REGULATION STANDARDS UPDATE

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Introduction

Minimum design standards are commonly used to ensure safety for users. The ANSI B109 standards not only specify these design & material requirements but also include performance requirements, test procedures, and guidelines for data presentation to customers. This ensures that customers are not only using safe products but also enables the customer to better assess which product is best suited for their requirements.

This paper highlights the topics of ANSI B109.5, focusing on those portions of the standard that are not found in ANSI B109.4, and outlines some of the most critical sections.

Keep in mind that ANSI standards are guidelines, and there is no requirement that gas distribution companies, or even manufacturers, are compliant with these standards. The ANSI standards are the result of years of experience supplemented by extensive research.

ANSI B109 Standards Overview

The ANSI B109 committee was established in 1967, and the first standard was published in 1973. Today, the ANSI B109 committee is made up of 26 members from a variety of gas utilities, manufacturers, and at-large members. ANSI B109 has published 6 standards covering diaphragm meters, rotary meters, ultrasonic meters, and regulators. The first edition of the ANSI B109.4 standard for Self-Operated Diaphragm-Type Natural Gas Regulators was approved in April 1998. In 2020, discussions began for a standard for larger regulators used in commercial and industrial applications.

ANSI B109.5 is essentially an expansion on the ANSI B109.4 standard, of which the 2nd edition came in 2016. The 2nd edition featured expanded guidance on materials, but the most significant addition was set points up to 2 psig and recommended maximum allowable operating pressures (MAOP) for the downstream system. The 3rd edition (current edition) was released in 2021 and featured the addition of Slam-Shut valve design and testing requirements. Be sure to ask your supplier which year of the ANSI standard they are compliant with.

In 2024, the first version of the ANSI B109.5 standard was released covering regulators up to and including 2 inches, that not covered in ANSI B109.4, inlet pressures up to 125 psig, and delivery pressures up to 20 psig. The standard includes over pressure protection options including internal relief valves (IRVs), Self-operated integral Slam-Shut valves, Integral Monitors, and Internal Monitors.

Many similar standards exist across the world. In Europe, EN88-2 is used by most members of the EU for domestic natural gas regulators. In Canada, CSA 6.18 is required for all residential services. In the USA, UL144 covers LPG regulators. EN, CSA, and UL standards all require testing to be done by the standard body or a 3rd party accredited laboratory. ANSI standards differ because ANSI standards allow for self-certification by the manufacturer. Regardless, many manufacturers have sought 3rd party approval to ANSI standards, meaning they can provide a certificate of compliance. However, all manufacturers that advertise ANSI approved products should be able to provide data showing their products meet these requirements.

ANSI B109.5 consists of five sections & four appendices. We will review the contents of each section.

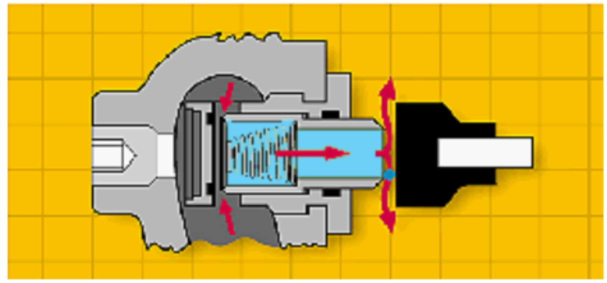
Section 1 & 2: Scope & Definitions

Section 1 of the ANSI B109.5 standard defines the scope, which was already discussed. Because much of the ANSI B109.5 standard is similar to B109.4, which has been published for years, we will focus on the differences between these 2 standards.

Section 2 features 52 definitions to common industry terms, making this standard a great resource for newer users. Two of the added terms in B109.5 include definitions of Internal Monitor and Integral Monitor which are not in previous ANSI standards.

"Integral Monitor: A fully independent redundant device sharing only the same body of the pressure regulator and capable of taking over the pressure control at an elevated safe pressure in the event of the working regulator failure." Basically, consider an Integral Monitor is two regulators in one body.

"Internal Monitor: An internal mechanism sharing several parts with the regulator like, but not limited to diaphragm and stem, which provides a secondary sealing during lock-up condition in the vent of primary sealing seat failure." This is also known as a sliding-orifice, where the orifice has a piston that can slide to provide a secondary shut-off point. Figure 1 below shows an example of an Internal Monitor.



B. Standard regulator orifice failed; upstream monitor orifice control

Figure 1: Internal Monitor (Courtesy of Roots Regulators)

Another new term in B109.5 is Limited relief, which is a relief that does not exceed 2.5 SCFH. This limit is aligned with ANSI Z21.80/CSA6.22 standard for indoor appliance regulators with a Vent-Limiter. Z21.80 states that if an indoor regulator features a Vent-Limiter, then it does not require vent piping outside the home. B109.5 does not expand on Limited Relief test procedures, but they are available from some manufacturers today.

For any Canadian readers, please note that ANSI standards use Over Pressure Shut Off (OPSO) instead of "OPCO". These terms can be used interchangeably but should not be confused with Under Pressure Shut Off (UPSO) which is also included in the ANSI standards.

Section 3: General

General requirements include the temperature requirement (-20 to 150 ºF), inlet pressure up to 125 psig, and some basic material requirements. This is where it's also defined that Slam-Shut device's operating mechanisms shall be independent from the regulator, and that the Slam-Shut shall require a manual reset.

Section 3 also defines that both an Internal Monitor and an Integral Monitor are considered Over-Pressure Protection (OPP) devices, but only an Integral Monitor is considered a safety device equivalent to a Slam-Shut. This is because the Internal Monitor relies on several critical components from the regulator, like the diaphragm and stem/linkages. Integral Monitors and Slam-Shuts only share the body of the regulator.

Disclaimer: ANSI standards are not required codes.

Section 4: Design Requirements

Valve body, diaphragm casing, diaphragm, loading spring, linkage and disk, and orifice all have material requirements and minimum test requirements in Section 4. One of the most extensive tests called out in the entire standard is in Section 4.7, where the procedure for a 2,000-hour UV light test and a 1,000-hour salt spray test are outlined to ensure the exterior surface is of the highest quality. One addition of B109.5 is the requirement that all materials, including internal components, must be able to pass a 24-hour salt-spray test with no visible signs of corrosion. This helps to ensure the quality of the internal components.

Section 4 continues to specify requirements for the regulator vent and markings, including nameplates for the regulator and Slam-Shut, if equipped.

Section 5: Qualification Test for Service Regulator Performance

Test requirements are very similar to ANSI B109.4, and many manufacturers referred to B109.4 when building larger regulators prior to the release of B109.5. One of the most critical definitions in both of these standards is how to establish set point. Establishing set point requires careful control of the inlet pressure, regulator outlet pressure, and the flow rate. This procedure is required before completing most other tests in the standard. B109.4 and B109.5 both state that set point should be established with a 40 psig inlet pressure. Outlet pressure must be very tightly controlled as well, according to the table in Figure 2.

TABLE IV

Outlet Pressure Range	Set Point Tolerance
X ≤ 14 inches w.c. gauge (3.48 kPa gauge)	± 0.1 inches w.c. gauge (0.025 kPa gauge)
14 inches w.c. gauge (3.48 kPa gauge < X < 1 psig (6.89 kPa)	± 0.2 inches w.c. gauge (0.050 kPa gauge)
1 psig (6.89 kPa gauge) < X < 2 psig (13.8 kPa gauge)	± 0.03 psig (0.2 kPa gauge)
2 psig (13.8 kPa gauge) < X < 20 psig (138 kPa gauge)	± 1.5% of set point

Figure 2: Table IV from ANSI B109.5-2024

B109.5 states that for an orifice greater than ½" and up to and including 1" shall use a setting flow of 200 SCFH of air (5.7 Sm3/h). Orifices larger than 1" shall use a setting flow of 400 SCFH of air (11.3 Sm3/h).

Controlling inlet pressure, outlet pressure, and flow ensures all test data effectively has the same starting point for the test. This process ensures that all manufacturers are advertising comparable test data. If a manufacturer uses a higher setting flowrate when establishing set point, it has the same effect as increasing set point above the advertised value. This can lead to inflated capacity data, high lock-up values, and misrepresentation of data to customers.

Other tests in Section 5 include Hysteresis, Lock-Up, Inlet Pressure Sensitivity, Flow Capacity, Relief Set Point, and the Shell Pressure Test. 2 of the most extensive tests in the standard, Endurance and Environmental testing. Endurance testing requires 100,000 cycles, fully open to fully closed, to simulate the life-cycle of a regulator. The Environmental testing requires a freezing rain test, to ensure operation as ice builds on the regulator.

Section 5.3.7: Flow Capacity

The test that requires the most labor hours to complete is the Flow Capacity tests specified in 5.3.7. The tests are relatively simple but must be redone for each combination of inlet pressure, orifice size, body size, and delivery pressure. The ANSI standards also call out accuracy requirements for these flow tests, shown below in Table V:

TABLE V

Set Point	Regulator Accuracy Range
X ≤ 14 inches w.c. gauge (3.48 kPa)	+ 2 inch w.c. / -1 inch w.c.
14 inches w.c. gauge (3.48 kPa gauge) < X < 1 psig (6.89 kPa gauge)	+ 2 inch w.c. / -2 inch w.c.
1 psig (6.89 kPa gauge) ≤ X ≤ 20 psig (138 kPa gauge)	± 1% absolute pressure

Figure 3: Table V from ANSI B109.5-2024

The accuracy requirements for set points below 1 psig are clearly defined, except it should be noted that most users allow 2” w.c. droop for 14” w.c. set points, so that is most commonly shared by manufacturers. Set points of 1 psig or higher require a calculation for the accuracy range. 1% of the absolute pressure is calculated by adding the atmospheric pressure to the gauge pressure before multiplying by 1%. For example, 1% Absolute (ABS) accuracy for a 2 psi gauge (psig) set point would be 1% of 16.7 psi absolute.

$$1\%\ ABS\ Accuracy = \frac{(2\ psig + 14.7\ psi)}{100}$$

This would give an accuracy band of +/- 0.167 psig from the 2-psig set point. This level of accuracy is commonly referred to as Fixed Factor Measurement (FFM) or Pressure Factor Measurement (PFM). Note that some manufacturers advertise their accuracy as a function of gauge pressure, but this is not covered in the ANSI standards. 10% gauge, or Accuracy Class 10 (AC10), for a 2-psig set point would give an accuracy range of +/- 0.2 psig, meaning this is a lower accuracy requirement than 1% ABS when the set point is 2 psig. However, for 1 psig set points, AC10 creates a tighter accuracy than 1% ABS. Since a meter requires volume, temperature, and pressure to accurately account for the amount of gas delivered, the pressure regulator plays a critical role in determining meter accuracy. So be sure to check that your manufacturer is advertising flow data according to the accuracy required for your meters.

The flow curve in Figure 2 shows a similar example for a 1 psig set point. The black lines represent the set point conditions, the dashed orange line represents AC10, and the solid red line represents 1% ABS. Note that the different accuracy classes don’t indicate any change to the regulator. They are simply different ways of calculating the acceptable amount of droop, or pressure variation, from set point.

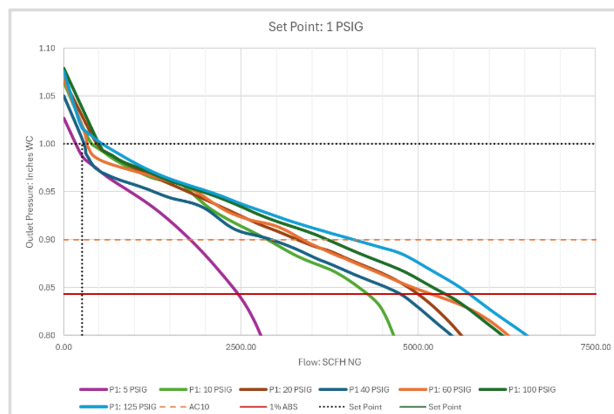


Figure 4: Example Flow Curve (Courtesy Cavagna Group)

You will also find that Appendix A specifies how these graphs should be prepared to ensure data is not distorted. If you are looking at ANSI B109 approved regulators, your supplier should be able to provide this data upon request.

Section 5.3.9: Internal Relief-Valve Performance Test

Arguably the most critical update in B109.5 is section 5.3.9 for the Internal Relief Valve Performance (IRV) Test. In the past, commercial regulator manufacturers could choose how to define a failure-mode for their IRV capacity curves. Decades ago, many used the "wire-across-the-seat" method to simulate debris impacting lock up. Then the industry migrated toward the Block-Open per Orifice Size, where the regulator would be mechanically blocked open a certain distance, which is calculated based on the orifice diameter. This change limited the capabilities of many older regulator designs.

For ANSI B109.5, gas utilities provided failure examples they had seen in the field, and it was determined that the Lever-Disconnect method should be adopted for the larger regulators. Lever-Disconnect testing is considered the worst-case failure mode and requires a much higher capacity IRV than other methods. A Lever-Disconnect test requires that the regulator is failed by disconnecting the linkage between the diaphragm and the valve mechanism. While lever disconnects are not common in the field, they can happen and it is the required IRV test method for ANSI B109.4 regulators. When reviewing IRV capacity charts, be sure to check for the defined failure mode used by the manufacturer.

Section 5.4: Slam-Shut Test Procedure

Section 5.4 test procedure for Slam-Shut devices was originally created for the 2021 version of B109.4. This section includes several tests that are very similar to the regulator test requirements in previous sections. There are some key differences in these test procedures as well.

First, the seat leakage test specifies the Slam-Shut must meet FCA/ANSI 70-3 Class VIII or better. This requirement is zero bubbles over the course of a minute and is most stringent shut off class in the 70-3 standard.

Next, the Slam-Shut set point procedure is fairly standard, but it must be repeated 25 times to ensure accuracy over the life-cycle of the device. The procedure also requires the regulator to be flowing at least 50% of the rated capacity for one test to verify set point under flowing conditions. After this, the data can be reviewed to determine the Accuracy Group (AG) by calculating the largest variation between the initial set point and the recorded activation points. This value is then compared to the table in Figure 5. AG is different from the Accuracy Class (AC) commonly used for regulators, but they are a similar concept.

TABLE IX

Accuracy Group	Allowed Tripping Pressure Deviation [a]
AG 1	+/ 1%[b]
AG 2.5	+/- 2.5%[b]
AG 5	+/- 5%
AG 10	+/- 10%
AG 20	+/- 20%
AG 30	+/- 30%

[a] setpoint deviation from gauge pressure
[b] or 0.5" wc whichever is greater

Figure 5: Table IX from ANSI B109.5-2024

The Endurance Test is similar to the regulator test, except that a portion of the cycles must be completed at the maximum and minimum advertised temperature. Some manufacturers complete regulator cycle testing at these advertised temperatures, but it is not required by the ANSI B109 standards.

Last, for Vibration Resistance, B109.5 refers to EN 14382. EN 14382 is the most comprehensive Slam-Shut standard available and is widely used across Europe where Slam-Shuts are common on most homes and even at district stations. This test requires that the Slam-shut is armed and connected to a piece of outlet piping. A weight will then be dropped onto the outlet pipe, while pressurized to just before the activation pressure, to ensure the Slam-Shut does not activate due to impact or vibration. This test is repeated 10 times, and the Slam-Shut cannot activate on any test. The test will be completed at pressures slightly lower than OPSO set points, and slightly higher than UPSO set points.

Section 5.5 and 5.6: Internal Monitor & Integral Monitor Test Procedure

These sections specify endurance testing and seat leakage testing for Internal Monitor & Integral Monitors as the same as the regulator. The Internal Monitor Lock-up test consists of simulating debris one-fourth of the orifice size, while the Integral Monitor Lock-up test requires a complete lever disconnect to simulate the worst-case failure.

Appendices

B109.5 includes 4 appendices. Appendix A provides guidelines for presentation of regulator performance data, to ensure that graphs are consistent among manufacturers. Appendix B and C list Metric and Imperial symbols, respectively. Finally, Appendix D lists the other ASMT, ASME, ANSI, and EN standards referenced in this standard.

Summary

The ANSI B109.5 standard is a great resource to ensure that regulator manufacturers are meeting minimum safety and quality standards for the natural gas industry. They also ensure that test data is completed and recorded in a defined procedure to allow users to easily evaluate which product is best suited for their system. ANSI standards are consistently updated, and any suggestions can be submitted through the AGA website listed below, where you can also find a link to purchase the standard.

The ANSI B109 committee meets at AGA conferences, following the Customer Field Services & Measurement committee meeting. All are welcome to attend the meetings and apply for committee membership.

References

ANSI B109.5-2024
ANSI B109.4-2021
AGA Website: https://www.aga.org/b109
Product bulletins from various manufacturers

Disclaimer

This article provides general information about the ANSI B109 standards. The words and other contents provided are not intended and should not be construed as warranties, guarantees, or technical advice. If a reader wants assistance, please refer to the relevant ANSI B109 standard.