

ZULE: LANDFILL GAS ULTRA LOW EMISSION FLARE SYSTEM

Part 1. General

1.01 Description

- A. Information within this specification describes an enclosed flare system designed specifically for emitting low NO_x, low CO, and having high destruction efficiencies when combusting landfill gas. The flare system shall exhibit industrial quality and shall be completely manufactured, including the control system, by the flare supplier. The supplier shall have a minimum 10 years experience in the design and manufacture of flare equipment and shall have a minimum of 100 landfill gas flares operating successfully in the United States.
- B. The flare system supplied shall be complete and operable as specified within.

1.02 Design Criteria

- A. The enclosed flare shall be designed to operate continuously with landfill gas as the primary fuel source.
- B. The landfill gas stream is characterized by the following parameters.

Flow Rate:	_____ SCFM (maximum)
Composition:	30% to 50% CH ₄ remainder CO ₂ , air, and inert gases
Lower Heating Value (LHV):	_____ BTU/SCF (maximum)
Temperature:	100 °F
Moisture Content:	saturated
Heat Release:	_____ BTU/hr (maximum)

- C. The flare system shall satisfy the following site conditions.

Wind Speed:	110 mph (maximum)
Seismic Classification:	Zone 4
Site Elevation:	_____ ft above sea level
Electrical Area Classification:	non-hazardous (unclassified)

- D. The enclosed flare shall satisfy the following process conditions.

Smokeless Capacity:	100%
Operating Temperature:	1200 °F to 1800 °F (2000 °F shutdown)
Retention Time:	0.7 seconds (minimum) at 1800 °F
Inlet Pressure:	15" H ₂ O

E. The following utilities are required to support operation of the flare system.

Pilot Gas (intermittent):	22 SCFH of propane at 10 psig 50 SCFH of natural gas at 15 psig
Electricity:	480 V, three phase, 60 Hz

1.03 Performance Requirements

A. The enclosed flare must be capable of achieving the following performance requirements.

1. The flare shall sustain stable combustion with 10% to 50% methane concentrations at the maximum flow rate, while maintaining the operating temperature, without requiring any burner adjustment.
2. Considering a 50% methane concentration, all flares designed for flow rates of 1500 SCFM or greater must achieve a 5:1 instantaneous heat release turndown minimum. Flares designed for flow rates less than 1500 SCFM, must achieve a 3,500,000 BTU/hr heat release minimum. Achieving the specified turndown must not require any burner adjustment or flare modification.
3. The flare shall sustain stable combustion with methane concentrations of at least 10% without any burner adjustments or flare modification.
4. The pressure loss through the flare, from the inlet flange through the flare enclosure, shall be less than 15" H₂O.
5. The flare shall operate free of pulsation and vibration with at most 5% oxygen concentration in the landfill gas stream.
6. Emissions from the flare shall not exceed the following.

Nitrogen Oxide (NO _x):	0.025 lb per million BTU fired
Carbon Monoxide (CO):	0.06 lb. per million BTU fired

7. The flare system shall achieve a destruction efficiency greater than 99% of total non-methane organic compounds (NMOC) throughout the entire flare operating range, without any burner adjustments or flare modification.

Part 2. Products

2.01 General

- A. All equipment shall be designed and shall perform in accordance with these specifications, as a minimum.
- B. The content of these specifications is intended to describe an enclosed flare requiring no burner adjustment to accommodate varying flow rates or gas concentrations.
- C. Three (3) operation and maintenance manuals with essential instructions, appropriate vendor literature, and submittal drawings shall be supplied.

2.02 Equipment

- A. The flare system shall include the following items, as a minimum.
 - 1. Anti-flashback burners
 - 2. Flare stack
 - 3. Externally removable spark ignited pilot
 - 4. Ignition and control station
 - 5. Ancillary equipment
- B. The equipment provided shall be manufactured by the flare supplier at the supplier's own fabrication facility. All components directly supporting combustion, such as burners and pilots, must be manufactured by the flare supplier. Only ancillary equipment, such as gas blowers, flame arrestors, and instrumentation shall be manufactured by others.
- C. The control system shall be completely assembled and tested prior to shipment by the flare supplier at the supplier's own fabrication facility.

2.03 Equipment Description

- A. Anti-flashback burners
 - 1. All burners furnished within the enclosed flare shall be anti-flashback type, with an internal flame arresting seal, a flame stabilization device, and no adjustable, or moving, parts.
 - 2. All burners shall be individually flanged for removal through the damper opening.
 - 3. All burner material within 6" of the burner flame zone shall be made of high temperature material.
- B. Flare stack
 - 1. Stacks 7'-0" diameter and smaller shall be constructed of carbon steel with a 1/4" minimum thickness.
 - 2. Stacks between 8'-0" diameter and 11'-0" diameter shall be constructed of carbon steel with a 3/8" minimum thickness.
 - 3. Stacks 11'-0" diameter and larger shall be constructed of carbon steel with a 1/2" minimum thickness.
 - 4. The internal portion of the stack requires a 2" thickness minimum of ceramic fiber blanket refractory. The surface layer, exposed to flame, shall be 1" thick, 8 lb density backed by 1" thick, 6 lb density, both with a 2400 °F temperature rating minimum. The surface layer shall be overlapped horizontally for additional heat protection.
 - 5. Refractory shall be attached using Inconel 601 pins and keepers, with 8-3/4" horizontal spacing maximum and 10-1/2" vertical spacing maximum.

6. The stack shall contain a burner manifold with flanged inlet connection, and individual flanged burner connections, allowing proper gas distribution.
7. The external portion of the stack requires SSPC-SP-6 surface preparation and one coat of Sherwin Williams "Zinc Clad II" coating system, or equal, 3-4 mils DFT, gray-green color.
8. Two (2) 4" diameter FNPT sample ports and plugs minimum shall be located 90° apart and one-half stack diameter from the stack top for emissions testing. Each of the 4" diameter plugs shall be insulated with ceramic fiber refractory.
9. Connections for combustion air dampers shall be supplied on the stack.
10. Three (3) connections minimum shall be supplied on the stack for installing temperature control thermocouples.
11. One (1) connection shall be located in the lower one-third of the stack for installing the high temperature thermocouple.
12. The stack shall contain thermocouple conduit mounting brackets.
13. A stainless steel rain guard shall be provided at the stack top, covering the exposed edge of refractory, to prevent water damage. This rain guard shall consist of overlapping segments and not a continuous ring, to minimize thermal expansion affects.
14. The stack shall include an AISC designed, continuous baseplate for mounting and high wind stability.
15. Two (2) lifting lugs shall be located 180° apart for use during installation.

C. Externally removable spark ignited pilot

1. The pilot shall be mounted to the outside of the stack such that the assembly is externally removable.
2. The pilot shall be spark ignited.
3. The pilot shall be capable of firing on either propane or natural gas at pressures ranging from 3 to 15 psig.

D. Ignition and control station

Provide a complete and functional control system designed for 480 V, three phase, 60 Hz incoming power, including transformer conversion as required for operating the flare system. The following items shall be completely mounted, assembled, and wired on a structural steel rack.

1. One (1) weatherproof single phase power transformer to convert electrical service from 480 V to 120 V.
2. One (1) weatherproof Flare Control Panel including the following instrumentation for safe, overall system operation and control.
 - General Electric 9030 programmable logic controller, or equal
 - Honeywell UDC 3300 temperature indicating control module
 - High temperature shutdown switch
 - Flame scanner amplifier and relay

- Honeywell DR 4500 Truline digital circular chart recorder, or equal
- Three position thermocouple selector switch
- Ammeter for each gas blower motor (200% scale)
- Hourmeter for each gas blower motor
- One (1) 10 A duplex outlet.

The following switches and pushbuttons are required, as a minimum.

- Panel power (On/Off) switch
- System control (Local/Off/Remote) switch
- Gas blower (Hand/Off/Automatic) switch(es)
- Reset pushbutton
- Lamp test pushbutton

The following indications are required, as a minimum.

- Panel power on
- Purging
- Ignition sequence
- Flame proved
- Gas blower(s) ON
- Gas blower(s) failure
- Purge failure
- Automatic block valve failure
- Flame failure
- Flare low temperature
- Flare high temperature
- Burner flashback
- Low combustion air flow

3. Weatherproof combination motor starters for each gas blower.
4. Variable frequency drive for the combustion air blower.
5. One (1) Pilot Gas Control System including pressure regulator, fail-closed shutdown valve, manual block valve, and pressure gauge.

The following components shall be installed on or mounted to the flare stack.

1. One (1) weatherproof Ignition Panel with 6000 V transformer mounted to the stack for intermittent pilot ignition.
2. One (1) self-checking, ultraviolet flame scanner to monitor the main flame.
3. Three (3) temperature control thermocouples.
4. One (1) high temperature thermocouple.
5. Combustion air dampers with opposed, bolted blade design, galvanized finish, and stainless steel press-fit bearings.

The control station and instrumentation shall be assembled and wired completely in a facility approved by Underwriters Laboratories and shall be functionally tested prior to shipment simulating actual operation.

E. Ancillary Equipment

1. An eccentric flame arrester with aluminum body and removable, internal aluminum element shall be installed at the flare inlet flange.
2. A mixing chamber with static mixer for landfill gas and combustion air.
3. An automatic block valve assembly consisting of a high performance butterfly valve with 316 stainless steel disc and Teflon seal, and a fail-closed pneumatic actuator shall be supplied.
4. Gas blowers with totally enclosed, fan cooled (TEFC) motors shall supply the enclosed flare with landfill gas.
5. A moisture separator vessel with flanged inlet and outlet connections, stainless steel demister element capable of removing 99% of water droplets 10 micron and larger from landfill gas, and level gauge shall be supplied.
6. A suitable amount of thermocouple and ignition wire shall be supplied.
7. A combustion air blower with totally enclosed, fan cooled (TEFC) motor shall supply the required combustion air for proper dilution.

Part 3. System Operation

3.01 General

- A. The flare system shall operate with automatic temperature control and shall safely destroy organic compounds generated by solid waste.
- B. The system shall be controlled by a programmable logic controller (PLC) which receives and transmits signals with respect to operating conditions. If an unacceptable operating condition occurs, the system shall either adjust the operating parameters to correct the problem or discontinue operation.
- C. System operation shall include an initial purge cycle, timed ignition sequence, and fail-safe controls.
- D. System shutdown shall result from low purge air flow, pilot flame failure, main flame failure, flare low temperature, flare high temperature, low combustion air flow, and burner flash back.
- E. Both local and remote operating modes shall be available.
- F. A self-checking flame scanner shall monitor the main flame.

3.02 System Control Selection

System operation shall begin automatically by selecting either local or remote system control. Local control requires interaction at the control panel to start and stop operation. Remote control allows starting and stopping operation without interaction at the control panel.

3.03 Operating Permissives

System operation shall be permitted only after confirming two safety conditions exist. The closed limit switch for the automatic block valve must be satisfied, proving a closed valve position. Additionally, the flame scanner must not detect the presence of flame inside the flare enclosure.

3.04 Purge Cycle

Prior to beginning the ignition sequence, the combustion chamber and flare enclosure must be purged with ambient air to ensure no potentially explosive gas mixture exists inside. To create a safe condition for pilot ignition, the combustion air blower operates and the air damper louvers shall be maintained fully open for five minutes prior to each ignition attempt and "Purging" will be indicated. If the blower operation fails, or the purge air is not satisfied, "Purge Failure" will be indicated and system operation discontinues.

3.05 Ignition Sequence

The ignition sequence shall begin immediately after the purge cycle is complete. The pilot gas solenoid valve opens automatically, supplying gas to the pilot, "Ignition Sequence" is indicated, and the ignition transformer energizes. The ignition transformer continues for ten seconds and then the pilot thermocouple verifies flame is present. "Flame Proved" is indicated and the pilot gas solenoid valve remains open.

3.06 Gas Supply

Once the thermocouple detects pilot flame, the combustion air flow increases to a pre-determined rate, the automatic block valve opens, operation of the selected gas blower begins, supplying gas to the flare. After the gas blower has been on for a pre-determined time, the combustion air flow will decrease to the corrected flow rate. While the flame scanner verifies the presence of flame, system operation continues. If the open limit switch for the automatic block valve is not achieved within twenty seconds, "Automatic Block Valve Failure" is indicated and system operation discontinues.

3.07 Automatic Temperature Control

The operating temperature, or temperature maintained inside the flare enclosure, is controlled by varying the ambient air available through the air damper louvers. The elevation of the temperature control thermocouple is selected depending on the gas flow rate and methane concentration. The operating temperature is maintained by adjusting automatically the position of the louvers. Closing the louvers reduces the amount of air available and increases the operating temperature, while opening the louvers increases the amount of air available and decreases the operating temperature. The louvers are maintained open initially, before beginning automatic temperature control modulation,

which introduces air inside the flare enclosure while the enclosure is cold and lacking draft, to minimize smoke during initial operation.

Part 4. System Failure

4.01 Purge Failure

A purge air flow meter shall monitor positive pressure during the purge cycle. If enough flow is not detected during the purge cycle, "Purge Failure" will be indicated and system operation discontinues.

4.02 Automatic Block Valve Failure

If either the open or closed limit switch for the automatic block valve indicates improper valve position any moment during operation, the "Automatic Block Valve" light flashes and system operation discontinues.

4.03 Pilot Flame Failure

During the ignition sequence, pilot flame failure shall occur when the thermocouple is unable to detect the presence of flame inside the flare enclosure. If the thermocouple is unable to detect flame, the entire purge cycle and ignition sequence is repeated. "Flame Failure" is indicated and system operation discontinues only after three consecutive, unsuccessful attempts occur.

4.04 Main Flame Failure

Main Flame Failure occurs, once the ignition sequence is complete, when the flame scanner is unable to detect flame is present inside the flare enclosure. When Main Flame Failure occurs, system operation is interrupted momentarily. Then the entire purge cycle and ignition sequence are repeated automatically. A Shutdown occurs only after three consecutive Failures, or unsuccessful attempts. Once Main Flame Shutdown occurs, "Flame Failure" is indicated and system operation discontinues.

4.05 Flare Low Temperature

Flare low temperature shall occur when a temperature below 1200 °F is detected inside the flare enclosure by the selected controlling thermocouple and exists for ten minutes consecutively. The corresponding "Flare Low Temperature" is indicated and system operation discontinues. The low temperature timer resets the moment a temperature above 1200 °F is detected during normal operation.

4.06 Flare High Temperature

Flare high temperature shall occur the moment a 2000 °F temperature is detected inside the flare enclosure by a dedicated high temperature thermocouple. "Flare High

Temperature" is indicated and system operation discontinues immediately.

4.07 Low Combustion Air Flow

Low combustion air flow shall occur the moment the measured air flow is determined to be an incorrect flow ratio with the given landfill gas flow rate and methane concentration, as determined by the PLC. "Low Combustion Air Flow" will be indicated and system operation discontinues immediately.

4.08 Burner Flashback

Burner flashback shall occur when a temperature above the desired set point is detected on the burner thermocouples. "Burner Flashback" is indicated and system operation discontinues immediately.