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Reducing Methane Emissions through Directed Inspection and Maintenance (DI&M)

IAPG & US EPA Technology Transfer Workshop

November 5, 2008
Buenos Aires, Argentina

Directed Inspection and Maintenance and Infrared Leak Detection Agenda

- What are fugitive equipment leaks?
- What is DI&M
- Infrared Leak Detection
- Partner Experience
- Discussion

Key Characteristics of Fugitive Equipment Leaks

- Fugitive equipment leaks are a major source of THC and CH4 emissions at oil and gas facilities.
- Most of these emissions are from a few big leaks rather than many small or medium sized leaks.
- 75 to 85% of the emissions from leaks are cost effective to fix (often payback of <6 months).
- Components in gas service leak more than those in liquid service.
- Components in sweet service more likely to leak than those in sour or odorized service.
- Leak potential tends to increase with time and usage.
- Different types of components and service applications have different leak potentials (i.e., leak magnitude and probability).
- Components in vibration, cryogenic or thermal cycling service have an increased leak potential.

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Why Do Big Leaks Occur?

- Big leaks often go unnoticed because they occur in difficult-to-access, low-traffic, congested or noisy areas, or the amount of leakage is not fully appreciated.

- Big leaks may also occur because of severe/demanding applications or the high cost or difficulty of repairs.

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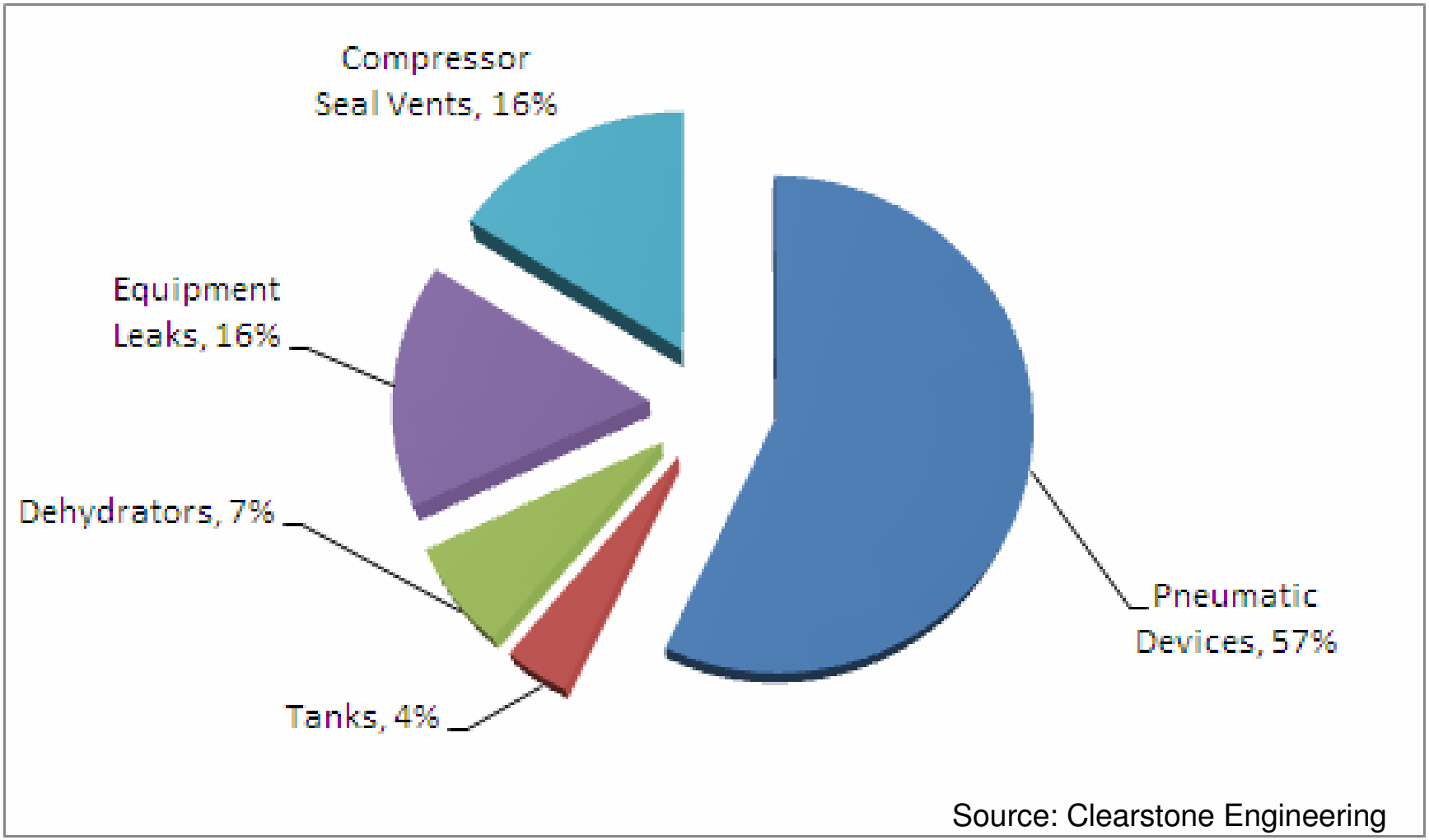
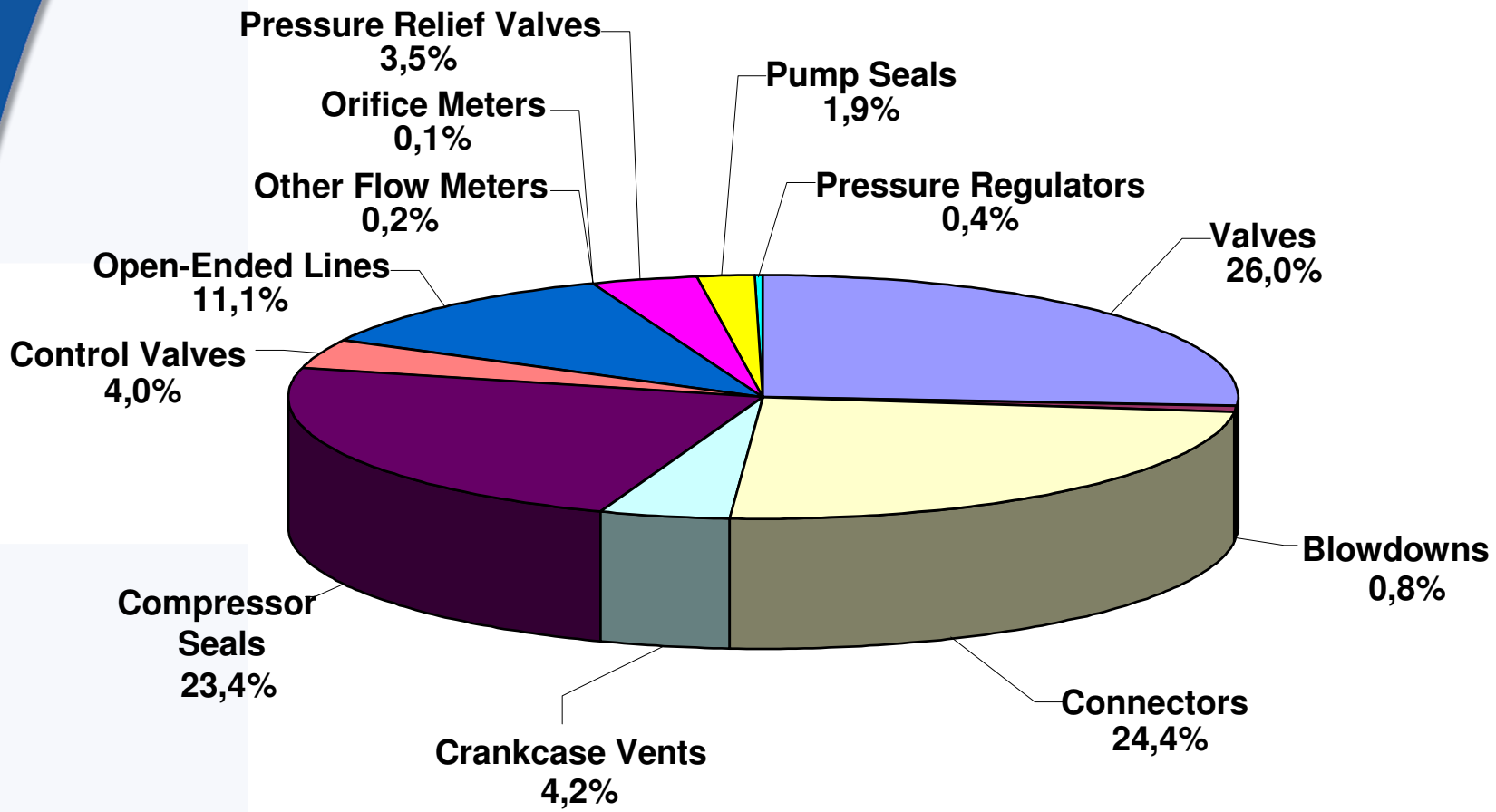
Methane Emissions at 76 Gas Production Facilities



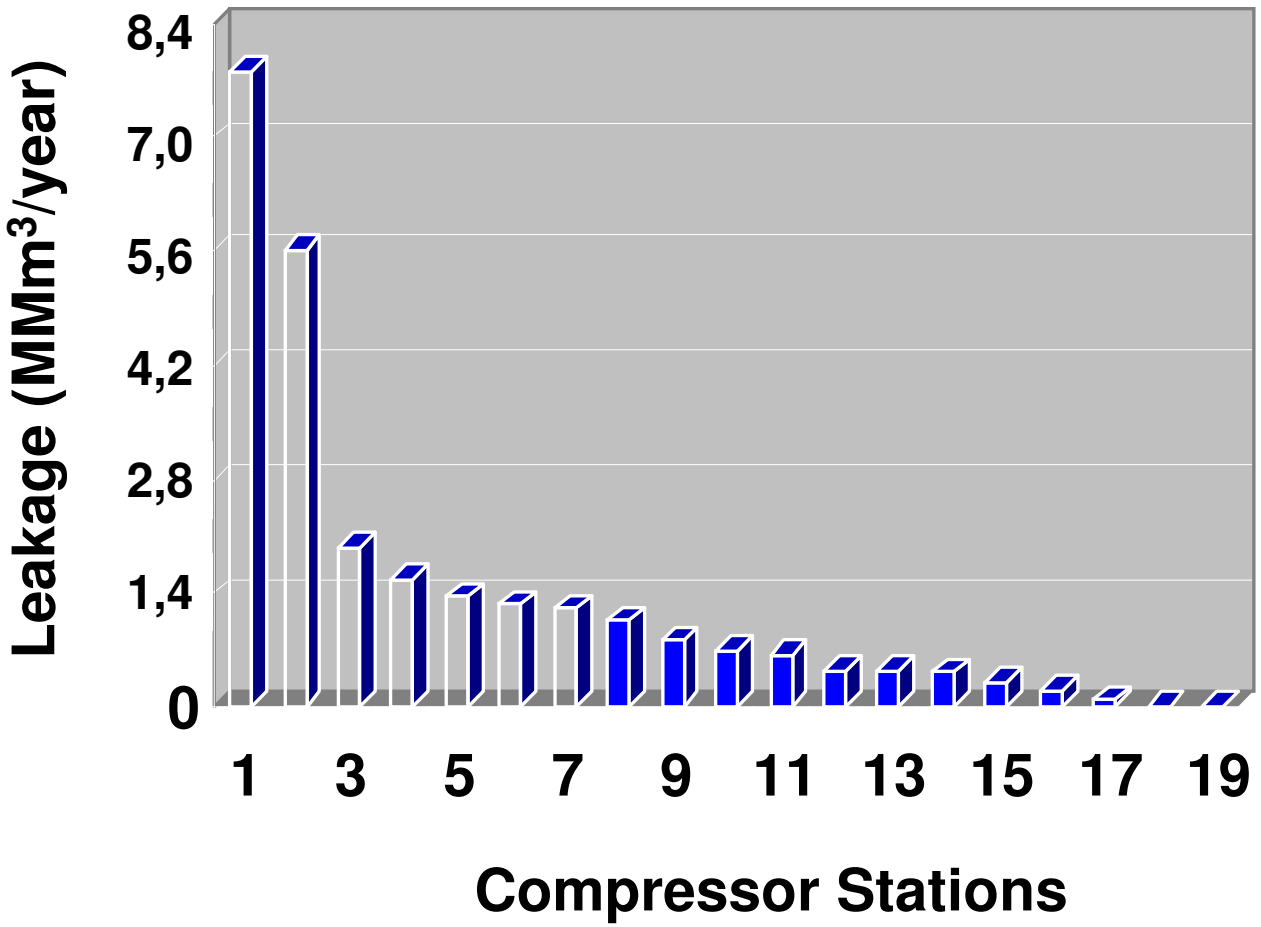
Source: Clearstone Engineering

Distribution of Losses by Type of Component (Processing)



Source: Clearstone Engineering, 2002

Measured Leakages in Compressor Stations



Source: Clearstone Engineering, 2002

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Leak Trends at Different Types of Facilities

Facility Type	Facility ID	Number of Components Surveyed	Leak Frequency	Emissions From All Leaking Sources				Contribution to THC Emissions	
				THC	Methane	GHG	Value	Top 10 Sources	Top 5 Sources
			[%]	[$10^3 m^3$/ year]	[tonnes/ year]	[tonnes CO_2E/year]	[$/year]	[%]	[%]
Gas Plant	GP-1	56 461	1,7	1 973	997	20 934	500 253	35	23
	GP-2	16 050	3,5	1 264	471	9 907	320 608	36	23
	GP-3	14 424	3,0	2 203	1 412	29 670	558 665	64	54
	GP-4	14 174	4,0	2 182	1 376	28 894	553 248	36	23
	GP-5	11 556	3,3	2 113	1 215	25 521	621 061	33	20
	GP-6	13 133	2,5	739	186	3 918	386 538	57	40
	GP-7	13 471	1,2	542	299	6 283	178 744	93	88
	GP-8	3 672	10,3	4 063	2 334	49 186	1 262 874	77	71
	GP-9	5 979	0,6	43	29	610	11 863	93	71
TOTAL		**148 920**		**15 123**	**8 320**	**174 923**	**4 393 854**		
AVERAGE		**16 547**	**2,5**	**1 680**	**924**	**19 436**	**488 206**	**54**	**43**
Compressor Station	CS-1	608	5,1	198	110	2 312	61 572	90	66
	CS-2	4 626	1,1	166	98	2 053	49 184	83	71
	CS-3	3 084	0,7	310	169	3 551	98 802	95	79
	CS-4	6 168	1,0	340	194	4 069	103 508	64	48
	CS-5	1 568	4,2	123	80	1 672	33 552	80	59
	CS-6	224	1,3	1	0	7	189	100	100
	CS-7	1 391	1,9	8	4	94	2 367	88	73
	CS-8	2 115	1,8	103	67	1 414	27 855	89	61
	CS-9	2 516	1,1	70	45	960	18 901	91	69
TOTAL		**22 300**		**1 317**	**767**	**16 131**	**395 928**		
AVERAGE		**2 478**	**1,5**	**146**	**85**	**1 792**	**43 992**	**83**	**64**
Well Sites	WS-1 to 3	1 474	0,2	2	1	18	501	100	100
	WS-4 to 8	1 617	1,5	1	1	13	351	88	66
	WS-9 to 12	1 797	0,4	2	1	30	585	100	99
TOTAL		**4 888**		**5**	**3**	**61**	**1 437**		
AVREAGE		**407**	**0,7**	**0**	**0**	**5**	**120**	**97**	**92**

Source: Clearstone Engineering, 2004

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What is Normal Leak Control Practice?

- Perform a leak check (using a bubble test or hand-held gas sensor) on equipment components when first installed, and after inspection & maintenance.
- Thereafter, leaks are detected by:
  - Area or building monitors.
  - Personal monitors.
  - Olfactory, audible or visual indicators.
- Leaks only fixed if this is easy to do or they pose an obvious safety concern.
- Unmanned facilities get less attention than manned facilities.
- Priority following a facility turnaround is to get it back on line rather than ensure all affected components have been leak checked.

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What is Directed Inspection & Maintenance (DI&M)?

It is a practicable ongoing approach to achieving significant cost-effective reductions in fugitive equipment leaks:

- Find the big leaks in an efficient manner:
  - Focus efforts on the most likely sources of big leaks with coarse or less frequent screening of other components.
- Only repair components that are cost-effective to repair or pose a safety or environmental concern.
- Minimize the potential for big leaks and provide early detection and repair of these when they occur.

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What are the benefits of DI&M?

- Attractive payback (often <6 months).
- Reduced maintenance costs.
- Reduced downtime.
- Improved process efficiency.
- Safer work environment.
- Cleaner environment.
- Resource conservation.

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Where Should Leak Monitoring Efforts Be Focused?

Table 1. Sample leak statistics for gas transmission facilities.

Source	Number of Sources	Leak Frequency	Average Emissions (kg/h/source)	Percent of Component Population	Contribution to Total Emissions (%)	Relative Leak Potential
Station or Pressurized Blowdown System[6]	219	59,8	3,41E+00	0,131	53,116	7616
Compressor Seal – Centrifugal [2]	103	64,1	1,27E+00	0,062	9,310	2838
Compressor Seal – Reciprocating [2]	167	40,1	1,07E+00	0,100	12,764	2400
Pressure Relief Valve	612	31,2	1,62E-01	0,366	7,062	362
Open-Ended Line	928	58,1	9,18E-02	0,555	6,070	205
Orifice Meter [7]	185	22,7	4,86E-02	0,111	0,641	109
Control Valve [4]	782	9	1,65E-02	0,468	0,919	37
Pressure Regulator	816	7	7,95E-03	0,488	0,462	18
Valve [9]	17029	2,8	4,13E-03	10,190	5,011	9
Connector [3]	145829	0,9	4,47E-04	87,264	4,644	1
Other Flow Meter [8]	443	1,8	9,94E-06	0,265	0,000	0,02

Source: Clearstone Engineering, 2007

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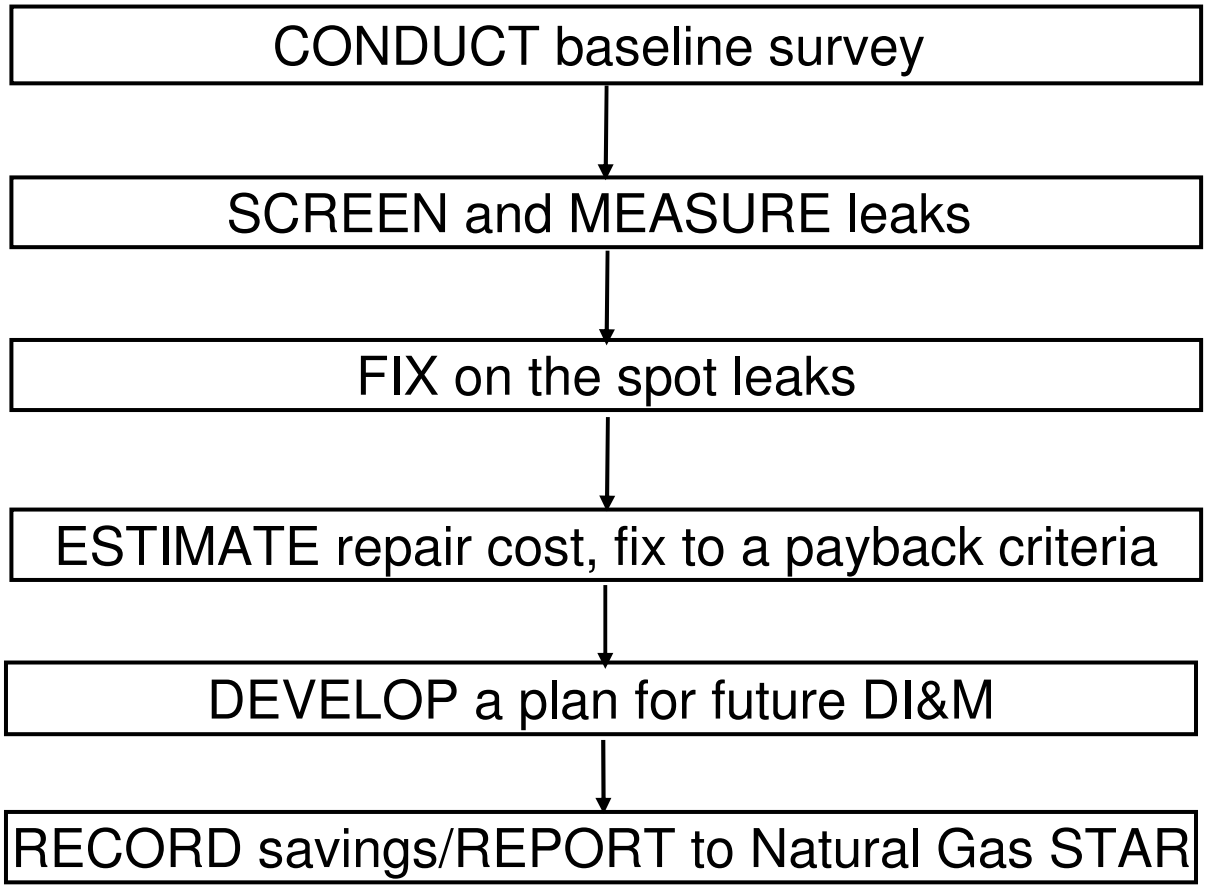
How Frequently Should Components Be Monitored?

Suggested leak monitoring frequencies for equipment components, presented by component category and type.				
Source Category	**Type of Component**	**Service**	**Application**	**Frequency**
Process Equipment	Connectors and Covers	All		Immediately after any adjustments and once every 5 years thereafter.
		All	Thermal Cycling.	Bi-annually.
		All	Vibration	Annually.
	Control Valves	Gas/Vapour/LPG		Annually.
		Gas/Vapour/LPG	Thermal Cycling	Bi-annually.
	Block Valves – Rising Stem	Gas/Vapour/LPG	All	Annually.
	Block Valves – Quarter Turn	Gas/Vapour/LPG	All	Once every 5 years.
	Compressor Seals	All	All	Monthly.
	Pump Seals	All	All	Quarterly.
	Pressure Relief Valves	All	All	Annually.
	Open-ended Lines	All	All	Annually.
	Emergency Vent and Blowdown Systems[1]	All	All	Quarterly.
Vapour Collection Systems	Tank Hatches	All	All	Monthly.
	Pressure-Vacuum Safety Valves	All	All	Monthly.

Source: Clearstone Engineering, 2006

How Do You Implement DI&M?



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How Do You Implement DI&M?

Screening - find the leaks

- Soap bubble screening
- Electronic screening ("sniffer")
- Toxic vapor analyzer (TVA)
- Organic vapor analyzer (OVA)
- Ultrasound leak detection
- Acoustic leak detection
- Infrared leak detection

Toxic Vapor Analyzer

Acoustic Leak Detection

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How Do You Implement DI&M?

- Evaluate the leaks detected - measure results
  - High volume sampler
  - End-of-pipe technologies
    - Velocity traverse
    - Rotameters
    - Calibrated bagging
  - Toxic vapor analyzer (correlation factors)

Leak Measurement Using High Volume Sampler

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How Do You Implement DI&M?

Summary of Screening and Measurement Techniques		
Instrument/ Technique	**Effectiveness**	**Approximate Capital Cost**
Soap Solution	★★	$
Electronic Gas Detector	★	$$
Acoustic Detector/ Ultrasound Detector	★★	$$$
TVA (Flame Ionization Detector)	★	$$$
Calibrated Bagging	★	$$
High Volume Sampler	★★★	$$$
End-of-pipe Flow Measurement	★★	$$
Infrared Leak Detection	★★★	$$$$
Source: EPA's Lessons Learned		

* - Least effective at screening/measurement

*** - Most effective at screening/measurement

$ - Smallest capital cost

$$$ - Largest capital cost

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Estimating Comprehensive Leak Survey Costs

- Cost of complete screening survey using high volume sampler (processing plant)
  - Ranges US$15.000 to US$20.000 per medium-size plant
  - Rule of Thumb: US$1 per component for an average processing plant
  - Cost per component for remote production sites would be higher than US$1
- 25 to 40% cost reduction for follow-up survey
  - Focus on higher probability leak sources (e.g. compressors)

DI&M by Infrared Leak Detection

Real-time detection of methane leaks

- Quicker identification of leaks.
- Screen hundreds of components an hour.
- Screen inaccessible areas simply by viewing them.

Infrared Leak Detection

Source: Leak Surveys Inc.

Remote Methane Leak Detector

Source: Heath Consultants

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Infrared Methane Leak Detection

Video recording of fugitive leaks detected by various infrared devices

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Is Recovery Profitable?

Repair the Cost Effective Components			
Component	**Value of lost gas[1] (US$)**	**Estimated repair cost (US$)**	**Payback (months)**
Plug Valve: Valve Body	8,428	200	0.3
Union: Fuel Gas Line	8,104	100	0.2
Threaded Connection	6,964	10	0.1
Distance Piece: Rod Packing	5,100	2,000	4.8
Open-Ended Line	4,640	60	0.2
Compressor Seals	3,856	2,000	6.3
Gate Valve	3,152	60	0.3

Source: Hydrocarbon Processing, May 2002 (Repair cost)
1 – Adjusted to US$70,63/$Mm^3$ gas price

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DI&M - Lessons Learned

- A successful, cost-effective DI&M program requires measurement of the leaks
- A high volume sampler is an effective tool for quantifying leaks and identifying cost-effective repairs
- Open-ended lines, compressor seals, blowdown valves, engine-starters, and pressure relief valves represent <3% of components but >60% of methane emissions
- The business of leak detection has changed dramatically with new technology

Source: Chevron

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Partner Experience - PEMEX

- Leak surveys implemented as part of PEMEX collaboration agreement with EPA from 2006 to date.
- Surveyed more than 3.000 components in random chosen sections at 3 major gas processing facilities in Southern Mexico using sniffers, FLIR camera and Hi-Flow Sampler
- Identified leaking rates as high as 62 Mm^3/year from single components
- Annual methane emissions reduction potential of 5,7 MMm3/year
- At US$70,63/$Mm^3$, potential gas savings would be worth US$ 400.000 / year
- PEMEX is implementing DI&M program

Source: M2M

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Discussion

- Industry experience applying these technologies and practices
- Limitations on application of these technologies and practices
- Actual costs and benefits