ENVIRONMENT, SAFETY AND HEALTH BULLETIN

DOE/EH-0697 Issue No. 2005-11 August 2005

Significant Radioactive Leak at Sellafield due to Operational Complacency

***Special Operations Reports** are issued to initiate management actions in response to events whose subject matter represents significant departmental safety concerns.*

***Environment, Safety and Health Alerts** are issued to initiate immediate action on potentially significant safety issues.*

***Environment, Safety and Health Bulletins** are issued to share information and recommend actions on potential safety issues.*

***Operating Experience Summaries** are issued to share lessons learned information, operating experience information, and best practices from significant events or important individual DOE activities.*

PURPOSE

The Office of Environment, Safety and Health is issuing this Environment, Safety and Health Bulletin to provide information about a serious process leak at British Nuclear Group's Thermal Oxide Reprocessing Plant (THORP) in Sellafield, England. Investigators determined that this leak was exacerbated by operators' failure to monitor process indicators.

DISCUSSION

On April 20, 2005, a camera inspection of a feed clarification cell at THORP revealed that 83,000 liters of dissolver solution had leaked from a broken pipe (Figure 1) into the cell sump. The highly radioactive dissolver solution, consisting of approximately 19 metric tons of uranium, plutonium and fission products dissolved in nitric acid, was entirely contained within the stainless steel-lined cell. No personnel were injured as a result of this incident. However, the cleanup costs for this event are expected to exceed $500 million, and the THORP facility faces a lengthy shutdown (possibly even permanent closure).

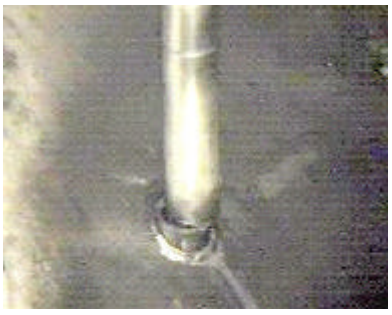

Figure 1. Failed Pipe Nozzle on Accountability Vessel

The stainless steel-lined clarification cell where the leak occurred measures 60 meters long, 20 meters wide, and 20 meters high (about 197 x 66 x 66 feet). Operations management directed the operations team to inspect the cell by camera because of calculated discrepancies in the nuclear material balance and indications of leakage into one of the sumps within the cell. Investigators determined that the dissolver solution had been leaking into the cell for many months, possibly since July 2004. Investigators believe that a pipe, which provides feed to an accountability vessel (tank), suffered a major break on or around January 15, 2005, based on records showing rapid increases in sump level and cell temperature.

The Board of Inquiry that investigated the incident identified design flaws associated with the accountability vessels that led to fatigue failure of the feed pipe. More seriously, the Board also identified multiple conduct-of-operations failures resulting in the failure to detect a persistent leak for 9 months. The Board characterized these failures as a culture of operational complacency. The Board Report can be accessed at http://www.eh.doe.gov/ll/BNFL_THORP_BOI-070705.pdf. The findings from the Board's report are summarized below.

Equipment Design Issues

The accountability vessels are suspended from the cell roof to enable operators to weigh the vessel and determine material balances. The vessels are supported by four rods that pass through the roof to a weighing mechanism (Figure 2). The vessels are normally operated in the suspended position, but they can be lowered onto a steel frame to establish data points or to perform calibrations.

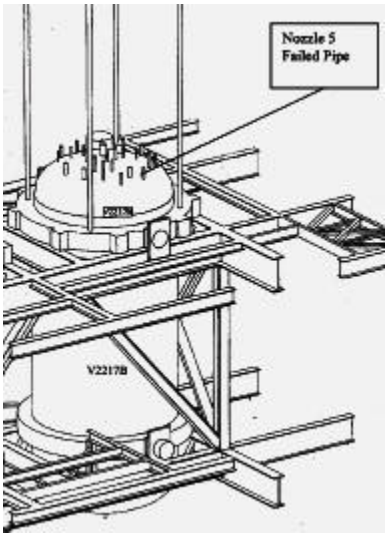

Figure 2. Accountability Vessel Assembly

The original design of these vessels required restraint blocks to prevent lateral movement of the

vessels. The design was changed to delete these restraint blocks, but it appears that the effect of this design change on piping stresses was not evaluated.

Investigators believe the feed pipe failed because of fatigue stresses induced by excessive vessel movement. This is supported by operator observations of excess vessel vibration and in video footage showing significant movement of the vessel during agitation and emptying cycles.

Conduct of Operations Issues

The Board determined that the leakage into the cell should have been detected much earlier. Operators failed to respond appropriately to off-normal conditions, including: nuclear material balance discrepancies, sump samples containing uranium and erratic sump level indicators.

From July 2004 to August 2004, a "Shipper/Receiver" difference fell slightly outside the normal expected tolerance for nuclear material accountancy, but safeguards personnel were not concerned by this small deviation. In March 2005, a significant discrepancy in the material balance occurred, but safeguards personnel believed that the discrepancy resulted from an error in the complex calculation. However, a subsequent calculation in April 2005 confirmed that 19 tons of uranium had been lost from the primary system over the course of three separation campaigns.

Two sumps in the clarification cell are sampled automatically and remotely. In November 2004 and February 2005, two samples showed positive for uranium. Investigators found no evidence that either of these sample results were ever acted upon at the time of discovery.

The sump level is monitored by a pneumatic liquid level indicator that warns operators in the event of a leak. The level indicator has had a history of erratic operation, with over 100 cases of spurious alarms from July 2004 through March 2005. Operators investigated only two of these alarm conditions, and there is no evidence that corrective actions were taken on the instrument.

The level indicator was within the normal range when the camera inspection showed significant quantities of dissolver solution in the cell sump. Investigators later discovered that air flow to the instrument was not set properly, causing the instrument to display levels much lower than actual. They believe that previous maintenance work inadvertently resulted in the low air flow.

Cultural Issues

Operators, safeguards personnel, team leaders, and managers believed that material losses of this magnitude could not have occurred and that it had to be an error in paperwork. Their belief was that because THORP was a "new plant," built to the highest standards with all welded piping and vessels, a leak would be extremely unlikely. Even if a major leak were to occur, they reasoned, the operators would be alerted by the sump alarm. Unfortunately, the sump alarms did not result in appropriate operator response. Investigators found that the "new plant" culture pervades all levels within the THORP organization and has continued despite previous operating experience that demonstrates leaks can and do happen, as illustrated by the following examples:

- In February 2005, three workers were grossly contaminated while changing out a thermocouple in a dissolver because dissolver solution had leaked through the primary boundary into the thermowell pocket.
- In 1998, erosion of an outlet pipe in the dissolver cell resulted in the leak of highly radioactive solution into the secondary containment. This leak went unnoticed for years despite sump-level indication, sump sampling, and contaminated radiological probes that suggested a problem existed.

The Board of Inquiry's view is that plant workers had not fully learned the lessons from these previous events, and continued to maintain an attitude that a loss of containment was not credible.

IMPLICATIONS

The incident at THORP underscores the importance of operator vigilance and strong conduct of operations. The failure to promptly recognize anomalous plant indications, coupled with operators who did not consider the loss of containment to be credible, resulted in a nuclear mishap and significant cleanup effort.

RECOMMENDED ACTIONS

Site managers should ensure that:

- Off-normal operating conditions are appropriately identified and acted upon.
- Equipment design issues are independently evaluated.

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