NYS & CSEA Partnership for Education and Training

Boiler Safety

Working Safely Around Hot Water and Steam Distribution Systems

www.nyscseapartnership.org

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The Partnership's programs and services meet a range of employee and workforce needs. Individual CSEA-represented employees enroll in job skills and professional development courses offered at training sites across the state and can also access an extensive online learning program. Thousands of employees use tuition benefits and advisement services to pursue their educational and career goals. Labor-management committees work with Partnership staff to learn how to strengthen their structure and relationships to address issues of mutual concern more effectively. A range of other programs and services are also available to employees and agency labor and management representatives.

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1.0 Introduction

This publication describes possible hazards of hot water and steam distribution systems and how to avoid them through proper maintenance and recognition of danger signs.
Boilers provide efficient and long-term heating applications for small areas and for huge building complexes. Boilers are available in a variety of sizes and designed for the buildings they heat. Modern boiler technology has made boilers not only more efficient, but safer as well. However, boilers are usually operated under high-temperature and pressure, which, if not properly controlled, can cause explosions with devastating effects.

Below are some examples of what can happen when working with boilers:

- In October of 1962, a historic boiler explosion occurred in the basement of a telephone company building in New York City. Safety devices malfunctioned and the boiler exploded. The resulting explosion tore through a concrete wall and destroyed a switching room, as well as numerous floor slabs above. This resulted in 21 casualties and extensive damage to the building.
- In October of 2002, a University at Buffalo stationary engineer employee was killed when a steam pipe exploded in a basement room of Crosby Hall (Page, 2002). The steam pipes were wrapped in asbestos, necessitating air testing before a safety and operational review could be conducted.
- In November of 2017, an employee working at a sewage treatment facility in Watertown, New York died while adjusting a fitting on a high-pressure hydraulic line. According to the Public Employee Safety and Health Bureau (PESH), "the release of stored energy caused the hydraulic line to strike the employee in the head resulting in his death and exposing a second employee to hazardous materials."

Not all boiler injuries result in death. According to the Occupational Safety and Health Administration (OSHA), other common boiler injuries include severe burns, broken bones, amputations, head trauma, and internal injuries. By using this resource, employees and agencies can gain knowledge in proper boiler maintenance and help ensure they are following the guidelines for safe boiler operation and maintenance procedures.

2.0 Hot Water and Steam Distribution Systems

Hot water and steam distribution systems are two types of heating systems that use hot water and pressure to move heat from a boiler to the desired location. Distribution can be from a central location piped to several buildings or through a stationary unit located within a building. *Figure 1* is a typical steam distribution system. Because of the nature of these systems, it is important that the distribution system is designed correctly and maintained in good working order for efficiency and safety.

Many factors determine how distribution systems must be configured to operate safely. Configuration factors include temperature, pressure, amount of hot water or steam to be distributed, the makeup of the steam, insulation, and drainage.

Depending on these factors, the system may contain different valves to regulate the pressure and movement of the hot water, steam, and condensate. When the distribution system is designed, operated, and maintained correctly, the user will receive the heat they need, and the hot water, steam, and condensate will flow smoothly through the system. Two factors that are most important for the continuing safe operation of a steam system are regular inspection and preventative maintenance.

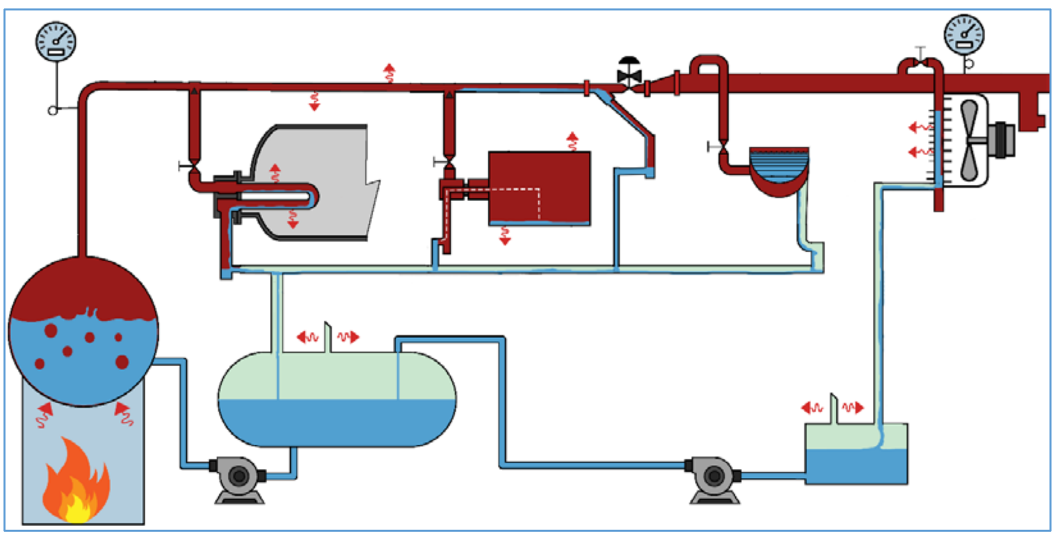

Figure 1: Typical Steam Distribution System

The following sections outline the system distribution components, procedures, safety protocol, and incident prevention. If you find any portion of a distribution system that does not appear correct, you should always contact your supervisor to have the item(s) addressed.

3.0 Water Hammer

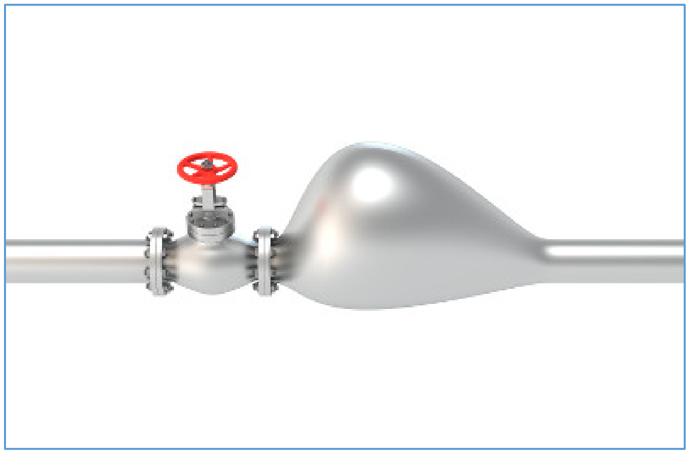

Figure 2: Hot Water Distribution – Water Hammer

Figure 2 is the result of **water hammer** in a hot water distribution system. A water hammer occurs in the hot water distribution system when a sudden change in the water flow causes a ripple or wave to form within the pipe, striking like a hammer. The size and force of the wave will cause the water to bounce back and forth causing damage to the system until the ripple or wave dissipates. All pressurized water systems can experience water hammer – both hot and cold.

Water hammer in a hot water distribution system has unmistakable warning signs:

- Pipe rattle or vibration
- Banging within the pipe
- Pipe with blistering
- Leaking valves
- Equipment failure
- Constant replacement of seals

Figure 3: Steam Distribution – Water Hammer

Figure 3 illustrates the result of water hammer in a steam distribution system. Water hammer in a steam distribution system occurs when a slug of water or condensate (steam that has condensed back to liquid water in the system) is pushed by the steam until it impacts a part of the system where it cannot pass through. The effects can range from a knocking sound to an explosion.

The outcome of a water hammer event includes:

- Valve failures.
- Heat exchanger equipment failures.
- Breaking pipe welds.
- Rupturing piping systems.
- Failure of pipe supports and guides.
- Bending internal system mechanisms.
- Overstressing pressure gauges.

- Cracking steam trap bodies.
- Gurgling sound in the pipes.
- Missing pipe insulation.

An explosion caused by a water hammer is the most common cause of death or severe injury for employees who work with or around hot water or steam distribution systems. Water hammer injuries can be caused by flying pieces of the exploding part, spraying of hot water, and pressure from the steam releasing. The best way to prevent water hammer is through proper distribution system design and maintenance.

Design and maintenance items include:

- Condensate drainage.
- Pipe pitch and support.
- Pressure relief and expansion devices.
- Corrosion prevention.

Sections 3.1 through 3.4 of this publication cover each of these topics. A proactive maintenance program with standard operating procedures will keep the system operating safe and efficiently.

3.1 Condensate Drainage

Condensate drainage water hammer is most often caused by a poorly designed, operated, or maintained condensate return line system.

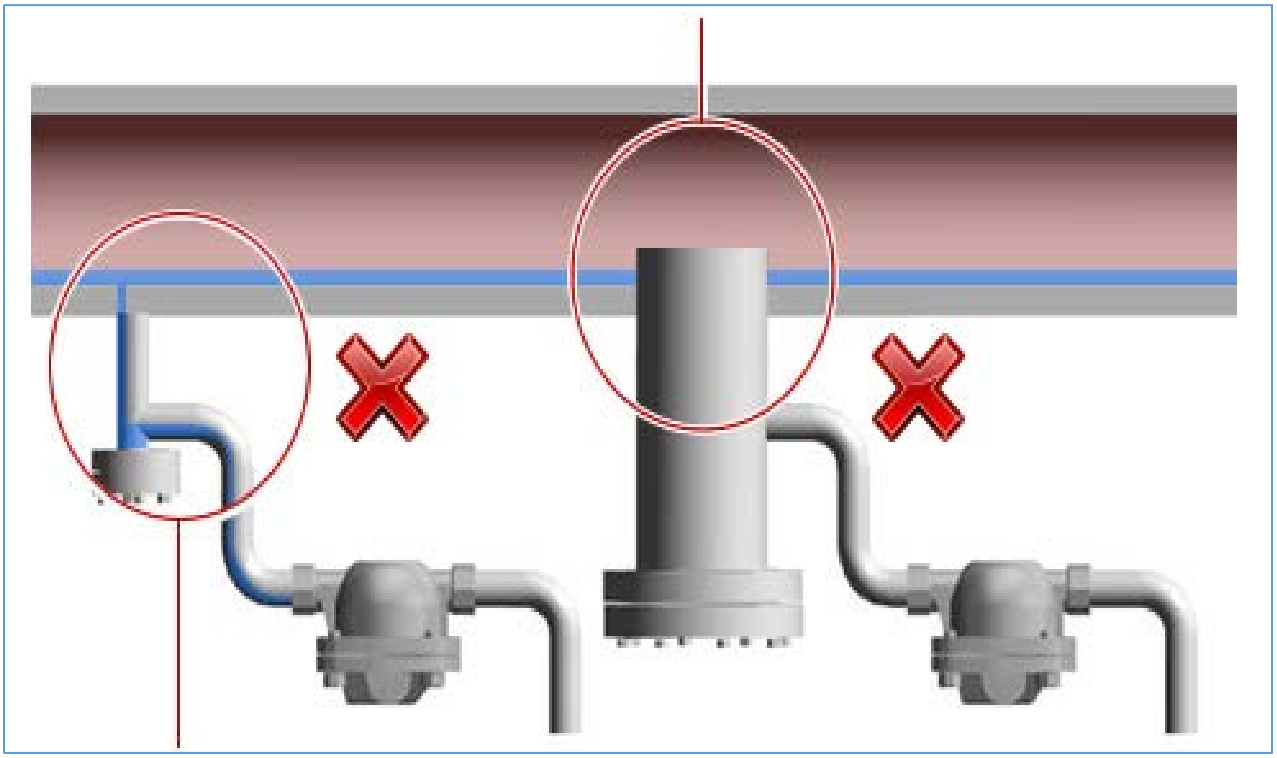

Figure 4: Improper Condensate Drainage

Figure 4 illustrates two examples of an improper condensate drainage system. Notice the drain pipes are not large enough or low enough for the volume of condensate. The results will be the condensate is pushed by the steam to create a water hammer.

Properly trained operation and maintenance personnel will keep the condensate drainage or return line system working efficiently and safely. If you notice an improperly designed system, please notify your supervisor. The re-designing of a system should be left to a trained engineer.

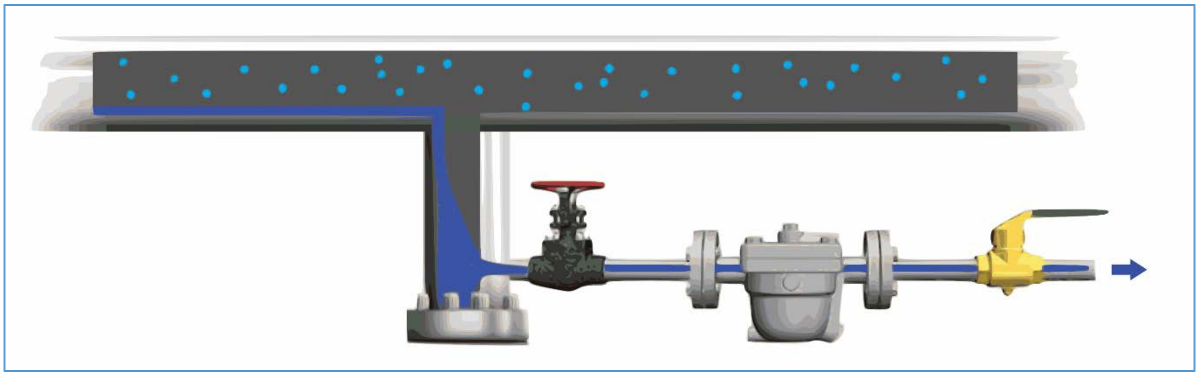

Figure 5: Properly Installed Condensate Drainage

Figure 5 illustrates a properly installed condensate drain.

There are three basic types of condensate drainage or return line systems. A condensate trap is used after all strainers to help prevent water hammer.

- **Non-flash two phase** - Steam is supplied to equipment and the return line supplies low-pressure steam directly to another piece of steam equipment before the condensate is returned to the boiler.
- **Flashing two phases** - Steam is supplied to equipment and the condensate flows into a holding tank. The lower temperature condensate flashes with the higher temperature condensate to create low pressure flash steam, which supplies low pressure steam to another piece of steam equipment before the condensate is returned to the boiler.
- **Pumped single phase** - Steam is supplied to equipment and the condensate will drain into a flash vessel (tank). The condensate is pumped from the vessel to the boiler.

Condensate drainage system components (steam traps, drip legs, and drain valves) must be properly sized, installed, and maintained. **Drip legs** are the piping installed to collect condensate and direct it to the steam trap. Drip legs must be able to hold enough condensate to prevent it from collecting in the steam line.

Steam traps are automated valves that allow condensate release without the loss of steam. These valves are part of a set located after the drip leg to control condensate removal. *Figure 6* shows the components for an inverted bucket steam trap set.

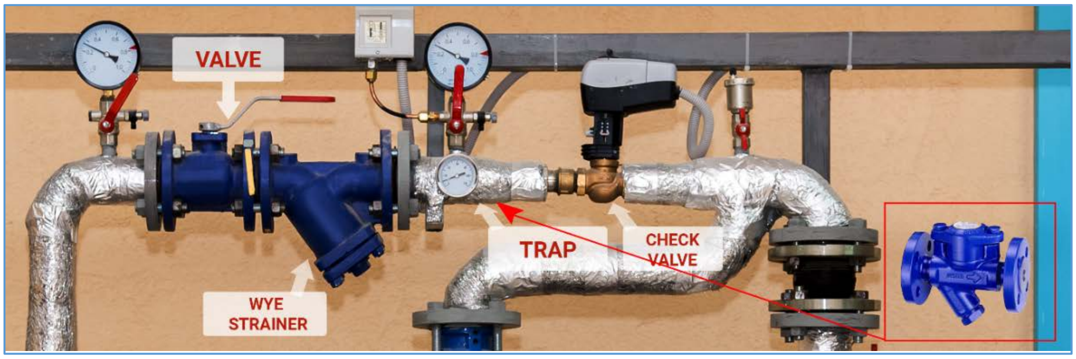

Figure 6: Inverted Bucket Steam Trap Set Components

Figure 7 shows a steam trap set using a newer high efficiency steam trap.

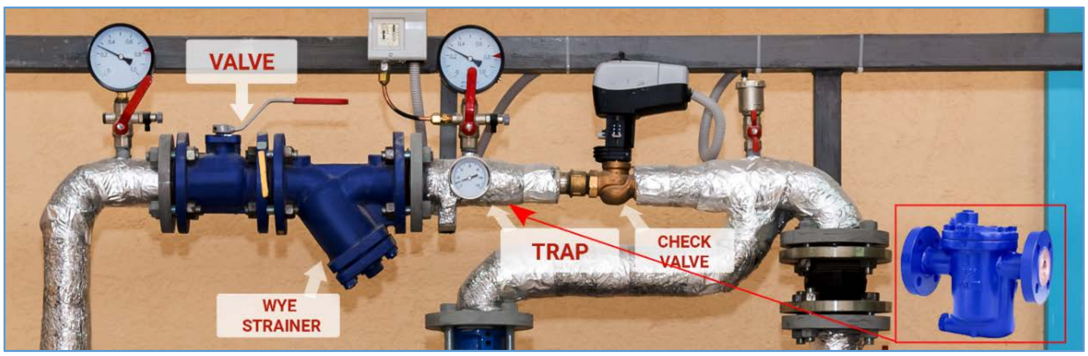

Figure 7: High Efficiency Steam Trap Set Components

The inverted bucket steam trap shown in *Figure 6* can handle higher condensate flow and is more resistant to water hammer damage than the high efficiency steam trap**.** Older system condensate drains may include sight glasses to allow quick and easy visual inspection of the condensate return. Additionally, sight glasses show the:

- Flow rate.
- Flow blockage.
- Vapor and steam leaks.
- Color of the condensate.

Proper operation and maintenance will help prevent water hammer due to a restricted or blocked condensate drain. More modern systems use conductivity testers to help prevent water hammer.

3.2 Steam Piping Pitch and Support

Gravity allows for the return condensate drains to operate properly. Piping must be properly pitched and supported to maintain flow and prevent the settling of condensate. Risers are required after the drip trap stations, the end of the main, and every 125 to 175 feet to prevent water hammer. Risers must be pitched to direct the flow of the condensate to the drains, preventing condensate from collecting.

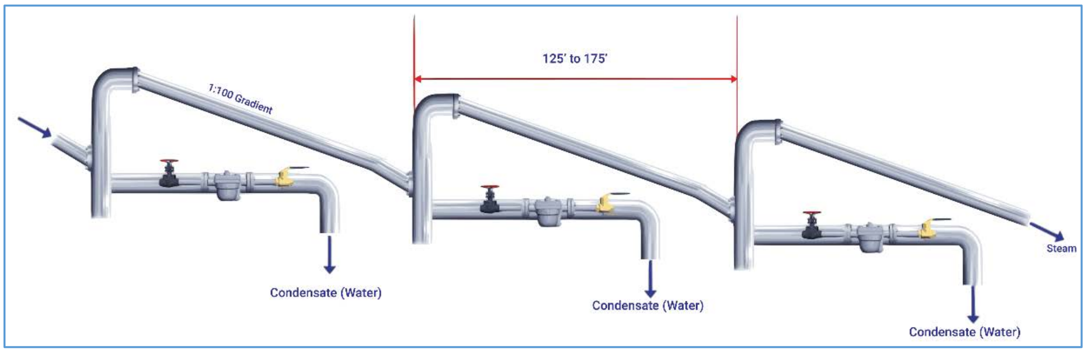

Figure 8: Proper Risers and Pipe Pitch to Prevent Water Hammer

Figure 8 is an illustration of pipe risers and pitch. The condensate will drop into the drip leg and the steam will rise above the riser bend; this process repeats for each section until the steam has dissipated. The drip leg has a condensate return drain line that moves the condensate back to the boiler. A check valve is in-line to prevent cross contamination.

All supports must be undamaged and in contact with the piping to maintain proper pipe pitch. Temperature changes can cause the pipe to expand and contract, straining and damaging the pipe supports so they are no longer holding the pipe in the proper position.

3.3 Pressure Relief and Expansion Devices

The cycling of heat will cause pressure, expansion, and contraction to occur in a hot water and steam distribution system. Catastrophic failure will occur if the system is not fitted with pressure relief valves and expansion devices. These devices include **expansion joints** that are designed to allow the system to safely expand and contract during the heating and cooling that occurs during normal operation. *Figure 9* is a picture of an expansion joint with the packing areas allowing movement of the pipework.

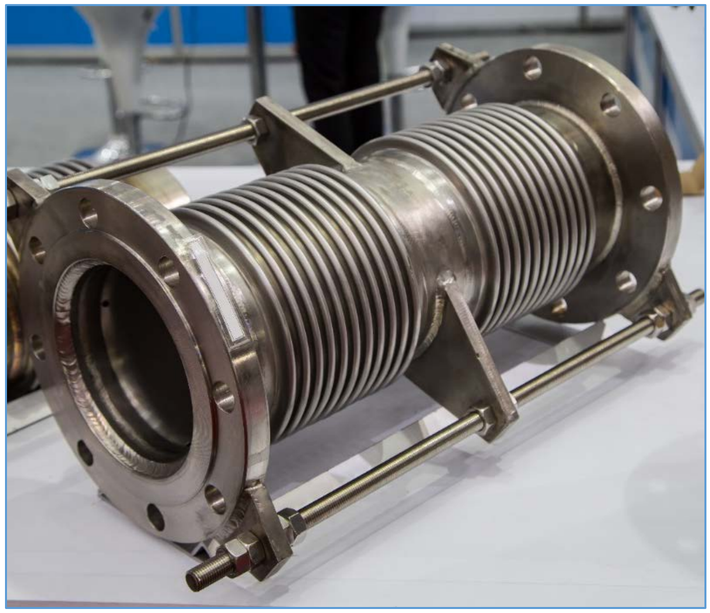

Figure 9: Expansion Joint

Pressure relief valves are designed to vent or release an unsafe buildup of pressure in the system in a safe manner and direction. *Figure 10* illustrates the basic operation of a pressure relief valve. The valve will either discharge the pressure into a drain or will return the steam back to the boiler through a return line.

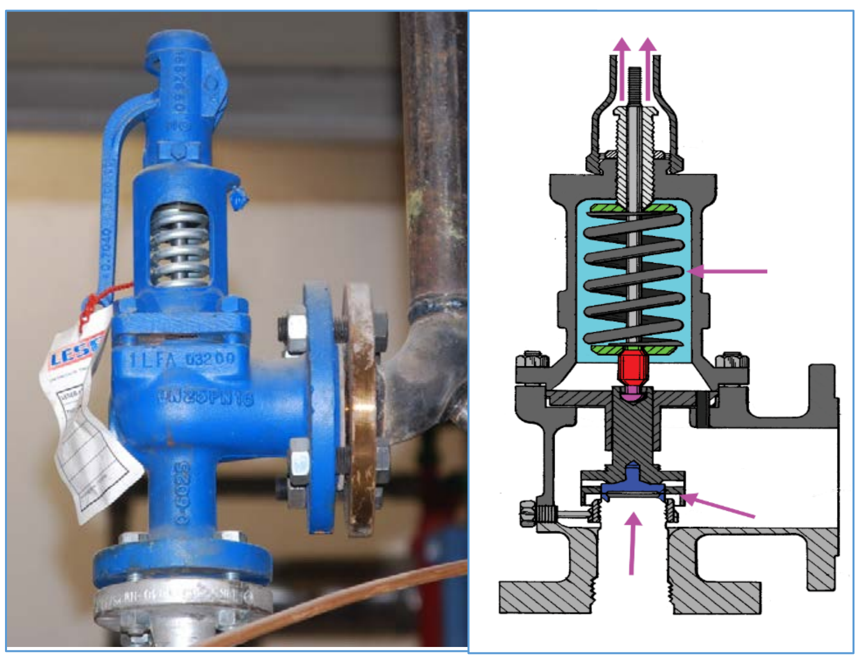

Figure 10: Pressure Relief Valve

3.4 Corrosion Prevention

Condensate water is 100% pure, distilled clean water and is very hot, which makes it perfect for boiler feed water. Hot boiler feed water will save on fuel cost for pre-heating the feed water.

The problem with using condensate is that it may collect numerous impurities during the exhaust system recovery. A common impurity is carbon dioxide, which converts to carbonic acid in the condensate from the pressure and heat created by the boiler.

Carbonic acid is a weak acid, but when mixed with pure condensate water, it can become very corrosive. *Figure 11* is an illustration of corrosion caused by the carbonic acid. The acid has weakened the pipe walls to the point of leaking. The cure for this type of corrosion is the neutralization of carbonic acid with volatile amines or ammonia in the condensate.

Figure 11: Corrosion from Carbonic Acid

It is not unusual to find tiny amounts of corrosion inside system equipment. Signs of excessive corrosion need to be reported immediately to management. When performing routine strainer maintenance, you should inspect the steam traps and all the drainage system components for excessive corrosion. Corrosion of parts will weaken them and can interfere with the proper operation of steam traps by blocking condensate flow, making it more likely that water hammer will occur and cause the system to fail.

Another cause of corrosion is the **dissimilar metals effect** or **galvanic reaction.** *Figure 12* is an example of dissimilar metals corrosion.

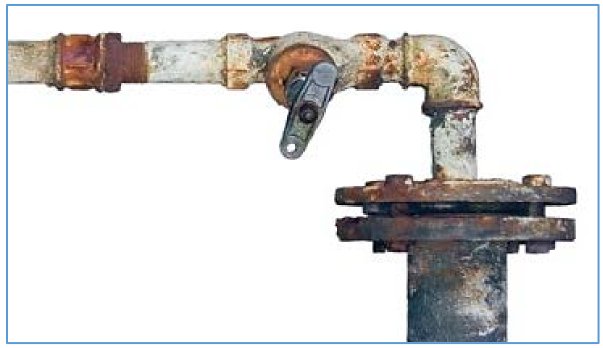

Figure 12: Corrosion from Dissimilar Metals

The term dissimilar metals refer to the corrosion that occurs when certain metals are put in contact with each other creating a chemical reaction that will cause one of them to rapidly corrode. If you are installing components into an existing system, make sure to use components that are compatible with the metals used in that the system or replace with a component made of the same metal that was removed. If you must use a component made of a different metal, refer to figure 13, the dissimilar metals chart, as it shows the metals that can, should not, and must not be used together to prevent this effect. If you see a component that appears to be prematurely corroding, check the metal it is made of and what the adjoining components are made of and compare them to the table to be sure they are compatible.

Dissimilar Metals

Galvanic Corrosion Potential Between Commonly Used Metals

	Aluminum	Brass	Bronze	Copper	Galvanized Steel	Iron Steel	Lead	Stainless Steel	Zinc
Aluminum		⊗	⊗	⊗	✓	⊖	⊖	✓	✓
Copper	⊗	⊖	⊖		⊖	⊗	⊖	⊗	⊗
Galv. Steel	✓	⊖	⊖	⊖		⊖	✓	⊖	✓
Lead	⊖	⊖	⊖	⊖	✓	✓		⊖	✓
Stainless Steel**	✓	⊗	⊗	⊗	⊖	⊖	⊖		⊗
Zinc	✓	⊗	⊗	⊗	✓	⊗	✓	⊗	

✓ Galvanic action is insignificant between these metals

⊖ Galvanic action may occur

⊗ Galvanic action will occur with direct contact

** Active Stainless Steel

Figure 13: Dissimilar Metals/Galvanic Action Chart

3.5 Standard Operating Procedures

Water hammer is most likely to happen during the start-up or shut-down of the distribution system. This occurs because as valves are opened or closed, water can become trapped, creating a slug that becomes the hammer. At a minimum, your employer should have in place written standard operating procedures for shutdown and startup of the steam distribution system, as these are the operations that present the greatest potential hazard.

Some general rules that should be included in those procedures are:

- All condensate drip valves should be opened to ensure liquid will drain from the distribution header.
- Perform a visual walk through of the system to ensure that all check valves are in working condition.
- Following inspection, advise the operator that steam can be introduced into the distribution system.
- Monitor expansion joints for proper movement as steam is introduced into the system – no noise should be present.
- Condensate drip points are to be monitored until dry steam is detected. When dry steam is observed, the valves are to be closed.
- Pre-heat the distribution system before start-up, whenever possible.
- To ensure normal system operation, listen for unusual noises such as water movement or loud banging.
- Open and close valves slowly during operation.
- Do not leave valves partially open to reduce flow.

A copy of the systems "Standard Operating Procedures" should be available in each system control area.

4.0 Releasing Steam and Hot Water During Maintenance

Steam and hot water are released when the distribution system needs to be opened for maintenance or repairs. If not released properly, severe burns and even death can occur from the pressure, heat, and chemicals the system carries. This hazard is avoided by using energy control or "Lockout/Tagout" procedures to isolate and release the energy safely before the maintenance work begins.

There are three primary components of a Lockout/Tagout program:

- Energy Control (Lockout/Tagout) Written Program
- Energy Control Procedures
- Affected and Authorized Employee Training

More information can be found on the Occupational Safety and Health Administration (OSHA) Lockout/Tagout information page at: osha.gov/dts/osta/lototraining/index.html.

4.1 Energy Control (Lockout/Tagout) Written Program

Figure 14: Lockout/Tagout

Existing regulations require employers to establish and implement a written Energy Control or Lockout/Tagout program for employees who perform maintenance work on equipment or piping that may contain stored energy. The written program will specifically outline:

- The scope of work – *Maintenance.*
- Purpose – *This program establishes the minimum requirements for lockout/tagout.*
- Authorization – *All employees shall be instructed by a trained and qualified individual.*
- Rules – *Guidelines for personal protective equipment, notifications, hardware, and other devices allowed by the employer for protection, isolation, and blocking of the energy source.*
- Procedures – *Specific instructions for the isolation, assurance that the equipment is de-energized, task to be performed, and the steps for placing of the equipment back in service.*
- Inspection – *Periodic inspections need to be performed to certify the energy controls are being utilized.*
- Training – *Each authorized employee shall receive training in the recognition, type, and magnitude of hazardous energy sources available in the workplace. Additional training is required to ensure that the purpose and function of the energy control program are understood by all employees.*

Types of energy sources, both active and stored, include mechanical, hydraulic, pneumatic, chemical, thermal, and gravity. Thermal is the main energy source that applies to maintenance work on hot water and steam distribution systems.

A written energy control program will help ensure the system cannot be re-energized until the maintenance work is complete. **The energy control written program must be available for review by each employee who uses these procedures.**

4.2 Energy Control Procedures

Energy control procedures specifically detail the type of energy, the magnitude of the energy, and the specific locations used to disconnect or control energy from a specific piece of equipment or distribution system. ***Sample:*** Sequence of Lockout Procedures

- Notify all affected employees that a lockout is required and the reason.
- If the equipment is operating, shut it down by the normal stopping procedure (such as depressing the stop button or opening the toggle switch).
- Operate the switch, valve, or other energy isolating devices so that the energy source(s) (electrical, mechanical, hydraulic, other) is disconnected or isolated from the equipment.
- Lockout energy using an isolation device with an assigned individual lock.
- Stored energy, such as that in capacitors, springs, elevated machine members, rotating fly wheels, hydraulic systems, and air, gas, steam or water pressure, must also be dissipated or restrained by methods such as grounding, repositioning, blocking, or bleeding down.
- After ensuring that no personnel are exposed, check that the system is isolated by operating the push button or other normal operating controls to make certain the equipment will not operate. **CAUTION!** Return operating controls to neutral or off position after the test.
- The equipment is now locked out.

Use of these procedures safely controls and physically isolates all energy sources (hot water, steam, and water treatment chemicals) from the system and describes how the stored energy (heat and pressure) is released so the maintenance work can be done safely. For example, if a valve in a distribution system needs to be replaced, the procedure would detail:

- What other valves must to be closed to isolate the valve to be replaced.
- How to safely bleed off the stored pressure.
- How to drain any remaining water.
- How long to let the system cool so the work could be performed safely.

These procedures must be provided to the employees performing the work as part of the preparations. Some employers have incorporated providing this procedure as part of their work order system.

4.3 Authorized and Affected Employee Training

The employees who perform the maintenance work on equipment that uses the Lockout/Tagout procedures are the **authorized employees**. Employees who work with or near that equipment are the **affected employees**. Both groups of employees are required to receive training about the Lockout/Tagout program.

- Affected employees must be trained about the purpose of the program, the prohibition on tampering with any equipment that is under Lockout/Tagout, and what the Lockout/Tagout devices look like.
- Authorized employees must be trained about the requirements of the employer’s Lockout/Tagout program and how to use the energy control procedures.

Annually, the employer must have an authorized employee observe other authorized employees performing the energy control procedures to assure they are being used properly. These are called periodic inspections. If the procedures are not performed correctly, it is referred to as trigger retraining.

5.0 Working in Confined Spaces

Figure 15: Confined Space

Confined spaces are areas that have limited means for entry and exit, can be bodily entered, and are not designed for continuous human occupancy. Employees working in pipe chases, boiler rooms, and service areas that are restricted must remove all equipment and supplies before exiting. Confined spaces include, but are not limited to:

- Tanks.
- Vessel pits.
- Manholes.
- Tunnels.
- Equipment housings.
- Ductwork.
- Pipe chases.

A **permit-required confined space** is a confined space that has one or more of these characteristics:

- May contain a hazardous atmosphere
- Contains a material with the potential to engulf someone
- A space that might cause an occupant to be trapped or asphyxiated
- Contains any other serious safety or health hazards

5.1 Permit-Required Confined Space Entry Program

Departments and agencies that require employees to enter permit-required confined spaces are mandated to develop and maintain a permit-required confined space entry program. The program should include:

- Employee training.
- Use of entry permits and provision of equipment for safe entry.
- Air monitoring requirements.
- Rescue provisions.
- The ability to reclassify a permit space to a non-permit (when appropriate).
- The allowance to perform alternate entry procedures (when appropriate).

Reclassification requires that all potential hazards in the space have been eliminated and not just controlled. Alternate entry procedures are only allowed for permit-required confined spaces where the only hazard is an actual or potential hazardous atmosphere, and it is controlled by providing continuous ventilation for the space.

More information can be found on the OSHA Permit-required Confined Space information page at: osha.gov/SLTC/confinedspaces/.

5.2 Entry Permit System

Figure 16: NYS Entry Permit

All employers who require employees to enter permit-required confined spaces must develop a permit-required confined space entry permit system. The permit system must include a mechanism for opening, closing, and maintaining the permit for Public Employee Safety and Health (PESH) inspections for at least one year. Information that is required to be on the permit includes:

- Names of the entrants.
- Name of the entry supervisor and the attendant.
- Location of the permit-required confined space.
- Potential hazards within the space.
- Job tasks to be performed.
- Acceptable entry conditions.
- Qualified rescue service to be used.

5.3 Entry Team

The entry into a permit-required confined space occurs when any part of the entrant's body breaks the plane of an opening into the space. Qualified entry teams must be trained to recognize the hazards that could be encountered in each permit-required confined space. They must have training on any specialized equipment such as retrieval systems, body harnesses, ventilation devices, and air monitoring equipment.

Entry teams will consist of three positions:

- **Entrant**: The person(s) physically entering the permit-required confined space to perform the assigned tasks.
- **Attendant**: Supports the entrant(s), keeps in constant contact with the entrant(s), monitors the space for any changing conditions, evacuates the space if a prohibited condition occurs, performs non-entry rescue if needed, and summons the rescue service when necessary.
- **Entry Supervisor**: Opens and closes the entry permit, ensures the rescue service is available, checks to ensure that the appropriate entries have been made on the permit, checks that all tests specified by the permit have been conducted, checks that all procedures and equipment specified by the permit are in place before opening the permit, and supervises the entry from start to finish.

5.4 Emergency Rescue

Figure 17: Rescue

Attendants must be trained to perform non-entry rescues. Where an employer has trained their employees to act as rescuers who are required to enter a permit-required confined space, rescuers must have the same training as an entrant and any additional training on specialized rescue and personal protective equipment. Employers that choose to use a qualified outside rescue service must assure that contacting that rescue service is required prior to making a permit-required confined space entry. Private firms that provide rescue services for a fee are available throughout the state.

5.5 Working in Confined Spaces During Inspection, Maintenance, and Outages

Prior to performing job tasks in enclosed or confined areas, the space must be evaluated to determine if it meets the definition of a permit-required confined space. If the space meets the definition, a permit must be used, and the associated hazards eliminated or controlled. Spaces that do not meet the definition of a permit-required confined space may still pose potential hazards. The job task itself (for example welding or applying a chemical coating) may have potential hazards that need to be controlled to ensure employee safety. Either way, job planning becomes an important hazard control mechanism.

The OSHA Confined Space Quick Card can be found at: osha.gov/OshDoc/data_Hurricane_Facts/confined_space_permit.pdf.

6.0 Working in Extreme Temperatures

Heat and cold stress are considered environmental hazards and can be either man made, such as steam, or a natural hazard when working outdoors. Activity in extreme temperatures should be planned accordingly due to the health issues that could occur in extreme temperatures.

6.1 High Temperature Illnesses

High temperature illnesses include:

- **Heat Rash**: Symptoms include red clusters of small blisters that look like pimples on the skin. These may occur on the neck, chest, groin, or in elbow creases.
- **Heat cramps**: Symptoms include heavy sweating during intense exercise and muscle pain or spasms.
- **Heat exhaustion**: Symptoms include heavy sweating, cold pale clammy skin, a fast but weak pulse, nausea or vomiting, muscle cramps, tiredness or weakness, dizziness, headache, and fainting. If these symptoms get worse or last longer than an hour, seek immediate medical attention.
- **Heat stroke**: Symptoms include high body temperature (103°F or higher), hot, red, dry or damp skin, fast strong pulse, headache, dizziness, nausea, confusion, and fainting. **Heat stroke is life threatening, call 911 immediately!** See *Figure 18* for more information on how to distinguish between heat exhaustion and heat stroke.

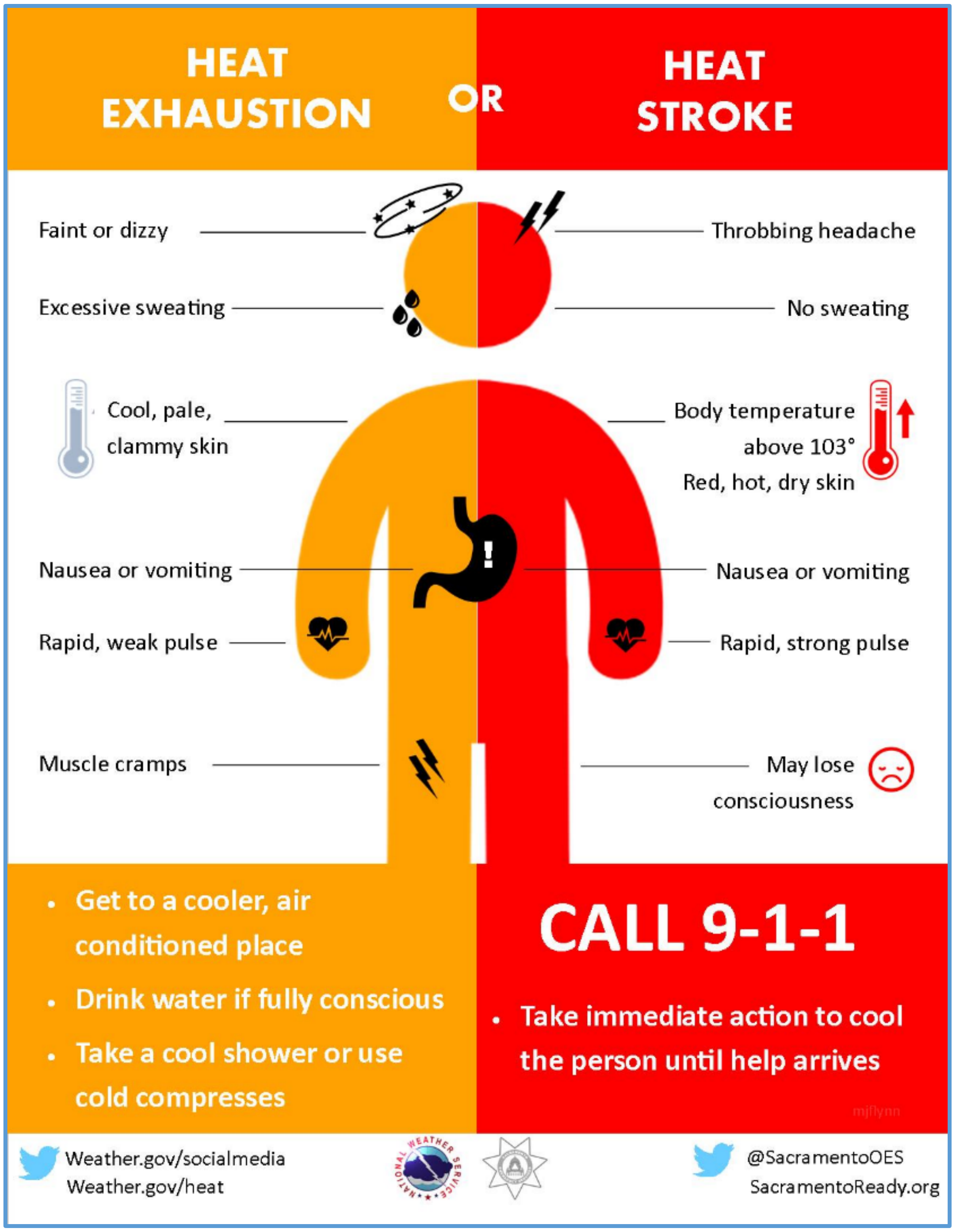

Figure 18: Heat Exhaustion or Heat Stroke?

Source: National Weather Service (2019)

More information on Heat Stress can be found on the OSHA information page at: osha.gov/SLTC/heatstress/.

The OSHA Quick Card for Heat Stress can be found at: osha.gov/Publications/osha3154.pdf.

6.2 High Temperature Hazard Control

There are no specific standards that address heat or cold stress. However, the Center for Disease Control (CDC), the National Institute for Occupational Safety and Health (NIOSH), and the American Conference of Governmental Industrial Hygienist (ACGIH) have recommendations for heat stress. Generally, control mechanisms include a work/rest regime. This work/rest schedule should consider the physical job task, temperature, and any required personal protective equipment. One very important factor is hydration. Avoid beverages that are diuretics, which are drinks that increase the production of urine. Drink water or electrolyte-replacing beverages that are at room temperature and not cold. It is difficult to drink enough cool water to replace the volume that can be lost by sweating. Drink often and do not wait until you are thirsty.

OSHA and NIOSH have published a Heat Safety Tool Smartphone App**.** This can be found at: osha.gov/heat/index.html. This is an excellent tool to be used in addition to training and provides information on symptoms of heat stress, safety tips, and the ability to calculate the heat index.

6.3 Low Temperature Illnesses

Exposure to cold temperatures can lead to **frost bite** or **hypothermia**. Frost bite generally affects the ears, nose, fingers, and toes. As wind chill increases, so does the potential risk of frost bite. Frost bite can lead to severe tissue damage and in some cases amputation. Symptoms of frost bite include white or grayish-yellow skin, skin that feels unusually firm or waxy, and numbness. Hypothermia occurs when the body core temperature drops to the point that it affects brain function, making the victim unable to think clearly or move well. Symptoms include a drop-in body temperature (if below 95 degrees Fahrenheit call 911), confusion, and initial shivering. Shivering will stop as hypothermia continues and confusion will increase. Hypothermia is generally associated with cold temperatures, but it can occur at temperatures above 40°F. This is especially true if a person becomes chilled from rain, sweat, or submersion in cold water.

6.4 Low Temperature Hazard Control

OSHA and ACGIH have cold stress guidelines. These are work/rest schedules that consider the temperature, wind chill factor, and require breaks to be taken in a warming area. Additional controls include appropriate clothing such as gloves, face, and eye protection suitable for the weather and job task. The United States Department of Labor via OSHA provides the following guidance on layer of clothing to prevent cold stress:

Dressing properly is extremely important to preventing cold stress. The type of fabric worn also makes a difference. Cotton loses its insulation value when it becomes wet. Wool, silk, and most synthetics, on the other hand, retain their insulation even when wet. The following are recommendations for working in cold environments:

- Wear at least three layers of loose fitting clothing. Layering provides better insulation. Do not wear tight fitting clothing.
  - An inner layer of wool, silk, or synthetic to keep moisture away from the body.
  - A middle layer of wool or synthetic to provide insulation even when wet.
  - An outer wind and rain protection layer that allows some ventilation to prevent overheating.
- Wear a hat or hood to help keep your whole body warm. Hats reduce the amount of body heat that escapes from your head.
- Use a knit mask to cover the face and mouth (if needed).
- Use insulated gloves to protect the hands (water resistant if necessary).
- Wear insulated and waterproof boots (or other footwear).

More information on cold stress can be found on the OSHA information page at: osha.gov/dts/weather/winter_weather/windchill.html.

The OSHA Quick Card for Cold Stress can be found at: osha.gov/Publications/OSHA3156.pdf.

6.5 Thermal Burns

Hot water and steam can cause thermal burns to skin and eyes. Piping, flanges, and bolts can retain heat for a prolonged period. First-degree burns affect the outer layer of the skin and often are red and painful. Second-degree burns affect the layers of the skin and often blister. Third-degree burns affect the deeper tissue and are often accompanied by first- and second-degree burns.

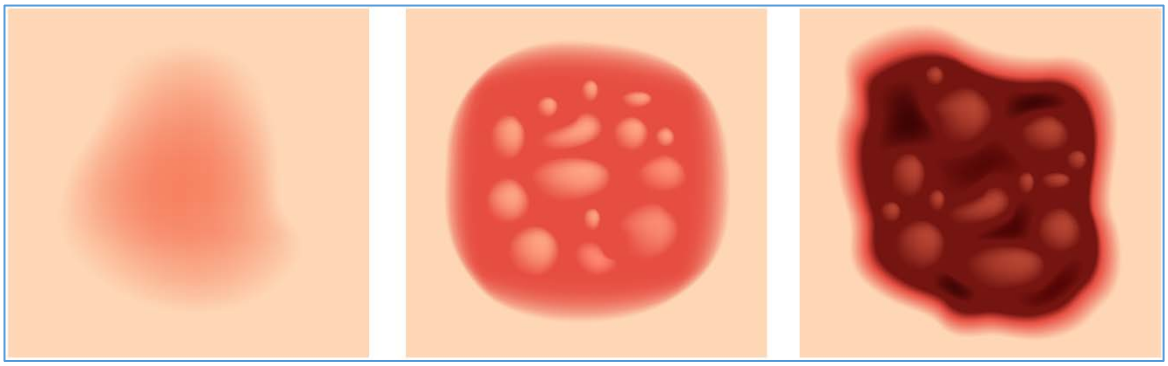

Figure 19: Degrees of Burns

Hot water used in a heating system can be operating at 120°F to 220°F. The Burn Foundation (2019) notes that hot water can cause a third-degree burn in as little as 15 seconds at 133°F and only one second at 156°F.

As the operating pressure of a steam boiler increases, the boiling point of the water will change accordingly. As an example, at 50.3 psig (pounds per square inch gauge) the boiling point of water is 298°F, and at 294 psig the boiling point of the water is 420°F.

Avoiding contact with steam and hot water are the best techniques to ensure safety. Use of infrared thermometers, blocking and bleeding, allowing for enough cool down time, and proper lockout/tagout isolation are key hazard control techniques. Additional controls can include the use of heat resistant gloves, use of clothing designed to protect against hot fluids and steam, and the use of thermal insulating blankets placed on adjacent items to prevent a contact hazard.

7.0 Slip, Trip, and Fall Hazards

Figure 20: Slips, Trips, and Falls

A slip hazard is present when the friction between the walking surface and a person's shoes is reduced, resulting in a loss of contact with the walking surface. Slips can occur on ice covered walkways or can be due to spilled materials like water.

A trip happens when a person's forward momentum is obstructed by a near ground object such as a tool, piping left in a walking path, or a curb at street level.

Falls are characterized as a fall to the same level or a fall from heights.

Falls to the same level occur most frequently and are often caused by slips or trip hazards and generally result in minor injuries. Falls from heights can result in more severe injuries that involve the head and spine.

Slip prevention includes simple techniques, such as quickly cleaning spilled materials. Even minor spills should be cleaned right away. When areas are going to remain wet after cleaning, posting signage to warn employees is an excellent control mechanism. Report any areas that require immediate attention, such as ice buildup, to your supervisor for prompt attention.

To prevent trips, keep tools off the floor and on service carts or secure the work area with cones or caution tape to prevent co-workers from walking into the work area.

7.1 Walking-Working Surface Requirements

Examples of **walking and working surfaces** include trailers, parking lots, mezzanines, tanks, ladders, loading docks, and floors.

All walking and working surfaces, including any associated guardrails and stair railings, are to be routinely inspected and maintained. Repairs are required to be overseen and performed by a qualified person. Step and extension ladders are to be inspected by the employee using the portable ladder prior to use. Damaged ladders are not to be used. Fixed ladders 24 feet and greater in length will require the installation of fall protection. Employees using fall protection are required to have training on all types of fall hazards they are exposed to and the use and limitations of any fall protection equipment required.

More information on Walking and Working Surfaces can be found on the OSHA information page at: osha.gov/walking-working-surfaces/.

More information on Fall Protection can be found on the OSHA information page at: osha.gov/SLTC/fallprotection/.

8.0 Exposure to Chemicals in Distribution Systems and Maintenance

Potential exposures to chemicals can include:

- Solvents.
- Welding fumes.
- Brazing fumes.
- Lead.
- Asbestos.
- Cleaning agents.
- Water treatment chemicals.

Each agency and department are required to comply with both the OSHA Hazard Communication Standard (29 CFR 1910.1200) and the NYS Right to Know Law (12 NYCRR Part 820). These regulations are in place to inform employees of the potential exposure to hazards in the workplace.

8.1 Written Hazard Communication Program

Under the OSHA and the NYSDOH regulations, each agency or department must have a written hazard communication program. The program needs to outline how employees are trained on the chemicals they may use, how safety data sheets (SDSs) are maintained, and how labeling is to be provided.

8.2 Right-to-Know Requirements

Program requirements include an inventory of hazardous chemicals used routinely in the workplace, a clear hazard communication process for non-routine tasks, how labels will be maintained, and how labels will be applied to containers that employees fill.

8.3 Hazard Communication and Right-to-Know Training

Employees who could be exposed to hazardous chemicals must be trained prior to working with a hazardous chemical and be trained whenever the hazard changes. Training must include the requirements of the OSHA and NYS Right to Know Standards including:

- Discussion of operations in work areas where hazardous chemicals are present.
- Location and availability of the written hazard communication program, and the required list(s) of hazardous chemicals and safety data sheets.
- Methods and observations that are to be used to detect the presence or release of a hazardous chemical in the work area. These include monitoring conducted by the employer, continuous monitoring devices, and visual appearance or odor of hazardous chemicals when being released.
- Physical, health, simple asphyxiation, combustible dust, and pyrophoric gas hazards, as well as hazards not otherwise classified of the chemicals in the work area.

Employees must be made aware of the measures to protect themselves from these hazards, such as appropriate work practices, emergency procedures, and personal protective equipment provided by the employer.

8.4 Pipe Labeling

The American National Standards Institute (ANSI), ANSI/ASME A13.1, Pipe Labeling, and Marking, is a common labeling scheme in industry. There are no specific OSHA regulations covering pipe labeling. OSHA has indicated that pipes are not required to be labeled with hazard communication labels because they are not considered "containers" under the Hazard Communication Standard. However, OSHA does require that employees be informed of and trained on the hazards associated with chemicals in unlabeled pipes, and the measures employees can take to protect themselves from these hazards.

The ANSI standard utilizes the color-coding scheme found in *Figure 21*.

Yellow	Flammable Fluids & Gasses
Red	Fire-Quenching Fluids
Orange	Toxic or Corrosive Fluids & Gasses
Green	All Water (Potable, Boiler, etc.)
Blue	All Air (Compressed, Lab, etc.)
Brown	Combustible Fluids & Gasses
Purple	Definable by user
Black	Definable by user
White	Definable by user
Gray	Definable by user

Figure 21: ANSI Pipe Color Scheme

More information on the Hazard Communication standard can be found on the OSHA information page at: osha.gov/Publications/OSHA3514.html.

The OSHA Quick Card for Hazard Communication can be found at: osha.gov/Publications/OSHA3493QuickCardSafetyDataSheet.pdf.

9.0 Lead Hazards

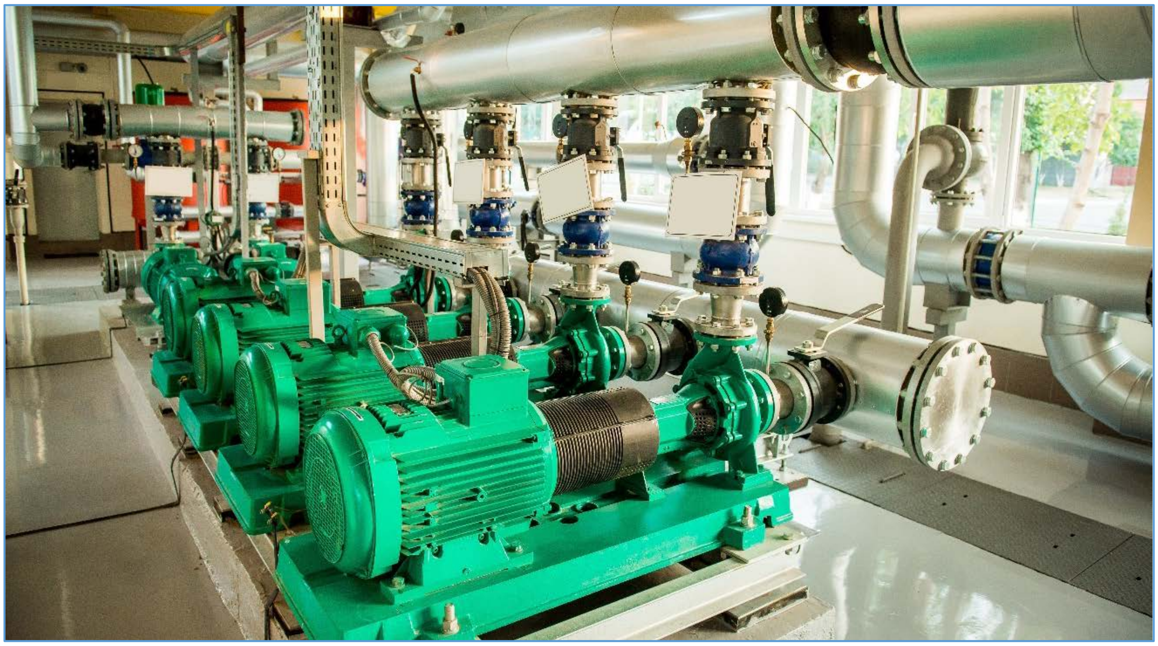

Figure 22: Modern Boiler Room

Lead can be found in coatings, paint, and pipe assemblies. The OSHA standard pertaining to lead exposure is 29 CFR 1910.1025, General Industry Lead. The standard requires that the employer provide an exposure assessment when an employee is exposed or potentially exposed to lead. There is no trigger concentration established for the amount of lead in the paint, solder or other product; the requirements are triggered by the amount of lead in the air generated by the work activity. Any concentration of lead in a coating or solder would require that an exposure assessment to be performed. Job tasks vary widely. For example, an employee grinding a coating with a low concentration of lead could be exposed above the established **Permissible Exposure Limit (PEL)**. However, an employee breaking two joints on a half inch copper line that contains lead solder most likely would have the same exposure. Both job tasks would require an exposure assessment. The standard requires a written lead exposure control plan, medical evaluation under certain circumstances, and employee training.

9.1 Lead Air Monitoring

Lead air monitoring is performed with a calibrated sample pump and a filter cassette. There are two accepted laboratory methods that are used. Samples must be obtained for at least the majority of the employee's shift; for example, eight-hour shift samples must run for at least seven hours to be representative. The samples are compared to two criteria, the Action Level (AL) and the PEL. The **Action Level** is defined as the employee exposure, without regard to the use of respirators, to an airborne concentration of lead of 30 micrograms per cubic meter of air (30 ug/m^3) averaged over an eight-hour period. The reason for the "without regard to respirators" is that if an employee is exposed above the AL for 30 days or more each year, then that employee is required to participate in a medical surveillance program. Any employee exposure above the AL requires the employer to develop a written program and provide the required training. There are additional requirements for follow-up air monitoring depending on if the results are over the AL or the PEL.

The PEL has been established at fifty micrograms per cubic meter of air (50 ug/m^3) averaged over an 8-hour period. When an employee works longer than an eight-hour shift the PEL is reduced by the following formula: maximum permissible limit (in ug/m^3) = 400 divided by hours worked in the day. If an employee is exposed above the PEL, the exposure must be controlled by use of either engineering controls or PPE.

9.2 Lead Exposure Controls

Engineering controls for lead include High Efficiency Particulate Air (HEPA) Filters as used in local exhaust. In some instances, establishing negative pressure enclosures should be used to reduce exposure. Use of HEPA filtered equipment, such as needle scalers, saws, and drills can also control exposures depending on the job task performed.

9.3 Lead Personal Protective Equipment

Personal protective equipment for lead includes gloves, eye protection, respiratory protection, and clothing. The use of respirators requires compliance with 29 CFR 1910.134, Respiratory Protection. This standard requires a medical evaluation, fit testing, and training on the use and limitations of respirators. Gloves should be provided based upon the job tasks. Respiratory protection must be determined based on the anticipated airborne exposure. The construction standard (29 CFR 1926.52) has established guidelines to select respiratory protection based on job task, until a formal respiratory assessment is performed. Disposable clothing must be treated as lead contaminated waste. Welding or cutting requires the use of flame-resistant clothing. Any clothing to be reused must be laundered by a qualified laundry service or disposed of as lead contaminated waste.

9.4 Lead Based Paint and Coatings

Lead based paints, coatings, and varnishes were heavily used prior to 1978. The USEPA defines lead-based paint as any paint or coating where the lead content is equal to or exceeds one milligram per square centimeter (1.0 mg/cm^2) or 0.5% by weight. The EPA regulations were developed to protect building occupants in regulated housing and child occupied buildings. As discussed above, OSHA defines lead containing as any concentration of lead and includes metallic lead, all inorganic lead compounds, and organic lead soaps. OSHA does not just regulate paint and coatings.

More information on lead can be found on the OSHA information page at: osha.gov/SLTC/lead/standards.html.

The OSHA Quick Card for Lead can be found at: osha.gov/Publications/OSHA3680.pdf.

10.0 Asbestos Hazards

Figure 23: Asbestos Fibers

Asbestos has been used in fire proofing and thermal insulation because of its fire resistance and insulation properties. There are OSHA regulations concerning asbestos that apply to both general industry and construction. The New York State Code Rule 56 also applies to asbestos.

10.1 New York State Industrial Code Rule 56

New York State Code Rule 56 was implemented as a public safety regulation. The New York State Legislature declared that “exposure to asbestos fibers, a known carcinogenic agent, creates a serious risk to the public safety and health, and that the public is more frequently exposed to these risks because of an increasing number of rehabilitations, reconstruction and demolition projects on buildings or structures containing asbestos or asbestos materials.” The regulation sets forth training requirements, contractor licensure, and work methods. The NYS Department of Labor’s Asbestos Control Bureau provides engineering support and enforcement.

Older insulation may contain asbestos. To determine if any building material contains asbestos, a survey must be performed by a New York State Certified Asbestos Inspector. Any repair clean-up or abatement must be performed by a NYS Licensed Contractor utilizing certified personnel. If asbestos containing materials are thought to be disturbed, report the situation to your supervisor. Incidental disturbances require NYS DOL notification and proper clean up.

10.2 Asbestos Air Monitoring

Air monitoring for asbestos is required on all asbestos projects. New York State requires area air monitoring to be performed prior to, during, and for clearance testing. The number of samples collected is dependent on the size of the project. OSHA requires personal air monitoring to determine employee exposures. The New York State clearance criteria is 0.01 fibers per cubic centimeter of air (F/cc). The OSHA PEL for asbestos is 0.1 f/cc of air as an eight-hour time-weighted average (TWA), with an excursion limit (EL) of 1.0 f/cc over a 30-minute period. The employer must ensure that no one is exposed above these limits.

10.3 Asbestos Exposure Controls

Hazard Control for asbestos includes a combination of engineering controls, work practices, and PPE. Engineering controls include the use of HEPA filtered negative pressure enclosures, glove bags, and tents. Work practices include the use of wetting agents to reduce dust during removal, and the requirement that all employees shower prior to leaving small and large containments.

10.4 Asbestos Personal Protective Equipment

PPE for asbestos includes disposable clothing, a minimum of a half face negative pressure respirator with P100 filters, eye protection, and gloves. P 100 filters are strongly oil resistant (the P) and filter out 99.97% of all particulates.

More information regarding Asbestos can be found on the OSHA information page at: osha.gov/SLTC/asbestos/ .

11.0 Noise Hazards

Figure 24: Protect Your Hearing

Exposure to loud noise for a prolonged period can be detrimental to hearing. Sensorineural hearing loss occurs when sound damages the nerve cells that are present in the inner ear. These nerve cells help us interpret loudness and the pitch of the sound. Once these nerve cells are damaged, they do not regenerate, and hearing loss can be permanent. The OSHA standard requires that all employees exposed above the PEL of 90 dBA over an eight-hour period be protected from the exposure by either engineering the hazard out or the use of hearing protection.

11.1 Noise Monitoring

Sound pressure level meters and noise dosimeters are generally used to monitor noise. Sound pressure level meters are excellent for spot checking noise sources to determine sound pressure. Noise dosimeters are best for sampling employee exposures. These units are lighter and can simultaneously sample for the OSHA PEL of 90 dBA and the Action Level of 85 dBA.

11.2 Hearing Conservation Program

The standard requires that a written hearing conservation program be developed and implemented for any employee exposed above the Action Level (85 dBA for an eight-hour shift). The elements required of a hearing conservation program include:

- Noise exposure measurements.
- Identification of high exposure areas or jobs.
- Annual audiometric testing and follow-up.
- Employee education.
- Engineering and administrative noise exposure control.
- Use of hearing protection.
- Recordkeeping requirements.

Employers must train employees annually in the effects of noise and include the following:

- Purpose, advantages, and disadvantages of various types of hearing protectors
- Selection, fit, and care of protectors
- Purpose and procedures of audiometric testing

11.3 Hearing Protection

Employers are required to provide hearing protection to all employees exposed above 85 dBA as an eight-hour time weighted average. Employers must provide employees with a selection of at least one variety of ear plug and one variety of ear muff. Employees should decide, with the help of a person trained to fit hearing protectors, which size and type protector is most suitable for the working environment. The protector selected should be comfortable to wear and offer enough protection to prevent hearing loss.

Hearing protectors must adequately reduce the noise level for each employee's work environment. Most employers use the Noise Reduction Rating (NRR) that represents the protector's ability to reduce noise under ideal laboratory conditions. The employer then adjusts the NRR to reflect noise reduction in the actual working environment. Noise reduction ratings are listed on the hearing protectors' packaging. For example, a noise reduction rating listed as NRR 23 dB will reduce the noise exposure 23 decibels. OSHA requires that the employee exposure be reduced by the following formula: monitored noise exposure in dBA minus (NRR on package -7). This formula is to be used when the sampling results are obtained on the A Scale (dBA). For example, if an employee was exposed to 100 dBA and was provided an ear muff with an NRR of 27, the adjusted exposure would be: 100 – (27-7) or 80 dBA. Hearing protectors must be selected so that the adjusted exposures are less than PEL of 90 dBA.

11.4 Loud Noises

A person can be exposed to loud noise in one of two ways. An acute exposure is a loud dose of noise for a short period of time, such as power tools being used during a work shift. Noise above 140 dB can cause pain and immediate hearing loss. Chronic exposures are generally lower doses over extended periods of time. An employee will not be able to determine how loud a noise exposure is without a sound level meter. These chronic types of exposures can still damage hearing. With chronic noise exposures there generally is no pain or indication that hearing loss is occurring. Only an annual audiogram will determine if hearing loss has occurred. The ability to hear higher frequencies decreases due to aging, which is called Presbycusis. It is highly suggested that for task based, short duration exposures, such as cutting pipe or walking through loud boiler or water rooms, hearing protection be worn. It is currently unknown how these incidental exposures could affect our hearing over a lifetime of working. Generally, if you must shout to talk to a person three feet from you, the noise is probably above 85 dBA, and hearing protection should be worn.

More information on Hearing Conservation can be found on the OSHA information page at: osha.gov/SLTC/noisehearingconservation/ .

12.0 Exposure to Hazards from Hot Work (Welding, Cutting, and Grinding)

Hazards associated with welding, cutting, and grinding include:

- Welding fumes.
- Thermal burns.
- Eye hazards due to ultraviolet light.
- Flying metal particulate.

The establishment of a hot work permit system is intended to help employees recognize and control hazards associated with open flame work or spark generating operations.

12.1 Hot Work Permit System

29 CFR 1910.252, Welding Cutting and Brazing, requires that before cutting or welding is permitted, the area shall be inspected by the employee responsible for authorizing the cutting and welding operations. This individual must designate precautions to be followed in granting authorization to proceed preferably in the form of a written permit. Hot work permits must address:

- Who can perform hot work.
- Use of fire watches.
- Use of any required ventilation.
- Occupant protection from welding fumes and the welding arc.
- A review of building fire protection systems to ensure that it is properly functioning.
- Ventilation requirements.
- Required PPE.

Fire watches must be present during hot work and up to one hour after the welding or cutting has ended. This includes breaks. When a hot work permit is required to be opened in a permit-required confined space, the hot work permit becomes part of the confined space entry permit.

12.2 Hot Work Hazards Exposure Controls

Exposure control for hot work may include:

- Welding screens.
- Curtains and blanket to protect combustible materials.
- Cover building floors.
- Protection for other employees from the welding arc.

Welding can generate welding fumes. The potential exposures will be dependent on the base metal and filler rod or wire. Welding on stainless steel can generate Hexavalent Chrome, which is a carcinogen. Welding may require the use of capture ventilation to ensure that employees and co-workers are not exposed to the welding fumes that is being generated. In addition, certain fluxes can contain fluoride that may need to be controlled. A review of the safety data sheets will help determine what hazards could be present and required controls or employee air monitoring requirements.

12.3 Hot Work Personal Protective Equipment

PPE for welding and cutting includes leather gloves, leather aprons, and leather safety shoes. The correct tint welding visor, speed glass or torch-cutting goggles are necessary for eye protection. While grinding, safety glasses with side shields and a face shield is required. If ventilation controls cannot be implemented or are ineffective, respiratory protection may be required. Half-face respirators with P100 cartridges or Powered Air Purifying Respirators with integrated speed glass are both options to consider.

More information on Hot Work can be found on the OSHA information page at: osha.gov/SLTC/etools/oilandgas/general_safety/hot_work_welding.html.

13.0 Injuries from Hand and Power Tools

Injuries associated with hand and power tools include bruises, sprains, lacerations, shock, entanglement, and eye injuries. Injuries can be caused by one or more of the following:

- Use of broken or defective tools
- Missing guards
- Exposed belts and blades
- Bad electrical cords
- Misuse of tools
- Mushroomed heads
- Cracked and split handles
- Not using required PPE

13.1 Hand and Power Tool Requirements

Perform daily inspections prior to using any tool and always:

- Use the correct tool for the job.
- Never use any equipment that has damaged cords or is missing a ground pin.
- Perform regular required maintenance.
- When working outdoors or in wet locations use ground fault circuit interrupters (GFCI). Test the GFCI prior to use.
- Operate all tools according to the manufacturer's instructions. Ensure all guards are in place, such as those on hand grinders or bench grinders.
- Wear all required PPE.

13.2 Personal Protective Equipment for Hand and Power Tools

PPE for hand and power tools includes gloves when moving stock and items with sharp edges or when grinding. Safety glasses and a face shield should be used when grinding and cutting. Aprons can be used when cutting or threading pipe. The leather apron can prevent metal from imbedding in clothing and prevent lacerations. Hearing protection may be required when cutting and drilling.

More information on Hand and Power Tool Safety can be found on the OSHA information page at: osha.gov/SLTC/handpowertools/index.html.

14.0 Conclusion

Working on and around steam distribution systems has many associated risks. In this booklet we discussed physical hazards such as thermal burns, steam explosions, and slips, trips, and falls. We also discussed health hazards such as asbestos and lead exposures. We provided some guidance on managing those risks, avoiding and controlling potential exposures. **With proper project planning, following established safety procedures, such as Lockout/Tagout, and using appropriate PPE for the job task, injuries and even fatalities can be avoided.**

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