WASHINGTON State FACE Program
Fatality Assessment & Control Evaluation

FATALITY INVESTIGATION REPORT

INCIDENT FACTS

DATE:
July 2012

TIME:
4:40 p.m.

VICTIM:
64-year-old maintenance mechanic

INDUSTRY/NAICS CODE:
Manufacturing/ 33

EMPLOYER:
Aluminum foil processing facility

SAFETY & TRAINING:
There was a written hazardous energy control program, but it did not include isolating the system from retained liquid under pressure

SCENE:
Boric acid evaporation system

LOCATION:
Washington State

EVENT TYPE:
Burn

REPORT #: 52-43-2018
REPORT DATE: 07/10/2018

Maintenance Mechanic Dies After Being Burned by Hot Boric Acid Solution While Removing Pump

SUMMARY

In July 2012, a 64-year-old maintenance mechanic at an aluminum foil processing facility died after being exposed to an approximately 180-degree Fahrenheit solution of boric acid and water while trying to remove a recirculation pump from its housing.

The pump was part of a boric acid evaporation system. Workers believed that the system had been completely drained. As the victim and other workers used two 1.5-ton “come-along” puller devices to free the pump from its housing, a small amount of hot water/boric acid solution fanned out from around the seal. Seconds later, the force of the solution pushed the pump out of the housing, and hundreds of gallons of hot liquid flowed out. The victim fell to the floor and was covered with the solution. He was wearing no personal protective equipment other than safety glasses, and received severe burns to over 80% of his body. He died two days later due to his injuries.

RECOMMENDATIONS

Washington State Fatality Assessment and Control Evaluation investigators concluded that to protect employees from similar exposure hazards, employers should:

- Design new equipment for manufacturing processes using the concept of Prevention through Design (PtD) to control risks by incorporating prevention methods in the final product.

- Enforce a comprehensive written hazardous energy control program. Train all potentially exposed workers in the hazardous energy control procedures for the system, and document training.

- Develop written standard procedures for regular maintenance operations. These should include information about hazards, required PPE, necessary safety checks, lockout/tagout procedures, and coordination with other workgroups to be done prior to beginning the task. Ensure that all workers performing maintenance tasks are trained on the procedures.

- Ensure that workers who may be exposed to hot liquids are provided with and use the proper personal protective equipment (PPE) for the job, including appropriate eye/face, hand, and body protection.

DEFINITIONS

ANSI	American National Standards Institute
APP	Accident Prevention Program
ASSE	American Society of Safety Engineers
DOSH	Division of Occupational Safety and Health
L&I	Washington State Department of Labor and Industries
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PHA	Process Hazard Analysis
PPE	Personal Protective Equipment
PSM	Process Safety Management
PtD	Prevention through Design
SHARP	Safety and Health Assessment and Research for Prevention
WA FACE	Washington State Fatality Assessment and Control Evaluation

WASHINGTON State FACE Program
Fatality Assessment & Control Evaluation

CONTENTS

WASHINGTON STATE FACE PROGRAM INFORMATION

The Washington State Fatality Assessment and Control (WA FACE) program is one of many workplace health and safety programs administered by the Washington State Department of Labor & Industries' Safety & Health & Research for Prevention (SHARP) program. It is a research program designed to identify and study fatal occupational injuries. Under a cooperative agreement with the National Institute for Occupational Safety and Health (NIOSH grant# 2U60OH008487), WA FACE collects information on occupational fatalities in WA State and targets specific types of fatalities for evaluation. WA FACE investigators evaluate information from multiple sources. Findings are summarized in narrative reports that include recommendations for preventing similar events in the future. These recommendations are distributed to employers, workers, and other organizations interested in promoting workplace safety. NIOSH-funded, state-based FACE programs include: California, Kentucky, Massachusetts, Michigan, New York, Oregon, and Washington. WA FACE does not determine fault or legal liability associated with a fatal incident. Names of employers, victims and/or witnesses are not included in written investigative reports or other databases to protect the confidentiality of those who voluntarily participate in the program.

Additional information regarding the WA FACE program can be obtained from:

www.lni.wa.gov/Safety/Research/FACE
PO Box 44330
Olympia, WA 98504-4330

SUMMARY

In July 2012, a 64-year-old maintenance mechanic at an aluminum foil processing facility died after being exposed to an approximately 180-degree Fahrenheit solution of boric acid and water while trying to remove a recirculation pump from its housing.

The pump was part of a boric acid evaporation system. The system took several days to completely cool through draining and flushing before it was safe to remove the pump. Workers in another department reported that they had completed draining the system.

As the victim and other workers used two 1.5-ton “come-along” puller devices to free the pump from its housing, a small amount of hot water/boric acid solution fanned out from around the seal. Seconds later, the force of the solution pushed the pump out of the housing, and hundreds of gallons of hot liquid flowed out. The victim fell to the floor and was covered with the solution. He was wearing no personal protective equipment other than safety glasses, and received severe burns to over 80% of his body.

Some of the workers were able to get him to an emergency shower and began removing his soaked clothing, while others called 911. Emergency responders arrived within fifteen minutes and the victim was airlifted to a burn trauma unit. He died two days later due to his injuries.

INTRODUCTION

In July of 2012, the Washington State L&I Division of Occupational Safety and Health (DOSH) notified the Washington State Fatality Assessment and Control Evaluation (WA FACE) program of the death of a 64-year-old maintenance mechanic.

WA FACE investigators interviewed the safety coordinator of the facility where the victim had been employed. Documents reviewed during the course of this FACE investigation include the DOSH investigation file, company accident records, and the death certificate.

EMPLOYER

The employer was a manufacturing company that processed aluminum foil for the production of electrolytic capacitors. Aluminum foil is anodized at the facility in boric acid baths where electrical current is applied. The company had been in business at the incident location for 18 years.

EMPLOYER SAFETY PROGRAMS and TRAINING

At the time of the incident, the employer had a written accident prevention program (APP), but it did not include specific information about potential hazards associated with removal of the recirculation pump. Safety training for new hires was tailored to the department they would be working in, and was documented.

Each department conducted a monthly safety meeting, and there was a safety committee that also met once a month.

There was a written lockout/tagout program for the electrical supply to the recirculation pump.

WORKER INFORMATION

The victim was a 64-year-old maintenance mechanic. He had worked at the company for approximately 14 years, and had previous experience in the manufacturing industry. He had regularly performed maintenance on the pump system since it had been installed. He typically performed removal of the recirculation pump when necessary, and trained new employees in the procedure.

Photo 1 Recirculation pump, removed from housing.

EQUIPMENT

The plant's boric acid evaporation system had been designed, engineered, and installed by an outside contractor approximately eleven years prior to the incident. The 150 HP recirculation pump (photo 1) used to circulate solution in the boric acid evaporation system had been installed at the same time. It was typically removed 1-3 times a year for maintenance. At the time of the incident, it needed to be removed to repair an oil leak.

The power supply to the pump had been designed to accept lockout/ tagout devices, but the plumbing system in and out of the pump itself was not designed with the capability to be isolated or blocked to prevent the accidental release of solution during pump removal if system drainage was incomplete.

INCIDENT SCENE

The incident occurred in the indoor section of an area of the facility that housed the boric acid evaporation system (figure 1). The recirculation pump sat at the lowest point of the system, connected to incoming pipes from the heat exchanger above and the outside tank. It was located between the building wall and a support column for the heat exchanger (photo 2).

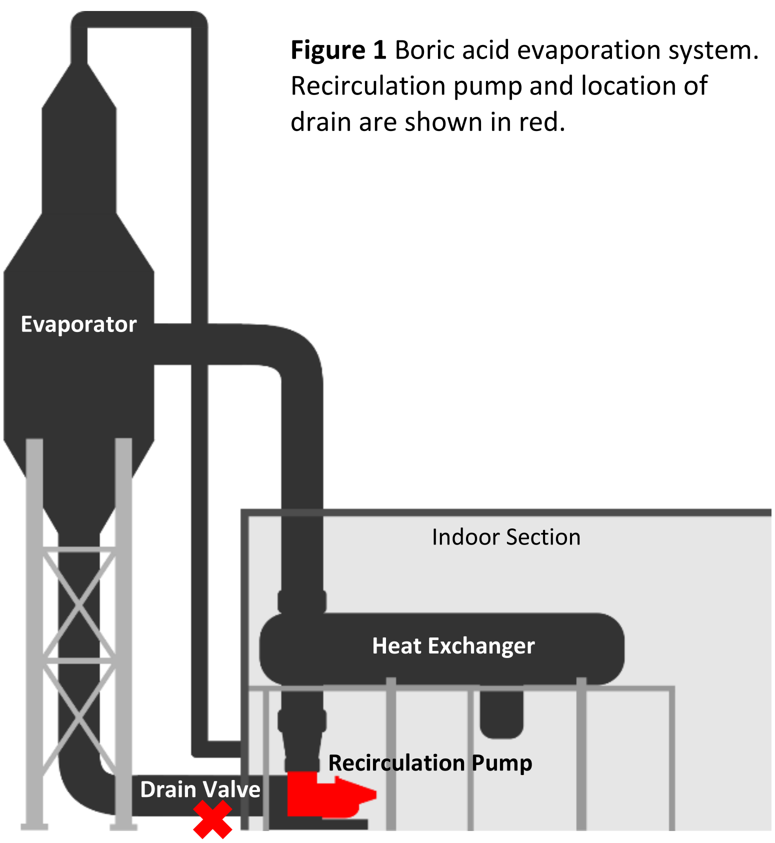

Figure 1 Boric acid evaporation system. Recirculation pump and location of drain are shown in red.

Photo 2 Recirculation pump location behind heat exchanger support column.

INVESTIGATION

At the time of the incident, the plant was undergoing a scheduled facility-wide maintenance shutdown. The recirculation pump for the boric acid evaporation system had developed an oil leak and was scheduled to be removed the following day as part of the maintenance outage. Before removing the pump, the evaporation system needed to be drained of boric acid solution and flushed through with city water to cool it and remove the boric acid solids.

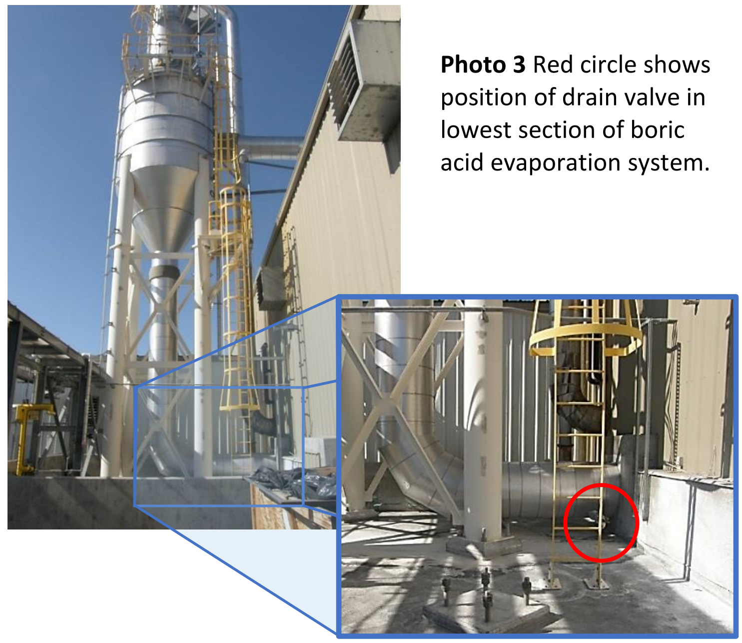

Photo 3 Red circle shows position of drain valve in lowest section of boric acid evaporation system.

The recirculation pump had been removed using the same procedure approximately 10-12 times since it had been in use. There was no written procedure for removal of the pump. The victim had been involved in the original installation of the pump over a decade earlier, had removed and reinstalled the pump for maintenance purposes several times, and had trained newer employees in the pump removal process.

Drainage of the boric acid evaporation system was done by a work crew from the plant's environmental operations department, not by the maintenance workers who would actually remove the pump. To empty the system, hoses were attached to drainage valves and the solution was drained into a holding area outside the building. Before draining and flushing, the system contained between 20,000 to 25,000 gallons of solution that was approximately 12-15% boric acid solids, at a temperature of around 220°-230° Fahrenheit.

Environmental crew workers reported that they had completed draining the system the night before the incident and checked to make sure that draining was complete. This check was done by confirming that no more solution was flowing out of the lowest ball valve in the system (photo 3). A worker ensured that boric acid solids were not blocking drainage by inserting a metal rod into the valve opening. There were no devices to measure the actual volume of fluid that had drained from or remained in the system.

At around 4:20 on the day of the incident, less than an hour before the end of their shift, the victim and another maintenance worker began to remove the recirculation pump from its housing. It is unclear why the victim decided to remove the pump ahead of the scheduled time the following day. The victim had trained the other maintenance worker in the pump removal procedure. Before beginning, they locked out the electric power supply to the pump. The victim's co-worker, the other maintenance worker, reported that he checked that all drain valves for the system were open and that no solution was coming out before they began the pump removal procedure.

There was no mechanism to lockout the pump from other stored energy, such as fluid under pressure.

When the victim and his co-worker initially attempted to remove the recirculation pump from its housing, it would not come loose. Four other employees were in the vicinity, and two came over to help. They attached two 1.5-ton manual lever pullers, or "come-alongs" to the sides of the pump (photo 4). The victim stood next to the pump and in front of the support column (photos 5 & 6). When they began to pull using the come-alongs, the pump loosened and a small amount of boric acid/ water solution sprayed out from around the pump housing. Workers reported that it was not unusual for a small amount of residual solution to leak out during pump removal, and they stopped pulling to wait for the flow to stop.

Photo 4 “Come-along” lever pullers attached to recirculation pump.

Seconds later, the pump suddenly slid several feet forward out of the housing, and 300-500 gallons of hot boric acid and water solution flowed out from behind it. The temperature of the solution was estimated to have been around 180° Fahrenheit. The area filled with steam as the workers rushed away from the flow. Everyone except the victim was able to get to safety. Standing in the tight space next to the pump, the victim was not able to quickly escape the flood of hot solution and was knocked to the floor. He had been wearing safety glasses, but no other personal protective equipment. The other workers could hear him screaming in pain. His co-worker ran back and found him sitting in hot solution. He helped the victim to his feet as another worker turned on the emergency shower. They moved the victim to the emergency wash and began to remove his clothing while another worker called 911 on his cell phone.

Emergency medical services arrived in 10-15 minutes. The victim was airlifted to a burn trauma unit with burns to over 80% of his body. He died in the hospital two days later as a result of his injuries.

Photos 5 & 6 Red Xs indicate the approximate position of victim at time of incident.

CAUSE OF DEATH

The death certificate listed the immediate cause of death as “Thermal burns (200 degree F aqueous boric acid solution) to 80% total body surface area.”

CONTRIBUTING FACTORS

- Incomplete draining of the evaporation system before pump removal.
- No method to identify the potential for solution to remain in the system after standard draining procedures were conducted.
- No way to adequately determine the level and temperature of solution left in system.
- No method to estimate the time need for cooling of the system to a safe level.
- No mechanism to lock out the pump from other stored energy, such as solution under pressure.
- The pump was located directly behind the heat exchange support column, leading to limited access and egress for workers during pump maintenance.
- Not wearing appropriate personal protective equipment.

POST-INCIDENT CORRECTIVE ACTIONS TAKEN BY EMPLOYER

Following the incident, the employer added two 20" isolation valves on the pipes connected to the recirculation pump system. These valves allow the plumbing around the pump to be effectively locked out after the system is drained for pump removal (photo 7).

Additional digital temperature indicators were added at an easier to see level (photo 8).

An additional sample port was installed above the level of the drain valve that had been used to determine if the system had drained completely. The new valve was designed to be located high enough that it would avoid getting clogged with boric solids and workers could more accurately test if all of the solution had drained (photos 9 & 10).

The employer also created a detailed written procedure for the removal of the recirculation pump, including steps for lockout using the new isolation valves, and necessary personal protective equipment to be worn during the procedure.

Photo 7 Red arrows point to valves installed post-incident that allow the pump to be isolated and locked out.

Photo 8 New system temperature indicator installed post-incident.

Photo 9 Boric acid evaporation system drain valve at time of incident.

Photo 10 New sample port installed post-incident above drain level.

RECOMMENDATIONS/DISCUSSION

Recommendation 1: Design new equipment for manufacturing processes using the concept of Prevention through Design (PtD) to control risks by incorporating prevention methods in the final product.

Discussion: Prevention through design, or PtD, emphasizes anticipating possible hazards to workers who will use and maintain the system in the design and engineering phase. When possible, employers should include workers who will be impacted by the hazards in the design process.

The concept behind PtD is that one of the most effective ways to control hazards in the workplace is to "design out" or control for risks during the design, redesign, or retrofit of equipment or processes.[1] Before designing or altering a system or work process, an in-depth hazard analysis and risk assessment should be done to identify potential exposures.[2] Workers who are or will be using the systems may offer important insights and should be involved in the risk assessment process.

The hazard identification process should specifically look to identify tasks where workers are at risk for unwanted energy release. In this case, the potential for solution to be retained in the boric acid evaporation system behind the recirculation pump after the drain valves had been opened was apparently not anticipated, and no mechanism to lockout or otherwise protect workers from an unwanted release of solution was designed into the system. ANSI/ASSE guidelines exist for addressing occupational hazards using PtD.[3]

In this incident, the boric acid evaporation system had been designed, enigineered and installed by an outside contractor over a decade prior to the incident. Employers should ensure that outside contractors and vendors understand and employ PtD principles in their design and engineering processes, and that company safety experts and workers are involved in any design or redesign phases.

Recommendation 2: Enforce a comprehensive written hazardous energy control program. Make sure all potentially exposed workers are trained in the hazardous energy control procedures for the system, and document training.

Discussion: Ensure that all parts of a system capable of releasing stored energy, including water pressure, are equipped with mechanisms to isolate and lockout the system during maintenance or repair.

Workers servicing equipment can be injured or killed by the unexpected release of hazardous stored energy. Hazardous energy is *any electrical, mechanical, hydraulic, pneumatic, chemical, nuclear, thermal, gravity or other energy that could cause harm to personnel.*[4] As part of a hazardous energy control program, systems or equipment must have energy-isolating mechanisms, and lockout devices to make sure the energy-isolating mechanism remains in place during repair and maintenance.

In this incident, the employer's hazardous energy control procedures were not comprehensive. The victim was able to lock out the electrical power supply to the recirculation pump before removal, but deenergizing the pump did not address all potential forms of hazardous energy in the system. There was no way to physically isolate the pump from the residual solution in the system, and therefore also no way to lock the system out during maintenance.

Both OSHA and Washington State rules require that employers protect workers from hazardous stored energy during maintenance and service operations.[5,6,7] This includes appropriate means to control hazardous energy, and lockout/tagout systems for energy-isolating devices. Hazardous energy control programs must:

- Be written.
- Specifically address when the procedures will be used.

- Include the specific steps that need to be taken to shut down, isolate, block, and secure systems or equipment; and how to lockout/tagout the system.
- Designate who is responsible for doing it.

Any worker who may be at risk of exposure to hazardous stored energy needs to be trained in these procedures. Employers should document the training and make sure the procedures are being followed through spot-checks.

In this case, the boric acid solution that remained in the evaporation system was at a high temperature at the time of the incident. It was ultimately thermal burns caused by the temperature of the solution that led to the victim's death, and not chemical exposure or physical injury caused by the force of the solution. However, had the system been isolated and locked out at the time of the incident, exposure to the residual solution would not have been a risk to workers performing pump maintenance.

Both OSHA and the Washington State Department of Labor and Industries have established standards requiring the process safety management (PSM) of highly hazardous chemicals.[8,9] (29 CFR 1910.119 and WAC 296-67.) Although the boric acid solution involved in this incident is not specified in these standards, following some of the guidelines, such as those for conducting a thourough process hazard analysis (PHA), set forth in the PSM safety standards could aid in identifying hazards.

A PHA is a methodology to identify the hazards of a specific process, including the range of safety and health effects to workers should the controls in place fail. The PHA is performed by a team, including an employee, with expertise in the process, and is updated at least every five years.

PSM also requires that there be written operating procedures for a number of processes, including normal shutdown, that there is a training process for maintenance activities, and that there are safe work practices for opening process equipment.

Recommendation 3: Develop written standard procedures for regular maintenance operations. These should include information about hazards, required PPE, necessary safety checks, lockout/tagout procedures, and coordination with other workgroups to be done prior to beginning the task. Ensure that all workers performing maintenance tasks are trained on the procedures.

Discussion: In this incident, while there were established lockout procedures in place, the employer did not have written standard maintenance procedures for the process of removing and replacing the recirculation pump. Removal of the recirculation pump was done periodically, though infrequently. Since its installation, the victim had been the primary employee to remove the pump when required, and trained other employees to do the task.

Just as there are standard operating procedures (SOPs) for manufacturing processes, employers should consider creating standard written procedures for maintenance processes that need to be done on a routine or periodic basis to ensure that these tasks are done the correct way each time and that workers are reminded of hazards and safety procedures. Written maintenance procedures should be reviewed prior to each time the process is to be completed and should include: clear, detailed information about how the maintenance process should be performed, including any necessary photographs or diagrams; checks to be done before beginning the task; hazards; and required personal protective equipment.

Recommendation 4: Ensure that workers who may be exposed to hot liquids are provided with and use the proper personal protective equipment (PPE) for the job, including appropriate eye/face, hand, and body protection.

Discussion: In this incident, the victim wore safety glasses, but no other PPE specificly designed for working with hot liquid or chemical solutions. Although the victim and his co-workers did not anticipate that a large volume of solution could have remained in the system after draining, several workers reported that it was not unusual for some boric acid/water solution to spray out from around the housing during pump removal. Even small amounts of solution at high temperatures can cause burn injuries. A PPE assessment[10] could have identified possible worker exposure to hot boric acid/water solution during recirculation pump removal and prompted a requirement that workers wear appropriate foot, hand, body, and face protection during the procedure.[11]

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INVESTIGATOR INFORMATION

Todd Schoonover has a PhD in Industrial Hygiene from the University of Illinois at Chicago. He is a Certified Industrial Hygienist (CIH) and Certified Safety Professional (CSP). Todd is currently the Principle Investigator for the WA FACE Program.

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ACKNOWLEDGEMENTS

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- The employer involved in the incident
- Occupational Safety and Health Administration (OSHA)
- Federal FACE Program management (NIOSH)
- Safety & Health Assessment & Research for Prevention (SHARP)