REGULATOR & RELIEF VALVE FIELD CHALLENGES

WRITING & IMPLEMENTING FIELD PROCEDURES FOR TESTING REGUALTOR LOCK UP AND RELIEF SET POINTS

WGMSC-SF
2026

KEN GOODWIN
SUBJECT MATTER EXPERT – FISHER REGULATORS
APPLIED CONTROL

Targeted readers: Natural Gas Operator personnel writing and implementing field procedures and their supervisor/managers.

Introduction

This paper will discuss writing and implementation of functional inspection procedures, used to enhance the reliability and safety of Operators and their natural gas systems. Discussion will focus on pilot operated pressure reducing regulators and pilot operated relief valves and the dynamics field personnel experience operating them. Device set point adjustments and lock up dynamics will be reviewed to assist with Operator's execution of PHMSA 49CFR192-199 and -739. This paper reviews field challenges and identifies potential risks of elements included or not included in these types of procedures. Practices and techniques applied at - regulator stations and larger customer meter sets will also be reviewed, for both monitor and single cut applications.

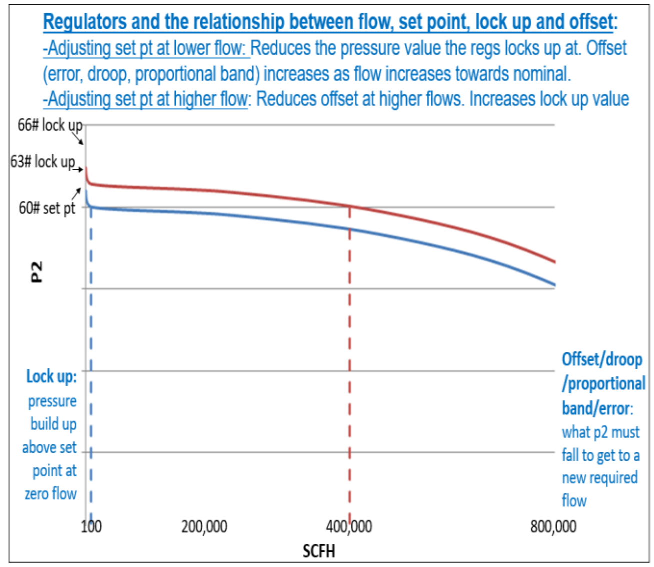
Five areas of study will be reviewed:

1) Understanding the dynamics of regulator adjustments and MAOP: Depending how and when a regulator is adjusted influences the value at which it locks up while also influencing the amount of regulator delivery pressure offset that may exist when flowing. Understanding this dynamic is important as inspection procedures are written/implemented. There are two methods used in the industry regarding the adjustments of regulators. The first method includes making the adjustment based on the pressure value at which the regulator locks up. The second method includes adjusting the regulator when flowing where flow is established by opening a bleed valve or by opening station isolation valves. It's important to remember regulator lock up is pressure build up above set point when flow is zero. Regulator offset (proportional band, droop, error) is what downstream pressure must fall to whenever downstream flow demand is greater than the flow present when regulator set point was initially adjusted. We'll now describe in detail these two methods:

-Method #1: Adjustments based on lock up pressure value: This method involves locking up the regulator and then adjusting it until the lock up value is at an acceptable pressure. This technique is often considered to maximize station send out and delivery pressure as it eliminates the required deadband between the regulator lock up pressure and relief's (token or full capacity) start to discharge pressure. When the lock up procedure is complete and station isolation valves are opened the flowing pressure will be below the documented lock up pressure. This procedure is often only considered at regulator stations. Once this adjustment method is established the document writer can then evaluate if procedure will allow the regulator lock pressure to be below the MAOP, at the MAOP, or above the MAOP (in the 10%, 6psig, or 50% DOT allowance area, depending on downstream MAOP).

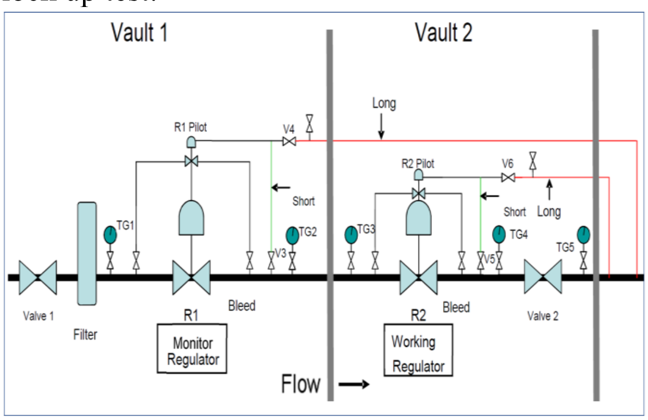
-Method #2: Adjustments made when flowing: As mentioned, this method includes making the regulator adjustment during flowing conditions. It's important to remember that delivery pressure may be lower than what it was set to if set point was established during a lower flow condition. It's worth noting if a regulator is adjusted during 'normal' flow there will be no outlet pressure offset when flow is 'normal'. It's also important to note adjusting a regulator at higher flow increases the value the regulator locks up at. Including required flow in the adjustment procedure will allow for repeatability and an understanding that all field personnel are using the same adjustment standard. To reduce risk, some Operators are reviewing the concept of creating a standard procedure template and any deviation from the standard will require management of change process review that has been approved by a professional who has attained a certain level of proficiency.

The image below is a simplified reflection of the dynamic relationship between flow, set point and lock up. The blue solid and blue dash lines represent flow curve when 60# set point was adjusted when flowing 100scfh and associated lock up value of 63#. The red solid and red dash lines represent flow curve when 60# set point was adjusted when flowing 400,000scfh and its associated lock up value of 66#. Note how both curves have similar shape. The blue curve has a lower lock up value and more offset (error, droop, proportional band) at higher flows. The red curve has less offset at higher flows and locks up at a higher value. Adjusting regulators at higher flow shifts the flow curve higher on the scale:



2) Regulator lock up procedures and sense line locations. To lock up a regulator the sense line tap must be located between the regulator and a downstream isolation valve. A lock up test cannot be performed if the sense line tap is located downstream of the Operator's last station isolation valve. This can be problematic as engineers consider the required straight run of pipe for the sense line tap location in their station design. To overcome this issue more Operators are designing stations with two sense lines per regulator. A short sense line (between the regulator and the closest downstream isolation valve) used during inspection lock up tests and a second long sense line (often located in the bypass run located near the regulator runs) used during normal operation. Its important collaboration occurs between procedure writers and station designers. This communication often leads to an increased probability for the field personnel to properly perform their inspection testing. Also, procedures that include the documentation of lock up test results are a leading industry practice. This documentation can provide important internal company station history and history that could also be accessed for external auditors. Also, procedure writers may have to evaluate the use of station bypass valves (not to be confused with the bypass valve near the regulator runs). If the station bypass valve and its nearby gauge is located beyond the eyesight of a technician, one must also evaluate if the procedure should require two technicians during the test.

Below image includes red long sense lines used during normal operation. The green lines are the short lock up sense lines that are only used during lock up test:



Finally, procedure writers must evaluate how many times the technician should lock up the regulator. Most Operator procedures include one lock up test per regulator. If the regulator locks up the test is complete and test results are documented. If the regulator does not lock up many procedures require the regulator to be retested after being rebuilt.

3) Regulator style type, principles of operation and station lock up procedures. We'll now discuss the most common regulator types used in regulator stations and customer meter sets, so this knowledge can be applied to writing/implementing test procedures.

<u>-Pressure loading regulators:</u> Pilot supply gas is applied to the main diaphragm to open the main valve on increasing downstream flow demand.

<u>-Pressure unloading regulators:</u> Pilot supply gas is removed off the main diaphragm on increasing downstream flow demand. Note this is opposite of pressure loading type.

Generally, a pressure loading regulator will lock up closer to set point verses pressure unloading style. For this reason, Operators will consider pressure loading regulators at stations where regulator/relief and monitor set points must be calibrated with little deadband between them.

How both these regulator types are tubed will impact the implementation of the field procedure and the performance of the device. Like topic 2, collaboration between station designers and procedure writers is a leading practice. The communication process will often include the evaluation of the following pressure unloading style regulator dynamics in the writing/implementing of regulator station and large meter set field procedures:

<u>-Station lock up and wide-open monitor adjustments</u>: We understand monitors are a means of protecting to one failure. If one regulator fails, the second regulator takes control and holds downstream pressure to maximum safe value without venting. It's important to understand in monitor schemes we do not just consider the lock up of one regulator. We must consider the lock up and interaction of two regulators. We call this station lock up. How monitors are tubed and how the field procedures are written can influence the implementation of station lock up field test procedures. Let's now discuss device dynamics when the monitor is the first regulator and when it's the second regulator.

<u>-Wide open downstream monitor:</u>

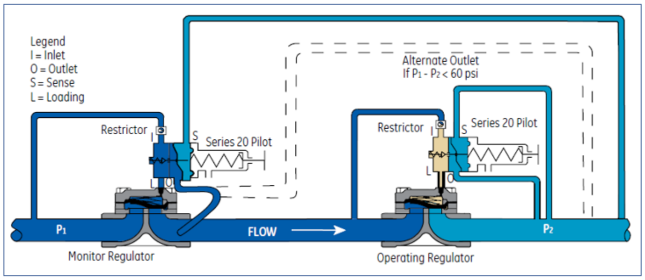
- Lock up: During normal conditions if first regulator's (worker) pilot out (exhaust) is tubed to either intermediate pressure or down from the monitor (second regulator) <u>station lock up</u> will be slightly higher than the first regulator (worker). However, it's important procedures include performing lock up tests on each regulator independently. Unlike above described pilot, some pilots are designed such that only one piece of tubing is connected downstream. With this design the tubing serves as both sense and pilot out (exhaust). It's important to understand with this configuration the pilot will be open (exhausting) whenever downstream pressure is lower that it's set point. This dynamic is significant in downstream monitor designs as it requires one to fail the upstream worker open to test monitor lock up independent of the worker. To force the upstream worker open some will adjust it's set point to a value greater than the monitor set point. However, in this scenario the monitor lock up will be slightly higher than the new worker set point. To avoid this problem procedure writers may want to include disconnecting the worker's downstream tubing to force the worker open to perform this test. Some Operators like stations with downstream monitor designs as the monitor diaphragm is exercised (moves) with each load change.

- Set point adjustments: First, make sure all block and vent valves are closed. Then, back out the pilot adjusting screw(s). Move restrictor fully clockwise. For future startups, the restrictor can be left in the desired run position. SLOWLY OPEN the block valves in the following order-pilot supply and control line valve(s)-inlet block valve-outlet block valve. Turn restrictor counter clockwise until gauge flutters then turn clockwise half an increment.
  - Adjust the upstream working pilot until intermediate pressure is higher than the desired setpoint of the monitor pilot. Adjust the downstream monitoring pilot to the desired monitoring takeover pressure. Reduce the upstream pilot to the normal outlet pressure setting.

<u>-Wide open upstream monitor:</u>

- Lock up: If first regulator's (monitor) pilot out (exhaust) is tubed to intermediate pressure (between first and second reg) <u>station lock up</u> will be slightly higher than the second regulator (worker). The monitor diaphragm will move when load changes. If first regulator's (monitor) pilot out (exhaust) is tubed down from second regulator (worker) <u>station lock up</u> will be slightly higher than set point of the monitor. The monitor diaphragm will always be in fully open position during normal conditions. As outlined earlier, during testing it's important each regulator is locked up independent of the other.
- Set point adjustments: First, make sure all block and vent valves are closed. Then, back out the pilot adjusting screw(s). Move restrictor fully clockwise. For future startups, the restrictor can be left in the desired run position.
  - SLOWLY OPEN the block valves in the following order-pilot supply and control line valve(s)-inlet block valve-outlet block valve. Turn restrictor counter clockwise until gauge flutters then turn clockwise half an increment.
  - Adjust the downstream working pilot to a setpoint higher than the setpoint of the monitor pilot. Adjust the upstream monitoring pilot to the desired monitor takeover pressure. Then reduce set point of downstream working pilot to required outlet pressure setting.

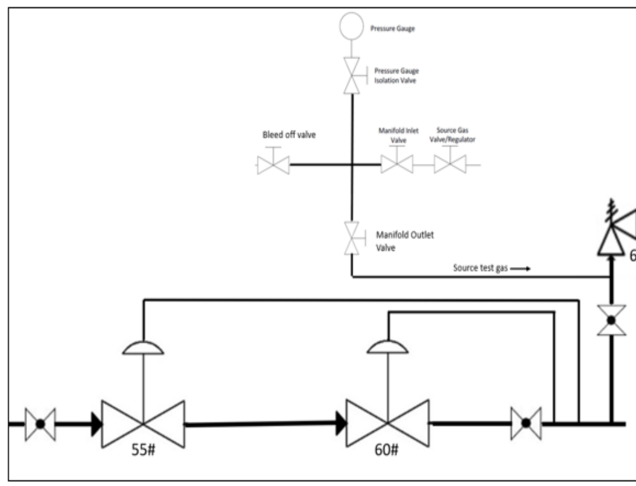
Image of typical monitor:



<u>-Single cut regulators</u>: station lock up will be the lock up value of the one regulator.

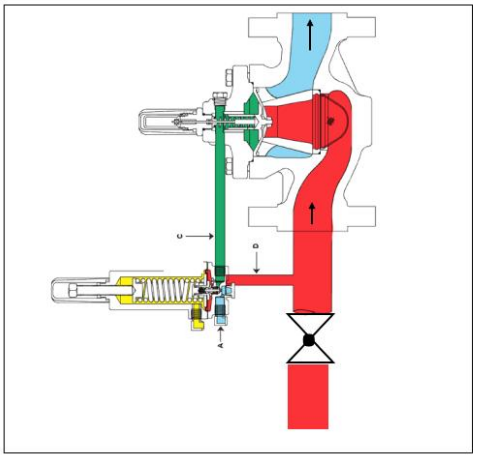
4) Relief valve operation test methods. There are several relief valve test methods than can be evaluated and then included in the writing/implementation of the inspection procedures. Many procedure writers will consider the limitations and challenges field personnel face when implementing relief test methods. In this process it's important to understand the pilot on a relief valve opens first during the opening cycle of the device. After the pilot starts moving, the main valve will start to move. A common challenge that may confront field workers is the pilot's ability to dump the supply/test gas, used to operate the assembly, quick enough preventing the main valve from opening. The pilot's ability to exhaust the supply/test gas doesn't allow required minimum differential to build high enough to overcome the main valve's spring which holds the main valve closed. These conditions prevent the field worker to determine if the assembly will relieve at the correct pressure, as directed by 49CFR192.739. The industry has found test equipment is often the root cause of the technician inability of fully completing this operational test. Experiences have found test equipment that includes the use of pete's plugs limits the test/supply gas volume to a level below the minimum differential pressure to operate the main valve. Test equipment that includes as few restrictions as possible increases the probability of the technician being able to complete the test. Operators often define critical test equipment parameters in the procedure such as: full port ball valves, test hose diameter, test hose length and discouraged use of pete's plugs.

Image of typical relief valve test equipment manifold (Christmas tree).



<u>-To further understand the dynamics of pilot operated relief's the following is a quick review of the principles of operation of a common pressure unloading relief valve</u>: During normal conditions the pilot and main valve are held closed by a spring. If pressure coming into relief (see below red pressure) exceeds the pilot spring force the pilot opens and dumps the main valve's loading pressure (green pressure) that was helping the spring in the main valve keep the device closed. This allows the main valve to open and for gas then to enter the vent stack (blue pressure) and exhaust to atmosphere.

Image of typical pressure unloading style relief valve:



Additional concepts to evaluate when writing relief valve test procedures:

- Should the test procedure specifically state that both the pilot and main shall be operated during the annual inspection?
- Should the set point of the relief be defined in the procedure? If so, will it be below the MAOP, at the MAOP or above the MAOP (in appropriate allowance area).
- How many opening tests should be required? One or two or three? Is an average taken? While considering this it's important to understand the required pressure build up during the first test is often higher than subsequent tests.
- To increase the probability of getting the main valve to operate should the procedure allow the readjustment of the pilot to a lower setting?
- Should failing (opening) the regulator upstream of the relief be allowed if the technician cannot generate enough differential pressure to open during the operational test? If yes, what procedure should be included to force the regulator open? (i.e. Loosening the sense line fitting, adjust the regulators set point to a value higher than the relief set point…)
- To increase of the probability of operating the main valve during testing should the use of test manifolds (Christmas trees) and its restriction be allowed?
- To reduce the amount of restrictions during the test should test procedures include utilizing two test port thread-o-lets? During station design two test ports will be included, one for test gas injection the second for gauge/bleed port.
- How is test procedure written to verify the operation of the pilot/main safely?

  Verify the operation by:

  - Listening
  - Observing a vent stack cap
  - Observing a travel indicator on the main valve
  - Apply plastic bag on vent stack.
  - Observing a gauge located in the pipe pup between the relief valve and it's upstream isolation valve? What should the gauge read when main valve is open? It's worth noting when the main valve opens the gauge reading should drop significantly or stabilize as test/supply gas flow is increased. Note that the first pressure which the technician notices stabilization is likely the pilot dumping rather than the main valve opening. The technician must continue to apply test/supply gas to observe the second stabilization or decrease in pressure to

insure main valve has opened.

- Is disconnecting the pilot's exhaust tubing (if one is installed) allowed in hopes of verifying it's opening?

5) Additional safety risk reduction considerations and procedures. Beyond the regulatory requirements, some Operators are considering below concepts to reduce risk:

- Increased inspection frequency: Use a tighter interval than 49CFR192.739 requirement of not exceeding 15 months but at least once per calendar year. Within this potential procedure change some Operators are considering: station history, station type, recent construction/pigging activity in the vicinity of the station, complexity of station configuration, below/above grade site, sulfur history, station maximum differential pressure and maximum shutoff pressure.
- Update test procedures at all retrofitted stations where new design may now include an additional layer of overpressure protection that protects to two failures.
- Add replacement parts schedule to the procedure: consider requiring regulator/relief parts be replaced at periodic time intervals.
- Reduce the possibility that a single physical event failure could impact the operation of station's regulator and over pressure protection device.
    - Consider the application of an external and internal registration device.
    - Consider applying a spring to open and spring to close device.
    - Consider applying a pressure loading and pressure unloading device.
- Add regulator/relief leak survey to the inspection procedure?
- Should a certain professional competency level of personnel stamping Operator procedures be required?

References:

Emerson, D350927X012 2015

GEA 19187, Mooney Flowgrid Regulator Rev 08.2012

Paper written in collaboration with:
Matt Davidson, Pacific Gas and Electric
Dan MacDonald, Dominion Energy

Kgoodwin@appliedcontrol.com
2026