Noise Mitigation in Regulator Stations

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Introduction

Natural gas regulator stations serve as critical assets in the gas distribution network. Their core objective is to reduce high pressure gas to the appropriate downstream system pressure. The process inevitably generates noise. With increased urbanization, more often is that our natural gas infrastructure is operating near urban communities. Thus, excessive noise generated can affect the communities' acceptance and compliance with state and municipal noise ordinances. However there exists mitigation strategies which would allow modernizing regulator stations to operate more quietly and efficiently.

Sources of Noise

The most predominant source of noise is the "Aerodynamic Noise" which is produced when high pressure gas experiences rapid expansion or turbulent flow. This typically occurs at orifices, expanders, bends or flow restrictors. Other type of

less common noise sources are "Structural" and "Mechanical". Structural noise is mainly cause by vibration energy transmitted through pipe radiating to the surrounding area. Mechanical noise originates from actual "mechanical" movements of components such as regulator operation, valve movement, or auxiliary systems such as odorizing equipment, analyzers or sampling equipment. Understanding the noise source is essential for determining the most effective noise mitigation method.

Noise Assessment Techniques

Assessing noise produced by regulator stations involves field measurements, acoustic modeling, and diagnostic evaluation. Field measurements require calibrated sound level meters, proper measurement distance, and consistent environmental conditions. A-weighted sound levels (dBA) are typically used for environmental assessments because they reflect human hearing sensitivity.

Engineers also apply acoustic modeling software to predict noise levels based on regulator type, gas conditions, and station geometry. Diagnostic evaluation techniques, including spectral analysis, are used to identify dominant frequency ranges and pinpoint specific noise sources such as regulator chatter or turbulent piping flow.

Sound Pressure Level and Noise Scale

Sound pressure level (SPL) is a logarithmic measure of the effective sound pressure relative to a reference value which is the quietest sound a healthy human ear can detect. That sound pressure level is expressed in decibels (dB). A logarithmic scale is essential because human hearing is logarithmic and not linear. A sound that is 10x intense is not 10x louder. For instance, the softest sound the ear can hear is (2×10^{-6} Pa) compared to a jet-engine (200Pa) that is a difference of a factor of 10 million. Additionally, the logarithmic scale allows us to combine noise levels at station much easier. Below is an illustrative noise levels with examples. Noise level values strongly depend on distance.

dBA	Example Source	Typical Distance	Notes
60	normal conversation	(3–10 ft)	Baseline ambient for "quiet areas"
70	odorizer pump	(3–10 ft)	Noticeably louder voice raised to communicate
80	Large portable air compressor; busy traffic curbside	(3–16 ft)	Hearing protection recommended for sustained exposure
90	Gas-powered lawnmower; diesel gen-set (small)	(16–33 ft)	OSHA action level exceeded over time; hearing protection required
100	Chainsaw; vent/relief event at distance	(33–82 ft)	Very loud—short exposures without hearing protection can be harmful
120	Emergency siren at close range;	(3–16 ft)	Pain threshold territory; immediate hearing protection essential
140	Jet engine near takeoff; explosive gas jet at nozzle	(3–6 ft)	Possible Instant ear damage; avoid proximity

Evaluating and Adding Multiple Nosie Sources

Evaluating multiple noise sources involves identifying, measuring, and quantifying noise contributions from regulators, expanders, and piping vibrations. Ideally each should be measured alone where possible or approximated using manufacture data.

Field measurements should be taken from a reference distance using calibrated sound level meter and under defined operating conditions. When field measurements aren't possible use API, AGA or manufacture-provided noise curves or acoustic modeling software. Additionally manufacture provided flow-noise equations can be used to estimate regulator noise. When sources of noise are measured from different distances normalizing the distance is needed to allow addition using the following equation $L_2 = L_1 - 20 \cdot \log_{10}(D_2/D_1)$. Where "D" is for distance and L for dB level.

Then for adding multiple noise sources, you must use logarithmic energy summation. This equation is essentially:

(1) Converting each (dB) value to linear intensity
(2) Summing up the intensities
(3) Converting back to dB level

$$L = 10 \, \mathrm{Log}_{10}\left(\sum_{i=1}^{n} 10^{(L_i/10)} \right)$$

Rules-of-Thumb can be used without a calculator in the field to approximately add (2) noise sources. This involves adding to the louder noise source a certain dB level based on the dB difference of the two sources. See below table. As you can notice, whenever the difference between two noise levels is greater than 10 dB the lower noise level source is negligible.

Difference	Add to louder source
0 dB	+3 dB
1 dB	+2.5 dB
2 dB	+2 dB
3 dB	+1.5 dB
5 dB	+1 dB
10 dB	+0 dB

Predominant Noise Sources

It has been found that the dominant noise from a regulator station is from "Aerodynamic Noise", since the addition of "Kinematic" and "Structural" noise are negligible. Targeting that source of noise is the most effective way to lower the station dB level. Furthermore, the aerodynamic noise from a station is also predominantly from the regulator and the pipping header. If the noise level caused by both is comparable, mitigating both sound sources would be essential for an effective total noise reduction.

The main cause for a "noisy" regulator is due to high flowrate; excessive pressure drops, regulator trim or regulator outlet size.

Mitigation Strategies Through Operational Improvements

Operational adjustments can significantly influence noise output. Among those strategies include:

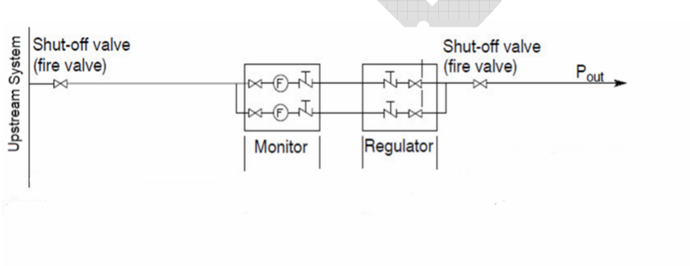
- Load shifting. This includes balancing flows between multiple regulators feeding a specified system. For example, operating two regulators at 50% each is usually much quitter than one at 100% since noise increases
- Avoiding large instantaneous pressure drop and thus relying on a multistage cut. A single large pressure drop creates higher turbulence and regulator seat vibration. The gradual pressure cut transition reduces the acoustic energy.

Mitigation Strategies Through Design Improvements

Design enhancements are available to reduce the noise effect of aerodynamic noise such as:

- Optimizing pipeline geometry by reducing the number of turns, increasing bend radii, and implementing flow conditioning devices. This reduces turbulence which contributes to elevated noise levels. These strategies are particularly important during the planning phase of regulator station upgrades or new installations**.**
- Increase header piping wall thickness.
- Increasing regulator downstream piping size to reduce velocity.
- Increase the regulator size to reduce acoustic noise created by the trim and regulator outlet size. Note, oversizing the regulator creates other problems and is not always the correct solution.
- Avoiding expanders larger than one pipe size.
- Avoid locating above ground stations near sound reflective surfaces that can redirect noise upward and sideways.
- Selecting low noise regulators. More details in the next section.

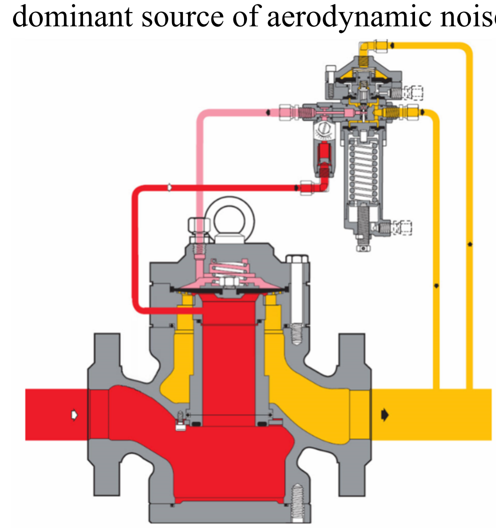
Below is an example of a single line station design that minimizes the number of turns and optimizes the amount of buried header piping.



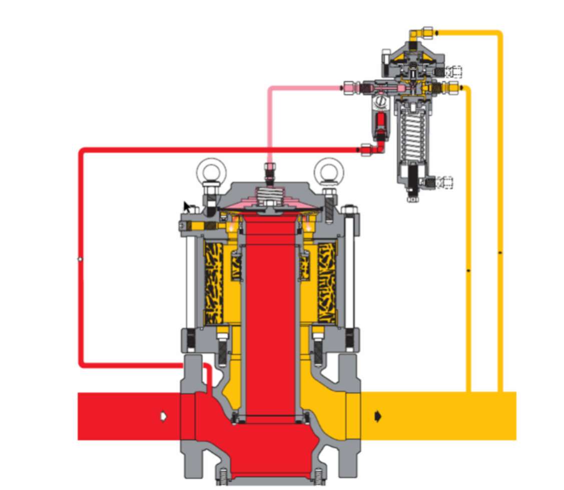
Regulators With Noise Attenuators

Regulators with built-in noise attenuators are designed to reduce the noise generated by gas pressure regulators, particularly the aerodynamic and mechanical noise produced when high-pressure gas flows through a regulator or a control valve. Below are the types of noise attenuators:

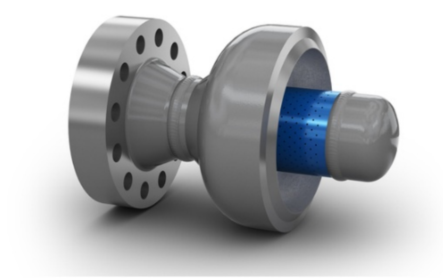
- Internal Noise Attenuation Trim. Manufactures design regulator trims differently, comparing different regulators based manufacturer noise approximations or through field testing maybe warranted. Generally, manufactures design the inlet side of the regulator (in red below) to optimize the opening to ensure smooth throttling and reduce turbulence at the initial pressure drop. Once the jet crosses the plug, (In orange below) the internal geometric profile of the regulator trim plays a main role to lower jet velocity and lessen turbulent mixing which is the dominant source of aerodynamic noise.



- Silencers. For installations requiring extra-low noise, an optional silencer can be added. This silencer further reduces dBA levels by smoothing expansion and absorbing high frequency components at the predominant noise source. Below example of a PF regulator with an added silencer option.



- Downstream Diffusers. These come in two different forms, either an integral part on the outlet side of the regulator or an in-line diffuser bolted against the regulator. The purpose of the diffuser is to split the total pressure drop with the regulator. Splitting the pressure drop with the regulator reduces noise. It also breaks the high velocity gas jet into many smaller jets, this reduces noise produced by downstream pipping due to high turbulence. Below is an image of an in-line diffuser that is typically added downstream of regulators. This diffuser has a perforated tube. To my knowledge PG&E has no experience with noise attenuating diffusers.



Mitigation Strategies Through Interrupting Noise Propagation

- The addition of acoustic insulation. This method is done by adding insulation to the "noisy sections. That could be around regulator, and pipping. This method is relatively easy but less effective.
- Placing regulator station within underground vaults and burying as much of the header pipping as possible.
- Installing regulator stations inside a building.
- Install acoustic barrier walls around the above-ground station. Barrier performance depends on placing the walls as close to the noise-generating equipment as possible and ensuring they are tall enough to block direct line-of-sight between the source and the receiver. The walls should be constructed with acoustically rated materials and designed to withstand outdoor environmental conditions.

Conclusion

Noise control is essential for regulatory compliance, community relations and operational excellence. Understanding these interactions among noise sources is critical for an effective mitigation method. Also, designing stations with aerodynamic noise reduction in mind particularly with regulator selection and piping layout is the most effective strategy.

Biography

Belal graduated from UC Berkeley with a degree in mechanical engineering. He has worked in the natural gas industry for 13 years. Focusing on designing natural gas facilities. Prior to joining PG&E, he designed wellhead gas production and processing facilities. At PG&E he has supported modernization of the company's gas storage, transmission and distribution system.