Hydrostatic Testing
‘Means to an End or Ends to a Mean’?

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Abstract

Hydrostatic testing of pressure systems often is performed without questioning the methodology used and results obtained. There are various methods to hydrostatically test piping systems and, more specifically, welded joints, which have their own set of performance parameters. This paper explains the frequently used methods to hydrostatically test welded flange to pipe joints with their individual set of considerations and capabilities.

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Introduction

Pressure testing the fabrication and repair of welded flange connections under ASME code traditionally requires several steps:

1. Isolating the weld area
2. Welding the flange/pipe
3. Blinding the pipe ends
4. Filling the piping system with test media
5. Pressurizing the pipe to piping system
6. Draining and properly disposing of the test medium

Testing flange to weld connections in this way is tried and true but can be time consuming and expensive when factors such as disposal of the potentially contaminated test medium, system downtime, and labour hours required to perform the work, are included with the cost of materials. In situations where the welded flange connection is attached to piping that contains potentially explosive vapors, the safety of personnel during the fabrication and testing of welded flange connections requires that any explosive gasses remaining in the pipe be removed from the hot work area during both the welding and pressure testing phases.

Over the last three decades, pipe flange isolation and hydrostatic testing plugs are available to assist maintenance staff and contractors perform flange change outs onsite. Typical markets for these products include refineries, chemical and petrochemical plants, fertilizer plants, power plants and other industrial applications.

In addition to replacing or adding flange connections on site, concerns over verifying adequate joint strength, when pressure testing welded flange connections, have been brought to light in the marketplace.

EST Group, a business unit of Curtiss-Wright Flow Control Company, is a global manufacturer and designer of pipe and tube pressure testing and plugging equipment, located in Hatfield, Pennsylvania, USA and its EMEA operation is located in Alphen aan den Rijn, The Netherlands.

This paper provides an overview of the development and technology of hydrostatic isolation and test plugs and their effectiveness in addressing the need to safely isolate hot work areas, while also providing the means to pressure test flange weld connections under hoop, radial and longitudinal stress.

High Lift Flange Weld Test Plug

Companies in the oil, gas, and refining industry acknowledged two desired areas for improvement to their current methods for performing flange change outs in the field. These included the following:

- A quicker and safer method for isolating hot work areas.
- A more economical and effective method for hydrostatically testing test flange repairs in the field.

Using previous methods, flange modifications required blind flanging and the evacuating of the entire line. The use of plumber's plugs to further isolate hot work areas was a significant safety concern. Once welding was completed, the entire line was hydrostatically tested. These hydrostatic tests raised additional concerns in regard to the time and cost associated with water disposal and the complexities involved in isolating the entire system.

In response to these concerns, the EST Group developed the High Lift Flange Weld Test Plug (Figure 1).

Figure 1. High Lift Flange Weld Test Plug

The High Lift Flange Weld Test Plug attaches to the flange connection and creates an isolated cavity between the seal and flange weld area (Figure 2).

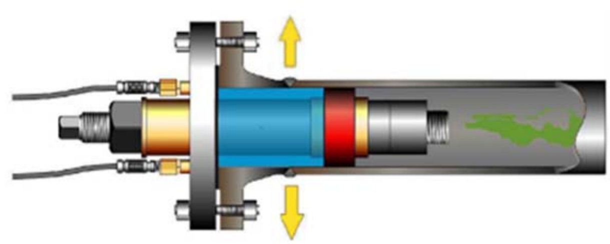

Figure 2. High Lift Flange Weld Test Plug in pipe

The distinctive design of the plug accomplishes the following:

- The seal isolates potentially dangerous vapors from the hot work area.
- Upstream conditions are monitored via a ported connection on the shaft.
- Once welding is complete, the cavity between the seal and flange can be filled with a designated test medium to hydrostatically test the integrity of the welded connection.

The plug also offers adequate seal-to-pipe clearance so that the plug can be removed easily even if a severe weld protrusion is present.

This design greatly reduces test medium costs and downtime delays. There's no need for a vacuum truck, which is typically used for evacuating the line. During its weld plug (isolation) configuration, the Flange Weld Test Plug can be used to flow shield gas through the isolated cavity, thereby reducing the consumption of this shield gas significantly. The use of flange weld plugs also significantly reduces the area of the pipe that requires dehydration after testing, further reducing costs related to testing.

During testing, the joint is subjected to the required hoop and radial stresses. However, induced longitudinal stress is negligible.

Double Block and Bleed Test Plug

With an increasing focus on safety worldwide, the need for new innovations that ensure safer working environments has increased. Specifically, customers required a product that would verify that hot work areas were free from explosive vapors and gases.

The Double Block & Bleed Test Plug (DBB) shown in Figure 3, addressed this requirement and revolutionized isolation and testing of pipe connections.

Figure 3. Double Block and Bleed Test Plug

The Double Block & Bleed Test Plug (DBB) is designed to positively isolate and monitor potentially explosive vapors during hot work, while also enabling personnel to hydrostatically test the new weld connection with the same plug.

The unique design of the plug accomplishes the following:

- The plug seals and isolates potentially dangerous vapors from the hot work area.
- The double seals assures isolation by providing a cavity for positive pressurized shield gas.
- Upstream conditions are monitored via a ported connection on the shaft.
- Once welding is complete, the plug can be moved and the cavity between the seals filled with a designated test medium to hydrostatically test the integrity of the welded connection without pressurizing the entire system.

The plug is positioned upstream of the hot work area and utilizes a double-seal design to create a cavity between the seals. One of the ported connections on the plug is used to fill the cavity with an inert medium while the other provides venting of any explosive vapors or back pressure that may exist upstream. The inert medium is placed under pressure in the cavity and as long as the pressure is greater than the potential upstream pressure, no explosive vapors can propagate into the hot work area. After welding is completed, the plug is repositioned to allow for hydrostatic testing (Figure 4).

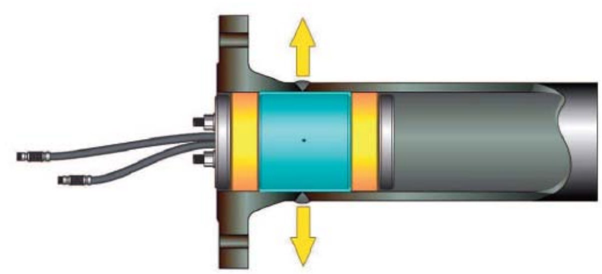

Figure 4. Double Block and Bleed Test Plug hydrostatic test

The lightweight aluminum/steel construction makes the test plug easier to handle and position than comparable flange test plugs. The volume of water required for a test is so small that a hand pump is all that is needed for most plug sizes, greatly facilitating testing in remote areas of the facility.

The joint tested is subjected to the required hoop and radial stresses. However, the weld is still subjected to a negligible amount of longitudinal stress when compared with the longitudinal stress it could see during normal operation.

GripTight® Isolation Test Plug

Although the DBB has an upstream pressure monitoring connection, it doesn't allow for dealing with unexpected large volumes of backpressure. These may be caused by sources ranging from upstream valve seepage to an inadvertent valve opening by lock-out / tag-out procedural failure.

A "gripping" style Double Block and Bleed Test Plug (Figure 5) is designed to be capable of holding unexpected upstream pressure from the system during isolation as well as hydrostatic testing. The unique design of the GripTight Isolation Test Plug accomplishes the following:

- The double seals isolate potentially dangerous vapors from the hot work area.
- The addition of GripTight grippers adds an extra safety component regarding plug movement due to unexpected back pressure.
- Upstream conditions are monitored via a ported connection on the shaft.

Once welding is complete, the plug can be moved and the cavity between the seals can be filled with a designated test medium to hydrostatically test the integrity of the welded connection without pressurizing the entire system.

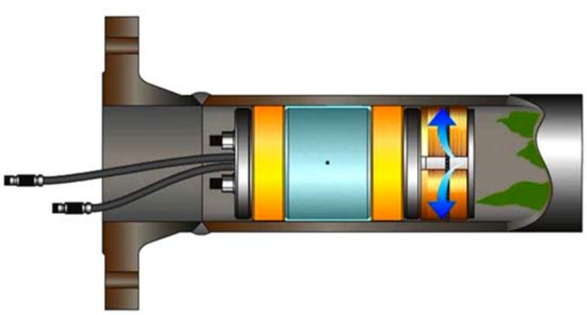

Figure 5. GripTight Isolation Plug

The benefit of the design is that while monitoring the upstream pressure could trigger the abandoning of the test, the grippers safely allow the operator time to decide either to vent or block the system.

Reverse Pressure GripTight Test Plug

In 2003, concerns arose about testing the longitudinal strength of flange to pipe welds. Previously designed flange weld hydrostatic testing devices produce radial and hoop stresses in the flange and weld connection but not axial or longitudinal stress. EST Group's design and development of the Reverse Pressure GripTight Test Plug (Figure 6) addresses this difficulty in a safe, cost effective way.

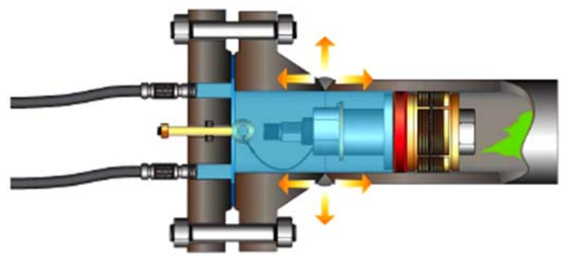

Figure 6. Hydrostatically testing with installed Reverse Pressure GripTight Test Plug

The unique design of the Reverse Pressure GripTight Test Plug accomplishes the following:

- The combination of a seal and GripTight self-gripping technology isolates potentially dangerous vapors from the hot work area.
- The addition of GripTight grippers adds an extra safety component regarding unexpected plug movement due to back pressure.
- Once welding is complete, the cavity between the seals can be filled with a designated test medium to test the integrity of the welded connection without pressurizing the entire system.
- The plug and test flange act independently of each other so that the weld joint is

subjected to real world stresses during pressure testing.

See Figure 7 for a visual representation of hoop (σ_c), radial (σ_r), and longitudinal (σ_a) stress components within a pipe.

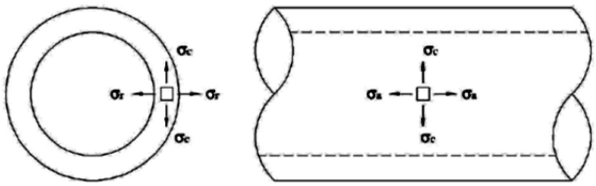

Figure 7. Stresses in a pipe

The Reverse Pressure GripTight Test Plug is installed within the pipe, upstream of the flange to be tested, using a special threaded handle and a deep socket installation tool. Once installed, the plug acts as a rigid connection to the pipe and only the pipe. A modified test blind flange is attached to the plug by a safety lanyard and bolted to the newly welded flange. This modified flange is equipped with a fill and vent port to fill the cavity with test media and expel any residual air between the two rigid connections.

The plug is designed so that it cannot accidentally release into the pipeline. Concerns over plug movement are addressed using a lanyard connected to a visual indicator, showing any signs of plug movement. The lanyard also works to prevent improperly installed plugs from being pushed downstream as the connection is pressurized.

Pressure testing with a Reverse Pressure GripTight Test Plug effectively verifies the weld integrity by testing radial, hoop, and longitudinal stresses thereby providing the user confidence that the flange and weld will properly function when placed into service. Testing flange-to-pipe welds with the Reverse Pressure GripTight Test Plug eliminates the need to blind, fill and pressurize the entire piping system.

Conclusion

Hydrostatic pressure testing should not simply rely on pressurizing the joint to be tested to the required pressure. One should consider the full array of requirements in regards to the full technical scope of the job at hand (refer to Table *1* at the end).

The key is to effectively verify the weld integrity, while providing the user confidence that the flange and weld will properly function when placed into service.

Sometimes the piping system may not even be able to handle the dead weight of filling the entire piping system with an incompressible testing fluid. Utilizing test plugs eliminates the need to blind, fill, and pressurize an entire pipe system.

The use of traditional Flange Weld Tester or (Gripping) Double Block and Bleed test plugs may be sufficient for certain systems. Where they are insufficient, the Reverse Pressure Test plugs offer the option of full radial and longitudinal stress testing, which may be a key driver for the actual testing requirements.

Any hydrostatic testing performed should meet governing local requirements and reference is made (where applicable) to meet the requirements of ASME/ANSI B16.5.

Method	Strength	Weakness
Traditional Blind Flange System Test	• No additional equipment • Tested in exact usage configuration	• Time consuming • Safety issues with vapor isolation • Practicality • Test media waste disposal
Flange Weld Test Plug	• Reduces test time & test media • Flange & weld to hydrostatic test pressure • Isolates hot work area • Monitors/vents backpressures	• Weld is subject to negligible longitudinal stress • Withstands backpressure only after full strength weld flange to pipe
Double Block and Bleed Test Plug	• Reduces test time & test media • Weight reduction • Allows verification of hot work area isolation with double seal • Monitors/vents backpressure	• Weld is subject to negligible longitudinal stress • Withstands unexpected back pressure up to 10 psig (0.7 barg)
GripTight Isolation Test Plug	• Reduces test time & test media • Weight reduction • Allows verification of hot work area isolation with double seal • Withstands/monitors/vents backpressure	• Weld is subject to negligible longitudinal stress
Reverse Pressure GripTight Test Plug	• Reduces test time & test media • Weight reduction • Withstands or vents backpressure • Flange and weld is subjected to radial, hoop and longitudinal stresses	• Requires specialized installation hardware • Does not monitor upstream pressure (does contain bleed connection for safety purposes)

Note: It is critical to determine governing parameters to perform a safe and valid isolation and hydrostatic test.

Table 1. Comparative hydrostatic testing matrix