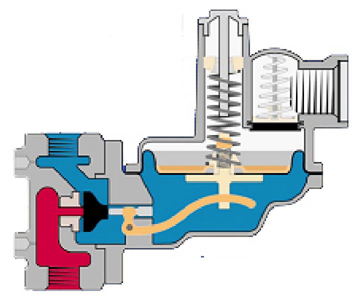
FOLLIN FLO CONTROLS
a division of BIG WAVE inc

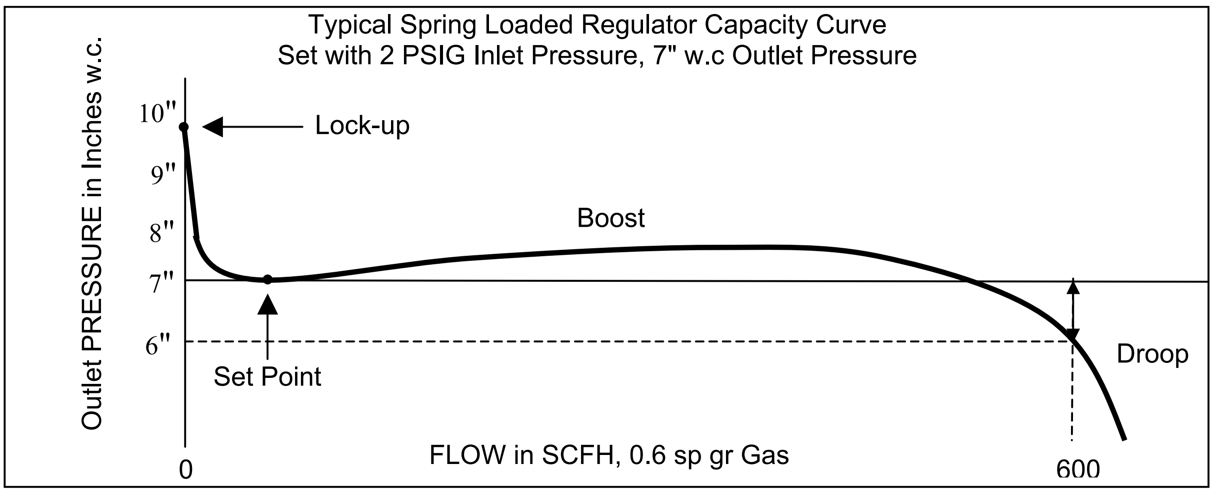
Technical Note

True Lock-up Regulators

v.1

A spring loaded regulator uses a spring on the atmospheric side of the diaphragm to provide an equal and opposite force to the gas pressure that is on the other side of the diaphragm. A regulator is set under flowing conditions at a specific outlet pressure. This is defined as the set pressure. In order for the diaphragm to move down and open the valve, the outlet pressure must drop slightly. This is defined as droop. Inversely, in order to throttle the valve closed, the pressure must rise slightly to overcome the spring force and begin to close the valve. When there is no demand for gas, the pressure will ultimately rise, the valve will close and settle at some pressure above the set point. The state in which there is no-flow and the regulator is closed is defined as lock-up.





Appliance Regulator Lock-up

Many appliance style regulators are non-lock up regulators. These regulators conform to ANSI 21.18. They are typically used for fine tuning pressure and are sometimes referred to as “inches to inches” regulators. They are often installed directly on the gas train of an individual appliance and are used to adjust the final pressure for combustion. There are no specific lock-up requirements within the ANSI Z21.18 Appliance Regulator standard. A feature of many of these style regulators is a metal on metal valve seat. This means that when there is no demand from the appliance, the valve can not shut bubble tight and the pressure will equalize across the valve such that the outlet pressure will equal the inlet pressure. Appliance regulators of this design are consider non-lock regulators. An example of a non lock-up regulator is a Maxitrol RV series. Some appliance regulators are “lock-up type” regulators. This simply means that the under no flow conditions the outlet pressure will settle at some pressure below the inlet pressure. As an example, with 2 PSIG inlet, set at 7” w.c., a Maxitrol 210 series might lock-up at 1 PSIG. This does not meet the more stringent requirements of the Line or Service Regulator specifications (see below).

Line Pressure Regulator Lock-up

Line pressure regulators go in-between the appliance and the service regulator. These regulators conform to ANSI Z21.80. They may feed one or more appliances. A characteristic of all line pressure regulators is a soft valve seat that pushes on a metal orifice, permitting "***bubble tight lock up***" under no-flow conditions. The ANSI Z21.80 Line Pressure regulator code defines two different performance criteria depending on the classification of the regulator.

Classification	Lock pressure shall not exceed:
Class I regulator (maximum outlet set pressure of ½ PSI)	150 percent of Initial outlet pressure or the initial outlet pressure + 5" w.c., which ever is greater
Class II Regulator (maximum outlet set pressure of 2 PSIG)	150 percent of initial outlet pressure

Examples:

Class 1 regulator set at 2 PSIG inlet, 7" w.c. should lock up under no-flow conditions at 12" w.c. or less.

Class 2 regulator set at 5 PSIG inlet, 2 PSIG should lock up under no-flow conditions at 3 PSIG or less.

Line pressure regulators that meet the above code requirements are considered ***"True Lock-up"*** or ***"Bubble Tight lock-up"*** regulators. The Maxitrol 325 series and the Pietro Fiorentini Governor are CSA certified ANSI Z21.80 ***True Lock-up*** Line Pressure regulators.

Service Pressure Regulator Lock-up

Service pressure regulators go on the outside of the building. They typically feed line pressure & appliance pressure regulators that are downstream of them. Often the service regulator is the property of the local gas distribution company. Because of the variation of pressure in gas distribution system there is tremendous variety in the design and performance of service regulators. There is no single standard that covers all service regulators. One can however look to ANSI B109.4 for some guidance. This standard covers spring loaded regulators with connection sizes up to 1.25", inlet pressures up to 125 PSIG and outlet pressures up to 14" w.c.
Section 5.3.5 of B109.4 covers Lock-up:

> "When the demand for flow from the regulator is zero, the flow of the gas should be stopped against the maximum inlet pressure recommended by the manufacturer for the applicable orifice. The outlet pressure under no-flow conditions or **lock-up pressure shall not exceed 3.0 inches w.c.** *(above set point)*
>
> At temperatures below 70F, the lock-up pressure will increase as the temperature decreases. The lock-up shall not exceed the relief-valve set point. Performance details pertinent to low-temperature operations shall be made available by the manufacturer.
>
> Lock up shall be demonstrated by maintaining the inlet pressure for a minimum of 10 seconds without any rise in the downstream pressure"

It is interesting to note that B109.4 directly addresses the fact that temperature and time can have an effect on lock-up. Service regulators tend to have the most stringent test and performance requirements.

Summary

The advent of high efficiency equipment and most importantly the wide spread use of spark ignition makes lock-up a critical regulator performance characteristic. Without a standing pilot a regulator must close bubble tight each and every time an appliance turns off. The type of regulator selected (be it appliance, line or service) will determine the standard and base lock-up performance to which the regulator is built. In general Service regulators have the best lock up performance, Line regulators are in the middle and appliance regulators have the worst performance. With that said, many other factors can have an effect on lock-up:

Debris: The most common reason for high lock-up is simply debris lodging on the soft seat of the valve seat and impeding the closure of the valve. Most appliance & line regulators have an inspection plate that can removed, allowing the internals to be cleaned. On service regulators it is normal to find a witness mark on the valve seat – this is from the sharp orifice pushing into the soft rubber seat. Over time this witness mark can get deeper or even get small pieces of dirt lodged into it – leading to higher lock up. Again the diaphragm case can be removed to permit the valve seat to be inspected, cleaned and / or replaced. Consult the trouble shooting guides for individual makes and models for more detail.

Vents: All regulators have a vent on atmospheric side of the diaphragm. This allows air to move in and out of the diaphragm case as the diaphragm moves up and down to control the flow. As a rule of thumb a vent line should be increased one pipe diameter for 10 effective feet, but in practice this is often not possible As a result , long lengths of vent lines constrict the vent and limit the free flow of air. It is analogous to trying to breath through a 50 foot straw. This can hamper the ability of the regulator to close quickly and thus result in a spike in lock-up pressure. Likewise, some vent limiters can restrict the free flow of air on very fast on/off loads also leading to these momentary spikes.

Regulator position: Most regulators perform best with the diaphragm in a horizontal plane. In this position friction is limited and gravity acts evenly on the diaphragm and main valve. Some regulators like Maxitrol 325's with vent limiters must never be installed in vertical lines. Others like the Pietro Governor are multi-positional, but the vent limiter itself must be installed in horizontal plane.

Fast on off Appliances: Some high efficiency appliances make use of snap acting solenoids for flow control. This can create line pack (analogous to water hammer). When the downstream valve shuts, the gas is moving as such a high velocity that it packs the line before the regulator can respond and close, resulting in a spike and high lock-up. This issue can be exacerbated if a rotary style meter is in the line. There are a variety of methods to remedy this including:

- oversizing the regulator to limit the stroke that the regulator has to travel to open and close.
- Converting the regulator from internal sensing to external sensing.
- Increasing the diameter of the downstream piping to limit piping velocities.

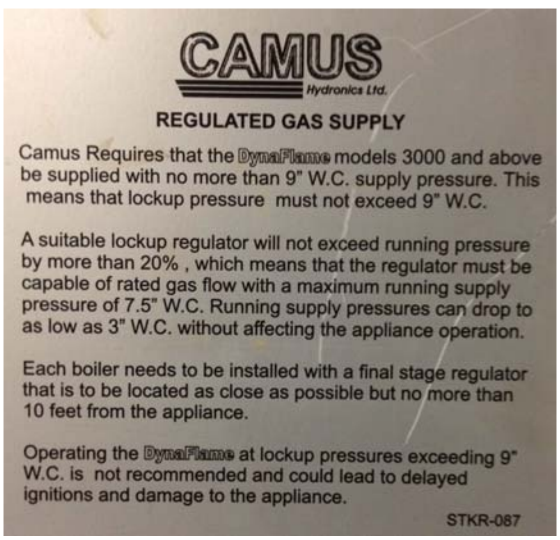
- Moving the regulator further from the appliance to create a reservoir to absorb the line pack.

Generators require very specific regulator selection and installation guidelines to function properly. Certain high efficiency boilers such as CAMUS, Lochinvar and Fulton also have specific sizing requirements. Consult out technical notes on best practices for generator and high efficiency boiler installation.

Time & Temperature: Without a standing pilot, the pipe between the regulator and the appliances is in effect a closed pressure vessel. If long lengths of pipe run across a roof (exposed to the sun) or under the ceiling of a boiler room (exposed to the heat of a boiler), the temperature of the gas will rise. This leads to a steady increase in lock-up pressure over time. Pipe exposed to the sun should be painted yellow or silver to reflect the sun's rays. In some cases it may be necessary to add a relief valve or a second regulator.

To the left an example of a boiler manufacturer's lock-up requirement that is nearly impossible to meet. To the right an example of a Generator manufacturer's regulator specifications.

High Efficiency Boiler Spec



Generator Lock up Spec

Utility High Pressure Fuel Supply
2.0 PSI Absolute Minimum.
15.0 PSI Maximum.
Note: Optimum pressure, 5 PSI.

Primary Fuel Pressure Regulator
Commercial/Industrial Rated.

Shall be rated for Engine/Mechanized application.

2.0in Connectors (Inlet & Outlet).

Minimum CFH Rating of 1.5x Greater Than the 100 percent Required Fuel Flow Rating of the Genset. Calculated using a Specific Gravity of 0.65 NG, 1.6 LPG-V.

6inH20 to 14inH20 Spring Rate.

Orifice Size dependent upon CFH Flow Rate requirement of Genset.

Output Pressure to be set at 13.0inH20.

Maximum Allowable Pressure Drop from a static condition to full load, shall not be equal to or greater than 2.0inH20.

Installed 6 to 10ft. from flex hose connection, on the same side as the flex hose connection.

The Diaphragm case shall be orientated in a Vertical Plane.

This document referred to the following codes and standards:

ANSI Z21.18-2000/CSA 6.3-2000 Addenda 1: ANSI Z21.18a-2001 Addenda 2: ANSI Z21.18b-2005/CSA 6.3b-2005	***Gas Appliance Pressure Regulators***. Details test and examination criteria for gas appliance pressure regulators for use with natural, manufactured and mixed gases, liquefied petroleum gases and LP gas-air mixtures. Such devices, either individual or in combination with other controls, are intended to control selected outlet gas pressures ***to individual gas appliances***.
ANSI Z21.80-2003/CSA 6.22-2003 Addenda 1: ANSI Z21.80a-2005/CSA 6.22a-2005	***Line Pressure Regulators***. Details test and examination criteria for line pressure regulators, either individual or in combination with over pressure protection devices intended for application in natural gas piping systems ***between the service regulator and the gas appliance(s)***. This standard applies to regulators rated at 2, 5, or 10 psi with maximum outlet pressure of « or = 2 psi, depending on the intended application.

ANSI B109.4 - 98	***Self-Operated Diaphragm Type Natural Gas Service Regulators*** A basic standard for the safe and reliable operation, and the substantial and durable construction of self-operated diaphragm type natural gas service regulators, for nominal pipe size of 1-1/4 inches and smaller with outlet pressure of 14 inch water column or less. Pertains to cast iron or alu. regulators, (w/ no external sensing lines) at operating pressures up to 125 PSIG, with the following characteristics: Removable valve orifice, valve disk of resilient material. May also incorporate an IRV capable of limiting downstream pressure to 2 PSIG in event of wide open failure.
AGA/GAMA X-50865 *	***Service Regulator Specifications***. These specifications were prepared by the Task Committee on Service Type Regulators, comprised of members of AGA (District Operating Section) & GAMA (Meter & Regulator Div.). They establish specifications for (1) materials, strengths and operating characteristics for service type regulators, (2) standard methods of testing and reporting testing (3) allowing freedom for introduction of new materials, designs and technology in the manufacture of Service Type Regulators. Apply to Pounds to inches style regulators, sizes 2" and smaller. Applicable to regulators with the following characteristics: (A) capable of reducing Pounds to inches, (B) Single valve orifice, (C) Valve disc made of resilient material (D) self contained, no external control lines
CSA 6.18-02 (CAN/CGA-6.18-M91)	***Service Regulators for Natural Gas***. These provisions apply to the construction, materials, performance, and testing of NPS 1-1/4 in and smaller self-acting service-type regulators with internal relief valves or overpressure cut-off (OPCO)* devices, or both, utilized to control the pressure of gas delivered to a customer's piping at a delivery pressure of 5 to 9 in water column (1.24 to 2.24 kPa), for installations designed for capacities up to 250 SCFH (7.1 m3/h). *Overpressure cut-off (OPCO) devices are also referred to as overpressure shut-off (OPSO) devices.
NFPA 54 / ANSI Z223.1	**National Fuel Gas Code.** Provides safety requirements for the design and installation of fuel gas piping systems in homes and other buildings.
UL144	**Standard for Pressure Regulating Valves for LP-Gas.** Regulators covered by these requirements are intended for non-refrigerated systems in accordance with NFPA 58, NFPA 54, AGA Z21.58 and NFPA 501C. Covers Low Pressure LP-Gas Regulators defined as reducing cylinder pressure (gaseous phase only) in excess of 1 PSIG to an outlet pressure of 1 PSIG or less. Second stage service of 20 PSIG inlet or less. High Pressure regulators are defined as being capable of handling gaseous or liquid phases. The standard defines construction, performance, testing and marking.