

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION V

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SUBJECT: Procedures for Modeling a Flare

FROM: *M Koerber*
Michael Koerber
Regional MeteorologistTO: Dean Wilson (MD-14)
Source Receptor Analysis Branch

Attached is a suggested procedure for modeling a flare prepared by Mark Garrison and me. The procedure is being sent to the Model Clearinghouse for informational purposes; no response is expected. Please feel free to use the procedure as you wish (e.g., inclusion in revised screening guidelines, current guidance, etc.).

cc: Mark Garrison, Region III
Joe Tikvart, SRAB
Jim Dicke, SRAB

ATTACHMENT #1

PROCEDURES FOR MODELING A FLARE

At certain types of industrial sources, flares are used to dispose of waste gases through combustion. As the gases are vented up a tall vertical pipe and then ignited at the top of the pipe, heat and other combustion products are released. Depending upon combustion efficiency, pollutant emissions may be important and dispersion modeling may be necessary.

Treatment of a flare as a point source is debatable in view of the differences between a flare and conventional combustion source. A recent study ("Observations of Plume Rise from Sour Gas Flares", Leahey and Davies, 1984), however, indicates that use of the standard Briggs plume rise formulas (i.e., 2/3 law) provides a good approximation of the plume rise from a flare. Consequently, it is reasonable to model flares as elevated point sources with appropriately chosen "stack" parameters. (Note, the stack exit parameters suggested by the Leahey and Davies study agree well with the parameters suggested by other approaches - e.g., see "User's Guide to the Texas Episodic Model", October 1979 and "Notes on Dispersion Modeling - Plume Rise of Flares", Trinity Consultants, 1984.)

The following steps are proposed for deriving the stack parameters for a flare:

STEP 1: Calculate the total heat release (H) of the flared gas based on the gas heat content and the gas consumption rate

STEP 2: Assume that 45% of H is released as sensible heat (Q_H)

$$Q_H(\text{cal/sec}) = 0.45 \times H(\text{cal/sec})$$

STEP 3: Calculate the effective stack diameter using the following formula*

$$d_s(\text{m}) = 9.88 \times 10^{-4} \times [Q_H]^{1/2}$$

STEP 4: Final stack parameters for model input are as follows

h_s = height of flare stack
 d_s = (calculated in STEP 3)
 v_s = 20 m/sec
 T_s = 1273 °K

*This formula was derived by combining two equations for the buoyancy flux parameter (i.e., $F = (gQ_H)/(\pi \rho c_p T_a)$ (Eq. 4.20, Briggs, 1969) and $F = g v_s (d^2/4)(1 - T_a/T_s)$ (Turner, 1972)), solving for "d", and assuming $T_a = 293^\circ\text{K}$, $T_s = 1273^\circ\text{K}$, $v_s = 20 \text{ m/sec}$, $\rho = 1205 \text{ g/m}^3$, and $c_p = 0.24 \text{ cal/g}^\circ\text{K}$.

EXAMPLE FLARE CALCULATION

GIVEN: Process flare X burns the following gas mixture

	AMOUNT (#/HR)	HEAT CONTENT (cal/#)	HEAT RELEASE (cal/sec)
N ₂	30.0	0	0
H ₂ S	67.9	1.6×10^6	30,180
Organics	126.0	3.9×10^6	136,500
			<u>166,680</u>

STEP 1: $H = 166,680 \text{ cal/sec}$ STEP 2: $Q_H = 0.45 \times H = 75,000 \text{ cal/sec}$ STEP 3: $d_s = 9.88 \times 10^{-4} \times [Q_H]^{1/2} = 0.27 \text{ m}$ STEP 4: Stack parameters are h_s =height of flare stack, $d_s=0.27 \text{ m}$,
 $v_s=20 \text{ m/sec}$, $T_s=1273 \text{ }^\circ\text{K}$