not aware of any indications of corrosion developing in the upper source position switch, which is constructed using materials similar to the original bottom source down-position switches. The upper switch is located away from the water line and is exposed to higher temperatures and lower humidity when the source rack is in the raised/exposed position. However, if conditions exist in the area around the upper switch that are favorable to corrosion (e.g., high humidity or a caustic atmosphere), this switch could corrode also.

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