LSC
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PRODUCTS, LLC

COMBUSTION EFFICIENCY AND REGULATORY COMPLIANCE OF CF-5 LANDFILL GAS FLARES

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Fluidic flares are used in many industries to safely and efficiently destroy combustible gases that cannot be economically recovered. The quality of combustion of the CF-5 landfill gas flare is governed by the flame stability which is a function of gas quality, flow rate and flarehead design. Flame temperature, residence time in the combustion zone, and the amount of oxygen available for combustion also influence combustion efficiency. Fluidic flares operating with stable flames typically achieve combustion efficiencies greater than 98%. The patented double-expansion design of the CF-5 flare head assures flame stability under conditions conforming to the design specifications of the flare. This unique flare head produces very stable combustion even in extremely windy conditions. An external windshield is not required.

Table 1 shows typical flow rates and gas conditions which conform with flare operation standards specified at 40 CFR 60.18. Also, the CF-5 employs continuous electronic spark ignition with a spark indicator light on the panel. Almost all modern gas appliances now employ electronic ignition. The USEPA has determined that formal compliance with 40 CFR 60.18 at "NSPS/EG" landfills requires addition of a thermocouple and flame pilot. Although these components are not necessary for the function of the flare, they are available if formal compliance with paragraph (f)(2) is required.

Generation and character of landfill gas depends on several factors which include (1) the size, configuration, and operating conditions of the landfill; and (2) the characteristics of the refuse such as moisture content, age, and composition. Typical landfill gas constituents are methane, carbon dioxide, oxygen, nitrogen, and trace gases such as hydrogen sulfide and various non-methane organic compounds. Methane emissions have been identified by the EPA as a large contributor to "greenhouse gases" (18%) and landfills are one of the largest sources of methane emissions (36%, EPA Regulations, p. 9909).

LSC Environmental Products, LLC's research agrees with EPA guidance at 40 CFR 60.18, which assumes greater than 98% NMOC destruction efficiency if the BTU content of the gas is greater than 200 BTU/SCF and the maximum exit velocity is less than 60 feet per second. Typical landfill gas contains 500-600 BTU/SCF and the exit velocity at our recommended limit of 90 CFM is less than 5 feet per second. The CF-5 flare, when operated in accordance with LSC recommendations, is well within the zone of flame stability defined by Pohl and Tichenor (1) and therefore can comfortably be assumed to be greater than 98% efficient.

Flare temperatures vary significantly depending upon gas flow rate, gas quality and ambient wind temperature and velocity. Our observations of measurements in the 900° F. to 1200° F. range represent thermocouple readings at various locations in the flame zone and under various operating conditions. Operation with normal LFG (40-60% CH_4) and in the mid- to upper-flow rate range will produce the greatest temperatures. Low flows of gas and/or low BTU

gas will result in lower operating temperatures. The key parameter for NMOC destruction is flame stability as described in reference (1); therefore, the CF-5 is designed to perform reliably when operated within our recommended limitations. These limitations coincide with naturally point source passive LFG emissions, and, normally, the envelope can only be exceeded by use of a blower.

The residence time of gases in the CF-5 flame zone varies according to the typical flame height produced by different flow rates. At a low flow of 2 CFM, the flame height is only about 6 inches, and the average residence time is about 0.6 seconds; at a high flow of 90 CFM, the flame height reaches a total of about 6 feet (5 feet above the flare tip), and the minimum residence time is about 0.3 seconds. Thus, the lower temperature condition is balanced by a longer residence time while the shortest residence time occurs at higher temperatures.

It is not normally possible to obtain undiluted field samples of the combustion gases from a fluidic flare; therefore, open flares, such as the CF-5, are presumed by the regulations (see 40 CFR 60.33c) to provide 98% non-methane organic compound (NMOC) reductions if operated in accordance with the above-mentioned standards. The high destruction efficiency for methane and hydrogen sulfide (greater than 99%) will usually dominate the calculation and will conservatively result in average efficiencies greater than 99% of total organics.

TABLE 1

CF-5 OPERATING PARAMETERS TO CONFORM WITH 40 CFR 60.18

1) VISIBLE EMISSIONS:	During a two-hour observation period, there cannot be visible emissions (smoke) for more than five minutes. This does not include heat waves or water vapor.
2) BTU CONTENT OF GAS:	Must be greater than 200 BTU/SCF. Landfill gas typically contains 500 to 600 BTU/SCF.
3) MAXIMUM EXIT VELOCITY:	Must be less than 60 feet per second (fps) at the flare tip. The maximum flow rate of 90 cubic feet per minute (cfm) would produce a calculated exit velocity of less than 5 fps. When corrected for the temperature increase and gas mixing occurring in the operating flarehead, actual exit velocities remain well below maximum. Even the raw gas inlet velocity at the two-inch base of the flarehead is less than 60 fps under these conditions and, therefore, the CF-5 clearly provides much more than minimum retention time.

4) PILOT LIGHT & PILOT OPERATION INDICATOR:

The regulation requires either a flame-type pilot with thermocouple to monitor the presence of the pilot flame, or an equivalent device. Modern gas appliances utilize electronic ignition systems rather than flame pilots and the CF-5 incorporates this superior technology with a panel indicator light to verify presence of the ignition spark which is applied continuously each 1.5 seconds regardless of flare combustion status. USEPA has determined that formal compliance with 40 CFR 60.18 at "NSPS/EG" landfills subject to Subpart WWW requires addition of a thermocouple and flame pilot. Although these components are not necessary for the function of the flare, they are available if formal compliance with paragraph (f)(2) is required.

SUMMARY

The CF-5 gas vent flare is intended for use at passive landfill gas pressures with a minimum of 30% methane. The flare is intended to operate at flow rates ranging from 5-140 SCFM at gas pressures approximately 0.5 to 5 inches of water column. When properly equipped and operated, this unit is consistent with requirements specified at 40 CFR 60.18 and 40 CFR 60.33c.

REFERENCES

Pohl, John H., Joannes Lee, Roy Payne and Bruce A. Tichenor. "Combustion Efficiency of Flares." Combustion Science and Technology. Vol. 50, pp. 217-231, 1986.

U.S. Environmental Protection Agency. Air Emissions from Municipal Solid Waste Landfills - Background Information for Proposed Standards and Guidelines. Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina. March 1991. EPA-450/3-90-011a. Chapters 3 and 4.

U.S. Environmental Protection Agency. Standards of Performance for New Stationary Sources and Guidelines for Control of Existing Sources: Municipal Solid Waste Landfills. Federal Register/Vol. 61, No. 49, pgs. 9905-9944.

U.S. Environmental Protection Agency. 40 CFR 60.18, from 40 CFR. Chapter 1, pgs. 51-52.