



OREGON FATALITY ASSESSMENT AND CONTROL EVALUATION

www.ohsu.edu/croet/face

Center for Research on Occupational and Environmental Toxicology



Fatality Investigation Report

OR 2011-16-1

Millwright fatality involving a hydraulic accumulator

SUMMARY

A 61-year-old senior millwright with over 32 years of experience was killed, and 2 other millwrights were injured, while trying to disassemble a hydraulic accumulator to rebuild it. The victim had previously rebuilt at least one other accumulator salvaged from another part of the mill. He was viewed by everyone, including managers, as the expert in this task. Warning labels on the accumulator and in the rebuild kit instructions stated that all gas pressure must be released prior to disassembly. However, this step was skipped in the disassembly process and pressurized nitrogen gas remained in the accumulator. While the victim was slowly removing an 8-inch diameter cap from the end of the accumulator, the cap violently exploded off the cylinder and hit the victim in the abdomen and pelvis. The flying cap killed the victim. His co-workers were injured by the cap and related debris.



Warning label on the side of the hydraulic accumulator warns that contents are under pressure and should be released by opening and removing the gas valve prior to disassembly.

RECOMMENDATIONS

- Employers should ensure employees follow manufacturer's recommendations and confirm all pressure is released prior to performing any maintenance work on pressurized systems and components (in this case both hydraulic and gas).
- Install a "dump valve" in hydraulic systems to ensure hydraulic energy is released from the system when the equipment is shut down.
- Employers should ensure that all employees are trained to recognize the potential hazard of stored energy and how to eliminate or control it.
- Employees should be empowered to stop work and re-evaluate a situation whenever potentially hazardous or unusual methods are being used to accomplish a task.
- Manufacturers or employers should consider altering the placement of warning labels, or applying additional labels or seals, on the cap area of accumulators to ensure they remain visible while removing the caps.

Keywords: General Industry, Pressurized Machinery [NAICS=321113]

Publication Date: November 2013

This report is public information and free to copy

Oregon FACE Program

OR 2011-16-1

Page 1

- **Warning labels are a necessary form of safety communication, but label messages should be reinforced in the workplace through additional person-to-person communication.**

OR-FACE supports the prioritization of safety interventions using a hierarchy of safety controls, where top priorities are hazard elimination or substitution, followed by engineering controls, administrative controls (including training and work practices), and personal protective equipment.

INTRODUCTION

In May 2011, three millwrights were in the process of rebuilding a hydraulic accumulator. One was killed and the other two sustained serious but non-life threatening injuries (concussion, multiple fractures to arms). OR-FACE was notified of the event by the Oregon Public Health Program and obtained medical examiner, police, and OR-OSHA field and inspection reports to complete the investigation. In addition, OR-FACE contacted the manufacturer of the hydraulic accumulator and obtained and reviewed their bulletin and maintenance instructions in addition to reviewing information from manufacturers of similar accumulators.

The employer was operating a hardboard/stud mill. There were approximately 211 employees at this mill, and approximately 600 total employees working at a number of mills in Oregon.

A 61-year-old millwright with over 32 years of experience and over 37 years with the employer, was rebuilding a hydraulic accumulator that he had salvaged from another part of the mill. According to company managers he had successfully rebuilt at least one other accumulator prior to the incident, believed to be of the same (or similar) type based on photographs of accumulators at the worksite. The employer and other millwrights viewed the deceased as the expert at this task and he was the only worker who rebuilt accumulators for the company.

Hydraulic accumulators are used in equipment and processing systems throughout general industry, construction, and agriculture to provide a separate reservoir of pressurized fluid which supplements pump flow, provides stored energy, dampens shock loads and pulsation in hydraulic systems, and can also act as an auxiliary power source. In operation, pressurized hydraulic fluid enters the accumulator chamber where, depending upon the type of accumulator, it either compresses a spring, raises a weight, or compresses a gas. Pressure drops at the chamber inlet allowing the spring, weight, or compressed gas to discharge the fluid back into the system. The accumulator in this incident was a gas type having a hydraulic fluid chamber and gas chamber separated by a piston. The manufacturer's maintenance procedures are to release the pressure from both the hydraulic fluid chamber and the nitrogen gas chamber of the accumulator prior to disassembly. Releasing both hydraulic and gas pressure involves two separate steps, each performed at opposite ends of the accumulator.

None of the employees interviewed believed the deceased would have worked on the accumulator without releasing the gas pressure at the start of the process. The directive to

release gas pressure was stated in warning labels on the side of the accumulator, and in the maintenance and repair kit bulletin.

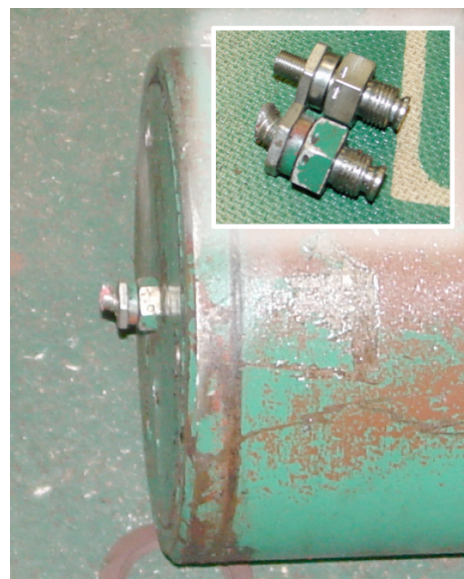
The victim was described repeatedly as experienced in working with this type of equipment and had rebuilt them in the past without incident. Employees and managers interviewed had worked with the deceased for a number of years, and all agreed there was nothing out of the ordinary in the victim's demeanor or behavior on the day of the incident.

INVESTIGATION

On the day of the incident, the employee behaved and acted normally. No one who was in contact with him noted anything out of the ordinary. The employee was known for "trying to do jobs safely." As confirmation of the victim's orientation to following procedures, he had completed a hot work permit in advance of using an oxy-acetylene torch to heat the end of the hydraulic accumulator cap on the day of the incident. The victim was described repeatedly as experienced and had been working with this type of equipment for years. He had rebuilt at least one similar unit in the past without incident.

As per the rebuilding kit instruction manual, once the gas has been released using the manufacturer recommended charging and gauging assembly, the gas valve must be removed. After removal of the gas valve, the accumulator can then be strapped down in order to release hydraulic pressure and remove the hydraulic end cap on the opposite end. The gas pressure release valve (shown at upper right) is the only externally visible part of the accumulator in addition to the hydraulic valve end cap (lower photo in red circle), and it functions similarly to a bike tire or "schrader" valve. It is used to add nitrogen and to bleed off gas pressure. Evidence suggested that the damage to the valve as shown in the photo at right occurred when the accumulator flew off the table during the incident.

However, Oregon OSHA investigated the functionality of the damaged gas pressure release valve. Some orange/red material was wedged in the valve, so it was investigated whether the valve port was plugged with debris. No evidence was found to show a plugged valve port. The valve also includes an engineering control feature, which



ABOVE: Gas pressure release valve in incident, believed to be damaged when accumulator flew off the table. Shown removed next to a new valve.

BELOW: Hydraulic accumulator (same model as in incident) with hydraulic pressure end cap shown in the red oval.



is a small hole bored through the side of the valve body that will relieve accumulator pressure as the valve is removed, should pressure still exist from port blockage or failure to release. However, evidence was clear that the valve had not been removed before the fatal attempt was made to disassemble the accumulator.

Based on the witness interviews, the accumulator had been strapped to a metal workbench. It is unknown if the side-located warning label was visible to the victim after the accumulator had been strapped to the bench. A steel plate adapter with a large nut welded to the center had been bolted onto the end cap (in red circle in photo on prior page) so a socket “breaker bar” wrench could be attached to help turn the cap. A “cheater bar” had been attached to the breaker bar for even more

leverage and one millwright was assigned to apply pressure to the cheater bar. A pipe wrench had also been placed over the socket. The deceased hooked the pipe wrench to a small electric hoist that was also applying pressure to the cap and a second assistant millwright was helping to hold the pipe wrench. With time and considerable effort the cap was slowly unscrewed and was almost completely off when the pressurized nitrogen gas caused the cap to “explode” off the end of the accumulator. Actual gas pressure was unknown, but presumed to be up to 750 psi, which is the normal operating pressure specified by the manufacturer. The deceased was standing directly in front of the cap when it released and was struck in the pelvic area by the cap and other tools, and his right femoral artery was lacerated. The other two millwrights sustained non-life threatening injuries from being struck by other flying tools.

Neither of the two millwrights thought to ask if the pressure had been released. However, they were not trained to perform this task, and may not have seen the warning labels. While earlier heating of the cap with an oxy-acetylene torch was initially considered a potential contributing factor by the OR-OSHA investigator, he concluded that this was not a factor and identified the pressurized gas in the accumulator as the direct cause of the incident.

CAUSE OF DEATH: Blunt force pelvic trauma with laceration of right femoral artery and exsanguination hemorrhage.

RECOMMENDATIONS/DISCUSSION

Recommendation # 1: Employers should ensure employees follow manufacturer recommendations and confirm all pressure is released prior to performing any maintenance work on pressurized systems (in this case both hydraulic and gas).

- There were two warning labels on the accumulator stating the nitrogen gas had to be released prior to performing repairs. This is also mentioned in the service bulletin that was in the shop. A pressure gauge was available in the shop that if used, would have



Shelf damaged by flying tools demonstrates violent nature of the event.

confirmed the gas had not been released. The fact that the valve was still installed may have also lead to the same conclusion, had the significance of that been understood by the millwrights. Releasing all stored energy prior to work is also required as part of the OR-OSHA lockout/tagout rules (see references 1 and 2).

Recommendation # 2: Install a “dump valve” in hydraulic systems to ensure hydraulic energy is released from the system when the equipment is shut down.

- Manufacturers offer and recommend the use of a “dump valve” as part of the installation of hydraulic accumulators. The manufacturer’s maintenance document from includes recommendations for their use (see reference 3). The benefit is that when making adjustments or performing maintenance the dump valve will release the hydraulic pressure from the system when power is removed from the system allowing hydraulic components such as accumulators to be safely removed.
- However, the dump valve will not release the gas inside the accumulator which must be must be safely released, and the gas valve removed, prior to starting service or repair work.

Recommendation # 3: Employers should ensure that all employees are trained to recognize the potential hazard of stored energy and how to eliminate or control it.

- According to the employer and employees, the deceased was the expert and the only person on site with the knowledge of how to safely perform the work. It’s impossible to know that if others had been trained and knowledgeable whether or not they would have questioned his actions, asked to confirm the gas had been released, or noted the gas valve was still attached to the cap. However, if more workers had been trained these preventive actions may have been more likely to occur, and may have prevented the fatality.
- In this incident, workers employed several improvised methods in response to difficulties removing the hydraulic end cap. Methods employed included heating the cap, attaching a breaker bar, adding a “cheater bar” to the breaker bar, and using a small electric hoist. While all of these problem-solving techniques may be common in a shop environment for disassembling equipment, they provide further evidence that workers did not recognize the hazard of pressurized gas in the accumulator.

Recommendation #4: Employees should be empowered to stop work and re-evaluate a situation whenever potentially hazardous or unusual methods are being used to accomplish a task.

- Employees should be empowered to stop work if improvised or unusual work methods cause concern for injury. In the current case the victim’s co-workers did not express concern about their safety, but it was novel for them to be asked to assist with this task. Workers should be encouraged to stop work and discuss normal and/or safe operations for unfamiliar tasks before proceeding.

Recommendation #5: Manufacturers or employers should consider altering the placement of warning labels, or applying additional labels or seals, on the cap area of accumulators to ensure they remain visible while removing the caps.

- Changing the warning label location so it is readily visible when attempting to remove the cap may prevent fatalities of this type. The label explicitly stated the potentially fatal nature of the hazard “Failure to read and follow these instructions can cause rapidly discharging gas and/or hydraulic fluid which can result in death, property damage or injury.” However, it’s unknown if the label located on the side of the accumulator was visible to the victim once the accumulator had been laid on the work bench. Relocating the label to the ends, or requiring the worker to break a seal that included this warning, might increase the chance that the warning would be viewed and followed.

Recommendation #6: Warning labels are a necessary form of safety communication, but label messages should be reinforced in the workplace through additional person-to-person communication.

- Warning labels are a valuable form of safety communication, and a great deal of research has been invested to inform the design of labels so that they influence worker awareness and behavior (see reference 4). However, warning labels are necessary, but generally not sufficient, to sustain best safety practices in a workplace. People habituate to and are less likely to notice labels that are viewed repeatedly in a familiar environment (see reference 4). For this reason labels alone are not likely to serve a reliable “error trapping” function that prevents workers from missing critical steps in procedures.
- The control practices for the hazard specified in warning labels would literally have saved a life in the current incident. Life threatening hazards and control practices should be reinforced through additional forms of safety communication at work in order to sustain best practices or trap occasional errors or missed steps that expose workers to risk. This includes formal safety tool box talks or trainings that review a hazard and best safety practices, but also includes people informally reminding each other about hazards and how to control them while they work.

REFERENCES

1. Oregon OSHA (2010). Oregon Administrative Rules, Chapter 437. Division 2 General Occupational Safety & Health Rules: The Control of Hazardous Energy (Lockout/Tagout). 1910.147. Available online: http://www.cbs.state.or.us/osh/pdfs/rules/division_2/div2_j.pdf#page=79
2. Oregon OSHA (2009). Hazardous Energy: Oregon OSHA's guide to controlling hazardous energy. Available online: <http://www.cbs.state.or.us/osh/pdfs/pubs/3326.pdf>
3. Parker Hannifin. (n.d). Hydraulic Piston Accumulators Maintenance Instructions. Available online: http://www.parker.com/literature/Global%20Accumulator%20Division/Catalogs%20&%20Bulletins/GAD%20HY10-1630%205-2012/HY10_1630US_5_2012-Maintenance_Instructions.pdf
4. Wogalter, M.S., V.C. Conzola, and T.L. Smith-Jackson (2002) Research-based guidelines for warning design and evaluation. *Applied Ergonomics*, 33, 219–30.

FOR MORE INFORMATION

OR-FACE/CROET L606
Oregon Health & Science University
3181 SW Sam Jackson Park Rd
Portland OR 97239-3098

Phone 503-494-2281
Email: orface@ohsu.edu
Website: www.ohsu.edu/croet/face/

Oregon Fatality Assessment and Control Evaluation (OR-FACE) is a project of the Oregon Institute of Occupational Health Sciences (formerly CROET) at Oregon Health & Science University (OHSU). OR-FACE is supported by a cooperative agreement with the National Institute for Occupational Safety and Health (NIOSH) (grant #2U60OH008472-06) through the Occupational Public Health Program (OPHP) of the Public Health Division of the Oregon Health Authority.

OR-FACE reports are for information, research, or occupational injury control only. Safety and health practices may have changed since the investigation was conducted and the report was completed. Persons needing regulatory compliance information should consult the appropriate regulatory agency.

The prior report is the product of our Cooperative State partner and is presented here in its original unedited form from the state. The findings and conclusions in each report are those of the individual Cooperative State partner and do not necessarily reflect the views or policy of the National Institute for Occupational Safety and Health.