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Directed Inspection and Maintenance Leak Survey at a Gas Fractionation Plant Using Traditional Methods and Optical Gas Imaging

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Introduction

- 1.1 Canadian Gas Fractionation Plant - Facility Description

Introduction

1.2 Objectives

- Primary objective –
  - to identify and measure hydrocarbon emissions from fugitive equipment leaks and highlight potential cost-effective emissions reduction opportunities.
- Secondary objective –
  - to compare the overall performance of the Hawk passive IR camera optical gas imaging method to conventional leak detection methods.

Methodology

2.1 Emissions Survey: main elements

- **screening of equipment components to detect leaks**,
- **measurement of emission rates** from identified leaking equipment components (i.e., leakers),
- **measurement of emissions from continuous vents** and residual flows from emergency vents during passive periods,
- **developing counts** of the surveyed equipment components,
- **development of the emissions inventory**,
- **determination of site-specific average emission factors** for fugitive equipment leaks, and
- **cost-benefit analysis** of the identified control opportunities.

Methodology

The following basic information was recorded for each leaking component:

- component type,
- model or style of component,
- service,
- size,
- process unit,
- process stream,
- pressure, and
- temperature.

Figure 2.1. Bubble test on leaking valve

Rapid Screening procedure used bubble tests with soap solution, portable hydrocarbon gas detectors, and ultrasonic detectors

Methodology

2.1.2 Leak-Rate Measurements

- The HiFlow Sampler was the primary method used to measure emission rates from leaking equipment components.

Methodology

Hawk Passive IR Camera

Overview of the Emissions

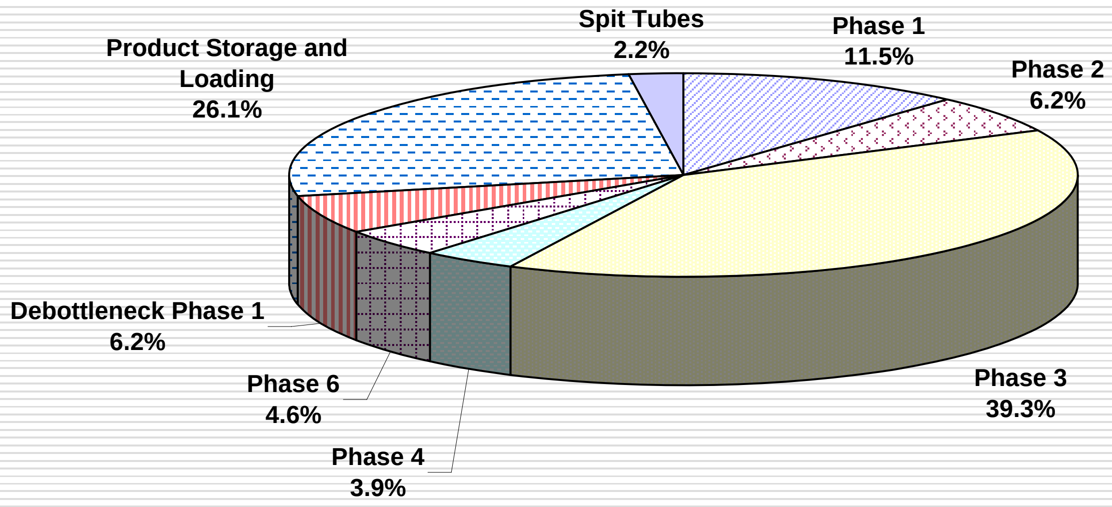
3.1 Emissions Inventory

Table 1 **Summary of greenhouse gas emissions from fugitive sources at NGL Fractionation Plant (October 18 to 22, 2004), presented by process area.**

Process Area / Source	THC (tonnes/y)	CO_2[1] (tonnes/y)	CH_4[1] (tonnes/y)	CO_2E[2] (tonnes/y)
Phase 1	128.96	0.53	35.34	742.67
Phase 2	69.56	0.11	7.36	154.66
Phase 3	439.23	0.02	1.50	31.59
Phase 4	43.56	0.08	5.51	115.77
Phase 6	51.49	0.000	0.001	0.02
Debottlenecking Phase 1	68.68	0.05	3.46	72.71
Product Loading and Storage	291.09	0.000	0.08	1.72
Rail Car Spit Tubes	24.30	0.01	0.00	0.13
TOTAL	**1 117**	**0.79**	**53.25**	**1 119**

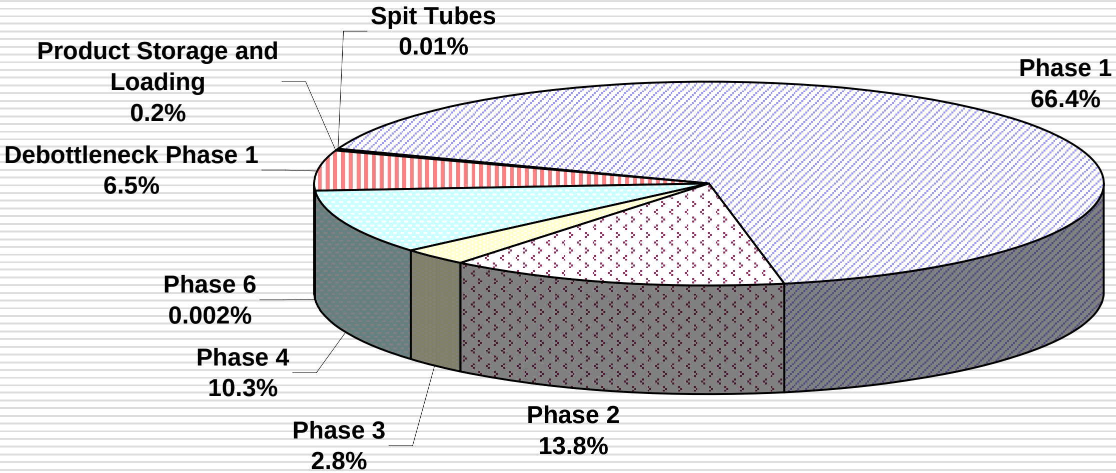
1 THC emissions are speciated using typical stream analyses for the plant.
2 Carbon dioxide equivalent emissions are calculated using the most recent 100 year global warming potentials (IPCC, 1996) (i.e., 1.0 for CO2 and 21.0 for CH4).

Overview of the Emissions



Summary of THC emissions, by process area or source, from the Gas Fractionation Plant.

Overview of the Emissions



Summary of GHG emissions, by process area or source, from the Gas Fractionation Plant.

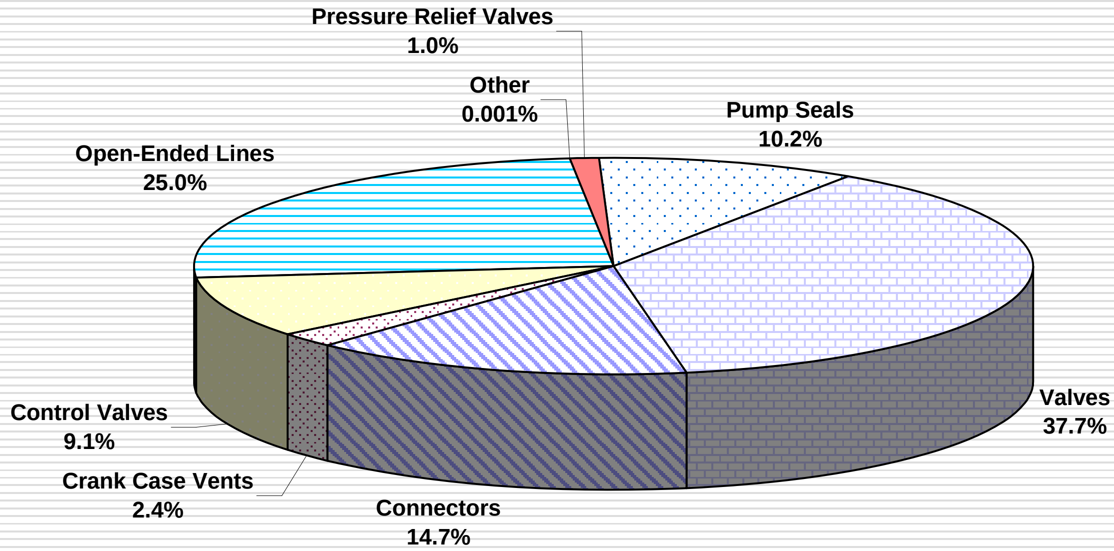
Overview of the Emissions

3.2 Average Component Emission Rates

Table 2 Fraction of leaking components and average component emission rates for data collected at Gas Fractionation Plant (October 18 to 22, 2004).

Component	Number of Components Surveyed	Number of Leakers	Percentage of Components Leaking	Average Emission Rate (kg/h/source)	95 % Confidence Limits	
					Lower	Upper
Connectors	68 670	107	0.14	0.000211	0.000092	0.000331
Block Valves	7 471	284	3.80	0.006452	0.00495	0.00796
Control Valves	579	27	4.66	0.01665	0.0113	0.0220
Open-Ended Lines	667	19	2.85	0.05554	0.000	0.148
Pressure Regulators	18	1	5.56	0.000040	0.000039	0.000042
Pump Seals	107	6	5.61	0.122	0.000340	0.244
Crank Case Vents	2	2	100.00	0.518	0.000092	0.000331
Orifice Meters	26	0	0.00	0.0	N/A	N/A
Compressor Seals	3	0	0.00	0.0	N/A	N/A
Pressure Relief Valves	257	1	0.39	0.00479	0.0000	0.0129
Total	77 880	447	0.56			

Overview of the Emissions



Relative distribution, on a volumetric basis, of total hydrocarbon (THC) emissions from leaking equipment components at the Gas Fractionation Plant.

Overview of the Emissions

3.3 Site-Specific Emission Factors

Table 3 Comparison of average emission factors derived from collected data to other published values (kg/h/source).

Source	Fractionation Plant[1]	CAPP[2] Gas Facilities	U.S. EPA Gas Facilities[3]	U.S. EPA Refineries[4]
Connectors	2.11e-04	2.53e-03	3.048e-04	2.5e-04
Block Valves	6.45e-03	4.351e-02	3.400e-03	2.68e-02
Control Valves	1.67e-02	N/A	N/A	N/A
Open-Ended Lines	5.55e-02	3.73e-03	9.015e-04	2.30e-03
Pressure Regulators	4.05e-05	N/A	N/A	N/A
Pump Seals	1.22e-01	2.139e-01	N/A	1.14e-01
Crank Case Vents	5.18e-01	N/A	N/A	N/A
Orifice Meters	ND	N/A	N/A	N/A
Compressor Seals	ND	8.049e-01	1.172e-00	6.36e-01
Pressure Relief Valves	4.79e-03	1.210e-01	2.238e-03	1.60e-01

N/A Average emission factor for this source type is not available.
ND Leaks for this type of component not detected at the Gas Fractionation Facility.
1 Based on data collected at Gas Fractionation Plant October 18 to 22, 2004.
2 Source: Canadian Association of Petroleum Producers. 1999. A Detailed Inventory of CH4 and VOC Emissions from Upstream Oil and Gas Operations in Canada. Volume 2: Development of the Upstream Emissions Inventory. Calgary, AB.
3 Source: U.S. EPA and GRI. 1996. Methane Emissions from the Natural Gas Industry. Volume 8: Equipment Leaks. Research Triangle Park, NC 27711
4 Source: U.S. EPA and GRI. 1995. Protocol for Equipment Leak Emission Estimates. Table 2-2: Refinery Average Emission Factors, pg. 2-13.

Emission Reduction Opportunities

4.1 Fugitive Equipment Leaks

- Total gas losses: 470.8 x 10^3 m^3/y
- Value product lost: est. CAN $386,465 annually.
- 423 leaking components;
- 320 of these are estimated to be economical to repair.
- Implementing all cost-effective equipment repairs identified would result in net present savings of CAN $1,055,850 and reduce hydrocarbon losses by 465.0 x 10^3 m^3/y and GHG emissions by 826.5 tonnes per year CO2E.

Table 5 Summary of ten largest cost-effective emission reduction opportunities.

CEL Tag ID (Yellow)	LSI Tag ID (Blue and Yellow)	Process Unit / Location	Component Type	Emission Rate (10^3 m^3/y)	Value of Gas ($/year)	Payout Period (years)
	Y133	CM-12.201/Splitter Compressor - 0.5" Gate valve seat	Open-ended line - 4"	111.920	115494	0.002
	B22	PM-18.204/LPG Transfer Pump - GREATER THAN 18.4%	Gate valve - 4"	13.246	12620	0.02
5305		HT-16.207AB/Depropanizer Overhead Condenser -	Gate valve - 6"	13.697	10624	0.02
5641	Y200	PV-17.11/Butane Treater - union	Threaded connection - 1"	8.678	8955	0.003
	B77	PM-18.15/Propane Loading Pump - GREATER THAN 18.4%	Pump seal - 6"	22.397	17373	0.03
5213	B238	PM-18.209/Debutanizer Reflux Pump -	Gate valve - 8"	2.672	3919	0.1
5637A	B194A	Next to PV-17.11 – union	Threaded connection - 1"	6.942	7164	0.004
	B97	PM-18.702/Propane Loading Pump	Gate valve - 10"	4.327	3356	0.1
5371		CM-12.02/Regen Gas Recycle Compressor - B11 (GREATER THAN 18.42%)	Valve cover - 1"	30.293	6026	0.03
	Y141	PM-18.401/EP to Pump – FLAMEOUT	Pump seal	12.471	12007	0.04

Note: not 100% overlap of leak survey with traditional methods and optical gas imaging

Leak Detection Methodology Comparison

Table 6 Qualitative comparison of traditional leak detection techniques and the optical infrared LSI Hawk camera technology.

Parameter	Conventional Leak Detection Techniques	Optical Infrared LSI Hawk Camera
Speed	**Screening speed:** Typically 1,200 components/person/day For a two person team: 2,400 components/day or 240 components/hour. Screening technicians that are not familiar with the process and appropriately trained may needlessly screen non-target components (e.g., electrical conduit and components in water service).	**Screening speed:** For a two person team: 23,000 components/day or 2,300 components/hour. However, greater time is required to tag the identified leakers since the camera operator must communicate the leak location to his/her assistant. Similar potential for needlessly screening non-target components.

Table 6 Comparison of advantages and disadvantages of traditional leak detection techniques and the optical infrared LSI Hawk camera technology.

Parameter	Conventional Leak Detection Techniques	Optical Infrared LSI Hawk Camera
Mobility	**Size:** Gas detectors and spray bottles are small and light-weight and allow the operator to be very mobile in all areas.	**Size**: Size and weight have improved over the Hawk version.
	Difficult to access components: Depending on component, ladders or other access points must be found. Extension poles may be used to screen roofline vents and other elevated sources.	**Difficult to access components:** **Using the camera elevated components and other difficult access locations can be screened from the ground or at a distance.**

Table 6 Comparison of advantages and disadvantages of traditional leak detection techniques and the optical infrared LSI Hawk camera technology.

Parameter	Conventional Leak Detection Techniques	Optical Infrared LSI Hawk Camera
Leak Identification	**Application of Leak Definition:** An objective leak definition (i.e., US EPA definition of 1 percent hydrocarbon concentration in vicinity of leaker) can be applied using gas detectors. **Leak Isolation:** It is sometimes difficult to identify a leaking component where there are high background readings due to interference from other nearby leaking sources and in congested areas. **Unconventional Leakers:** Traditional techniques focus in on expected sources and locations (e.g., seal vents, mechanical connections, covers, etc). Leakage at other points on a component or on piping (e.g., due to corrosion and mechanical damage) may not be identified. **Missed Sources:** The reliability of the method is highly dependent on the care and attention used by the screening technician.	**Application of Leak Definition:** The camera operator is able to qualitatively assess the size of each leaker (i.e., small, medium, large), but the technology currently does not apply an objective leak definition. **Leak Isolation:** Camera can more clearly 'see' a source of leakage despite the close proximity of other leaking and non-leaking components. **Unconventional Leakers:** The camera is more apt to pick up leaking equipment components in unconventional places since a wide field of view is used. **Missed Sources:** Less sensitive to but still dependent on the level of care and attention of the screening technician.

Table 6 Comparison of advantages and disadvantages of traditional leak detection techniques and the optical infrared LSI Hawk camera technology.

Parameter	Conventional Leak Detection Techniques	Optical Infrared LSI Hawk Camera
Potential Application for Routine LDAR Screening	Traditional techniques are relatively simple to learn and require limited expertise. Data can have high degree of variability.	Camera use requires individuals with specific training. Flir GasFindIR has automatic contrast control, easier to use than HAWK but still requires training and experience.

Table 6 Comparison of advantages and disadvantages of traditional leak detection techniques and the optical infrared LSI Hawk camera technology.

Parameter	Conventional Leak Detection Techniques	Optical Infrared LSI Hawk Camera
Cost	Conventional Screening Equipment: $5,000 - $10,000 (USD) Charge for experienced two person contract team: $1,200 per day (USD) plus expenses. Cost would be much less if the work is performed by summer students.	Camera: $75 - 95,000 (USD) Change for experienced two person contract team: $3,000 per day (USD) plus expenses
Weather	Operators are limited by very inclement weather and cold (less than -15°C). Screening equipment is not affected by poor weather other than extreme cold.	Camera cannot be used during rain or fog and is not as effective during overcast skies. The camera has a specified nominal operating range for ambient temperature.

Table 6	Comparison of advantages and disadvantages of traditional leak detection techniques and the optical infrared LSI Hawk camera technology.	
Parameter	**Conventional Leak Detection Techniques**	**Optical Infrared LSI Hawk Camera**
Safety	**Intrinsic Safety:** All traditional screening equipment is rated intrinsically safe. **Slips, trips and falls:** Traditional leak detection techniques require the screening technician to be in close contact with the process equipment which poses a risk of slips, trips and falls. Other injuries resulting from burns and pinched fingers are more likely. **Exposure to Vapours:** Operators must be in close proximity to equipment components in order to identify leakers, therefore, there is a greater chance of operator exposure to hazardous compounds in the gas (e.g., H_2S and benzene).	**Intrinsic Safety:** The camera is not intrinsically safe; therefore its use is limited in hazardous areas. Hot work permits are usually required to conduct work within.operating unit boundaries. **Slips, trips and falls:** The size and weight of the camera, coupled with the operator's restricted view when using the camera may contribute to slips, trips and falls. Furthermore, once leaks are detected, the operator must still get in amoungst the equipment to install leaker tags. **Exposure to Vapours:** Risk considered minor given that leaking equipment components are viewed at some distance.

Conclusions

- The emissions survey of the Gas Fractionation Plant provided the following:
  - an assessment of total hydrocarbon, methane and greenhouse gas emissions at the facility
  - average site-specific emission factors for future estimation of emissions from fugitive equipment leaks
- Emissions from leaking equipment components were generally well-controlled (0.56% leak rate); attributed to good maintenance practices.

Conclusions

- Optical gas imaging technology has the ability to screen difficult to monitor components more easily than traditional screening techniques.
- Both techniques are dependent on operator experience and diligence for a valid and complete leak screening assessment.