



# VERIFYING THE INTEGRITY OF THE GAS TRAIN

June 2020



# The basics

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## What is the gas train?

The gas train is the collection of components from the gas delivery all the way to the burner. The gas train contains all of the components from the gas pressure regulator to the gas safety shutoff valves.

While it is obviously important to verify that there are no external gas leaks from any of the threaded or bolted connections, it is also important to periodically verify that there are no internal leaks.

Internal leaks are much harder to identify as there will not likely be any accompanying odor until there has been quite a large amount of leaked gas. Usually these types of leaks can be the most catastrophic, but fortunately there are ways to quickly and easily identify issues with the integrity of the gas train so they can be fixed before any incidents can occur.

# Components

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## What is required to be in the gas train?

The codes that apply to the installation will likely require more than just a single gas safety shutoff valve. Some of the codes to consult are:

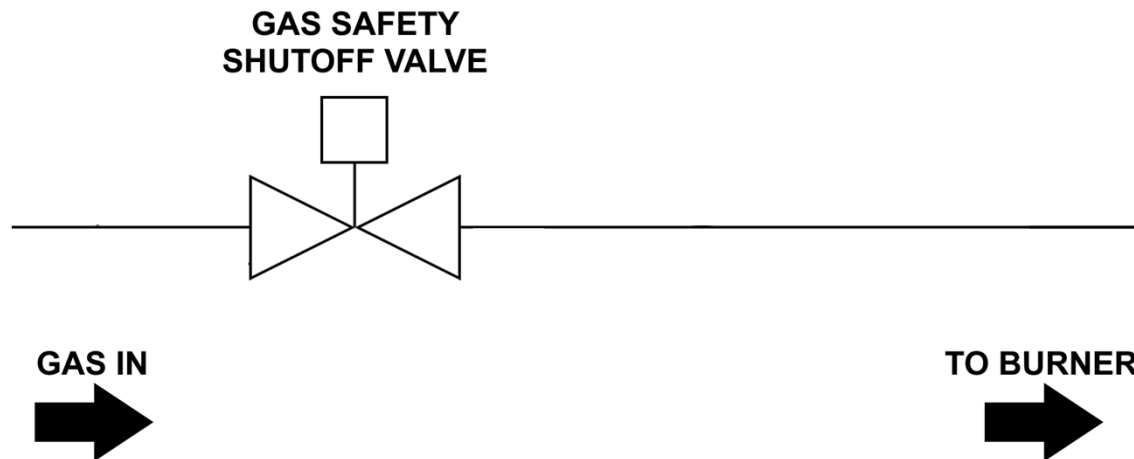
- EN 161
- EN 676
- NFPA 54
- NFPA 85
- NFPA 86
- ASME CSD-1
- UL
- FM
- GE GAP (formerly IRI)

# Components

## Basic gas train

There will be at least a single gas safety shutoff valve controlled by the flame safeguard.

UL only requires a single valve from 400 to 2500 MBh, while FM only requires a single valve from 400 to 2499 MBh. NFPA 85 and CSD-1, however, will require two valves for any installation less than 5000 MBh. It is not common for an installation to have only one valve unless it is less than 400 MBh (primarily residential applications).



**NOTE:** Codes change, so always consult an up to date copy of the code you need to follow!

# Components

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## Types of valves

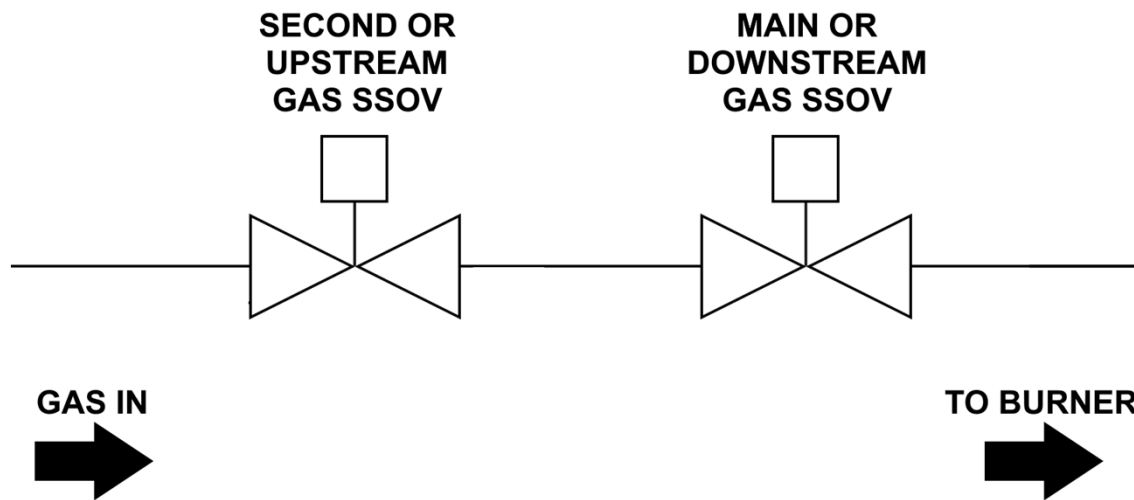
There are three primary types of valves:

- **Diaphragm** – The diaphragm type uses a standard diaphragm configuration that can regulate pressure, but can also be shut using an electrical signal. These are not allowed on any GE GAP gas trains but are allowed by UL from 400 to 2500 MBh and by FM from 400 to 2499 MBh.
- **Solenoid**– The solenoid type uses a magnetic coil to open a valve. It is analogous to a relay as it converts an electrical signal into another form. These are primarily used for pilot valves and vent valves.
- **Motorized** – The motorized valve uses a motor to close a valve stem. These often use hydraulics internally to achieve this. UL only allows motorized valves for the safety shutoff from 2501 MBh upward, while FM requires the same from 2500 MBh upward. GE GAP requires motorized valves from 400 MBh upward.

# Components

## Second safety shutoff valve

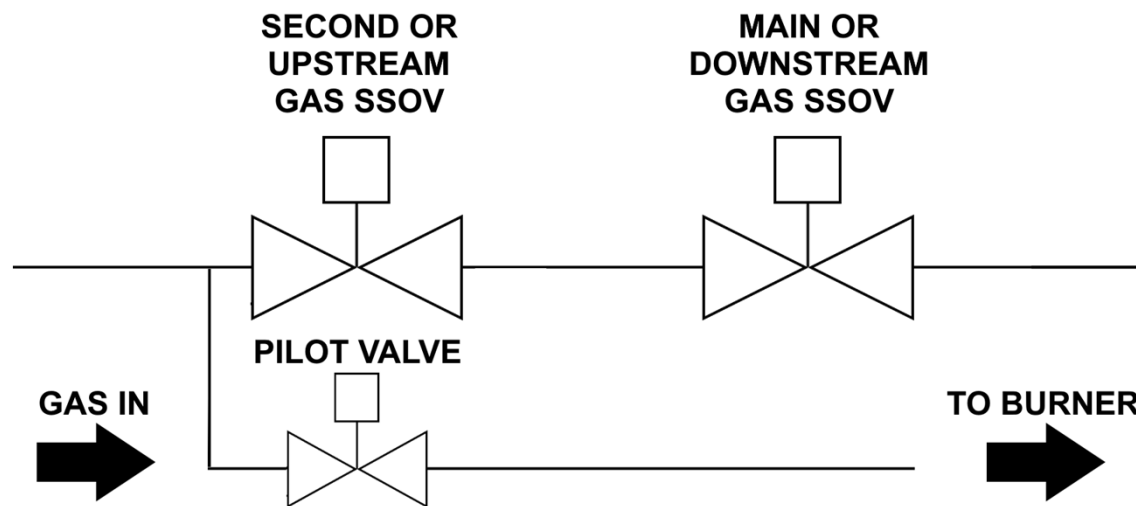
As mentioned, NFPA 85 and CSD-1 require two valves at or below 5000 MBh. UL requires two from 2501 MBh and upward, while FM requires the same from 2500 MBh and upward. GE GAP requires two safety shutoff valves from 400 MBh and upward.



# Components

## Pilot valve

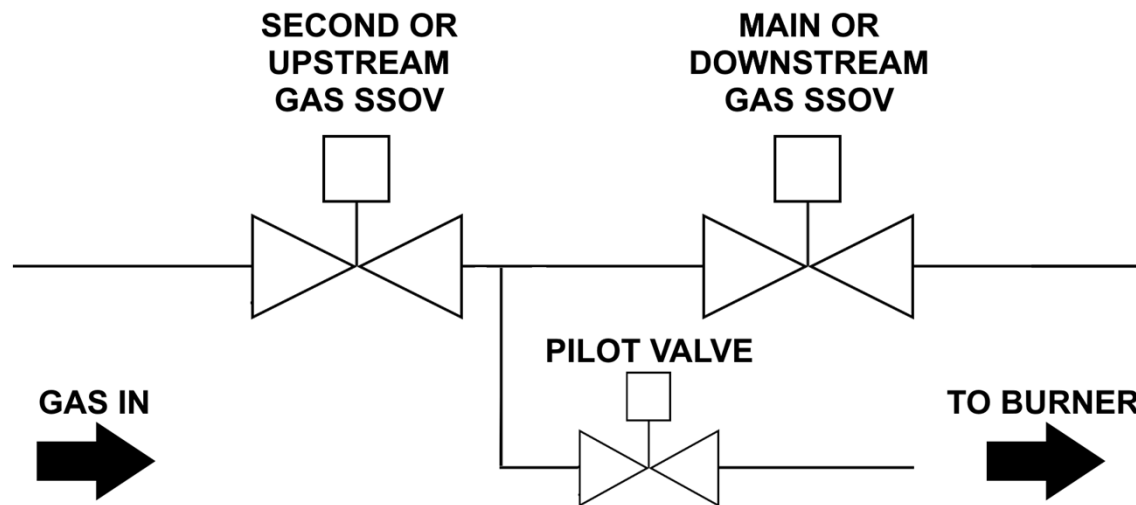
If used, the pilot line will have a separate gas safety shutoff valve as well, usually piped in parallel to the upstream safety shutoff valve.



# Components

## Pilot valve

Alternatively, the pilot line may be piped in parallel to the downstream safety shutoff valve. This is common in European codes. The flame safeguard must have a separate output for the upstream valve as this valve must open with the pilot valve prior to PTFI.

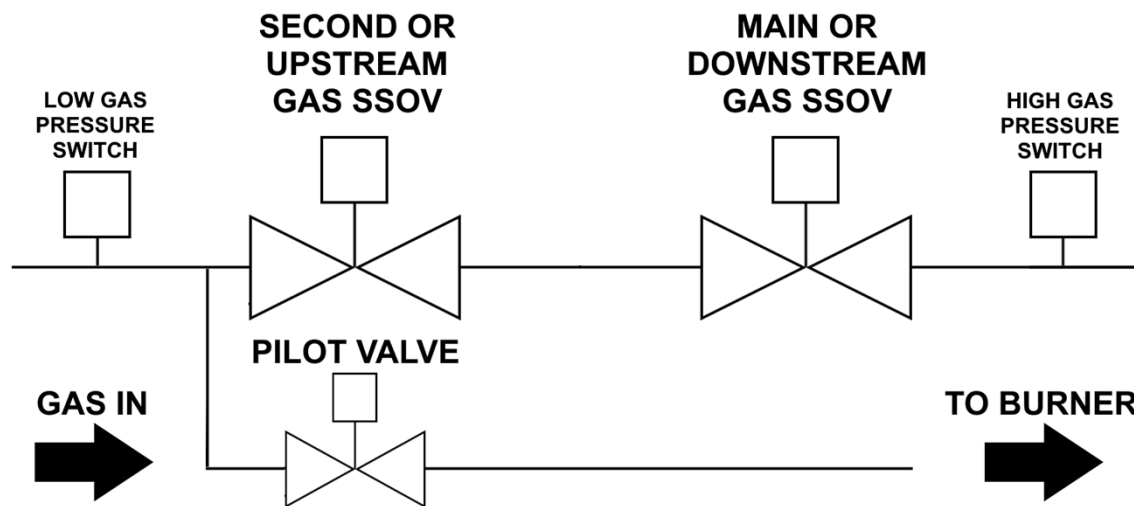




# Components

## Gas pressure switches

High and low gas pressure switches may be required to be installed and wired to the flame safeguard so that there is a lockout if either trips. UL requires these at and above 2501 MBh while FM requires these at and above 2500 MBh. GE Gap requires at and above 400 MBh.



# Components

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## Proof of closure

Gas valves may have a mechanical switch that is adjusted to provide independent verification that the valve is physically closed. If debris or some other impediment would cause the valve not to fully close (thereby leaking gas by), the switch will not indicate that the valve is closed.

This feature is known by various names:

- Proof of closure (POC)
- Fuel valve end switch (FVES)
- Closed position indication (CPI)

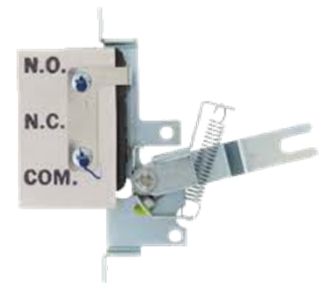
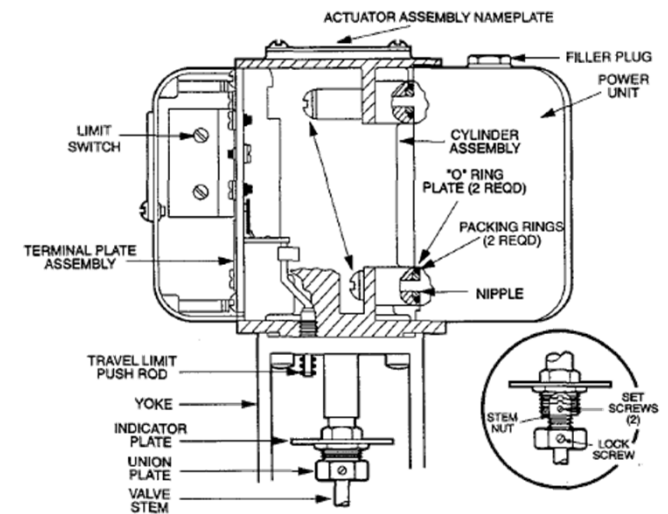
The switch is wired so that there is continuity when the valve is closed. All valves with proof of closure switches are wired in series to an input on the flame safeguard that is monitored until the fuel valves are required to open. If the proof of closure isn't made, the sequence will not start or there will be a lockout.

By most codes, a proof of closure switch should not be field-adjustable.

# Components

## Proof of closure

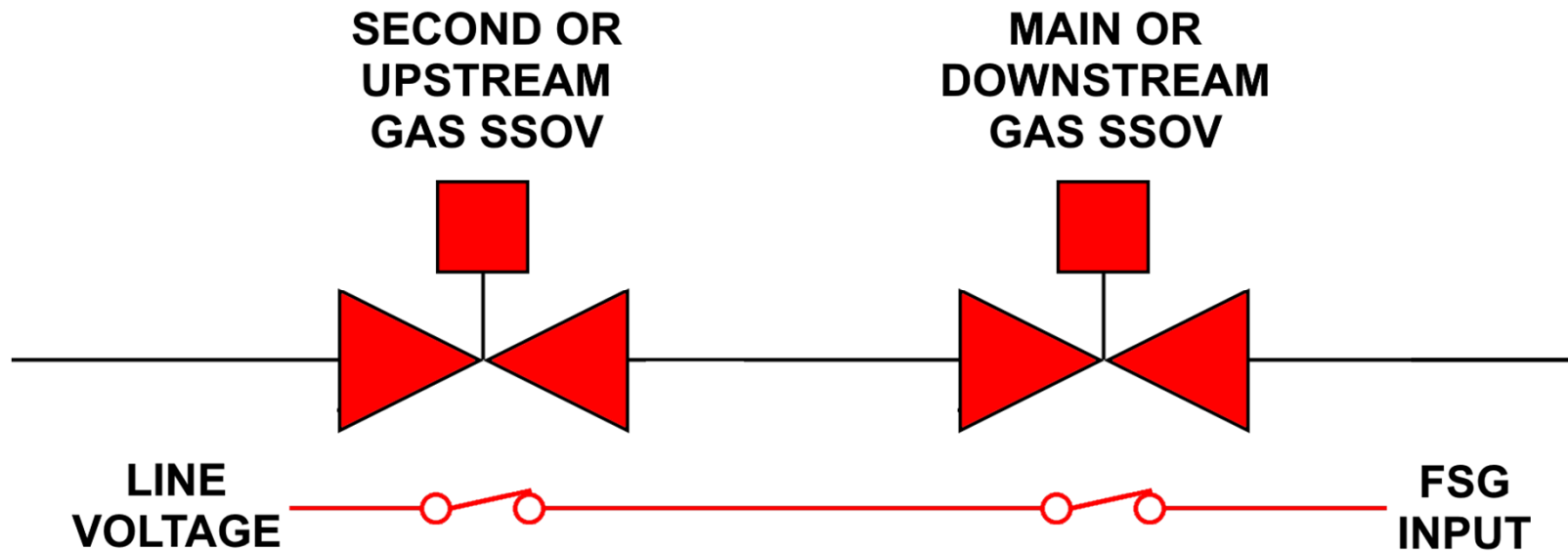
Proof of closure is usually required by code depending upon the size of the burner and the jurisdiction. Both UL, FM and GE GAP require at least the downstream valve to have proof of closure at 5001 MBh and greater, and GE GAP requires both valves to have proof of closure at and above 12500 MBh. Both NFPA 85 and CSD-1 also have the same requirements as GE GAP.



# Components

## Proof of closure

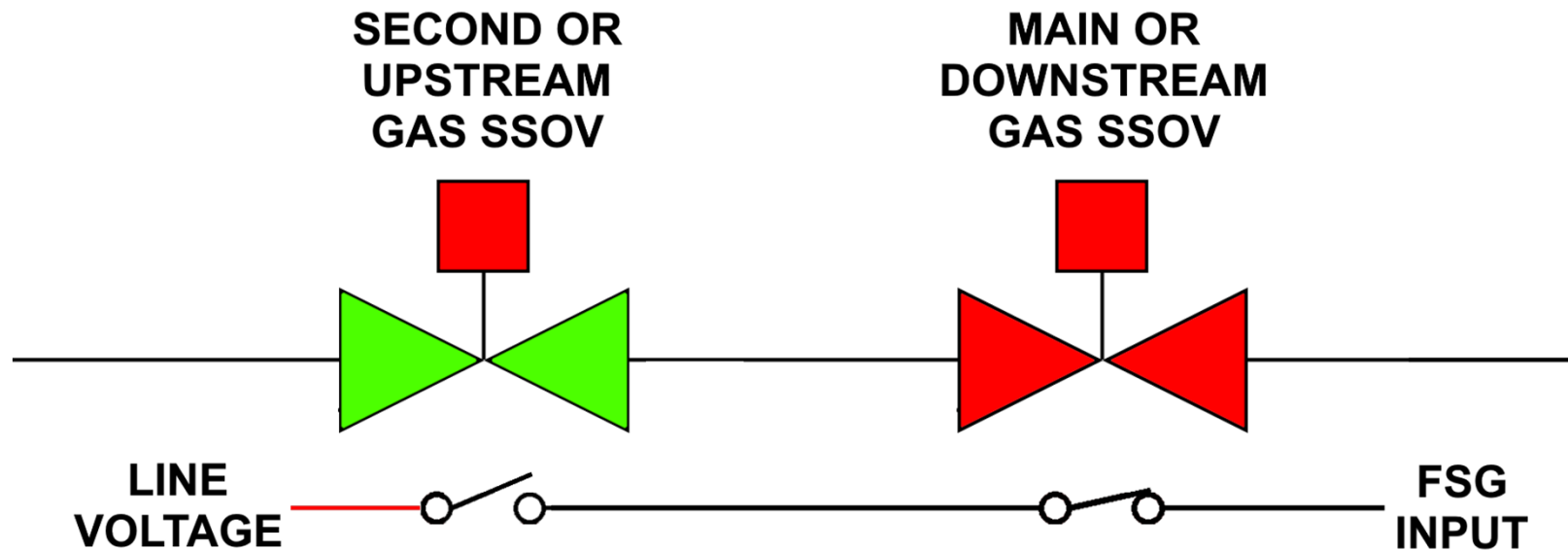
In the diagram below, both valves are closed as indicated by the red color. Line voltage is able to pass through both proof of closure switched into the flame safeguard input, indicating that it is safe to begin the startup sequence.



# Components

## Proof of closure

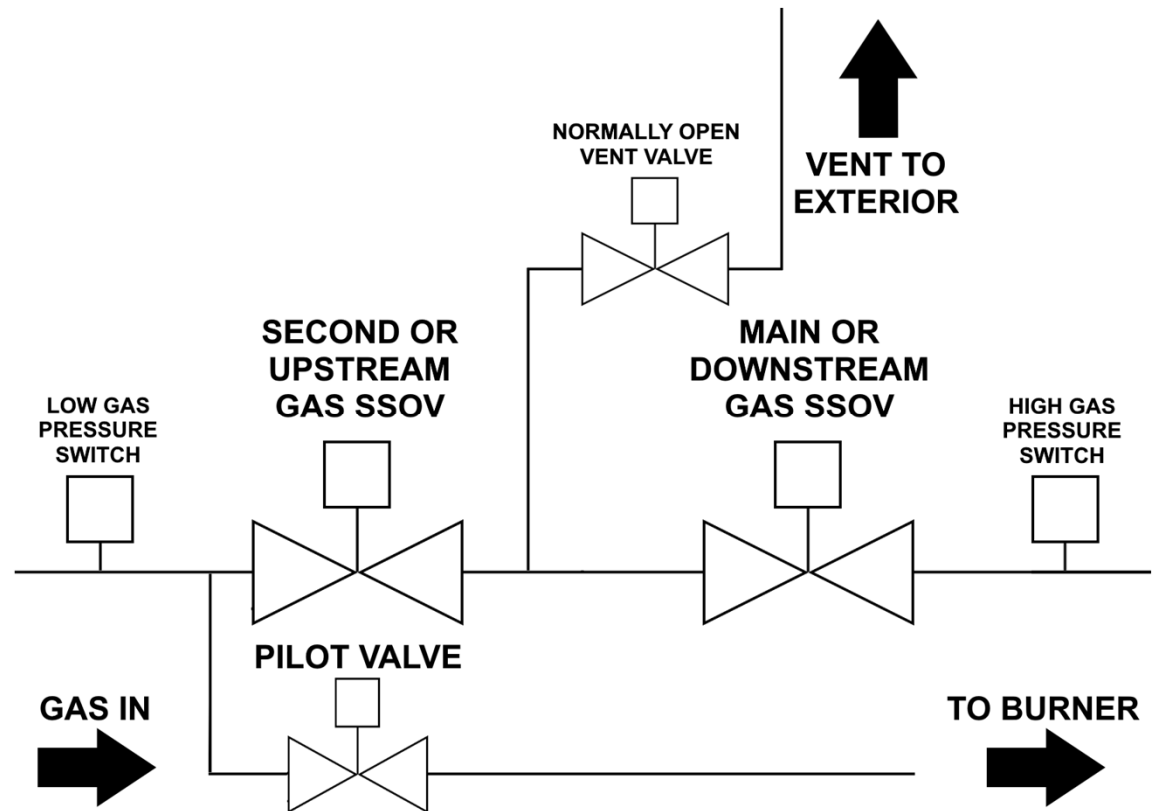
If one of the valves is not closed either due to the wrong command or a physical blockage to the valve seat, the proof of closure input will not receive voltage. In this example, there is a blockage to the upstream valve seat (indicated by the green color) while it is being commanded off.



# Components

## Vent valve

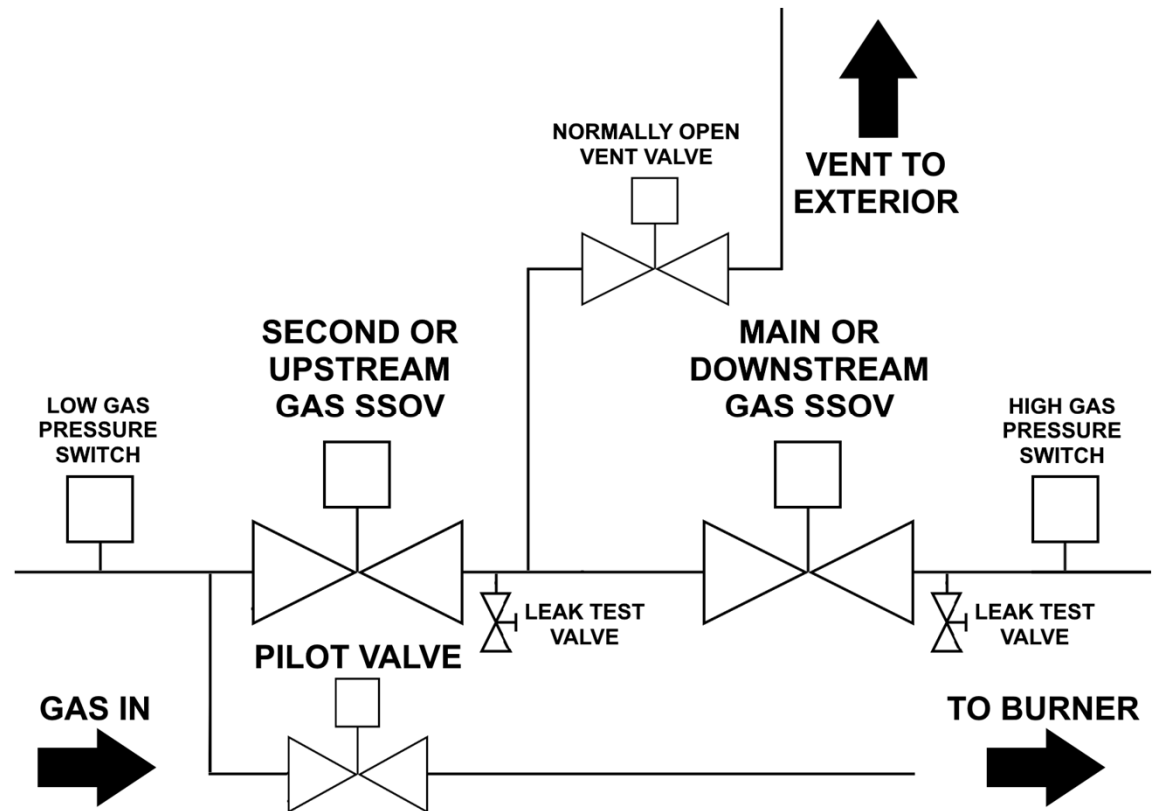
Another method used to ensure gas isn't leaking into the combustion chamber is to add a vent valve in between the upstream and downstream safety shutoff valves. This is normally a solenoid valve that is open when there is not any power, and is typically referred to as a "normally open vent valve". Power is applied to the solenoid at the same time as the gas valves, so the gas valves open and the vent valve closes.



# Components

## Leak test valves

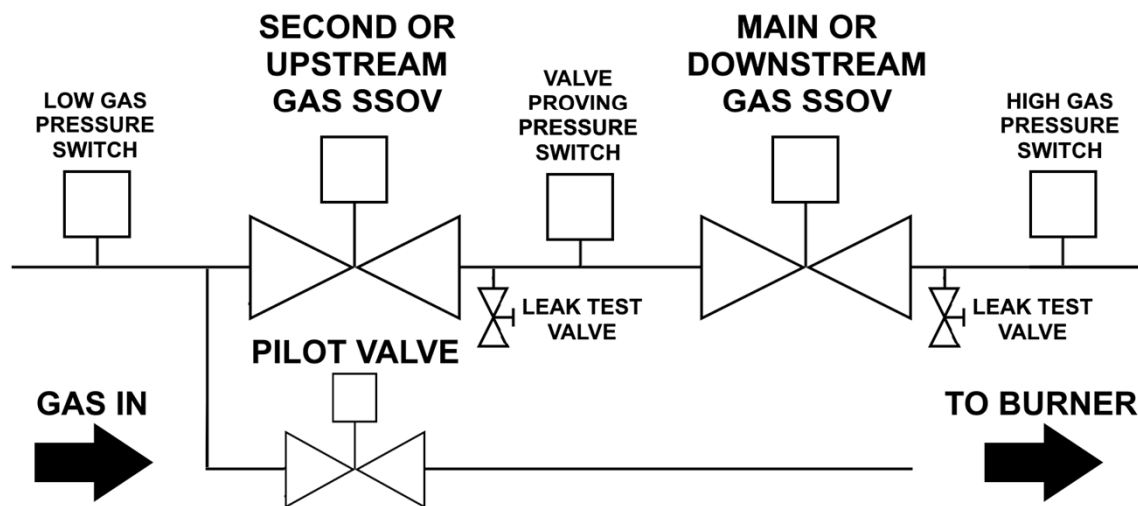
Leak tests are required by NFPA 54, NFPA 85, NFPA 86 and ASME CSD-1 at least once per year. Other codes likely have a similar requirement. Manual leak test valves must be provided after each safety shutoff valve for the purposes of this test. These valves have a pipe plug fitted when not being used for testing.



# Components

## Valve proving system

A valve proving system is a function in the flame safeguard that uses a gas pressure switch or transducer to stage the safety shutoff valves and monitor the state of the gas pressure. This allows a leaking valve to be detected instead of just venting to the atmosphere. EN 676, NFPA 85, FM and GE GAP allow a valve proving system to be used in place of a vent valve. BurnerPRO, NXF4000 and NX6100 offer a valve proving system option.

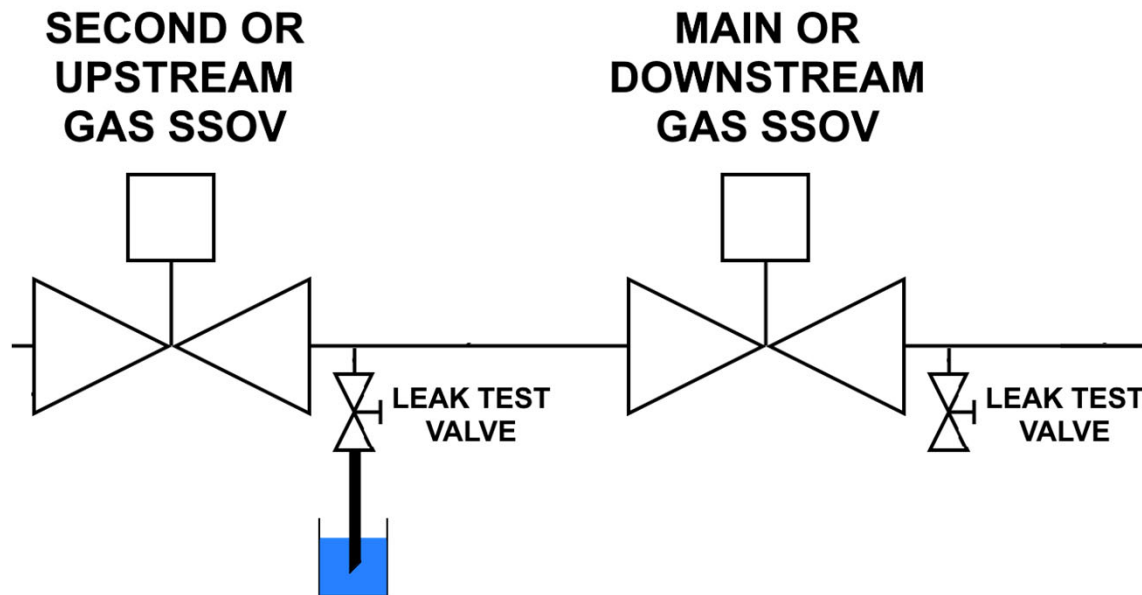




# Leak test

## Method

Performing the leak test requires connecting a tube (cut at a 45-degree angle) to the leak test valve and submerging into a container of clean water. The leak test valve is then opened and observed for a set period with the number of bubbles counted and compared to the acceptable amount.



# Leak test

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## Sequence

Conducting the leak test requires that jumpers are placed between line voltage and the safety shutoff valves and vent valve to isolate the valves being tested. Care needs to be taken with this step and jumpers should only be placed when the power is off.

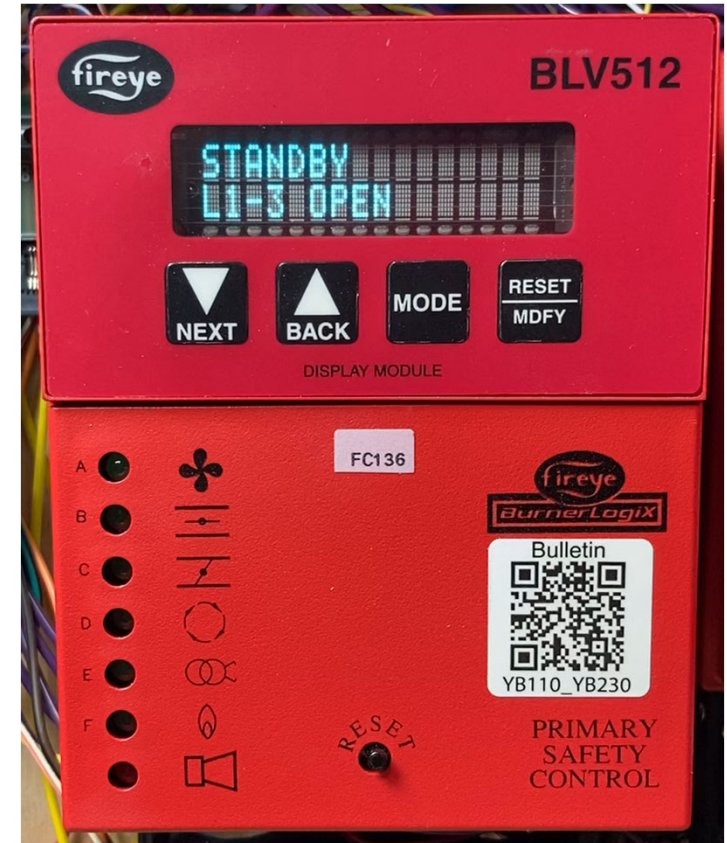
Steps:

1. Remove the flame safeguard from the wiring base if possible. Otherwise, disconnect the gas valves from the flame safeguard.
2. If there is not a vent valve, the upstream valve can be tested without any jumpers. Gas is already at the seat of the upstream valve but would leak to atmosphere if the vent valve is left open (unpowered). If there is a vent valve, apply power only to the vent valve but not the downstream safety shutoff valve before leak testing the upstream valve.
3. While keeping the vent valve powered (if present), also power the upstream valve in order to leak test the downstream valve. This allows gas to reach the seat of the downstream valve.

# Proof of closure

## Support

Most Fireeye flame safeguards support proof of closure. Consult the bulletin for the particular model to see when the terminal to connect to and the sequence to follow.



# Valve proving

## BurnerPRO

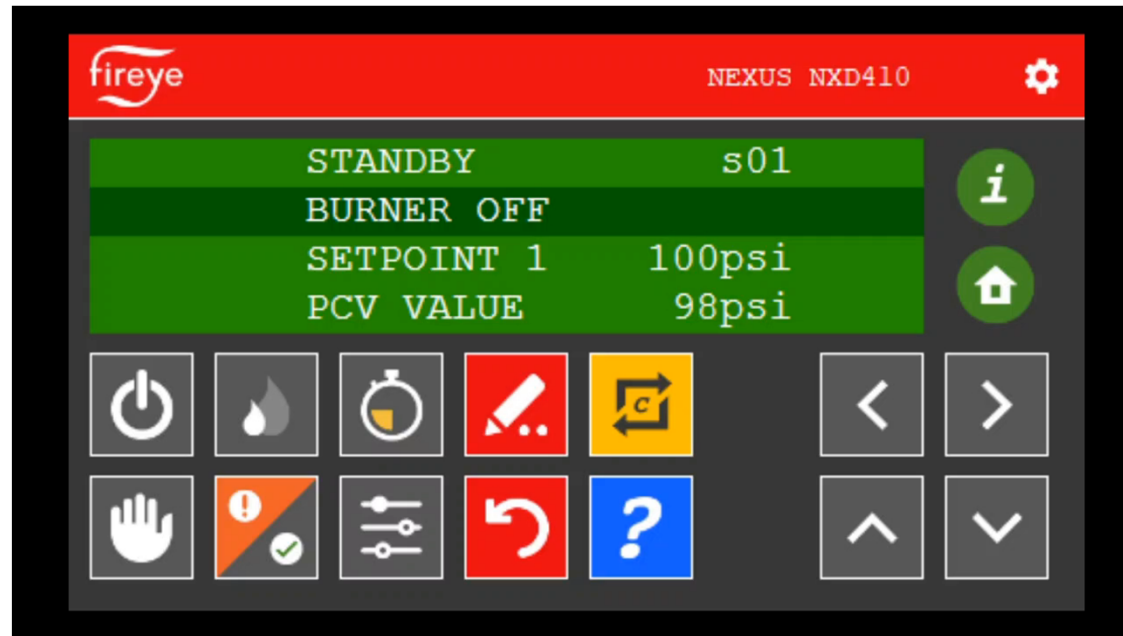
The BurnerPRO family of flame safeguards has a model specific to valve proving. Any generation 3 BurnerPRO with a model number ending in “P” has valve proving enabled. Timings can be changed using the *Config Wizard for BurnerPRO* software or the BP410TS touchscreen.



# Valve proving

## NXF4000 and NX6100

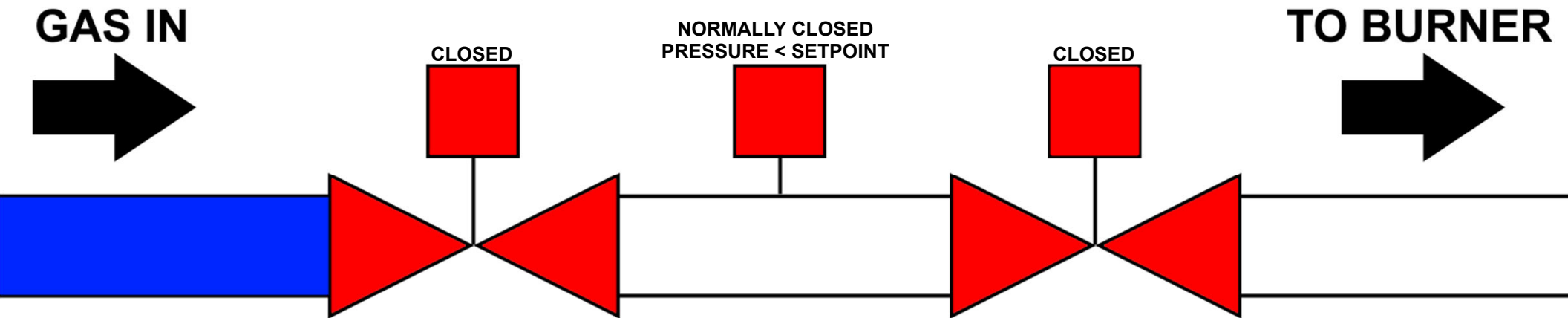
The Nexus family of parallel positioning controls allow valve proving to be enabled as an option. The video here demonstrates how to enable on an NXF4000.



# Valve proving

## Method

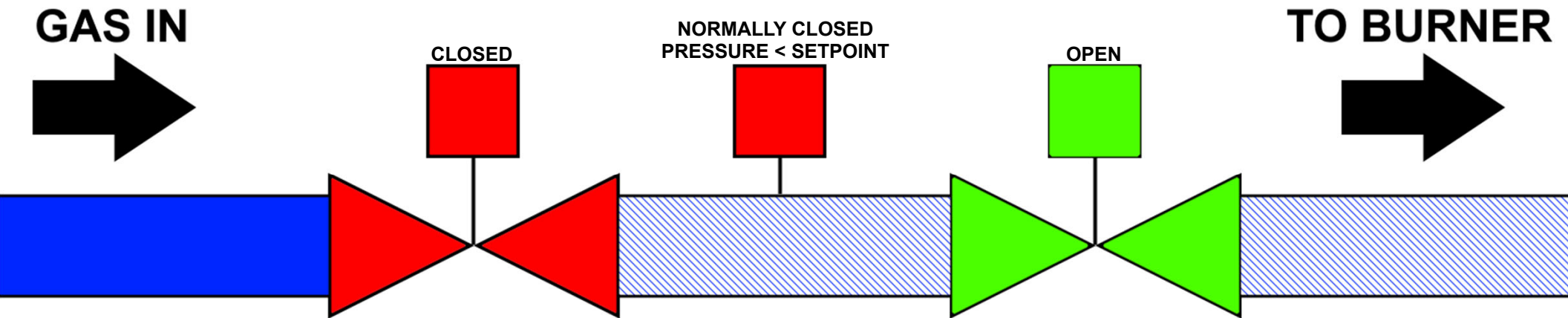
Valve proving can be programmed to occur either at the beginning of the sequence (before the prepurge) or at the end of the sequence (after postpurge). In either case, the valve proving test consists of the same steps. In the following diagrams, blue represents gas is present, red indicates the valve is closed or the switch is in the normally closed state and green indicates the valve is open or the switch is in the normally open state.



# Valve proving

## Evacuation

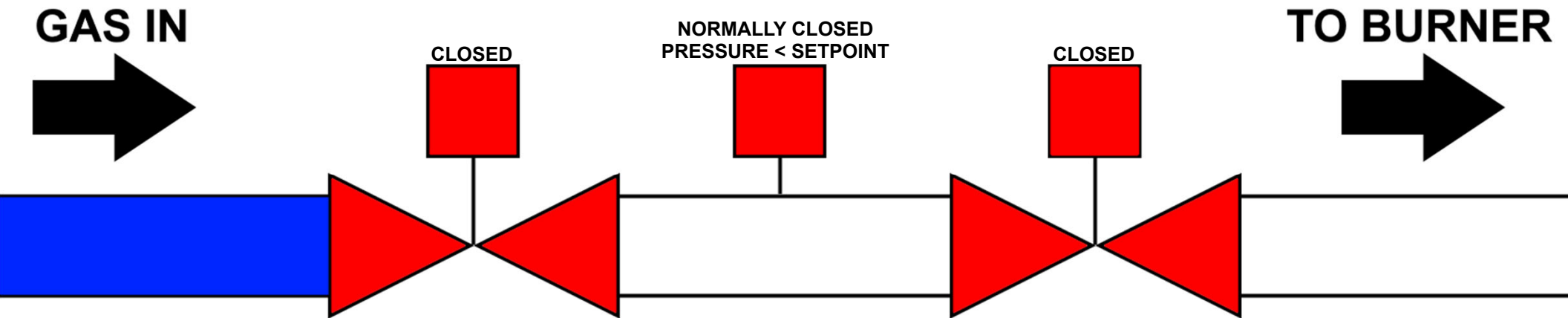
The first step is the evacuation. The downstream valve is opened so any gas that was present in between the valves is evacuated into the combustion chamber (to be then evacuated during prepurge). The length of time the valve remains open may be adjustable but will normally be around five seconds.



# Valve proving

## Evacuation test time

Following the evacuation, a test is performed for a set amount of time to ensure that the gas pressure switch remains in the normally closed state. This time period may be adjustable and is normally around 25 seconds. If the test fails, the flame safeguard will lockout. This lockout indicates that the upstream valve may be leaking since the space in between is pressurizing.

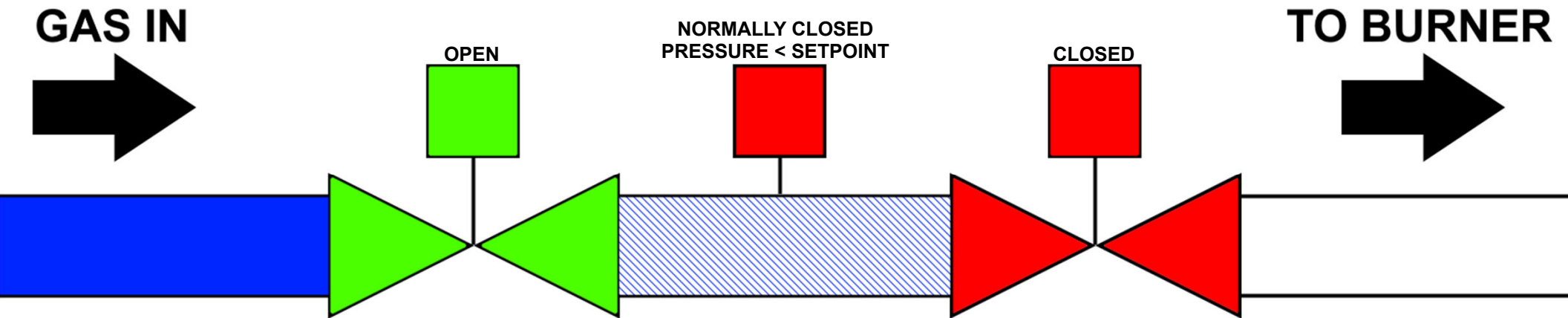




# Valve proving

## Pressurization

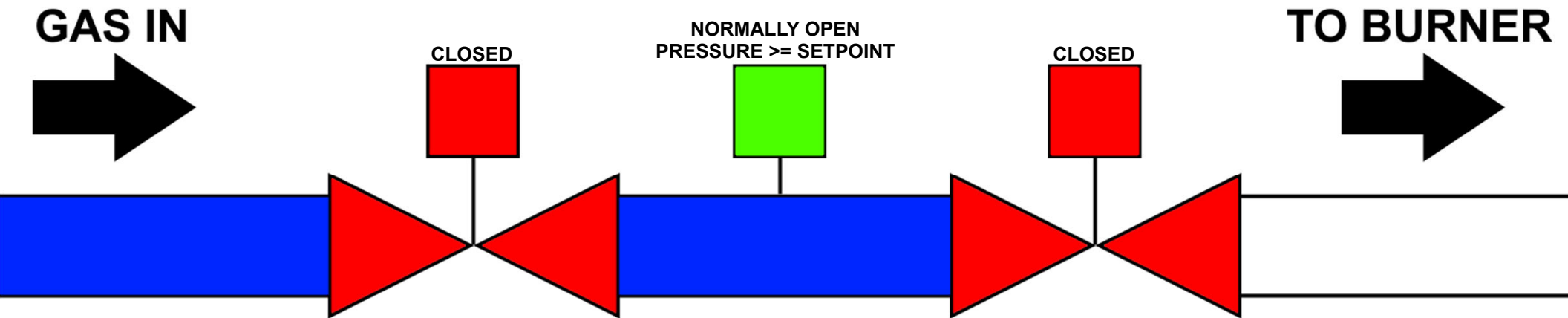
After the evacuation test is passed, the upstream gas valve opens for an adjustable period (normally around five seconds) to pressurize the space between the safety shutoff valves.



# Valve proving

## Pressurization test time

Following the pressurization, a test is performed for a set amount of time to ensure that the gas pressure switch changes to the normally open state. This time period may be adjustable and is normally around 25 seconds. If the test fails, the flame safeguard will lockout. This lockout indicates that the downstream valve may be leaking since the space in between is losing pressure.



# Valve proving

## BurnerPRO

The following is a demonstration of the BurnerPRO performing a valve proving test, with a lockout due to a valve proving switch failure.










# Valve proving

## BurnerPRO

The Smart LEDs indicate the lockout code.



BurnerPRO LED ERROR / LOCKOUT CODES

	OPERATION LED ● = ON	FAN	OPEN DAMPER	CLOSED DAMPER	AUTO	IGNITION	FLAME	STATUS
	ICON							
1	MODBUS RESET	●						RED
2	LOCAL RESET		●					RED
3	CAB FAULT	●	●					RED
4	SUPERVISORY MCU INPUT DIAG FAULT			●				RED
5	FLAME ROD FLAME LOSS MTFI	●		●				RED
6	FLAME ROD CIRCUIT FAIL		●	●				RED
7	SPI COMMUNICATION FAULT	●	●	●				RED
8	REMOTE RESET				●			RED
9	FLAME ROD DECISION MISMATCH	●			●			RED
10	MAIN PROGRAM SEQ FAULT		●		●			RED
11	RAM TEST	●	●		●			RED
12	VALVE PROVE SWITCH FAILURE			●	●			RED
13	INPUT READING FAULT	●		●	●			RED
14	TIMER2 FAULT		●	●	●			RED

# Valve proving

## BurnerPRO

The following is a demonstration of the BurnerPRO performing a valve proving test, with a failure during the pressurization test.










# Valve proving

## BurnerPRO

The Smart LEDs indicate the lockout code.



	OPERATION LED ● = ON	FAN	OPEN DAMPER	CLOSED DAMPER	AUTO	IGNITION	FLAME	STATUS
	ICON							
33	STANDBY FALSE FLAME		●				●	RED
34	LGP SWITCH ACTIVE	●	●				●	RED
35	SW WDT RESET			●			●	RED
36	FR SELF CHECK NOT PERFORMED	●		●			●	RED
37	INPUTS WAITING TIME FAULT		●	●			●	RED
38	VALVE PROVE TEST TIME 1 FAIL	●	●	●			●	RED
39	VALVE PROVE TEST TIME 2 FAIL				●		●	RED
40	HARDWARE RESET	●			●		●	RED
41	BOILER IN AUTO FAULT						●	RED



# Valve proving

## BurnerPRO

The following is a demonstration of the BurnerPRO performing a valve proving test with no failures.



# Valve proving

## NXF4000

The following is a demonstration of the NXF4000 performing a valve proving test, with a failure during the evacuation test.

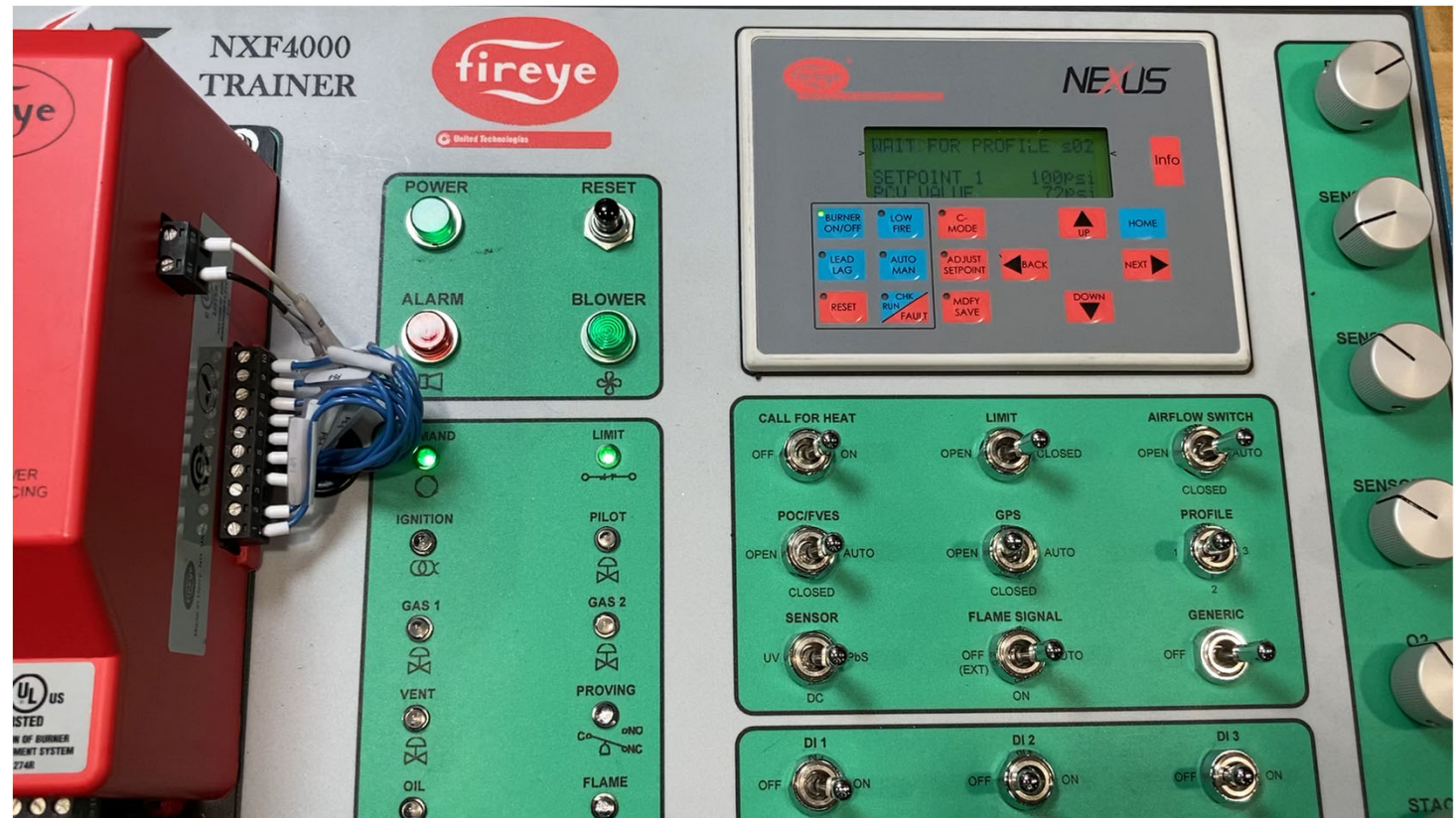




# Valve proving

## NXF4000

The following is a demonstration of the NXF4000 performing a valve proving test, with a failure during the pressurization test.



# Valve proving

## NXF4000

The following is a demonstration of the NXF4000 performing a valve proving test with no failures.





THANK YOU

