

AEOD TECHNICAL REVIEW REPORT

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 EVALUATOR/CONTACT: M. R. Harper

SUBJECT: INADVERTENT CONTAINMENT SPRAY ACTUATIONS

EVENT DATE: Multiple

SUMMARY

On November 20, 1990, at San Onofre 2, about 5000 gallons of borated water was unintentionally sprayed into containment while the plant was at full power. An engineered safety features actuation signal was apparently generated through personnel error by I&C technicians. The safety significance of this event involves an increased potential for degradation of equipment, primarily electrical components, inside containment due to borated water intrusion.

A search of several operating experience data bases was made for information on previous containment spray events in which an actual spray occurred, to identify the lessons learned (e.g., possible equipment damage and corrective actions). Data was retrieved from NUDOCS, from SCSS (via contractors at Oak Ridge National Laboratory (ORNL)) and from the ESF data base at Idaho National Engineering Laboratory (INEL). Six such events were found from 1984 on. Containment spray actuation events occurred at Calvert Cliffs 1 in April 1987, Waterford in February 1985, Kewaunee in January 1985, Pilgrim in September 1984, Palisades in July 1984, and San Onofre 2 itself in March 1984. In addition, six events were reported for the period of 1980 through 1983.

Inadvertent containment spray actuations have been reported every year or two, primarily due to personnel errors, but also due to equipment problems. The events at San Onofre 2 in 1984 and in 1990 indicate that corrective actions requiring independent verification of the completion of steps in a procedure involving resetting of channels during testing alone can not guarantee that such events will not recur.

Examination of the damage caused by six actuations from 1984 on indicates that there was a limited amount of short term damage caused by these events. Some electrical equipment was degraded due to grounds, electrical shorts, or corrosion. The fact that equipment inside containment must be designed to operate during postulated accident environments (e.g., hot and wet) appears to have limited the damage to safety-related equipment. However, the potential for degradation of electrical equipment can not be dismissed, as was shown by the inadvertent reactor coolant pump (RCP) pump start at Kewaunee, and the degradation of non-safety electrical connectors in the recent San Onofre event. The effects of containment spray on electrical equipment can only be practically assessed through visual inspection and testing of equipment performance for items identified as most susceptible to damage. Potential long term effects has been identified by NRR as an area for further review.



DISCUSSION

On November 20, 1990, at San Onofre 2, about 5000 gallons of borated water was unintentionally sprayed into containment while the plant was at full power. An engineered safety features actuation signal (ESFAS) was apparently generated through personnel error by I&C technicians. The technicians were performing a plant protection system matrix test. The actuation signal was initiated because the technicians tested one channel without resetting the previous channel. The safety significance of this event involves an increased potential for degradation of equipment, primarily electrical components, inside containment due to borated water intrusion.

The containment spray lasted for about one minute. Because spray was terminated before full flow was established, the spray pattern was concentrated in the outer portions of the containment. No alarms or electrical faults were initially detected. Safety injection pumps started, but did not inject. The licensee decided to continue power operation. However, three days after the actuation, a ground fault was detected on a control rod drive mechanism (not safety-related), and seven other electrical faults were subsequently found in connectors due to wetting of preexisting corrosion. The licensee decided to shut down the unit to conduct a more extensive examination of electrical penetrations and junction boxes. The unit was restarted on November 28, 1990.

A search of several operating experience data bases was made for information on previous containment spray events in which an actual spray occurred, to identify the lessons learned (e.g., possible equipment damage and corrective actions). Data was retrieved from NUDOCS, from SCSS (via contractors at Oak Ridge National Laboratory (ORNL)) and from the ESF data base at Idaho National Engineering Laboratory (INEL). Six such events were found from 1984 on. Containment spray actuation events occurred at Calvert Cliffs 1 in April 1987, Waterford in February 1985, Kewaunee in January 1985, Pilgrim in September 1984, Palisades in July 1984, and San Onofre 2 itself in March 1984. In addition, six events were reported for the period of 1980 through 1983. The events since 1984 resulted in 10,000 gallons or less being sprayed into containment. An event at Sequoyah in 1981, however, resulted in more than 100,000 gallons sprayed.

The event at Calvert Cliffs 1 occurred on April 14, 1987, and was reported in LER 87-008 (a voluntary report). With the unit shut down for refueling, operators erroneously closed a valve on the wrong unit. As a result, containment spray actuated and continued for about three minutes, resulting in approximately 4000 gallons of borated water being sprayed into the containment. Partially because of the Calvert Cliffs event, the NRC issued Information Notice No. 87-25: "Potentially Significant Problems Resulting from Human Error Involving Wrong Unit, Wrong Train, or Wrong Component Events" on June 11, 1987.

The LER for the Calvert Cliffs event includes a one page attachment that lists actions taken subsequent to actuation of the containment spray. Examples of the actions taken included inspection of polar crane electrical junction boxes, all electrical equipment with covers removed, radiation monitors, and nuclear instrumentation, plus inspection and wipe down of cable trays, RCP motors, and junction boxes. In addition, iodine filters were tested, and



resistance measurements were performed on RCP motors and various fan motors. The complete list of actions taken is attached.

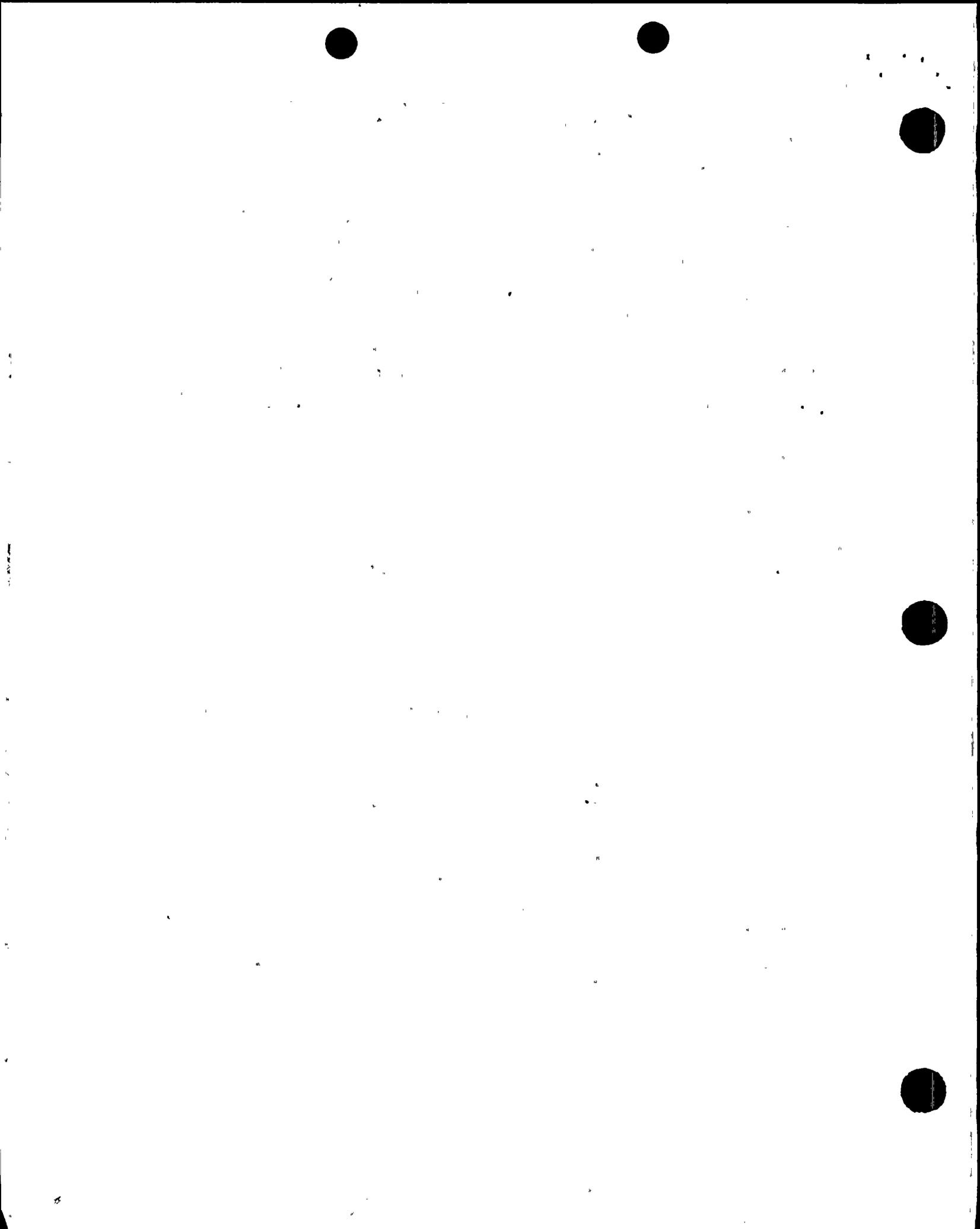
At Waterford in February 1985, during a functional test of the plant protection system in preparation for initial criticality, operators failed to reset initiation relays for the containment spray actuation signal, resulting in an inadvertent containment spray actuation. Less than 1000 gallons of water was sprayed into the containment. The actuation also resulted in isolation of the component cooling water (CCW) system. Operations personnel could not restore CCW flow to the pumps because the RCP seal cooler isolation valves closed and could not be reopened. Since CCW could not be restored within 3 minutes, the RCPs were secured. About 40 minutes after the containment spray actuation, RCP seal package degradation was observed. Seal packages for all four RCPs were replaced. Except for a minor ground on the polar crane, no other equipment damage was observed. (LER 85-006).

Of particular interest is an event at Kewaunee on January 22, 1985. With the plant at full power, the containment spray pump ran for about 1 minute and 40 seconds, resulting in a discharge of about 2500 gallons of borated water into the containment. After the event, the decision was made to remain at full power until a scheduled refueling outage (LER 85-001). However, on February 8, the plant was shut down to begin a refueling outage one week early because of a primary to secondary leak. On February 10 (nineteen days after the containment spray event), another event occurred (LER 85-004), an inadvertent start of a RCP, caused by a ground condition. The ground was caused by water accumulation in a pressure switch as a result of the containment spray event.

The containment spray actuation event at Kewaunee also resulted in alarms received from RCP, control rod drive, and various non-safety-related conditions due to short circuits caused by the borated water. The alarms cleared as the water evaporated. Pools of water were observed one and one-half hours after the spray, and boric acid crystals were forming as the water evaporated. Three hours after the actuation, grounds were found on both positive and negative battery circuits. An abnormal RCP bearing temperature indication resulted from the water intrusion. A control rod position indication also behaved erratically.

Corrective actions at Kewaunee included cleanup of the boric acid crystals, testing the safeguards actuation logic during refueling, monitoring RCP performance, performing a valve timing test on air operated containment isolation valves inside containment, flushing of containment spray piping, performing a core flux map, and a random check for corrosion on insulated carbon steel lines inside containment.

The event at Pilgrim in September 1984 was the only containment spray actuation reported for a BWR. (Containment spray is not automatic at most BWRs, so inadvertent actuations are somewhat less likely.) During refueling, about 10,000 gallons of water were sprayed into the drywell. The cause of the event was personnel error in that there was a failure of communications between maintenance and operations personnel. As a result of the spray, pipe insulation in the drywell was damaged and required replacement. No electrical equipment damage was observed. No injuries or contamination occurred (LER 84-015).



In July 1984, at Palisades, with the plant at hot shutdown, personnel errors by technicians calibrating pressure switches resulted in 1000 to 3000 gallons of borated water being sprayed into containment. There was no discussion of equipment damage or containment clean up in the licensee event report (Reference: LER 84-011).

In March 1984, approximately 6000 gallons of borated water was sprayed into the San Onofre 2 containment while the unit was at 100 percent power (LER 84-016). This water also contained sodium hydroxide. Technicians were testing the ESF matrix section of the plant protection system. They omitted steps involving resetting of channels, resulting in the actuation. This event also caused a safety injection, followed by a manual reactor trip. The containment was inspected, and no damage was observed.

After the San Onofre event, procedures were changed to require dual verification of the completion of each step that requires resetting or restoring a channel or system to normal service during testing. However, as described above, a containment spray actuation recurred due to the same cause during the same test at San Onofre 2 in November 1990.

FINDINGS

1. Inadvertent containment spray actuations have been reported at a rate of a little more than one per year for the past decade.
2. All but one of the events have been reported for Pressurized Water Reactors (PWRs). (Containment spray is not automatic at most BWRs, so inadvertent actuations are somewhat less likely.)
3. Most of the spray actuations reported were the result of personnel errors.
4. The 1984 and 1990 events at San Onofre 2 were due to the same cause (technician error) during the same test. Corrective actions requiring independent verification of steps involving resetting of channels did not prevent the 1990 event. The event at Waterford 3 in 1985 also involved failure to reset a channel during a functional test.
5. Most of the events occurred during shutdown, but three of the events occurred with the unit at full power - both the 1984 and 1990 events at San Onofre 2 and one at Kewaunee.
6. After two of the events - at Kewaunee in 1985 and at San Onofre 2 in 1990 - the decision was made to remain at full power.
7. An inadvertent RCP start at Kewaunee was caused by the consequences of an inadvertent containment spray actuation three weeks earlier.
8. Reactor coolant pump seal package degradation resulted from the containment spray actuation event at Waterford. As a result, seal packages for all four RCPs were replaced.



CONCLUSIONS

Inadvertent containment spray actuations have been reported every year or two, primarily due to personnel errors, but also due to equipment problems. The events at San Onofre 2 in 1984 and in 1990 indicate that corrective actions requiring independent verification of the completion of steps in a procedure involving resetting of channels during testing alone can not guarantee that such events will not recur.

Examination of the damage caused by six actuations from 1984 on indicates that there was a limited amount of short term damage caused by these events. Some electrical equipment was degraded due to electrical shorts and corrosion. The fact that electrical equipment inside containment must be designed to operate during postulated accident environments (e.g., hot and wet) appears to have limited the damage to safety-related equipment. However, the potential for degradation of electrical equipment can not be dismissed, as was shown by the inadvertent RCP pump start at Kewaunee, and the degradation of non-safety electrical connectors in the recent San Onofre event. The effects of containment spray on electrical equipment can only be practically assessed through visual inspection and testing of equipment performance for items identified as most susceptible to damage. Potential long term effects has been identified by NRR as an area for further review.

REFERENCES

1. U.S. Nuclear Regulatory Commission, NRC Information Notice No. 87-25: "Potentially Significant Problems Resulting from Human Error Involving Wrong Unit, Wrong Train, or Wrong Component Events," June 11, 1987.
2. LER 317/87-008, event date April 14, 1987.
3. LER 382/85-006, event date February 20, 1985.
4. LER 305/85-004, event date February 10, 1985.
5. U.S. Nuclear Regulatory Commission, Region III, Safety Inspection Report No. 50-305/84-22(DRP), February 28, 1985.
6. LER 305/85-001, event date January 22, 1985.
7. U.S. Nuclear Regulatory Commission, Region I, Safety Inspection Report No. 50-293/84-262, November 21, 1984.
8. LER 293/84-015, event date September 29, 1984.
9. LER 255/84-011, event date July 19, 1984.
10. LER 361/84-016, event date March 9, 1984.



ACTION TAKEN SUBSEQUENT TO
ACTUATION OF CONTAINMENT SPRAY
IN UNIT 1 CONTAINMENT
APRIL 14, 1987

1. Inspect polar crane (manual & radio control) electrical junction boxes.
2. Perform a general inspection and wipe down of the following:
 - * General areas
 - * Cable trays
 - * Insulation
 - * Polar crane (motor level, cables, drums)
 - * Refueling machine
 - * Electrical platform
 - * Missile shield (accessible areas)
 - * Vent ducting
 - * RCP motors and studs
 - * Inside pressurizer house
 - * Containment iodine filters
 - * Containment sump
 - * Containment coolers' junction boxes
 - * Reactor coolant pumps' junction boxes
 - * CEDM coolers' junction boxes
3. Perform an operational check of the following:
 - * 69' area radiation monitors
 - * RC drain tank pump
 - * Wide-range nuclear instrumentation
4. Sampled and determined volume of TSP.
5. Performed 18-month surveillance tests on containment iodine filters.
6. Performed resistance measurements on the following:
 - * Cavity cooling fan motors
 - * Containment filter fan motors
 - * CEDM cooler fan motors
 - * Reactor coolant pump motors
7. Inspected and cleaned, as necessary, all electrical equipment with covers removed for Environmental Qualification inspections.

