# 2009 HRVOC Control Cost and Flare Analyses

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- *Cost Analysis of Highly Reactive Volatile Organic Compound (HRVOC) Controls on Refineries and Chemical Plants* (Project 2009-52)

- *Control of HRVOC Emissions in Flares at Low Flow Conditions* (Project 2009-53)

# *Project Purpose*

**HRVOC Control Cost Analysis (2009-52)** – Collect additional information on HRVOC emission reduction projects at refineries and chemical plants and to use this information to perform an analysis of the costs of controlling HRVOC emissions from different types of facilities.

**HRVOC Flare Analysis (2009-53)** – Gather information comparing the maximum design capacity and the average routine loading for flares in HRVOC service at various facilities.

# Data Collection

Both the HRVOC Control Cost and Flare Analyses included data collected from:

- ENVIRON questionnaires from Project 2008-104 (*Cost Analysis of HRVOC Controls on Polymer Plants and Flares*), known as "Phase 1"
  - 16 Harris County sites contacted, 11 participated
- ENVIRON questionnaires submitted in 2009, known as "Phase 2"
  - 38 Harris County sites contacted, 24 participated

# *Industry Sectors*

Both analyses categorized sites/flares into four industry sectors:

- Chemical manufacturing (**Chemical**)
  - Includes both olefin and non-olefin manufacturing
- Polymer manufacturing (**Polymer**)
- Petroleum refining (**Refinery**)
- Independent storage terminals (**Terminal**)

**In the analyses, some sites are in more than one industry sector because certain sites perform multiple operations, such as sites that manufacture both polymers and olefins (i.e., site operations separated into “plants”).**

# *Data Received by Industry Sectors*

| Industry Sector | TCEQ HECT[1] Sites to Survey | Phase 1 | Phase 2 |
|---|---|---|---|
| Chemical | 21 | 2 | 12 |
| Polymer | 9 | 7 | 2 |
| Polymer/Chemical[2] | 4 | 2 | |
| Refinery | 4 | | 2 |
| Terminal | 10 | | 8 |
| **Total** | **48** | **11** | **24** |

[1] HRVOC Emissions Cap and Trade (HECT) Program

[2] Sites with olefin and polymer plants.

# *HRVOC Control Cost Analysis*

# *HRVOC Control Cost Analysis*

## *Types of HRVOC Emission Reduction Projects*

- **Process change** – Change in how the product is made
- **Change in operating procedure** - Items include enhanced maintenance or use of more robust process simulation to reduce emissions during startup and shutdown
- **Vent gas control** – Installation of controls on vent streams where none existed previously, or upgrading to control systems with higher control efficiencies
- **Flare minimization** – Recovery of vapor or gas for reuse instead of sending it to the flare

# *HRVOC Control Cost Analysis*

## *Types of HRVOC Emission Reduction Projects*

**Summary of HRVOC Emission Reduction Projects by Industry Sector**

| Industry Sector | Number of Plants Participating[1] | Type of HRVOC Emission Reduction Project | | | |
|---|---|---|---|---|---|
| | | Process Change | Change in Operating Procedure | Vent Gas Control | Flare Minimization |
| Chemical | 16 | 0 | 11 | 0 | 6 |
| Polymer | 9 | 0 | 16 | 7 | 7 |
| Refinery | 3 | 0 | 0 | 0 | 4 |
| Terminal | 8 | 0 | 0 | 0 | 0 |
| **Total** | **36** | **0** | **27** | **7** | **17** |

[1]Two of the survey respondents manufacture both polymers and olefins at the site. One site contains both refining and olefins manufacturing operations.

# HRVOC Control Cost Analysis

## Cost Effectiveness of HRVOC Emission Reduction Projects

| Industry Sector | Plants | Projects | Total Annual Cost[1] ($) | HRVOC Emission Reductions (tpy) | Cost Effectiveness Range[2] ($/tpy) | Average Cost Effectiveness[3] ($/tpy) |
|---|---|---|---|---|---|---|
| Chemical | 8 | 17 | $1,506,250 | 361 | $2,610 - $30,545 | $4,175 |
| Polymer | 8 | 30 | $5,116,350 | 346.31 | $2,012 - $59,933 | $14,774 |
| Refinery | 1 | 1* | $240,000 | 13.5 | N/A | $17,778 |
| Terminal | 0 | 0 | $0 | 0 | N/A | $0 |
| **Total** | **17** | **48** | **$6,862,600** | **720.81** | **N/A** | **$9,521** |

[1]Assuming a five-year project life: [(sector's total capital cost) ÷ 5] + (sector's one year of direct and indirect costs)

[2]A range of the plant's cost effectiveness in the specified industry sector

[3](Total annual cost) ÷ (HRVOC emission reductions)

*Two of the refinery projects were not undertaken solely for the purpose of reducing HRVOC emissions.

# HRVOC Control Cost Analysis Conclusion

**Conclusions:**

- Large variations in the amount of HRVOC emission reductions
  - Variation example: A polymer plant reduced its HRVOC emissions by 3 tpy, and the cost effectiveness is $59,933 per ton; however, the industry sector average cost effectiveness is $14,774 per ton
- 76% of the total HRVOC emission reduction projects had a total annual cost less than or equal to $250,000
- A majority of the HRVOC emission reduction projects resulted in emission reductions of 20 tpy or less

# HRVOC Control Cost Analysis Conclusion

**Potential Reasons for Large Variations:**

- Certain plants might have had the capability to implement inexpensive emission reductions that other plants did not have
- Throughput-based HECT allowance allocation amount
  - Sites with sufficient allowances would not need to install controls
  - Sites with insufficient allowances would have to determine the amount of controls needed to comply with the HECT program
- Industry sector definition too broad (i.e., certain processes that are defined in the same industry sector might not be able to use the same controls because of chemical composition)
- Insufficient or inaccurate information

# *HRVOC Flare Analysis*

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## *Flare Specifications*

**Size Categories:**

- **Small** – Maximum design capacities less than 1 million standard cubic feet of waste gas per hour (MMscf/hr)
- **Medium** – Maximum design capacities equal to or greater than 1 MMscf/hr, but less than 10 MMscf/hr
- **Large** – Maximum design capacities greater than or equal to 10 MMscf/hr

**Flare Service Type:**

- **Routine –** Everyday process emissions
- **Upset/Maintenance, Startup, Shutdown (MSS) –** Emergency emissions
- **Both –** Both routine and upset/MSS

# *HRVOC Flare Analysis*

## *Maximum Rated Capacities*

| Industry Sector | Flare Service Type | Small (<1 MMscf/hr) | Medium (1 - 10 MMscf/hr) | Large (≥10 MMscf/hr) | Size Not Specified | Total |
|---|---|---|---|---|---|---|
| Chemical | Routine | 2 | 2 | | | **4** |
| | Upset/MSS | 1 | 1 | 2 | 1 | **5** |
| | Both | 12 | 5 | 6 | 5 | **28** |
| Polymer | Both | 2 | 9 | 1 | 6 | **18** |
| | Not Specified | | | | 1 | **1** |
| Refinery | Both | | | | 9 | **9** |
| | Not Specified | | | | 2 | **2** |
| Terminal | Both | 9 | 1 | | | **10** |
| | Upset/MSS | 4 | | | 1 | **5** |
| **Total** | | **30** | **18** | **9** | **25** | **82** |

# HRVOC Flare Analysis

## *Maximum Rated Capacities*

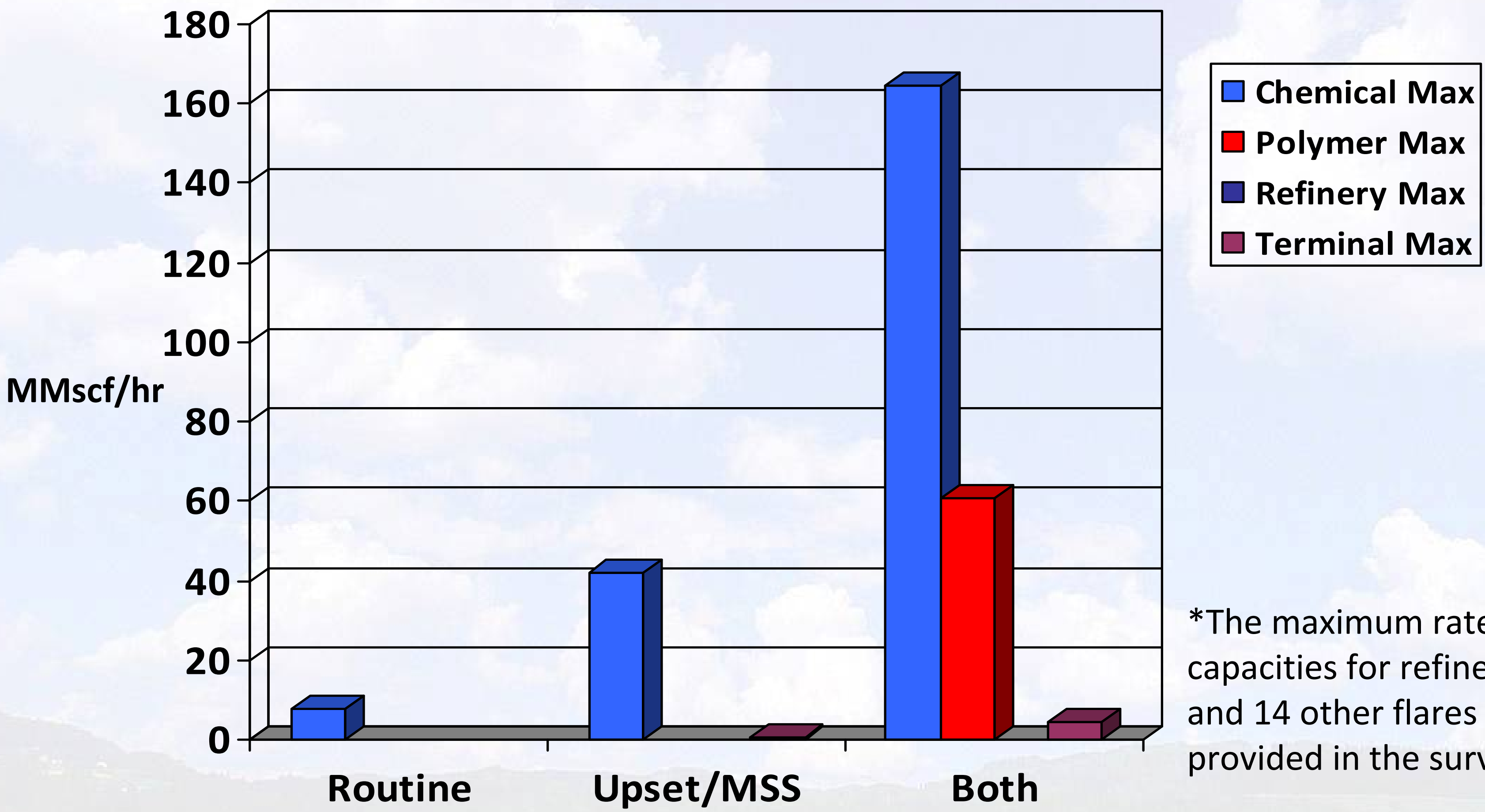
| Maximum Design Capacity Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| **Mean (Average)** | **Median (Middle #)** | **Mode (Most Frequent #)** | **Standard Deviation** | **Minimum** | **Maximum** |
| 4.92 MMscf/hr | 0.78 MMscf/hr | 0.70 MMscf/hr | 8.29 MMscf/hr | 0.0002 MMscf/hr | 37.13 MMscf/hr |

- **Small flares** – 80% have a maximum design capacity equal to or less than 0.5 MMscf/hr
- **Medium flares** – 67% have a maximum design capacity equal to or less than 5 MMscf/hr
- **Large flares** – 56% have a maximum design capacity equal to or less than 20 MMscf/hr

# *HRVOC Flare Analysis*

## *Maximum Rated Capacities*

**Cumulative Flare Maximum Rated Capacities by Industry Sector Represented in HRVOC Flare Analysis***



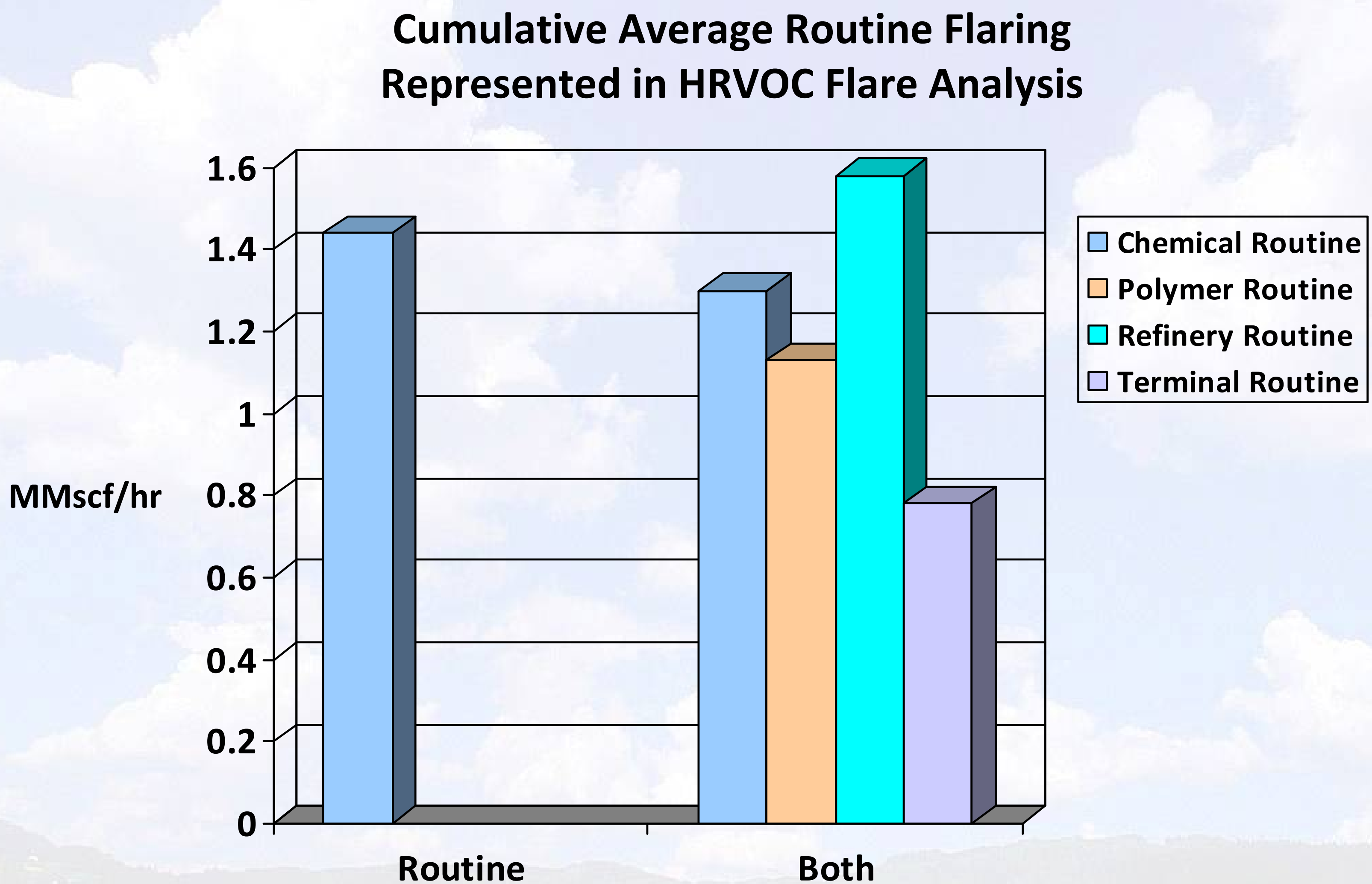

*The maximum rated capacities for refinery flares and 14 other flares were not provided in the survey.

# HRVOC Flare Analysis
## Routine Flaring

| Routine Flare Loading Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| **Mean (Average)** | **Median (Middle #)** | **Mode (Most Frequent #)** | **Standard Deviation** | **Minimum** | **Maximum** |
| 0.01 MMscf/hr | 0.04 MMscf/hr | 0.01 MMscf/hr | 0.15 MMscf/hr | 0.0000048 MMscf/hr | 0.79 MMscf/hr |

- **Small flares** – 17 out of 25 operated at an average of less than or equal to 25% of the maximum design capacity
- **Medium flares** – 15 out of 17 operated at an average of less than or equal to 5% of the maximum design capacity
- **Large flares** – 11 out of 12 operated at an average of less than or equal to 0.5% of the maximum design capacity
- **Altogether**, 92% operated at an average of less than or equal to 0.25 MMscf/hr

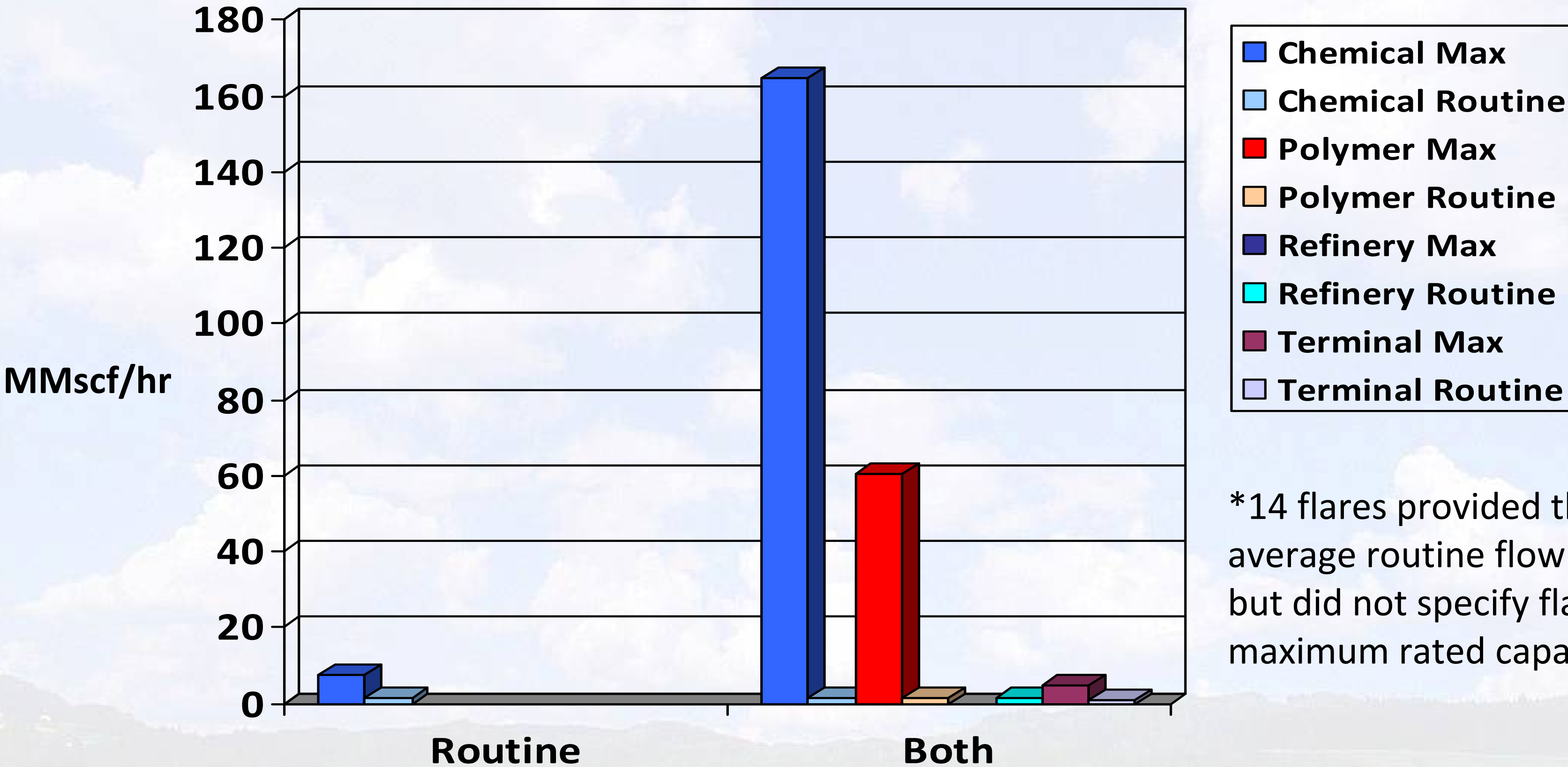
# HRVOC Flare Analysis
## Routine Flaring



# HRVOC Flare Analysis
## Routine Flaring

**Cumulative Flare Maximum Rated Capacities by Industry Sector Versus Average Routine Flaring Represented in HRVOC Flare Analysis***

**All Flow Rates are Total, Unspeciated Flow Rates**



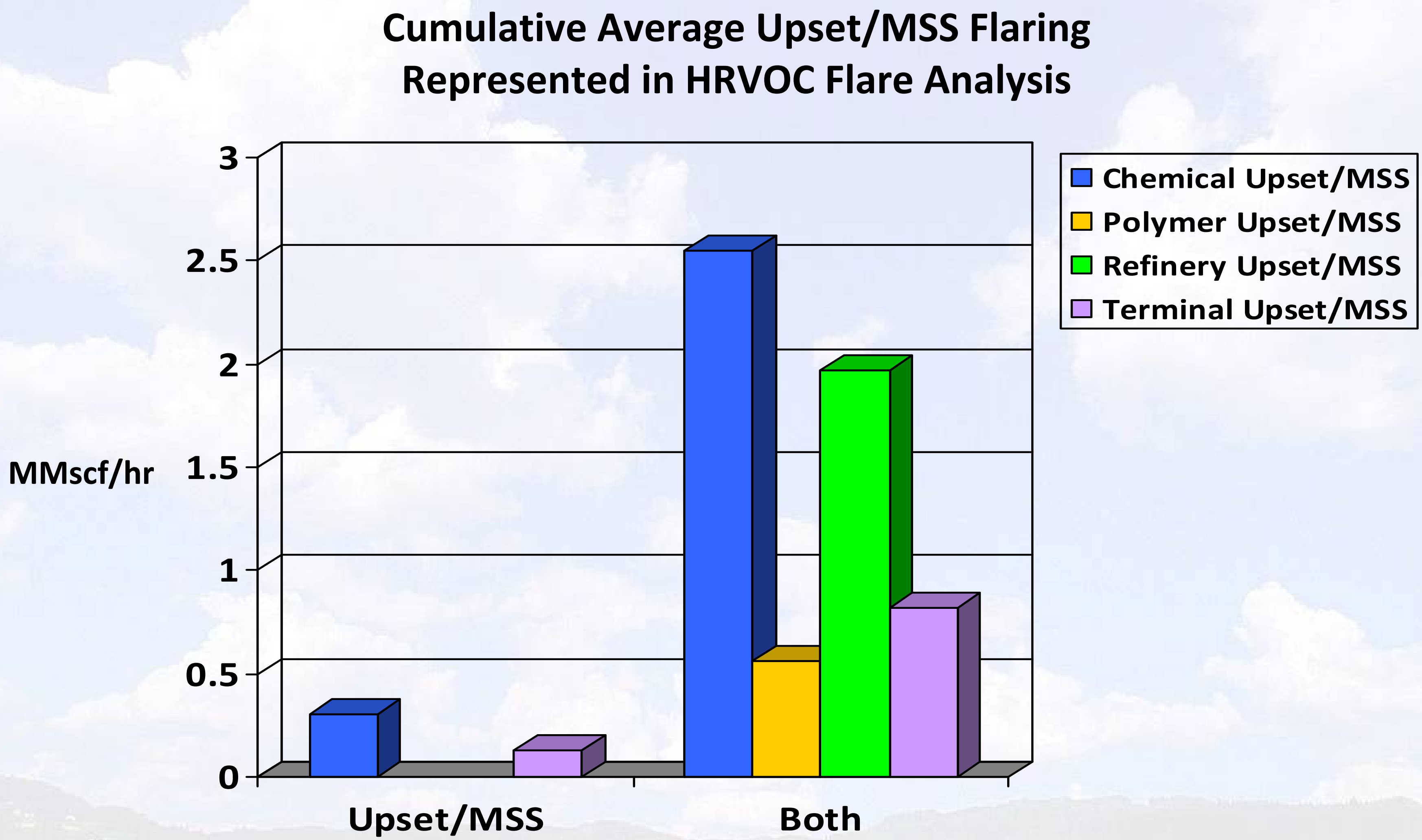

*14 flares provided the average routine flow rate, but did not specify flare maximum rated capacity.

# *HRVOC Flare Analysis*
## *Upset/MSS Flaring*

| Upset/MSS Flare Loading Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| **Mean (Average)** | **Median (Middle #)** | **Mode (Most Frequent #)** | **Standard Deviation** | **Minimum** | **Maximum** |
| 0.14 MMscf/hr | 0.05 MMscf/hr | 0.003 MMscf/hr | 0.21 MMscf/hr | 0.0000098 MMscf/hr | 1.10 MMscf/hr |

- **Altogether**, 78% of the flares had an upset/MSS loading at an average of less than or equal to 0.2 MMscf/hr

# HRVOC Flare Analysis
## Upset/MSS Flaring



# *HRVOC Flare Analysis Conclusion*

**Conclusions:**

- Polymer plant flares, on average, operated at approximately 4% of maximum design capacity
- Chemical plant flares, on average, operated at approximately 11% of maximum design capacity
- Terminal flares, on average, operated at approximately 20% of maximum design capacity
- Almost 85% of flares operated at an average of less than or equal to 25% of the maximum design capacity

# HRVOC Flare Analysis Conclusion

**Conclusions:**

- Flares designed for both routine as well as emergency emissions operated at an average of 0.04% - 50% of the maximum design capacity
- Flares designed for routine emissions only operated at an average of 0.03% - 37.8% of the maximum design capacity
- Flares designed for upset/MSS emissions only operated at an average of 0.05% - 24.58% of the maximum design capacity
- Approximately 82% of flares surveyed are designed to handle both routine as well as emergency flows

# *HRVOC Flare Analysis Conclusion*

**Potential Reasons for Low Flow Rates:**

- The majority of flares are designed to handle maximum potential flow rates for emergency emissions but are more commonly used for flaring routine emissions

- Sites not operating at maximum productivity

# Questions?

**HRVOC Control Cost Reports:**
Brandon Greulich x4904
Control Strategy Development

**Flares:**
Lindley Anderson x0003
Control Strategy Development