Shell Global Solutions

Comparison of Leak Detection and Measurement Methodologies

Presented by
Paul Tupper, Shell Global Solutions (US) Inc.
Joe Wilwerding, Sage Environmental Consulting

SAGE
ENVIRONMENTAL CONSULTING

Why This Topic?

- Product Recovery Opportunities
- Process/Worker Safety
- Emissions Inventory Reporting Requirements
- Potential GHG Emission Reporting Requirements

Common Gas Processing Fugitive Emission Sources

- Potential Leak Sources
  - Compressor unit valves
  - Fuel and relief valves
  - Piping and vessel flanges
  - Online gas analyzers
  - Compressor packing and seals
  - Tank/thief hatches and vents
  - Pneumatic instrumentation

Leak Detection Methods

- Method 21 (Instrument)
- Optical Imaging (IR Camera)
- Methane LASER
- LEL/CGI Meters
- Other Methods
  - Snoop (Method
  - DIAL

Primary Emissions Estimations Methods

- Method 21-based Emission Factors/ Equations
- IR Camera Leak/No-leak Emission Factors
- High Flow Sampler – Direct Measurement

Method 21

- What Is It ?
  - Work practice regulation/fugitive emissions identification method
  - Test leak interfaces on various types of plant processing equipment with hydrocarbon analyzer
  - Did bagging studies to correlate volumetric (ppm) readings from analyzer to measured mass flow rates
  - Used to set thresholds for repair under various regulations (NSPS, MACT, other)

Method 21

- Estimate Emissions
  - Monitor equipment and collect screening value
  - Use 1995 Protocol for Estimating Equipment Leaks Table 2-10 for non-pegged screening values >0 ppm
  - Enter screening value into equation for specific equipment type monitored to get estimated mass emissions rate for leak

TABLE 2-10. PETROLEUM INDUSTRY LEAK RATE/SCREENING VALUE CORRELATIONS[a]

Equipment type/service	Correlation[b,c]
Valves/all	Leak rate (kg/hr) = 2.29E-06 × (SV)$^{0.746}$
Pump seals/all	Leak rate (kg/hr) = 5.03E-05 × (SV)$^{0.610}$
Others[d]	Leak rate (kg/hr) = 1.36E-05 × (SV)$^{0.589}$
Connectors/all	Leak rate (kg/hr) = 1.53E-06 × (SV)$^{0.735}$
Flanges/all	Leak rate (kg/hr) = 4.61E-06 × (SV)$^{0.703}$
Open-ended lines/all	Leak rate (kg/hr) = 2.20E-06 × (SV)$^{0.704}$

Method 21

- Estimate Emissions (cont.)
  - For hydrocarbon analyzer pegged values, use Table 2-14

TABLE 2-14. 10,000 ppmv and 100,000 PPMV SCREENING VALUE PEGGED EMISSION RATES FOR THE PETROLEUM INDUSTRY

Equipment type/service	10,000 ppmv pegged emission rate (kg/hr/source)[a,b]	100,000 ppmv pegged emission rate (kg/hr/source)[a]
Valves/all	0.064	0.140
Pump seals/all	0.074	0.160[c]
Others[d]/all	0.073	0.110
Connectors/all	0.028	0.030
Flanges/all	0.085	0.084
Open-ended lines/all	0.030	0.079

Method 21

- Estimate Emissions (cont.)
  - For analyzer zero values, use Table 2-12

TABLE 2-12. DEFAULT-ZERO VALUES: PETROLEUM INDUSTRY

Equipment type/service	Default-zero emission rates[a,b] (kg/hr/source)
Valves/all	7.8E-06
Pump seals/all	2.4E-05
Others[c]/all	4.0E-06
Connectors/all	7.5E-06
Flanges/all	3.1E-07
Open-ended lines/all	2.0E-06

Other Method 21-Based Emissions Estimations Techniques

- Leak / No-Leak: Not Used Frequently With Today's Analyzer Technology
  - Use 10,000 ppm threshold to define leak and non-leak
- Use Average Factors Where Method 21 Is Not Practical /Possible Or Screening Value Data Is Not Available
  - Easiest, but usually results in highest calculated emissions
  - Today's plant fugitive emissions profile looks different than 30 years ago
    - Better technology equipment (material, packing and seals)
    - Better plant maintenance
    - More awareness on lost product

Gas Processing Plant Analysis

Total Process Units	62		Avg Tons VOC per Unit	
Equipment Type	Equipment Counts	Leak Percentage	Leak (>10k ppm)	No-Leak (<10k ppm)
Valves	87054	4.6%	57.2	0.28
Compressors	197	1.6%	0.042	0.003
Pumps	523	3.3%	0.24	0.034
PRVs	2085	0.8%	0.214	0.037
Total			57.7	0.4
Total			58.0	

Optical Imaging

- What Is It?
  - Cameras Which Are 'Tuned' to Wavelengths in Which Energy is Absorbed by Hydrocarbons
  - Best-demonstrated Field Technology is Passive IR
    - FLIR GasFindIR
  - Detection Sensitivities Much Higher Than Method 21
  - Can Quickly Scan Larger Areas and Optically Confirm The Presence and Source of Large Leaks
  - Can Be Fitted With Longer Lenses to Easily Spot Large Leaks from the Facility Perimeter

Optical Imaging

- Estimate Emissions
  - Use AWMA Industry Technical Paper
    - ISSN:1047-3289 J. Air & Waste Manage. Assoc. 57:1061-1070
  - Not Adopted/Approved By EPA
  - May Meet 'Best Available Data' Standards For Normal Emissions Reporting Requirements

Optical Imaging

- Estimate Emissions (cont.)
  - Studies Show Lower Emissions Than Standard Method 21 Emission Factor-based Emissions

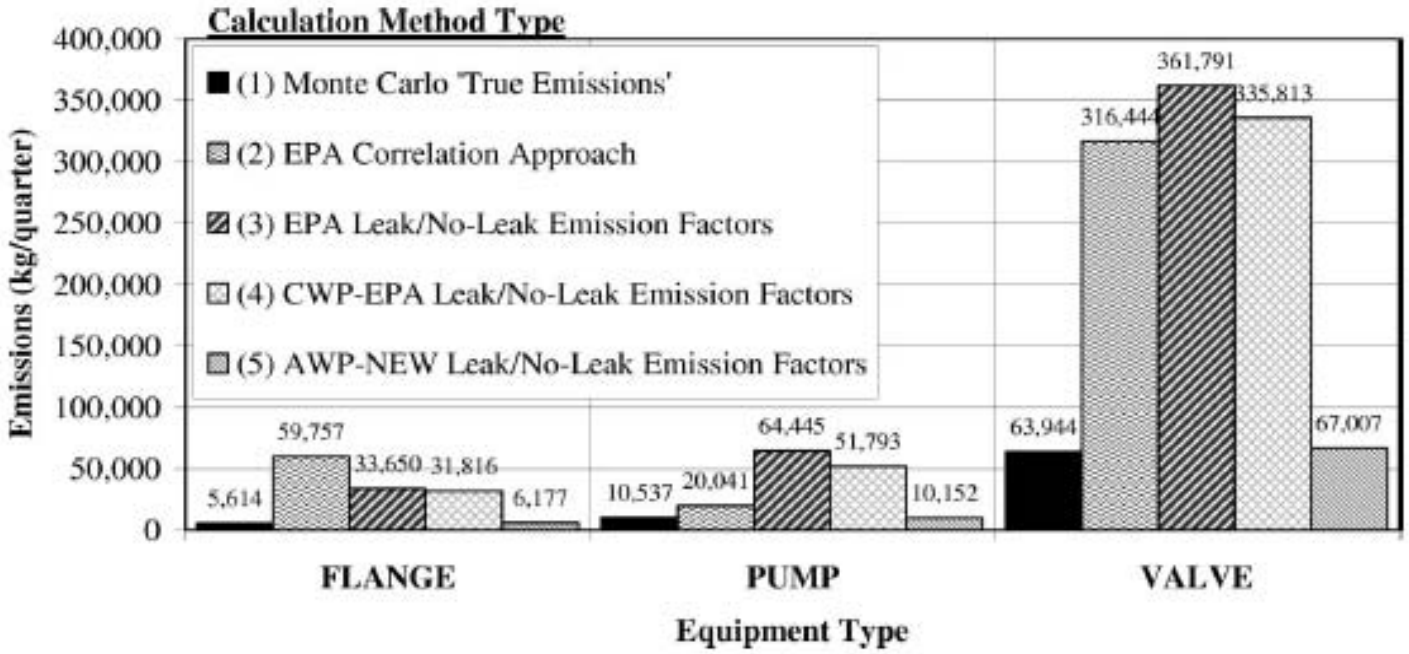


Figure 5. Comparison of total emissions by component type using the OAG screening dataset for the hypothetical refinery.

Optical Imaging

- Estimate Emissions (cont.)
  - Use Table 3 Factors Based on Emissions Detection Sensitivity Threshold Used for Optical Imaging

Table 3. Leak/no-leak EFs derived from 1000 MC simulations using the OAG SVC percentages for each component type.

Component Type	EF Type	1995 EPA Protocol Factors[a]	EF (g/hr/component) for Specified AWP Leak Definition (g/hr)			
			3	6	30	60
Valves	No-leak	0.88	0.019	0.043	0.17	0.27
	Leak	160	55	73	140	200
Pumps	No-leak	13	0.096	0.13	0.59	0.75
	Leak	420	140	160	310	350
Flanges	No-leak	0.06	0.0026	0.0041	0.0100	0.014
	Leak	38	29	45	88	120
All Components	No-leak	0.33	0.0070	0.014	0.051	0.081
	Leak	69	56	75	150	210

Method 21 vs Optical Imaging

- Required To Implement an LDAR Program By Federal Regulations (NSPS, MACT, etc)?
- Now Can Use New AWP to Satisfy Regulatory Requirements
- Sage Cost-Effectiveness Study (2009 NPRA White Paper)

Method 21 vs Optical Imaging

- Sage Cost-Effectiveness Study (2009 NPRA White Paper)
  - AWP Program Percent Savings: Imaging Speed and Monitoring Frequency Sensitivity Analysis

	Ratio of Quarterly to Annual Inspections Required in 27,500 Valve LDAR Program						
Ratio of IR Camera Imaging Rate to a 400-component/day M21 Monitoring Rate	0.1	0.25	0.5	1	2	5	10
1	-402%	-318%	-248%	-188%	-146%	-115%	-104%
2	-195%	-145%	-104%	-69%	-44%	-27%	-20%
3	-126%	-87%	-55%	-29%	-10%	3%	8%
4	-92%	-58%	-31%	-9%	7%	18%	22%
5	-71%	-41%	-17%	3%	17%	27%	30%
6	-57%	-30%	-7%	11%	24%	33%	36%
7	-47%	-21%	0%	17%	28%	37%	40%
8	-40%	-15%	5%	21%	32%	40%	43%
9	-34%	-10%	9%	24%	35%	43%	45%
10	-30%	-7%	12%	27%	37%	44%	47%

High Flow Sampling

- What Is It?
  - Originally Intended To Be a Powered Dilution Probe, But Really Is a Shortcut Bagging Technique
  - How Used:
    - High flow rate of air increases leak capture efficiency to near 100% (much like a laboratory hood)
    - Probe end adapters improve the capture efficiency by blocking off wind

Target Emission Services, Canada

High Flow Sampling

- Calculate Emissions
  - The Flow Meter And Analyzer are Meant for Methane Service
    - Uses a catalytic oxidation/thermal conductivity detector
    - Calibrate to methane
  - 2 Samples are Taken at Different Flow Rates To Ensure Full (Within +/- 10%) Capture of Leak
  - Leak Calculation Performed:
    - Leak = Flow x (Gas_{sample} - $Gas_{background}$) x 10-2
    - Results reported in liters/min or scfm CH_4
    - Measureable leak rates from 0.05 to 8.00 scfm
  - Shell Has Developed an Adaptation Which Allows High Flow Sampling to be Used to Estimate VOC/HAP Emissions
  - Mentioned as a Primary Method in O&G GHG Reporting

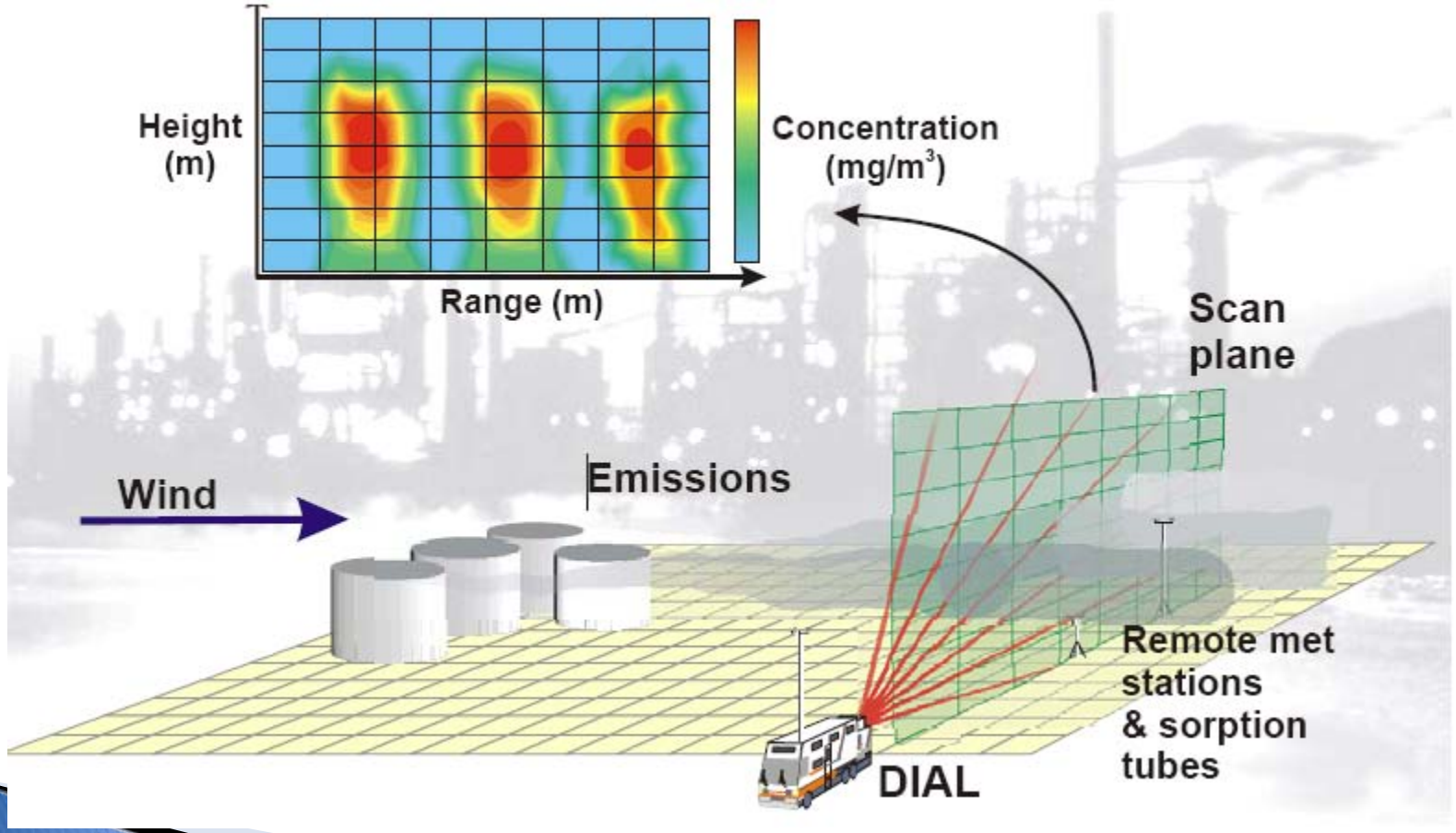
Conclusions

Comparison Chart of Leak Detection and Estimation Methodologies for Method 21, Optical Imaging & High Flow Sampling

LDAR Parameter	Method 21	Optical Imaging	High Flow Sampling
Equipment Cost	Low	High	Medium
Monitoring Speed	Low	High	Very low
Overall Cost-Effectiveness for Detecting Leaks	Medium	Medium	Low
Ease of Estimating Emissions*	High	High	High
Accuracy of Estimated Emissions	Medium	Medium to Low	High for Sampled Components
Acceptance of Emissions Estimation Methods	High	TBD	High

* All methods require allocation of estimated emissions over time if more than one monitoring/sampling event exists.

Differential Absorption Light Detection and Ranging (DIAL)



DIAL Technology Implications

- Alberta Refinery Study

Table 8: Comparison of VOC Estimates and DIAL Measurements

	NPRI Report 2004 (tonnes/y)	DIAL C_{2+} Measurements (tonnes/y)
stack or point release	98.69	not measured
storage or handling	153.0	5,090[1]
fugitive releases	407.1	4,880
spills	11.5	not measured
Total	**670.4**	**9,970**

1) emissions from tanks vary with wind speed and other factors

DIAL Technology Implications (cont)

- Flares and Vapor Combustion Units Also Being Evaluated
- City Of Houston Has Been Given an EPA Grant To Use DIAL For Further Analysis of Fugitive Emissions
- EPA Is Evaluating Data Collected to Date For Comparison To Current Emission Factors

Questions?

Please Contact:

Shell Global Solutions (US) Inc.
Paul Tupper
+1 (281) 544-7757
paul.tupper@shell.com

Sage Environmental Consulting
Joe Wilwerding
+1 (303) 799-0105
joew@sageenvironmental.com