Quantification of Soot Emissions from Flares

Develop methods of measuring and reporting particulate emissions from solution gas flares

What is the purpose of this project?

While significant progress has been made in quantifying, understanding and reducing the impact of solution gas flares, most efforts have focused on flare carbon conversion efficiency – the ability of a flare to fully convert carbon contained in hydrocarbon fuel to carbon dioxide. Comparatively little attention has focused on potential emissions of particulate matter or soot.

In Canada, emissions of both PM10 (particulate matter less than 10 micrometres, or μm, in size) and PM2.5 (less than 2.5 μm) are classed as criteria air contaminants and are tracked in the National Pollutant Release Inventory (NPRI). Despite the scientific need and legal requirement for quantifying and reporting industry particulate matter emissions, there are critical gaps in the ability to accurately obtain this data. This problem is especially urgent in the upstream oil and gas sector, where the distinct lack of practical approaches for predicting or even measuring particulate matter emissions from open industrial sources, such as flares, is a critical issue.

Formation of soot in a turbulent diffusion flame such as a flare is a complex process affected by many factors. These include chemical composition of the fuel, temperature-time history of the fuel and reactant species, and turbulent diffusion of oxygen and other species in the flame. This project aims to develop practical methods for quantifying particulate emissions from solution gas flares.

How is the project being conducted?

To tackle this challenging problem and obtain results applicable to the broad range of conditions relevant to industry, it is necessary to consider individual aspects of the soot formation process. A large, lab-based controllable pipe-flare system has been constructed in partnership with the National Research Council in which the complete plume of combustion products from a test flare burning a range of gaseous fuels can be captured. Soot is measured using Laser Induced Incandescence (LII) via an innovative sampling protocol developed as part of this project.

What are the results?

Experiments are currently under way in which the mass emission rate of soot from lab-flares (quantified as mass of soot produced per mass of fuel burned) is measured directly, using the laser-induced incandescence based sampling protocol. Some of the first results are shown in Figure 2 below.

These data suggest that while overall emissions rates are potentially low, there is also a strong chemical dependence on soot emissions for different fuel compositions. These results were the first significant step toward developing emissions protocols or "soot factors" for flares.

What happens next?

A wide variety of parametric soot emission tests are planned for the summer of 2007, and data will continue to be analyzed as it becomes available. The PTAC technical steering committee is helping gather data on solution gas flare composition to help guide experiments. As more test data is collected, further effort will be directed toward developing models for soot emission rates. Identified trends will ultimately help develop emissions models, or soot factors, for solution gas flares relevant to meeting NPRI reporting requirements.

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Figure 1: Flare Soot Measurement Experiment Housed at NRC

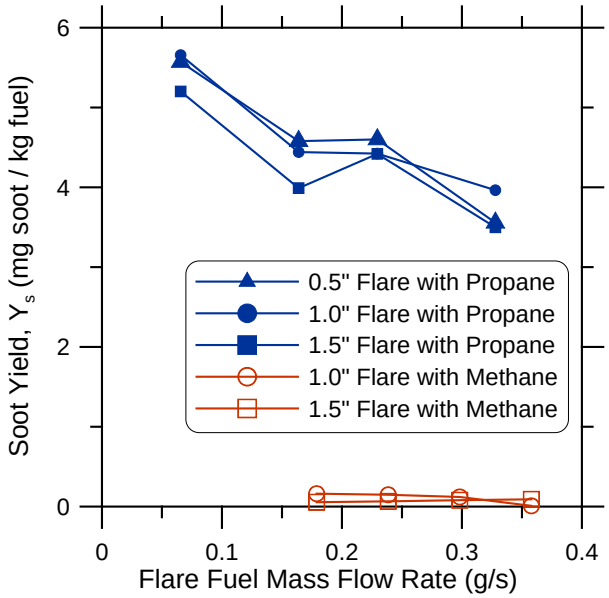

Figure 2: First Quantitative Measurements of Soot Yield for Lab-Scale Flares