SNAP CODE: **090203**

SOURCE ACTIVITY TITLE: **WASTE INCINERATION**
Flaring in Oil Refinery

NOSE CODE: **109.03.11**

NFR CODE: **1 B 2 c**

1 ACTIVITIES INCLUDED

Flares are commonly used during petroleum refining for the safe disposal of waste gases during process upsets (e.g., start-up, shut-down, system blow-down) and emergencies to combust the organic content of waste emission streams without recovering/using the associated energy.

2 CONTRIBUTION TO TOTAL EMISSIONS

Although flaring emission estimates are approximate, total hydrocarbon emissions from flaring at Canadian petroleum refineries during 1988 represented about 0.1% of the refinery sector process and fugitive emissions that also included petroleum marketing emissions (CPPE, 1990). Thus the flaring operation at refineries is estimated to contribute a very small fraction of the total HC emissions in Canada. Emissions from flaring activities may also include: particulate, SOx, NOx, CO and other NMVOC. The CO_2 contribution of both miscellaneous vent and flare emission sources represented approximately 9% of the total petroleum refinery SO_2 emission in Canada during 1988.

Emissions estimates from flaring in petroleum refineries as reported in the CORINAIR90 inventory are summarised in Table 1.

Table 1: Contribution to total emissions of the CORINAIR90 inventory (*28 countries*)

Source-activity	**SNAP-code**	**Contribution to total emissions [%]**							
		SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
Flaring in Petroleum Refineries	090203	0.1	0.1	0	-	0	0	-	-

0 = emissions are reported, but the exact value is below the rounding limit (0.1 per cent)
- = no emissions are reported

3 GENERAL

3.1 Description

Blowdown systems are used at petroleum refineries (see SNAP Code 0401) to collect and separate both liquid and vapour discharges from various refinery process units and equipment (U.S. EPA 1985, 1992). The gaseous fraction, that may represent a planned or unplanned hydrocarbon discharge, may be either recycled or flared. Flaring provides a widely-used safety mechanism and emission control option for blowdown systems when the heating value of the emission stream cannot be recovered due to uncertain or intermittent releases during process upsets/emergencies. Non-condensed vapours from the blowdown system may be combusted in a flare which is designed to handle large fluctuations of both the flow rate and hydrocarbon content of the discharge. Alternatively, thermal incineration is preferable to flaring for destroying gas releases that contain more corrosive halogenated or sulphur-bearing components.

Although different types of flares exist, the steam-assisted elevated flare systems are most commonly used at petroleum refineries whereby steam is injected in the combustion zone of the flare to provide turbulence and inspirated air to the flame. For waste gases of insufficient heating value, auxiliary fuels may also be used to sustain combustion.

3.2 Definitions

3.3 Techniques

Steam-assisted elevated flares are installed at a sufficient height above the plant and located at appropriate distances from other refinery facilities. The flare generally comprises a refractory flame platform with a windshield, steam nozzles, auxiliary gas/air injectors and a pilot burner mounted upon a stack containing a gas barrier. As reported (U.S. EPA 1980, 1992, MacDonald 1990), the flare combustion efficiency typically exceeds 98% with dependence on the following factors (i.e., for efficient performance):

excess steam assist (i.e., steam/fuel gas ratio less than 2),

sufficient gas heating value (i.e., greater than 10 MJ/m3),

low wind speed conditions (i.e., above 10 m/sec.),

sufficient gas exit velocity (i.e., above 10 m/sec.)

Similarly, different types of flare burners, designed primarily for safety requirements, may result in different efficiencies.

3.4 Emissions/Controls

Depending on the waste gas composition and other factors, the emissions of pollutants from flaring may consist of unburned fuel components (e.g., methane, NMVOC), by-products of the combustion process (e.g., soot, partially combusted products, CO, CO_2, NOx) and sulphur oxides (e.g., SO_2) where sulphur components are present in the waste gas. Steam injection is used to enhance combustion for smokeless burning and to reduce NOx by lowering the flame temperature. Increased combustion efficiency may reduce CH_4 and NMVOC, but will not reduce CO_2 emissions. Flaring emissions might best be reduced by minimising amounts of gases to be flared, provided that the associated wastes gases are not vented directly.

4 SIMPLER METHODOLOGY

Where limited information is available, the simplest inventory methodology is to combine the amounts of gases flared by petroleum refineries with a single hydrocarbon emission factor (i.e., derived in units of mass emission per volume of gas flared), with the assumption of a constant flare combustion efficiency. In the event that flare gas volumes are unavailable, an alternative but older emission estimation methodology would be to apply individual emission factors of various pollutants for petroleum refinery blowdown systems (i.e., including vapour recovery systems and flaring) in combination with total petroleum refinery feed (i.e., crude oil throughput).

5 DETAILED METHODOLOGY

The detailed methodology requires each refinery to estimate its flaring emissions using available information on the composition of flare gas, the types of smoke control used and the flare combustion efficiency in combination with flare gas volumes, using either measurement data, available emission factors or mass balance approaches. It is recognised that flare emissions are challenging to estimate and/or quantify with certainty, since: conventional or direct extractive source testing is not feasible for elevated flares; both flare gas volume determinations and/or gas composition may be very uncertain especially during process upsets or emergency releases; and very limited data are available with respect to flare combustion efficiencies which depend on both process and external wind condition factors. For normal operations, the general types of refinery and other information required to estimate flare emissions, as currently done at Canadian refineries (CPPI 1991), are:

- the actual quantities of gases flared at each flare (e.g. m^3/year) based upon measured flare gas flowmeter or other records,
- the average composition of flare gas including: H/C molar ratio on the basis of flare design or test data, the molecular weight and sulphur content,
- the types of smoke controls used, such as: steam/air, manual/automatic and/or TV monitor,
- an emission HC factor based upon typical steam/fuel gas ratios, gas heating values and/or flare combustion efficiencies,
- a sulphur mass balance of fuels consumed by flaring and other refinery process heaters/boilers.

In some instances, flare emissions may only be estimated currently by difference or rough approximations. However, remote sensing of flare emissions by LIDAR/DIAL measurements of plume cross section seams are assisting in determining or verifying flare emission rates and the composition of refinery flare emissions (Bodon, Moncrieff and Wootton, 1992).

6 RELEVANT ACTIVITY STATISTICS

For the simpler methodology, either the quantities of flare gases consumed or the refinery crude oil feed is required. For more detailed methodology, the quantities, composition and heating values of flare gases burned are required for each petroleum refinery.

7 POINT SOURCE CRITERIA

All significant refinery flares are to be inventoried as part of refinery point sources.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

Only limited published petroleum refinery flare emission factors are available. For the simpler methodology, somewhat dated emission factors have been reported (U.S. EPA, 1985) as in Table 2.

Table 2: Emission Factors for Flaring in Petroleum Refineries

	Emission Factors (kg 10^3 litres refinery feed)					
Process	Particulate	SO_2	CO	THC	NOx	Rating
Refinery Blowdown System - Vapour Recovery System and Flaring	Neg.	0.077	0.012	0.002	0.054	C

In the current U.S. EPA CHIEF database, the VOC emission factor for petroleum refinery flares is: 5.6 lb VOC/million cubic feet of flare gas burned with a quality rating of D. The above mentioned VOC emission factor comprises: methane (20%), ethane (30%), propane (30%) and formaldehyde (20%).

A VOC emission factor, reported in a Norwegian survey (OLF Report Phase 1, Part A), of 0.0095 kg/m3 of flare gas was cited in documentation of the UNECE Task Force - VOC Emissions from Stationary Sources. The flare emissions were reported to consist of 65% methane and 35% NMVOC and suggested a typical flare efficiency of 99.2%.

Remote sensing (DIAL) measurements of full-sized flare emissions at a Norwegian petroleum refinery under normal operating conditions also has indicated that the flare combustion efficiency exceeded 98%, comprising various amounts of methane and C2 to C6+ alkane components (Boden, Moncrieff and Wootton, 1992).

Flare combustion efficiencies, under atypical operating or other conditions and presumably during upset conditions, may have lower destruction efficiencies, based upon other test data (MacDonald 1990).

9 SPECIES PROFILES

(See section 8).

10 UNCERTAINTY ESTIMATES

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

As flare emissions can vary significantly with dependence on several factors, more measurements to determine flare combustion efficiencies and chemical composition should be done (e.g., perhaps using remote sensing techniques) under a variety of conditions, in order to verify available emission estimates and assure that flare combustion efficiencies generally represent the stated efficiencies.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

13 TEMPORAL DISAGGREGATION DATA

No temporal apportionment of these emissions is possible if the simpler methodology is used. Temporal disaggregation of detailed emission estimates can be done from records of petroleum refinery shutdowns and other operating data.

14 ADDITIONAL COMMENTS

15 SUPPLEMENTARY DOCUMENTS

16 VERIFICATION PROCEDURES

As noted above, remote sensing monitoring programs may be useful to verify flaring emission estimates.

17 REFERENCES

Boden, J.C., Moncrieff, J.T.M. and Wootton, A.G., 1992. “DIAL Measurements of Flare Emissions at the Statoil Refinery Mongstad”. Summary Report No. 3297 prepared by BP Research Sunbury Research Centre and Spectrasyne Ltd.

Canadian Petroleum Products Institute (CPPI), 1991. “Atmospheric Emissions from Canadian Petroleum Refineries and the Associated Gasoline Distribution System for 1988”. CPPI Report No. 91-7 prepared for CPPI and Environment Canada by B.H. Levelton & Assoc. Ltd. and RTM Engineering Ltd.

MacDonald, R.J., 1990. “Industrial Flare Efficiency” University of Waterloo. Report prepared for Industrial Program Branch, Environment Canada.

U.S. Environmental Protection Agency (U.S. EPA), 1992. “Air Pollutant Engineering Manual”. Ed. Anthony J. Buonicore and Wayne Davis. Air and Waste Management Association TD889.A39. Van Noostrand Reinhold, New York.

U.S. Environmental Protection Agency (U.S. EPA), 1985. “Compilation of Air Pollutant Emission Factors”, AP-42 4th Edition and Supplements. Environmental Protection Agency, Research Triangle Park, N.C.

18 BIBLIOGRAPHY

19 RELEASE VERSION, DATE AND SOURCE

Version: 1.3

Date: November 1995

Source: Marc Deslauriers
Environment Canada
Canada

20 POINT OF ENQUIRY

Any comments on this chapter or enquiries should be directed to:

Marc Deslauriers

Environment Canada
Criteria Air Contaminants Division
Pollution Data Branch
351 St Joseph Boulevard, 9th Floor
Hull, Quebec, K1A 0H3
Canada

Tel: +1 819 994 3069
Fax: +1 819 953 9542
Email: marc.deslauriers@ec.gc.ca