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LIQUID NITROGEN DEWAR EXPLODES

Liquid nitrogen dewar exploded because of overpressurization on December 23, 1992, in an office building at the Plutonium Processing Facility at the Los Alamos National Laboratory, causing $35,000 in damage. No one was near the explosion. This event was significant because of its potential to cause major injuries and because it raised significant issues of management control, work planning, design, and training. Laboratory managers issued an alert to users of similar cryogenic systems and formed a committee to conduct a Type C investigation. (ORPS Final Report ALO-LA-LANL-TA55-1992-0045)

The explosion occurred in an experimental liquid nitrogen filling system designed by a technician in the Material Control and Accountability Group. The system (see Figure) consisted of an inverted 30-liter dewar, which fed nitrogen into two 1.5-liter dewars used to cool germanium detectors. The nitrogen flowed from the large dewar into the smaller ones through 0.25-inch outer-diameter, stainless-steel fill lines, each of which was equipped with a valve. The large dewar was equipped with a 0.5-inch fill valve and a 0.375-inch outer-diameter vent line.

The technician noticed excessive venting during the first successful attempt to fill the dewar. He halted the second attempt when he saw liquid nitrogen coming out of the vent tube. On the third attempt, the morning of December 23, he filled the flask more slowly to reduce the rate at which the liquid evaporated. Three times during the day, office workers in a nearby room heard a sound similar to a coffee percolator in the room where the dewar was located, but the technician assured them that this was normal. Another staff member heard similar sounds, investigated, found liquid venting from the pressure relief valve on the detector dewar, and notified the technician, who again stated it was normal. The technician topped off the large dewar at 1630 hours, and all workers left the building by 1715 hours, the end of the normal working day. Motion detectors alarmed three minutes later, security personnel investigated, and they found the wreckage left by the explosion.

Investigators determined that an obstructed vent line caused the inner vessel of the dewar to rupture, which allowed the liquid nitrogen to contact the outer vessel. Heat from the outer vessel vaporized the nitrogen, causing the explosion. Investigators believe a cap screw threaded into the end of the vent line after the dewar was topped off with nitrogen created the obstruction because photographs taken during the investigation show thread marks inside the vent line.

Investigators found that the flawed design of the gravity feed system contributed to the explosion. The valves used for the fill system were not cryogenic. The filler cap was made of aluminum and was not insulated, causing the nitrogen to boil off quickly. The vent line passed through the liquid nitrogen, allowing a freeze plug to form from condensation in the tube. The dewar flask was inverted to fill the germanium detector dewars, which placed abnormal structural loads on the fiberglass sleeve between the inner and outer vessels. In addition, the vent line did not provide adequate relief for the nitrogen, which expands by a factor of about 700 when it evaporates.

Investigators determined that a lack of training also contributed to the explosion. No one in the Group was formally trained or qualified to design equipment, nor was the fabricator qualified to construct cryogenic equipment. They were also unaware of the expansion ratio of liquid nitrogen when it evaporates, as well as the requirement for review of the design by the Industrial Hygiene and Safety Group.

Investigators concluded that the root cause of the occurrence was a deficiency in work organization and planning. The group manager selected new detectors with 1.5-liter dewars to replace detectors with 7.5-liter dewars. A need to keep the dewars cold over long shutdowns prompted the design of the filler system, but no one considered this when

instead of buying one because of cost. No one realized that fabrication of apparatus was a significant change in their operation, and they failed to obtain approval for the equipment design or fabrication. The group manager did not adequately supervise the design or fabrication of the system. Finally, the building landlord was unaware of the activities taking place.

The group leader initiated several corrective actions as a result of this event. He instructed all personnel in writing that any new activity or change in existing operation, other than routine office activity, must be reviewed by the section leader. He arranged for the technicians involved in the incident to receive cryogenic and pressure safety training and for a commercial fill system to be purchased. He had a safe operating procedure governing the use of liquid nitrogen developed and established a system of annual safety inspections and daily facility walkdowns.

Liquid nitrogen dewars are used throughout DOE, and there have been several other incidents of dewar failure caused by overpressure. The most recent was on August 8, 1995, when overpressurization of an automated nitrogen fill system at Savannah River Chest Count Facility resulted in burst fill lines and failure of the nitrogen dewars. (ORPS Final Report Number SR--WSRC-HPIH-1995-0005)

Several lessons were learned from this event. Employees must be responsible for analyzing their qualifications and notifying their supervisors if they are unable to perform their assignments. Supervisors must assure that personnel assigned to a project are qualified and routinely monitor the work performance of those involved in hazardous work. Managers are responsible for assuring that personnel assigned to them are in compliance with safety requirements, that designs are reviewed, and that work is properly planned.