Fermilab

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Memorandum

June 15, 2015

To: Martha E. Michels
Chief Safety Officer

From: Terry E. Tope
Chair Mechanical Safety Subcommittee

Subject: Final Incident Report – Employee Injured While Calibrating A High Pressure Relief Valve

The Team has completed the final report for the subject incident.

The final HPI database entry can be found here:

https://www-bd.fnal.gov/cgi-msd/admin/hpiForm.pl?hpiID=80&urlDeptID=

Supporting materials, interview minutes and photos available here:

https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=3072

The final response to the charge is included in this memo.

Sincerely,

Terry Tope

On behalf of the Team

cc:
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Team Members
Team Chair: Terry Tope, Mechanical Safety Subcommittee Chair
Member: Mike Bonkalski, ESHQ Manager, HPI Certified SME
Member: Eric McHugh, Division Safety Officer, HPI Certified SME
Member: Tom Nicol, Engineer
Member: Kurt Krempetz, Engineer
Team Observers: Michael Herr and Alan Harris, FSO

Charge:
Please conduct the investigation using the HPI methodology and prepare a report that addresses (at a minimum) the following issues:

What was the cause of the event?
The technician did not thread the pipe thread connection properly resulting in inadequate thread engagement. Approximately three threads were engaged when at least five threads were required by code. The three engaged threads were not strong enough to hold the valve at the test pressure. Thread engagement, rather than torque, determines proper threading of a pipe thread joint. The pipe thread connection was comprised of stainless steel components. Stainless on stainless threads have a tendency to gall if tightened without lubricant, or if over tightened. Although the Teflon tape wrapped around the threads should provide adequate lubrication and is necessary for sealing, the technician was concerned about galling the threads and damaging the customer's relief valve. This concern contributed to the inadequate thread engagement. The technician tightened the threaded joint using the relief valve discharge pipe instead of an appropriate wrench such that the relief valve was tightened with inadequate leverage. Concern with respect to the potential to gall likely made the use of an improper tool acceptable to the technician who did not want to over tighten the joint. Had the threaded joints been leak checked at low pressure the limited thread engagement likely would have been discovered due to leakage and the incident avoided. The relief valve cycled and shook violently (chattered, not unusual for a relief valve to chatter in typical service or in testing) and may have exacerbated the result of inadequate thread engagement, but this was not the root cause of the event. The Culpability Decision Tree was evaluated and the incident was found to be a System Induced Error.

Is there any indication that S/CI are involved?
There is no indication that S/CI are involved. However the pipe fittings do not have identifying markings that would make S/CI identification possible thus the team cannot rule out S/CI for sure. It is possible to purchase threaded pipe fittings with identifying markings such as pressure rating but this is not required nor is it lab procurement policy to purchase threaded pipe fittings with identifying markings. However for a test stand which operates over a wide range of pressures, it is recommended to utilize adaptor fittings with clearly indicated pressure ratings.

What is the extent of condition?
Is this the only test stand of this type on site?

- Two additional test stands were identified and visited by the committee.
- A test stand in Technical Division located at IB1 is used to both test and calibrate relief valves with set points of less then 300 psig. This test stand is used 20-30 times per year.
- A test stand in Accelerator Division located at CHL is used to test relief valves with set points of less than 1,500 psig. Valve adjustments are not made using this test stand. If adjustment is needed, valves are sent off-site. The operator interviewed did not recall testing any relief valves at a pressure higher than 475 psig. This test stand is used sparingly now that CHL does not regularly operate. This test stand had the most complete documentation.

Are there other activities with high hazard and limited frequency that are self-performed by the Lab?

- Load tests of cranes.
- Pressure tests of vessels and piping.
- Electrical vault entry.
- Pressure tests of vessels and piping are frequent and on the order of monthly. Pressure tests are carried out only after an engineering peer review and DSO approval. A pressure testing permit is required for the test and serves as the procedure and hazard analysis for each pressure test. Ordinarily, D/S safety personnel are asked to witness pressure tests of vessels and piping and are present during testing.
- Load tests of cranes and electrical vault entry are less frequent and on the order of annually.
- These three high hazard activities must be conducted on the FNAL site.

What is the frequency of these tests and must they be conducted on the FNAL site?

- Pressure testing of relief valves with set points in excess of 1,000 psig has happened 27 times since January of 2013 in the PAB Calibration Shop.
- These 27 occurrences include some relief valves adjusted multiple times.
- Pressure testing and/or calibration of relief valves at all set points has happened approximately 164 times since January of 2013 in the PAB Calibration Shop.
- Fermilab sends some pressure vessel relief valves off site for calibration if these relief valves must be calibrated by a certified ASME code shop or if they are larger than our facilities can handle for testing. Fermilab is not able to certify ASME code stamped valves.
- However Fermilab does test pressure vessel relief valves to see if the relief valves are within specification. Sending pressure vessel relief valves off site for testing only would impact operations due to the 1-2 week turn around typical of such services.
- Sending the relief valves off site for testing in addition to calibration does not eliminate Fermilab making up the high pressure threaded joint which was the root cause of the incident. When the high pressure relief valve returns from offsite testing Fermilab must reattach it to the system and typically this is a threaded connection. Sending the relief valves off site would eliminate repeated use of adaptors on a test stand. However wear of pipe thread fittings was not a contributing factor to this incident.
- Fermilab calibrates relief valves for pressure tests and for installation on piping systems. These relief valves are not required to be calibrated by an ASME code certified shop.
- Its not uncommon for relief valves for pressure tests to require multiple calibrations to adjust set pressures or mitigate leakage such that sending the valves off site would be an operational impact.
- For many systems Fermilab requires relief valves to be helium mass spectrometer leak tight. Relief valve manufacturers do not specify relief valves as helium mass spectrometer leak tight nor do they have this test capability. Thus Fermilab often performs helium mass spectrometer leak checks before and after actuating the relief valve to verify its suitability for systems which must be absolutely leak tight.

In conclusion, although it is possible to send all relief valve work off site, the investigation team recommends testing and calibration of relief valves continue at Fermilab at all pressures once the recommendations from this investigation have been implemented due to the negative operational impact of sending this work off site.

What is the appropriate PPE/ mechanical enclosure/set back or exclusion zone for this activity?

- Hearing protection.
- Safety eyewear.
- An exclusion zone to prevent entry into the test area by non-test personnel. The exclusion zone should be determined by the local DSO and local engineer for each test stand, taking into account the physical layout of the area around the test stand.
- When pressure tests of systems are performed at Fermilab these tests utilize an exclusion zone to protect personnel from system failures. On the pressure relief valve test stand the operator must interact with the relief valve such that a relief valve restraint takes the place of the operator exclusion zone.

Was the hazard analysis and work control procedure in place at the time of the test?

- A hazard analysis was not in place.
- A procedure was in place but lacked sufficient detail. The procedure did not require checking for proper thread engagement nor did the procedure call for a low pressure leak check. Either one of these details likely would have prevented the incident.

What are the lessons learned from this event?

- Procedures for proper pipe thread joint threading and for subsequent pre and post inspection of the fittings and system should be communicated to the lab's technical population. Interviews suggest this has not been adequately communicated.
- Proper tools must be used to tighten pipe thread fittings.
- Pipe thread joints should be leak checked at low pressure before proceeding to high pressures.
- A complete and detailed hazard analysis and procedure must be in place.

What error precursors existed before this event took place?

- Inaccurate risk perception – Had the technician thought about the stored energy the pipe fittings might have been tightened correctly.
- Complacency / Overconfidence – The technician had tightened the pipe threads without the proper tools the prior day and the test was successful which led to complacency and overconfidence. The technician successfully tightened 27 relief valves tested at a similar pressures such that this test felt routine.
- Unexpected equipment conditions – The correct tools for tightening the pipe fittings had been borrowed by another technician for use in the field.
- Workarounds / OOS instruments – Without the proper tools on hand the pipe fittings were tightened using the vent pipe of the relief valve which did not provide as much leverage as the correct tools would have. The pipe thread joint felt tight when it was not fully tightened.

What organizational weaknesses exist that may indicate other areas that are vulnerable?

- Lack of pipe thread joint training is an organizational weakness.
- Lack or inconsistent use of hazard analysis and lack of or insufficient procedures is another organizational weakness.

What corrective actions do we need to implement to ensure this does not recur?

Recommendations 1-2 are required to resume pressure relief valve testing operations.

1. All three test stands at the lab should have adequate hazard analysis and procedures. These procedures should include:
    a. Documenting adequate thread engagement for threaded joints
    b. Leak checking of threaded joints at low pressure
    c. Adjustment of relief valves only when test stand is depressurized
    d. Utilization of adaptor fittings with a pressure rating indicated on the fitting
    e. Eye protection and hearing protection
    f. An exclusion zone which can only be entered by the test stand operator when tests occur.
    g. Dissimilar metal adaptor fittings should be available at the pressure relief valve test stands to encourage operators to fully tighten the threaded connections without fear of galling.
    h. Go-no-go gauges should be available at the test stands to periodically check the condition of pipe threads which see repeated use.
2. A lessons learned should be communicated which discusses proper threading of a threaded joint. The lessons learned should also discuss the pressure rating of pipe fittings which the investigation found in inappropriate service. It should be mandatory that supervisors of technicians performing this type of work discuss the lessons learned at a tool box meeting.
3. Proper threading of a pipe thread joint and the pressure rating of common gas fittings should be added to the Lab's compressed gas training class. A refresher requirement for this training should be implemented to remind users of high pressure equipment the hazards involved. The goal of this refresher is to reduce the complacency that often develops after years of incident free use of compressed gasses. This recommendation is not required immediately to resume test stand operations.

The team feels that if the above recommendations are implemented the incident will not occur again such that a relief valve restraint system or barrier is not necessary. The team visited a vendor which tests thousands of relief valves each year and the vendor did not utilize relief valve restraints. Commercial relief valve test stands are available for purchase and these do not include a relief valve restraint. However a relief valve restraint would offer an additional level of protection against such an incident occurring again. Design of a relief valve restraint is beyond the scope of this team and would require engineering design to ensure effectiveness.