Measurements of Benzene Destruction Efficiency In a Lab-Scale Flare

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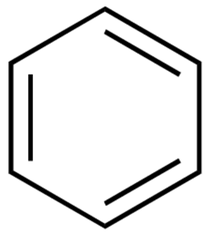
Motivation

- Benzene commonly emitted from glycol dehydrators
  - Mostly vented, but sometimes flared



- Benzene is a serious health concern
  - Known human carcinogen
- Reporting guidelines and emission regulations are limited

National Pollutant Release Inventory (NPRI) Reporting Guideline[1]	Alberta Energy Regulator (AER) – Directive 060[2]	
Benzene emissions are only reported to the NPRI if:	**Date facility or lease site commissioned**	**Emissions limit (tonnes/year)**
• Total VOCs released is ≥ 10 tonnes; and • Total Benzene released is ≥ 1 tonne	Before January 1, 1999:	
	≥ 750m to permanent residence or public facility	5
	≤ 750m to permanent residence or public facility	3
	January 1, 1999 to January 1, 2007 (all)	3
	After January 1, 2007 (all)	1

Existing Literature

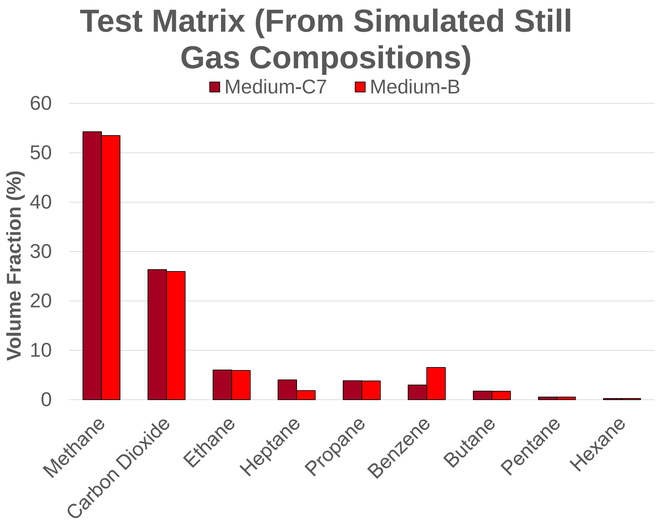
Report	Destruction Removal Efficiency (DRE)
Control of Benzene Emissions From Glycol Dehydrators[3]	90%
Locating & Estimating Emissions from Sources of Benzene[4]	89.5%
Evaluating The Efficiency of Industrial Flares[5]	99.59%

- Flaring is considered a good method of emissions reduction
- The efficiency of benzene destruction in flares is uncertain:
  - Prescribed values are conflicting, unsupported, or unrepresentative

Test Selection

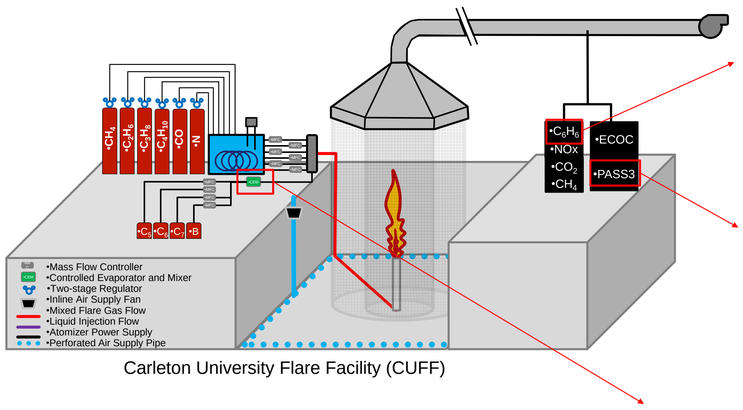
- Glycol dehys use liquid glycol to remove water vapour from raw natural gas
- Liquid glycol becomes saturated with water and hydrocarbons (such as benzene)
- Glycol is then boiled, releasing water and hydrocarbons through the still as waste gas

Glycol Dehydrator



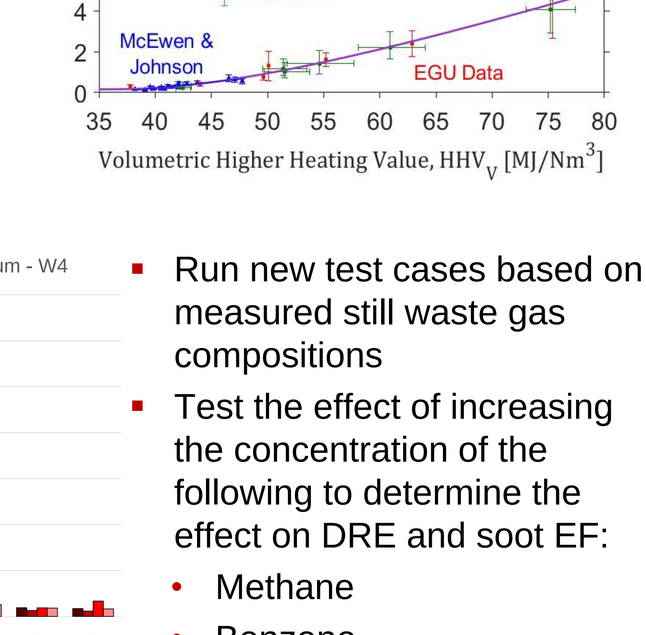
- Simulated still waste gas composition data based on glycol dehydrator operating parameters was used to generate test cases
- Test case Medium-C7 was chosen based on the 50th percentile Volumetric Higher Heating Value (HHV_v)
- Test case Medium-B was generated to test the effect of increased benzene content

Experimental Setup



Carleton University Flare Facility (CUFF)

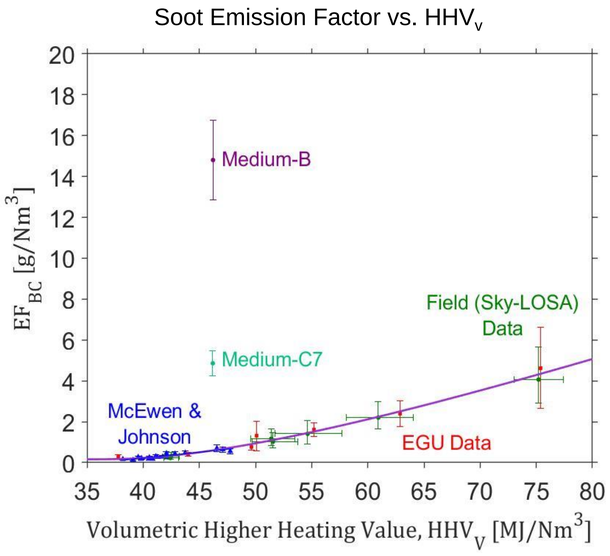
- Baseline-Mocon 9100 Gas Chromatograph measures benzene concentration in ppb range (5% uncertainty at 0.5 ppb)
- PASS3 measures absorption to calculate soot emission factor (EF)
- Bronkhorst Controlled Evaporation Mixing (CEM) W-303B:
  - Vaporizes benzene, C5-C7 liquid fuels into carrier gas (methane)
  - This is mixed with C1-C4, N_2, CO_2 to produce desired final fuel mixture



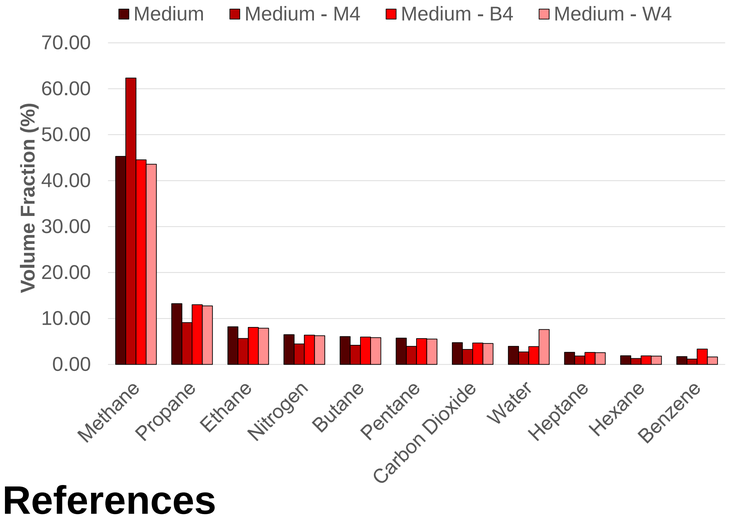
Preliminary Benzene DRE Results

Fuel	Medium-C7	Medium-B
Benzene Injected VF (%)	2.98	6.52
Average Benzene DRE (%)	99.99 ± 0.27	99.93 ± 0.27

- Benzene DRE found to be nearly 100% regardless of benzene content in the fuel
- Soot EF found to increase up to 20 times more than recent EERL alkane-based fuel mixture study[6]



Future Work



- Run new test cases based on measured still waste gas compositions
- Test the effect of increasing the concentration of the following to determine the effect on DRE and soot EF:
  - Methane
  - Benzene
  - Water

References

[1] ECCC, "Guide for Reporting to the National Pollutant Release Inventory", 2017
[2] AER, "Directive 060: Upstream Petroleum Industry Flaring, Incinerating, and Venting", 2018
[3] CAPP, "Control of Benzene Emissions from Glycol Dehydrators", 2006
[4] U.S. EPA, "Locating and Estimating Air Emissions from Sources of Benzene", 1998
[5] J. Pohl, N. Soelberg, "Evaluating the efficiency of industrial flares: Flare head design and gas composition", 1985
[6] B.M. Conrad, B.M. Crosland, A.M. Jefferson, and M.R. Johnson, 2018