# Lessons Learned

## From Natural Gas STAR Partners

# OPTIONS FOR REDUCING METHANE EMISSIONS FROM PNEUMATIC DEVICES IN THE NATURAL GAS INDUSTRY

## Executive Summary


Pneumatic devices powered by pressurized natural gas are used widely in the natural gas industry as liquid level controllers, pressure regulators, and valve controllers. Methane emissions from pneumatic devices, which have been estimated at 51 billion cubic feet (Bcf) per year in the production sector, 14 Bcf per year in the transmission sector and <1 Bcf per year in the processing sector, are one of the largest sources of vented methane emissions from the natural gas industry. Reducing these emissions by replacing high-bleed devices with low-bleed devices, retrofitting high-bleed devices, and improving maintenance practices can be profitable.

Natural Gas STAR partners have achieved significant savings and methane emission reductions through replacement, retrofit, and maintenance of high-bleed pneumatics. Partners have found that most retrofit investments pay for themselves in little over a year, and replacements in as little as 6 months. To date, Natural Gas STAR partners have saved 36.4 Bcf by retrofitting or replacing high-bleed with low-bleed pneumatic devices, representing a savings of $254.8 million worth of gas. Individual savings will vary depending on the design, condition and specific operating conditions of the controller.


| Method for Reducing Methane Emissions | Volume of Natural Gas Savings (Mcf/yr) | Value of Natural Gas Savings ($/yr)[1] | Cost of Imlementation ($) | Payback (Months) |
|---|---|---|---|---|
| **Replacement:** | | | | |
| Change to low-bleed device at end of life. | 50 to 200 | 350 to 1,400 | 210 to 340[2] | 3 to 8 |
| Early-replacement of high-bleed unit. | 260 | 1,820 | 1,850 | 13 |
| **Retrofit** | 230 | 1,610 | 675 | 6 |
| **Maintenance** | 45 to 260 | 315 to 1,820 | Negligible to 500 | Immediate to 4 |

[1]Cost of gas $7.00/Mcf.
[2]Incremental cost of low-bleed over high-bleed equipment.

This is one of a series of Lessons Learned Summaries developed by EPA in cooperation with the natural gas industry on superior applications of Natural Gas STAR Program Best Management Practices (BMPs) and Partner Reported Opportunities (PROs).

## Technology Background

The natural gas industry uses a variety of control devices to automatically operate valves and control pressure, flow, temperature or liquid levels. Control devices can be powered by electricity or compressed air, when available and economic. In the vast majority of applications, however, the gas industry uses pneumatic devices that employ energy from pressurized natural gas.

Natural gas powered pneumatic devices perform a variety of functions in all three sectors of the natural gas industry. In the production sector, an estimated 400,000 pneumatic devices are used to control and monitor gas and liquid flows and levels in dehydrators and separators, temperature in dehydrator regenerators, and pressure in flash tanks. In the processing sector, about 13,000 gas pneumatic devices are used for compressor and glycol dehydration control in gas gathering/booster stations and isolation valves in processing plants (process control in gas processing plants is predominantly instrument air).

In the transmission sector, an estimated 85,000 pneumatic devices actuate isolation valves and regulate gas flow and pressure at compressor stations, pipelines, and storage facilities. Non-bleed pneumatic devices are also found on meter runs at distribution company gate stations for regulating flow, pressure, and temperature.

As part of normal operation, pneumatic devices release or bleed natural gas to the atmosphere and, consequently, are a major source of methane emissions from the natural gas industry. The actual bleed rate or emissions level largely depends on the design of the device.

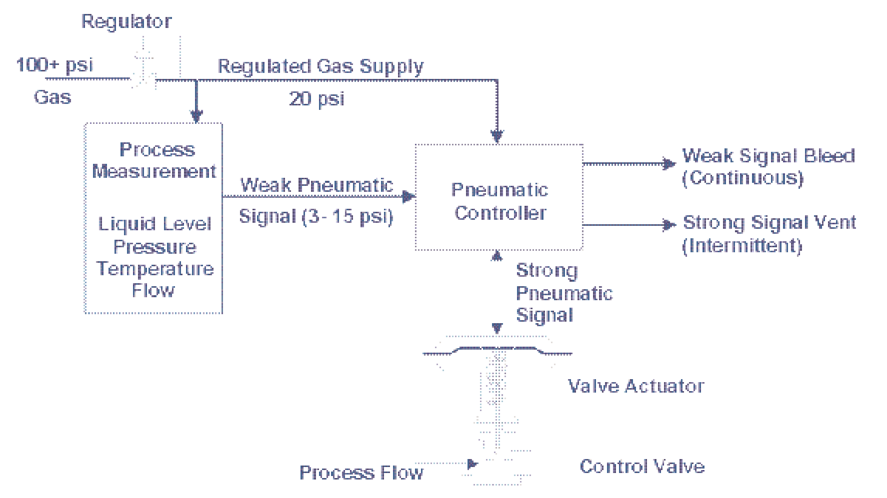
**Definition of High-Bleed Pneumatic**

Any pneumatic device that bleeds in excess of 6 scfh (over 50 Mcf per year) is considered a high-bleed device by the Natural Gas STAR Program.

Exhibit 1 shows a schematic of a gas pneumatic control system. Clean, dry, pressurized natural gas is regulated to a constant pressure, usually around 20 psig. This gas supply is used both as a signal and a power supply. A small stream is sent to a device that measures a process condition (liquid level, gas pressure, flow, temperature). This device regulates the pressure of this small gas stream (from 3 to 15 psig) in proportion to the process condition. The stream flows to the pneumatic valve controller, where its variable pressure is used to regulate a valve actuator.

To close the valve pictured in Exhibit 1, 20-psig pneumatic gas is directed to the actuator, pushing the diaphragm down against the spring, which, through the valve stem, pushes the valve plug closed. When gas is vented off the actuator, the spring pushes the valve back open. The weak signal continuously vents (bleeds) to the atmosphere. Electro-pneumatic devices use weak electric current instead of the weak gas stream to signal pneumatic valve actuation.

**Exhibit 1: Pneumatic Device Schematic**




In general, controllers of similar design usually have similar steady-state bleed rates regardless of brand name. Pneumatic devices come in three basic designs:

★ **Continuous** bleed devices are used to modulate flow, liquid level, or pressure and will generally vent gas at a steady rate;

★ **Actuating or intermittent** bleed devices perform snap-acting control and release gas only when they stroke a valve open or closed or as they throttle gas flows; and

★ **Self-contained** devices release gas into the downstream pipeline, not to the atmosphere.

To reduce emissions from pneumatic devices the following options can be pursued, either alone or in combination:

1. Replacement of high-bleed devices with low-bleed devices having similar performance capabilities.
2. Installation of low-bleed retrofit kits on operating devices.
3. Enhanced maintenance, cleaning and tuning, repairing/replacing leaking gaskets, tubing fittings, and seals.

Field experience shows that up to 80 percent of all high-bleed devices can be replaced with low-bleed equipment or retrofitted. Exhibit 2 lists the generic options applicable for different controller requirements.

**Exhibit 2: Options for Reducing Gas-Bleed Emissions by Controller Type**

| Action | Pneumatic Types | | |
|---|---|---|---|
| | Level Controllers | Pressure Controllers | Positioners/ Transducers |
| Replacements<br>High-bleed with low-bleed | X | X | X<br>(electro-pneumatic) |
| Retrofits<br>Install retrofit kits | X | X | X |
| Maintenance<br>Lower gas supply pressure/replace springs/re-bench | X | X | X |
| Repair leaks, clean and tune | X | X | X |
| Change gain setting | X | X | |
| Remove unnecessary positioners | | | X |

In general, the bleed rate will also vary with the pneumatic gas supply pressure, actuation frequency, and age or condition of the equipment. Due to the need for precision, controllers that must operate quickly will bleed more gas than slower operating devices. The condition of a pneumatic device is a stronger indicator of emission potential than age; well-maintained pneumatic devices operate efficiently for many years.

## Economic and Environmental Benefits

Reducing methane emissions from high-bleed pneumatic devices through the options presented above will yield significant benefits, including:

★ **Financial return from reducing gas-bleed losses.** Using a natural gas price of $7.00 per thousand cubic feet (Mcf), savings from reduced emissions can range from $315 to $1,820 or more per year per device. In many cases, the cost of implementation is recovered in less than a year.

★ **Increased operational efficiency.** The retrofit or complete replacement of worn units can provide better system-wide performance and reliability and improve monitoring of parameters such as gas flow, pressure, or liquid level.

★ **Lower methane emissions.** Reductions in methane emissions can range from 45 to 260 Mcf per device per year, depending on the device and the specific application.

## Decision Process

Operators can determine the gas-bleed reduction option that is best suited to their situation, by following the decision process laid out below. Depending on the types of devices that are being considered, one or more options for reducing pneumatic gas bleed may be appropriate.

**Five Steps for Reducing Methane Emissions from Pneumatic Devices:**

1. Locate and describe the high-bleed devices;
2. Establish the technical feasibility and costs of alternatives;
3. Estimate the savings;
4. Evaluate the economics; and
5. Develop an implementation plan.

**Step 1: Locate and describe the high-bleed devices.** Partners should first identify the high-bleed devices that are candidates for replacement, retrofit, or repair. The identification and description process can occur during normal maintenance or during a system-wide or facility-specific pneumatics survey. For each pneumatic device, record the location, function, make and model, condition, age, estimated remaining useful life, and bleed rate characteristics (volume and whether intermittent or continuous).

The pneumatic device's bleed rate can be determined through direct measurement or from data provided by the manufacturer. Direct measurement might include bagging studies at selected instruments, high-volume sampler measurements (see "Directed Inspection and Maintenance at Compressor Stations" Lessons Learned) or the operator's standard leak measurement approach. Operators will find it unnecessary to measure bleed rates at each device. In most cases, sample measurements of a few devices are sufficient. Experience suggests that manufacturers' bleed rates are understated, so measurement data should be used when it can be acquired.

Appendix A lists brand, model, and gas bleed information—as provided by manufacturers—for various pneumatic devices. This is not an exhaustive list, but it covers the most commonly used devices. Where available, actual field data on bleed rates are included.

**Step 2: Establish the technical feasibility and costs of alternatives.** Nearly all high-bleed pneumatic devices can be replaced or retrofitted with lower-bleed equipment. Consult your pneumatic device vendor or an instrumentation specialist

Some high-bleed devices, however, should not be replaced with low-bleed devices. Control of very large valves that require fast and/or precise response to process changes often require high-bleed controllers. These are found most frequently on large compressor discharge and bypass pressure controllers. EPA recommends contacting vendors for new fast-acting devices with lower bleed rates.

for availability, specifications and costs of suitable devices. Low-bleed devices can be requested by specifying bleed rates less than 6 standard cubic feet per hour (scfh). It is important to note that not all manufacturers report bleed rates in the same manner, and companies should exercise caution when making purchases of low-bleed devices.

Appendix B lists cost data for many low-bleed pneumatic devices and summarizes the compatibility of retrofit kits with various controllers. This is not an exhaustive list, but it covers the most commonly used devices.

## Nelson Price Indexes

In order to account for inflation in equipment and operating & maintenance costs, Nelson-Farrar Quarterly Cost Indexes (available in the first issue of each quarter in the *Oil and Gas Journal*) are used to update costs in the Lessons Learned documents.

The "Refinery Operation Index" is used to revise operating costs while the "Machinery: Oilfield Itemized Refining Cost Index" is used to update equipment costs.

To use these indexes in the future, simply look up the most current Nelson-Farrar index number, divide that by the February 2006 Nelson-Farrar index number, and, finally, multiply by the appropriate costs in the Lessons Learned.

Maintenance of pneumatics is a cost-effective method for reducing emissions. All companies should consider maintenance as an important part of their implementation plan. Cleaning and tuning, in addition to repairing leaking gaskets, tubing fittings, and seals, can save 5 to 10 scfh per device. Tuning to operate over a broader range of proportional band often reduces bleed rates by as much as 10 scfh. Eliminating unnecessary valve positioners can save up to 18 scfh per device.

**Step 3: Estimate the savings.** Determine the quantity of gas that can be saved with a low-bleed controller, using field measurement of the high-bleed controller and a similar low-bleed device in service. If these actual bleed rates are not available, use bleed specifications provided by manufacturers.

Gas savings can be monetized to annual savings using $7.00 per Mcf and multiplying bleed reduction, typically specified in scfh, by 8,670 hours per year.

Gas Savings = (High-bleed, scfh) — (Low-bleed, scfh)

Annual Gas Savings = Gas Savings (scfh) * 8,760 hrs/yr * 1 Mcf/1000scf * $7.00/Mcf

**Step 4: Evaluate the economics.** The cost-effectiveness of replacement, retrofit, or maintenance of high-bleed pneumatic devices can be evaluated using straightforward economic analysis. A cost-benefit analysis for replacement or retrofit is appropriate unless high-bleed characteristics are required for operational reasons.

Exhibit 3 illustrates a cost-benefit analysis for replacement of a high-bleed liquid level controller. Cash flow over a five-year period is analyzed by showing the magnitude and timing of costs (shown in parenthesis) and benefits. In this example, a $513 initial investment buys a level controller that saves 19 scfh of gas. At $7.00 per Mcf, the low-bleed device saves $1,165 per year. Annual maintenance costs for the new and old controllers are shown. The maintenance cost for the older high-bleed controller is shown as a benefit because it is an avoided cost. Net present value (NPV) is equal to the benefits minus the costs accrued over five years and discounted by 10 percent each year. Internal rate of return (IRR) is the discount rate at which the NPV generated by the investment equals zero.

**Exhibit 3: Cost-Effectiveness Calculation for Replacement**

| Type of Costs | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|---|
| Implementation Costs, $ (Capital Costs)[1] | (513) | | | | | |
| Annual Savings, $ (New vs. Old)[2] | | 1,165 | 1,165 | 1,165 | 1,165 | 1,165 |
| Maintenance Costs, $ (New Controller)[3] | | (34) | (34) | (34) | (34) | (34) |
| Avoided Maintenance, $ (Replaced Controller)[3] | | 70 | 70 | 70 | 70 | 70 |
| Net Benefit | (513) | 1,202 | 1,202 | 1,202 | 1,202 | 1,202 |

NPV[4] = $4,042
IRR = 234%

Notes:
[1] Quoted cost of a Fisher 2680 device. Adjusted to 2006 equipment costs. See Appendix B.
[2] Annual savings per device calculated as the change in bleed rate of 19 scfh x 8,760 hrs/yr = 167 Mcf/yr at $7/Mcf.
[3] Maintenance costs are estimated.
[4] Net Present Value (NPV) based on 10% discount rate for 5 years.

Exhibit 4 illustrates the range of savings offered by proven methods for reducing gas bleed emissions. For simplicity, it is assumed that the cost of maintenance of the pneumatic device will be the same before and after the replacement, retrofit, or enhanced maintenance activity.

As seen in Exhibit 4, sometimes more than one option to reduce gas bleed may be appropriate and cost-effective for a given application. For the listed options, please note that the payback period with respect to implementation cost can range from less than one month to two years.

| Exhibit 4: Economic Benefits of Reducing Pneumatic Device Emissions | | | | | |
|---|---|---|---|---|---|
| **Action** | **Cost[1]** ($) | **Bleed Rate Reductions[2]** (Mcf/yr/device) | **Annual Savings[3]** ($/year) | **Payback Period** (Months) | **IRR[4]** (%) |
| Replacement | | | | | |
| Level Controllers | | | | | |
| High-bleed to low-bleed | 513 | 166 | 1,165 | 6 | 226 |
| Pressure Controllers | | | | | |
| High-bleed to low-bleed | 1,809 | 228 | 1,596 | 14 | 84 |
| Airset metal to soft-seat | 104 | 219 | 1,533 | <1 | >1,400 |
| Retrofit | | | | | |
| Level Controllers | | | | | |
| Mizer | 675 | 219 | 1,533 | 6 | 226 |
| Large orifice to small | 41 | 184 | 1,288 | <1 | >3,100 |
| Large nozzle to small | 189 | 131 | 917 | 3 | >450 |
| Pressure Controllers | | | | | |
| Large orifice to small | 41 | 184 | 1,288 | <1 | >3,100 |
| Maintenance | | | | | |
| All types | | | | | |
| Reduce supply pressure | 207 | 175 | 1,225 | 3 | >500 |
| Repair leaks, retune | 31 | 44 | 308 | 2 | >900 |
| Level Controllers | | | | | |
| Change gain setting | 0 | 88 | 616 | immediate | --- |
| Positioners | | | | | |
| Remove unnecessary | 0 | 158 | 1,106 | immediate | --- |

[1] Implementation costs represent average costs for Fisher brand pneumatic instruments installed.
[2] Bleed rate reduction = change in bleed rate scf/hr x 8,760 hr/yr.
[3] Savings based on $7.00/Mcf cost of gas.
[4] Internal rate of return (IRR) calculated over 5 years.

## Methane Content of Natural Gas

Non-associated natural gas found in the production sector contains approximately 78.8% methane and pipeline quality natural gas found in the transmission sector contains approximately 93% methane. Methane emission reductions can be approximated by applying the appropriate methane content to the natural gas savings calculated in this document.

| Exhibit 5: Case Studies on Retrofits To Reduce Gas Leaks at Natural Gas STAR Partner Sites | | | | | |
|---|---|---|---|---|---|
| **Study** | **Implementation Costs ($)** | **Emissions Reductions (Mcf/yr)** | **Annual Savings ($/yr)** | **Payback (Months)** | **IRR (%)** |
| Company 1: | | | | | |
| Platform 1 | 8,988 | 2,286 | 16,002 | 7 | 177 |
| Platform 2 | 13,892 | 3,592 | 25,144 | 7 | 180 |
| Retrofit Liquid-level controllers | 5,452 | 1,717 | 12,019 | 6 | 220 |
| Company 2: | | | | | |
| Per device | 702 | 219 | 1,533 | 6 | 218 |

The case studies in Exhibit 5 above present analyses performed and savings achieved by two Natural Gas STAR partners who installed retrofit kits at gas production facilities.

**Step 5: Develop an implementation plan.** After identifying the pneumatic devices that can be profitably replaced, retrofitted or maintained, devise a systematic plan for implementing the required changes. This can include modifying the current inspection and maintenance schedule and prioritizing replacement or retrofits. It may be most cost-effective to replace all those devices that meet the technical and economic criteria of your analysis at one time to minimize labor costs and disruption of operation.

Where a pneumatic device is at the end of its useful life and is scheduled for replacement, it should be replaced with a low-bleed model instead of a new high-bleed device whenever possible.

When assessing options for replacement of high bleed pneumatic devices, natural gas price may influence the decision making process. Exhibit 6 shows an economic analysis of early replacement of a high bleed pneumatic device with a lower bleed device at different natural gas prices.

| Exhibit 6: Gas Price Impact on Economic Analysis | | | | | |
|---|---|---|---|---|---|
| | **$3/Mcf** | **$5/Mcf** | **$7/Mcf** | **$8/Mcf** | **$10/Mcf** |
| **Value of Gas Saved** | $780 | $1,300 | $1,820 | $2,080 | $2,600 |
| **Payback Period (Months)** | 29 | 18 | 13 | 11 | 9 |
| **Internal Rate of Return (IRR)** | 31% | 64% | 95% | 110% | 139% |
| **Net Present Value (i=10%)** | $1,107 | $3,078 | $5,049 | $6,035 | $8,006 |

## Other Technologies

Instrument air, nitrogen gas, electric valve controllers, and mechanical control systems are some of the alternatives to gas powered pneumatics implemented by partners.

- ★ **Instrument Air.** These systems substitute compressed, dried air in place of natural gas in pneumatic devices, and thus eliminate methane emissions entirely. Instrument air systems are typically installed at facilities where there is a high concentration of pneumatic control valves and full-time operator presence (for example, most gas processing plants use instrument air for pneumatic devices). The major costs associated with instrument air systems are capital and energy. Instrument air systems are powered by electric compressors, and require the installation of dehydrators and volume tanks to filter, dry and store the air for instrumentation use. Generally, partners have found that cost-effective implementation of instrument air systems is limited to field sites with available utility or self-generated electrical power. The Lessons Learned study, "Covert Gas Pneumatic Controls to Instrument Air," provides a detailed description of the technical and economic decision process required to evaluate conversion from gas pneumatic devices to instrument air.
- ★ **Nitrogen Gas.** Unlike instrument air systems that require capital expenditures and electric power, these systems only require the installation of a cryogenic liquid nitrogen cylinder, that is replaced periodically, and a liquid nitrogen vaporizer. The system uses a pressure regulator to control the expansion of the nitrogen gas (i.e., the gas pressure) as it enters the control system. The primary disadvantage of these systems stems from the cost of liquid nitrogen and the potential safety hazard associated with using cryogenic liquids.
- ★ **Electric Valve Controllers.** Due to advances in technology, the use of electronic control instrumentation is increasing. These systems use small electrical motors to operate valves and therefore do not bleed natural gas into the atmosphere. While they are reliant on a constant supply of electricity, and have high associated operating costs, they have the advantage of not requiring the utilization of natural gas or a compressor to operate.
- ★ **Mechanical Control Systems.** These devices have been widely used in the natural gas and petroleum industry. They operate using a combination of springs, levers, flow channels and hand wheels. While they are simple in design and require no natural gas or power supply to operate, their application is limited due to the need for the control valve to be in close proximity to the process measurement. Also, these systems are unable to handle large flow fluctuations and lack the sensitivity of pneumatic systems.

Each of these options has specific advantages and disadvantages. Where Natural Gas STAR partners do install these systems as replacements to gas powered pneumatic devices, they should report the resulting emissions reductions and recognize the savings.

### One Partner's Experience

Marathon Oil Company surveyed 158 pneumatic control devices at 50 production sites using the Hi-Flow Sampler to measure emissions. Half of these controllers were identified as non-bleed devices (e.g. weighted dump valves, spring operated regulators, enclosed capillary temperature controllers, non-bleed pressure switches). High-bleed devices accounted for 35 of 67 level controllers, 5 of 76 pressure controllers, and 1 of 15 temperature controllers. Measured gas emissions were 583 scfh total; 86 percent of emissions came from level controllers, with leaks up to 48 scfh, and averaging 7.6 scfh. Marathon concluded that "control devices with higher emissions can be identified qualitatively by sound prior to leak measurement, making it unnecessary to quantitatively measure methane emissions using technologically advanced equipment."

### One Partner's Experience

Union Pacific Resources replaced 70 high-bleed pneumatic devices with low-bleed pneumatic devices and retrofitted 330 high-bleed pneumatic devices. As a result, this partner has estimated a total reduction of methane emissions of 49,600 Mcf per year. Assuming a gas price of $7 per Mcf, the savings corresponds to $347,200. The costs of replacing and retrofitting all the devices, including materials and labor, is $166,300 at 2006 costs, resulting in a payback period of less than one year.

## Lessons Learned

Natural Gas STAR partners offer the following Lessons Learned:

- Hear it; feel it; replace it. Where emissions can be heard or felt, this is a sign that emissions are significant enough to warrant corrective action.
- Control valve cycle frequency is another indicator of excessive emissions. When devices cycle more than once per minute, they can be replaced or retrofitted profitably.
- Manufacturer bleed rate specifications are not necessarily what users will experience. Actual bleed rates will generally exceed manufacturer's specifications because of operating conditions different from manufacturer's assumptions, installation settings and maintenance.
- Combine equipment retrofits or replacements with improved maintenance activities. Do not overlook simple solutions such as replacing tubes and fittings or rearranging controllers.

- ★ The smaller orifices in low-bleed devices and retrofit kits can be subject to clogging from debris in corroded pipes. Therefore, pneumatic supply gas piping and tubing should be flushed out before retrofitting with smaller orifice devices, and gas filters should be well maintained.
- ★ When replacing pneumatic control systems powered by pressurized natural gas with instrument air or other systems, do not forget to account for the savings from the resulting methane emission reductions.
- ★ Include methane emission reductions from pneumatics in annual reports submitted as part of the Natural Gas STAR Program.

## References


Burlage, Brian, Fisher Controls International, Inc., personal contact.

Colwell, Chris, Masoneilan, personal contact.

Fisher Controls International, Inc. *Pneumatic Instrument Gas Bleed Reduction Strategy and Practical Application.*

Frese, Jack, Norriseal, personal contact.

Garvey, J. Michael, DFC Becker Operations, personal contact.

Hankel, Bill, Ametek - PMT Division, personal contact.

Henderson, Carolyn, U.S. EPA Natural Gas STAR Program, personal contact.

Husson, Frank, ITT Barton, personal contact.

Loupe, Bob, Control Systems Specialist Inc., personal contact.

Murphy, John, Bristol Babcock, personal contact.

Radian Corporation. *Pneumatic Device Characterization.* Draft Final Report, Gas Research Institute and U.S. Environmental Protection Agency, January 1996.

Tingley, Kevin, U.S. EPA Natural Gas STAR Program, personal contact.

Wilmore, Martin R., Shafer Valve Company, personal contact.

Ulanski, Wayne. *Valve and Actuator Technology.* McGraw-Hill, 1991.

# Appendix A

The following chart contains manufacturer-reported bleed rates. Actual bleed rates have been included whenever possible. Discrepancies occur due to a variety of reasons, including:

★ Maintenance.

★ Operating conditions.

★ Manufacturer vs. operating assumptions.

It is important to note that manufacturer information has not been verified by any third party and there may be large differences between manufacturer-reported bleed rates and those found during operations. Until a full set of information is available, companies should be careful to compare bleed rates in standard units (CFH) when comparing manufacturers and models. During this study we found that manufacturers reported information in a wide range of different units and operating assumptions.

| Gas Bleed Rate for Various Pneumatic Devices | | | |
|---|---|---|---|
| Controller Model | Type | Consumption Rate (CFH) | |
| | | Manufacturer Data | Field Data (where available) |
| High-Bleed Pneumatic Devices | | | |
| **Fisher 4100 Series | Pressure controller (large orifice) | 35 | |
| **Fisher 2500 Series | Liquid-level controllers (P.B. in mid range) | 10-34 | 44-72 |
| *Invalco AE-155 | Liquid-level controller | | 44-63 |
| *Moore Products – Model 750P | Positioner | 42 | |
| *Invalco CT Series | Liquid-level controllers | 40 | 34-87 |
| **Fisher 4150/4160K | Pressure controller (P.B. 0 or 10) | 2.5-29 | |
| **Fisher 546 | Transducer | 21 | |
| **Fisher 3620J | Electro-pneumatic positioner | 18.2 | |
| Foxboro 43AP | Pressure controller | 18 | |
| **Fisher 3582i | Electro-pneumatic positioner | 17.2 | |
| **Fisher 4100 Series | Pressure controller (small orifice) | 15 | |
| **Fisher DVC 6000 | Electro-pneumatic positioner | 14 | |
| **Fisher 846 | Transducer | 12 | |
| **Fisher 4160 | Pressure controller (P.B. 0.5) | 10-34 | |
| **Fisher 2506 | Receiver controller (P.B.0.5) | 10 | |
| **Fisher DVC 5000 | Electro-pneumatic positioner | 10 | |
| **Masoneilan 4700E | Positioners | 9 | |
| **Fisher 3661 | Electro-pneumatic positioner | 8.8 | |

| | | | |
|---|---|---|---|
| **Fisher 646 | Transducer | 7.8 | |
| **Fisher 3660 | Pneumatic positioner | 6 | |
| **ITT Barton 335P | Pressure controller | 6 | |
| *Ametek Series 40 | Pressure controllers | 6 | |
| | **Low or No-Bleed Pneumatic Devices** | | |
| **Masoneilan SV | Positioners | 4 | |
| **Fisher 4195 Series | Pressure controllers | 3.5 | |
| **ITT Barton 273A | Pressure transmitter | 3 | |
| **ITT Barton 274A | Pressure transmitter | 3 | |
| **ITT Barton 284B | Pressure transmitter | 3 | |
| **ITT Barton 285B | Pressure transmitter | 3 | |
| **Bristol Babcock Series 5457-70F | Transmitter | 3 | |
| **Bristol Babcock Series 5453-Model 624-II | Liquid-level controllers | 3 | |
| **Bristol Babcock Series 5453-Model 10F | Pressure controllers | 3 | |
| **Bristol Babcock Series 5455 Model 624-III | Pressure controllers | 3 | |
| **ITT Barton 358 | Pressure controller | 1.8 | |
| **ITT Barton 359 | Pressure controller 1.8 | 1.8 | |
| **Fisher 3610J | Pneumatic positioner | 16 | |
| **Bristol Babcock Series 502 A/D | Recording pneumatic controllers | <6 | |
| **Fisher 4660 | High-low pressure pilot | <5 | |
| **Bristol Babcock Series 9110-00A | Transducers | 0.42 | |
| Fisher 2100 Series | Liquid-level controllers | 1 | |
| **Fisher 2680 | Liquid level controllers | <1 | |
| *Norriseal 1001 (A) (snap) | Liquid-level controller | 0.2 | 0.2 |
| *Norriseal 1001 (A) | Liquid-level controller | 0.007 | 0.007 |
| *Norriseal 1001 (A) (throttle) | Liquid-level controller | 0 | 0 |
| **Becker VRP-B-CH | Double-acting pilot pressure control system (replaces controllers and positioners) | 0-10 | |
| **Becker HPP-5 | Pneumatic positioner (Double Acting) | 0-10 | |
| **Becker EFP-2.0 | Electro-pneumatic positioner | 0 | |
| **Becker VRP-SB | Single-acting pilot pressure control system (replaces controllers and positioners) | 0 | |

| | | | |
|---|---|---|---|
| **Becker VRP-SB GAP Controller | Replaces pneumatic "gap" type controllers | 0 | |
| **Becker VRP-SB-PID Controller | Single-acting pilot pressure control system specifically designed for power plant type feeds (replaces controllers and positioners) | 0 | |
| **Becker VRP-SB-CH | Single-acting pilot pressure control system (replaces controllers and positioners) | 0 | |
| **Becker HPP-SB | Pneumatic positioner (Single Acting) | 0 | |
| **Actuator Model** | **Size** | **Manufacturer Data** | **Field Data** |
| *Shafer RV-Series | 33" x 32" | 1,084 | |
| Rotary Vane Valve | 36" x 26" | 768 | |
| Actuators | 26" x 22" | 469 | |
| | 25" x 16" | 323 | |
| | 20" x 16" | 201 | |
| | 16.5" x 16" | 128 | |
| | 14.5" x 14" | 86 | |
| | 12.5" x 12" | 49 | |
| | 12" x 9" | 22 | |
| | 11" x 10" | 32 | |
| | 9" x 7" | 12 | |
| | 8" x 6.5" | 8 | |
| | 6.5" x 3.5" | 6 | |
| | 5" x 3" | 6 | |
| **Actuator Model** | **Size** | **Number of Snap-acting Strokes per CF** | **Number of Throttling Strokes per CF** |
| **Fisher Valve Actuators | 20 | 21 | 39 |
| **Fisher Valve Actuators | 30 | 12 | 22 |
| **Fisher Valve Actuators | 34/40 | 6 | 10 |
| **Fisher Valve Actuators | 45/50 | 3 | 5 |
| **Fisher Valve Actuators | 46/50 | 2 | 3 |

* Last updated in 1996.

** Last updated in 2001.

# Appendix B

| Controllers Compatible with MIZER Retrofits | |
|---|---|
| **Type** | **Brand/model Number** |
| Liquid-level controllers | C.E. Invalco – 215, 402, AE-155 |
| | Norriseal – 1001, 1001A |
| Pressure controllers | Norriseal - 4300 |

| Suggested Retail Prices for Various Brand Low-Bleed Pneumatic Devices (Estimates Based on Best Information Available at Time of Publication) | |
|---|---|
| **Brand/Model** | **Price per Device** |
| **ITT Barton 335P (pressure controller) | $920 |
| **ITT Barton 273A (pressure transmitter) | $1,010 |
| **ITT Barton 274A (pressure transmitter) | $1,385 |
| **ITT Barton 284B (pressure transmitter) | $1,605 |
| **ITT Barton 285B (pressure transmitter) | $1,990 |
| **ITT Barton 340E (recording pressure controller) | $1,400 |
| **ITT Barton 338E (recorder controller) | $2,800 |
| **Ametek Series 40 (pressure controllers) | $1,100 (average cost) |
| **Becker VRP-B-CH | $1,575.00 |
| **Becker HPP-5 | $1,675.00 |
| **Becker VRP-SB | $1,575.00-$2,000.00 |
| **Becker VRP-SB-CH-PID | $2,075.00 |
| **Becker VRP-SB-CH | $1,575.00 |
| **Becker HPP-SB | $1,675.00 |
| **Mizer Retrofit Kits | $400-$600 |
| **Fisher 67AFR (airset regulators) | $80 |
| **Fisher 2680 (liquid-level controllers) | $380 |
| **Fisher 4195 (pressure controllers) | $1,340 |
| **Bristol Babcock Series 9110-00A (transducers) | $1,535-$1,550 |
| **Bristol Babcock Series 5453 (controllers) | $1,540 |
| **Bristol Babcock Series 5453 40 G (temperature controllers) | $3,500 |
| **Bristol Babcock Series 5457-624 II (controllers) | $3,140 |
| **Bristol Babcock Series 502 A/D (recording controllers) | $3,000 |
| **Bristol Babcock Series 5455-624 III (pressure controllers) | $1,135 |
| **Bristol Babcock Series 5453-624 II (liquid level controllers) | $2,345 |
| **Bristol Babcock Series 5453-10F (pressure controllers) | $1,440 |

* Last updated in 1996.

** Last updated in 2001.

1EPA

United States
Environmental Protection Agency
Air and Radiation (6202J)
1200 Pennsylvania Ave., NW
Washington, DC 20460

EPA xxx
xxx 2006