Lessons Learned

From Natural Gas STAR Partners

DIRECTED INSPECTION AND MAINTENANCE AT GATE STATIONS AND SURFACE FACILITIES

Executive Summary

In 2001, fugitive methane emissions from gate stations and surface facilities in the United States totaled about 27 million cubic feet (MMcf) from leaking meters and regulating equipment. Implementing a directed inspection and maintenance (DI&M) program is a proven, cost-effective way to detect, measure, prioritize, and repair equipment leaks to reduce methane emissions.

A DI&M program begins with a baseline survey to identify and quantify leaks. Repairs that are cost-effective to fix are then made to the leaking components. Subsequent surveys are based on data from previous surveys, allowing operators to concentrate on the components that are most likely to leak and are profitable to repair. This Lessons Learned study focuses on maximizing the savings that can be achieved by implementing DI&M programs at gate stations and surface facilities.

Natural Gas STAR distribution partners have reported significant savings and methane emissions reductions by implementing DI&M. Based on partner data, implementing DI&M at gate stations and surface facilities can result in gas savings worth up to $1,800 per year, at a cost of between $20 and $1,200.

Leak Source	Annual Volume of Gas Gas Lost(Mcf/site)	Method for Reducing Loss	Value of Gas Saved[1] per site	Total Cost to Find and Fix Leaks	Annual Partner Savings
Gate Station and Surface Facility Equipment	0 to 600 (typical estimates for leaking facilities is 30 to 200)	Locating and repairing leaks.	Up to $1,800	$20 to more than $1,200 (varies depending on facility size and types of repairs)	$50 to more than $1,000 (varies depending on survey costs, leak rates, number of sites)

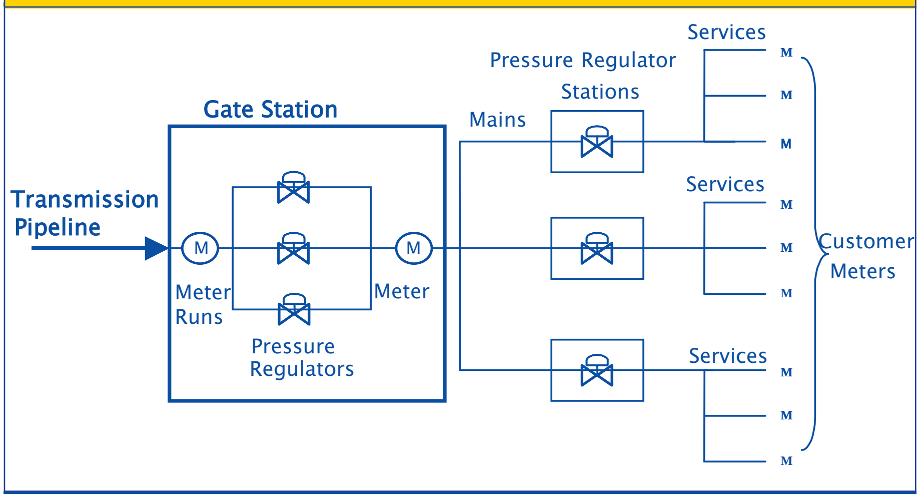
[1]Gas valued at $3 per Mcf.

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).

Introduction

Gate stations (or ‘city gates’) are metering and pressure regulating facilities located at the custody transfer points where natural gas is delivered from transmission pipelines into the high-pressure lines of a local distribution company. Gate stations typically contain metering runs as well as pressure regulators, which reduce the transmission line pressure from several hundred pounds per square inch gauge (psig) to a suitable pressure for the distribution system (usually less than 300 psig). Other surface facilities within a distribution system include heaters to replace the heat lost from gas expansion, and downstream pressure regulators, which further reduce gas pressure so that gas can be delivered safely to customers. Exhibit 1 is a schematic illustration of a gas distribution system showing a gate station and pressure regulating facilities.

Exhibit 1: Distribution System Schematic Showing Gate Station and Pressure Regulators



Gate stations and surface facilities contain equipment components such as pipes, valves, flanges, fittings, open-ended lines, meters, and pneumatic controllers to monitor and control gas flow. Over time, these components can develop leaks in response to temperature fluctuations, pressure, corrosion and wear. In general, the size of the facility and the facility leak rate correspond to the inlet or upstream gas pressure; the higher the inlet pressure, the larger the gate station and the greater the number of equipment components that may develop leaks.

Technology Background

DI&M is a cost-effective way to reduce natural gas losses from equipment leaks. A DI&M program begins with a comprehensive baseline survey of all the gate stations and surface facilities in the distribution system. Operators identify, measure, and evaluate all leaking components and use the results to direct subsequent inspection and maintenance efforts.

The following sections describe various leak screening and measurement techniques that can be cost-effective at gate stations and pressure regulating facilities. The appropriateness of the various screening and measurement techniques will depend upon the configuration and operating characteristics of individual distribution system facilities.

Leak Screening Techniques

Leak screening in a DI&M program may include all components in a comprehensive baseline survey, or may be focused only on the components that are likely to develop significant leaks. Several leak screening techniques can be used:

★ **Soap Bubble Screening** is a fast, easy, and very low-cost leak screening technique. Soap bubble screening involves spraying a soap solution on small, accessible components such as threaded connections. Soaping is effective for locating loose fittings and connections, which can be tightened on the spot to fix the leak, and for quickly checking the tightness of a repair. Operators can screen about 100 components per hour by soaping.

★ **Electronic Screening** using small hand-held gas detectors or "sniffing" devices provides another fast and convenient way to detect accessible leaks. Electronic gas detectors are equipped with catalytic oxidation and thermal conductivity sensors designed to detect the presence of specific gases. Electronic gas detectors can be used on larger openings that cannot be screened by soaping. Electronic screening is not as fast as soap screening (averaging 50 components per hour), and pinpointing leaks can be difficult in areas with high ambient concentrations of hydrocarbon gases.

★ **Organic Vapor Analyzers (OVAs) and Toxic Vapor Analyzers (TVAs)** are portable hydrocarbon detectors that can also be used to identify leaks. An OVA is a flame ionization detector (FID), which measures the concentration of organic vapors over a range of 9 to 10,000 parts per million (ppm). A TVA combines both an FID and a photoionization detector (PID) and can measure organic vapors at concentrations exceeding 10,000 ppm. TVAs and OVAs measure the concentration of methane in the area around a leak.

  Screening is accomplished by placing a probe inlet at an opening where leakage can occur. Concentration measurements are observed as the probe is slowly moved along the interface or opening, until a maximum concentration reading is obtained. The maximum concentration is recorded as the leak screening value. Screening with TVAs is somewhat slow—approximately 40 components per hour—and the instruments require frequent calibration.

★ **Acoustic Leak Detection** uses portable acoustic screening devices designed to detect the acoustic signal that results when pressurized gas escapes through an orifice. As gas moves from a high-pressure to a low-pressure environment across a leak opening, turbulent flow produces an acoustic signal, which is detected by a hand-held sensor or probe, and read as intensity increments on a meter. Although acoustic detectors do not measure leak rates, they provide a relative indication of leak size—a high intensity or "loud" signal corresponds to a greater leak rate. Acoustic screening devices are designed to detect either high frequency or low frequency signals.

Exhibit 2. Acoustic Leak Detection

Source: Physical Acoustics Corp.

High Frequency Acoustic Detection is best applied in noisy environments where the leaking components are accessible to a handheld sensor. As shown in Exhibit 2, an acoustic sensor is placed directly on the equipment orifice to detect the signal. Alternatively, *Ultrasound Leak Detection* is an acoustic screening method that detects airborne ultrasonic signals in the frequency range of 20 kHz to 100 kHz. Ultrasound detectors are equipped with a hand-held acoustic probe or scanner that is aimed at a potential leak source from a distance up to 100 feet. Leaks are pinpointed by listening for an increase in sound intensity through headphones. Ultrasound detectors can be sensitive to background noise, although most detectors typically provide frequency tuning capabilities so that the probe can be tuned to a specific leak in a noisy environment.

Leak Measurement Techniques

An essential component of a DI&M program is measurement of the mass emissions rate or leak volume of identified leaks, so that manpower and resources are allocated only to the significant leaks that are cost-effective to repair. Four leak measurement techniques can be used: conversion of TVA and OVA screening concentrations using general correlation equations; bagging techniques; high volume samplers; and rotameters.

Data available for total fugitive emissions rates from gate stations and surface facilities indicates that the leak rate for many components is relatively small. For most gate stations, DI&M will only be cost-effective using the lowest cost measurement technique, which is likely to be conversion of TVA/OVA screening values using EPA correlation equations and TVA or OVA instruments that may already be at hand.

★ **OVAs and TVAs** can be used to estimate mass leak rate. The screening concentration detected at a leak opening is not a direct measurement of the mass emissions of the leak. However, the screening concentration in ppm is converted to a mass emissions rate by using EPA correlation equations. The EPA correlation equations can be used to estimate emissions rates for the entire range of screening concentrations, from the detection limit of the instrument to the “pegged” screening concentration, which represents the upper limit of the instrument. If the upper measurement limit of the TVA is 10,000 ppm, a dilution probe can be used to detect screening concentrations up to 100,000 ppm.

OVAs and TVAs must be calibrated using a reference gas containing a known compound at a known concentration. Methane in air is a frequently used reference compound. The calibration process also determines a response factor for the instrument, which is used to correct the observed screening concentration to match the actual concentration of the leaking compound. For example, a response factor of “one” means that the screening concentration read by the TVA equals the actual concentration at the leak.

Screening concentrations detected for individual components are corrected using the response factor (if necessary) and are entered into EPA correlation equations to extrapolate a leak rate measurement for the component. Exhibit 3 lists the EPA correlation equations for equipment components at oil and gas industry facilities.

Exhibit 3: U.S. EPA Leak Rate/Screening Value Correlation Equations for Equipment Components in the Oil and Gas Industry			
Equipment Component	**EPA Leak Rate/Screening Value Correlation (kg/hr/source)**	**Leak Rate Correlation (kg/hr) for "Pegged" Screening Value >10,000 ppm**	**Leak Rate Correlation (kg/hr) for "Pegged" Screening Value >100,000 ppm**
Valves	$2.29E\text{-}06 \times (SV)^{0.746}$	0.064	0.140
Pump Seals	$5.03E\text{-}05 \times (SV)^{0.610}$	0.074	0.160
Connectors	$1.53E\text{-}06 \times (SV)^{0.735}$	0.028	0.030
Flanges	$4.61E\text{-}06 \times (SV)^{0.703}$	0.085	0.084
Open-Ended Lines	$2.20E\text{-}06 \times (SV)^{0.704}$	0.030	0.079
Other Components (instruments, pressure relief, vents, all others)	$1.36E\text{-}05 \times (SV)^{0.589}$	0.073	0.110

The correlations presented are revised petroleum industry correlations. Correlations predict total organic compound emissions rates.

Correlation factors for methane: 1kg methane = 51.92 scf; 1kg/hr = 1.246 Mcfd.

Source: U.S. EPA, 1995, Protocol for Equipment Leak Emission Estimates.

Exhibit 4 provides a table based on the above EPA correlation equations for TVAs and OVAs. This can be used to estimate mass leak rate from the screening concentrations detected at leaking components at gate stations and surface facilities.

Exhibit 4. Example Screening Concentration/Leak Rate Correlations						
Screening Concentration (ppmv)	**Estimated Mass Leak Rate (Mcf/yr)**					
	Valves	**Pump Seals**	**Connectors**	**Flanges**	**Open-Ended Lines**	**Other[1]**
1	0.001	0.023	0.001	0.002	0.001	0.006
10	0.006	0.093	0.004	0.011	0.005	0.024
100	0.032	0.380	0.021	0.053	0.026	0.093
1,000	0.180	1.547	0.112	0.269	0.130	0.362
10,000	1.004	6.301	0.606	1.360	0.655	1.404
100,000	5.593	25.669	3.293	6.864	3.313	5.450
Screening value pegged at >10,000	29.109	33.657	12.735	38.660	13.645	33.203
Screening value pegged at >100,000	63.676	72.773	13.645	38.206	35.931	50.031

[1]"Other" equipment components include: instruments, loading arms, pressure relief valves, stuffing boxes, and vents. Apply to any equipment component other than connectors, flanges, open-ended lines, pumps, or valves.

Source: U.S. EPA, 1995, Protocol for Equipment Leak Emission Estimates.

- ★ **Bagging Techniques** are commonly used to measure mass emissions from equipment leaks. The leaking component or leak opening is enclosed in a “bag” or tent. An inert carrier gas such as nitrogen is conveyed through the bag at a known flow rate. Once the carrier gas attains equilibrium, a gas sample is collected from the bag and the methane concentration of the sample is measured. The mass emissions rate is calculated from the measured methane concentration of the bag sample and the flow rate of the carrier gas. Leak rate measurement using bagging techniques is accurate (within ± 10 to 15 percent) but, slow and labor intensive (only two or three samples per hour). Bagging techniques can be expensive due to the labor involved to perform the measurement, as well as the cost for sample analysis.
- ★ **High Volume Samplers** capture all of the emissions from a leaking component to accurately quantify leak emissions rates. Leak emissions, plus a large volume sample of the air around the leaking component, are pulled into the instrument through a vacuum sampling hose. Sample measurements are corrected for the ambient hydrocarbon concentration, and mass leak rate is calculated by multiplying the flow rate of the measured sample by the difference between the ambient gas concentration and the gas concentration in the measured sample. High volume samplers measure leak rates up to 8 cubic feet per minute (scfm), a rate equivalent to 11.5 thousand cubic feet (Mcf) per day. Two operators can measure 30 components per hour using a high volume sampler, compared with two to three measurements per hour using bagging techniques. High volume samplers can cost approximately $10,000 to purchase. Alternatively, contractors can provide leak measurement services at rate that ranges from $1.00 to more than $2.50 per component measured.
- ★ **Rotameters** and other flow meters are used to measure extremely large leaks that would overwhelm other instruments. Flow meters typically channel gas flow from a leak source through a calibrated tube. The flow lifts a "float bob" within the tube, indicating the leak rate. Because rotameters are bulky, these instruments work best for open-ended lines and similar components, where the entire flow can be channeled through the meter. Rotameters and other flow metering devices can supplement measurements made using bagging or high volume samplers.

Decision Process

A DI&M program can be implemented in four steps: (1) conduct a baseline survey; (2) record the results and identify candidates for cost-effective repair; (3) analyze the data, make the repairs, and estimate methane savings; and (4) develop a survey plan for future inspections and follow-up monitoring of leak-prone equipment.

Decision Steps for DI&M
1. Conduct baseline survey.
2. Record results and identify candidates for repair.
3. Analyze data and estimate savings.
4. Develop a survey plan for future DI&M.

Step 1: Conduct Baseline Survey. A DI&M program typically begins with baseline screening to identify leaking components. For each leaking component the mass leak rate is estimated using one of the techniques described above. In the distribution sector, the emissions from leaking equipment components at gate stations and surface facilities may be one or more orders of magnitude less than emissions from leaks at compressor stations. For DI&M to be cost-effective at gate stations and surface facilities, the baseline survey costs must be minimal.

Some distribution sector partners elect to conduct leak screening only, using very low cost and rapid leak detection techniques, which are incorporated into ongoing maintenance operations. In these cases, all of the leaks that are identified are repaired. A baseline survey that focuses only on leak screening is substantially less expensive. However, leak screening alone does not quantify leak rate or potential gas savings, each of which is critical information needed to make cost-effective repair decisions in cases where partners do not have the resources to repair all leaks.

Step 2: Record Results and Identify Candidates for Repair. Leak measurements collected in Step 1 must be recorded to pinpoint the leaking components that are cost-effective to repair.

As leaks are identified and measured, operators should record the baseline leak data so that future surveys can focus on the most significant leaking components. The results of the DI&M survey can be tracked using any convenient method or format. The information that operators may choose to collect includes: (1) an identifier for each leaking component; (2) the component type (e.g., gate valve); (3) the measured leak rate; (4) the survey date; (5) the estimated annual gas loss; and (6) the estimated repair cost. This information will direct subsequent emissions surveys, prioritize future repairs, and track the methane savings and cost-effectiveness of the DI&M program.

Natural Gas STAR partners report that the most common leaks at gate stations and surface facilities are pinhole leaks and component flaws, loose connections, and loose or worn valve stem seals. High frequency leak locations identified by partners include: orifice plate/fittings, plugs installed on test points, grease fittings on valves, multiple or large diameter meter runs, couplings, valve stem packing, and flanges. The largest leaks are generally located at pressure relief valves, open-ended lines, flanges, gate valves, and gate valve stem packing. Leaks are prioritized by comparing the value of the natural gas lost with the estimated cost in parts, labor, and equipment downtime to fix the leak.

Gate stations and surface facilities vary significantly in size and pressure capacity depending upon the size and complexity of the distribution system. As a result, there can be substantial variation in fugitive methane emissions from such facilities. A 1994 field study sponsored by EPA and the Gas Research Institute (GRI—now GTI, the Gas Technology Institute) used a tracer gas technique to measure total facility methane emissions at 40 gate stations and 55 district pressure regulators. This study found that average annual methane emissions ranged from 1,575 Mcf per year for gate stations with inlet pressures greater than 300 psig to less than 1 Mcf per year for district regulators with inlet pressures less than 40 psig. Average annual facility emissions, based on all 95 sample facilities were 425 Mcf. This study estimated that a large component of total site emissions are contributed by pneumatic controllers, which are designed to bleed gas to the atmosphere.

In 1998, EPA, GRI, and the American Gas Association Pipeline Research Committee International (PRCI) conducted a second study of methane emissions from equipment components at 16 natural gas metering and regulating facilities in transmission and distribution. Four of the facilities studied were distribution system gate stations. This analysis included component counts for each site, and leak screening and measurement of individual component leaks using a high volume sampler. As in the earlier study, pneumatic controllers were found to contribute most of the total site emissions (more than 95 percent). Because pneumatic devices are designed to bleed gas during normal operation, these emissions are not considered leaks. Pneumatic controllers provide a significant opportunity to reduce methane emissions from gate stations and surface facilities, which is the subject of *Lessons Learned: Convert Gas Pneumatic Controls to Instrument Air* and *Options for Reducing Methane Emissions from Pneumatic Devices in the Natural Gas Industry.*

Exhibit 5. Average Emissions Factors for Equipment Leaks at Sixteen Metering and Regulating Facilities			
Component	**Emissions Factor (Mcf/yr/component)**	**Total Number Components Screened**	**Average Number Components per Site**
Ball/Plug Valve	0.21	248	18
Control Valve	0.46	17	1
Flange	0.13	525	38
Gate Valve	0.79	146	10
Pneumatic Vent	134.3	40	1
Pressure Relief Valve	4.84	5	1
Connectors	0.11	1280	91
Total		**2,261**	**162**
Source: Indaco Air Quality Services, 1998.			

Exhibit 5 summarizes average component emissions factors obtained during the 1998 field study. Approximately 5 percent of the 2,261 total components screened were found to be leaking.

Exhibit 5 shows that pressure relief valves were found to be the largest leak source, followed by gate valves and control valves. The smallest leaks were found at connectors, flanges, and ball/plug valves. Exhibit 5 indicates that the typical leak to be expected at gate state stations and surface facilities is relatively small, and the number of components to be surveyed at each facility is over 100.

Based on the leak measurements of individual equipment components, the 1998 study determined the average total gas emissions from metering and regulating facilities to be 409 Mcf per year. Excluding the total facility emissions contributed by pneumatic controllers, the average total emissions contributed by equipment leaks was in the range of 20 to 40 Mcf per site, although substantial leaks in the range of 60 to 100 Mcf per year were reported for some of the sites.

The 1998 field study reinforces the point made in Step 1, that a cost-effective DI&M program at gate stations and surface facilities must rely upon very low cost and rapid screening techniques. Otherwise, the cost of finding the leaks might not outweigh the savings gained from fixing the leaks.

Step 3: Analyze Data and Estimate Savings. Cost-effective repair is a critical part of successful DI&M programs because the greatest savings are achieved by targeting only those leaks that are profitable to repair. Some leaks can be fixed on the spot, for example, by simply tightening a valve-stem packing-gland. Other repairs are more complicated and require equipment downtime or new parts. For these repairs, operators may choose to attach identification markers, so that the leaks can be fixed later.

Easy repairs should be done on the spot, as soon as the leaks are found. In all cases, the value of the gas saved should exceed the cost to find and fix the leak. Partners have found that an effective way to analyze baseline survey results is to create a table listing all leaks with their associated repair cost, expected gas savings, and expected life of the repair. Using this information, economic criteria such as payback period can be easily calculated for each leak repair. Partners can then decide which leaking components are economic to repair.

Exhibit 6 provides an example of this type of repair cost analysis, which summarizes the repair costs, total gas savings, and the estimated net savings for the anticipated repairs. The leak and repair data featured in Exhibit 6 are from the 1998 EPA/GRI/PRCI field study, during which leak repairs were evaluated for two of the sixteen facilities included in the study.

Exhibit 6. Example of Repair Costs and Net Savings for Selected Equipment Components

Component Description	Type of Repair	Repair Cost[1] (includes labor & material)	Total Number of Components Fixed at Two Sites	Total Gas Savings (Mcf/yr)	Estimated Net Savings[2] \$/yr	Repair Payback Period (Years)
Ball Valve	Re-grease	\$13	5	60 Mcf	\$115	0.4
Gate Valve	Replace valve stem packing	\$3	5	67 Mcf	\$36	0.8
Gate Valve	Replace valve stem packing	\$3	1	92 Mcf	\$243	0.1
Connectors	Tighten Threaded Fittings	\$3	4	11 Mcf	\$21	0.4
Sr. Daniel Orifice Meter	Tighten Fittings	\$33	1	68 Mcf	\$171	0.2
Flange[3]	Tighten (estimated)	\$ 40	5	99 Mcf	\$97	0.7

[1]Average repair costs are in 2002 dollars.

[2]Assumes gas price of \$3/Mcf.

[3]Repair cost not reported in original study. Flange repair cost estimated based on similar 1997 data on leak repair cost for "off-compressor" flanges at compressor stations.

Source: Indaco Air Quality Services, Inc., 1998, Trends in Leak Rates at Metering and Regulating Facilities and the Effectiveness of Leak Detection and Repair (LDAR) Programs, Draft Report.

Because of safety concerns, some partners repair all leaks found at gate stations and meter stations. In this case, a DI&M program may be useful for improving the cost-effectiveness of ongoing inspection and maintenance operations by prioritizing repairs—the major leaks are identified and repaired first, or inspection and maintenance is conducted more frequently at facilities with the greatest leak frequency.

As leaks are identified, measured, and repaired, operators should record baseline data so that future surveys can focus on the most significant leaking components. This information will direct subsequent emissions surveys, prioritize future repairs, and track the methane savings and cost-effectiveness of the DI&M program.

Step 4: Develop a Survey Plan for Future DI&M. The final step in a DI&M program is to develop a survey plan that uses the results of the initial baseline survey to direct future inspection and maintenance practices. The DI&M program should be tailored to the needs and existing maintenance practices of the facility. An effective DI&M survey plan should include the following elements:

- ★ A list of components to be screened and tested, as well as the equipment components to be excluded from the survey.
- ★ Leak screening and measurement tools and procedures for collecting, recording, and accessing DI&M data.
- ★ A schedule for leak screening and measurement.
- ★ Economic guidelines for leak repair.
- ★ Results and analysis of previous inspection and maintenance efforts which will direct the next DI&M survey.

Operators should develop a DI&M survey schedule that achieves maximum cost-effective gas savings yet also suits the unique characteristics of the facility—for example, the age, size, and configuration of the facility and the inlet pressure. Some partners schedule DI&M surveys based on the anticipated life of repairs made during the previous survey. Other partners base the frequency of follow-up surveys on maintenance cycles or the availability of resources. Since a DI&M program is flexible, if subsequent surveys show numerous large or recurring leaks, the operator can increase the frequency of the DI&M follow-up surveys. Follow-up surveys may focus on components repaired during previous surveys, or on the classes of components identified as most likely to leak. Over time, operators can continue to fine-tune the scope and frequency of surveys as leak patterns emerge.

Estimated Savings

Savings achieved by Natural Gas STAR partners implementing DI&M programs at gate stations and surface facilities vary widely. Factors affecting results include the number of stations in the DI&M program, the stage of program development (i.e., new versus mature program), and the level of implementation and repair costs. Costs differ between facilities because of the type of screening and measurement equipment used, frequency of surveys, and number and type of staff conducting the surveys.

Exhibit 7 provides a hypothetical example of the costs and benefits of implementing DI&M at three gate stations. The leak rates and number of leaking components in this example are based on actual leak rates reported for three sites in the 1998 EPA/GRI/PRCI study. Exhibit 7 illustrates the type of calculations that distribution partners should make to evaluate whether DI&M could be cost-effective for their operations.

Exhibit 7 illustrates that although the costs of finding and fixing leaks may not be recovered by the value of the gas saved at each and every site, if multiple sites are included in the DI&M program, the overall program can still be profitable. For the hypothetical example in Exhibit 7, DI&M is not cost-effective at Site 2, although DI&M is profitable for the three sites considered as a whole. In this case, the operator would use the experience gained from the baseline survey of Site 2 to direct subsequent surveys; possibly excluding Site 2 from subsequent surveys, screening Site 2 less frequently, or screening only a selected group of components.

Exhibit 7. Example of Estimating the Savings from Implementing DI&M at Gate Stations and Surface Facilities	
General Assumptions:	
Leak screening by soaping; 80 components per hour	2 hours x $/hour labor cost
Leak measurement using TVA correlations	1 hour x $/hour labor cost
Hourly labor rate	$50/hour
TVA capital cost	$0 (assume already owned by partner)[1]
Estimated repair life	12 months
Site 1	
Number of leaks	20 leaks (six valves repaired—2 x 30 Mcf/yr; 2 x 10 Mcf/yr; 2 x 1 Mcf/yr)
Hypothetical repair cost	Assume 3 repairs x $10 and 3 repairs at $3
Total gas savings	82 Mcf
Site 2	
Number of leaks (assume fewer leaks to measure)	8 leaks (2x10 Mcf/yr; 6x2 Mcf/yr)
Hypothetical repair cost	Assume 2 repairs x $5; 6 repairs at no cost
Total gas savings	32 Mcf
Site 3	
Number of leaks	16 leaks (1x60 Mcf; 2x30 Mcf; 1x15 Mcf; 6x10 Mcf; 6x1 Mcf)
Hypothetical repair cost	Assume 1 repair x $33; 2 repair x $15; 5 repair x $3; remaining repairs at no cost
Total gas savings	201 Mcf

	Total Survey Cost	Total Repair Cost	Value of Gas Saved ($3/Mcf)	Net Savings	Payback Period
Site 1	$150	$39	$246	$57	9.2 months
Site 2	$125	$10	$96	($39)	17 months
Site 3	$150	$78	$603	$375	4.5 months
Total	**$425**	**$127**	**$945**	**$393**	**7 months**

[1]TVAs can cost up to $2,000. Savings from avoided emissions may not support purchasing a TVA.

Partner Experience

From 1995 to 2000, 18 Natural Gas STAR partners reported gas savings from implementing DI&M at gate stations and surface facilities. Three examples are shown in Exhibit 8.

Exhibit 8: Partners' Experience Implementing DI&M at Gate Stations and Surface Facilities

Company A: During 2000, this company surveyed 86 facilities and found leaks at 48 sites. A total of 105 leaks were identified, and 66 leaks (63 percent) were repaired. The total cost to find and fix the leaks was $2,453, an average of $29 per facility surveyed. Total gas savings were 1,519 Mcf per year, worth $6,557 at $3 per Mcf. Total savings from DI&M was $4,104. Net savings were approximately $50 per facility surveyed.

Total Gas Savings	$6,557
Total Survey Costs	$1,700
Total Cost of Repairs	$753
Net Savings	**$4,104**

Company B: Eighteen facilities were surveyed in 1997 for a total cost of $1,080. Fifteen small leaks were identified including 1 flange, 2 swage lock fittings, and 12 small valves. The average leak rate was 17.5 Mcf per year. The 15 leaks were repaired for a total cost of $380, which resulted in gas savings of 263 Mcf per year. At $3 per Mcf, the value of the gas saved was $789. The total cost of the leak survey and repairs, $1,460, was not recovered in the first year. The average survey and repair cost was $60 per facility surveyed.

Total Gas Savings	$789
Total Survey Costs	$1,080
Total Cost of Repairs	$380
Net Savings	**$(671)**

Company C: This company surveyed 306 facilities and identified and repaired 824 leaks. Four leaks were described as "large", seven were described as "medium", and the remaining leaks were described as "small," meaning that an electronic detector or soaping was required to locate the leak. Total survey and repair costs were approximately $16,500, an average of $54 per site surveyed. Total gas savings were 117,800 Mcf, an average of 143 Mcf per leak. Net savings were approximately $1,100 per facility surveyed (at $3 per Mcf).

Total Gas Savings	$353,430
Total Cost of Survey and Repairs	$16,500
Net Savings	**$336,930**

The number of facilities included in partners' DI&M programs ranged from less than 20 facilities to more than 2,100 facilities. Leaks were found at 50 percent of facilities, and an average of two leaks were found per leaking facility. The average emissions saved per leak repair was 100 Mcf per leak.

Partner-reported survey and repair costs varied substantially. Incremental costs for DI&M surveys ranged from "negligible" for partners with ongoing leak inspection programs already in place, to more than $1,200 per facility. The highest DI&M survey costs were reported for large distribution systems in urban areas where labor costs are higher, and the gate stations are presumed to be larger and to have more components. Reported repair costs similarly ranged from negligible for simple repairs made on the spot, to more than $500 per repair.

Lessons Learned

DI&M programs can reduce survey costs and enhance profitable leak repair. Targeting problem stations and components saves time and money needed for future surveys, and helps identify priorities for a leak repair schedule. The principal lessons learned from Natural Gas STAR partners are:

★ To be cost-effective, DI&M at gate stations and surface facilities must use the most low cost and rapid screening and measurement techniques. Soaping, listening for audible leaks, portable gas "sniffers," and TVAs/OVAs are recommended for leak screening. TVA screening concentrations and EPA's correlation equations are recommended as a cost-effective method for estimating mass leak rate, especially if a TVA or OVA is already available at the facility.

★ A small number of large leaks contribute to most of a facility's fugitive methane emissions. Partners should focus on finding leaks at equipment components that are cost-effective to repair. One of the most cost-effective repairs is simply to tighten valve packings or loose connections at the time the leak is detected. Partners have found it useful to look for trends, asking questions such as "Do gate valves leak more than ball valves?"

★ Partners have also found that some sites are more leak-prone than others. Tracking of DI&M results may show that some facilities may need more frequent follow-up surveys.

★ Institute a "quick fix" step that involves making simple repairs to simple problems (e.g., loose nut, valve not fully closed) during the survey process.

★ Re-screen leaking components after repairs are made to confirm the effectiveness of the repair. A quick way to check the effectiveness of a repair is to use the soap screening method.

★ Frequent surveying (e.g., quarterly or twice yearly) during the first year of a DI&M program helps identify components and facilities with the highest leak rates and leak recurrence, and builds the information base necessary to direct less frequent surveying in subsequent years.

★ Record methane emissions reductions for each gate station and/or other surface facilities and include annualized reductions in Natural Gas STAR Program reports.

References

Bascom-Turner Instruments, personal communication.

Foxboro Environmental Products, personal communication.

Gas Technology Institute (formerly the Gas Research Institute), personal communication.

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

Indaco Air Quality Services, Inc., 1995, *A High Flow Rate Sampling System for Measuring Leak Rates at Natural Gas Facilities.* Report No. GRI-94/0257.38. Gas Technology Institute (formerly Gas Research Institute), Chicago, IL.

Indaco Air Quality Services, Inc., 1998, *Trends in Leak Rates at Metering and Regulating Facilities and the Effectiveness of Leak Detection and Repair (LDAR) Programs,* Draft Report prepared for PRC International, Gas Research Institute, and the U.S. Environmental Protection Agency.

Radian International, 1996, *Methane Emissions from the Natural Gas Industry, Volume 2, Technical Report,* Report No. GRI-94/0257.1. Gas Technology Institute (formerly Gas Research Institute), Chicago, IL.

Radian International, 1996, *Methane Emissions from the Natural Gas Industry, Volume 10, Metering and Pressure Regulating Stations in Natural Gas Transmission and Distribution,* Report No. EPA600-R-96-080j.

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

U.S. Environmental Protection Agency, 1994–2001, *Natural Gas STAR Program, Partner Annual Reports.*

U.S. Environmental Protection Agency, 1995, *Natural Gas STAR Program Summary and Implementation Guide for Transmission and Distribution Partners.*

U.S. Environmental Protection Agency, 1995, *Protocol for Equipment Leak Emission Estimates,* Office of Air Quality Planning and Standards, EPA453-R-95-017, November 1995.

U.S. Environmental Protection Agency, 2001, *Lessons Learned: Convert Gas Pneumatic Controls to Instrument Air,* EPA430-B-01-002.

U.S. Environmental Protection Agency, 2003, *Lessons Learned: Options for Reducing Methane Emissions from Pneumatic Devices in the Natural Gas Industry,* EPA430-B-03-004.

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

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