VHA Boiler Plant Safety Device Testing Manual
Third Edition

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1 INTRODUCTION

1.1 OBJECTIVE

The purpose of this manual used with manufacturers' manuals and design set points is to support the development of an individual boiler plant safety program for your specific boiler plant. The text presents a concise and thorough treatment of boiler safety as applied to automatically-fired gas and oil, heating and process boilers and boiler support equipment servicing healthcare facilities. The text includes a description of each boiler safety device, how it works, what its purpose is, and how to test the device. The safety devices are organized by categories in four chapters: Water Level Control, Pressure Containment, Fuel Train Safety Devices, and Burner and Air Train Safety Devices. A fifth chapter provides detailed step by step procedures for testing every device covered. This chapter can be used as a checklist and guide for safety testing. Some boilers will not include all of these devices.

The text does not replace existing standards. It succinctly states the main import of the standards. The final guide to safety should include all applicable standards. However, the testing envisioned in this text is far more rigorous than current industrial practice, even though the basic concept of this manual is that all boiler safety devices should consistently function properly. Proper function requires 1) proper installation, 2) proper calibration, and 3) proper activation. In situations that may arise where adherence to this manual would adversely affect the operation of the boiler, special authority may be requested to deviate from the manual through the Director, Health Care Engineering (10NB).

1.2 BACKGROUND INFORMATION

One must understand that the use of the term "boiler" may refer to the system that includes the generation, distribution, and use of steam. There are many safety devices such as level alarms, safety valves, relief valves, etc that are found on the components involved in the distribution and use of steam. The safety checks are necessary and must be conducted on **<u>all devices in the system</u>** in order to insure that the system is safe.

It is important that one has the manufacturer's manuals on all equipment to be tested before beginning the tests described herein. This is essential to know the manufacturer's recommended operating conditions, the wiring diagram, etc.

1.3 GENERAL OBSERVATIONS ON SAFETY TESTING

1.3.1 Items to be Checked on Any Interlock Device

Many safety devices utilize switches that actuate based on some set point to automatically alarm or shut the boiler off by shutting the two automatic fuel shut off valves. It is extremely important that one recognize that there are four attributes to such systems required for proper operation. These are:

- The switch must be in the right place.
- The switch must have the proper setpoint.
- The switch must activate at the proper setpoint.
- The switch must produce the desired effect.

All safety testing described in this text involving such switches centers around making sure that all these requirements are met. The most common failure in this regard is a failure to insure that the switch has the proper set point which requires measuring operating parameters in order to determine the proper set point.

1.3.2 Confirming That All Devices Actually Function for Intended Purpose

In testing any interlock device that operates through the automatic control system, it is paramount that the testing procedure verifies compliance with the four requirements listed above.

1.3.3 Lockable Valve Requirements

In order to facilitate testing of some types of interlock devices, it is sometimes convenient to temporarily isolate the interlock device and provide test ports by means of manual valves. However, these modifications cannot be allowed to increase risk by locking out a safety device during normal operation and should clearly indicate test and normal position. Any such manual valve that could isolate a safety device from its normal operating circuit should be lockable and the lock should be lockable **only** in the correct operating position.

1.3.4 Confirming That Jumpers Are Removed and Valves Properly Locked

In many cases in order to test a device, it will be necessary to either electrically jumper (bypass) a device or to valve out the device. The safety testing personnel should only carry a fixed number of jumpers and should make sure that at the end of a test that all jumpers being used are accounted for and that all lockable valves are locked in their correct position.

1.4 NOMENCLATURE

AFOSV	Automatic Fuel Oil Shutoff Valves
ALWCO	Auxiliary Low Water Cutoff
APFGSOV	Automatic Pilot Fuel Gas Shutoff Valves
APFGSVV	Automatic Pilot Fuel Gas Solenoid Vent Valve
CAPI	Control Air Pressure Interlock
CAPS	Combustion Air Pressure Switch
DA	Deaerator
DAODS	Deaerator Overflow Drain System
DASV	Deaerator Safety Valve
FDDWOPS	Forced Draft Damper Wide-Open Pre-Purge Proving Switch
FDMIS	Forced Draft Motor Interlock Switches
FGRDI	Flue Gas Recirculation Damper Interlock
AFGSOV	Automatic Fuel Gas Shutoff Valves and Solenoid Vent Valve
AFGSVV	Automatic Fuel Gas Shutoff Solenoid Vent Valve
FPI	Furnace Pressure Interlock
FSMFO	Flame Scanner-for main flame out
FSNSIS	Flame Scanner Not Sensing Igniter Spark
HFGPCS	High Fuel Gas Pressure Cutoff Switch
HFOPCS	High Fuel Oil Pressure Cutoff Switch
HWAB	High Water Alarm on Boiler
HWACT	High Water Alarm on Condensate Tank
HWADT	High Water Alarm on Deaerator Tank

IT	Igniter Timing
LAMDPS	Low Atomizing Media Differential Pressure Switch
LAMPS	Low Atomizing Media Pressure Switch
LFGOLI	Low Flue Gas Oxygen Level Interlock
LFGPCS	Low Fuel Gas Pressure Cutoff Switch
LFOPCS	Low Fuel Oil Pressure Cutoff Switch
LFPS	Low-Fire Proving Switch
LPFGPCS	Low Pilot Fuel Gas Pressure Cutoff Switch
LRVE	Liquid Relief Valve on Economizer
LRVOPS	Liquid Relief Valve on Oil Pump Set
LWA	Low Water Alarm
LWACT	Low Water Alarm on Condensate Tank
LWADT	Low Water Alarm on Deaerator Tank
LWCO	Low Water Cutoff
MFIT	Main Flame Ignition Timing
MV	Manual Valve
NRBSPLS	Non-Recycle Boiler Steam Pressure Limit Switch
OADI	Outside Air Damper Interlock
OBPS	Oil Burner Position Switch
OSDI	Outlet Stack Damper Interlock Switch
PAPS	Purge Airflow Proving Switch
POC_AFOSV	Proof of Closure on Automatic Fuel Oil Shutoff Valves
POC-AFGSOV	Proof of Closure on Automatic Fuel Shutoff Valves
PPT	Pre-Purge and Post-Purge Timing
PRV	Pressure Reducing Valve
RBSPLS	Recycle Boiler Steam Pressure Limit Switch
SVB	Steam Safety Valves on Boiler
SVFPRV	Safety Valve Following PRV
TP	Test Port

1.5 PREPARATION OF SYSTEM FOR SAFETY TESTING

The normal boiler installation does not generally allow easy access and control for testing. Safety testing is an ongoing activity for safe boiler plant operation. Modifications should be made to allow safe convenient testing. In this section a discussion is given of system modifications that will allow easy testing. The discussion is organized around classes of different safety devices. For detailed drawings illustrating a convenient test setup for each device, refer to the safety testing procedures given in the appendix.

1.5.1 Setup for testing a Steam Safety Valve Following a PRV

In order to test a safety valve following a PRV, a manual isolation valve should be installed downstream of the safety valve so that the valve can be tested without raising the pressure on the system downstream of the valve. (See Figure 1.1)

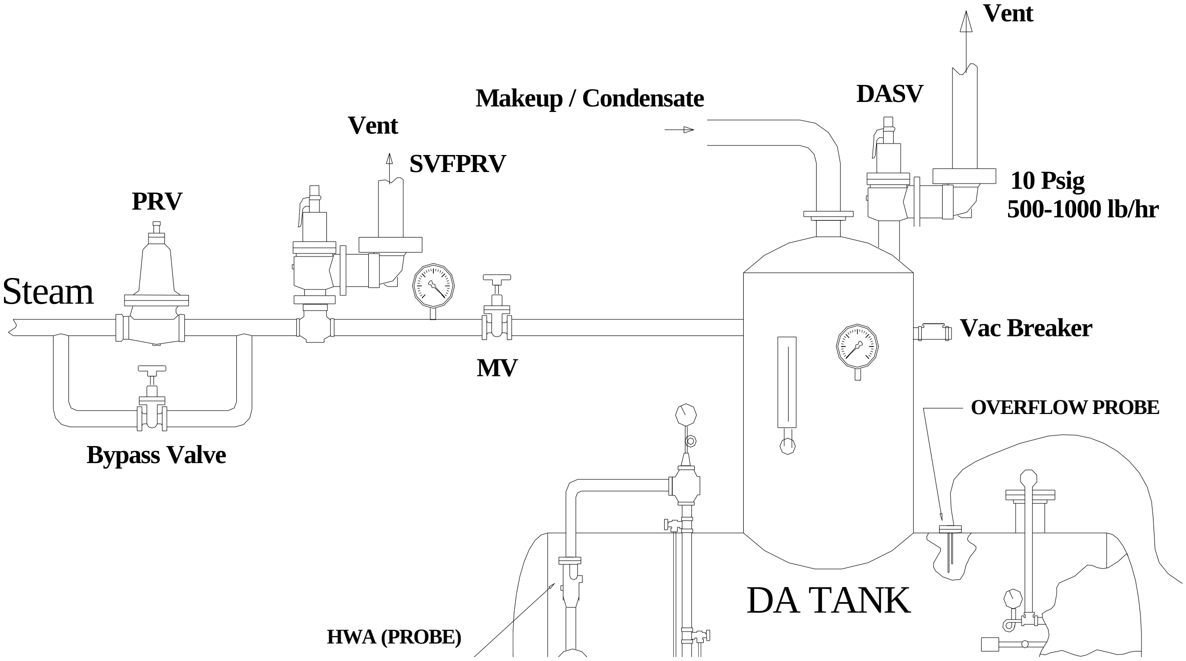


Figure 1.1 Safety Valve Following a PRV

1.5.2 Setup for testing a combustion air switch, purge air switch, furnace pressure switch, control air pressure switch, and high pressure switches for main gas and pilot.

In order to test these switches it is convenient to be able to temporarily isolate these switches from the normal pressure source and to apply test pressures that can be accurately measured. At the same time the piping should be such that the actual pressure that the switch senses can also be measured. The arrangement that is pictorially shown in Figure 1.2 for testing the combustion air pressure switch allows this objective to be met for all switches covered in this section.

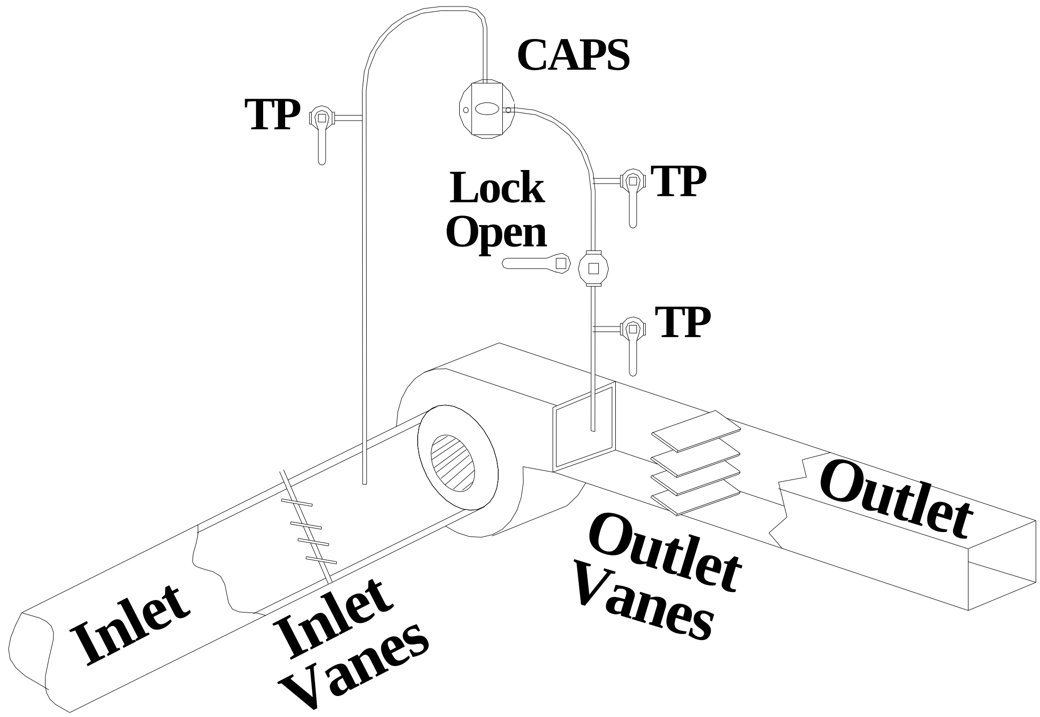


Figure 1.2 Air Pressure Switch

1.5.3 Setup for Leak Checking Oil and Gas Block Valves and Gas Bleed Vent Valve

In order to easily test for leaks in the block valves a test port (TP) and pressure gage must be available both in the line between the valves and downstream of the second valve. Also in the case of gas, a lockable manual valve downstream of the solenoid bleed vent valve is required. A port and pressure gage in the line between the solenoid valve and lockable manual valve is also needed. Note, there are two test ports (TP) for determining normal operating pressures and one test port (TP) for testing the isolated interlock. This arrangement is schematically shown for natural gas in Figure 1.3 and Figure 4.4 for oil fuel.

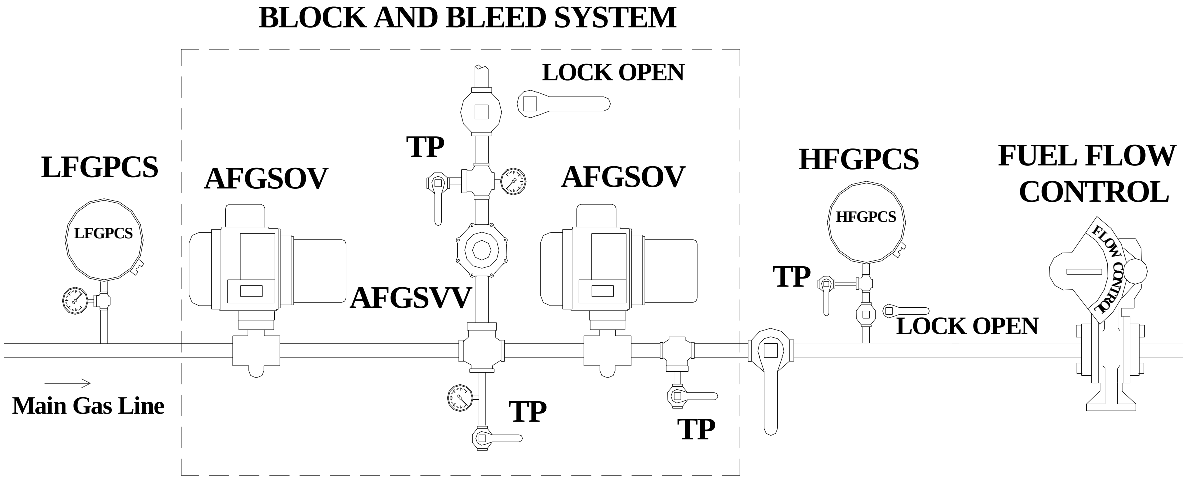


Figure 1.3 Leak Checking Automatic Shutoff Valves

1.5.4 Setup for Checking Dangerous Gas Detection System For the Building

Sample gas with a level of CO and combustibles slightly exceeding the sensor set points should be available with a means to supply the gas to the sensor per the manufacturers test procedures.

1.5.5 Setup for Checking the Deaerator Overflow System and Oil Liquid Relief Valve

A sight glass with turbine wheel should be installed downstream of the valve in order to visually confirm that flow exists. The oil liquid relief valve also requires a pressure gage at the pump discharge.

1.5.6 Setup for Checking Proof of Closure Switches, Low Fire Proving Switch, Force Draft Damper Vane Interlock, Outlet Stack Damper Interlock, Recycle Steam Pressure Switch, Non-recycle Pressure Switch, Primary Low Water Cutoff, and Recirculation Damper Interlock

It is necessary to electrically isolate these switches for testing. The two electrical leads from each of these switches should be wired into an electrical control panel and the terminals to which they run should be clearly identified. Only one wire should be under a given terminal.

1.5.7 Setup for Hydrostatic Testing

In order to hydrostatically test any device it is necessary that valves are available to isolate the device, a test port is available to apply the test pressure, and a pressure gage is available to monitor the pressure in the device (See Figure 1.4). All devices that could be damaged by the test pressure must be removed prior to conducting the hydrostatic testing.

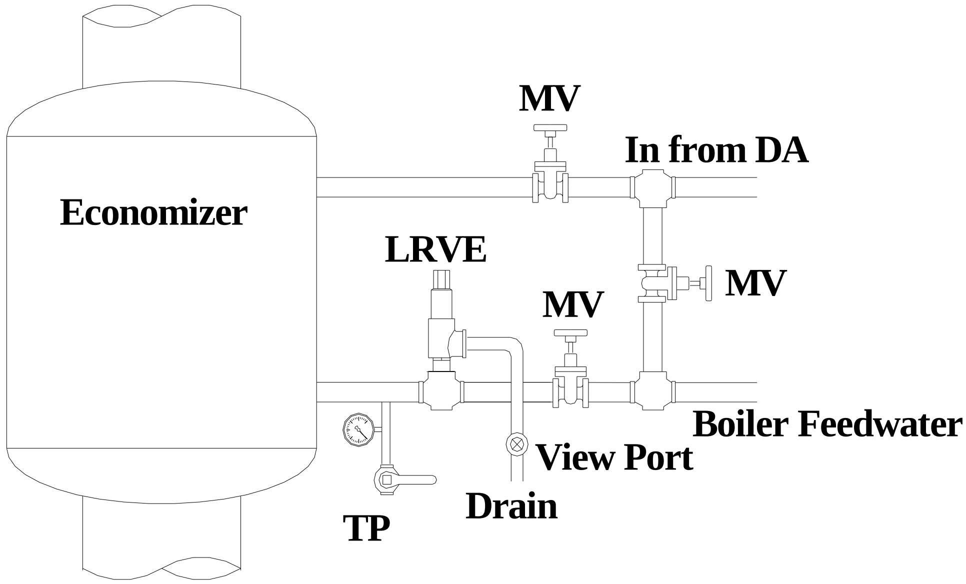


Figure 1.4 Hydro Testing

2 WATER LEVEL CONTROL

2.1 LOW WATER CUTOFFS

2.1.1 Description

A low water cutoff is a device that causes causing the automatic fuel safety shutoff valves to close if the water level in the boiler drops below a pre-set safe level. Low water causes about 50 percent of all boiler incidents. Low water can cause the boiler to overheat which could lead to the failure of the pressure vessel with enormous potential damage (explosion). Two low-water cutoffs are required. Low-water cutoffs operate either on a "float" system or electrode system. In the float system there is a cross arm connection to the boiler (high and low connection points). Between these connection points there is a vertical section containing a volume sufficient to house the float. If the water level falls below a prescribed level, the falling float will cause a switch to actuate causing the automatic fuel valves to close. (See Figure 2.1)

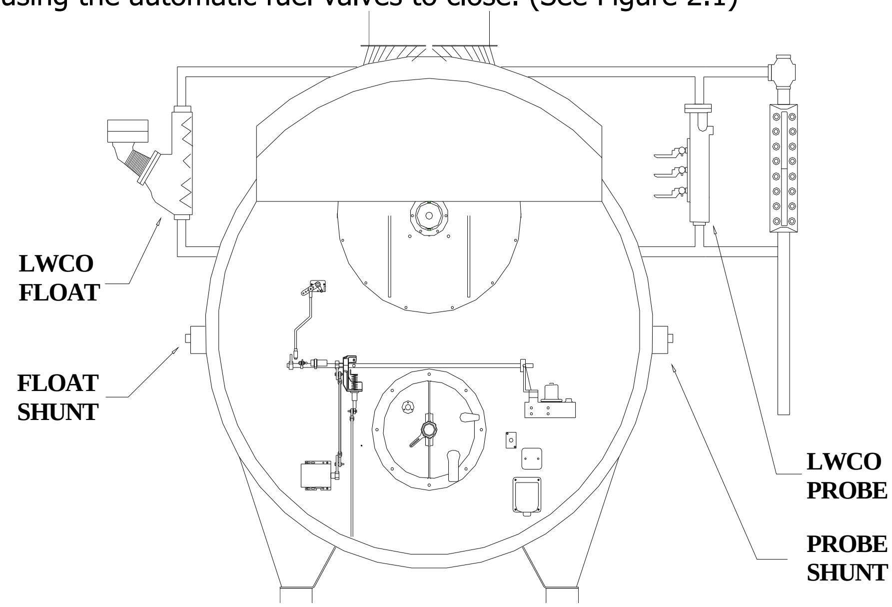


Figure 2.1 Low Water Cutoff

In the electrode system, there is a similar cross arm arrangement as in the float system. Probes extend vertically downward into the vertical pipe connecting the cross arms. The electrodes are located at the bottom of the probe and are used to measure the conductivity of the media in which the electrodes are immersed. The conductivity of water is much higher than steam. Hence, if the water level drops below the probe, a drastic change in conductivity occurs. This change is used in an electrical circuit to cause the automatic fuel shut-off valves to close. Most safety codes require at least one float system be included to protect against low water. This is shown in Figure 2.1. The VA requires one float and one probe. True redundancy requires two separate cross arm arrangements. Use of a single cross arm could lead to a situation in which blockage in the cross arm renders both level control safety devices useless.

Some low-water cutoffs are provided with non-latching "shunt" switches by which the cutoff switch is bypassed. Arrangements for shunt switches include individual shunt switches on one or both cutoffs or a switch which shunts both cutoffs. Operators can use the shunt switch in "testing" of the low-water cutoff to prevent the boiler from shutting off. Operators electrically check the low-water cutoff using this method. When no shunt is available or the shunt is across both low water cutoffs, it is necessary to use an electrical jumper to temporarily by-pass one cutoff in order to test the other cutoff.

A boiler control system should never allow the boiler to automatically restart after a low-water cutoff has actuated to stop boiler operation.

A detailed step by step test procedure is given in Appendix A.

2.1.2 Consequences of Low Water Cutoff Failure

If the low water cutoffs both fail, the boiler would then be fired with no water in the boiler. This will cause the metal temperatures to rise rapidly and the metal strength to be significantly decreased. In fire tube boilers the main Morrison tube typically collapses which could allow steam onto the boiler fireside. The steam pressure has been known to blow the ends out of the boiler through concrete block walls a distance of hundreds of feet. Similar catastrophes could occur in water tube boilers.

2.1.3 Testing a Low Water Cutoff

Low-water cutoffs must be tested in a mode in which they fail. Testing is basically done by allowing the water level to lower in a "slow drain". In order to be in a realistic mode, one must not follow a procedure that actuates the cutoff by <u>rapidly</u> blowing off a volume of water from the cross arms. This is very important in testing a float type cutoff. It is recommended that the rate of decrease in water level be a maximum of 1 inch/minute.

A detailed step by step test procedure is given in Appendix A.

2.2 LOW WATER ALARM

2.2.1 Description

The low water alarm provides audible and visual warnings that the water level is approaching a dangerously low level. These alarms are based either on a conductivity probe or float as described in the previous section. These alarms are used on the boiler, deaerator and condensate receiver tanks. On the boiler, the low water alarm must be set to activate before either of the low water level cutoff switches shuts off the boiler. On the deaerator and condensate receiver tanks, the alarm is the only indication of a low water problem. On these devices the setting should be above the point of pump cavitation and with visible water in the sight glass. The alarm should not be set so high that it causes excessive alarm activation. Of course lack of water in the deaerator or condensate receiver will quickly result in loss of water to the boiler with the problems described in the section of low water level control.

The alarm testing should include a careful consideration as to whether the alarm setpoint is at the correct level for its intended purpose.

2.2.2 Consequence of Water Level Alarm Failure

Low water in a condensate or deaerator tank is a precursor to low water failure in a boiler with the problems described above. There is also the hazard of damage to a condensate transfer or boiler feed pump from running dry. A low water alarm on a boiler is a warning to operators of an impending potential problem of a "boil out" of water.

2.2.3 Testing Low Water Alarms

This alarm is tested by causing a drop in water level in the vessel being tested. The alarm should activate at the desired setpoint (the setpoint must be above the level at which dangerous operations will occur, at a level allowing operators to restore the proper level, and visible in the appropriate sight glass).

A step by step procedure is given in Appendix A for three situations: boilers, deaerators, and condensate tanks.

2.3 HIGH WATER ALARM

2.3.1 Description

A high water alarm is used on a boiler, deaerator, and condensate tanks to aid in preventing overfilling. Due to the failure rate of float type devices used for this purpose, high water alarms should always be a conductivity probe type device.

2.3.2 Consequence of High Water Alarm Failure

High water in a condensate tank could lead to backup of condensate in condensate lines. High water in a deaerator will result in poor deaeration but also leads to violent shaking of the vessel. High water in a boiler could result in pushing liquid into the steam line. Slugs of water in the steam system can move at high velocity due to the motive force of steam causing water hammer. Water hammer can cause valves and other fittings to explode and steam piping to rupture. Death and injury from these events is a regular occurrence. This same effect could produce high water levels in the steam supply to a steam powered appliance connected to the system with detrimental effects on the process.

2.3.3 Testing the High Water Alarm

The high water alarm can be tested off-line. Slowly fill the vessel with water, observe the water level in the sight glass, and note the point at which the alarm sounds. Be careful not to overfill the system, above the level at which the alarm should actuate.

A step by step procedure is given in Appendix A for three situations: boilers, deaerators, and condensate tanks.

2.4 OVERFLOW DRAIN SYSTEM

2.4.1 Description

Deaerator tanks and condensate storage tanks have overflow systems to prevent overfilling. The deaerator overflow is shown in Figure 2.2. The overflow system on the condensate tank also helps guarantee that the condensate tank remains at atmospheric pressure and consists of a drain line connected to the vessel. The drain line from a deaerator includes a normally closed device that opens if the water level is too high and allows water to drain either to sewer or into the condensate tank. Three different types of overflow control valve systems have been utilized on deaerator tanks:

- A float valve which opens when liquid water comes into a standpipe that has an opening near the top of the deaerator.
- An electronic valve which is operated by a conductivity probe indicating that water level is too high. In this case the water should be drained from the bottom region of the tank to avoid the possibility of exhausting steam in case the valve opens before the water level reaches proper height.
- An electronic valve which is operated by a differential pressure cell indicating that water level is too high. In this case the water should be drained from the bottom region of the tank to avoid the possibility of exhausting steam in case the valve opens before the water level reaches proper height.

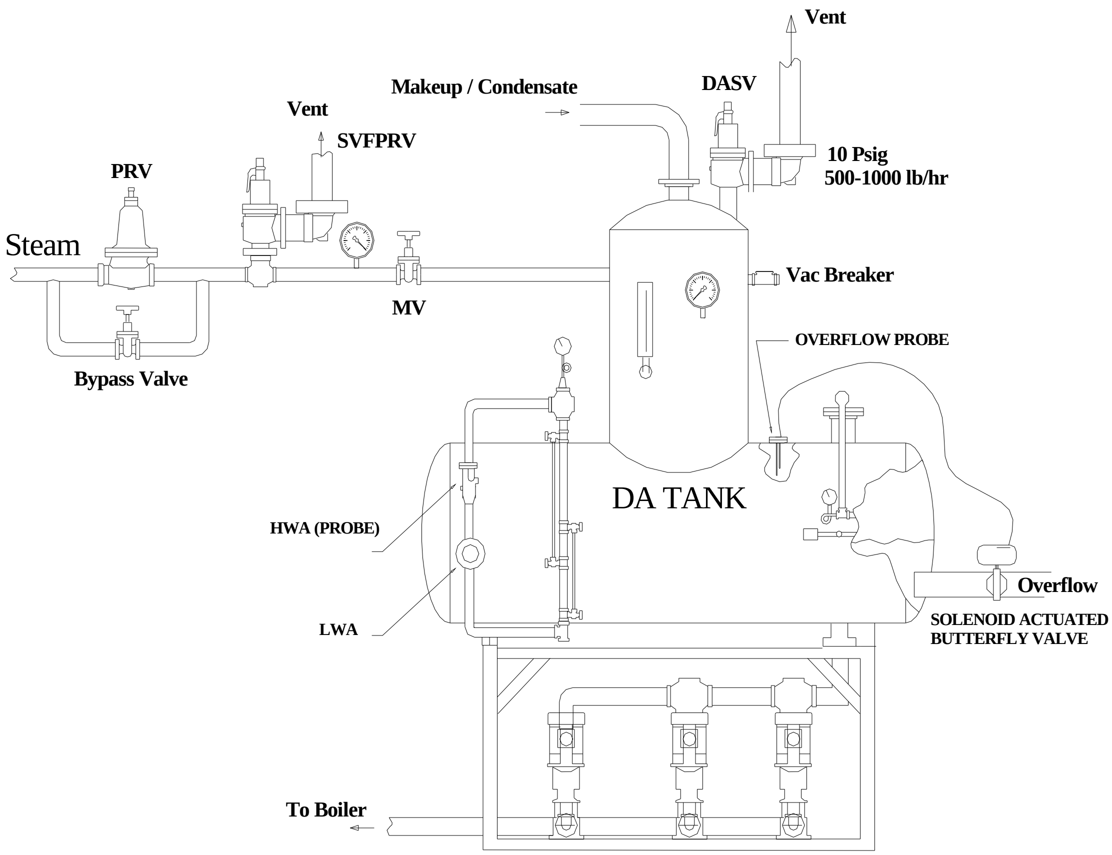


Figure 2.2 Overflow Drain System

2.4.2 Consequence of Overflow Drain Failure

The consequence of an overflow drain failure is the same as that discussed in section 2.3.2.

2.4.3 Testing the Overflow Drain System

The purpose of the test is to determine if the system is capable of draining water from the deaerator at a rate equal to or greater than the maximum potential supply of water to the deaerator. The system can be tested with the deaerator out of service (steam valved out and feedwater pumps off). To test the drain system, fill the deaerator with water at a rate equivalent to the maximum rate that could possibly be supplied to the deaerator. Observe the water level in the sight glass. Use the sight glass to confirm that the drain system is capable of maintaining the water level at the drain level.

A step by step procedure is given in Appendix A.

3 PRESSURE CONTAINMENT

3.1 SAFETY VALVES

3.1.1 Description

The safety valves are connected to a boiler, steam line, or other device that must be protected from over-pressure. Each safety valve discharges into a drip pan ell which discharges through a slip joint into an oversized vent pipe that extends to outside the building. By utilizing drip pan ells, there is no direct connection between the vent pipe and the safety valve so that there is no stress imposed on the safety valve from the thermal expansion of the vent pipe. Liquid relief valves on unheated services, such as fuel oil, can be directly connected to a vent. Safety valves must be present on the boiler, deaerator, any pressurized condensate receiver, and at all points in steam lines just downstream of any pressure-reducing valves. Each safety valve must have a dedicated separate vent line (See Figure 3.1). Properly designed redundant safety systems for this extremely important safety device allow the system to prevent a boiler explosion even if one of the safety valves and / or vent system fails.

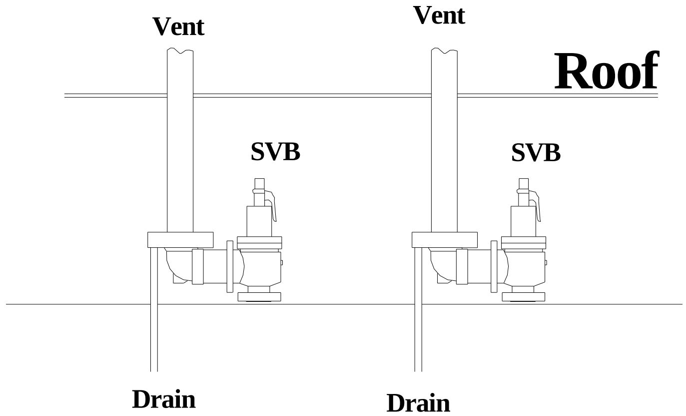


Figure 3.1 Boiler Safety Valves

3.1.2 Consequences of a Safety Valve Failure

Safety valves are the last line of defense against the over-pressurization of the boiler or steam system components. If these valves fail along with all the other measures designed to prevent over-pressurization, a violent explosion could occur. Of course, such an explosion could wipe out buildings and people within several hundred feet of the boiler or system component.

3.1.3 Checking a Safety Valve

The aspects of the safety valve that must be checked include:

- Is the safety valve vented to the outside with proper piping?
- Is the lift pressure set correctly?
- Does the valve open at the correct pressure?
- Are the safety valves present capable of handling the maximum boiler/steam capacity?
- Is the blowdown (set-point minus reseat pressure) correct?

- Is the safety valve properly drained?
- Can the safety valve be safely checked?

Some authorities recommend doing all safety valve testing on a test stand. However, there is a chance that the valves could be mixed up or damaged in installation so that this test method is not as reliable as testing the valves in situ. Also some authorities check a safety valve by lifting the handle. This test does not confirm that the valve opens at its setting. It does confirm that the valve can vent steam (is not blocked). This test should never be performed at a working pressure less than 75 percent of the safety valve setting.

A detailed test procedure which allows the 7 points enumerated above to be checked is given in Appendix A for three situations: boilers, deaerators, and piping following a PRV station.

3.2 RELIEF VALVES

3.2.1 Description

Relief valves are spring-loaded valves that open if the liquid pressure in the system that they protect increases above a pre-set limit. They are similar to safety valves with the exception that they do not exhibit "popping" action or blowdown. (Relief valves do not incorporate the "huddling" chamber found on safety valves). These valves are connected to an exhaust pipe that conveys the fluid to the building exterior or storage tank. Two important pieces of equipment requiring relief valves in boiler applications are economizers and oil pump sets

3.2.2 Consequences of a Relief Valve Failure

Failure of a relief valve could lead to a pressure vessel explosion with serious consequences. For example, there are several cases yearly in which the relief valve on domestic water heaters fail with the result that an entire house is "leveled". A even more devastating event could result from the explosion of an economizer. Failure could also lead to equipment damage due to overheating-e.g. in operation of an oil pump.

3.2.3 Checking a relief valve

There are several aspects of a safety or relief valve that must be checked. These include:

- Is the valve vented with proper piping?
- Is the lift pressure correct?
- Does the valve open at correct pressure?
- Will the valve handle the maximum capacity of the device that it protects?

Testing procedure for the relief valve on an oil pump set and economizers are given in Appendix A.

3.3 HIGH STEAM PRESSURE LIMIT SWITCHES

3.3.1 Description

A boiler should be fitted with two, high-steam-pressure-limit switches (HSPLS). Both switches have the function of causing the two automatic fuel shut off valves to close if a preset pressure limit is exceeded. One switch may be a recycle switch meaning that once the pressure falls below the set point pressure the boiler will automatically restart. The other switch must be a non-recycle switch meaning that it must be manually reset after a pressure excursion above its limit. The pressure setting on the non recycle switch should be slightly higher than the setting on the recycle switch but lower than the maximum working pressure for the boiler. The non-recycle limit should also be lower than the lowest lift pressure for the safety valves. The required differences in the settings described above should be sufficient to allow the boiler to operate without excessive nuisance trips or blowing of safety valves.

3.3.2 Consequences of High Steam Pressure Limit Switch Failure

If both HSPLS switches were to fail, the safety valve becomes the last line of defense against a pressure vessel explosion. A tendency of boiler operators is to not worry about the performance of the HSPLS (especially the non-recycle one) because the safety valve is still available to save the operation. This thinking represents the "slippery slope" in safety because true safety relies on redundant measures. In looking at accidents in industry one can almost always find several unsafe factors that led to the particular accident. Ignoring the first warning escalates the risk.

3.3.3 Checking High Steam Pressure Limit Switches

Items to be checked about the HSPLS include:

- Are the limits on the switches set correctly, and
- Do the switches work?

These tests are described in Appendix A.

3.4 BOILER HYDROSTATIC TESTING

3.4.1 Description

A hydrostatic test is performed on a boiler, deaerator, and economizer to determine if it is capable of withstanding the potential operating pressure. It is very important to understand that any leak is a sign of weakness in the vessel and should be thoroughly inspected by a professional and properly repaired before the vessel is put back into operation. (These leaks could represent small cracks or metal thinning/corrosion/etc that is not discernable to the eye).

3.4.2 Consequences of Failure to Hydrostatic Test

If weak spots are present and the vessel is operated, a significant chance exists that a pressure vessel explosion could occur with tremendous loss of property and life. Failure to perform a proper hydrostatic test would allow a weakened vessel to be operated with the attendant dangers of such operation.

3.4.3 Performing a Hydrostatic Test

To perform a hydrostatic test, fill the vessel completely full of water below 200 F. Remove and plug all safety and relief valves. Close all supply and discharge lines. The boiler should be completely locked and tagged out from all energy sources following OSHA requirements and the fireside opened for inspection. The hydrostatic pressure for the test at about 1.5 times working pressure should be applied for several hours. The dry side should be checked for any sign of leaks. Any leaks should be professionally evaluated in terms of whether the vessel can be operated safely without repair.

In applying the hydrostatic pressure, care must be exercised not to overpressure the vessel. If the vessel were pressurized above its elastic limit, the vessel would not be fit for further use and should be scrapped!

4 FUEL TRAIN SAFETY DEVICES

4.1 LOW PRESSURE FUEL CUTOFF SWITCH

4.1.1 Description

The low-pressure fuel cutoff switch causes the automatic fuel shutoff valves to close if the fuel pressure is below the lower limit for safe operation. LPFCS safety devices are found on the main gas line, main oil line, and pilot gas line. The switch in all three of these applications senses the supply fuel pressure after the pressure regulating valve and upstream of any fuel control valve (See Figure 4.1). For the main oil and gas supply lines, the switch is in continuous operation once the boiler is in the run mode. For the pilot gas supply, the switch operates continuously while the pilot flame is on.

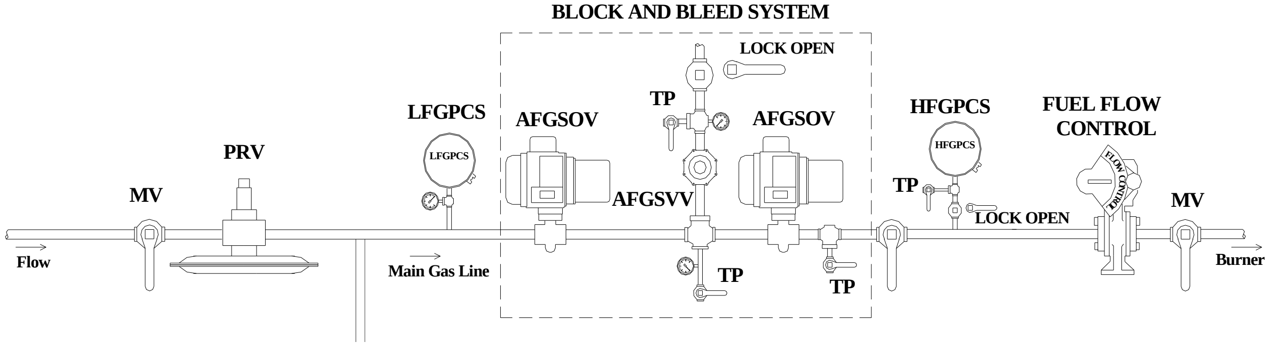


Figure 4.1 Low Pressure Fuel Cutoff

4.1.2 Consequences of Low Pressure Fuel Cutoff Switch Failure

Low fuel pressure can result in unstable burning or flameout conditions. When fuel pressure returns to normal, the combustion chamber can overfill with fuel before igniting. This can easily result in combustion explosions that are violent enough to blow the "ends" of the boiler and even through surrounding structures. Extensive property damage, injury, and even death can result.

4.1.3 Checking the Low Pressure Fuel Cutoff Switch

The checking procedure for this switch is designed to answer three questions:

(1) Is the switch in correct place?
(2) Are its limits correctly set?
(3) Does the switch work to produce the desired result?

The switch should never be located upstream of the pressure regulating valve and should never be located downstream of the fuel flow control valve. The low pressure limit should be 80% of the normal regulated supply pressure. (On gas operation, some pressure regulation devices require improvement because they allow a substantial "dip" in supply pressure on initial light-off). A step by step test procedure for the low pressure fuel cut out switch for the main gas and main oil supply systems as well as the pilot gas system is given in Appendix A.

4.2 HIGH PRESSURE FUEL CUTOFF SWITCH

4.2.1 Description

The high fuel pressure cutoff switch is used to cause the automatic fuel shutoff valves to close if fuel pressure is above a given the higher limit for safe operation. These switches are used for both the main gas and main oil fuel supply systems (See Figure 4.2). In both of these applications the switch senses the supply fuel pressure after the pressure regulating valve and upstream of the fuel control valve. The switch is in continuous operation once the boiler is in the run mode.

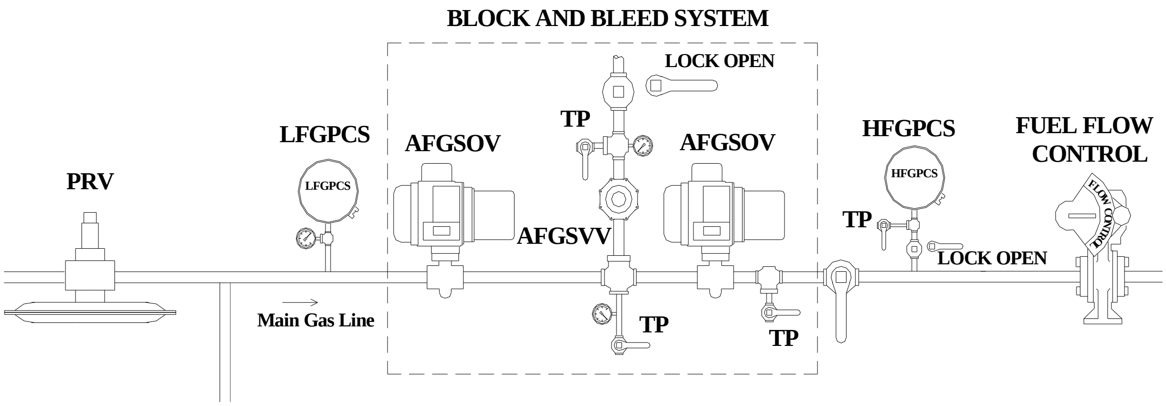


Figure 4.2 High Pressure Fuel Cutoff

4.2.2 Consequences of High Pressure Fuel Cutoff Switch Failure

High fuel pressure can cause unstable flame conditions but more importantly it can result in over-firing the boiler. Over-firing can damage burner/boiler materials to the point of meltdown and explosion. The generation of steam can be so intense that a pressure vessel explosion can occur. High fuel pressure can easily occur if a pressure regulator and high-pressure cutoff switch were to fail.

4.2.3 Checking the High Pressure Fuel Cutoff Switch

The checking procedure for this switch is designed to answer three questions:

- Is the switch in correct place?
- Are its limits correctly set?
- Does the switch work?

The switch should never be located upstream of the pressure regulating valve and should never be located downstream of the fuel flow control valve. The high pressure limit should be 120% of the normal regulated supply pressure for natural gas and 110% for light oil.

A step by step test procedure for the high pressure fuel cut out switch for the main gas and main oil supply systems is given in Appendix A.

4.3 VENTING BETWEEN AUTOMATIC GAS SHUTOFF VALVES

4.3.1 Description

The volume between the automatic fuel shutoff valves for gas should be vented to the atmosphere with a system as shown in Figure 4.3 for both the main gas and pilot line automatic shut off valves. While the boiler is running the solenoid valve is shut and gas flows through the two automatic shutoff valves to the burner. When the fuel shut-off valves close, the solenoid valve opens and vents any residual gas in the space between the valve and any leakage of gas through the first automatic shutoff valve.

The purpose of the vent system is to insure that even if the first automatic shutoff valve leaks, the gas is vented rather than allowed to move through the second automatic fuel-shutoff valve and then into boiler. The vent line should be vented to the atmosphere.

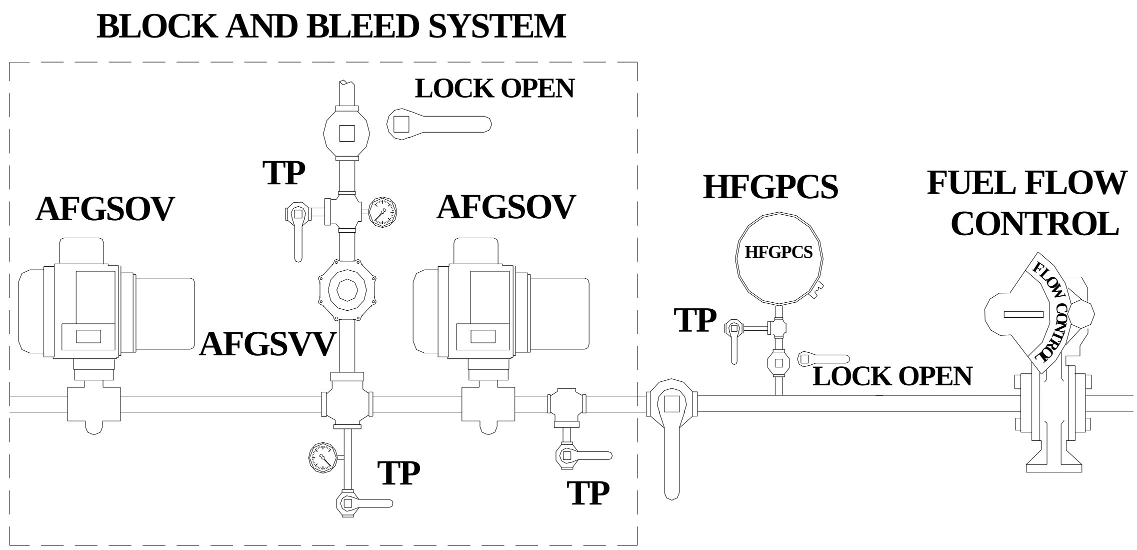


Figure 4.3 Gas Train Vent Valve

4.3.2 Consequences of a Failed Vent Valve

Fuel leaks into the boiler are obviously dangerous because if both automatic shut off valves leak, gas would fill the boiler furnace while the boiler is off. Fuel mixed with air is an explosive. Any source of ignition could result in disaster. On ignition if purging did not adequately vent this gas, a tremendous explosion would result when igniting the fuel. This combustion explosion could easily wipe out all property and personnel within several hundred feet of the boiler.

4.3.3 Testing the Gas Train Vent Valve (solenoid valve)

Testing of the vent system should include verifying that the correct physical system is in place, that the vent valve is closed (does not leak) when the boiler is firing, and that the vent valve is open when the boiler is not firing. Vent piping should be checked for insect nests that can block the flow of gas.

A detailed step by step procedure to check all these aspects of the vent valve are given in Appendix A.

4.4 LEAK TEST OF AUTOMATIC FUEL SHUT OFF VALVES

4.4.1 Description

A block and bleed system is provided as discussed in section 4.3 to prevent fuel from entering and potentially collecting in the boiler while the boiler is off. This system is used on the main oil and gas supply lines to the burner as well as the pilot gas supply. (On the main oil supply line a vent is not required.) The two automatic shut off valves used in either case are the means by which the boiler is automatically shut down in case any operating limit is not satisfied. It is absolutely essential that these valves do not leak when closed. For both oil and gas, applicable codes require two automatic shut off valves. It is that important.

4.4.2 Consequences of Leaking Automatic Shut off Valves

There is a slight probability that one or more of the automatic fuel shut off valves would leak. If both valves leaked and the vent system did not function in the case of gas, fuel would be introduced into the burner and into the boiler furnace while the boiler is off. This fuel would produce a combustible mixture in the boiler. Fuel leaks into the boiler are obviously dangerous because it allows the presence of a combustible air-fuel mixture that could explode when the fuel is ignited on startup. This combustion explosion could easily wipe out all property and personnel within several hundred feet of the boiler.

4.4.3 Testing the Automatic Fuel Shut off Valves for Leaks

The testing for leaks can be done when the boiler is off. The best test procedure for gas is a situation in which the leak could be measured with a "bubble test". This method involves connecting a tube to a confined space downstream of the valve being tested with positive pressure on the upstream side of the valve. The tube is placed approximately $1/16^{th}$ of an inch below a water surface. Any leak will show up as a bubble generated in the water at the tube exit. Any testing by watching pressure fall is difficult to evaluate because generally there are many potential sources for leaks in the system which will obscure the results. For oil a test port can be provided to visually observe whether oil drains from the test port.

A step by step procedure is given in Appendix A.

4.5 OIL LOW ATOMIZING MEDIA PRESSURE SWITCH

4.5.1 Description

An atomizing fluid (compressed air or steam) is usually used to aid in the combustion of the oil fuel (See Figure 4.4). A safety switch is required that shuts the boiler off in case of low atomizing pressure. This switch measures pressure in the atomizing fluid line immediately after the pressure regulating system and causes the automatic fuel control valves to close if the atomizing pressure falls below its setpoint. If there is a differential pressure regulator, the sensor should be located upstream of that regulator.

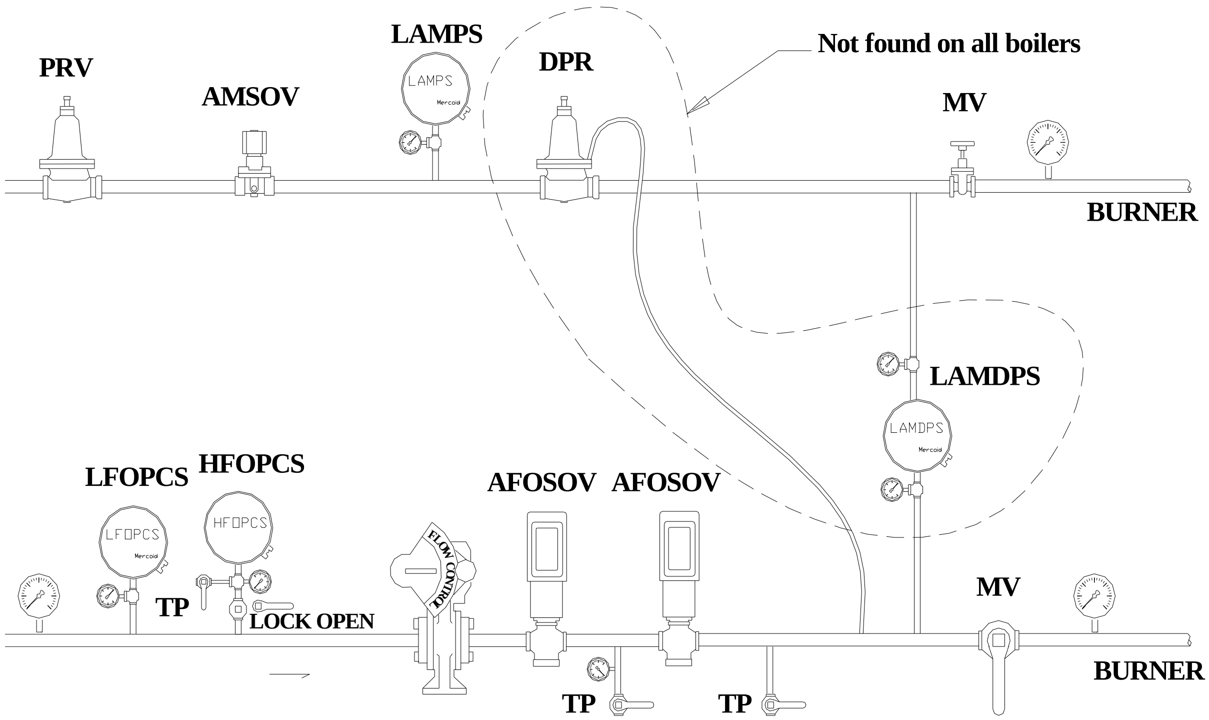


Figure 4.4 Low Atomizing Media Pressure Switch

4.5.2 Consequences of Low Atomizing Media Pressure

Low atomizing pressure could cause poor combustion leading to the production of carbon monoxide, flame instability, and possible combustion explosions leading to serious loss of property and injury/death.

4.5.3 Testing the Oil Low Atomizing Media Pressure Switch

There are basically three items that need checking;

- Is the switch correctly set?
- Is the switch located correctly?
- Does the switch work to produce the desired effect?

The setpoint on the oil low atomizing pressure switch should not allow the atomizing media pressure fall below level recommended by the burner manufacturer. Testing is accomplished on-line by slowly lowering the oil atomizing media pressure and observing that the switch operates at the correct set point. In order to test the low oil atomizing media switch a calibrated pressure gage or other method to measure pressure is required. Make certain that the burner is producing negligible combustibles at the set point pressure condition.

A step by step procedure is given in Appendix A.

4.6 AUTOMATIC FUEL SHUTOFF VALVE PROOF OF CLOSURE SWITCH

4.6.1 Description

The function of an automatic fuel shutoff valve is absolutely essential. All safety devices that require fuel shutdown rely on the two automatic fuel shutoff valves to perform this task. Proof of Closure switches must be present in both automatic shut off valves. Both oil and gas automatic shut off valves require proof of closure switches. The switches in the two valves should be wired in series so that an indicated failure in either valve will prevent the boiler from starting. The proof of closure switch is an integral part of the automatic fuel shutoff valve. It has a simple function to guarantee that the automatic fuel shutoff valve is closed before allowing the boiler to go through the burner startup sequence. If the automatic fuel shutoff valve is not closed, the proof of closure switch will be open, breaking the circuit and not allowing the burner to start. The proof of closure switch is active only during the startup sequence.

4.6.2 Consequences of a Failed Proof of Closure Switch

If the proof of closure switches fail, they could "stick" closed even with the valve open. This malfunction would present a false signal to the burner management system indicating that the valve is closed when it might not be closed. This malfunction could allow the fuel to be ignited with a large quantity of fuel in the furnace. Under this scenario, a horrible combustion explosion would occur. The result could be a tremendous loss of property and death as well as physical harm to personnel within several hundred feet of the boiler.

4.6.3 Testing the Automatic Fuel Shutoff Valve (Proof of Closure) Switch

In order to test a proof of closure switch one must demonstrate the following:

- That the switch is closed when the valve is closed.
- That the switch opens immediately once the valve starts to open.
- The boiler will not start with the switch open.

A detailed step by step procedure to determine whether the proof of closure switches meet the above requirements is given in Appendix A.

5 BURNER AND AIR TRAIN SAFETY DEVICES

5.1 THE FLAME SCANNER

5.1.1 Description

A flame scanner is a device that continually monitors the flame to determine whether a flame is present in the combustion chamber. If the flame is extinguished for any reason, the scanner causes the two automatic fuel shutoff valves to close.

Modern flame scanners work by converting either the ultraviolet (UV) or infrared (IR) portion of the thermal radiation produced by the flame to an electrical signal. The UV scanner has some disadvantage in that it can sometimes see the igniter spark as a flame. The IR scanner has a disadvantage in that it can mistake glowing refractory for a flame. Properly adjusted, the UV scanner is superior and is required by the VA. The strength of the electrical scanner signal is then the indication as to whether an adequate flame is present.

UV scanners can fail unsafe, showing a flame detected when none is present. Some organizations do not consider this a problem on boilers that cycle on/off frequently as the burner management system will not allow a burner to start if a flame is "detected" while the burner is off. On V.A. boilers, which operate continuously for long periods, it is necessary to utilize "self-checking" UV scanners. The "self-checking" feature detects a scanner failure and immediately shuts down the burner."

5.1.2 Consequences of a Failed Flame Scanner

If the flame scanner allows fuel to be supplied to the combustion zone when no flame exists, horrific combustion explosions can occur. The combination of a spark due to some type of "glowing" material and a "pocket" of fuel/air mixture at an explosive ratio can result in an explosion. Another scenario is relighting the boiler with an explosive mixture of fuel and air present. There have been numerous accidents in which the front or back of the boiler have blown off and through masonry walls with loss of life and property damage.

5.1.3 Checking a Flame Scanner

There are many potential tests for a flame scanner depending on the situation. The guiding principle is to try to check the scanner operating in the same mode that a potential failure might occur. The best test is then to cause the flame to extinguish and to determine whether the flame scanner then causes the two automatic fuel shut-off valves to close. It is very important that the flame scanner be checked on both oil and gas firing.

There are really three attributes of the flame scanner that one should check:

1. Is the flame scanner a UV self-checking scanner?
2. Does the flame scanner sense the igniter spark?
3. Will the flame scanner cause the automatic fuel shut-off valves to close within the allowable time (4 sec) when the fire is extinguished?

A detailed step by step procedure is given for testing the flame scanner in Appendix A.

5.2 LOW FIRE PROVING SWITCH

5.2.1 Description

In the startup procedure for the boiler, the safest way to light the main burner is with a minimum of fuel input. There are electrical position switches located on the control systems for the fuel flow control valves and the combustion air damper that activate when the damper is at low-fire position. These low-fire proving switches have the function of not allowing the main flame to be ignited if the firing position is not a minimum. In some electronic control systems a potentiometer is used to determine the position of the inlet damper by the output of a voltage level to the controller. The required V.A. system is position switches actuated by the fuel control valves and the damper themselves rather than at some point nearer the drive motors that operate the valves and damper. Parallel position systems require separate proof of the low fire position for air and fuel.

5.2.2 Consequences of a Failed Low Fire Proving Switch

Failure of the low-fire proving switch could allow the boiler to start in a high fire position. This result could easily lead to a violent combustion explosion with property loss as well as injury and death to individuals within a few hundred feet of the boiler.

5.2.3 Testing the Low-Fire Proving Switch

The low-fire proving switch should be tested during the boiler startup sequence. There are basically three things that should be tested:

- Is the switch the right type and located correctly?
- Is the switch "activated" at any position other than "low fire"?
- Does the switch in the non-activated position prevent the boiler from firing?

A detailed step by step procedure for testing the low fire proving switch is given in Appendix A.

5.3 COMBUSTION AIR FLOW SWITCH

5.3.1 Description

A combustion airflow switch is used for the purpose of causing the two automatic fuel shutoff valves to close if the forced draft fan is not producing airflow (See Figure 5.1). Typically, this switch uses a pressure measurement across the fan. The switch is in the safety control circuit anytime the boiler is in the run position. A set point for the switch is established by measuring the minimum pressure rise seen by the switch over the firing range and setting its value at approximately 80% of the minimum pressure rise. For the combustion air flow switch one desires that the pressure rise being measured is as large as possible and is "flat" i.e. independent of firing rate.

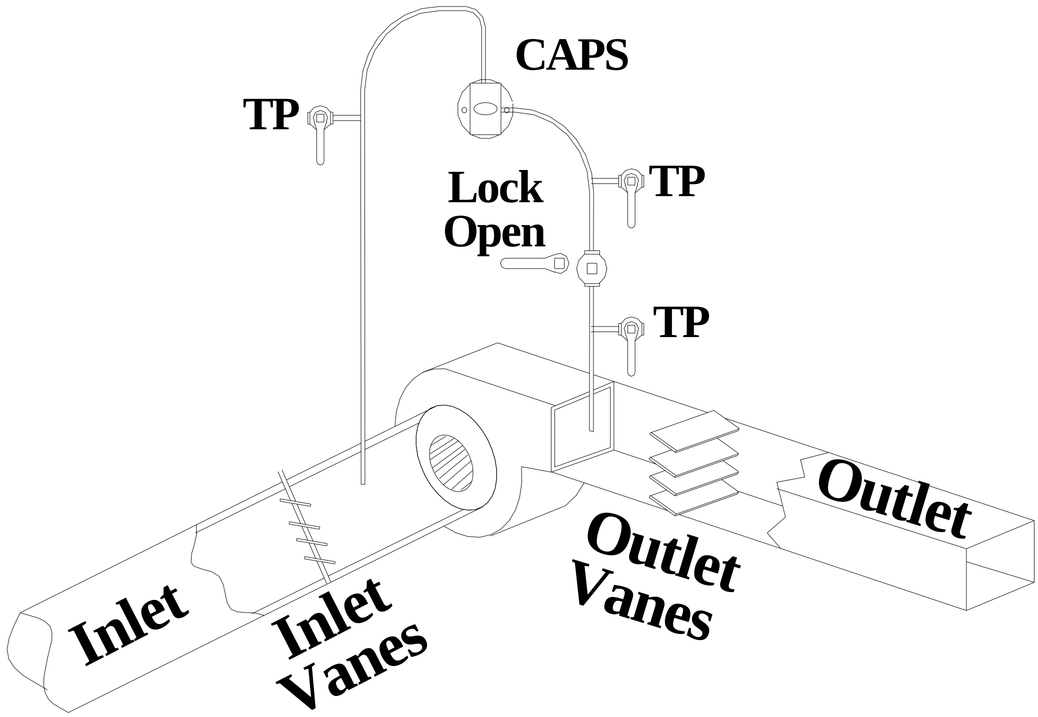


Figure 5.1 Combustion Air Pressure Switch

5.3.2 Consequences of a Failed Combustion Air Switch

If the fan fails to produce adequate combustion air, seriously incomplete combustion will occur. The flame will be highly unstable and the risk of a combustion explosion which could send boiler parts flying for several hundred feet is high. In addition, the production of carbon monoxide with its attendant toxicity can easily cause death for operators.

5.3.3 Testing Combustion Air Flow Switch

The combustion air flow switch should be tested while the boiler is running. There are basically three things that should be tested:

- Is the switch located correctly?
- Is the switch setpoint correct?
- Does the switch stop the boiler from firing with insufficient combustion air?

A detailed step by step procedure for testing the combustion air flow switch is given in Appendix A.

5.4 PURGE AIR FLOW PROVING SWITCH

5.4.1 Description

The purpose of the purge airflow-proving switch (PAPS) is to insure that during purging sufficient air volume is moved through the boiler. Four air changes are required for fire tube boilers and 8 air changes are required for water tube boilers. A boiler cannot be overpurged. Hence, the PAPS serves the role of proving airflow rate during purging. The PAPS works by measuring pressure change across a boiler element. One desires that the switch sees a small pressure change at low fire with a much larger change in the purge (high fire) position. Typically this pressure should be measured across the boiler bank without variable restrictions. The proper set point for the switch is approximately 80% of the maximum pressure change sensed by the switch.

5.4.2 Consequences of a Failed Purge Airflow Proving Switch

If this switch were to malfunction, it would be possible to ignite the pilot and or main flame with combustible gas mixtures present in the boiler. This could lead to a terrible combustion explosion with serious loss of property and life.

5.4.3 Testing the Purge Airflow Proving Switch

The purge air flow proving switch should be tested during the boiler startup sequence. There are basically three things that should be tested:

- Is the switch located correctly (i.e. pressure taps across right element)?
- Is the switch setpoint correct?
- Does the switch in the non-activated position stop the boiler from leaving purge?

A detailed step by step procedure for testing the purge air flow proving switch is given in Appendix A.

5.5 BURNER POSITION SWITCH

5.5.1 Description

Some manufacturers of oil burners require a position switch to indicate that the burner is in the correct position before firing. The switch is generally a simple proximity switch that is electrically closed by depression of the switch by the burner as it is fully inserted into the boiler. For those boilers utilizing this switch it must be tested.

5.5.2 Consequences of Burner Position Switch Failure

If the boiler could fire on oil with the burner partly retracted, fire, production of carbon monoxide, flame instability, and combustion explosions could result. This could lead to serious loss of property and injury/death.

5.5.3 Testing the Burner Position Switch

The switch must be periodically tested to determine if the boiler would fire on oil with the burner partially retracted. If the switch is properly set up, the boiler control will not allow the boiler to leave purge with the burner out of position. A detailed step by step testing procedure is give Appendix A.

5.6 FORCED DRAFT MOTOR INTERLOCK

5.6.1 Description

The forced draft motor interlock provides an extra level of safety relative to proving "purge air flow" and "combustion air flow" and protects the fan motor from running with an inadequate power supply. There are three types of interlocks currently being used. The simplest interlock is an auxiliary contact which is a single pole switch that "makes" when the main switch supplying 3-phase power to the fan is closed. One could cut any or all of the power leads going to the motor and this switch would indicate acceptable operation. Clearly, this interlock is not acceptable. A second design utilizes phase monitors on all three legs which looks at the incoming power characteristics which will work if one loses incoming power to the panel. However, the fan motor could be disconnected electrically and the phase monitor would indicate acceptable operation. Again this interlock is not acceptable. The proper interlock is based on current relays in which current in all three legs supplying power to the motor is measured (See Figure 5.2). This interlock involves encircling each power lead with a current pickup. The lack of current through any of these current pickups will stop boiler operation. For testing it is best if one uses a type of current pickup around each lead that could be opened and removed without disconnecting the power lead from its terminal strip.

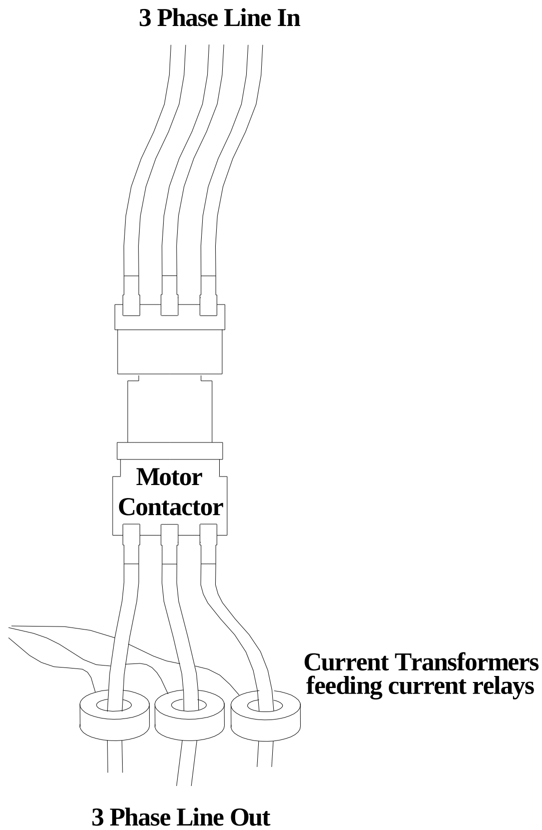


Figure 5.2 Forced Draft Motor Interlock

5.6.2 Consequences of a Failed Forced Draft Fan Motor Interlock

If the fan fails to run or runs at a lower speed, the boiler would produce combustibles leading to the same problems discussed in section 5.5.2.

5.6.3 Testing the Forced Draft Fan Motor Interlock

The test for this interlock consists of determining whether the right type of switch is in place and then removing the current pickups, one at a time, and determining if the boiler shuts down. A detailed step by step procedure is given in Appendix A.

5.7 FURNACE PRESSURE INTERLOCK

5.7.1 Description

The purpose of the high furnace pressure interlock (FPI) is to insure that the furnace pressure does not exceed an acceptable limit due to some type of blockage. The FPI works by measuring pressure in the boiler furnace while the boiler is running. A pressure that exceeds the FPI setpoint “breaks” the interlock to an open position and causes the boiler to shut down. The proper set point for the switch is approximately 120% of the actual furnace pressure at high fire condition.

5.7.2 Consequences of Low Furnace Pressure Interlock Failure

A blockage in the exit portion of the boiler combustion gas circuit, leads to high furnace pressure and incomplete combustion. Under this condition carbon monoxide is generated and the combustion gases are potentially highly explosive. If the FPI were to malfunction two highly undesirable consequences might occur. First, high furnace pressure would cause incompletely combusted gasses internal to the boiler furnace to be expelled into the boiler room. Carbon monoxide levels in the boiler room could reach a point where occupants would be killed. Secondly, these incomplete combustion gases could explode if a supply of oxygen became available (For example the flame might be temporary extinguished, and the explosively re-ignited by a "hot spot" in the boiler.) Therefore, the consequences of a failed FPI could be the loss of life of many people from carbon monoxide poison and flying debris from a boiler explosion.

5.7.3 Testing the Furnace Pressure Interlock

The FPI can be tested by first determining the furnace pressure at high fire in order to establish a proper setpoint for the interlock. It can then be tested offline by pressurizing the interlock with air. There are basically four items that need checking;

- Is the switch located correctly (i.e. pressure taps between the internal volume of the boiler furnace and atmosphere)?
- Is the interlock set point correct?
- Does the interlock break at the correct set point?
- Does the interlock in the open position stop the boiler from operating?

A detailed step by step procedure for testing the FPI is given in Appendix A.

5.8 OUTLET DAMPER POSITION INTERLOCK

5.8.1 Description

The purpose to the outlet damper position interlock (ODPI) is to insure that the outlet damper is open during purge. This interlock is a part of the safety system to insure that adequate purging has occurred prior to the ignition sequence. Therefore, it is a pre-ignition interlock. The ODPI is a displacement electrical switch that should be activated by movement of the outlet damper into the correct position for purging. (In many cases this interlock is on the jackshaft drive motor that is linked to the damper, but this arrangement does not meet VA specifications.) If the interlock is not "made", the safety controller for the boiler does not allow the boiler to leave purge.

5.8.2 Consequences of Outlet Damper Position Interlock

A blockage in the exit portion of the boiler combustion gas circuit due to a closed or partially closed outlet damper, leads to inadequate flow of combustion air. Under this condition there is the potential for highly combustible gases to be present in the boiler furnace after purging is complete because the air flow restriction reduces the volume of purge gases to the point hat combustible gases remain in the boiler or exhaust system. If the ODPI were to fail, these incomplete combustion gases could explode when the igniter attempts to light the pilot. This explosion would cause boiler parts to fly hundreds of feet leaving anyone in its path badly injured or dead.

5.8.3 Testing the Outlet Damper Position Interlock

The ODPI can be tested by determining the point at which the interlock "makes". This point should be with the outlet damper within one or two degrees of wide open. A wire can then be disconnected from the interlock which would simulate a failed interlock. The boiler should not prove purge under this condition. There are basically three things that should be tested;

- Is the interlock located correctly (i.e. actuated by damper movement itself)?
- Does the interlock "make" at the proper point?
- Does the interlock prevent boiler from leaving purge if it is not "made"?

A detailed step by step procedure for testing the ODPI is given in Appendix A.

5.9 FORCED DRAFT DAMPER WIDE OPEN PRE-PURGE PROVING SWITCH

5.9.1 Description

The FDDWOPS is necessary to show that the inlet vanes are wide open for purge. This switch is of the proximity type. It can be located such that the movement of the linkages moving the inlet vanes activates the switch when the vanes are in the wide-open position. The VA required system would be a switch actuated by the damper itself rather than at some point nearer the drive motor operating the damper.

5.9.2 Consequences of a Failed FDDWOPS

If this switch failed, the boiler and stack could contain a highly explosive mixture of combustible gases due to inadequate purge. This gas mixture could explode when either the pilot or main flame are operated. This massive explosion would likely cause severe property damage and personal injury and death in an area several hundred feet from the boiler.

5.9.3 Testing the FDDWOPS

The FDDWOPS should be tested during the boiler startup sequence. There are basically three things that should be tested:

- Is the switch the right type and located correctly?
- Is the switch "activated" at any position other than "high fire"?
- Does the switch in the non-activated position prevent the boiler from firing?

A detailed step by step procedure for testing the FDDWOPS is given in Appendix A.

5.10 PRE-PURGE AND POST-PURGE TIMERS

5.10.1 Description

There is a purge cycle at light off and also when the boiler shuts down. The purpose of purging is to make sure that no combustible gas is present in an unfired boiler nor prior to pilot ignition. It is necessary to prove that the purge cycle extends for the correct duration to achieve the required air changes, as determined by the applicable codes. A timer in the burner management system accomplishes this function. Older timers, no longer acceptable, can be adjusted at any time. Timers that are acceptable are adjusted when the burner is commissioned and then "burn in" the timing so that subsequent changes cannot be made without replacing the timer. Codes require that fire tube boilers have a minimum pre-purge of 4 air changes and water tube boilers a minimum of 8 air changes. Before testing, one must verify the correct duration of the purge cycle. Generally, post purge timing is 15 seconds, minimum.

5.10.2 Consequences of Improper Purge Timing

If the timer does not function correctly, the boiler and stack could contain a highly explosive mixture of combustible gases due to inadequate purge. This gas mixture could explode when either the pilot or main flame are operated. The massive explosion that results would likely cause severe property damage and personal injury and death in an area several hundred feet from the boiler.

5.10.3 Testing the Pre and Post Purge Timer

The test is simple in that the duration of purge can be measured simply with a stop watch. The amount of purge air actually moved is more difficult to determine. An approximate calculation for the cubic feet of air moved is given by the following formula:

Standard Cubic Feet of Air =

[(boiler steam capacity in lb/hr)/3600] x [purge duration in seconds]/.075

This amount of cubic feet of air should exceed four times the fireside volume of a firetube boiler and eight times the fireside volume of a water tube boiler. A detailed step by step test procedure is given in Appendix A.

5.11 IGNITER TIMER AND MAIN FLAME IGNITION TIMER

5.11.1 Description

The igniter serves as a spark to light the pilot flame. Moving quickly from an ignition source to pilot light to main flame does not allow a large amount of combustible gas in the boiler without the presence of an ignition source at anytime during light off. The igniter and main flame ignition time is controlled by the burner management system and should not be adjustable by operators. NFPA currently sets the maximum igniter spark duration of 10 seconds. For natural gas or light oil, the time allowed from the time that the two automatic shut off valves open until they close is 14 seconds (this is 10 sec for main flame ignition and 4 seconds for valves to close).

5.11.2 Consequences of Excessive Igniter or Main Flame Ignition Timing

If the igniter stays on too long and the pilot flame fails to ignite, an excessive amount of pilot gas could enter the boiler leading to a boiler explosion. Similarly if the trial time for main flame ignition is excessive, large amounts of fuel could enter the boiler and subsequently explode. Such explosions would likely cause severe property damage and personal injury and death in an area several hundred feet from the boiler.

There is an electronic timing mechanism that regulates the duration of time that the igniter produces a spark. If the trial for ignition (igniter or main flame) is too long, it allows time for a large amount of combustible fuel to enter the boiler. Then if ignition does finally occur the massive explosion described above will take place

5.11.3 Testing the igniter timer

The test of igniter time requires that one close both the main and pilot fuel supplies and measure the time the igniter is on during start up of the boiler. To test the time for trial for main flame, pilot gas is supplied to the boiler with the main fuel line manual valve closed. With this set up a stop watch can be used to measure the time that the main fuel valves remain open during an attempt to start the boiler. A detailed step by step procedure for these tests is given in Appendix A.

5.12 AUTOMATIC FUEL SHUTOFF VALVE CLOSURE TIME AFTER MAIN FLAME FAILURE

5.12.1 Description

When the main flame is extinguished for any reason, the flame scanner should sense a lack of flame and, through the burner management control system, cause the automatic fuel shutoff valves to close. It is essential that these valves close quickly to prevent large amounts of combustible fuel from entering the furnace without a flame present. It should take less than 4 seconds for the automatic fuel valves to close and in most case about 3 seconds.

5.12.2 Consequences of Excessive Time to Close Main Fuel Valves

If large amounts of combustible fuel were present without a flame due to the automatic shut off valves remaining open too long after a flame failure, and subsequently ignition sources were applied, a massive boiler explosion would result likely causing severe property damage and personal injury and death in an area several hundred feet from the boiler.

5.12.3 Testing the Automatic Fuel Shutoff Valves Closure Time After a Main Flame Failure

The automatic fuel shutoff valve closure time can be tested at the same time the flame scanner is tested. The test is conducted with the boiler running. The fuel supply to the boiler is cut off by the manual valve located just before the burner and the time for the automatic fuel shut off valves to close is measured. A detailed step by step test procedure is given in Appendix A.

5.13 AUTOMATIC FUEL SHUTOFF VALVE CLOSURE TIME AFTER IGNITION FLAME FAILURE

5.13.1 Description

If the pilot flame fails during the ignition period, the flame scanner should sense a lack of flame and, through the burner management control system, cause the automatic fuel shutoff valves to close. It is essential that these valves close quickly to prevent large amounts of combustible fuel from entering the furnace without a flame present. If large amounts of combustible fuel were present without a flame and subsequently ignition sources were applied, a massive boiler explosion would result likely causing severe property damage and personal injury and death in an area several hundred feet from the boiler.

5.14 MINIMUM PILOT FLAME TEST

5.14.1 Description

The startup sequence begins with an electronic spark that is used to ignite the gas pilot. The gas pilot in turn is used to start the main flame. The pilot flame is crucial to smooth ignition of the main flame. The length of the pilot flame is crucial to reliable ignition. The pilot flame needs to be of a length such that it will ignite the main flame very quickly to prevent the buildup of combustible fuel in the furnace. The pilot flame length increases with gas pressure supplied to it. The minimum possible gas pressure supplied to the pilot is guaranteed by the set point on the low gas pressure cutoff switch in the pilot fuel train. This set point should be about 80% of the regulated pilot gas pressure. The shortest pilot flame that will reliably ignite the main flame occurs at this minimum pilot gas pressure. Hence, a test to determine if the pilot length is adequate should be done at this minimum pilot gas pressure.

A complication exists in many situations for the backup fuel source for the pilot. Many systems normally use natural gas for the pilot fuel with propane or propane-air mixtures as the back up fuel. Natural gas and propane-air mixes should exhibit about the same burning characteristics. Propane has more energy per unit volume than natural gas and hence will have a different flame shape. If the situation being tested may involve both natural gas and propane as the pilot fuels, testing should be done to prove that the pilot flame is acceptable with either fuel. This test will also verify that the pilot can be successfully operated on either fuel.

5.14.2 Consequences of Inadequate Pilot Flame

Accidents commonly occur when boiler operators make multiple unsuccessful tries to ignite the fuel. Typically, these accidents involve introducing significant amounts of fuel into the boiler in several attempts to fire the main burner. If purging is not adequate, a point can easily be reached in which an explosive mixture of fuel is ignited. The massive explosion that often results usually causes severe property damage and personal injury and death in an area several hundred feet from the boiler. Even in the case of one try for main flame ignition, it must be remembered that if the igniter duration is too long, failure to quickly ignite the flame because of inadequate pilot flame length can cause a devastating explosion.

5.14.3 Testing for minimum pilot flame

The test involves setting the pilot gas pressure to a level just above the set point pressure on the low pilot gas cutoff switch. Then trials are made to see if the pilot can smoothly light both gas and oil. A detailed step by step procedure is given in Appendix A.

5.15 CONTROL AIR PRESSURE INTERLOCK

5.15.1 Description

Some older control systems use compressed air to operate various boiler controls. If air pressure is lost, the ability to regulate air and fuel flow into the boiler, feedwater flow, etc is lost. A control air pressure interlock switch that continuously measures air pressure in the air supply lines to the boiler controls is required. If the air pressure drops below a level necessary to operate the controls, the switch will trip and not allow the boiler to start, or if the boiler is running, will shut the boiler down. The person testing this switch should know the required air pressure specified by the control manufacturer and should adjust the setpoint pressure on the interlock to 120% of the minimum allowed pressure. An alarm to indicate problems at a pressure higher than the interlock setpoint is desirable.

5.15.2 Consequences of Failed Control Air Pressure Interlock Switch

Low control air pressure could easily result in a situation in which the air/fuel ratio moves into a situation where a furnace explosion could occur or dangerous levels of carbon monoxide is generated.

The explosion and toxic fumes that can be generated in this way could easily damage property and injure/kill people within hundreds of feet from the boiler. Also if the feedwater control valve is pneumatically operated, low control air pressure could result in the boiler running out of water with the problems described in section 2.1.2

5.15.3 Testing the Control Air Pressure Interlock

The test can be done with the boiler off. The control air pressure supplied to the switch can be reduced to just below the set point. At this condition the boiler should not start. A detailed step by step procedure is given in Appendix A.

5.16 FLUE GAS RE-CIRCULATION DAMPER SET FOR PRE-PURGE

5.16.1 Description

Some newer boilers are fitted with flue gas re-circulation in order to decrease NO_x levels produced in the combustion process. This system consists of a duct connected to the stack that re-circulates some flue gas into the incoming combustion air stream. There is a damper in this duct to control the amount of flue gas that is re-circulated. On the pre-purge cycle, it is necessary to insure that all combustible gases are purged from the re-circulation duct. Hence it is necessary to insure that the damper be in the wide-open position during purge. The flue gas re-circulation damper switch is used to show that the re-circulation damper is wide open for purge. This switch is of the proximity type. It is located such that the movement of the linkages moving the damper close the switch when the damper is in the wide-open position. The safest system would be a position switch actuated by the damper itself rather than at some point nearer the drive motor operating the damper.

5.16.2 Consequences of a Closed Flue Gas Recirculation Damper During Purge

If the pre-purge cycle does not eliminate all combustible gases from the system before the ignition sequence, a massive explosion could occur causing serious property damage, injury, and death within several hundred feet of the boiler.

5.16.3 Testing the Re-circulation Damper Interlock Switch

The re-circulation damper interlock switch should be tested during the boiler startup sequence. There are basically three things that should be tested:

- Is the switch the right type and located correctly?
- Is the switch "activated" at any position other than "wide open"?
- Does the switch with the damper in a non-activated position prevent the boiler from beginning the purge count

A detailed step by step procedure for testing the recirculation damper interlock switch is given in Appendix A.

5.17 LOW FLUE GAS OXYGEN LEVEL INTERLOCK

5.17.1 Description

The V.A. requires that all boilers have a low flue gas oxygen level alarm and interlock, which protects against firing with a "rich" fuel/air mixture. This system consists of using a zirconium oxide sensor in the stack to continuously measure oxygen. This signal is used to provide an alarm and interlock if the oxygen level falls below a setpoint. The setpoint should be as low as possible without the possibility of excessive CO and combustibles being present in the exhaust gas from the boiler. This interlock is electronically integrated into the burner management system for the boiler.

5.17.2 Consequences of a Failed Low Oxygen Alarm and Interlock

Insufficient combustion air results in flue gas with low oxygen and high combustibles which represent two very significant safety hazards. First, carbon monoxide will be a significant portion of the combustibles and can be fatal if breathed by humans at a sufficient level. Second, these combustible gases can produce a violent explosion if air is introduced. The explosion and toxic fumes that can be generated in this way could easily damage property and injure/kill people within hundreds of feet from the boiler.

5.17.3 Testing a Low Oxygen Alarm and Interlock

To properly test the alarm or cutoff it is necessary to know three things:

- Does the zirconium oxide sensor read the correct value?
- Has the trip point of the low oxygen interlock been set at the oxygen level at which the combustion is safe?
- Does the alarm interlock work? (i.e. provides an alarm and shuts the boiler down if levels below setpoint exist).

A detailed step by step procedure for the required test is given in Appendix A.

5.18 INTERLOCK OF OUTSIDE AIR DAMPER WITH BURNER MANAGEMENT SYSTEM

5.18.1 Description

Air for combustion must be available from the outside atmosphere (outside air) in the amount necessary to burn the fuel. Natural gas and oil require about 15 lb of air to burn 1 lb of fuel. The safety issue in this situation involves a scenario in which the outside air openings are closed to the point that insufficient air is supplied to the boiler. Boiler rooms can be placed into two distinct categories in terms of outside air supply. One type boiler room has so many leaks, open windows/vents/doors that there is no chance of starving the boiler for outside air. A second type boiler room is one in which normally there are a lot of openings to the outside but the possibility exists that these openings could be closed to a point where the boiler would be starved for air.

In the first type boiler room there is no need for an interlock because it is not possible to starve the boiler for air. In the second type boiler room there is generally no control to prevent the boiler from operating even though a potential danger exists. In this case, consideration of some method to prevent operation of the boiler with insufficient outside air should be given. Since generally there are several openings that must be closed to produce insufficient combustion air, no one position switch mounted at one of these openings will suffice to prevent the problem for all boilers. In some cases each boiler is provided combustion air through adjustable louvers with an interlock switch that prevents that boiler from being operated with the air intake louver closed. A cheaper solution is to permanently install sufficient area to provide the necessary outside air for all boilers by either welding or locking windows open or replacing windows with fixed air intake louvers.

5.18.2 Consequences of Inadequate Outside Air

This situation will cause high levels of combustibles in the boiler. High combustibles represent two very significant safety hazards. First, carbon monoxide will be a significant portion of the combustibles and can be fatal if breathed by humans at a sufficient level. Second, these combustible gases can produce a violent explosion if air is introduced. The explosion and toxic fumes that can be generated in this way could easily damage property and injure/kill people within hundreds of feet from the boiler.

5.18.3 Testing the Outside Air Damper Switch

Basically, the test involves determining whether sufficient outside air openings are guaranteed and sufficiently sized. If an outside air damper switch is used to make that guarantee, it can be simply tested by trying to start the boiler with the outside air damper closed. A detailed step by step procedure is given in Appendix A.

Appendix A STEP BY STEP TEST PROCEDURES

Appendix A.1 INTRODUCTION

This appendix presents step by step test procedures for each safety device. The appendix provides forms for obtaining and recording all necessary data for each safety device being tested. It begins with tables that allow a thorough definition of the testing agency/personnel, responsible parties at the site, and boiler/burner data. This base data is followed by overarching requirements for safety testing. This information is then followed by one sheet for each device being tested to be used by the testing agency personnel as a check list and data form.

Appendix A.2 BASIC INFORMATION

VISN: ______________________________
VA Medical Center: ___________________
Contact Name: _______________________
Phone: _____________________________
Email: _____________________________
Evaluators: __________________________
Date: ______________________________

Individuals in Attendance:

Boiler and Burner Description

Boiler #	
Manufacturer:	
Model and Capacity:	
Serial #: National Board No.:	
Typical Operating Pressure:	
Design Pressure:	
Date of Manufacture:	
Boiler Controls:	
Burner	
Manufacturer:	
Type of burner:	
Fuels:	
Date of Manufacture:	

Appendix A.3 GENERAL REQUIREMENTS FOR TESTING

The following test procedures make certain assumptions that are listed below.

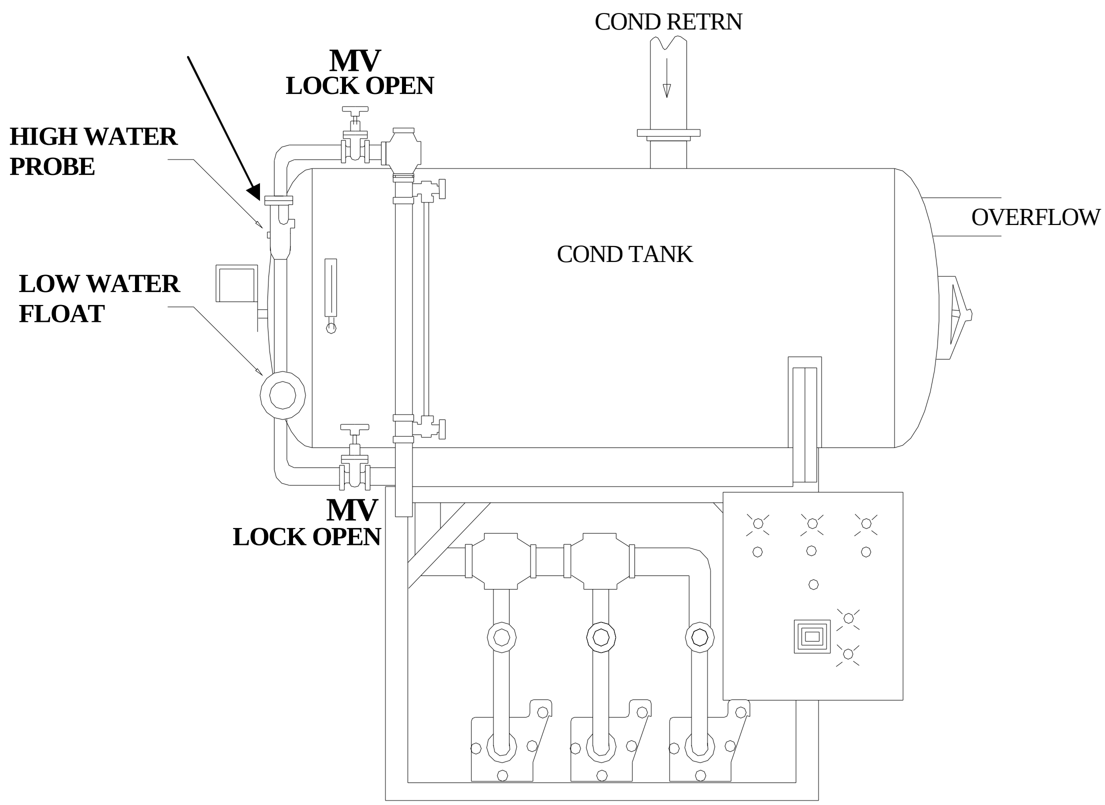
- After each test, equipment should be returned to normal operating condition and the boiler should be fired to confirm its operability.
- "Jumping" means disabling the switch electrically
- Any electric "jumper" application requires that all power to the device being "jumpered" be shut off.
- All pressure gages used in a test must be recently calibrated.
- Any valve that disables a safety device should be lockable only in the operating position.
- The setpoint is the value at which the switch indicator is set. The trip point is the actual value at which the switch activates. Some language used in the test procedures assumes that the setpoint equals the trip point.
- Potentiometers used as safeties should be evaluated to determine if they are also used as the control. This is not acceptable.

Appendix A.4 Detailed Test Procedures - Checklists

Checklist for High Water Alarm on Condensate Tank (HWACT)

Item	Make	Float / Probe	Alarm Setpoint	Correct Device Type Y / N	Correct Location Y / N
HWACT					

*Alarm setpoint should be below 2/3rds of tank height & at least 4" below the overflow.
*Alarm type should be a probe sensor.



- Drain sight glass without draining alarm column and quickly close drain valve. Water level should quickly rise in sight glass indicating good communication with tank.
- Use bypass valve to add water to the condensate tank at a rate not to exceed 1 inch per minute. Use water level sight glass to observe point that alarm sounds. DO NOT ALLOW WATER LEVEL TO LEAVE SIGHT GLASS.
- Put maximum water supply to condensate tank and verify overflow is adequate.

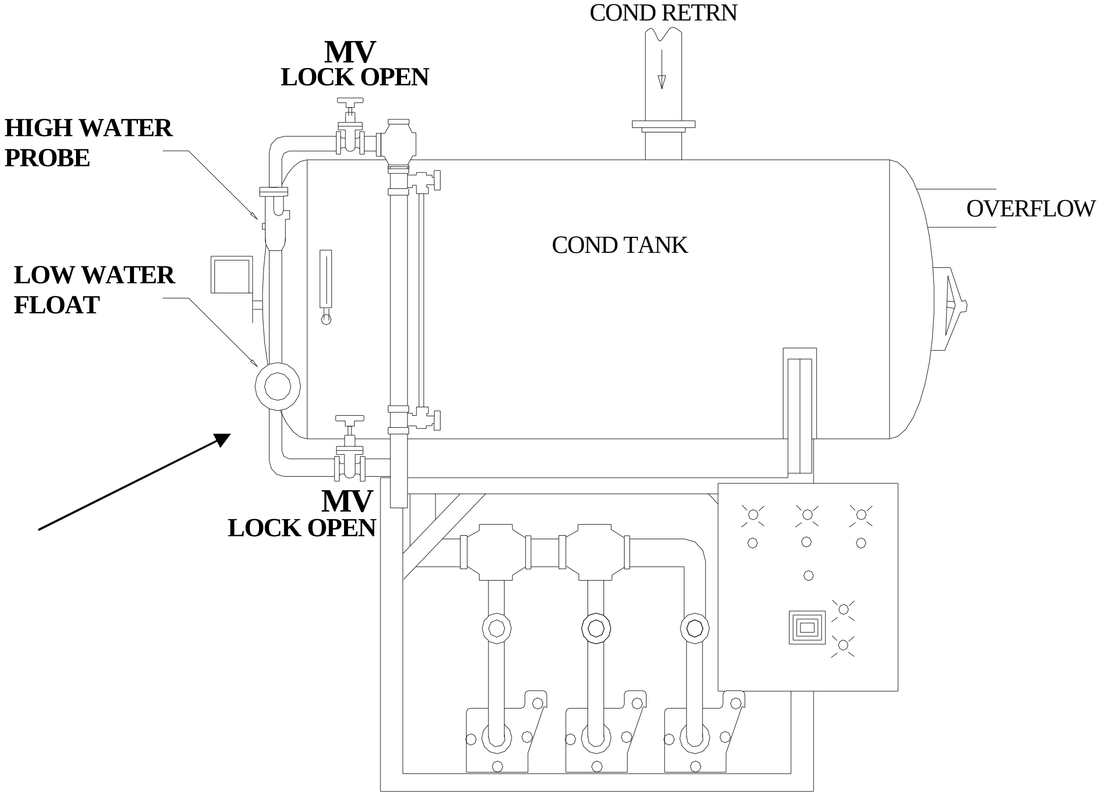
Result	Y/N	Water Level
Did the alarm work correctly?		
What was the water level in sight glass at alarm point?		
Is overflow adequate?		
Can the switch be isolated with manual valves		

Comment:

Checklist for Low Water Alarm on Condensate Tank (LWACT)

Item	Make	Float / Probe	Alarm Setpoint	Correct Device Type Y / N	Correct Location Y / N
LWACT					

*Alarm set point should be above 1/3rd of tank height?



- Drain sight glass without draining alarm column and quickly close drain valve. Water level should quickly rise in sight glass indicating good communication with tank.
- Drain the water from the condensate tank at a rate not to exceeded 1 inch per minute. Use water level sight glass to observe alarm point. DO NOT ALLOW WATER LEVEL TO LEAVE SIGHT GLASS

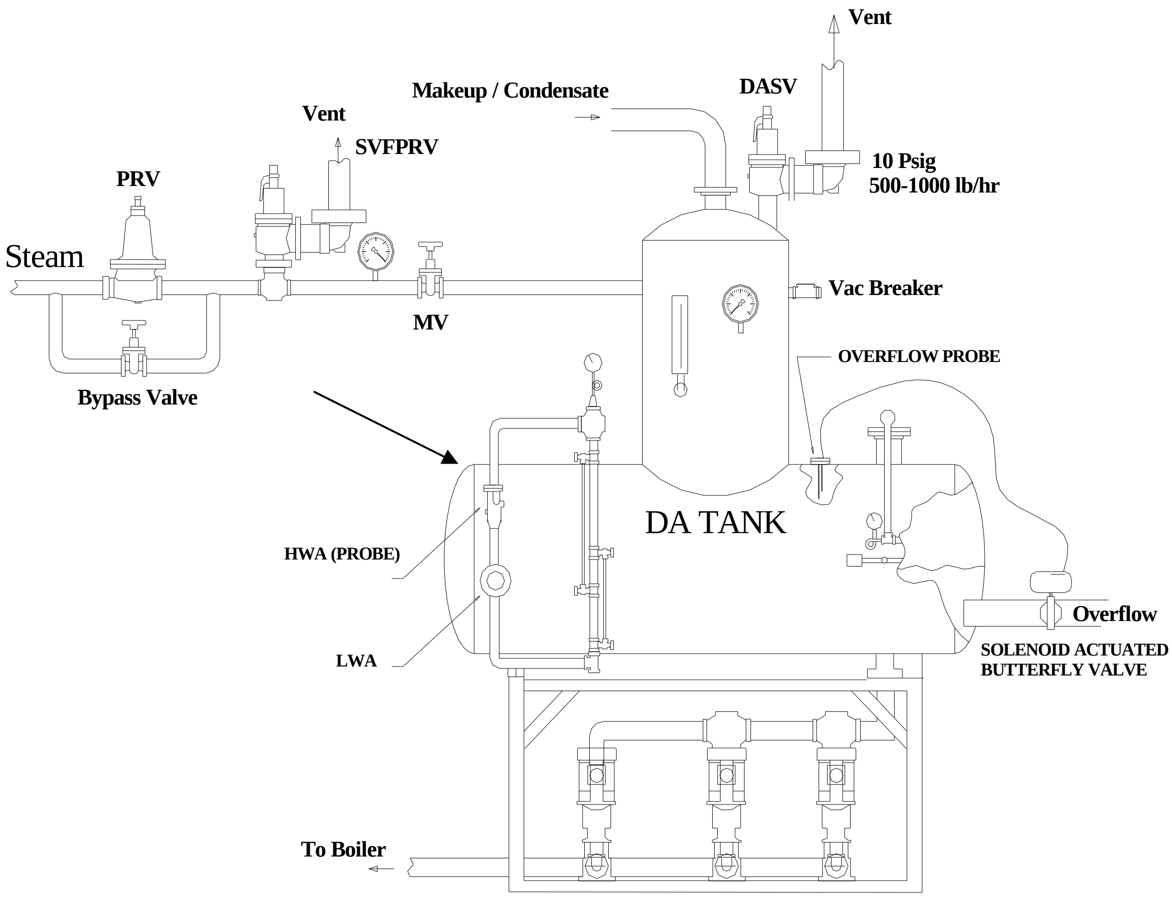
Result	Y/N	Water Level
Did the alarm work correctly?		
What was the water level in sight glass at alarm point?		
Can the switch be isolated with manual valves		

Comment:

Checklist for High Water Alarm on Deaerator Tank (HWADT)

Item	Make	Float / Probe	Alarm Setpoint	Correct Device Type Y / N	Correct Location Y / N
HWADT					

*Alarm setpoint should be below 2/3rds of tank height & at least 4" below the overflow.
*Alarm type should be a probe sensor.



- Drain sight glass without draining alarm column and quickly close drain valve. Water level should quickly rise in sight glass indicating good communication with tank.
- Use bypass valve to add water to the deaerator at a rate not to exceed 1 inch per minute. Use water level sight glass to observe point that alarm sounds. DO NOT ALLOW WATER LEVEL TO LEAVE SIGHT GLASS.

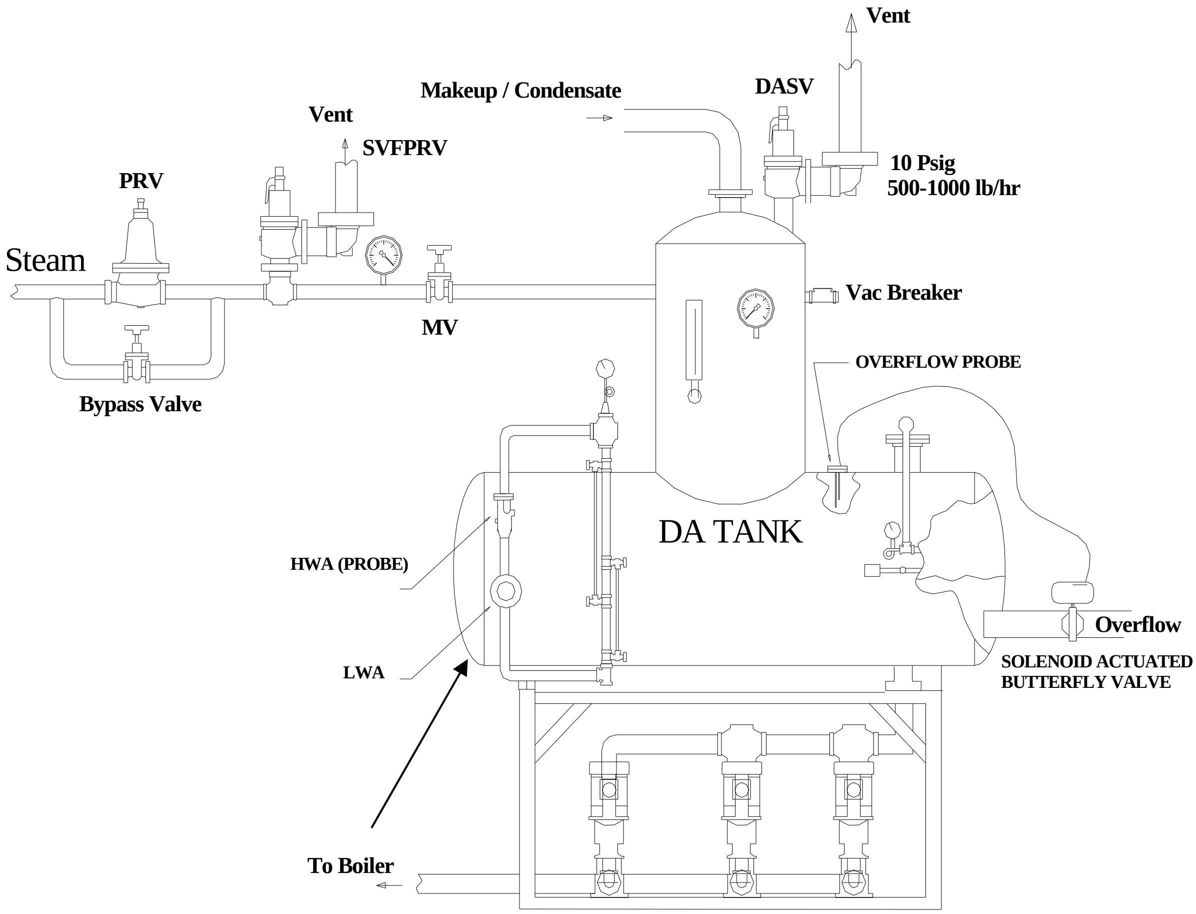
Result	Y/N	Water Level
Did the alarm work correctly?		
What was the water level in sight glass at alarm point?		
Can the switch be isolated with manual valves		

Comment:

Checklist for Low Water Alarm on Deaerator Tank (LWADT)

Item	Make	Float / Probe	Alarm Setpoint	Correct Device Type Y / N	Correct Location Y / N
LWADT					

*Alarm set point should be above 1/3rd of tank height.



- Drain the sight glass and quickly close drain valve. Water level should quickly rise in sight glass indicating good communication with tank.
- Drain the water from the deaerator at a rate not to exceed 1 inch per minute. Use water level sight glass to observe alarm point DO NOT ALLOW WATER LEVEL TO LEAVE SIGHT GLASS.

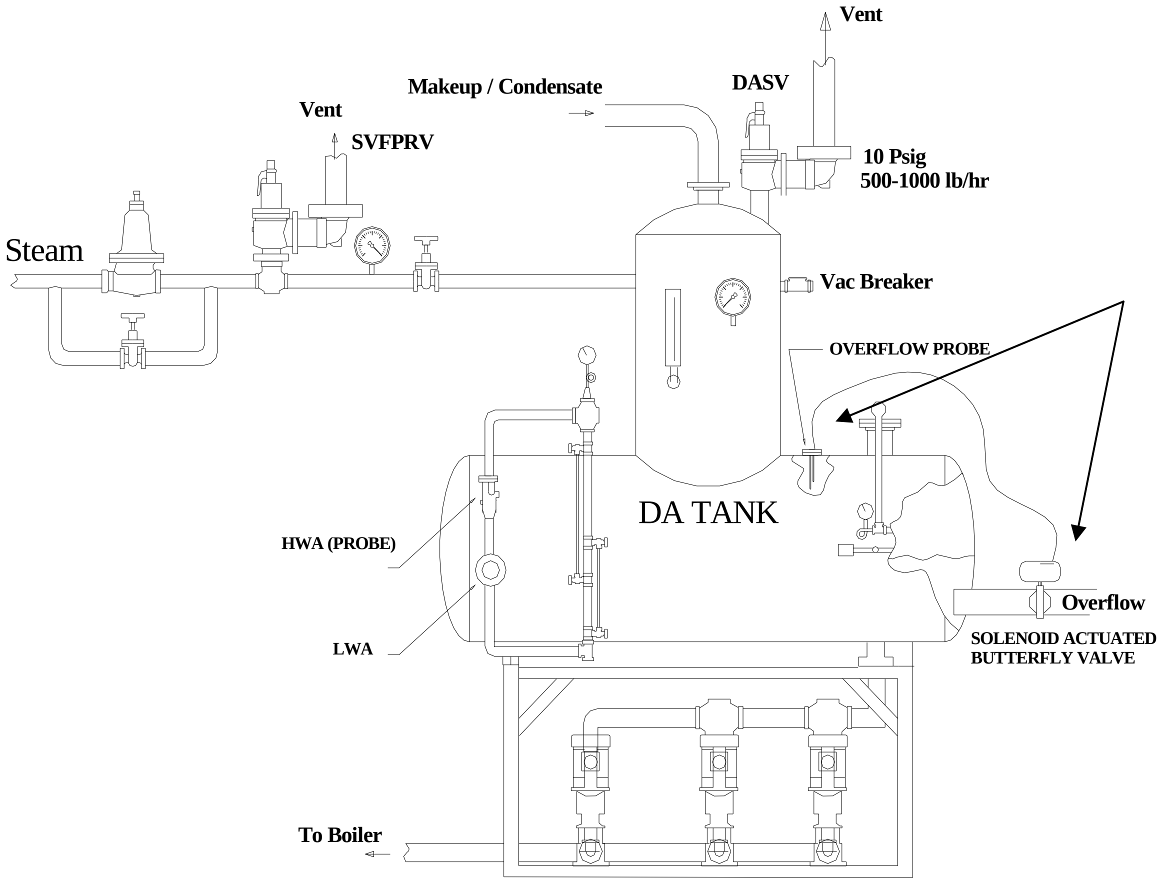
Result	Y/N	Water Level
Did the alarm work correctly?		
What was the water level in sight glass at alarm point?		
Can the switch be isolated with manual valves		

Comment:

Checklist for Deaerator Overflow Drain System (DAODS)

Item	Make	Float / Probe	Overflow Setpoint	Correct Device Type Y / N	Correct Location Y / N
DAODS					

*Overflow type should be a conductivity probe connected to electronic valve.
*Setpoint should be at least 4” below top of tank.



- Drain the sight glass and quickly close drain valve. Water level should quickly rise in sight glass indicating good communication with tank.
- Open manual bypass valve to supply feedwater at maximum rate.
- Use sight glass in drain system to determine that dump valve has opened. Use water level sight glass to observe whether dump valve maintains water level visible in sight glass. DO NOT ALLOW WATER LEVEL TO LEAVE SIGHT GLASS.

Result	Y/N	Water Level
Did the overflow valve work correctly?		
Was the water level maintained in sight glass.		
View port in place to view overflow?		

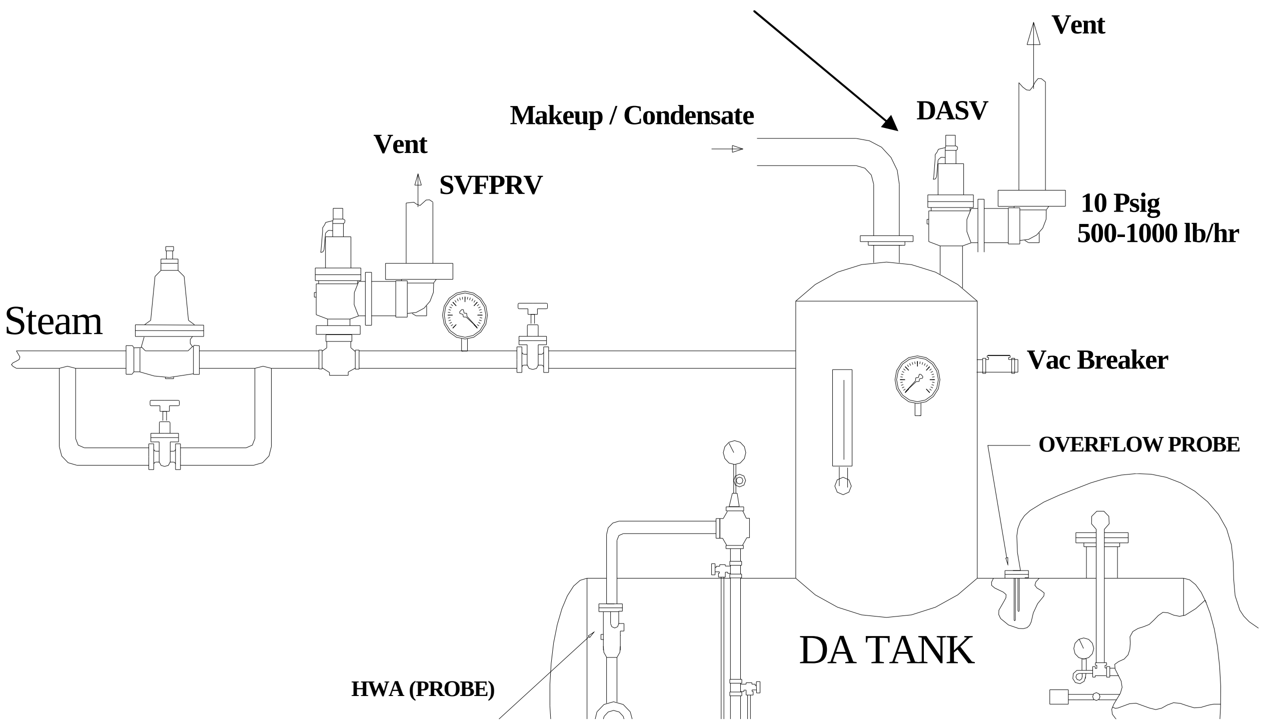
Comment:

Checklist for Deaerator Safety Valve (DASV)

Item	Make	Capacity (lb/hr)	Range	DASV Setpoint	DA PRES (psig)	Correct Installation
DASV						
Pressure Gage						

*Setpoint should be about 5 PSIG higher than DA pressure
*Capacity should be approximately (1000 lb/hr)

Item	Make	Type	MAWP	NDT (date)
Deaerator				



- Abort testing if NDT is not current within six years.
- Pour water into drip pan ell drain and confirm that it is open.
- Slowly open bypass valve to raise pressure until safety lifts. DO NOT RAISE PRESSURE MORE THAN 2 PSIG ABOVE SET POINT PRESSURE.
- Re-seat pressure should be about 6% less than lift pressure.
- After lifting valve, close bypass valve and allow safety to reseat.

Result	Y/N	Pressure
Did the safety valve work correctly?		
What was the safety valve relief pressure?		
What is the re-seat pressure?		
Is vacuum breaker present (VA requirement)?		

Comment:

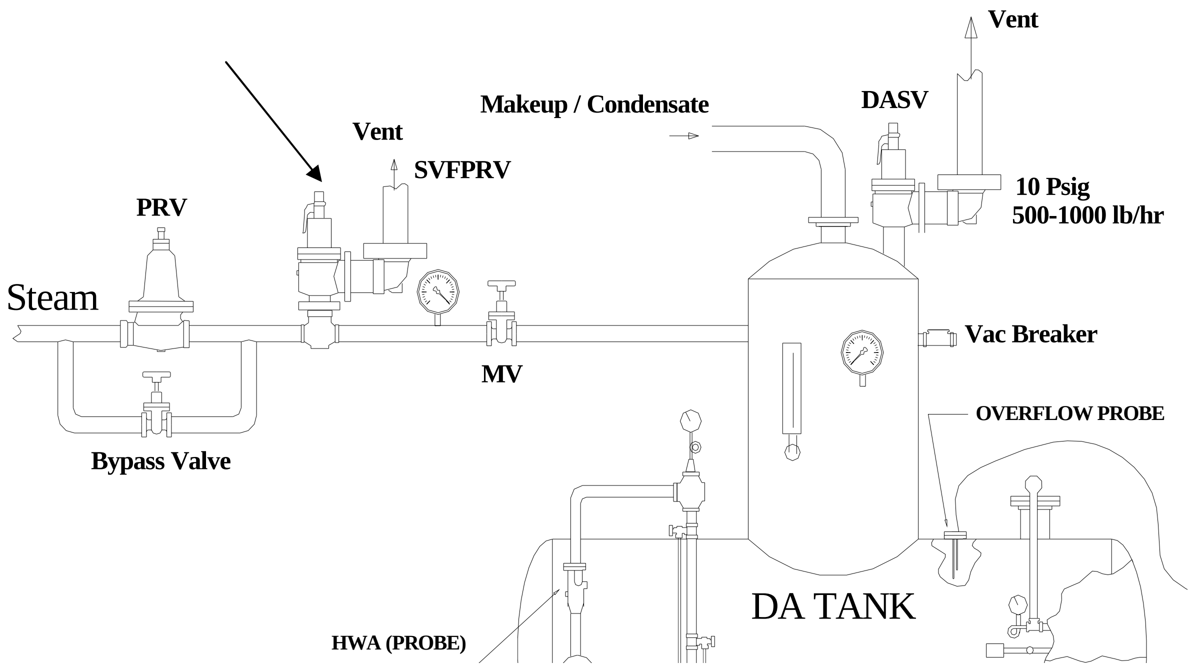
Checklist for Safety Valve Following PRV (SVFPRV) - Steam

Item	Make	Capacity (lb/hr)	Range	SVFPRV Setpoint	DA PRES (psig)	Correct Installation
SVFPRV						
Pressure Gage						

*Setpoint should be about 5 PSIG higher than DA safety lift point.

Item	Make/ Type	Size (in)	Pressure upstream	Pressure downstream	Wide Open Flow Capacity lb/hr
PRV					
Bypass					

*SVFPRV must relieve largest wide open flow capacity, PRV or bypass valve.



- Pour water into drip pan ell drain and confirm that it is open.
- Close the manual valve in steam line following the safety valve.
- Slowly open bypass valve to raise pressure until safety lifts. DO NOT RAISE PRESSURE MORE THAN 2 PSIG ABOVE SETPOINT PRESSURE.
- Re-seat pressure should be about 6% less than lift pressure.
- Open lager of the bypass valve or PRV completely and perform accumulation test. The pressure should rise no more than 6% above the setpoint pressure.
- After lifting valve, close bypass valve, open manual valve in steam line after PRV and allow safety to reseat.

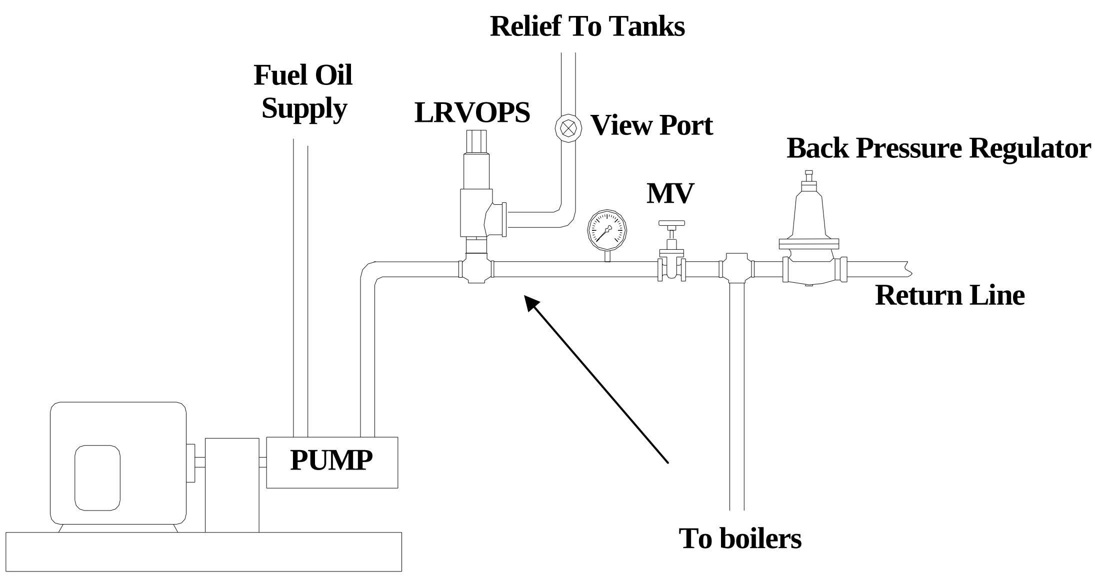
Result	Y/N	Pressure
Did the safety valve work correctly?		
What was the safety valve relief pressure?		
What is the re-seat pressure?		

Comment:

Checklist for Liquid Relief Valve on Oil Pump Set (LRVOPS)

Item	Make	Capacity (gal/hr)	Range	LRVOPS Setpoint	Oil Supply Pressure	Correct Installation
LRVOPS						
Pressure Gage						

*Setpoint should be less than the max allowable pump pressure and less than 10 psig above normal regulated oil supply pressure.
* Liquid relief should not be used as a backpressure regulator.



- Slowly close manual valve in oil line after relief valve or raise pressure regulator set pressure until relief valve lifts (use view port to determine if valve is open).
- The pressure should rise no more than 10 psig above normal regulated oil supply pressure.

Result	Y/N	Pressure
Did the relief valve work correctly?		
What was the safety valve relief pressure?		
Did valve re-seat?		
View port in place to view oil flow thru relief valve?		
Is a back pressure regulator present?		

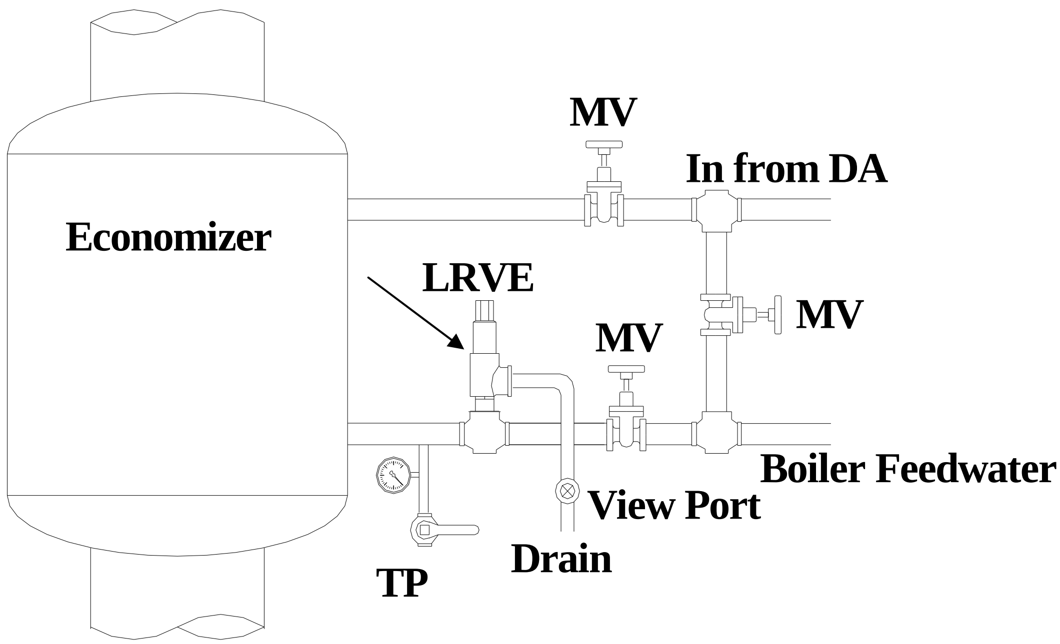
Comment:

Checklist for Liquid Relief Valve on Economizer (LRVE)

Item	Make	Capacity (gal/hr)	Range	LRVE Setpoint	Feedwater Pressure	Correct Installation
LRVE						
Pressure Gage						

*Setpoint should be less than the max allowable economizer pressure and more than maximum feedwater pressure.

Item	Make	Max Stack Temp	MAWP
Economizer			



- With boiler offline use manual valves to isolate economizer and relief valve. Use hydrostatic tester to raise pressure and open relief valve (use view port to determine when valve is open). DO NOT RAISE PRESSURE MORE THAN ALLOWABLE ECONOMIZER PRESSURE!
- An alternate method is to raise economizer pressure by operating boiler with isolation valves closed.

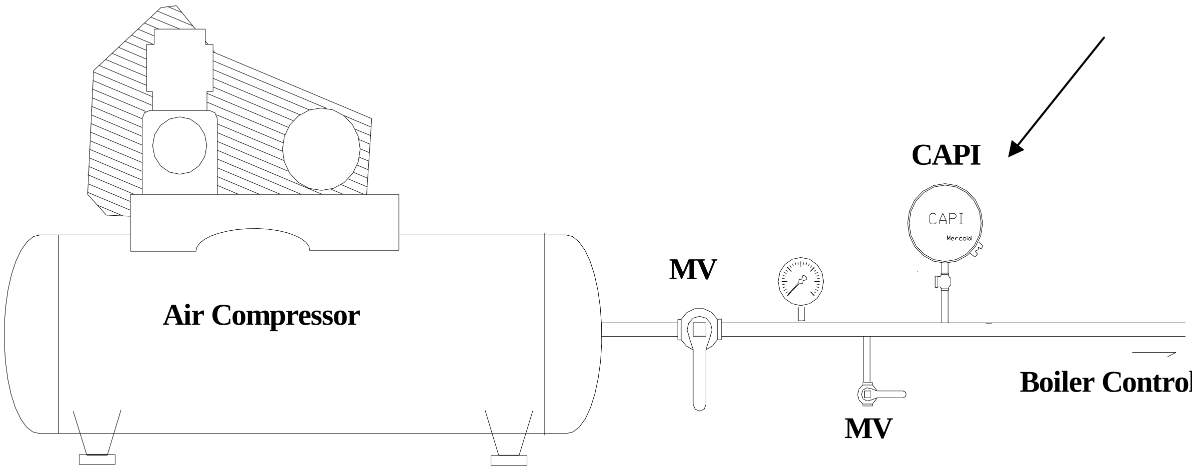
Result	Y/N	Pressure
Did the LRVE work correctly?		
What was the safety valve relief pressure?		
Maximum allowable economizer pressure?		
What is the re-seat pressure?		
View port in place to view water flow thru relief valve?		

Comment:

Checklist for Control Air Pressure Interlock (CAPI)

Item	Make	Range (psig)	Switch Setpoint	Regulated Pressure	Required Pressure	Correct Location Y/ N
CAPI						
Pressure Gage						

*Setpoint should be more than pressure required to actuate any pneumatic control device.



- Slowly close manual test valve to lower air supply pressure. Observe the pressure at which boiler shuts down. DO NOT LOWER PRESSURE BELOW REQUIRED PRESSURE TO ACTUATE ANY PNEUMATIC CONTROL DEVICE!

Result	Y/N	Trip Point
Did the CAPI work correctly?		
Is a lockable manual test valve in place as shown in figure?		
What was the interlock trip point?		
Is the setpoint higher than pressure required to actuate any pneumatic control device		

Comment:

Checklist for Propane Pilot Backup System

- Connect and/or align propane system to boiler.
- Attempt to light boiler FIRING ON FUEL OIL.

Result	**Y/N**
Is system in place and operable?	

Comment:

Checklist for Carbon Monoxide and Combustible Gas Alarms in the Boiler Plant

Item	Make	Number of Alarms	Alarm Setpoint	Test Gas Y/N	Correct Location Y / N
Combustible Alarm					
CO Alarm					

*CO setpoint should be 50 ppm or less.
*Combustible setpoints should be 10% or less of the LEL.
*Test gasses for CO and combustibles should be 225-250 ppm.
*Location and number of CO and combustible sensors determined by VA directive.

- Supply proper test in accordance with manufacturers recommendation to test alarms.

Result	Y/N
Did the combustibles alarm work correctly?	
Did the CO alarm work correctly?	
Are the number and locations of the sensors adequate?	

Comment:

Checklist for Outside Air Damper Interlock (OADI)

- If OADI exists, close outside air damper and prove that interlock shuts off boiler.
- If OADI does not exist measure fixed air intake area (fixed area required is 1.5 times the total combustion inlet air area for all boilers).

Result	Y/N	Manufacturer
Is there adequate FIXED opening to supply combustion air?		
If there is not adequate fixed opening, is there and OADI?		
If OADI exists, did it work?		

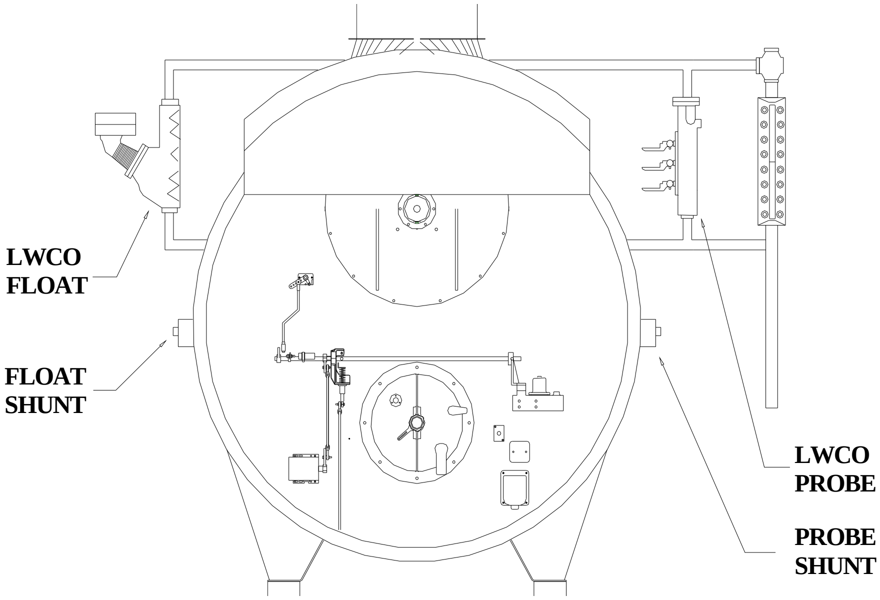
*Fixed intake area should be 1.5 times intake area for all boilers.

Comment:

Checklist for Low Water Alarm and Cutoffs on Boiler (LWA/LWCO/ALWCO)

Item	Make	Float / Probe	Correct Installation
LWA			
LWCO			
ALWCO			

*Independent shunt switches should be installed for each LWCO



- IN PERFORMING TEST NEVER LET WATER LEVEL LEAVE SIGHT GLASS!!!
- Drain sight glass without draining alarm column and quickly close drain valve. Water level should quickly rise in sight glass indicating good communication with tank.
- With boiler in manual at low fire, close the feedwater valve to generate a slow drain. You may "crack" the blowdown valve but do not exceed a drain rate of 1 inch per minute. Use water level in sight glass to observe alarm point. The alarm should sound first.
- Continue to drain until the primary cutoff activates.
- If shunt exists verify that it **ONLY** isolates the LWCO.
- Jumper or shunt the primary cutoff, restart the boiler, and set up drain as described above.
- Continue the drain until the secondary cutoff activates.

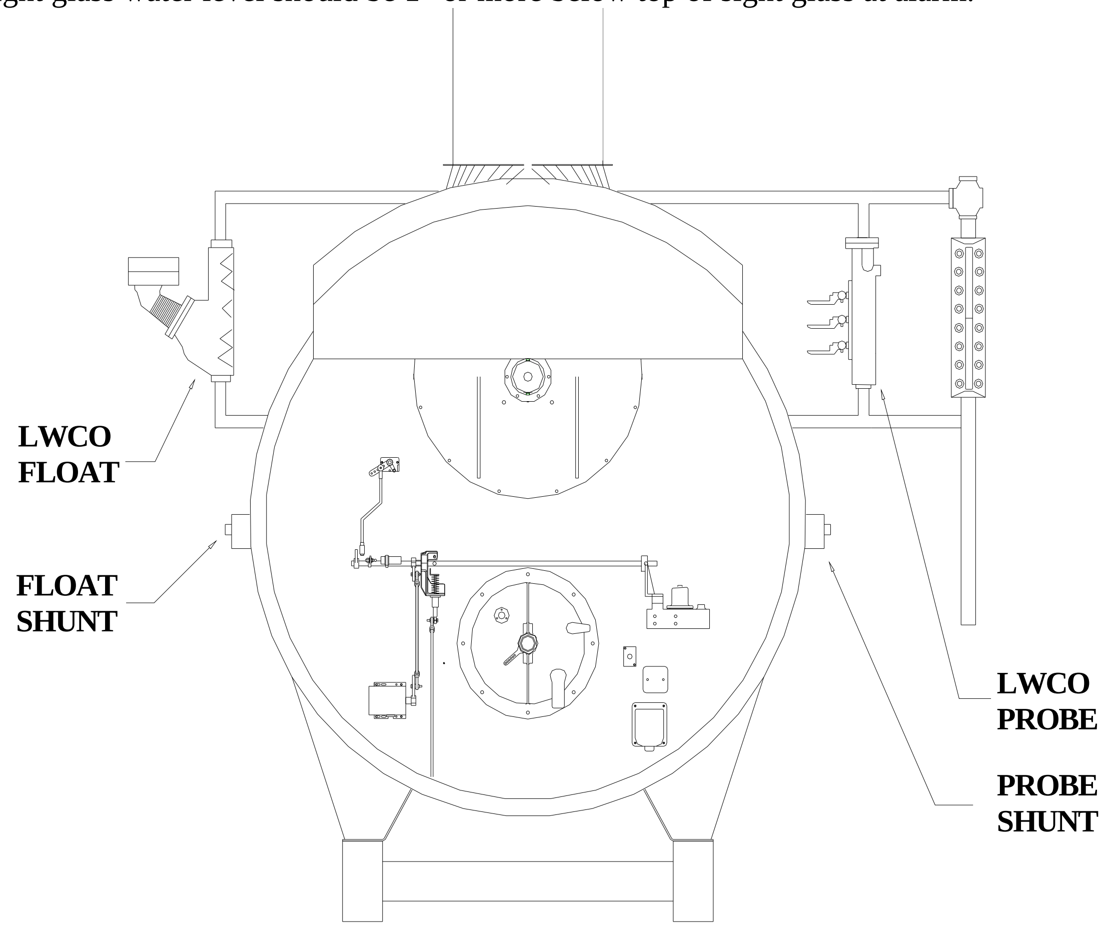
Result	Y/N	Water Level
Did the LWA work correctly? Record Level.		
Did the Primary cutoff work correctly? Record Level.		
Did the secondary cutoff work correctly?		
Was the alarm point above the primary and secondary cutoff point?		
Overall, did alarm and 2 low water cutoffs work correctly?		

Comment:

Checklist for High Water Alarm on Boiler (HWAB)

Item	Make	Float / Probe	Correct Installation
HWA			

*Sight glass water level should be 1" or more below top of sight glass at alarm.



- Drain sight glass without draining alarm column and quickly close drain valve. Water level should quickly rise in sight glass indicating good communication with tank.
- With boiler off, open the bypass feedwater valve to fill the boiler. Use water level in sight glass to observe alarm point. The alarm should sound before water level leaves sight glass. DO NOT ALLOW WATER LEVEL TO LEAVE SIGHT GLASS
- Close the bypass on feedwater line

Result	Y/N	Water Level
Did the alarm work correctly?		
What was the water level in sight glass at alarm point?		

Comment:

Checklist for Recycle and Non-Recycle Boiler Steam Pressure Limit Switches (RBSPLS & NRBSPLS)

Item	Make	Range (psig)	Switch Setpoint	Normal Steam Pressure (psig)	Lowest SVB Setpoint (psig)	Correct Setpoint Y / N
RBSPLS						
NRBSPLS						
Pressure Gage						

*RBSPLS setpoint should be 10 psig or more of normal steam pressure.
*NRBSPLS setpoint should be 5 psig or more of the RBSPLS setpoint & 5 psig or more less than the lowest SVB setpoint.

- Never exceed the boiler MAWP during this test.
- Place boiler in minimum fire and manually close the steam supply valves from the boiler.
- Raise the steam pressure slowly by firing the boiler.
- Raise until RBSPLS activates – record activation pressure in table below.
- Jumper the recycle switch out of the circuit.
- Fire boiler and raise the steam pressure slowly.
- Raise until NRSBPLS activates – record activation pressure in table below .

Result	Y/N	Pressure
Did the RBSPLS work correctly? Record Pressure.		
Did the NRSBPLS work properly? Record Pressure.		

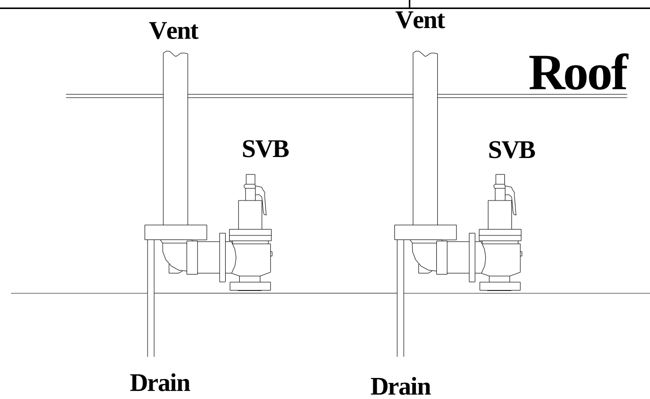
Comment:

Checklist for Steam Safety Valves on Boiler (SVB)

Item	Make	Capacity (Lb/hr)	Range	SVB Setpoint	Normal Steam Pressure	Correct Installation / Capacity
SVB 1						
SVB 2						
SVB 3						
Pressure Gage						

*SVB1 should be set 5 psig higher than NRBSPLS & 10 psig below boiler MAWP.
*SVB2 should be set 5 psig or higher than SVB1 & 5 psig or more below boiler MAWP.

Item	MAWP (psig)	Capacity (lb/hr)
Boiler		



- NEVER ALLOW BOILER PRESSURE TO EXCEEDE MAWP
- With boiler off, jumper recycle and non-recycle steam pressure switches.
- Close the steam supply valves from the boiler and test the drains on the safety valve drip pan ells by pouring water into them and noting that water flows freely. Unstop drains before proceeding.
- Raise the steam pressure slowly by firing the boiler at low fire.
- Note the pressure that the first & second safety valve opened. (may require increasing firing rate).
- Place boiler in high fire and determine if steam pressure rises with both SVB open.
- Shut boiler off and note the pressure that the safety valves close.

Result	Y/N	Lift (P)	Reseat (P)
Did the first SVB correctly? Record Pressure.			
Did the second SVB work correctly? Record Pressure.			
Did the third SVB work correctly? Record Pressure.			
Maximum pressure observed during accumulation test?			
Is SVB vent plumbing adequate?			

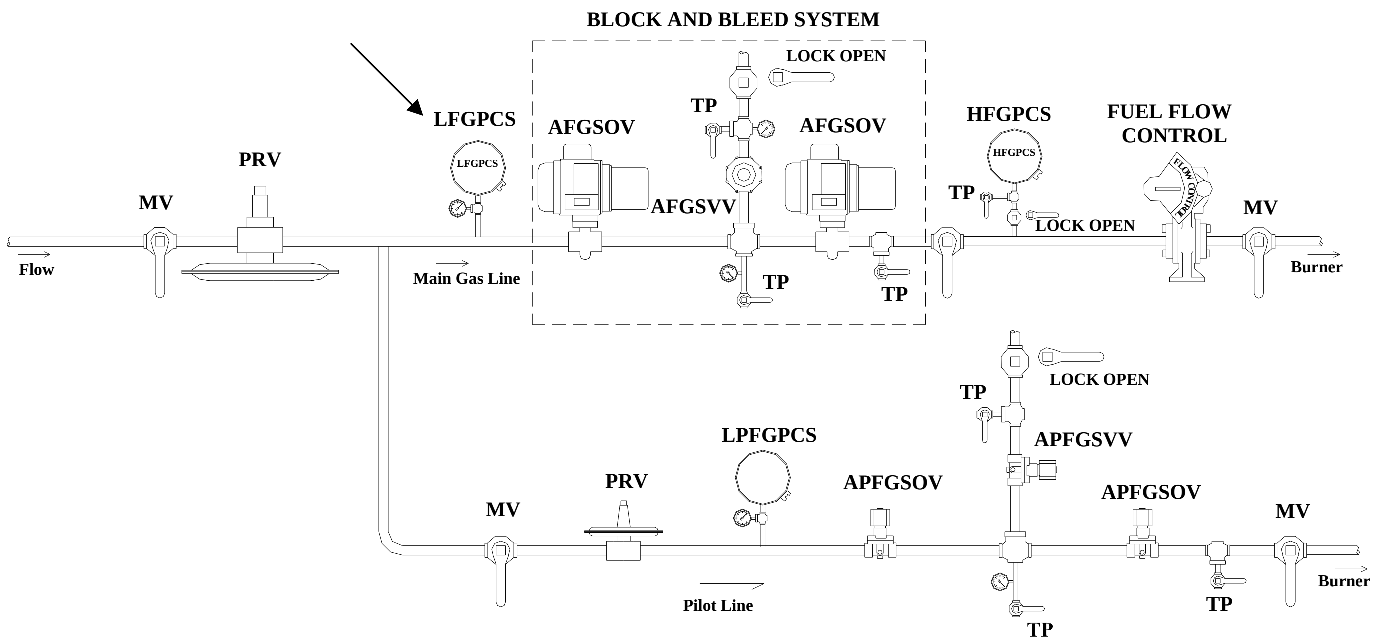
*Max lift pressure of 3% higher than rated lift pressure. Blowdown should be less than the greater of 2 psig or 2% of the set pressure, and shall not exceed 6% of set pressure.
*Maximum accumulation pressure seen should not exceed 110% of highest SVB setpoint and never exceed boiler rated pressure.

Comment:

Checklist for Low Fuel Gas Pressure Cutoff Switch (LFGPCS)

Item	Make	Range (inwc/psig)	Switch Setpoint (inwc/ psig)	Regulated Pressure (inwc/psig)	Correct Location Y / N
LFGPCS					
Pressure Gage					

*LFGPCS must be downstream of PRV and upstream of AFGSOV with a setpoint of 80% or higher than regulated pressure.



In low fire, throttle upstream fuel valve slowly until switch trips the boiler offline due to low fuel pressure but NO LOWER THAN 80% OF REGULATED PRESSURE

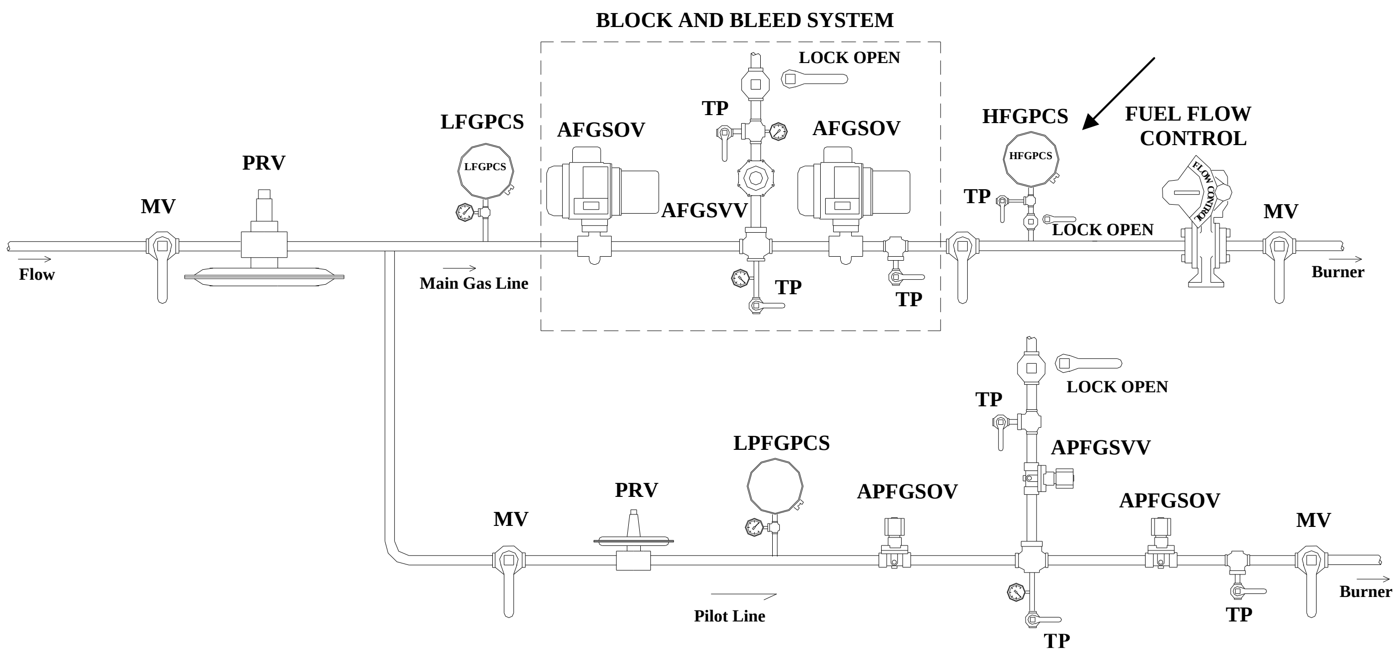
Result	Y/N	Pressure
Did the switch work correctly? Record pressure.		
Is switch trip point 80% or more of regulated pressure?		

Comment:

Checklist for High Fuel Gas Pressure Cutoff Switch (HFGPCS)

Item	Make	Range (inwc/psig)	Switch Setpoint (inwc/ psig)	Regulated Pressure (inwc/psig)	Correct Location Y / N
HFGPCS					
Pressure Gage					

*HFGPCS must be downstream of PRV and upstream of flow control with a setpoint of less than 120% of regulated pressure.



- With boiler in low fire close lockable manual valve isolating the HFGPCS.
- Open test port between lockable manual valve and HFGPCS and pressurize with compressed air or nitrogen.
- Slowly raise pressure until switch trips boiler offline due to high test gas pressure, BUT NO HIGHER THAN 120% OF REGULATED PRESSURE.

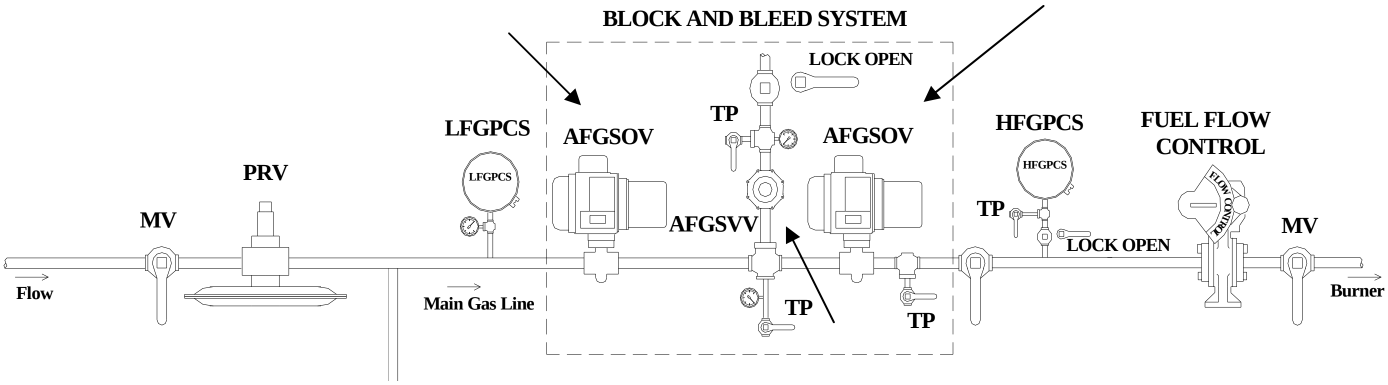
Result	Y/N	Switch Trip Point
Did the switch work correctly?		
Are manual test valves and test port valves in place as shown?		
What was the switch trip point?		
Is switch trip point 120% or less of regulated pressure?		

Comment:

Checklist for Automatic Fuel Gas Shutoff Valves and Solenoid Vent Valve Seat Leakage (AFGSOV & AFGSVV) – Main Gas Line

Item	Make	Range (inwc/psig)	Correct Installation Y/N
AFGSOV			
AFGSVV			
Pressure Gage			

*Maximum allowable leak rate is zero bubbles in 2 minutes.



- Verify all test port valves are closed and manual valve in vent line is open. Connect flexible tubing to the 3 test ports as shown.
- The test utilizes placing the flex line no more than ¼ inch in water. This test can be accelerated by pressurizing the flex line before submerging in water.
- With the boiler in low fire, close manual lockable valve in vent line and open test port valve in vent line. Verify that no bubbles appear.
- Provide regulated gas pressure (or more) before upstream AFGSOV and between AFGSOVs.
- Using the two test ports in the main gas line and the test port in the vent line, open the test port valves and observe water for sign of bubbles for 2 minutes.
- If no bubbles appear, the respective valve is not leaking.
- Open and lock manual vent valve and shut boiler off and verify that the pressure between AFGSOV is atmospheric.

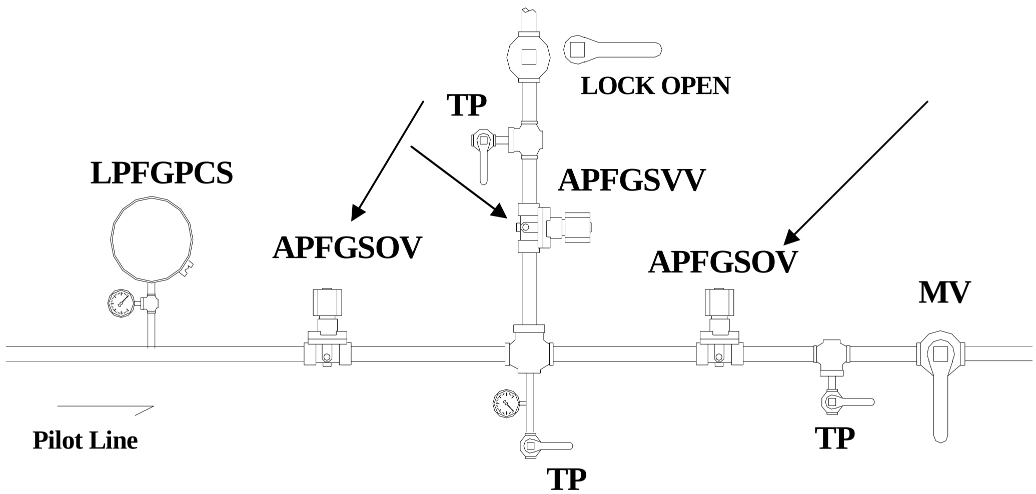
Result	Y/N
Did upstream AFGSOV leak?	
Did downstream AFGSOV leak?	
Did AFGSVV leak?	
Did AFGSVV open with boiler off	

Comment:

Checklist for Automatic Pilot Fuel Gas Shutoff Valves and Automatic Pilot Fuel Gas Solenoid Vent Valve Seat Leakage (APFGSOV & APFGSVV) – Pilot Line

Item	Make	Range (inwc/PSIG)	Correct Installation Y/N
APFGSOV			
APFGSVV			
Pressure Gage			

*Maximum allowable leak rate is zero bubbles in 2 minutes.



- Verify all test port valves are closed and manual valve in vent line is open. Connect flexible tubing to the 3 test ports as shown.
- The test utilizes placing the flex line no more than ¼ inch in water. This test can be accelerated by pressurizing the flex line before submerging in water.
- With the boiler in low fire, close manual lockable valve in vent line and open test port valve in vent line. Verify that no bubbles appear.
- Provide regulated gas pressure (or more) before upstream APFGSOV and between APFGSOVs.
- Using the two test ports in the main gas line and the test port in the vent line, open the test port valves and observe water for sign of bubbles for 2 minutes.
- If no bubbles appear, the respective valve is not leaking.
- Open and lock manual vent valve and shut boiler off and verify that the pressure between APFGSOV is atmospheric.

Result	Y/N
Did upstream APFGSOV leak?	
Did downstream APFGSOV leak?	
Did APFGSVV leak?	
Did APFGSVV open with boiler off	

Comment:

Checklist for Proof of Closure on Automatic Fuel Shutoff Valves (POC-AFGSOV) – Natural Gas

Item	Make
POC-AFGSOV	

*Switch should open with a very slight opening of the valve.
*Switches should be wired in series.

- Close manual fuel valve downstream of AFGSOV. Perform the following test on each AFGSOV separately.
- Remove cover on both automatic shut off valves to provide access to two wires connected across proof of closure switch. Can also access wires in appropriate junction box. Disconnect both leads from switch going to control circuit.
- Temporarily connect the two wires that were disconnected from the POC switch in order to electrically bypass the switch.
- Start boiler and verify that switch opens with a very slight opening of the valve by measuring resistance across switch.
- Shut boiler down and disconnect two wires going to control circuit. Try to start boiler and verify that the boiler does not allow ignition sequence to begin.
- Repeat procedure for switch on 2nd valve.

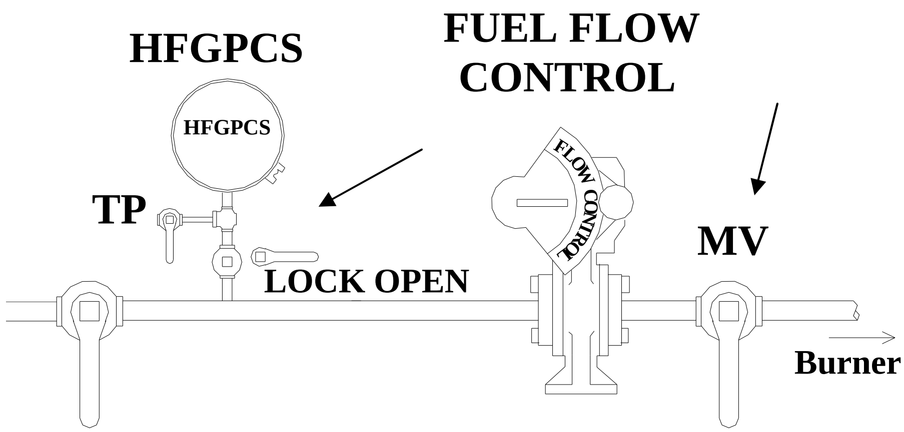
Result	Y/N
Is POC present in both valves?	
Did either valve being open allow the boiler to fire?	
Did both switches open with very slight opening of valve?	

Comment:

Checklist for Flame Scanner-for main flame out (FSMFO)

Item	Make	Model	UV or IR	Self-Checking Y/N	Correct Scanner Y/N
Flame Scanner					

*Maximum allowable timing is 4 sec.
*Only a UV– Self checking scanner is allowed. If scanner is IR, system must be replaced.



- Close the lockable manual valve between the fuel line and the HFGPCS.
- Quickly close the manual valve in fuel line before burner.
- Observe the time required for the flame scanner to close the automatic fuel safety shutoff valves. (Valves should close within 3 to 4 seconds from the time the flame goes out in the firebox).

Result	Y/N	Time (seconds)
Did the scanner work correctly?		
Time to close fuel valves?		

Comment:

Checklist for Flame Scanner Not Sensing Igniter Spark (FSNSIS)

Item	Make	Model	Rebuilt Y/N
Programmer			

*The scanner should not indicate a voltage-voltage indicates that scanner senses spark.

- Close manual valves in main fuel line and pilot gas line.
- Attempt to start boiler.
- Determine if the scanner output indicates a voltage.

Result	Y/N
Did the scanner work correctly?	

Comment:

Checklist for Igniter Timing (IT)

Item	Make	Model
Programmer		

* Maximum allowable duration is 10 sec.

- Close manual valves in main fuel line and pilot gas line.
- Start boiler.
- View igniter by means of furnace front or back view port and time the ignition spark. (You can hear the igniter click on and off so that it may not be necessary to view the spark if not easily visible).
- Observe the duration of the ignition spark with a stop watch.

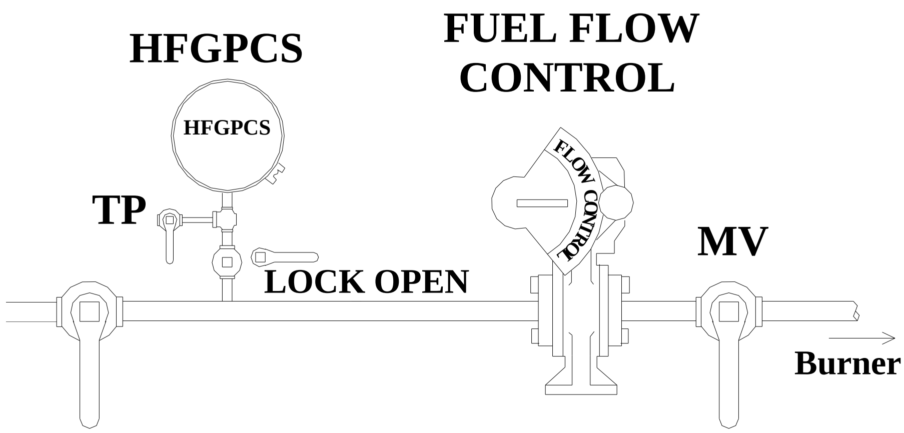
Result	Y/N	Time (seconds)
Did the scanner work correctly?		
Igniter timing?		

Comment:

Checklist for Main Flame Ignition Timing (MFIT)

Item	Make	Model
Programmer		

* Maximum timing should be 14 seconds.



- Close the lockable manual valve between the fuel line and the HFGPCS..
- Close manual valves in main fuel line.
- Attempt to start boiler.
- Time the AFGSOV from the time they begin to open until they close with a stopwatch.

Result	Y/N	Time (seconds)
Did the programmer work correctly?		
Time to AFGSOVs?		

Comment:

Checklist for Pre-Purge and Post-Purge Timing (PPT)

Item	Make	Model	Adjustable Timing Y/N
Purge Timer			

Boiler make	Fire Tube / Water tube	Boiler Fireside Volume (ft^3)

* Eight air changes are required for a water tube boiler and 4 air changes for a fire tube boiler.

- Begin firing boiler and record the pre-purge time in the table below.
- Repeat this step for post purge cycle.

Result	Time (sec)	Y/N
Low fire to high fire?		
Time in high fire?		
High fire to low fire?		
Time in post purge?		
Equivalent High Purge Time?		
Is purge adequate?		

*Equivalent purge is all time spent at high fire plus half of the time spent in getting to high fire and returning to low fire.

Comment:

Checklist for Low-Fire Proving Switch (LFPS)

Item	Make	Model
LFPS		

*Should not be made above a 5% point load increase above low fire.
*LFPS must be separate from the control system that modulates the firing rate.

- Measure the voltage across the switch during the purge cycle. (The switch should be closed at start up (no voltage) and should open with less than a 5% point increase in load).
- Disconnect one electrical lead from switch. Allow boiler to complete the purge cycle and return to low fire. Boiler should not start.

Result	Y/N	Switch Trip point
Did the switch work correctly?		
What was the switch trip point?		

Comment:

Checklist for Forced Draft Damper Wide-Open Pre-Purge Proving Switch (FDDWOPS)

Item	Make	Model
FDDWOPS		

* Must be open at positions lower than 90% of wide open (damper vanes).

- Measure the voltage across the switch during the purge cycle to determine if the switch is open or closed. Note load that switch closes.
- Disconnect one electrical lead from switch. Let boiler go through purge cycle. (Boiler should stay at high purge).

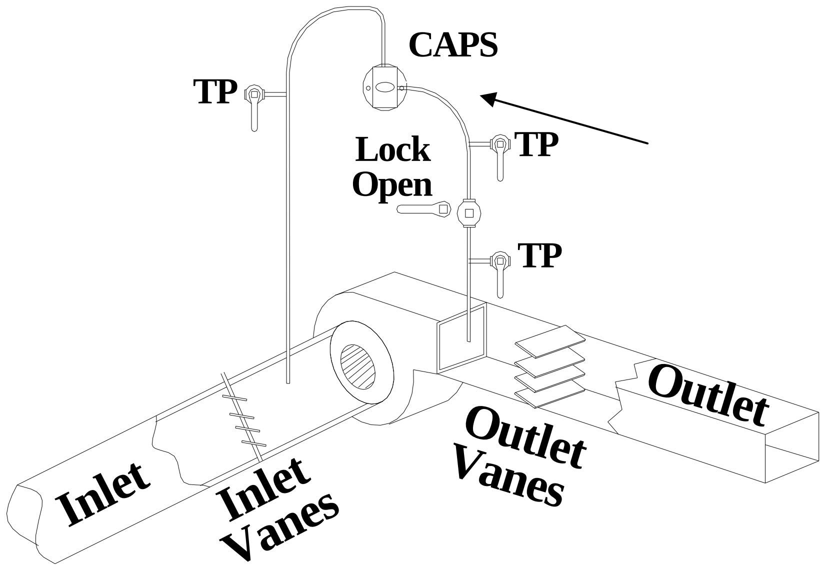
Result	Y/N	Load that switch closes.
Did the switch work correctly?		

Comment:

Checklist for Combustion Air Pressure Switch (CAPS)

Item	Make	Low Pressure Tap Location	High Pressure Tap Location	Switch Range (inwc)	Switch Setpoint (inwc)
CAPS					

*CAPS should open if pressure drops to 80% of minimum pressure difference.
* If the switch senses the correct pressure difference, the variation in pressure difference from low to high fire will vary only a few percent.



- Install appropriate flex tubing to a manometer from the test ports closest to CAPS to measure the pressure difference that the switch senses by opening the lockable test ports across the switch.
- Start the boiler and record the pressure difference read by manometer from the low fire to high fire position.
- Slowly allow the pressure to drop in the high pressure leg by using the test port closest to the fan outlet and observe the pressure at which the switch opens and shuts off boiler.
- It may be necessary to partially close the Lock Open valve to actuate the switch.
- Record value of pressure difference at which switch tripped.

Firing Rate	Pressure Difference (inwc)	Minimum Pressure Difference (inwc)	Switch Trip (Break) Point (inwc)
Low			
Med			
High			

*Switch trip point should be 80% of the minimum pressure difference.

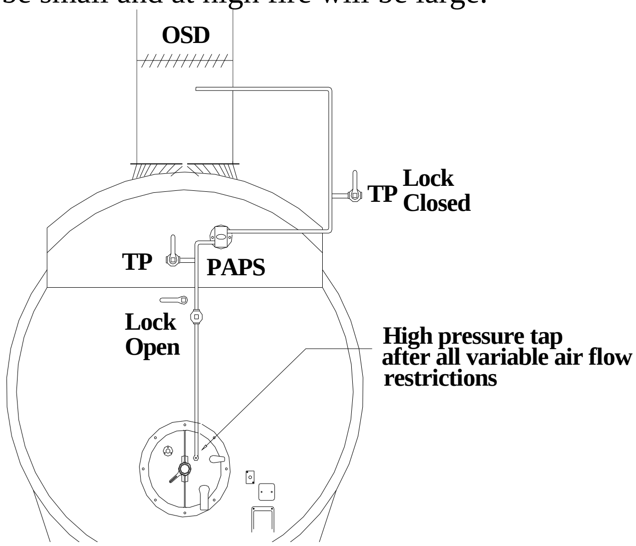
Result	Y/N	Switch Trip (Break) point (inwc)
Did the switch work correctly?		

Comment:

Checklist for Purge Airflow Proving Switch (PAPS)

Item	Make	Low Pressure Tap Location	High Pressure Tap Location	Switch Range (inwc)	Switch Setpoint (inwc)
PAPS					

*Should make at 80% maximum pressure signal.
* If the switch senses the correct pressure difference, the variation in pressure difference at low fire will be small and at high fire will be large.



- Connect a manometer to measure the pressure difference that the switch senses by opening the test ports across the switch and installing appropriate flex tubing to the manometer from the test ports.
- Start the boiler and record the pressure difference indicated by manometer from low fire to high fire positions.
- With boiler offline disconnect one lead from the PAPS.
- Close lock open valve and slowly pressurize the high pressure leg with air. Determine switch trip point using a manometer and measuring electrical resistance across the switch.
- With lock open valve open and high pressure leg test port open attempt to restart boiler. Boiler should hold in purge.
- Open lock open valve and close test port. Boiler should light.

Firing Rate	Pressure Difference	Maximum Pressure Difference (inwc)	Switch Trip (Make) Point (inwc)
Low			
Med			
High			

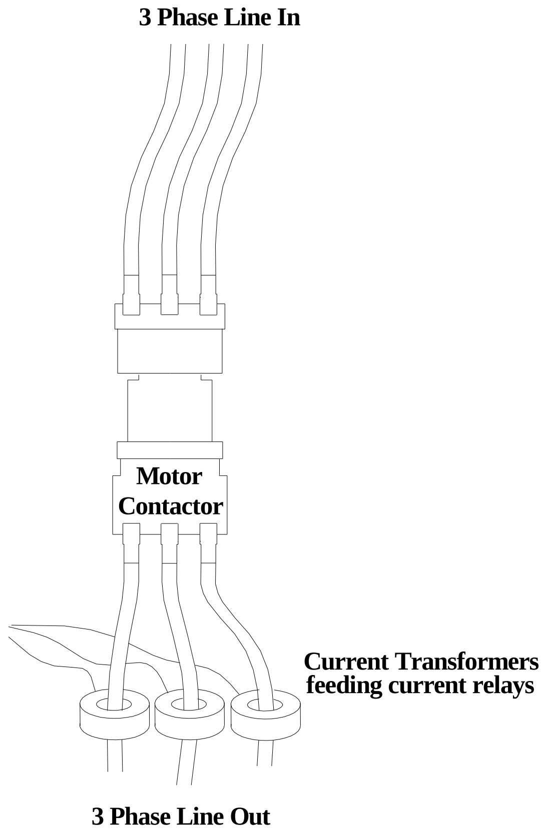
Result	Y/N	Switch Trip (Make) point (inwc)
Did the switch work correctly?		

Comment:

Checklist for Forced Draft Motor Interlock Switches (FDMIS)

Item	Make	Type of Switch: Aux. Contact Phase Monitor Current Relays
FDMIS		

*Current relays are the only acceptable FDMIS



- If current relays are not in place, abort test.
- With power to fan off, remove one electrical power lead to fan from terminal block and slip power lead out of the current transformer ring. Reconnect power lead to fan. (Note some "donut" rings are in form of a clamp and can be removed without disconnecting power lead).
- Attempt to start boiler. Boiler should shut down quickly.
- Repeat above process for each of three power leads to fan.

Result	Y/N
Did the switch work correctly?	

Comment:

Checklist for Outlet Stack Damper Interlock Switch (OSDI)

Item	Make
OSDI	

*Must be open if dampers are not at least 80% open.
*Not required if damper is welded in the wide open position and there are no other potential obstructions.

- Connect a multimeter across the switch and measure voltage.
- Start the boiler and monitor voltage across the switch. The switch should be open (no voltage) until the damper opens to wide open position.
- Stop boiler and turn off power to controls.
- Disconnect one lead from switch.
- Start boiler. The boiler should not complete purge sequence.

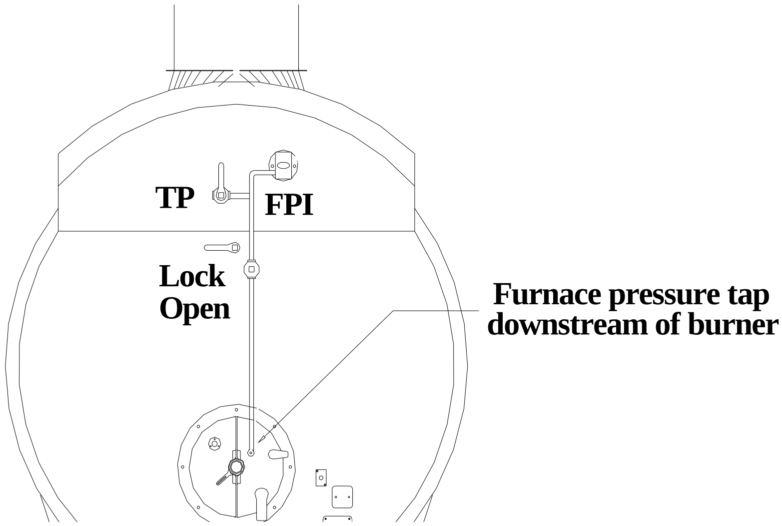
Result	Y/N
Did the switch work correctly?	

Comment:

Checklist for Furnace Pressure Interlock (FPI)

Item	Make	Low Pressure Tap Location	High Pressure Tap Location	Switch Setpoint (inwc)
FPI				

*Not required on boilers with no outlet stack damper or other possible obstructions in the flue gas outlet system.
*Required trip point is the greater of 1"wc or 20% above maximum boiler furnace pressure.



- Open the test port valve and connect a manometer using appropriate flex tubing to the high pressure test port with other side of manometer open to atmosphere.
- Start the boiler and record the pressure sensed by the switch over the entire firing rate.
- Return the boiler to low fire.
- Open the TP valve.
- Close manual lockable valve in high pressure leg.
- Connect flex tubing to TP.
- Slowly pressurize the switch.
- Note the pressure that the boiler trips off line.

Firing Rate	Pressure Difference	Maximum Pressure Difference (inwc)	Switch Trip Point (inwc)
High			
Mid			
Low			

* The boiler should trip off line at less than 120% of furnace pressure at high fire.

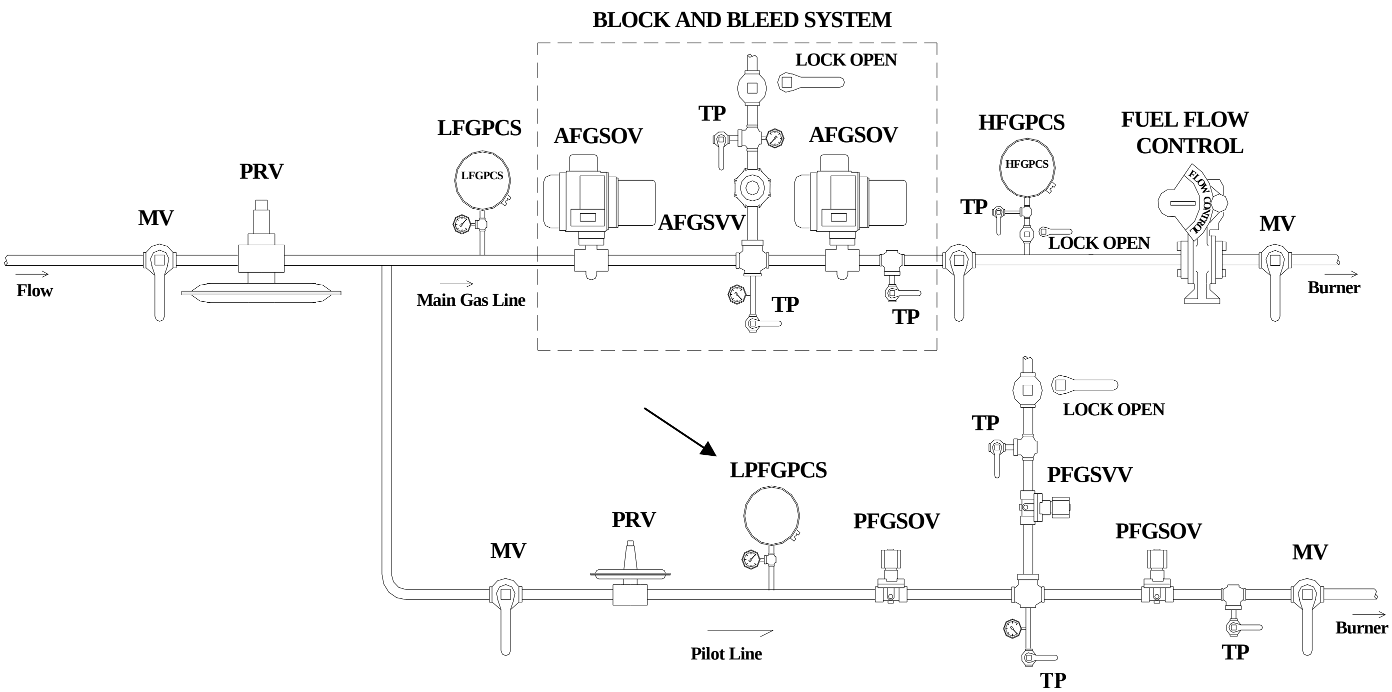
Result	Y/N	Switch Trip point
Did the switch work correctly?		

Comment:

Checklist for Low Pilot Fuel Gas Pressure Cutoff Switch (LPFGPCS)

Item	Make	Range (inwc/psig)	Switch Setpoint	Regulated Pressure	Correct Location Y/N
LPFGPCS					
Pressure Gage					

*Switch setpoint should be 80% of regulated pressure.



- Close the main fuel valve and allow the pilot burner to light and place programmer in check mode while holding in the pilot cycle.
- In low fire throttle manual valve upstream of the LPFGPCS slowly until switch trips the boiler offline due to low pilot fuel pressure.
- Open the pilot gas valve and again put boiler in check mode with pilot lit. Slowly close the pilot gas valve and regulate the pilot gas pressure to a value just above the trip point.
- Open the main gas valve, place the programmer in the “run” mode, and carefully observe that the main burner ignites immediately and smoothly.
- Be prepared to stop the burner immediately if this does not occur.

Result	Y/N	Switch Trip point
Did the boiler light smoothly with low pilot gas pressure?		

Comment:

Checklist for Flue Gas Recirculation Damper Interlock (FGRDI)

Item	Make
FGRDI	

*Open switch should prevent completion of the pre purge cycle.
*Dampers should be at least 80% open to close the switch.

- Connect a multimeter across the switch and measure voltage.
- Start the boiler and monitor voltage across the switch. The switch should be open (no voltage) until the damper opens to wide open position.
- Stop boiler and turn off power to controls
- Disconnect one lead from switch
- Start boiler. The boiler should not complete the purge sequence.

Result	Y/N	Switch Trip Point
Did the switch work correctly?		

Comment:

Checklist for Low Flue Gas Oxygen Level Interlock (LFGOLI)

Item	Make	Alarm or Interlock
LFGOLI		

*Low oxygen alarm only is inadequate and should be replaced with interlock and alarm.
*Interlock should prevent boiler from operating with more than 200 ppm CO or combustibles in the flue gass.

- Measure the property values listed in the table below.

% Load	Steam P (psig)	O_2(%)	CO (ppm)	EFF (%)	T-Stack	NOx	Economizer Temp IN	OUT
Low								
Med								
High								

- Use an flue gas analyzer to measure % O_2 and CO with the boiler at approximately 30% load.
- Slowly block the boiler air intake or increase fuel without increasing air. USE EXTREME CARE NOT TO CREATE A DANGEROUS CONDITION. NEVER ALLOW THE CO CONTENT OF FLUE GAS TO EXCEED 200 PPM!

Item	O_2% where interlock activated	CO (ppm) where interlock activates
LFGOLI		

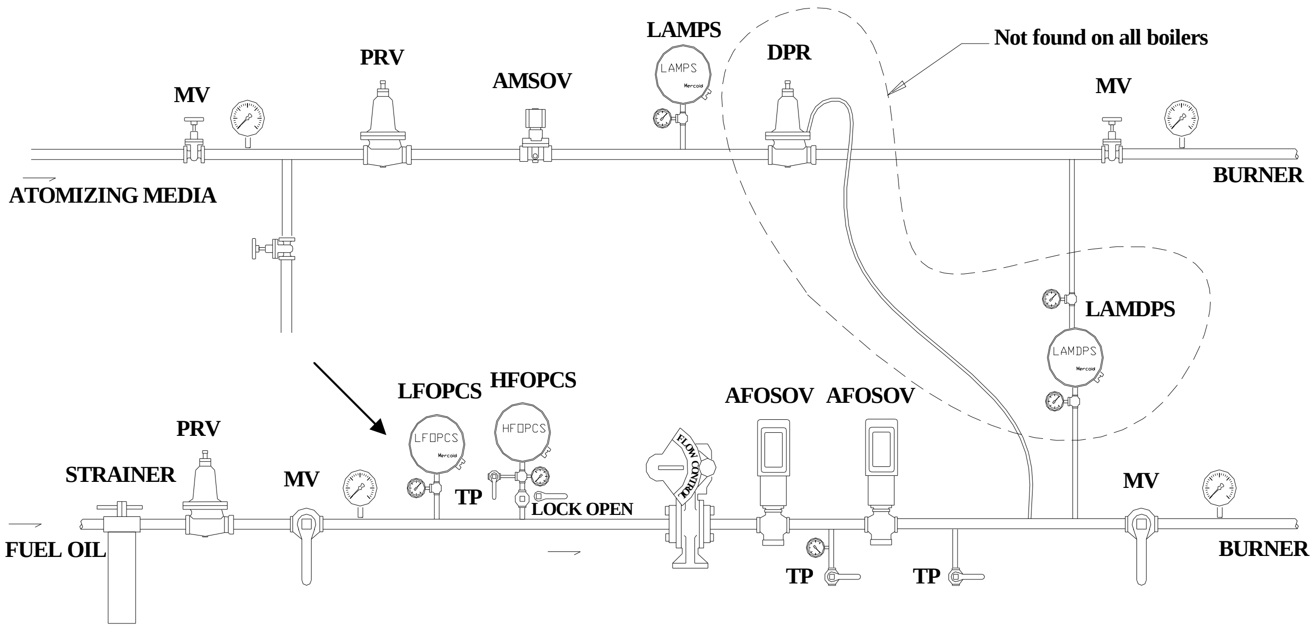
Result	Y/N
Did the interlock work correctly?	
Did the LFGOLI activate with less than 200 ppm of CO?	

Comment:

Checklist for Low Fuel Oil Pressure Cutoff Switch (LFOPCS)

Item	Make	Range (inwc/psig)	Switch Setpoint	Regulated Pressure	Correct Location Y/N
LFOPCS					
Pressure Gage					

*The LFOPCS location must be downstream of PRV and upstream of flow control valve.
*Trip point of LFOPCS should be equal to or greater than 90% of regulated pressure.



- In low fire, throttle upstream fuel valve slowly until switch trips the boiler offline due to low fuel pressure but NO LOWER THAN 80% OF REGULATED PRESSURE.

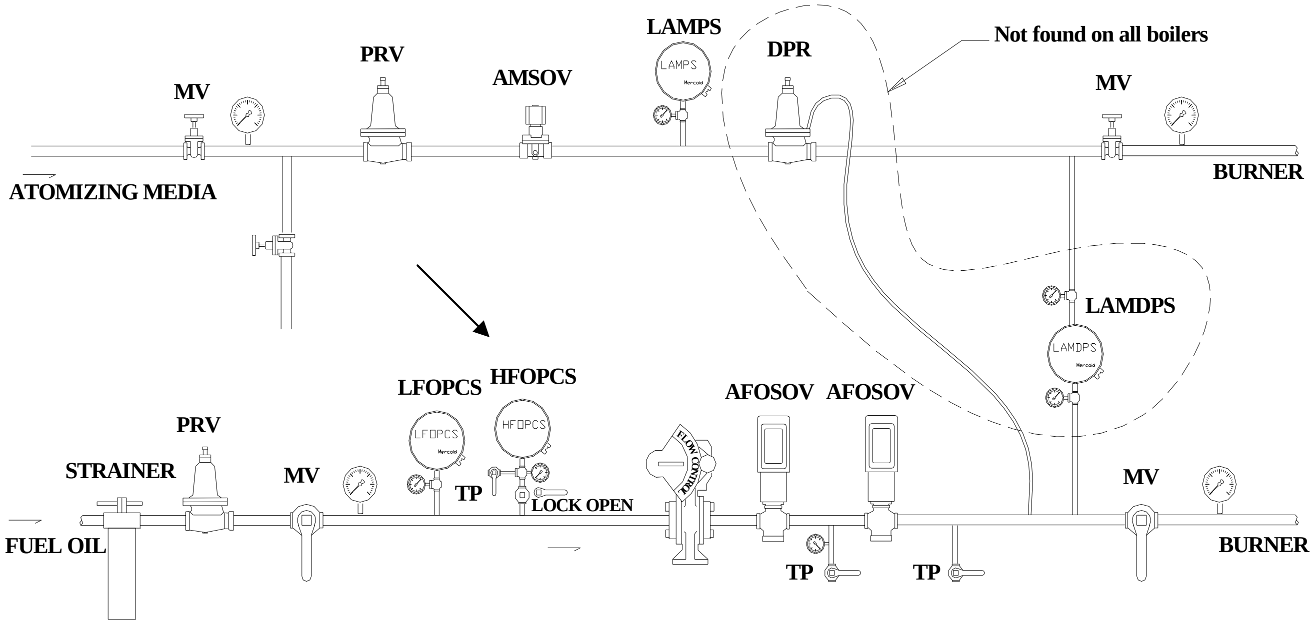
Result	Y/N	Switch Trip point
Did the switch work correctly?		
Is switch setpoint 90% or more of regulated pressure?		

Comment:

Checklist for High Fuel Oil Pressure Cutoff Switch (HFOPCS)

Item	Make	Range (inwc/psig)	Switch Setpoint	Regulated Pressure	Correct Location Y/N
HFOPCS					
Pressure Gage					

*The HFOPCS location must be downstream of PRV and upstream of flow control valve.
*Trip point of HFOPCS should be equal to or less than 110% of regulated pressure.



- With boiler in low fire close lock open manual valve isolating the HFOPCS.
- Open test port between lockable manual valve and HFOPCS; pressurize switch with compressed air or nitrogen.
- Slowly raise pressure until switch trips boiler offline due to high fuel pressure.

Result	Y/N	Switch Trip Point
Did the switch work correctly?		
Is switch setpoint 110% or less of regulated pressure?		

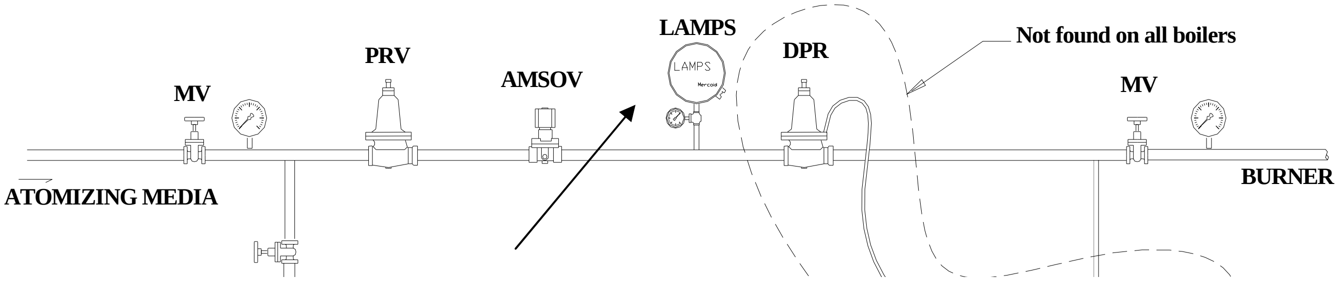
Comment:

Checklist for Low Atomizing Media Pressure Switch (LAMPS)

Item	Pressure
Atomizing media pressure at low fire	

Item	Make	Range (inwc/psig)	Switch Setpoint	Regulated Pressure	Correct Location Y/N
LAMPS					
Pressure Gage					

*Setpoint Should be 80% or more of atomizing media pressure at low fire



- Operate boiler and determine data in following table.

Item	Minimum Fire (psig)	Mid Fire (psig)	High Fire (psig)
Oil pressure at burner			
Atomizing Pressure at burner			
Oil pressure downstream PRV			
Atomizing pressure downstream PRV			

- In low fire throttle manual valve in atomizing media line before the switch slowly until switch trips the boiler offline due to low atomizing media pressure but NO LOWER THAN 80% OF ATOMIZING MEDIA PRESSURE AT LOW FIRE.

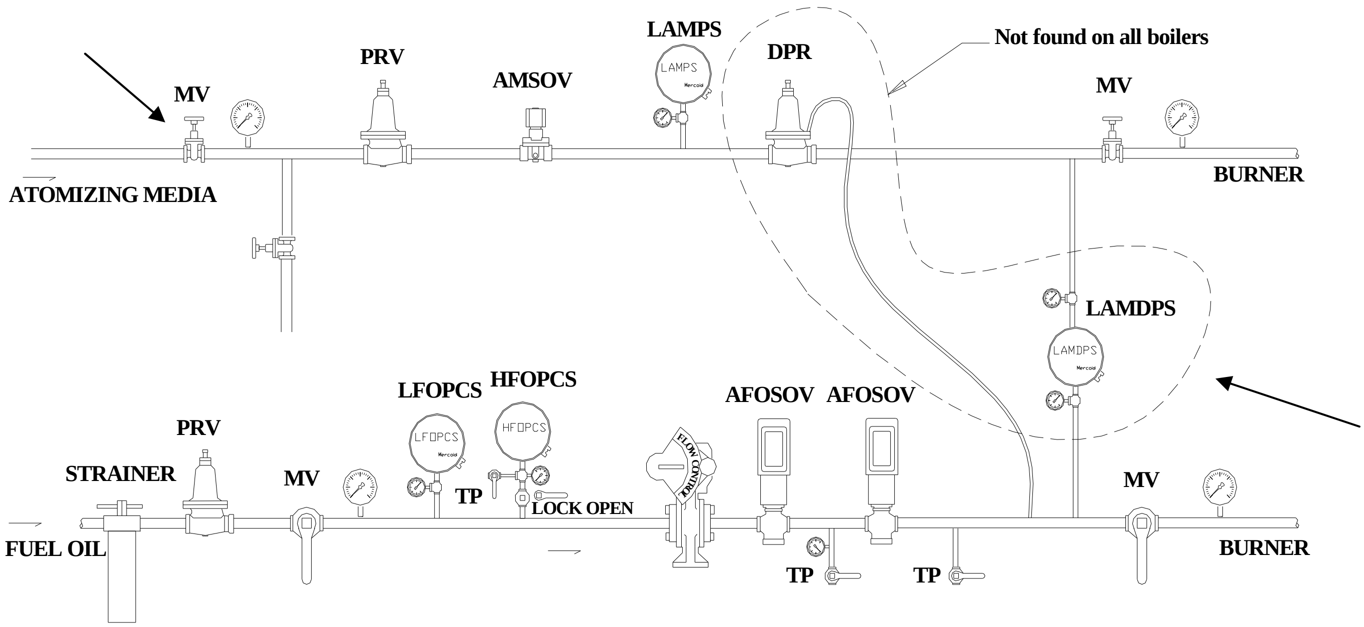
Result	Y/N	Switch Trip Point
Did the switch work correctly?		

Comment:

Checklist for Low Atomizing Media Differential Pressure Switch (LAMDPS)

Item	Make	Range (inwc/PSIG)	Switch Setpoint	Minimum Diff Pressure	Correct Location Y/N
LAMDPS					
Pressure Gage Fuel Oil Burner					
Pressure Gage Atomizing media					

*This switch is not required if oil pressure exceeds atomizing pressure at any firing rate.
*For this case the LOLI is the only protection against inadequate atomizing media.
*Setpoint should be 80% or more of minimum differential pressure between oil and atomizing media.



- Determine the minimum differential pressure from data table in LAMPS checklist and record in above table.
- In low fire throttle manual valve in atomizing media line before the LAMDPS slowly until switch trips the boiler offline due to low differential pressure but NO LOWER THAN 80% OF MINIMUM ATOMIZING MEDIA DIFFERENTIAL PRESSURE.

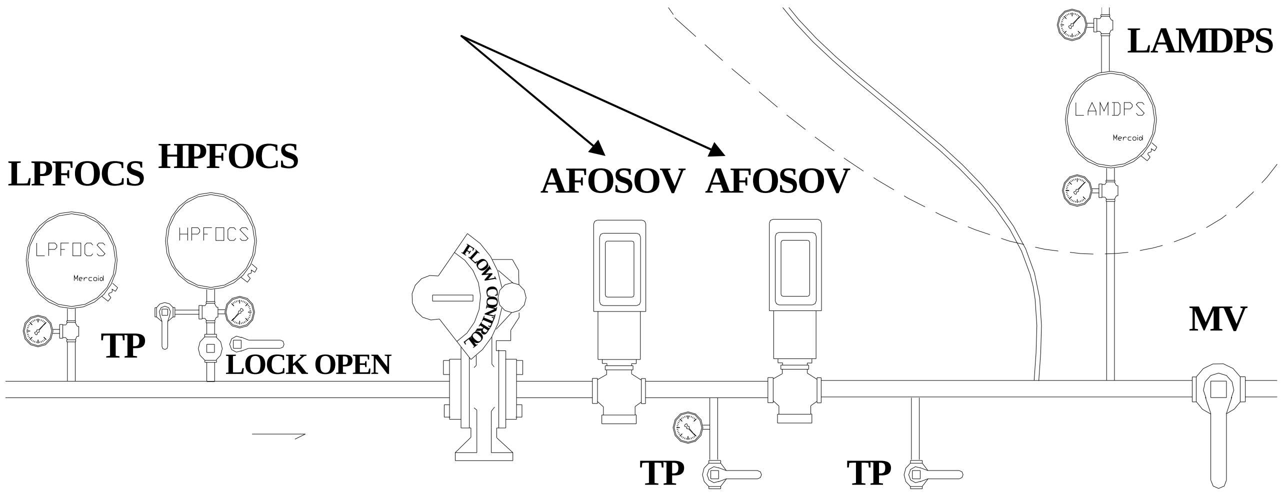
Result	Y/N	Switch Trip point
Did the switch work correctly?		

Comment:

Checklist for Automatic Fuel Oil Shutoff Valves (AFOSV) - for Seat Leakage

Item	Make	Range (inwc/psig)	Correct Installation Y/N
AFOSV			
Pressure Gage			

*After equilibrium is established, leak rate should be less than one drop in 10 seconds.



- While the boiler is firing quickly close the manual valve in oil line located after the automatic shut off valves.
- Place a container under the test port downstream of both automatic shut off valves. Open the downstream test port valve and observe oil flow. In order to consider the valve as not leaking, oil flow should be less than 1 drop in 10 seconds. Some time is needed to establish equilibrium. Make sure that the pressure gage between the 2 auto shut off valves indicates pressure approximately equal to regulated pressure or higher. If downstream shut off valve leaks this pressure will fall.
- Place a container under the test port between the automatic shut off valves. Open the downstream test port valve between the automatic shut off valves and observe oil flow. In order to consider the valve as not leaking, oil flow should be less than 1 drop in 10 seconds. Some time is needed to establish equilibrium.

Result	Y/N
Did upstream AFOSV leak?	
Did downstream AFOSF leak?	

Comment:

Checklist for Proof of Closure on Automatic Fuel Oil Shutoff Valves (POC-AFOSV) – Oil

Item	Make
POC-AFOSV	

*Switch should open with a very slight opening of the valve.
*Switches on the two valves must be wired in series.

- Close manual fuel valve downstream of AFOSOV. Perform the following test on each AFOSOV separately.
- Remove cover on both automatic shut off valves to provide access to two wires connected across proof of closure switch. Can also access wires in appropriate junction box. Disconnect both leads from switch going to control circuit.
- Temporarily connect the wires disconnected from the POC switch in order to bypass the switch.
- Start boiler and verify that switch opens with a very slight opening of the valve by measuring resistance across switch.
- Shut boiler down and disconnect two wires going to control circuit. Try to start boiler and verify that the boiler does not allow ignition sequence to begin.
- Repeat procedure for switch on 2nd valve.

Result	Y/N
Is proof of closure present in both valves?	
Did either valve being open allow the boiler to fire?	
Did both switches open with very slight opening of valve?	

Comment:

Checklist for Oil Burner Position Switch (OBPS)

Item	Make
OBPS	

*If no switch is present this test is not required and test is complete.

- Retract the gun enough to disengage the switch. Attempt to start the boiler. The boiler controls should not allow the purge process to begin. IF BOILER BEGINS TO MOVE TO THE PURGE POSTION SHUT THE BOILER DOWN IMMEDIATELY. IN THIS CASE THE OBPS SWITCH IS DEFECTIVE.

Result	Y/N
Did the switch work correctly?	

Comment:

Checklist for Water Treatment

Sample	**TDS** ( )	**Sulfite** (ppm)	**Phosphate** (ppm)	**( )-Alk** (ppm)	**Hardness** (ppm)	**pH**
Boiler						
Feedwater						
Condensate						
Makeup						

$$\%Makeup = \frac{Conductivity\_of\_Feedwater - Conductivity\_of\_Condensate}{Conductivity\_of\_MU - Conductivity\_of\_Condensate} * 100$$

$$\%Blowdown = \frac{Conductivity\_of\_Feedwater}{Conductivity\_of\_Boiler - Conductivity\_of\_Feedwater} * 100$$

Checklist for General Plant Safety & Reliability

Item	Present Y/N
Deaerator Tank Bypass.	
Condensate Tank Bypass.	
Softener Bypass.	
Auxiliary makeup to Deaerator.	
Emergency water to Boilers.	
High Oil Alarm on Oil Tanks.	
High Gas Pressure Cutout on Main Gas Line Coming into plant.	
Emergency Kill Switch (Oil and Gas) in Office and ALL Points of Egress.	

Sign In Sheet

<u>PRINT</u> **Name**	**VA Location**