MCAA
Mechanical Contractors Association of America

Guide to Steel and Copper Piping System Pressure Testing Safety

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Mechanical Service Contractors of America

PCA
Plumbing Contractors of America

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Guide to Steel and Copper Piping System Pressure Testing Safety

Application

This guide applies to pressure testing safety for steel and copper piping systems only. It does not apply to any other type of piping system.

The Guide

This guide was first published in 2013. MCAA revised the guide in 2020 to include new and better safe work practices pertaining to hydrostatic and pneumatic pressure testing of steel and copper piping systems.

Forward

MCAA frequently receives requests for information about how to safely perform pressure testing on steel and copper piping systems. There are several excellent piping standards that address pressure testing with a liquid under pressure (hydrostatic testing), and air or an inert gas under pressure (pneumatic testing). The standards are published by the American Society of Mechanical Engineers (ASME). The ASME piping standards most frequently used by mechanical construction firms are:

- ASME B31.1 Power Piping;
- ASME B31.3 Process Piping;
- ASME B31.5 Refrigeration Piping and Heat Transfer Components; and
- ASME B31.9 Building Services Piping.

Pressure testing is a very small part of each of these standards. For example, ASME B31.1 Power Piping covers the testing procedures for hydrostatic and pneumatic tests in only two pages. The emphasis is on the process of pressure testing, rather than pressure testing safety. To bridge the gap, this publication emphasizes safe work practices designed to help prevent worker injury during hydrostatic and pneumatic testing on steel and copper piping systems.

Disclaimer

This guide is intended to provide the user with basic safe work practices for pressure testing steel and copper piping systems. It is not intended to provide exhaustive treatment on the subject of steel and copper piping system pressure testing safety. It should never be used as a substitute for reading and complying with applicable federal, state, and local regulations and standards, and piping system component manufacturers' specifications and recommendations. Further, it is not intended to provide legal advice. Employers must make independent determinations regarding the need for legal assistance.

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Introduction

Safely pressure testing piping systems is challenging at times, but it can be accomplished with minimal risk to workers. The key to safe pressure testing is knowing the potential hazards and understanding how to eliminate or minimize them as much as possible.

Hydrostatic Testing is the preferred method of testing because it generates considerably less stored energy than pneumatic testing and involves less risk to workers. In this type of testing, a liquid, usually water, is pumped into the system before it is pressurized with air or an inert gas. Water cannot be compressed like air or gases used by themselves for pneumatic testing, so considerably less stored energy is generated. While there are still hazards associated with hydrostatic testing, MCAA recommends its use over pneumatic testing whenever possible. At times, hydrostatic testing may not be acceptable, such as when the following apply:

- The owner requires/specifies the system be tested pneumatically;
- The building is complete and cannot be subjected to the release of a liquid test medium;
- The piping system is designed in such a way that it cannot be filled with water or another liquid test medium; and/or
- The piping system will be used for a specific type of service that cannot accept traces of a liquid test medium, such as high purity piping systems for pharmaceuticals or food.

Pneumatic Testing is more hazardous for workers and should be performed only when hydrostatic testing is not acceptable for one or more of the reasons described above. Pneumatic testing generates potentially dangerous stored energy because the air or other test gases are so easily compressed. To understand how potentially hazardous pneumatic testing can be, look at the following comparisons between the stored energy in piping systems, and the equivalent stored energy in Trinitrotoluene (TNT), an explosive that is the standard measure of strength for bombs.

- 500 feet of one-inch pipe at 150 psi is equal to 1.6 ounces of TNT
- 500 feet of two-inch pipe at 150 psi is equal to 8 ounces of TNT
- 500 feet of six-inch pipe at 150 psi is equal to 5 pounds of TNT

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Safe Pressure Testing

Most of the hazards associated with pressure testing come from the sudden, unintended release of stored energy. The risk of injury from a failing joint, connection, gauge, valve, fitting, or another component increases during the testing process, especially during pneumatic testing. Safe work practices are needed for all types of pressure testing to protect the workers performing the tests, and others in the test area.

Pressure Testing Hazards

Pressure testing hazards include:

- Flying objects such as valves, flanges, gauges, and fittings;
- Flying shrapnel such as small pieces of pipe, pipe fittings, or other system components that shatter into parts from the pressure;
- Oxygen displacement from an inert gas used for testing; and
- Flooding in areas where energized electrical sources are present.

Injuries from Pressure Testing

Most, but not all injuries from improper pressure testing are inflicted by flying objects. Some of the more obvious pressure testing injuries include:

- Puncture wounds;
- Eye damage;
- Lacerations;
- Broken bones;
- Contusions;
- Concussions; and
- Internal injuries.

Less obvious pressure testing injuries include:

- Asphyxiation from the unexpected release and accumulation of inert testing gases such as nitrogen or argon, especially in confined spaces or low-lying areas; and
- Electrocutions from flooding in areas where energized electrical sources contact a conductive liquid (usually water).

Workers can protect themselves from these injuries when they are provided with an appropriate Standard Operating Procedure (SOP), have the proper training, including safe work practices, and carefully implement the safe work practices in conjunction with the SOP. MCAA recommends each company establish a pre-test safety plan for each specific pressure testing application. All workers who will

be involved in a pressure test should be part of the pre-test safety planning process.

Primary Causes of Pressure Testing Failures

The primary causes of piping system failures during pressure testing operations include:

1. Over pressurizing a system;
2. Inadequate/improper pressure testing equipment;
3. Inadequate/improper system component design;
4. Operator error;
5. Inadequate repairs/modifications to a piping system;
6. Failure to properly isolate parts being tested from other parts of a system;
7. Failure to properly isolate equipment from the piping system being tested;
8. Failure to perform lockout/tagout or improper lockout/tagout method;
9. Failure to verify the system is completely depressurized; and
10. Failure to properly vent air from the component being tested.

General Pressure Testing Safety

Now that we have identified ten primary causes of piping system failures that occur during pressure testing, let us look at each of them individually to determine how best to address them.

Over-Pressurizing Piping Systems

Over-pressurizing any piping system can result in failure and create hazards. To keep from over-pressurizing a piping system you will need to know the test pressure before you start the test. The engineer or other qualified person making the determination will establish the maximum allowable working pressures for each component of the piping system, such as gauges, valves, fittings, etc. Maximum allowable working pressures for components in the system will be isolated from the test are not considered in the calculation. Maximum allowable working pressures and other vital specifications, such as measuring temperatures (certain concentrations of steel become brittle when cold enough) are provided by the manufacturers of the pipe and other system components. Once the information is obtained, the engineer or other qualified person will use the appropriate ASME code or mechanical engineering formula to determine the test pressure.

To avoid over-pressurizing the piping system:

- Determine the test pressure;

- Where appropriate, install a calibrated pressure relief valve set to 1.5 times the test pressure (pneumatic testing only);
- Increase the pressure gradually according to the applicable ASME code; and
- Never exceed the test pressure.

Inadequate/Improper Pressure Testing Equipment

Pressure testing equipment includes items such as gauges, pumps, cylinders, hoses, connections, etc. Test equipment is considered inadequate if it is poor quality, not designed for the maximum pressure it will endure, not properly calibrated, and/or not working properly. Inadequate test equipment will likely result in failure and create hazards.

- Use only test equipment designed and built by reputable manufacturers;
- Use the most current/accurate information provided by the manufacturer to ensure the equipment is designed for your specific pressure testing application;
- Ensure the test gauges are calibrated. Use either brand-new manufacturer calibrated gauges or refer to the calibration stickers to ensure that used gauges have been professionally calibrated within the past 12 months;
- Check each calibrated gauge just prior to installation to ensure it is registering zero. If it is not at zero, it is damaged and must be replaced with a properly working calibrated gauge before proceeding with the test;
- Test pressure should register on the gauges as close to the 12 o'clock position as possible. For example, if the test pressure is determined to be 100 psi, select a 200-psi analog pressure gauge. The test pressure (100 psi) will be at the top in the 12 o'clock position;
- Inspect all reused equipment for pressure testing operations, such as fittings, gauges, hoses, etc., and permanently remove any defective equipment/materials from service;
- Verify the correct number and size of fittings and temporary closures are used for the test; and
- Install whip checks on hoses to prevent injury if they become detached while under pressure.

Inadequate/Improper System Component Design

A system is improperly designed if any single component is inadequate for the application. When any part of the system, such as a fitting, valve, gauge, flange, adaptor, hose connection or flex connector is not designed to endure the anticipated test pressure, failure will occur. Use of poor-quality materials, and/or inadequate assembly and installation may also lead to failure.

- Verify proper system design prior to installation. Before performing a pressure test on an unfamiliar system, verify tthe engineer or another qualified person has established the original design rating from original data reports or new calculations based on sizes, wall thicknesses, etc.; and
- Verify the quality of all piping systems materials, assembly, and installation is adequate.

Operator Error

Operator error usually occurs when workers are rushed or distracted. Under those circumstances, they may not carefully follow the safe work practices and pressure testing procedures established during the test hazard analysis. That is when failures occur, and hazards are generated. For example, failure to verify all affected valves are open, and all pressure in the piping system is released before removing a component can be catastrophic. Even attempting to tighten, align, or adjust a piping system component while the system is under pressure can be devastating.

- Ensure all affected workers receive the proper training, tools, materials, and supervision they need to perform the tests safely;
- Identify and limit workplace distractions as much as possible;
- Allow enough time so the pressure testing operations will not be rushed;
- Include all affected workers in the test hazard analysis, and pre-test safety briefing; and
- Ensure each affected worker is utilizing the established checklist.

Inadequate Repairs/Modifications to Piping Systems

Inadequate repairs or modifications to piping systems can lead to problems. Use of improper fittings, misalignments, rolled or cut gaskets, etc. result in inadequate repairs or modifications, and are likely to cause pressure testing failures and potential hazards.

- Carefully inspect all parts of the piping system included in the test before starting;
- Pay close attention to joints and connections; and
- Make any necessary corrections before you proceed.

Failure to Properly Isolate the Parts of the System Being Tested from the Parts of the System Not Being Tested

Failure to isolate one or more parts of a system that are not part of the test can result in failure and generate hazards. For example, failure to isolate a relief valve not designed for the test pressure will activate the valve and unexpectedly

release the test medium into the environment under pressure. Even worse, failure to isolate a gauge, meter, or some other component not designed to endure the test pressure can cause it to shatter under pressure creating flying shrapnel.

- Review the safe work practices and pressure testing procedures established during the test hazard analysis, including the piping system drawings or Building Information Models (BIM), just before starting the testing operation;
- Carefully follow the safe work practices and pressure testing procedures;
- Utilize the checklist established during the test hazard analysis to ensure you do not inadvertently omit an important part of the isolation process; and
- Make sure the checklist includes isolating/blocking parts of the system not to be included in the test.

Failure to Properly Isolate Equipment from the Piping System to be Tested
Failure to isolate equipment from the system could result in injury or damaged equipment. When equipment arrives for installation it has most likely already been tested. And, equipment typically has a lower maximum allowable working pressure than that of the piping system. To ensure proper isolation of equipment:

- Carefully follow the appropriate safe work practices and pressure testing procedures;
- Utilize the checklist established during the test hazard analysis to ensure you do not inadvertently omit an important part of the isolation process; and
- Verify isolating/blocking the equipment is included on the checklist.

Failure to Perform Lockout/Tagout or Use of Improper Lockout/Tagout Method
Failure to lockout/tagout a piping system being tested, or use of an improper lockout/tagout method, could result in someone unexpectedly pressurizing the system. The results of a worker unwittingly breaking into a pressurized system can be catastrophic.

- Be sure to perform lockout/tagout by referring to, and following the correct pressure testing checklist;
- To ensure the correct lockout/tagout method is being used, refer to the test hazard analysis; and
- Use only the lockout/tagout method described in the analysis.

Failure to Verify the System is Completely Depressurized
Failure to verify a piping system under test was completely depressurized before being opened has resulted in numerous pressure testing failure injuries and fatalities.

- Carefully follow the correct post-test portion of the pressure testing checklist; and
- Do not count on others to perform the verification properly.

Failure to Properly Vent Air from the Component Being Tested
Failure to properly vent air from the part of the system being tested can result in unsafe pressure levels.

- Carefully follow the appropriate safe work practices and pressure testing procedures;
- Utilize the checklist established during the test hazard analysis to ensure that you do not inadvertently omit an important part of the venting process; and
- Verify the system has been properly vented to prevent pressure build-up.

Safe Work Practices for Hydrostatic Testing

Standard Operating Procedures (SOP)
Establish an SOP for each specific pressure testing application based on the most current/applicable ASME standard and this publication's safety guidelines.

- Use the safe work practices section of this guide and the applicable ASME standard to develop your company's SOP for each specific pressure testing application.

Checklist
Using your SOP for the specific hydrostatic testing application, develop a checklist to help affected workers perform the test safely.

- See Appendix B for a sample hydrostatic pressure test checklist.

Pre-Test Safety Plan
Develop a pre-test safety plan using the applicable SOP and corresponding checklist.

- Include all affected workers, companies, and owners in the pre-test safety planning process;

- Identify the potential hazards and the protective measures affected workers will use to protect themselves from those hazards; and
- See Appendix A for guidance on pre-test safety plans.

Worker Training
Train all affected workers on the hydrostatic test process used for the specific application.

- Use the applicable SOP and corresponding checklist as training resources; and
- Ensure the affected workers understand the potential hazards and how to protect themselves from those hazards.

Pre-Test Safety Briefing
Just prior to performing the hydrostatic test, conduct a pre-test safety briefing.

- Review the pre-test safety plan;
- Ensure the affected workers fully understand the process, the potential hazards, and the protective measures;
- Ensure the affected workers have the proper equipment, materials, and personal protective equipment they need to safely perform the hydrostatic test;
- Establish the communication system (two-way radios, cell phones, etc.) for affected workers to communicate with each other during the test; and
- Establish an emergency response plan including emergency shutdown procedures and provide affected workers with emergency contact information/telephone numbers.

Walk-Down
Carefully perform a walk-down inspection of the system. Take the checklist with you so you do not inadvertently omit critical tasks. Pay close attention to detail as you perform the walk-down and be sure to include each of the following:

- Identify all equipment adjacent to the test area that could be affected by failure to isolate it, or otherwise protect it;
- Verify the system was completed according to the appropriate drawings or Building Information Models (BIM), no ends of the piping system have been left open, and there are no closed valves left open;
- Verify the system is vented at all the high points to bleed the air out when it is being filled with the test liquid. Determine system readiness, including verification there are adequate low point drains, and high point vents. When necessary, install a low point drain, or another appropriate method for removal of water from low points;

- Verify all affected joints and connections are exposed for inspection/evaluation during the testing procedure. When necessary, remove piping system insulation;
- Identify any damaged piping system components, misaligned segments, or anything else out of place;
- Verify the nuts are fully engaged with the threads on the bolts;
- Verify all piping system segments/components that are not part of the test, are properly isolated from the parts of the system that will be tested. This includes, but is not limited to existing gauges and/or relief valves that cannot be isolated by a valve, and are not rated for the test pressure;
- Verify any portion of the system not tested is adequately vented to prevent pressure build-up;
- Verify the expansion joints are equipped with temporary restraints where required, or otherwise isolated from the test;
- Verify the components designed for vapor or gas are equipped with additional temporary supports to withstand the additional weight of the test liquid; and
- Verify all necessary lockout/tagout procedures follow applicable federal, state, and local safety standards, and have been properly completed.

Final Preparation

Carefully complete final preparations using the checklist to ensure nothing critical is omitted.

- Verify the maximum allowable working pressure, and the test pressure with the system engineer or another appropriate qualified person. Also, verify that person knows when the test will be performed overnight since ambient temperature changes will affect the pressure;
- Prior to the start of the test, replace or repair any piping system segments, or components identified during the walk-down that need replacement or repair;
- Use at least one test gauge for each pressure test, and use two test gauges when feasible. Piping systems that have a properly rated and properly calibrated integral gauge at the pressure source, or at the highest or furthest point away from the pressure source require only one additional test gauge at the opposite location;
- Verify the test gauges have a graduated range of no less than 1.5 times or more than 4 times the test pressure;
- Use only non-adjustable test gauges for pressure testing operations;

- Verify the test gauges selected for each test display the test pressure at the 12 o'clock position (For example, if the test pressure is 100 psi, use of a 200 psi (analog) gauge will display the test pressure at the 12 o'clock position on the gauge);
- Prior to the start of the test, verify proper test gauge calibration. Confirm the test gauges have been professionally calibrated against a standard dead-weight tester or a calibrated master gauge within the past 12 months. Use brand new gauges calibrated by the manufacturer, or ensure the dates of calibration shown on the used gauges (check calibration stickers) are within the past 12 months;
- Verify one gauge is installed at the pressure source where it is visible to the worker controlling the applied pressure, and the other at the highest or furthest point away from the pressure source;
- Verify the calibrated gauges register zero at the time of installation. Gauges that do not register zero are unusable. Take them out of service immediately, and replace them before testing operations begin;
- Verify the test equipment is securely connected to the piping system;
- Verify the test equipment hoses are properly secured in place;
- Verify the air pockets have bled out of the system, and all affected vents have been closed off and sealed;
- Barricade or cordon off the test area. When feasible, 140 feet is a reasonably safe distance. Use red danger tape, or other highly visible barricades and signs indicating a pressure test is occurring;
- Post warning signs to keep non-essential personnel outside the test area. Also, ensure there are no unprotected public areas where someone could inadvertently walk into the test area;
- Just prior to starting the test, verify all non-essential personnel have been informed the test is about to begin and have left the area;
- Ensure a qualified person remains onsite during the entire pressure testing operation, unless overnight testing is performed; and
- When overnight testing is performed, ensure the test area is barricaded or cordoned off, and warning signs indicating there is a piping system under pressure are placed in conspicuous locations around the perimeter of the test area.

Personal Protective Equipment

Personal protective equipment is critical in case there is a failure in the piping system during the testing operation.

- Ensure all affected workers wear a hardhat, safety glasses, face shield, and gloves.

Testing
Continue with the checklist to ensure you do not omit any critical tasks. Remember to verify the maximum allowable pressure for the system and pay close attention to the actual pressure shown on the test gauges.

- Ensure ventilation is adequate or ensure the test area is monitored for hazardous levels of oxygen displacement caused by the test gas;
- Monitor the gauges to ensure the recommended test pressure above the maximum allowable working pressure is never exceeded, and the test pressure never goes below the recommended level;
- Increase initial pressure in the piping system gradually to no more than ½ the maximum allowable working pressure, and maintain it for at least 10 minutes or for the code required minimum before administering any further increases in test pressure;
- Perform subsequent pressure increases in increments of 1/10th the test pressure, and maintain each increase for at least 10 minutes before increasing again to the next level;
- Maintain the required test pressure for at least 10 minutes or the code required minimum;
- When the test pressure holds steady for a minimum of 10 minutes, or longer if the code requires, reduce it to ¾ the test pressure and inspect the system for leaks;
- Maintain the pressure at each step for the length of time it takes to thoroughly evaluate the system for leaks, and to satisfy the customer's specifications;
- Once the system stabilizes after each pressure increase, inspect all joints and connections looking for signs of leaking.
  WARNING – If signs of yielding or system failure are observed, evacuate personnel from the pressure testing area as quickly as possible, except for one worker who is authorized to decrease the piping system pressure. Decrease the pressure to zero and make all the necessary repairs prior to retesting;
- Use a liquid leak detector whenever it is deemed appropriate by the competent person; and
- To locate major leaks in a system, a preliminary low-pressure test that does not exceed 5 psig may be performed. When a preliminary low-pressure test is performed and the pressure in the system reaches 5 psig, isolate the portion of the system being tested from the pressure source. Observe the test gauge for a minimum of 10 minutes to determine whether any substantial leaks are present in the system.

Post Test
Continue with the checklist to ensure you do not omit any critical tasks.

- Carefully follow the SOP to gradually release the pressure from the system and collect the waste liquid test medium when required;
- Never attempt piping system leak repairs, tightening of fittings, alignments, adjustments, or component replacements while the piping system is under pressure;
- Release the pressure in the piping system as soon as the pressure test has been completed;
- Verify and re-confirm the pressure is at zero before removing any valves, flanges, fittings, gauges, etc.;
- Position your head and body to one side of the component when feasible before repairing leaks, tightening fittings, making alignments or adjustments, replacing component parts, etc.;
- Completely drain the piping system;
- When one or more leaks are identified in a piping system, repair them after the pressure is decreased to, and verified at 0 psi;
- Retest the piping system using the safe work practices and procedures utilized for the initial pressure test; and
- When working with grooved piping systems, depressurize and drain the system before attempting to remove, loosen, align, adjust, or install fittings, valves, or other piping system components.

Safe Work Practices for Pneumatic Testing

Standard Operating Procedures (SOP)
Establish an SOP for each specific pressure testing application based on the most current/applicable ASME standard and this publication's safety guidelines.

- Use the safe work practices section of this guide and the applicable ASME standard to develop your company's SOP for each specific pressure testing application.

Checklist
Using your SOP for the specific pneumatic testing application, develop a checklist to help affected workers perform the test safely.

- See Appendix C for a sample pneumatic pressure test checklist.

Pre-Test Safety Plan
Develop a pre-test safety plan using the applicable SOP and corresponding checklist.

- Include all affected workers, companies, and owners in the pre-test safety planning process;
- Identify the potential hazards and the protective measures affected workers will use to protect themselves from those hazards; and
- See Appendix A for guidance on pre-test safety plans.

Worker Training
Train all affected workers on the pneumatic test process used for the specific application.

- Use the applicable SOP and corresponding checklist as training resources; and
- Ensure the affected workers understand the potential hazards and how to protect themselves from those hazards.

Pre-Test Safety Briefing
Just prior to performing the pneumatic test, conduct a pre-test safety briefing.

- Review the pre-test safety plan;
- Ensure the affected workers fully understand the process, the potential hazards, and the protective measures;
- Ensure the affected workers have the proper equipment, materials, and personal protective equipment to safely perform the pneumatic test;
- Establish the communication system (two-way radios, cell phones, etc.) for affected workers to communicate with each other during the test; and
- Establish an emergency response plan including emergency shutdown procedures and provide affected workers with emergency contact information/telephone numbers.

Walk-Down
Carefully perform a walk-down inspection of the system. Take the checklist with you so you do not inadvertently omit critical tasks. Pay close attention to detail as you perform the walk-down and be sure to include each of the following:

- Identify all equipment adjacent to the test area that could be affected by failure to isolate it, or otherwise protect it;
- Verify the system was completed according to the appropriate drawings or Building Information Models (BIM), no ends of the piping system have been left open, and there are no closed valves left open;
- Verify all affected joints and connections are exposed for inspection/evaluation during the testing procedure. When necessary, remove piping system insulation;

- Identify any damaged piping system components, misaligned segments, or anything else out of place;
- Verify the nuts are fully engaged with the threads on the bolts;
- Verify all piping system segments/components not part of the test, are properly isolated from the parts of the system that will be tested. This includes, but is not limited to existing gauges and/or relief valves that cannot be isolated by a valve, and are not rated for the test pressure;
- Verify any portion of the system not tested is adequately vented to prevent pressure build-up;
- Verify the expansion joints are equipped with temporary restraints where required, or otherwise isolated from the test; and
- Verify all necessary lockout/tagout procedures follow applicable federal, state, and local safety standards, and have been properly completed.

Final Preparation

Carefully complete final preparations using the checklist to ensure nothing critical is omitted.

- Verify the maximum allowable working pressure, and the test pressure with the system engineer or another appropriate qualified person. Also, verify that person knows when the test will be performed overnight since ambient temperature changes will affect the pressure;
- Prior to the start of the test, replace or repair any piping system segments, or components identified during the walk-down that need replacement or repair;
- Use at least one test gauge for each pressure test, and use two test gauges when feasible. Piping systems that have a properly rated and properly calibrated integral gauge at the pressure source, or at the highest or furthest point away from the pressure source require only one additional test gauge at the opposite location;
- Verify the test gauges have a graduated range of no less than 1.5 times or more than 4 times the test pressure;
- Use only non-adjustable test gauges for pressure testing operations;
- Verify the test gauges selected for each test display the test pressure at the 12 o'clock position (For example, if the test pressure is 100 psi, use of a 200 psi (analog) gauge will display the test pressure at the 12 o'clock position on the gauge);
- Prior to the start of the test, verify proper test gauge calibration. Confirm the test gauges have been professionally calibrated against a standard dead-weight tester or a calibrated master gauge within the past 12 months. Use brand new gauges calibrated by the manufacturer, or ensure the dates of calibration shown on the used gauges (check calibration stickers) are within the past 12 months;

- Verify the pressure testing gauges are connected to the system by adaptors made of the same material;
- Verify one gauge is installed at the pressure source where it is visible to the worker controlling the applied pressure, and the other at the highest or furthest point away from the pressure source;
- Verify the calibrated gauges register zero at the time of installation. Gauges that do not register zero are unusable. Take them out of service immediately, and replace them before testing operations begin;
- Where appropriate, verify a pressure relief valve with adequate capacity is installed and set to 1.5 times the test pressure, and the pressure released from the valve is controlled, so that it is emitted to a safe area;
- Verify the test equipment is securely connected to the piping system;
- Verify the test equipment hoses are properly secured in place;
- Verify the air pockets have bled out of the system, and all affected vents have been closed off and sealed;
- Verify the test gas is non-flammable and non-toxic. The appropriate Safety Data Sheet is easily accessible for reference;
- In work environments where the ambient air temperature is at or below 32^0 F (0^0 C), verify the material is measured immediately before the test begins to ensure ductile-brittle transition temperatures are not incurred during the pressure testing operations. When measurements show the material temperature is too low, the test is postponed until the material temperature increases to safe levels;
- Barricade or cordon off the test area. When feasible, 140 feet is a reasonably safe distance. Use red danger tape, or other highly visible barricades and signs indicating a pressure test is occurring;
- Post warning signs to keep non-essential personnel outside the test area. Also, ensure there are no unprotected public areas where someone could inadvertently walk into the test area;
- Just prior to starting the test, verify all non-essential personnel have been informed the test is about to begin and have left the area;
- Ensure a qualified person remains onsite during the entire pressure testing operation, unless overnight testing is performed; and
- When overnight testing is performed, ensure the test area is barricaded or cordoned off, and warning signs indicating there is a piping system under pressure are placed in conspicuous locations around the perimeter of the test area.

Personal Protective Equipment

Personal protective equipment is critical in case there is a failure in the piping system during the testing operation.

- Ensure all affected workers wear a hardhat, safety glasses, face shield, gloves, and hearing protection.

Testing

Continue with the checklist to ensure you do not omit any critical tasks. Remember to verify the maximum allowable pressure for the system and pay close attention to the actual pressure shown on the test gauges.

- Ensure ventilation is adequate or ensure the test area is monitored for hazardous levels of oxygen displacement caused by the test gas;
- Monitor the gauges to ensure the recommended test pressure above the maximum allowable working pressure is never exceeded, and the test pressure never goes below the recommended level;
- Increase initial pressure in the piping system gradually to no more than ½ the maximum allowable working pressure, and maintain it for at least 10 minutes or for the code required minimum before administering any further increases in test pressure;
- Perform subsequent pressure increases in increments of 1/10th the test pressure, and maintain each increase for at least 10 minutes before increasing again to the next level;
- Maintain the required test pressure for at least 10 minutes or the code required minimum;
- When the test pressure holds steady for a minimum of 10 minutes, or longer if the code requires, reduce it to ¾ the test pressure and inspect the system for leaks;
- Maintain the pressure at each step for the length of time it takes to thoroughly evaluate the system for leaks, and to satisfy the customer's specifications;
- Once the system stabilizes after each pressure increase, inspect all joints and connections looking for signs of leaking.
  WARNING – If signs of yielding or system failure are observed, evacuate personnel from the pressure testing area as quickly as possible, except for one worker who is authorized to decrease the piping system pressure. Decrease the pressure to zero and make all the necessary repairs prior to retesting;
- Use a liquid leak detector whenever it is deemed appropriate by the competent person; and
- To locate major leaks in a system, a preliminary low-pressure test that does not exceed 5 psig may be performed. When a preliminary low-pressure test is performed and the pressure in the system reaches 5 psig, isolate the portion of the system being tested from the pressure source. Observe the test gauge for a minimum of 10 minutes to determine whether any substantial leaks are present in the system.

Post Test

Carefully follow the SOP to gradually release the pressure from the system.

- Never attempt piping system leak repairs, tightening of fittings, alignments, adjustments, or component replacements while the piping system is under pressure;
- Release the pressure in the piping system as soon as the pressure test has been completed;
- Verify and re-confirm the pressure is at zero before removing any valves, flanges, fittings, gauges, etc.;
- Position your head and body to one side of the component when feasible before repairing leaks, tightening fittings, making alignments or adjustments, replacing component parts, etc.;
- When one or more leaks are identified in a piping system, repair them after the pressure is decreased to, and verified at 0 psi;
- Retest the piping system using the safe work practices and procedures utilized for the initial pressure test; and
- When working with grooved piping systems, depressurize and drain the system before attempting to remove, loosen, align, adjust, or install fittings, valves, or other piping system components.

Appendix A – Pre-Test Safety Planning Guidance

Perform a hazard analysis before starting any pressure test. Be sure the analysis is performed as close as possible to the start of the test. And, be sure to:

- Identify the worker responsible for supervising the test;
- Identify each worker performing the test;
- Inform each worker involved about the hazard analysis; and
- Require each affected worker to participate in the hazard analysis.

Supervisor's Responsibilities
The designated supervisor is responsible for ensuring that:

- Each worker performing the test has been properly trained to safely perform the work; and
- Each worker performing the test has received the necessary tools and equipment, including the safety equipment identified in the hazard analysis.

The steps for performing an effective hazard analysis are as follows:

1. Break the pressure test down into specific steps (refer to the applicable SOP).
2. Identify and record the hazards associated with each step.
3. Determine the best way to safely complete each step.
4. Develop and record safe work procedures for each step.
5. Include each affected worker in the safe work procedures development process.
6. Perform a pre-test briefing just before the test begins. Include the following topics in the pre-test briefing:
    - Review each hazard identified in the hazard analysis;
    - Review each of the established safe work procedures;
    - Determine whether any changes to the safe work procedures are needed due to last minute or scope changes.
    - Ensure all necessary personal protective equipment is present.
    - Provide each affected worker with a sign-off sheet to indicate they are familiar with the potential hazards and how to protect themselves from those hazards. Collect and file the completed sign-off sheets.

Appendix B – Sample Hydrostatic Test Checklist

Pre-Test:

___ GC, CM, or owner and affected workers' management approval
___ All affected persons informed (GC, CM, Owner, PMs, workers, other trades, suppliers, etc.)
___ Max. allowable working pressure and test pressure established by engineer/qualified person

Maximum Allowable Working Pressure_____ Test Pressure_____

___ Pre-test safety plan completed/reviewed
___ Affected workers properly trained
___ Affected workers' system of communication established
___ Public suitability protected where applicable
___ Test equipment, valves, fittings, gauges, etc. properly rated/adequate for test pressure
___ The range for both test gauges is approximately double the test pressure
___ Test gauges calibrated

Gauge #1 Date: _____ Gauge #2 Date: _____

___ Test gauges certified where applicable

Gauge #1 Date: _____ Gauge #2 Date: _____

___ Test area barricaded to keep non-essential personnel out of pressure testing area
___ Warning signs posted to keep non-essential personnel out of pressure testing area
___ Walk-down completed
___ System complete
___ Vent valves closed
___ Fill/block valves closed
___ Joints and connections exposed
___ Valves properly configured
___ System parts undamaged/properly aligned
___ Valve open/close procedures verified
___ Bolted connections torqued according to manufacturer specifications prior to pressurization
___ Lockout/tagout completed following the established procedure
___ Emergency contact information/telephone numbers established/provided
___ Emergency shutdown procedures established/provided and safe egress established
___ Equipment isolated/blocked from the piping system
___ Other parts of the piping system not included in the test removed or isolated

___ Pressure relief valve inspected, and re-use confirmed to be fewer than 12 times
___ Pressure relief valve installed in vertical position
___ Pressure relief valve set to appropriate pressure
___ Pressure from release controlled to emit to a safe area

Test:
___ Test equipment securely attached/restraints strong enough to hold at test pressure
___ Test pressure re-verified

Test Pressure _____
___ All non-essential personnel removed from area
___ All affected personnel wearing hardhats, safety glasses, gloves, and face shield
___ Pressure applied gradually according to the established procedures
___ Affected workers are adequately shielded when pressure is being applied
___ Barricades/warning signs in place for overnight pressure tests
___ Pressure maintained according to the established procedures
___ All joints and connections inspected for leaks after pressure reduced to inspection level

Post Test:
___ Pressure released from piping system gradually according to established procedures
___ Pressure released from charged hoses
___ Pressure confirmed at 0 psi before repairs begin
___ Test liquid collected according to established procedures
___ Test liquid disposed of properly according to established procedures
___ Leak repairs made if necessary/pressure confirmed at 0 psi before repairs begin
___ Piping system retested following repairs and new checklist started for retest

Appendix C – Sample Pneumatic Test Checklist

Pre-Test:

___ GC, CM, or owner and affected workers' management approval
___ All affected persons informed (GC, CM, Owner, PMs, workers, other trades, suppliers, etc.)
___ Max. allowable working pressure and test pressure established by engineer/qualified person

Maximum Allowable Working Pressure_____ Test Pressure_____
___ Applicable test procedures identified and reviewed
___ Pre-test safety plan completed/reviewed
___ Affected workers properly trained
___ Affected workers system of communication established
___ Public suitability protected where applicable
___ Test gas verified to be non-flammable/non-toxic
___ All test equipment, including test rig, adequate for anticipated maximum test pressure
___ The range for both test gauges is approximately double the test pressure
___ Test gauges calibrated

Gauge #1 Date: _____ Gauge #2 Date: _____
___ Test gauges certified where applicable

Gauge #1 Date: _____ Gauge #2 Date: _____
___ Steel pipe/components temperature measured/acceptable (when applicable)
___ Test area barricaded to keep non-essential personnel out of pressure testing area
___ Warning signs posted to keep non-essential personnel out of pressure testing area
___ Pressure relief valve properly sized
___ Pressure relief valve installed in vertical position
___ Pressure relief valve set to appropriate pressure
___ Pressure from release controlled to emit to a safe area
___ Walk-down completed
___ System complete
___ Vent valves closed
___ Fill/block valves closed
___ Joints and connections exposed
___ Valves properly configured
___ System parts undamaged/properly aligned
___ Valve open/close procedures verified
___ Bolted connections torqued according to mfr. specifications prior to pressurization

___ Lockout/tagout completed following the established procedure
___ Emergency contact information/telephone numbers established/provided
___ Emergency shutdown procedures established/provided and safe egress established
___ Equipment isolated/blocked from the piping system
___ Other parts of the piping system not included in the test removed or isolated
___ Test gas valve is in the closed position before attachment
___ Pressure regulator is fully backed out allowing zero flow
___ Equipment/materials inspected, and re-use confirmed to be 12 times or fewer

Test:
___ Test equipment securely attached/restraints strong enough to hold at test pressure
___ Test pressure re-verified

Test Pressure _____
___ All non-essential personnel removed from area
___ All affected personnel wearing hardhats, safety glasses, gloves, face shields, ear plugs
___ Pressure applied gradually according to established procedures
___ Affected workers are adequately shielded when pressure is being applied
___ Barricades/warning signs in place for overnight pressure tests
___ Pressure maintained according to established procedures
___ Joints and connections inspected for leaks after pressure is reduced to inspection level

Post Test:
___ Pressure released from piping system gradually according to established procedures
___ Leak repairs made if necessary/pressure confirmed at 0 psi before repairs begin
___ Piping system retested following repairs and new checklist started for retest

Appendix D – Sample Pneumatic Test Permit

XYZ Company, Inc. – Pneumatic Pressure Test Permit

System to be Tested: _____

Date: _____ **Start Time:** _____ **Finish Time:** _____

Notifications:	**Initials:**
___ Owner (when applicable)	_____
___ GC/CM	_____
___ Other Affected Trades	_____
___ Safety Department	_____

Comments:

_____
_____
_____
_____
_____
_____
_____

Pressure Test Supervisor:

___ Applicable SOP Established
___ Maximum Allowable Test Pressure Verified
___ Design Pressure Verified
___ Pre-Test Portion of Checklist Complete

Full Name: _____

Signature: _____ Date: _____

Pressure Test Approvals:

Superintendent: _____ Safety Officer: _____

Signature: _____ Signature: _____

Date: _____ Date: _____

Mechanical Contractors Association of America, Inc.
1385 Piccard Drive Rockville MD 20850 **T** 301 869 5800 **F** 301 990 9690 **MCAA.ORG**