

AVOIDING COMMON CONNECTION MISTAKES IN PRESSURE TESTING AND CALIBRATION: BEST PRACTICES FOR RELIABLE CONNECTIONS WITH HAND PUMPS, PRESSURE FITTINGS AND HOSES

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ABSTRACT

This paper provides a practical overview of hand pumps, pressure fittings, and hoses used in pressure testing and calibration applications. Emphasis is placed on proper component selection, system assembly, and connection techniques to ensure safe, reliable, and repeatable pressure measurements. Our live presentation of this material will focus on common causes of connection failure—including thread mismatch, improper sealing, and hose degradation—are examined, along with methods to mitigate these issues. Best practices for minimizing leaks, improving measurement stability, and enhancing safety in both laboratory and field environments are presented.

1. INTRODUCTION

Pressure calibration systems are widely used across industrial and laboratory environments to verify and maintain the accuracy of pressure-measuring instruments. While significant attention is often given to the accuracy and performance of pressure standards, the integrity of the connection system—comprising hand pumps, hoses, and fittings—is frequently overlooked.

In practice, many calibration errors, safety incidents, and inefficiencies can be traced not to the reference instrument, but to improper connections within the pressure system. Issues such as leaks, unstable pressure, and component failure are commonly the result of incorrect thread selection, improper assembly techniques, or degraded components.

This paper focuses on the practical aspects of pressure system connections, providing guidance on selecting appropriate components, assembling reliable systems, and avoiding common failure modes.

2. CAUSES OF PRESSURE CONNECTION FAILURES

Field and laboratory experience consistently show that pressure connection failures are primarily due to improper identification and use of connection types. Thread incompatibility—particularly between standards such as NPT and BSP—is a frequent cause of leakage and mechanical failure.

Improper identification and use of connection types are leading contributors to pressure system leaks and failures. Thread incompatibility—particularly between NPT, BSPP, and BSPT standards—can result in poor sealing performance, thread damage, and unsafe conditions if improperly assembled. Correct identification of both thread form and sealing method is critical to achieving reliable pressure connections (Ralston Instruments, *The Difference Between NPT, BSPP and BSPT Seals*).

Additionally, the use of excessive force to compensate for improper connections often leads to thread deformation, seal damage, and eventual failure. These issues are compounded when multiple adapters are stacked together, increasing the number of potential leak paths and mechanical stress points.

3. PRESSURE FUNDAMENTALS IN CALIBRATION SYSTEMS

Understanding basic pressure concepts is essential for safe and effective system design. Key distinctions include operating pressure, test pressure, and burst pressure. Components must be selected such that all elements in the system can safely withstand the intended operating and test conditions.

Importantly, the maximum allowable pressure of a system is limited by its lowest-rated component. This is often not the pump or reference instrument, but rather the hose or fitting used in the connection chain.

Temperature also plays a significant role in pressure system behavior. Variations in temperature can affect fluid properties, sealing performance, and pressure stability, potentially introducing measurement uncertainty (NIST Technical Note 1297).

4. PRESSURE GENERATION METHODS

Pressure generation in calibration systems is typically achieved using either hydraulic or pneumatic methods.

Hydraulic systems provide stable pressure control and are less susceptible to compressibility effects, making them suitable for high-precision applications.

Pneumatic systems, while often more convenient, store greater energy due to gas compressibility and can introduce instability during pressure adjustments. Care must be taken when using compressed gases to ensure safe operation and controlled pressurization.

Nitrogen is commonly preferred over compressed air in calibration applications due to its dryness and inert properties, which reduce contamination and improve measurement consistency (Compressed Gas Association).

Hand pumps remain a widely used solution due to their portability and ability to provide controlled pressure without external power sources. However, they are not intended to compensate for poor connections or improper system design.

5. FITTINGS AND CONNECTION INTEGRITY

Fittings are a critical component in any pressure system and are often the primary point of failure. Proper understanding of thread types and sealing methods is essential. For example, NPT threads rely on thread deformation and sealing compounds, while BSPP connections typically require an O-ring or bonded seal.

Proper installation and compatibility between thread types and sealing methods are essential for achieving reliable performance and preventing leaks. High-pressure sealing performance depends not only on thread engagement, but also on selecting the correct sealing method for the application, including tapered threads, bonded seals, gasket seals, or metal-to-metal sealing surfaces (Ralston Instruments, *High Pressure Connection Seals Explained*).

Each additional fitting or adapter introduces another potential leak path. Therefore, minimizing the number of connections and using properly matched components is a key design consideration.

6. HOSE SELECTION AND FAILURE MODES

Hoses are frequently overlooked in pressure systems but represent a significant risk if improperly selected or maintained. Hose failures can result from internal degradation, external abrasion, excessive bending, or operation beyond rated pressure.

Proper hose selection must consider operating pressure, temperature, flexibility, environmental exposure, and compatibility with the media being used. Hoses subjected to repeated bending, abrasion, or excessive pressure cycling may experience premature degradation, even when external damage is not immediately visible.

A hose that appears functional may still be compromised internally. Regular inspection and timely replacement are essential to maintaining system integrity.

7. SYSTEM ASSEMBLY AND LEAK PREVENTION

A typical pressure calibration system consists of a pressure source, hose, fittings, and the device under test. Each connection point represents a potential source of leakage.

Reducing the number of connection points and ensuring proper assembly techniques are critical to minimizing leak paths. Systems should be designed for simplicity, repeatability, and ease of inspection.

Standardized connection kits can significantly reduce setup time and improve reliability by eliminating variability in component selection.

8. CONNECTION TECHNIQUES AND COMMON ERRORS

Proper connection techniques are essential for reliable operation. Key considerations include correct thread identification, appropriate sealing methods, and proper tightening procedures.

Proper installation techniques are essential to maintaining sealing integrity. Over-tightening can deform threads and damage sealing surfaces, while under-tightening may prevent proper seal engagement and result in leakage. Understanding how different thread and seal designs function is critical to preventing connection failures (Ralston Instruments, *High Pressure Connection Seals Explained*).

Common errors include:

- Mixing incompatible thread types
- Overuse of thread sealant
- Misalignment during assembly
- Excessive use of adapters

Avoiding these errors requires both training and adherence to established best practices.

9. SAFETY CONSIDERATIONS

Pressure systems inherently involve stored energy, particularly when gases are used. OSHA guidelines highlight the importance of proper handling, secure connections, and controlled pressure release when working with compressed gases.

Safe practices include:

- Gradual pressurization
- Use of proper venting methods
- Avoidance of direct exposure to pressurized components

Failure to follow these practices can result in serious injury or equipment damage.

10. TROUBLESHOOTING AND BEST PRACTICES

When leaks or instability occur, a systematic approach should be used to isolate the issue. This involves checking each component in the system, including fittings, hoses, and sealing surfaces.

Best practices include:

- Standardizing connection types
- Minimizing adapter use
- Performing routine inspections
- Replacing damaged components rather than attempting temporary fixes

A consistent approach to system design and maintenance improves both reliability and efficiency.

11. PRACTICAL DESIGN APPROACHES (RALSTON INSTRUMENTS)

Ralston Instruments has focused on simplifying pressure connections by reducing complexity and improving usability in both field and laboratory environments. This includes designing systems that minimize connection points, standardize interfaces, and allow for rapid configuration changes.

By addressing common challenges such as thread identification and adapter stacking, these approaches help improve safety, reduce setup time, and enhance measurement stability.

The goal is not only to improve accuracy, but to make reliable connections easier to achieve consistently across a wide range of applications.

12. CONCLUSIONS

Reliable pressure calibration depends not only on accurate instruments, but also on the integrity of the connection system. Improper fittings, degraded hoses, and poor assembly practices are leading causes of failure and measurement error.

By applying best practices in component selection, system design, and connection techniques, users can significantly improve safety, reliability, and measurement quality.

Ultimately, most pressure system issues can be traced back to connection problems. Addressing these at the source leads to more consistent and dependable results.

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