Florida State University/National High Magnetic Field Laboratory – Worker Fatality During Attempted Removal of Blind Flange on Cell 14 Magnet Cooling Water System

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Statement: A pneumatic butterfly valve believed to be in a CLOSED position, may not be positively seated, resulting in leakage and pressure buildup in a high pressure water system. An adequate lock/tag/verify process (LTV), including lockout and tagout of all necessary isolation points and comprehensive zero energy verification, is absolutely critical prior to any work on the system.

Hazard(s): Mechanical stored energy, Exposure of personnel to mechanical injury.

Discussion: On October 21, 2015, two National High Magnetic Field Laboratory (NHMFL) mechanical technicians were involved in an incident while attempting to remove a Victaulic blind flange from supply piping on a Magnet Cooling Water (MCW) System. The mechanical technicians were assisting a welder to obtain final measurements to make final connections from the MCW system to a new Cell 14 cryostat as part of the Series Connected Hybrid magnet project. When loosening the nuts on the Victaulic flange collar, an explosion occurred. The flange, the water behind the flange, or some combination of both, struck and propelled one mechanical technician backward and into the metal support structure for the cryostat, resulting in his death. A second technician, who was approximately 10 feet away at the time of the explosion, sustained minor injuries.

Following the accident, it was discovered that a compressed air valve that delivers the compressed air needed to positively seat the pneumatic MCW butterfly valve was in a CLOSED position, and thus was not delivering compressed air to positively seat the pneumatic butterfly valve. Leakage of water past the valve caused high pressure water (~325 psig) to compress the air in the supply piping. As such a combination of pressurized water and pressurized air built up behind the Victaulic flange. The total stored energy from the compressed air and water was estimated to be about 1.4 million ft-lbf, which is equivalent to about 0.9 pounds (0.4 kg) of TNT explosive.

Analysis: Zero energy verification was initially performed for this segment of the MCW system when LTV was first established, approximately two weeks prior to the incident. Although the water drain and vent valves on the MCW supply piping were initially opened when the LTV was first established, neither of these valves nor the compressed air valve were locked into their OPEN positions. The Victaulic flanges were successfully removed and re-installed several times over the first week that the LTV was in force. During the second week, the LTV was placed into a “retest” status so that electricians could troubleshoot issues related to the solenoid actuators on the pneumatic butterfly valves. Upon completion of the electrical work, the LTV was re-established; however a re-verification to confirm zero energy in the system was not performed. Also, sometime during this period, the compressed air valve needed to seat the pneumatic butterfly valve was closed. It is unknown when this valve was closed. This, combined with the fact that there was no reverification to confirm zero energy prior to work being performed, led to the incident. Causal factors identified included:

- There was no physical re-verification performed by the Primary Authorized Employee to confirm zero energy in system prior to work being performed.
- There was no single person coordinating the day-to-day tasks for project construction, including all systems that are tied into Cell 14.
- Personnel relied on an ineffective LTV process in their efforts to eliminate hazards.
- Work planning and control for the MCW tie-in activity was less than adequate. Documents utilized for hazard mitigation for the work in Cell 14 reduced the apparent risk down to a point that called for no additional reviews by subject matter experts or safety personnel.
- Workers lacked a comprehensive understanding of the MCW system.
- The MCW Cell 14 system was not designed with positive isolation points to enable complete and verifiable separation of high-pressure water from the worker.
- Human factors, including labeling of piping, valves, and visual indicators, were not well integrated into the MCW system design.

Actions: Recommendations related to this incident are the following:

- System-specific, detailed step-by-step LTV procedures must be provided that positively confirm zero energy in system prior to work being performed.
- Appropriate instrumentation to indicate the presence of stored energy in the system is needed, not just in the final configuration, but during the construction phase.
- Detailed Piping and Instrumentation Diagrams (P&ID) should be generated and well-understood by workers.
- During construction, from inception to closeout, a person who has knowledge of every aspect of work coordination, e.g., water, pipes, valves, electrical, etc., must have a daily interaction with all workers so each person understands how their work may impact a set of workers focused on a different aspect of the project.
- A comprehensive LTV program commensurate with the complexity of the system (reference OSHA 1910.147 for best practices) is needed. Written programs should not be confused with written system-specific procedures needed for de-energizing equipment. The program also needs to address high risk items such as cryogens, high pressure and high voltage de-energization. Roles and responsibilities should to be clearly stated. Steps necessary to define the process when personal lock(s)/tag(s) need to be removed by those other than the originator should also be addressed.
- All isolation points must be locked in a safe position. Physical lockouts of butterfly, water, drain and vent valves should be included when appropriate.
- Ensure through engineering design review that appropriate positive isolation points have been incorporated into system designs and that all credible failure scenarios have been

identified and have proper controls in place to mitigate stored energy potential. Consider whether:

- Block valves are needed to isolate the process side still in service from the maintenance side. Blind(s) may also be needed to further isolate the system, in combination with a bleed valve to drain/vent any fluid trapped between the block valve and the blind;
- Actuators meet desired failure mode(s), when pneumatic valves are used;
- Pressure and temperature gauges are installed wherever appropriate, and referenced in appropriate Standard Operating Procedure(s); and,
- Compressed air supply pressures for pneumatic valve actuators are designed to be lower than the maximum values listed on the valve nameplates.

- System design should include, at a minimum (reference ASME A13.1 for best practices), standardized labeling, such as directional arrows to indicate fluid flow, indication of valve numbering, indication of whether valves are "normally open" or "normally closed", and detailed P&IDs.
- Formality of work control should consider both the complexity and consequence of the tasks to be performed. For example, complexity of a system LTV should be handled at a higher level of rigor to ensure adequate safety review by appropriate subject matter experts.
- Personnel should have complete knowledge of the system, including all the valves, indicator lights, and their meaning in terms of open or closed.

Keywords: Stored energy; Lockout/Tagout process; LTV process; work planning and control; pressure; compressed air; chilled water.