FUEL GAS BEST MANAGEMENT PRACTICES

Efficient Use Of Fuel Gas in Pneumatic Instruments

MODULE 3 of 17

SUBMITTED BY: CETAC WEST

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CETAC-WEST is a private sector, not-for-profit corporation with a mandate to encourage advancements in environmental and economic performance in Western Canada. The corporation has formed linkages between technology producers, industry experts, and industry associates to facilitate this process. Since 2000, CETAC-WEST has sponsored a highly successful eco-efficiency program aimed at reducing energy consumption in the Upstream Oil and Gas Industry.

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Background

The issue of fuel gas consumption is increasingly important to the oil and gas industry. The development of this Best Management Practice (BMP) Module is sponsored by the Canadian Association of Petroleum Producers (CAPP), the Gas Processing Association Canada (GPAC), the Alberta Department of Energy, Small Explorers and Producers Association of Canada (SEPAC), Natural Resources Canada (NRC) and the Energy Resources and Conservation Board (ERCB) to promote the efficient use of fuel gas in pneumatic instruments used in the upstream oil and gas sector. It is part of a series of 17 modules addressing fuel gas efficiency in a range of devices.

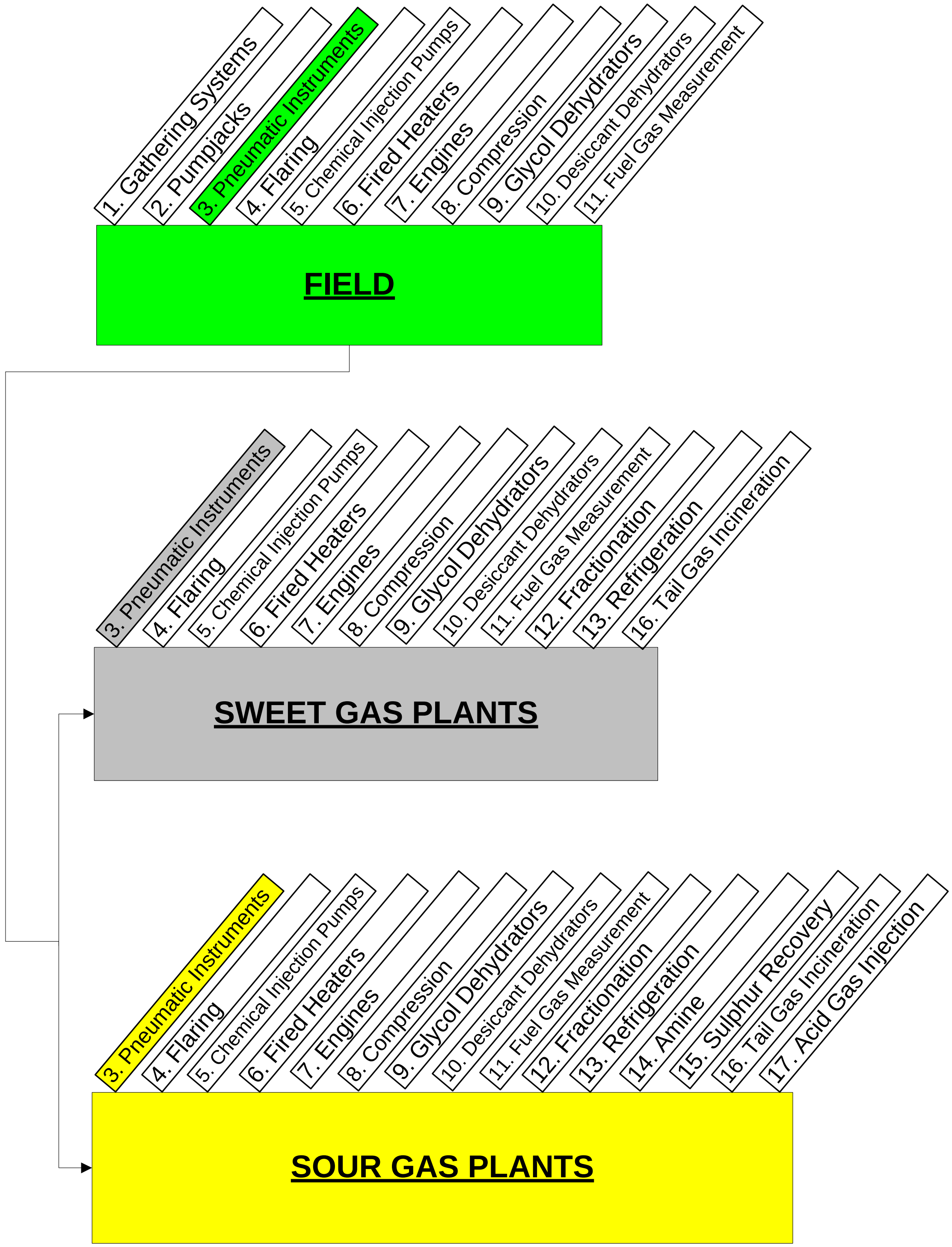
This BMP Module:

- identifies the typical impediments to achieving high levels of operating efficiency with respect to fuel gas consumption,
- presents strategies for achieving cost effective improvements through inspection, maintenance, operating practices and the replacement of underperforming components, and
- identifies technical considerations and limitations.

The aim is to provide practical guidance to operators for achieving fuel gas efficient operation while recognizing the specific requirements of individual pneumatic instruments and their service requirements.

EFFICIENT USE OF FUEL GAS
IN THE UPSTREAM OIL AND GAS INDUSTRY

MODULE 3 of 17: Pneumatic Instruments



1. Applicability and Objectives

Pneumatic instruments of all types are used throughout the oil and gas industry to perform the necessary functions which enable the production, processing, transfer and refining of petroleum products. Instrumentation is used to take measurements and control processes typically by sending a signal to a valve to adjust its position based on changes in the process conditions. Controllers can be used to control the process based on pressure, temperature, flow or liquid level. Because of the simplicity and reliability of pneumatic instrumentation as well as the lack of available electricity in many locations, pneumatic instrumentation has become the standard in the industry.

Pneumatic instruments may be powered by compressed air, natural gas or propane. However, the ready availability of pressurized natural gas has made it the energy of choice for instrumentation. In spite of the cost of natural gas and emissions to the atmosphere, its use as an energy source continues to dominate for the following reasons:

- Pneumatic instrumentation is simple and reliable, making it easy for field operators to adjust and repair.
- Reliable electricity is not available or economical at many locations.
- Electrical instrumentation can be many times the cost and in some cases does not meet the process control requirements.
- Low Bleed instrumentation is now available.
- Retrofit kits are available for high bleed instrumentation still in place.
- Conversion to air at larger facilities still requires pneumatic instrumentation.
- Most operators have considerable experience with pneumatic instruments.

There has long been a misunderstanding in the industry that the amount of gas pneumatic controllers bleed is insignificant. Work performed for the United States Environmental Protection Agency has shown that the largest source of methane emissions in the industry comes from pneumatic instrumentation. Fifty percent of all vented gas and 15 to 20 percent of total emissions in the United States (U.S.) are said to come from pneumatic instrumentation. The production segment accounts for 69 percent of these emissions in the US and it is likely that a similar percentage applies in Canada. Gas storage and transmission account for most of the remainder. In the US, venting from pneumatic instruments is estimated to be in the order of 61 billion standard cubic feet (Bscf) per year. In Canada the estimate is between 12 and 25 Bscf per year of gas being vented to the atmosphere through pneumatic instrumentation. Assuming a price of CDN$6 per 1000 scf, the value of vented gas is between $75 and $150 million dollars per year.

There are about 100,000 gas wells in Western Canada, the majority in remote locations without power. Although pressurized natural gas is the primary power source for pneumatic controllers, about 30 percent of the wells are sour gas wells which use bottled propane as the energy source to drive the pneumatics. Propane venting, like natural gas, adds to both the cost and environmental impact of operating pneumatic devices. In many cases propane is much more costly than natural gas due to trucking and logistics.

Typical pneumatic instruments used in the Canadian oil and gas industry are listed in the Instrument Table (Appendix B) and in general vent between 3 and 50 standard cubic feet per hour (scfh). A single device venting at 30 scfh will use 262,500 ft^3 in a year, more than $1,500 per year in lost reserves (assuming a gas price of CDN$6 per 1000scf) in addition to approximately 97 tonnes of CO_2 equivalent (CO_2E) emissions. The several hundred thousand pneumatic controllers in operation today, present a significant opportunity to reduce emissions and increase sales of natural gas.

Technology exists today to dramatically reduce this venting and at the same time have a positive economic impact on oil and gas operations. In addition to the large economic benefits there are many side benefits including:

- reducing emissions of GHGs,
- reducing odors which reduces landowner complaints,
- increasing worker safety, and
- reducing fire hazards.

This document discusses the different types of pneumatic instrumentation, gas consumption from these devices, and field optimization to improve both the economics and environmental aspects of operating pneumatic instrumentation. The best management practices presented here, both in text and in the form of a flowchart, are practical steps to minimize the amount of venting from pneumatic devices.

2. Basic Improvement Strategy

The critical factors to ensuring a successful long term strategy to optimize fuel gas consumption from field wide operations are to educate personnel to recognize opportunities, and to perform field optimization using logical steps. Efficient operation of pneumatic devices requires:

- a database or inventory of pneumatic devices,
- knowledge of the instrumentation, typical field bleed rates and alternatives,
- routine maintenance and repair of any problems, and
- optimization of existing equipment performance by implementing appropriate technology.

2.1 Technology and Equipment

When looking at the basic improvements to reduce fuel gas consumption it is imperative that there is understanding of the device, its application, limitations and the operational conditions that may affect its performance. This information provides the basis for an assessment on an individual device. Appendix A provides background on pneumatic devices; types, applications, fuel gas consumption and performance.

2.2 Efficiency Assessment

In order to optimize the performance of pneumatic instrumentation, it is recommended that the followings steps be implemented.

- Conduct a comprehensive <u>Field Survey</u>.
- Undertake <u>Field Measurements</u> to establish vent rates.
- <u>Review data</u> to identify opportunities for improvement.
- Evaluate <u>Economic and Environmental</u> options.
- <u>Implement</u> preferred options.

Section 5 provides details on each step and an easy to follow flowchart.

2.3 Training and Expertise

Pneumatic instruments are not complicated. However, they do control important processes which must be understood prior to working on an individual device. The basic assessment of the equipment should be performed by someone with adequate background in instrumentation, or by an experienced operator who understands pneumatic instruments. Prior to performing large scale field optimization both operational personnel and a local pneumatic instrumentation specialist should be involved.

3. Inspection, Monitoring and Record Keeping

Operators should record the pneumatic instruments testing and improvement program. Proper record keeping should assist in ensuring that sub-optimal instrumentation and devices are identified and that appropriate follow-up actions are implemented. This information will also assist in establishing the checking/testing frequency, to achieve cost-effective fuel gas efficiency improvements.

Although each company will define its record keeping system, consideration should be given to recording and retaining the following information:

- data sheets for each type of instrument in service,
- expected fuel gas consumption by device or system,
- records of changes/upgrades that have been performed,
- test results, and
- the economic analysis performed on high bleed instruments, where they have been adjusted/modified on economic grounds.

Appendix B provides the expected fuel gas consumption for the most common instruments and devices that are in use in the upstream oil and gas (UOG) industry.

4. Rapid Feasibility Assessment

4.1 Types of Pneumatic Devices

Pneumatic devices can be divided into three principle categories: Continuous Bleed, Intermittent Bleed, and No-Bleed. These categories are important when looking at the potential opportunity for optimizing your processes in terms of reducing gas venting.

The design of the instrumentation is a major factor in how much the device will vent or bleed. Both continuous bleed and intermittent bleed devices can be either high bleeders or low bleeders. In general terms high bleed devices have been categorized as those that bleed more than 6 scfh. This bleed rate does not include vent gas from any actuators. The instrument table in Appendix B outlines the devices that are throttling (continuous bleed) and snap acting (intermittent bleed) as well as manufactured specified bleed rates and where available field measured bleed rates. It is important to be aware that not all manufacturers use the same standards to measure bleed rates in the laboratory and typically results in field applications will be higher.

Continuous Bleed Devices or Throttling Devices

These include controllers, transducers and positioners. These devices are used to control flow, pressure, temperature and liquid level. Continuous bleed instrumentation is necessary for proportional control of the process, and is suitable where a steady state environment is desired.

Throttling devices continuously bleed because the design requires a constant supply and venting of gas in order for the controller to function. This bleed rate is steady when the process is steady and will change when the process changes. In addition to the continuous bleed of the controller, additional venting occurs when the actuator strokes.

Figure 1 demonstrates how a continuous bleed device known as a “flapper-nozzle” arrangement functions. The flapper-nozzle designed pressure controller (item e) gets its constant feed of supply gas from a pressure regulator (item f). This gas is used to operate the controller. For the controller to function properly it requires a constant source of supply pressure. The industry standard is either 20 or 35 psi. The controller is connected to the pipeline (item b) and the control valve (item c). The pipeline connection is where the measuring takes place. A measuring device, in this case a bourdon tube (item h), is attached to a flapper assembly (item i). As pressure increases or decreases the, bourdon tube reacts by moving the flapper assembly either closer or further away in relation to a fixed nozzle assembly (item k). When the pressure increases the bourdon tube will move the flapper closer to the fixed nozzle assembly creating a restriction of gas flow coming from the nozzle. Back pressure created in the nozzle will be transmitted to a relay device through the outlet (item j), opening a valve within that device, allowing output pressure to be diverted to the control valve. The valve opens according to the amount of output pressure transmitted. This allows pipeline pressure to decrease back to the desired set point predetermined inside the controller, bringing balance to the process loop (item a).

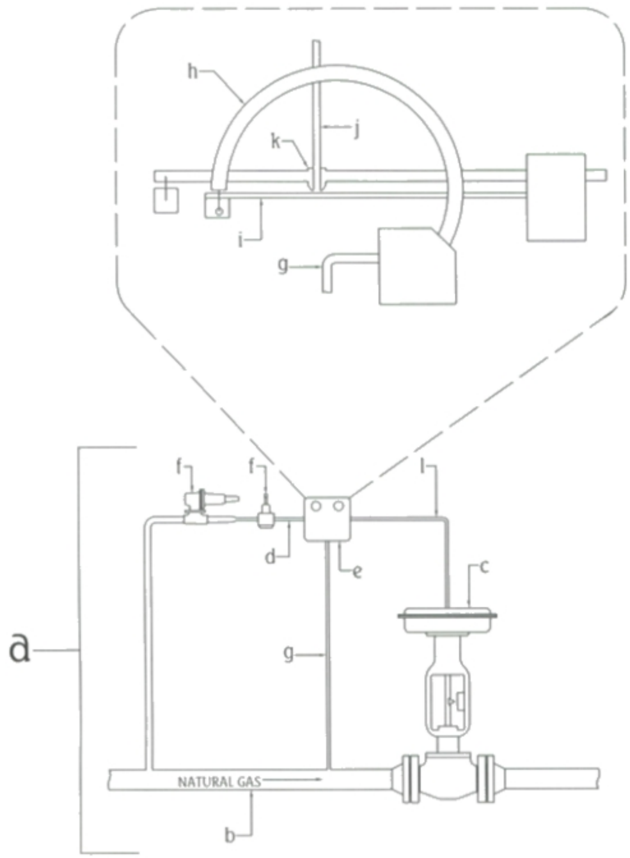


Figure 1
Flapper Nozzle Control Loop

Intermittent Bleed or Snap Acting Devices

These devices bleed only when the process requires a change. These devices are typically used for level control, or emergency shut down (ESD) operations. When no action is required no gas is used. When a situation occurs requiring a valve to operate this type of device reacts by sending a full output signal to the valve. Intermittent Bleed and snap acting devices are “all or nothing” controllers, that is, they are either on or off, no proportionality.

Refer to Figure 2 as an example of a snap acting device. When no action is required the supply valve is seated against the supply port prohibiting the movement of instrument gas, thus creating a no bleed situation. As level rises in the tank the flapper bar also rises. When the flapper bar rises it lifts the exhaust valve, pushing the supply valve upward. This action results in the closing of the exhaust port and the opening of the supply port, allowing gas to flow freely from the supply port through the output port to the control valve. At this time no gas has been vented to the atmosphere. With the liquid in the tank now flowing through the control valve, the level decreases. A decrease in level will eventually lower the flapper bar causing the exhaust valve to lower, allowing the supply valve to reseat the supply port, prohibiting the flow of supply gas. This action will also result in the opening of the exhaust port allowing the gas that was used to open the control valve to escape or bleed to atmosphere, eventually closing the valve and completing the cycle.

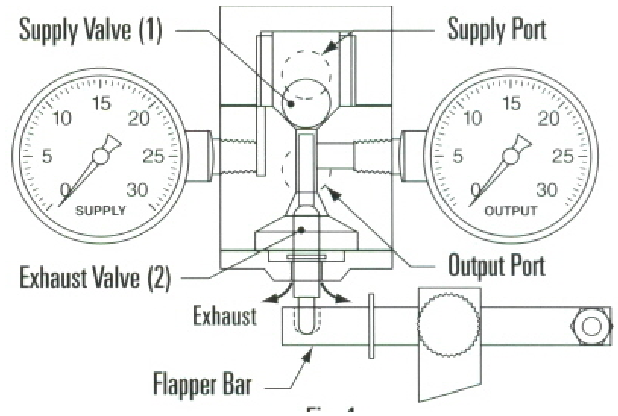


Figure 2
Wellmark 2001NB Snap Acting Pilot

No Bleed or Self Contained Devices

These devices include regulators, and most switches. These will not be discussed as they do not vent to the atmosphere.

4.2 Performance of Pneumatic Instrumentation

The amount an individual instrument vents is dependent on several factors, some of which we have control over after the instrument is purchased and some of which we do not. The factors affecting bleed rates of individual instruments are listed below in order of importance:

Instrument Design

The design of any instrument dictates how the device will bleed (Intermittent or Continuous) and how much it will bleed. As discussed above, instruments are classified as either high bleed or low bleed devices. High bleed, meaning they bleed at over 6 scfh and in some cases over 100 scfh. The design can be altered using a low bleed retrofit kit that is adaptable to many instruments, in effect changing the design and lowering the bleed rate. These low bleed retrofit kits are available from several manufacturers. Field results have shown that between 10 and 60 scfh is the typical saving after implementing a replacement low bleed device or retrofitting an existing device. In general these devices reduce gas consumption from 65 to 95 percent.

Appendix E is a case study describing two applications of low bleed retrofits. This case study was chosen as it contains both a typical controller and one not very typical which has a very low bleed rate for its design. Both have very good gas reductions but the lower bleed device would have a slower payback.

Device Condition

Device condition is a very important factor in keeping the bleed rates low. If the instrument is not maintained the parts will become dirty and worn. Dirt and particles in the moving parts will cause the device to operate out of its designed parameters and typically result in excessive venting. Field results have demonstrated that instrumentation in poor condition bleed 5 to 10 scfh more than they should. Typical problems include:

- worn seals, gaskets, and diaphragms resulting in leaks,
- nozzle corrosion or wear from poor quality gas leading to increased flow, and
- loose control tube fittings.

Gas Supply Pressure

The supply gas pressure directly affects the bleed rate of instrumentation. The supply pressure should be either 20 pounds per square inch (psi) (for 3-15 psi signal) or 35 psi (for 6-30 psi signal) depending on the instrument design. However it is common to see pressures significantly higher than the design of the instrument resulting in excess gas being vented through the device. The regulator must be set to the proper supply pressure. In some cases the process may have changed significantly and where once a 35 psi signal 6-30 output was needed for proper control, a 20 psi signal 3-15 psi output can now achieve the same result. This will have a significant effect on venting rates.

Controller Tuning

Controllers out of tune are more active, resulting in non-steady state operation, causing higher bleed rates from both the controller and the actuator. Tuning controllers on a periodic basis will maintain optimal conditions and reduce emissions.

Controller Features

The number of internal controls such as proportional band and reset contribute to the overall bleed rate of a controller. The common pressure controller shown in Figure 3 has several adjustments. Depending on the application these internal controls may play a significant role in the bleed rate of the controller. In many applications the reset valve can be removed resulting in less bleeding while still permitting proper control.

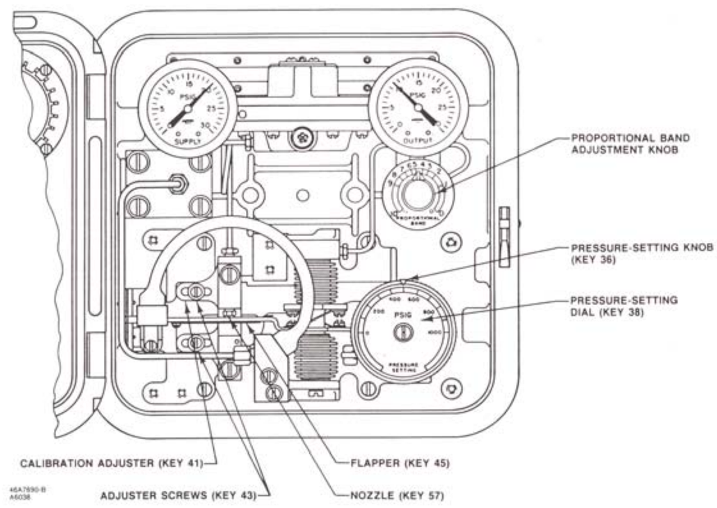


Figure 3
Common Pressure Controller

Age of Instruments

The age of the instrument can be a factor in vent rates although not as important as condition. Worn parts are typically a sign of age which may increase venting; however, if the device has been properly maintained and tuned then age have less effect on emission rates.

5. Operational Checks, Testing and Adjustments

In order to optimize the performance of pneumatic instrumentation, it is recommended that a program including the followings steps be implemented:

- Conduct a comprehensive field survey.
- Undertake field measurements to establish vent rates.
- Data review to identify opportunities for improvement.
- Perform economic/environmental evaluation of options.
- Implementation of preferred options.

5.1 Field Survey

Before starting a field survey a rough calculation can be made to determine the field wide opportunity for fuel gas savings. An approximation of the gas consumption can be obtained by taking the number of control loops and multiplying it by 60 scfh per control loop. Using this information as a rough guide gives a sense of the opportunity available for reducing emissions.

To determine what the opportunity in any field or operation may be, the first step is to understand what instrumentation is currently in place. The most efficient way to do this is to assign a person familiar with the field and instrumentation to complete a table similar to that below. The table should allow additional room for notes as shown in Appendix C (Field Survey). Keeping the table short and concise allows the operator to be efficient during the field survey process. The task should be focused on getting all the correct information as efficiently as possible.

The field survey should be restricted to the following pneumatic instrument types: pressure, temperature, level, differential pressure controllers, transducers, positioners and transmitters.

A quick check to ensure all field data has been collected prior to leaving a location is to count the pneumatic operated valves and compare it with the number of control devices; they should be the same.

Location LSD	Facility Description	Manufacturer	Model	Output Range	Supply Pressure	Throttle or Snap	Condition	Gas Type	Retrofit

Location LSD - This is the Land Survey Description.

Facility Description - Type of facility: well site, metering station, plant, separator, etc.

Manufacturer - The manufacturer of the instrument should be on the identification plate.

Model - This is also located on the identification plate.

Output Range - This can also be found on the identification plate.

Supply Pressure - If there is a gauge downstream of the regulator read the supply pressure here, otherwise it can be taken from the controller. Many times the controller gauges are inaccurate; however it may be the only option. Ensure the units (kPa or psi) are recorded.

Throttle or Snap Acting - This is important for level control only and indicates the design style of the controller. This may be indicated on the pilot or relay with an “S” for snap or “T” for throttle. The indication may also be located on the identification plate.

Condition - The condition of the controller should be indicated by either good or poor.

- Good - clean, no visible signs of wear and tear, gauges operating properly, no irregular sound or feel due to excessive venting of gas.
- Poor - any signs of wear and tear, dirty, fluid in controller, louder than normal venting, venting can be felt with fingers and is clearly high, door gasket in poor condition, non functioning gauges, visible corrosion around nozzle/pilot device.

Gas Type - This will typically be either fuel gas, propane, or air.

Retrofit - Has the device already been retrofitted with a low bleed kit? The retrofit may be located on the tubing between the instrument and the valve or directly inside the controller. Some training will be required to recognize these devices.

5.2 Field Measurements

The most accurate information for quantifying bleed rates from pneumatic instruments comes from field measurements, but this data is not always available. The Instrument Table in Appendix B outlines the field data available for many instruments. If there is no field data for your particular instrument, and you have a significant number of these devices, then you should perform field measurements to obtain accurate data. Statistical methods can be applied to ensure that a representative sample is taken.

Different field measurement techniques have been used to quantify the amount of vent gas coming from pneumatic instrumentation and some are more accurate than others. Because of the relatively low emission rates and pressures from individual instruments it is important to ensure that proper methodology is followed and accurate instruments are used when gathering data from these devices. When dealing with low volumes a small mistake can lead to a large error in measurement.

Vent gas from controllers does not necessarily leave the controller through the vent line. In many cases the controller will be leaking gas around the door or through fittings attached to the controller body. Not understanding this may lead to erroneous results when measuring vent gas. To ensure that all of the gas is vented through the vent line when measuring vent rates, the instrument needs to be bagged. A plastic bag encloses the instrument and is taped tightly using duct tape to force any fugitive emissions through the vent line. This ensures an accurate measure of the total venting from the controller.

An accurate meter needs to be selected that measures very low flow at near atmospheric pressure. The meter should be attached to the vent line and the fittings “snooped” to ensure no leaks are present. The total flow should be measured over as long a time as practical (at least one hour) to ensure accuracy of the data. A longer time will give a more representative measure of any flow rate changes that may occur as a result of process variations.

The data should then be converted to standard conditions of pressure and temperature and presented in terms of scfh.

5.3 Data Review

After the survey is complete the data needs to be reviewed to assess the opportunity for reducing emissions. By comparing the collected field data with the Instrument Table in Appendix B, you can determine how many high bleed devices are in the field. The Instrument Table provides bleed rates for these devices based on both manufacturer specifications and field data gathered from various sources. Experience suggests that manufacturer bleed rates are understated so field measurement data should be used when possible. If there is no field data available, field measurements should be performed on your instruments; however, it will be impractical to physically measure all bleed rates from all instruments. Focus should be applied to the instruments of which there are significant numbers in the field.

To begin the assessment of the field data refer to the flowchart in Appendix D. The first step in the flowchart is to determine the feasibility of converting all instruments to compressed air. The electrical power source for the instrument air must also be reliable as instrument air is required continuously. Conversion to instrument air is most viable when a facility wide change is already planned. A second benefit is the extension of life of the instrumentation because, unlike natural gas, no by products are present in air, which can harm the instrument. No effort in this paper has been made to specify the economic feasibility of converting to instrument air because each facility is different.

Knowing if an instrument is high or low bleed is the most relevant variable in assessing the opportunity for savings and the best return on investment. Low bleed devices in instrument air packages are also beneficial as maintenance costs can be reduced by reducing air consumption. If a field has already been converted to low bleed devices then tuning, and maintaining instruments will provide continuing benefits.

By referencing the flowchart in Appendix C along with the field data a complete assessment of each device can be made.

5.4 Economic/Environmental Evaluation

After reviewing the field survey data, the opportunities for gas savings should be understood, and whether additional field measurements are required. The devices which need to be replaced, retrofitted or repaired should be listed.

The primary driver is almost always economics. Using field measurements where possible, calculate the reduction in gas consumption based on either replacement to a low bleed device or retrofit with a low bleed conversion kit. Field measurements should be performed if measured data is not available.

Alternatively if you use manufacturers' specifications you will likely be conservative with any savings.

To calculate the amount of gas saved:

Replacement with low bleed - Use the field data bleed rate in scfh from the existing device minus the field data bleed rate in scfh from the new low bleed device.

$S = [(scfh)_{old} – (scfh)_{new}] \times 8{,}760 hr/yr \times P/1000$.

S = Savings in Canadian dollars for each year after installing the new device. Savings do not include the cost of replacement equipment or the additional savings from potential carbon credits.

$[(scfh)_{old}$ = field data bleed rate of existing device in standard cubic feet per hour.

$(scfh)_{new}$ = field data bleed rate of replacement low bleed device in standard cubic feet per hour.

P = price of gas in Canadian dollars per thousand standard cubic feet.

Retrofit with low bleed kit - use the field data bleed rate in scfh from the existing device multiplied by the percent reduction applicable to the retrofit package of choice.

$S = [(scfh)_{old} \times R_{percent}] \times 8{,}760 hr/yr \times P/1000$.

S = Savings in Canadian dollars for each year after retrofitting the old device. Savings do not include the cost of retrofit or the additional savings from potential carbon credits.

$[(scfh)_{old}$ = field data bleed rate of existing device in standard cubic feet per hour.

P_{ercent} = reduction in gas consumption applicable to the retrofit system you have chosen. For SER use 65% reduction (R=0.65) and for the Mizer use 95% reduction (R=0.95).

P = price of gas in Canadian dollars per thousand standard cubic feet.

When performing these calculations you must include the field time to retrofit or replace the old device, typically about two hours, in addition to the cost of the retrofit kit or replacement device. When replacing a device there is also an environmental impact from the disposal of the older instrument. In general if a retrofit can be performed it is a more economical and environmentally beneficial way to cut emissions.

Field experience has demonstrated that over 80 percent of all high bleed controllers can be economically retrofitted to become low bleed, or replaced with low bleed controllers. In general payouts are between 3 and 9 months based on gas savings. Annual savings by retrofitting or converting a high bleed device, bleeding at 35 scfh (306 million standard cubic feet per year), to a low bleed device are in the order of 250 mscfy or $1,500 in addition to 94 tonnes CO_2E. If CO_2 credits are applied the payouts may drop by 50%.

Maintenance and Repair - During the Field Study and Data Review many controllers will be found to require maintenance or repair. Prior to proceeding, the review should be completed to determine which instruments will need to be replaced or retrofitted. Due to the various types of instruments in the field it is difficult to provide a formula to assess the benefits of repairing a particular instrument. However, there is plenty of evidence to support the economics of a solid maintenance program. Field tests by various operators suggest that paybacks of less than 9 months are typical.

5.5 Implementation

The implementation of the plan is the most important part. Once the economic and technical justifications are complete and management has approved the project, implementation can start. Managing the implementation will be subject to individual operations and availability of skilled people to perform the tasks.

Appendix A
Types of Pneumatic Devices and Uses

A typical process control loop consists of a control device (i.e. pressure, flow, level, or temperature controller), a controlled device (i.e. valve, choke, louver, or pump), and a pressure regulator, which supplies power to the control device, which in turn operates the controlled device. Pneumatic devices include controllers, switches, transducers, positioners, and transmitters. A brief description and application is outlined for each below:

Controllers

These devices typically have a built in sensing device which measures the process variable. This allows the controller to transmit a pneumatic signal to the final controlled device based on a predetermined set point. It is the difference between this pneumatic signal and the set point that determines how much the final device changes, such as a valve opening or closing. Controller types include pressure, differential pressure, temperature, and level control devices.

Pressure Controller

These devices are used to control process pressure. For example in Figure 4 (Pressure Control Loop) below the controller and control valve are used to maintain the pressure in the pipeline based on a desired "set point" or process parameter. The pressure controller uses the supply gas from the regulator as its energy source for operation. The controller senses the pressure in the pipe line, and compares this pressure with the "set point". The controller then sends a pressure signal to the actuator of the control valve causing the valve to open or close. This results in a change in process conditions to bring the actual pressure closer to the desired pressure or "set point". In this process the valve is typically never fully open or closed. This type of process control is called proportional control and is achieved with a "throttling" controller.

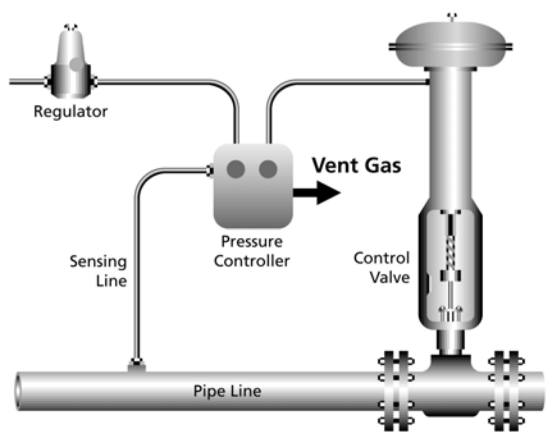


Figure 4
Pressure Control Loop

Differential Pressure Controller

A differential pressure controller operates in a similar fashion to the pressure controller. The differential pressure controller senses pressure from two points, typically across an orifice or nozzle. This measurement provides the information the controller needs to adjust a valve in order to maintain the set point. Typically differential pressure controllers are indirectly measuring and controlling flow in a process.

Temperature Controller

A temperature controller is used to control a process based on the difference between the "set point" and the process temperature.

Level Controller

These devices are typically used to control the level in a tank. For example Figure 5 (Level Control Loop) below depicts a process where the tank level will fluctuate and the level controller will maintain a desired "set point" or tank level. The level controller has a float which rises with the liquid level in the tank. Once it rises to a certain limit the controller is tripped and the controller sends a signal for the valve to open. Fluid then leaves the tank until the level lowers to a certain level again tripping the controller. At this point the controller again sends a signal to close the valve.

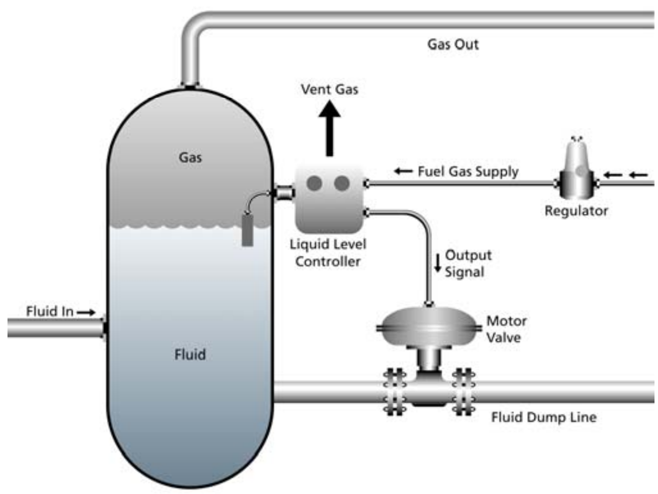


Figure 5
Level Control Loop

Transducers

These devices are used to convert an electric signal, usually 4 to 20 mA to a pneumatic signal either 3 to 15 psi or 6 to 30 psi. In general the application is to allow a feedback from an electronic SCADA system to operate a pneumatic control valve.

Positioners

Used on some control valves to establish a certain amount of travel on the valve based on the output signal of the controller. Typically positioners are used on larger actuators to get more accurate control and a quicker response. Bleeding occurs at the positioner in addition to the controller.

Switches

These devices are typically used as a safety device to protect the process during upsets, or if control problems occur. These devices typically open or close based on level, pressure or temperature.

Transmitters

These are used to transmit pneumatic signals to a central control point but with the advancement of electronic technologies pneumatic transmitters have nearly all been replaced with no-bleed electronic transmitters.

Appendix B
Instrument Characteristics

Controller Model	Signal Pressure (psi)	Manufacturer Data (scfh)	Field Data (scfh)	Number in Field	Throttling or snap	Retrofit choices	Low Bleed Alternatives
PRESSURE CONTROLLERS							
Ametek Series 40	20	6	N/A	low	throttling		
	35	6	N/A	low	throttling		
Bristol Babcock Series 5453-Model 10F	20	3	20 - 30	low	throttling	SER	
	35	3	20 - 30	low	throttling	SER	
Bristol Babcock Series 5455 Model 624-III	20	2	20 - 30	low	throttling	SER	
	35	3	20 - 30	low	throttling	SER	
Bristol Babcock Series 502 A/D (recording controller)	20	<6	N/A	low	throttling	SER	
	35	<6	N/A	low	throttling	SER	
Fisher 4100 Series (large orfice)	20	50	47	low	throttling	Replace	4195
	35	50	54	low	throttling	Replace	4195
Fisher 4150 and 4160	20	10-35	11 - 35	high	throttling	SER/Mizer	4195
	35	10-42	24 - 65	high	throttling	SER/Mizer	4195
Fisher 4194 (differential pressure)	20	3.5	12 - 14	moderate	throttling	SER	
	35	5	13-18	moderate	throttling	SER	
Fisher 4195	20	3.5	13-18	moderate	throttling	SER	
	35	5	12-115	moderate	throttling	SER	
Foxboro 43AP	20	18	N/A	moderate	throttling	SER	4195
	35	18	N/A	moderate	throttling	SER	4195
ITT Barton 338	20	6	20 - 30	moderate	throttling	SER	
	35	6	20 - 30	moderate	throttling	SER	
ITT Barton 335P	20	6	18 - 30	low	throttling	SER	4194
	35	6	20 - 30	low	throttling	SER	4194
Natco CT	20	35	N/A	low	throttling	Mizer	
	35	35	N/A	low	throttling	Mizer	
TRANSDUCERS							
Bristol Babcock Series 9110-00A	20	0.42	N/A				
	35	0.42	N/A				
Fisher 546	20		15 - 40	high	throttling	SER	646
	35	30	35 - 60	high	throttling	SER	646
Fisher 646	20	<1	N/A				
	35	<1	N/A				
Fisher 846	20	<1	N/A				
	35	<1	N/A				
LEVEL CONTROLLERS							
Fisher 2900	20	23	22-51	moderate	throttling	LBC/2901	2001NB/1001A
	20	23	18-127	moderate	snap	LBC/2902	2001NB/1001A
Fisher 2900 *(Continued)*	35	23	28-51	moderate	throttling	LBC/2903	2001NB/1001A
	35	23	27-153	moderate	snap	LBC/2904	2001NB/1001A
Fisher 2500 Series	20	42	N/A	moderate	throttling	SER	
LEVEL CONTROLLERS *(Continued)*							
	35	42	44-72	moderate	throttling	SER	

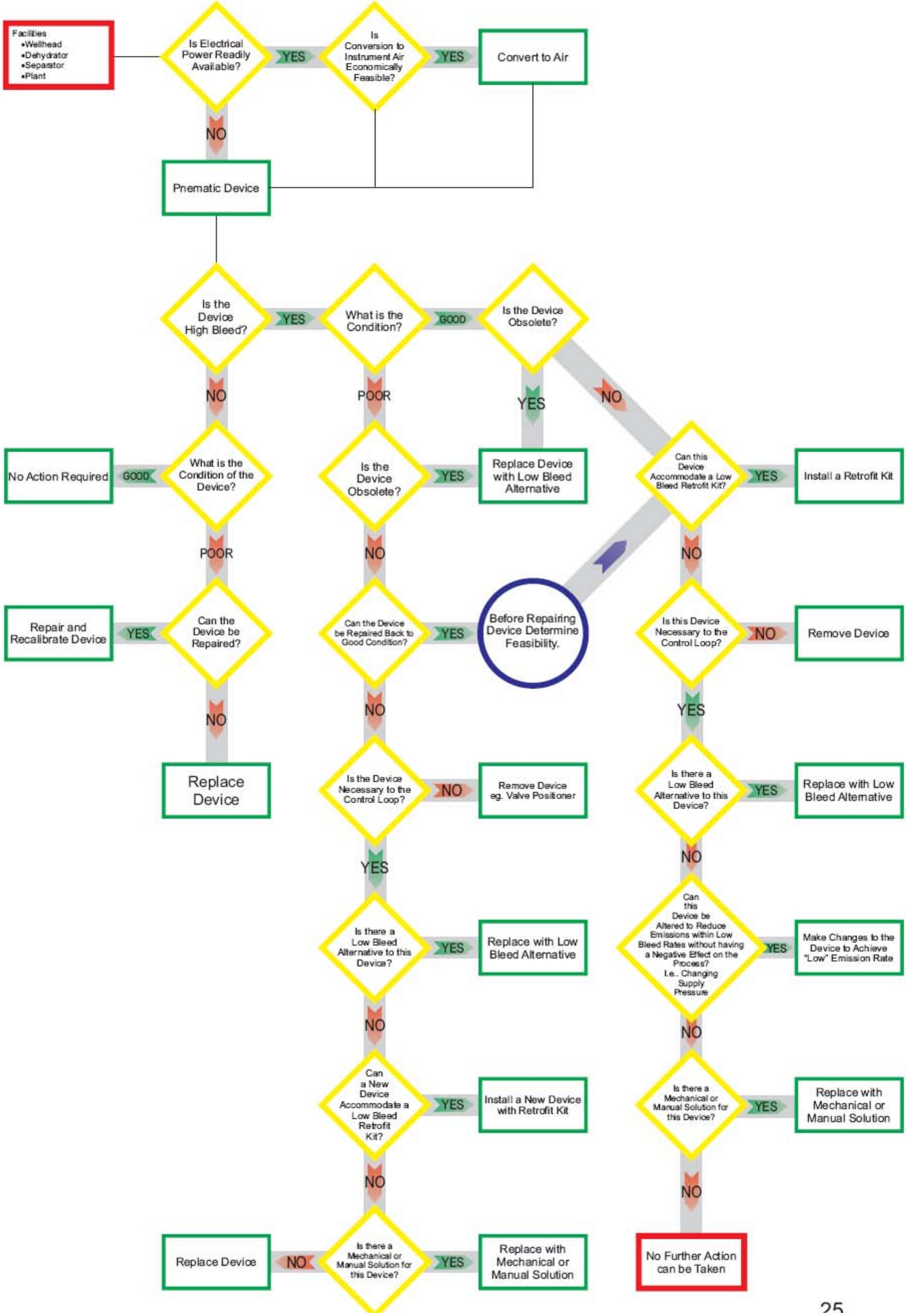
Controller Model	Signal Pressure (psi)	Manufacturer Data (scfh)	Field Data (scfh)	Number in Field	Throttling or snap	Retrofit choices	Low Bleed Alternatives
Fisher 2660 Series	20	1	N/A	moderate			
	35	1	N/A	moderate			
Fisher 2100 Series	20	<1	N/A	low			
	35	<1	N/A	low			
Fisher 2680	20	<1	N/A	moderate			
	35	<1	N/A	moderate			
Fisher L2							
Invalco CT Series	20		N/A	low	throttling	Mizer	
	35	40	34-88	low	throttling	Mizer	
Norriseal 1001	20	N/A	N/A	moderate			1001A/2001NB
	35	N/A	N/A	moderate			1001A/2001NB
Norriseal 1001 (A)	20	0.007	N/A	high	throttling		
	20	0.2	N/A	high	snap		
	35	0.007	N/A	high	throttling		
	35	0.2	N/A	high	snap		
Wellmark 2001	20	0.007	N/A	low	throttling		
	20	0.2	N/A	low	snap		
	35	0.007	N/A	low	throttling		
	35	0.2	N/A	low	snap		
POSITIONERS							
Fisher 3582	20	14	22	high	throttling		
	35	18	24	high	throttling		
Fisher 3661	20	8.8	N/A	moderate	throttling		
	35	12.1	N/A	moderate	throttling		
Fisher 3590 (electro-pneumatic)	20	24	N/A	high	throttling		
	35	36	N/A	high	throttling		
Fisher 3582i (electro-pneumatic)	20	17.2	N/A	moderate	throttling		
	35	24	N/A	moderate	throttling		
Fisher 3620J (electro-pneumatic)	20	18.2	N/A	moderate	throttling		
	35	35	N/A	moderate	throttling		
Fisher 3660	20	6	N/A	moderate	throttling		
	35	8	N/A	moderate	throttling		
Fisher Fieldvue Digital	20	14	N/A	moderate	throttling		
	35	49	N/A	moderate	throttling		
Masoneilan 4600B Series	20		N/A	low	throttling		
	35	18-30	N/A	low	throttling		
Masoneilan 4700B Series	20		N/A	low	throttling		
	35	18-30	N/A	low	throttling		
Masoneilan SVI Digital	20	<1	N/A	low	throttling		
Masoneilan SVI Digital *(Continued)*	35	<1	N/A	low	throttling		
Masoneilan 7400 Series	20	24-50	N/A	low	throttling		
	35	24-50	N/A	low	throttling		
POSITIONERS *(Continued)*							
Moore Products – Model 750P	20		N/A	moderate	throttling		
Controller Model	**Signal Pressure (psi)**	**Manufacturer Data (scfh)**	**Field Data (scfh)**	**Number in Field**	**Throttling or snap**	**Retrofit choices**	**Low Bleed Alternatives**

Moore Products – Model 750P	35	42	N/A	moderate	throttling			
Moore Products 73N-B PtoP	20	36	N/A	low	throttling			
	35		N/A	low	throttling			
PMV D5 Digital	20	<1	N/A	low	throttling			
	35	<1	N/A	low	throttling			
Sampson 3780 Digital	20	<1	N/A	low	throttling			
	35	<1	N/A	low	throttling			
VRC Model VP700 PtoP	20	<1	N/A	low				
	35	<1	N/A	low				

Appendix C
Field Survey

Location LSD	Facility Description	Manufacturer	Model	Output Range	Supply Pressure	Throttle or Snap	Condition	Gas Type	Retrofit	Notes:

Appendix D
Pneumatic Instruments Optimization Flowchart



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Appendix E
Case Study

Setting

Compressor Station - Dehydration/Compression

Initiated

September 2004

Situation

The client, an oil and gas producer, wished to reduce its greenhouse gas emissions as part of its corporate environmental stewardship objectives and to realize fuel gas cost savings. It was decided that a low-bleed retrofit kit for minimizing methane emissions from constant venting pneumatic controllers would be implemented.

Low-bleed technology was installed on two pressure controllers. One controller was located in the TEG dehydration skid and the other was located in the compressor skid. Initial readings on the controllers indicated a vent rate of 10 scf per hour for the dehydration location and 47 scf per hour for the compressor location, giving a combined venting rate of 55 scf per hour from these pneumatic devices.

Solution

The low bleed technology was installed in September 2004. The installation took approximately 4 hours with no loss of production for the field. The installation allowed for full valve stroke. Vent rates from the controllers after this procedure were as follows:

- dehydration location 3 scfh, and
- compressor location 12 scfh.

Conclusion

The combined net reduction in methane emissions to the atmosphere was 40 scfh or 73%. In addition, the client was able to prevent 130 tonnes per year CO_2 equivalent combined from being vented to the atmosphere unnecessarily. Payout of the units is achieved in 12 months using $5 per mcf gas.

Economics

Consumption	1,368 scf/day
Savings (73%)	960 scf/day
Price of gas	$5 Cdn/mcf
SER Cost	$ 1,770 (885/ea x 2)
Annual Savings	**$ 1,752**
Payout	**12 months**

Environmental Benefits

Methane Reduction*	**73%**
Methane Volume Reduction*	**350 mcf/year**
CO_2 Equivalent Reduction*	**130 tonnes/year**

*All figures refer to net reduction in emissions to the atmosphere.

Appendix F
References

1. Estimate of Methane Emissions From the US Natural Gas Industry, David Kirchgessner, Robert Lott, Michael Cowgill, Matthew Harrison, Theresa Shires

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4. Technology demonstration Report "Sirius Emission Reducer", CETAC-West, Clearstone Engineering, 2005

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