DISCLAIMER: PTAC does not warrant or make any representations or claims as to the validity, accuracy, currency, timeliness, completeness or otherwise of the information contained in this report , nor shall it be liable or responsible for any claim or damage, direct, indirect, special, consequential or otherwise arising out of the interpretation, use or reliance upon, authorized or unauthorized, of such information.

Flaring

Project Update

This multi-phase research program is intended to lead to technological advances that will help reduce petroleum industry flaring and the associated release into the atmosphere of potentially harmful products of incomplete combustion

ERAC - Environmental Research Advisory Council

January 2001

What is the purpose of this project?

Flaring of unwanted solution gases – the complex mix of gases that often accompanies extracted oil – is a common practice in the petroleum industry. About 6 per cent of Alberta's solution gas is currently flared, which in 1999 meant there were more than 4,500 solution gas flares, burning 938 million cubic meters of gas.

In 1998, industry, government and other organizations in the Clean Air Strategic Alliance (CASA) agreed to work toward the eventual elimination of routine solution gas flaring in Alberta. Subsequently, the Alberta Energy and Utilities Board (EUB) implemented a schedule for reducing, by the end of 2001, the volume of solution gas flared by 25 per cent from 1996 levels. Because this commitment will not eliminate all flaring, industry has also agreed to meet the EUB's new requirements for reducing the volumes and improving the efficiencies of remaining flares.

Little is known about the efficiency of flaring or its emissions. While most flaring is highly efficient, a recent Alberta Research Council study showed the combustion efficiency of some flares may be as low as 64 per cent. These inefficient flares emit many products of incomplete combustion, including poly-nuclear aromatic hydrocarbons (PAH), which raise health and environmental concerns. The source of these combustion problems is not well understood, although crosswinds, the energy content of burned gases, the flow rate of flare gases out of the flare stack and liquid droplets in the flare stream – from inadequately designed or maintained liquid separation systems – are believed to be important contributing factors.

This major research program was started in 1996 to stimulate technological advances that will help reduce flaring and the atmospheric release of potentially harmful products of incomplete combustion. For example, every 1 per cent increase in flare efficiency results in a 2.2-mega-tonne decrease in carbon dioxide emissions. As well, using solution gas as an alternative source of electrical power combusts potential toxins. The program will also provide the substantive science needed to underpin regulatory initiatives.

The program's seven research projects are primarily focused on better understanding and improving flaring, principally of open-pipe flares at oil producing facilities such as batteries. The projects have been grouped into the following three research topics:

- liquid separation,
- flare speciation and performance, and
- alternative technologies to flaring such as using solution gas in gas turbines and internal combustion engines to produce on-site power.

These projects are closely interrelated. For example, information gained from the liquid separation project will be used to determine the size of droplets needed in the speciation and performance projects. As well, Alberta researchers are working closely, and sharing their findings with their Ontario counterparts on different phases of the speciation and performance projects.

ERAC was founded in the mid-1970s by the Canadian Association of Petroleum Producers (CAPP) to initiate research and technology development on environmental issues relating to the production of crude oil and natural gas in western Canada. In the past five years, direct and in-kind contributions to ERAC from CAPP and individual member companies, federal and provincial governments, academic institutions, and research groups have totaled over $6 million.

Liquid Separation

What is the purpose of this project?

Typically, solution gas is "wet", meaning it contains water and hydrocarbon liquids. The water and liquids are typically removed by a separation or knockout vessel before the solution gas is combusted. The more that liquids are not removed, and hence are carried over into the burning process, the less efficient the combustion of the solution gas becomes.

The aim of this project is to evaluate the efficiency of this liquid separation process as it relates to flare knockout drum design and operation so as to improve performance and reduce emissions. Specifically, the study aims to determine the velocity at which carryover occurs and to estimate the average liquid particle size going to flare. This latter information is important for the speciation and performance projects since the larger the carryover droplet size, the less efficient the combustion flame becomes.

How was the project conducted?

Synergas Technologies Inc., in conjunction with the University of Calgary, conducted various experiments at a semi-scale field test facility built near Calgary in 1999. The facility consisted of gas and liquid inlets test separators and an entrained liquid collection in a filter/coalescer. The raw test data was entrained liquid carryover amount as a function of gas velocity data.

What are the results?

The experiments showed that liquid carryover rises sharply with just a slight decrease in velocity and separation efficiency. In other words, if the separator efficiency falls below 99.9 per cent, the amount of iquid entering the flare stream increases significantly.

The data also revealed that the diameter of entrained liquid carryover droplets was 200 to 600 microns for flare knockout drums of 10 to 100 pounds per square inch gauge (psig). Calculations showed the maximum stable droplet size can be very large at low velocities and that there can be substantial variation in droplet size and uniformity.

The research concluded that to avoid carryover, flare knockout drums should be designed using a maximum droplet size of 300 microns.

What happens next?

The liquid separation project was completed in late 2000. The results will be passed on to other research groups in the flaring research program. Researchers also hope to expand this research in 2001 by evaluating liquid separation in well test flares.

Flare Speciation and Performance

What is the purpose of these projects?

These research projects are focusing on identifying the products of incomplete combustion and understanding the factors that influence the combustion efficiency of flares. The results will help industry and regulators establish practical performance measures and operational practices for flares.

The main objective of the speciation projects is to quantify the production rates of important key toxic compounds in situations typical of solution gas flaring. As well, predictive models will be developed to allow forecasting of production rates of these compounds under a range of flaring situations such as crosswinds

and the composition and volumes of solution gas in the flare gas stream. Being able to predict flare emissions and understanding the causes of operational problems will resolve some of the uncertainty surrounding flaring and provide models for developing reasonable flaring policies.

A key component of the flare performance projects was to develop methods for measuring the efficiency of flares subject to crosswinds and containing liquid fuel droplets in the flare stream under laboratory conditions. This method was then applied to measure the combustion efficiency of various flares containing liquids and to compare the results with flares without liquids. As well, models were to be developed to forecast flaring efficiency under various conditions.

How are these projects being conducted?

Both the speciation and performance projects involve bench-scale research. Two sets of complimentary studies are being conducted – one in the University of Alberta's wind tunnel flare test facility and the other, on a larger scale, at CANMET's new flare test wind tunnel facility at the Advanced Combustion Technologies Laboratory (ACTL) in Ottawa.

For example, the speciation testing at the University of Alberta included capturing incompletely combusted particles from half-inch and one-inch flare pipes and identifying the specific compounds and their concentrations. The same tests are then being performed at ACTL's facility to see if the University of Alberta results hold true in the three- and four-inch pipes typical of actual flaring. The preliminary results of the University of Alberta's flaring performance tests were considered in the design of the ACTL flare testing facility and its operating parameters.

What are the results?

The University of Alberta wind tunnel studies showed the overall efficiency of flares was generally greater than 95 per cent under the conditions tested. But testing found the efficiency can range from 99 per cent to 66 per cent, depending on where measurements were taken within the flare plume. Other results revealed that crosswinds have a strong effect on combustion efficiency, with efficiencies falling dramatically as wind speeds increase. Flares with higher exit velocities were less susceptible to crosswind effects. Lowering the energy density of the fuel was also found to have a profound negative impact on flare efficiency.

In the University of Alberta emission speciation study, preliminary results confirmed the presence of toxic compounds – such as poly-nuclear aromatic hydrocarbons (PAH) and benzene, toluene, ethylbenzene and xylene (known collectively as BTEX) – bound up in the soot emitted from flares. The concentrations of these compounds in the vapour phase were found to be below detectable limits. The study also found that liquid fuel droplets in the flare stream significantly increase the amount of soot emitted.

The CANMET facility in Ottawa has been built and commissioned. Experiments began in the fall of 2000, and results should be available in the spring of 2001.

What happens next?

The University of Alberta and CANMET experiments will continue in 2001. The University of Alberta research team plans to build on the laboratory-scale performance and speciation results by conducting experiments in a full-scale wind tunnel in Ottawa and then hopefully progressing to an Alberta field facility. The idea is to see if the laboratory results hold true in a real-world, four-inch flare and to develop a measurement methodology for flare efficiency in the field.

These full-scale tests are part of a proposed five-year continuation of the flaring research program. The program proposes to include testing flaring performance on well tests flares, which have much higher gas pressures and velocities than solution gas flares. As well, researchers would like to develop an accurate method of remotely monitoring well test flare plumes, and their sulphur dioxide levels, particularly for those tests undertaken in mountainous terrain.

Alternative Technologies

What is the purpose of this project?

The alternative technology project is assessing the technical feasibility of using solution gas as a fuel source in gas turbines and internal combustion engines to generate electricity as an alternative to flaring. To gain acceptance, however, such technologies must prove they are economic, feasible and reliable and produce significantly less emissions than that of flaring.

The purpose of the alternative technologies project was to identify available options for the beneficial use of solution gas that would otherwise be flared. The goal was to provide information for identifying technologies that could potentially replace solution gas flares and determine under what circumstances those technologies might be appropriate.

How is the project being conducted?

The feasibility assessment of the turbine and engine technologies was performed by Ontario Power and the University of Calgary. It involved:

- requesting manufacturers to supply equipment specifications,
- visiting battery sites,
- assessing vendor literature, and
- talking with vendors and oil companies.

What are the results?

The literature review and assembly of vendor information was conducted and the alternative technology report completed. A peer review of the report identified information gaps in the characteristics of solution gas, which are needed to accurately analyse the data.

What happens next?

Researchers hope to fill the information gaps in 2001. Their report also identified a need for more emissions testing data from turbines and, particularly, internal combustion engines. It also called for a demonstration of identified technologies at suitable Alberta sites.

Program Funding

The primary funders of the flaring research program are Environment Canada, Natural Resources Canada (CANMET Energy Technology Centre), Canadian Association of Petroleum Producers (CAPP), Alberta Science Research Authority, Alberta Oil Sands Technology and Research Authority, Alberta Environment, Anderson Exploration, Gulf Canada Resources, BP Canada Energy, Petro-Canada, Talisman Energy, and University of Alberta.

More information on ERAC is available on CAPP's Internet Home Page: www.capp.ca. To order the above materials, ERAC project updates, or technical reports, or be added to the mailing list for the bi-annual newsletter *ERAC Reporter*, please call CAPP at (403) 267-1100.

Canadian Association of Petroleum Producers
2100, 350 – 7 Avenue S.W.
Calgary, Alberta, Canada T2P 3N9
Phone: (403) 267-1100 Fax: (403) 261-4622

2001-9830 Printed on recycled paper