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Monitor Regulator Installation

A monitor type regulator installation consists of two regulators installed in series with the downstream control line of both units connected to the line downstream of both units; one unit adjusted for the desired control pressure, the other for a slightly higher pressure. Which of the two units is used as the monitor varies greatly with companies. It varies all over the country. It also varies intra-company depending upon the pressures involved and the type of regulating equipment used.

Capacity wise, it makes no significant difference which of the two units is the monitor. At a given pressure drop across the installation, from the inlet of the first unit to the outlet of the second unit, the installation will pass a certain quantity of gas. This is so, and it makes no difference which of the units is adjusted for the higher downstream pressure (monitor). When monitors were first used, there was a difference of opinion on this point. In fact, the statement was made in an AGA Distribution Report compiled several years ago on monitor regulators that if the first regulator was made the control regulator, a larger monitor would be required. They were still thinking in terms of a double reduction, rather than what occurs in a monitor set, namely that the inlet pressure to the second unit varies with the flow rate. At a given pressure drop across the set you have a maximum flow rate, and at this point the pressure between the two units will be the same value regardless of which is which.

At maximum flow rate, the intermediate pressure between the two units runs from ≅ 76.7 percent of the inlet pressure into the set. If the pressure drop across the set is above critical flow, the intermediate pressure is:

$P_0 = 4/5\ P_1$ below critical flow;	P_1 = inlet pressure psi
	P_2 = outlet pressure psi
$P_0 = P_1 - 2/5\ (P_1 - P_2)$	P_0 = intermediate pressure psi

If the monitor regulator is first in the line, the intermediate pressure at zero flow is 100% of the inlet pressure, and as flow begins the intermediate pressure decreases until maximum flow is attained and the intermediate pressure becomes ≅ 76.7 percent of the inlet.

If the control regulator is first in the line, the intermediate pressure at zero flow is equal to the lock-up pressure of the control regulator, and as flow begins the intermediate pressure increases until maximum flow is attained and the intermediate pressure becomes ≅ 76.7 percent of the inlet.

As a final example of the capacity question, picture two orifice plates in a line. With the flow from left to right at a given pressure drop, you will have a certain flow. If you reverse the flow from right to left, with the same given pressure drop, will there be any difference in flow rate?

Reasons for Upstream Control Regulator

1. The primary control regulator, instead of the monitor, is initially exposed to the adverse effects of transient particles.

   One of the things a monitor set is to protect is the inability of a regulator to close when it is required. With an upstream monitor being in the wide open position, something might become lodged in the valve which would prevent its closing when required. Such object would probably not be detected. The differential pressure across the monitor would change slightly but the pressure chart would not disclose this since generally it is recording only the performance of the downstream control regulator - unless the obstruction were of sufficient magnitude to reduce the capacity materially and effect a drop in controlled pressure.

   With an upstream control regulator, the pressure chart would disclose an object lodged in the valve - the pressure would rise if the regulator were unable to close, or there would be a momentary dip as the regulator changed its differential. Also, since the valve would be generally in a throttling position, it would be unlikely that an object would pass through the control regulator and then become lodged in the downstream monitor, whose valve would be in the wide open position. Due to the greater turbulence in the gas stream as it exists from the control regulator, the downstream monitor tends to remain relatively free from foreign matter.

2. The pressure surge after abrupt failure of the primary control regulator should be less.

   Since the intermediate pressure is generally of a lower value and the differential across the downstream monitor is lower, less gas should pass through it before it can pick up control.

3. The packing device used in the first unit to seal off the outlet side of the body from the diaphragm chamber would generally be working at a lower differential pressure. It would be the same differential as across the monitor - it would start out low and increase to maximum flow, rather than start out high and decrease.

4. The downstream control line of the control regulator is elongated, rather than that of the monitor.

   The safety device (monitor) would be less exposed to damage.

5. If a pilot loaded or instrument loaded regulator is used as the control regulator, the supply line to the pilot is shorter.

   NOTE: When pilots are used, the supply line to both pilots should always be upstream of the first unit and a load limiting regulator is recommended.

6. If a pilot loaded regulator is used as the control regulator and a self-operated regulator as the monitor, it is better to have the monitor downstream.

   This is a little difficult to visualize, but it is caused by the change in the intermediate pressure as the flow rate changes and its effect on the setpoint of the first unit, if it is a self-operated type of regulator. A pilot operated type can correct for this change in forces.

   When a self-operated regulator is used first in the line as a monitor, the intermediate pressure is on the outlet side of the body exerting a closing force on the lower valve. The stem continues up through the diaphragm to atmospheric pressure up in the spring housing. The valve is thus unbalanced by the area of this stem. Also here, as we previously mentioned, the intermediate pressure starts out high and decreases as the flow rate increases. This means that if you adjust the setpoint of the monitor during low flow, you have a higher closing force being exerted on this regulator. As the flow increases, the closing force decreases and the setpoint of the monitor becomes higher, since the spring will now balance a greater outlet pressure. Conversely, if you make the initial setting of the monitor at high flow rate, the setpoint of the monitor decreases as the flow decreases.

   By placing the monitor downstream, a steady pressure is maintained on the outlet side by the control regulator, and the monitor setpoint remains constant.

Reasons for Upstream Monitor

Of the advantages discussed, the first three apply mainly to high pressure installations such as town border stations.

1. Temperature of the flowing gas is relatively higher, tending to minimize freezing problems.

   True, since you are making the major reduction downstream of the monitor. But, at maximum flow rate the temperature loss across the set should be the same - part of it at the monitor, part of it at the control regulator.

2. Pressure losses across the monitor are held to a minimum because of the greater density of high pressure gas.

   Probably true, but it doesn't affect the capacity of the set.

3. Noise emanating from monitor is minimized because of lower gas stream velocities.

   Maybe true, but one would think less noise would originate from a regulator which is wide open than from one which is throttling, so you may increase the noise at the control regulator.

4. For a monitor set reducing pounds to ounces and using two spring loaded regulators, such as our Model 461-S or 441-S spring loaded, it is preferable to use the upstream monitor.

   Due to the variation in the intermediate pressure mentioned previously, it is preferable to have the setpoint of the monitor change rather than the setpoint of the control regulator change. The upstream monitor allows the control regulator to hold a steadier delivery pressure. Wherever possible, it is preferable to use the same spring in each so that their operating characteristics are the same.

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Capacities

On its basis of a series of capacity tests, monitor sets of two similar regulators passed 70-76 percent of the capacity of one regulator, or of the mean capacity of two different size regulators. Therefore, a 70 percent factor is suggested for sizing monitor sets. If two different size regulators are used, the smaller regulator must be capable of achieving the maximum required rated capacity. The following illustrates this method of sizing:

Example #1

1. Pressure reduction 100 to 20 psi $\therefore$ $Fpr = \frac{\text{absolute inlet pressure}}{2} = \frac{100 + 14.4}{2} = 57.2$
2. Required maximum flow = 200,000 cfh $\therefore$ Monitor set capacity = $\frac{200{,}000}{.7}$ = 286,000 adjusted flow
3. Required $K = \frac{\text{adjusted flow}}{Fpr} = \frac{286{,}000}{57.2} = 5000$

Use two 2" 441-57S 1¾" valves or 2" 441-VPC Pilot Loaded as Control with 1¾" valves
& 2" 441-57S Spring Loaded as Monitor with 1¾" valves
Maximum capacity = 5450 x 57.2 x .7 = 218,200 cfh of monitor set using two regulators of the same size.

Example #2

1. Pressure reduction 100 to 20 psi $\therefore$ $Fpr = \frac{\text{absolute inlet pressure}}{2} = \frac{100 + 14.4}{2} = 57.2$
2. Required maximum flow = 100,000 cfh $\therefore$ Monitor set capacity = $\frac{100{,}000}{.7}$ = 143,000 adjusted flow
3. Required $K = \frac{\text{adjusted flow}}{Fpr} = \frac{143{,}000}{57.2} = 2500$

You need two regulators having a mean K value of 2500. Checking the K values on the tables, two #461 Regulators with 1" double seat are too small, and two 2" #441 with 1½" balanced value too large. A monitor set comprising two different regulators is suggested. Use a 2" 461-57S or 2" 1100 as the control regulator, and a 2" 441-57S as the monitor.

2" 461-57S	1" valves	K = 2000
2" 441-57S	1½" valves	K = 4270

Mean K value = $\frac{2000 + 4270}{2} = \frac{6270}{2} = 3135$

The monitor set comprised of two different regulators in **Example #2** would be acceptable because:
The capacity of the smaller regulator = Fpr x K = 57.2 x 2000 = 114,400 cfh, which is greater than the required 100,000 cfh *and:*
The maximum capacity of the monitor set = 57.2 x 3135 x .7 = 125,500 cfh, which is greater than the required 100,000 cfh.
When using two different sizes, it is preferable to use the larger regulator downstream.

Pilot Operated Regulators

Two things should be considered when both regulators are this type.

1. The lock-up pressure will be higher than if a self-operated monitor is used, since at zero flow the lock-up pressure of the monitor will prevail, regardless of which is first in the line.

   After the control regulator closes, the pilot bleed of the monitor acts as a by-pass building up the downstream pressure to the point at which the monitor pilot closes.

2. Many pilot operated regulators, such as the 1100 or 441-VPC, include a small relief valve to protect the main diaphragm against excessive loading pressure. To avoid excessive chattering of this relief valve, a small regulator should be installed on the inlet to the monitor pilot. By limiting inlet pressure to a lower value (as recommended by the regulator manufacturer) loading pressure cannot increase to the level where chattering occurs even though the pilot itself is wide open.