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Diaphragm Seal Filling Guide

Diaphragm Seals are often assembled and filled by distributors and service centers in the field where they can mix and match the variety of seals and gauges from stock. The field service people will have a close relation to the application, enabling them to understand the requirements for the seal and the pressure gauge, transducer or pressure switch.

Fill Fluids

The two most important considerations for selecting the fill fluid are the operating temperature and the compatibility with the process. The most common fill is a low viscosity silicone oil that has a wide temperature rating. 100 CST silicone oil is capable of operating from -130ºF to 400ºF for pressure applications. Vacuum gauge applications must consider the vapor pressure at high temperatures that may cause the fluid to evaporate, thereby increasing the fluid pressure, or worse yet, causing a vapor lock and compromising the hydraulic pressure communication. A higher viscosity silicone oil can be used to boost the temperature rating for vacuum gauge seals.

Another common fill is glycerin or glycerin and water. Glycerin is less toxic and cheaper than silicone. Glycerin should not be used for cold applications, below 50ºF, as the viscosity becomes so high that the seal will be sluggish.

For a diaphragm attached to a gauge, pressure transducer, or pressure switch that is used for a vacuum range or for both vacuum and pressure, for example a vacuum or compound gauge, selecting the right fill fluid is crucial. Below 25inHg vacuum, glycerin or glycerin and water will vaporize, even at room temperature. The vapor pressure prevents accurate readings at high vacuum. It is recommended that pure low viscosity silicone fluid, 50 cSt, be used. Evacuate for an extended time, and fill with 1 psi or by gravity. Food processing applications require that food grade silicone be used as a safe alternate to glycerin. Vegetable oil is often used in food and beverage applications and is actually a good fill between 10ºF to 300ºF.

Oxygen and chlorine service require special fluids that will not explode in the presence of oxygen or chlorine. Halocarbon® and Flurolube® have successfully been used.

Beyond using a fluid that has the temperature rating as described above, some consideration must be given to accounting for the thermal expansion of the fluid. The diaphragm displacement needs to be large enough to be able to extend without bottoming out. Generally, high temperatures, small diameter seals, and low pressure gauges do not work well.

The most important factor affecting a diaphragm seal's performance is the integrity of the filled assembly. A filled diaphragm seal and pressure instrument assembly must be free of contamination and air. The presence of contaminants and/or voids in the assembly will produce inaccuracies seen by the pressure instrument.

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Filling Diaphragm Seal Methods

There are generally three ways to fill a diaphragm seal pressure instrument assembly:

- Filling a diaphragm seal after it is assembled to the pressure instrument.
- Filling a diaphragm seal before it is assembled to the pressure instrument.
- Filling a diaphragm seal with a capillary mounted between the diaphragm seal and the pressure instrument.

Vacuum Filling of Pressure Instrument That Has Been Directly Mounted To Diaphragm Seal

After you have attached the diaphragm seal to a pressure instrument, Gauge / Switch / Transmitter/etc. remove the bleed screw and remove the bleed ball. Replace the bleed screw with a special vacuum adapter to the bleed port. Various adapters are available based on thread depths, position of port on the assembly, and radius of diaphragm seal surface.

EXAMPLE OF A BLEED SCREW FILL ADAPTOR

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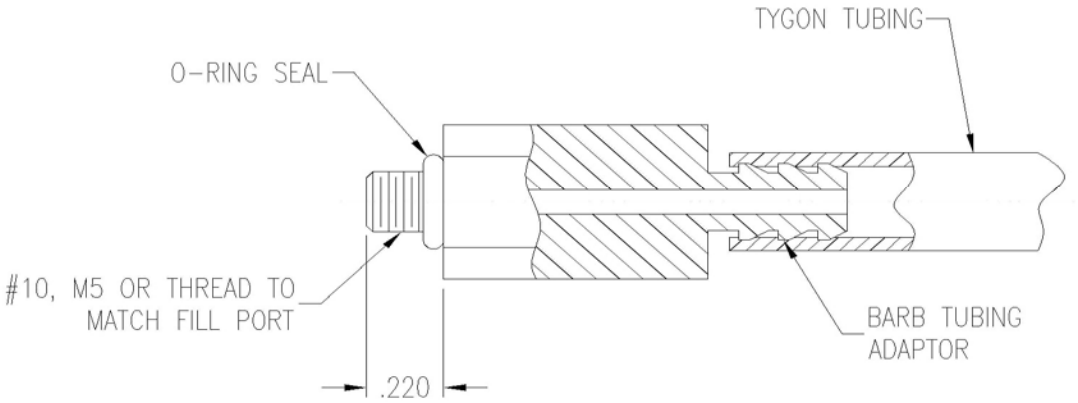
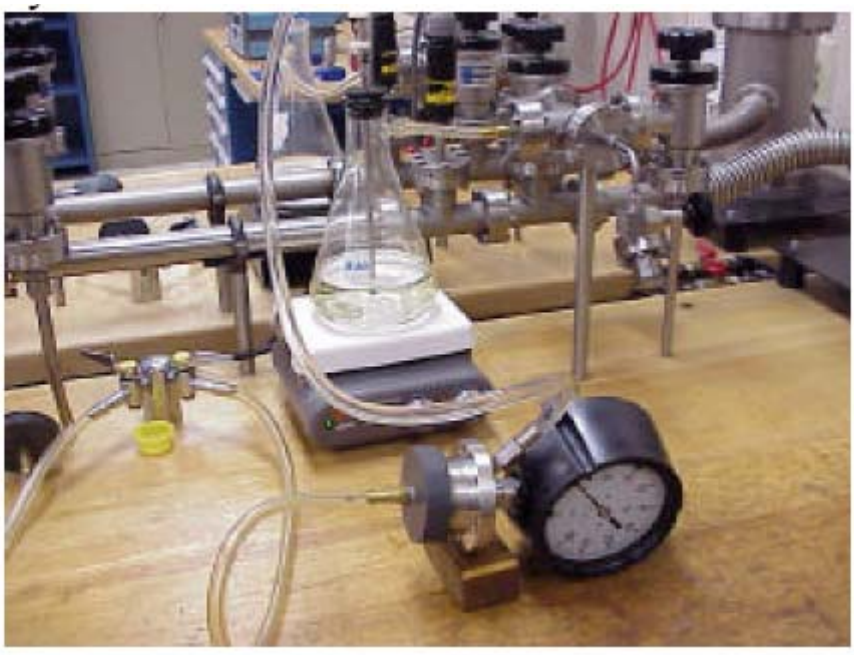


Using a quality vacuum pump, attach the diaphragm seal instrument assembly by using ¼" tygon tubing. Initiate vacuum pumping of the diaphragm seal and instrument assembly. Evacuation times will vary due to the size of assembly and the fill fluid selected. Plan on evacuating for 20 minutes. Periodically check assembly to make sure there are no vacuum leaks.

When the proper vacuum has been achieved lower the fill tube into the flask of fill fluid, verify that no air is bubbling from the tube below the fill fluid level. If you see bubbling this may be a sign of leaks in your system and the entire process may have to be repeated.

Closing off or isolating the vacuum source from the instrument assembly will allow you to open your control valve, enabling the fill fluid to be drawn into the evacuated area. Back filling time of the instrument assembly will vary depending on the viscosity of the fill fluid being used. Usually this time will be less then 50% of the evacuation time.



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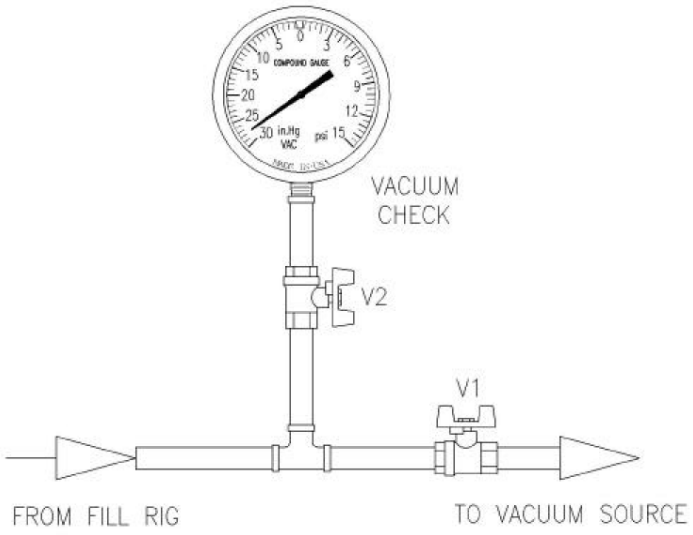
Evacuation time and the degree of vacuum is always a grey area and often depend upon the fill rig and the experience of the operator. To remove the mystery a simple vacuum check system can be used to help determine how long to evacuate and also to indicate if a leak exists.

Following is a procedure and a drawing of a vacuum check system that can be placed inline between the source and the fill rig. A description of the use of the vacuum check follows:

During pull down both valves V1 and V2 are open allowing a vacuum gauge to monitor the evacuation process. Use a good quality ½% accuracy vacuum or compound 30in.Hg/15psi gauge. To check for vacuum, valve V1 is closed to isolate the diaphragm assemblies with the gauge from the vacuum pump. If a leak exists the vacuum gauge will indicate a continuous diminishing level of vacuum. If the evacuation process requires more time the gauge will drop immediately to a lower vacuum and hold at that lower level. More evacuation time is required until the gauge no longer drops to a lower vacuum than during the pull down. When V1 is closed and the indicator doesn't budge the diaphragm seal assemblies are ready for filling. V1 and V2 are closed, and the fill is introduced.



After instrument assembly has stabilized, disconnect the tygon tubing from the filling adapter and drain the remaining fluid in the tube back to the flask. Remove the fill adapter, install bleed ball and screw.

You now have completed an instrument directly mounted to a diaphragm seal fill application.

The Vacuum Filling Rig

The procedure to vacuum fill diaphragm seals is further described by the understanding of the components of a vacuum fill rig: (see the following drawing) including the Vacuum Pump, Vacuum Reservoir Trap, Work Bench, Fill Port Manifold, Fill Fluid Storage Tank, Air Pressure Regulator, Valves to control the flow of vacuum or pressure, and gauges to indicate the vacuum or pressure.

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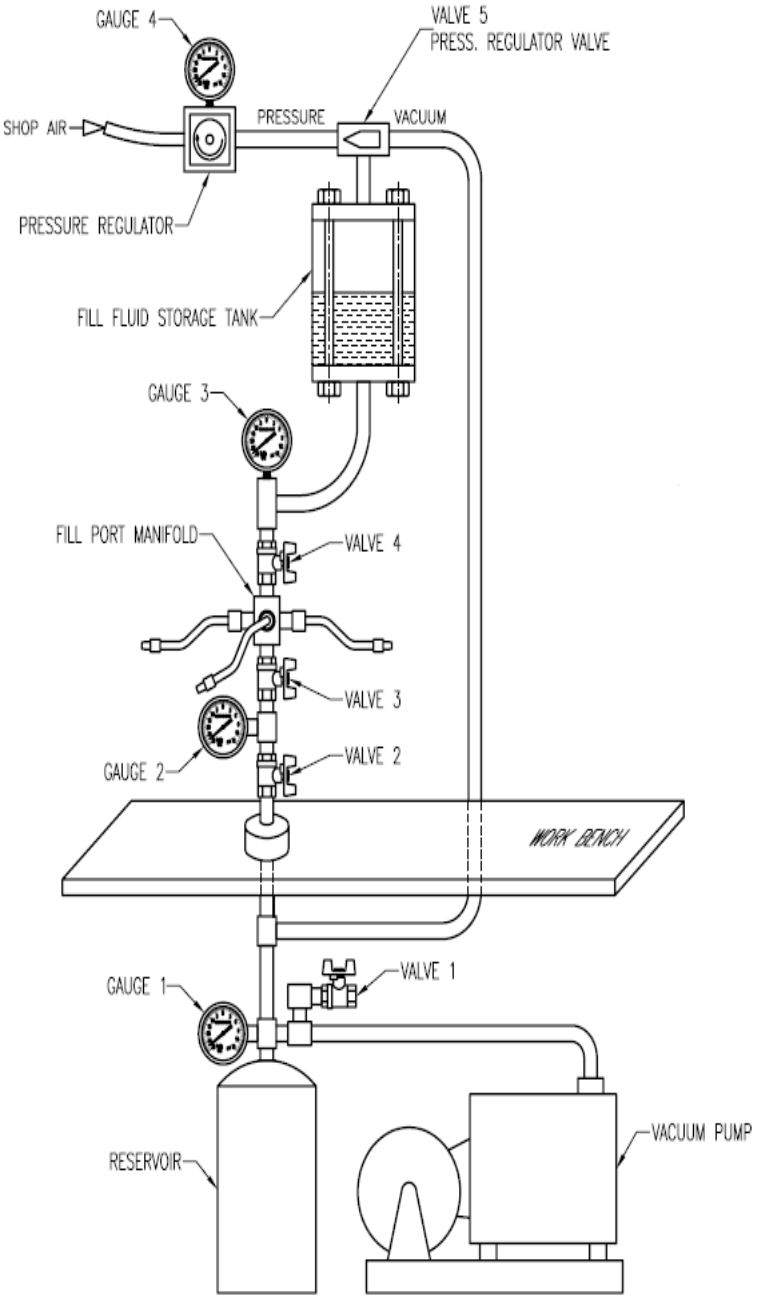


Vacuum Pump – Motorized device that drives a vacuum pump to evacuate the gauge and diaphragm seal. Vacuum is generally read in inches of mercury (inHg), mmHg (torr), or cmHG. A vacuum of 29inHg or more is needed to evacuate the system to be filled.

Reservoir Trap – An empty storage tank connected to the vacuum pump and a separate line to the fill rig. Fluid is collected in here, trapped, before being sucked into the vacuum pump.

Gauge 1 – This gauge indicates the vacuum directly from the pump into the reservoir before the fill rig. Use a 30inHg (or equivalent) vacuum gauge.

Valve 1 – Opens / Closes vacuum from reservoir trap to vent to the atmosphere. This valve is used to release the vacuum from the trap before emptying. All valves are ball valves, otherwise known as selector valves, rated for vacuum.

Valve 2 – This is the leak check valve, with this valve closed after the manifold is evacuated a leak will show up on Gauge 2. This procedure has been previously described.

Gauge 2 – This gauge is used to measure the degree of vacuum that enters the fill rig. Normally a compound gauge 30inHg/0/15psi.

Valve 3 – The main vacuum valve to the fill port manifold. In the evacuation process, this valve must remain open. In the filling process this valve must remain closed. Fluid should not be flowing anytime during an evacuation period. When valve 3 is open, during the evacuation period, you will notice that the pressure instruments being filled will indicate negative PSI below zero or the pointer will be against a pointer stopping mechanism.

Fill Port Manifold – The fill port manifold is the most essential part of the fill rig. All the processes localize in this area where the manifold directs the vacuum or the filling fluid into the pressure instruments. This manifold can have multiple connections in order to evacuate and fill multiple instruments and diaphragm seals. The connections preferably have a quick connect fitting so that any number of diaphragms can be filled at a time. If there is excess fluid inside the manifold after filling, the fluid will drain out of the fill rig and into the reservoir.

Port Connectors – Port connectors have Tygon® tubes, one end attached to a quick connect that inserts into the fill port manifold and the other end attached to a screw adapter, as previously described, to connect to the pressure instrument via the diaphragms fill port. The screw end is designed to the exact size of the diaphragm's fill port and includes an O-Ring to seal to the diaphragm seal. If trapped air or bubbles are seen inside the tubes it indicates air in the system that will affect the accuracy of the finished product.

Valve 4 – This is the main fill valve. In the evacuation process this valve must be closed. In the filling process this valve must be open in order to fill the pressure instrument with a slight positive pressure behind the fluid. It is important to first close valve 3 before allowing valve 4 to open. Instantaneously after valve 3 is shut and valve 4 is opened, the port connector tubes will solidly fill with fluid and you will notice the pressure instruments will now indicate positive pressure.

Gauge 3 – This pressure gauge measures pressure on the manifold during the filling process. This is an indication of the amount of pressure behind the fill fluid that will enter the fill port manifold via valve 4. You will notice an increase of positive pressure when valve 4 is opened and the port connector tubing is solidly filled.

Fill Fluid Storage Tank – The fill fluid is stored in this tank having a much larger volume then is needed to fill the pressure instruments and diaphragms. It is recommended that this tank is glass or clear plastic to view the fluid level. This tank is air tight and is equipped with a fill cap with an o-ring seal for filling the tank.

Valve 5 – This three way selector valve is used to introduce pressure or vacuum into the storage tank. An additional vacuum line bypasses the fill rig, when valve 5 is set to the vacuum side the top of the tank is evacuated, the fluid will appear to boil. This will outgas trapped air in the fluid. Valve 5 is then set to select pressure received from the pressure regulator. Use the vacuum selection initially to outgas and stabilize the fluid after filling the tank. Then valve 5 is set to pressure for the remainder of the time.

Pressure Regulator – The regulator controls the air supply pressure. A regulator with a water trap and air filter is recommended. Normally only 3 or 4 psi is used to pressurize the fill system., For flexible elasto-meric diaphragm seals such as Viton® the pressure should not exceed 1 PSI. Pressure and gravity may be used to fill an elasto-meric seal to avoid stretching the diaphragm.

Gauge 4 – The supply pressure gauge is connected to the top of the air pressure regulator and reads the pressure output from the regulator, normally 0 to 4 psi.

Pressure Purge Line – Not shown in the drawing, it is advantageous to blow the port connector lines out between fills so that the remaining fill fluid does not need to be pulled into the trap. The supply pressure can be used; however, it will make a mess when the fluid ejects at high speed all over the place. A separate regulator can be used, or if you are patient, the 4psi used to pressurize the reservoir can be used. The air pressure blows the excess fill fluid out of the filled port connector lines and drains the tube empty to be efficiently re-used for the next fill.

Spin Filling Diaphragm Seals

Mounted Procedure For Pressure Instrument And Diaphragm Seal That Have Been Filled Separately

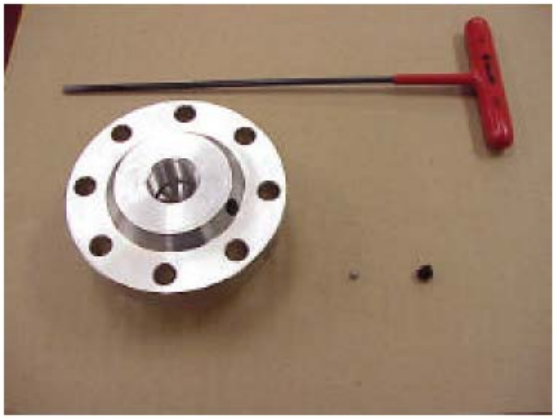
In many diaphragm seal applications it is necessary to use elastomers as the diaphragm wetted material. These materials may be Viton, Buna N, Teflon, Kel-F, and Kynar to name just a few. These elastomer diaphragms are mostly soft in nature and are difficult to control when subjected

to a vacuum source. These diaphragm materials being soft and flexible can be drawn up into the evacuation port or fill port of the diaphragm seal when placed under vacuum. This will not allow for the entrapped air to be pulled out by the vacuum source. As seen in all of these pictures and illustrations, a welded foil diaphragm seal, which is exposed to processes that are not extremely high temperature and vacuum sensitive can be filled in the same manner.

This is how Spin Filling can be initiated.

The pressure instrument and selected fill fluid is evacuated in the same manner as on the direct mounted unit as previously illustrated.

The diaphragm seal, however, is filled in a completely different manner. Inspect the diaphragm seal to be filled, remove the bleed screw and bleed ball.



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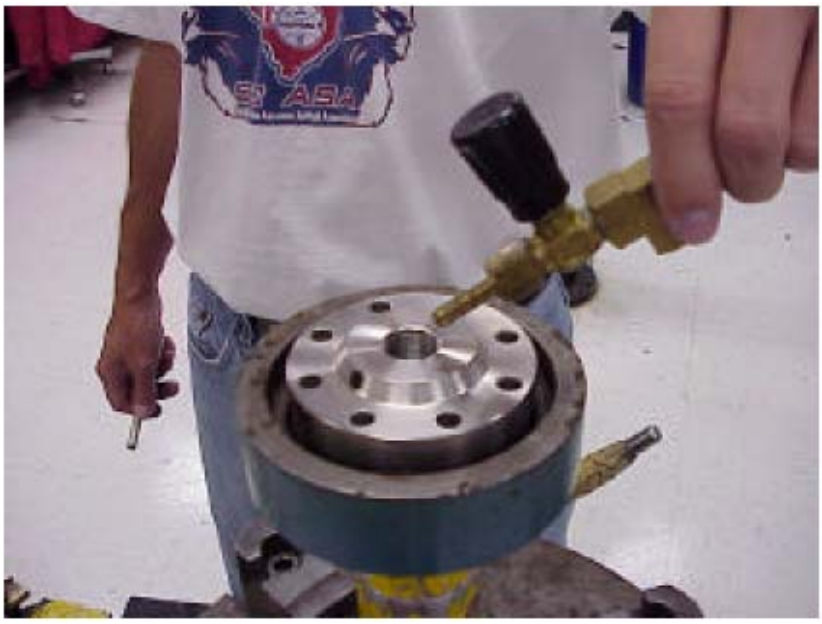
Secure or set the diaphragm seal in a device that will spin either manually or by a power source. Pour fill fluid that has been evacuated of air directly into the instrument connection of the diaphragm seal.



When the diaphragm seal is nearly full, stop filling the seal and slowly begin spinning the diaphragm seal. The spinning can be accomplished by using an air driven or electric motor. The speed needed to accomplish proper spreading of the fill fluid should be no more than 100 to 150RPM. The centrifugal force placed on the fill fluid will spread the fluid out to the edges of the diaphragm surface and force any entrapped air to the center and out through the instrument connection. On welded foil diaphragm seals it will be necessary to massage the diaphragm surface to push out entrapped air. This process of introducing the fill fluid into the instrument port is repeated until there is no air remaining in the diaphragm seal. After the Spin Filling procedure is complete, secure the diaphragm seal in a vice or other device for mounting the pressure instrument. Assuming you have completed the evacuation and filling of the pressure instrument you are ready to complete the assembly. Having the filled diaphragm seal secured, fill the instrument connection until it is slightly overflowing.

Apply thread sealant (Loctite PST 567) all the way around the threads of the pressure instrument to ensure proper engagement, and place one finger over the filled port of the pressure instrument.

Never use Teflon Tape as a sealant, the tape will come in contact with the fill fluid and act as if it were a wick, over time and when pressure is applied to the diaphragm seal assembly you may loose the fill fluid and the instrument will not function properly. Place the threaded connection of the pressure instrument into the overfilled instrument connection of the diaphragm seal and slowly begin to tighten. When the threads of the pressure instrument begin to engage the excess fluid that remains and the completed unit is now ready for testing.

You now have completed a Spin Filling Diaphragm Seal Application.

Filling A Diaphragm Seal With Capillary Line Mounted Between The Diaphragm Seal And The Pressure Instrument.

Mounting and filling this style of assembly is much like a direct mount version with a length of capillary tubing between the diaphragm seal and the pressure instrument. The pump time on this assembly can vary greatly regarding type of instrument, length of capillary line, and fill fluid selected. Due to long lengths of capillary lines, it is necessary to have a secondary vacuum source in which vacuum can be applied to the outside face of the diaphragm seals. This vacuum will hold the diaphragm in a neutral state when the internals are being evacuated, giving the entrapped air a clear path out of the instrument diaphragm seal assembly to the vacuum source.

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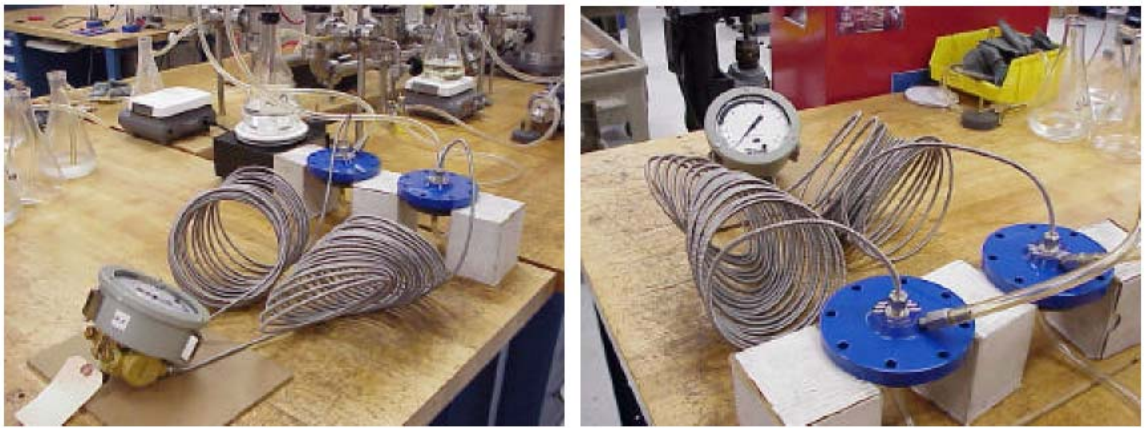

As in the direct mount version, the maximum vacuum will be reached at some point, normally within one hour. At this point the fill tubes will be lowered into the selected fill fluid, the system vented to the atmosphere, and the fill fluid is drawn into the evacuated instrument. Once the unit is completely filled, the secondary vacuum is released, and the bleed ball and screw are installed.

This unit is now ready to be pressure tested and calibrated.

Comparison of Vacuum and Spin Filling

Vacuum filling vs. spin filling of a diaphragm seal comes down to only a few simple factors.

A vacuum filled system is one that is nearly void of any entrapped air and contaminants whereas the instrument will operate at its peak performance. Vacuum filled process assemblies can range from very low inches of water to 20,000 PSI High Pressure requirements.

A spin filled system is a simple system that does not rely on the pressure instrument being extremely precise. A spin filled diaphragm seal will allow a pressure gauge to read a process pressure, and a pressure switch to open and close within its set point range; however, the process pressures for a spin filled system should be 50 PSI and above.

Both vacuum filling and spin filling are equal in importance depending on how they are applied to the processes that they will be monitoring.

When your application deems spin filling appropriate, it will generally take 15 – 20 minutes to complete the fill process. Vacuum filling generally can take 45 – 50 minutes to complete.

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INSTRUMENT SECTION MEMBERS and WEBSITES

AMETEK, U. S. GAUGE DIVISION

MID-WEST INSTRUMENT

MOELLER INSTRUMENT CO., INC.

NOSHOK, INC.

ORANGE RESEARCH

THUEMLING INSTRUMENT GROUP, INC.

TREND INSTRUMENTS INC.

WEISS INSTRUMENTS, INC.