

**State of the Art (SOTA)  
Manual  
for Petroleum Refineries**

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State of New Jersey  
Department of Environmental Protection  
Air Quality Permitting Program

**State of the Art (SOTA)  
Manual for Petroleum Refineries  
Section 3.3**

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### **3.3 SOTA MANUAL FOR PETROLEUM REFINERIES**

#### **3.3.1 Scope**

- A. These SOTA performance levels apply to the following sources at Petroleum Refineries: Storage Vessels, Fluidized-Bed Catalytic Cracking Units, Sulfur Recovery Units, Wastewater Treatment, Process Heaters and Flares.
- B. If a source operation in a Petroleum Refinery is not included in this manual then the Applicant shall document SOTA technology using a case-by-case approach pursuant to New Jersey Administrative Code (N.J.A.C.) 7:27-8 and N.J.A.C. 7:27-22.
- C. For air contaminants that may be emitted from the sources described in this manual but for which a SOTA performance level was not established, SOTA will be determined using a case-by-case approach pursuant to N.J.A.C. 7:27-8 and N.J.A.C. 7:27-22.

#### **3.3.2. SOTA Performance Levels**

##### **3.3.2.1. Storage Vessels**

Refer to Section 3.1 (SOTA Manual for Storage Tanks)

##### **3.3.2.2 Fluidized-Bed Catalytic Cracking Units (FCCU)**

- A. Particulate Matter - 0.02 grains per standard cubic foot (grains/scf) (by use of Test Methods specified in N.J.A.C. 7:27B)
- B. Sulfur Dioxide - Performance limits based on 40 CFR 60 Subpart J

Comply with one of the following:

1. With an add-on-control device, reduce sulfur dioxide emissions to the atmosphere by 90 percent or maintain sulfur dioxide emissions to the atmosphere less than, or equal, to 50 parts per million by volume (ppmv) dry, whichever is less stringent, or
  2. Without the use of an add-on control device, maintain sulfur oxide emissions to the atmosphere at less than, or equal to, 9.8 kilograms per 1,000 kilograms (kg/1000 kg) coke burn-off, or
  3. Process in the fluid catalytic cracking unit fresh feed that has a total sulfur content no greater than 0.30 percent by weight.
- C. Oxides of Nitrogen (NO<sub>x</sub>)

1. Existing Sources: 165 ppmv dry (one-hour average)
2. New sources with Carbon Monoxide (CO) boilers: 50 ppmv dry (one-hour average)
3. New Sources without CO Boilers: 165 ppmv dry (one-hour average)

D. Carbon Monoxide

1. 500 ppmv dry with CO Boilers (one hour average)
2. 150 ppmv dry with no CO Boilers (one hour average)

**3.3.2.3 Sulfur Recovery Units**

Performance levels based on 40 CFR 60 Subpart J (adopted 3/15/78, amended 10/25/79 & 8/17/89):

A. Existing Sources

Less than or equal to 0.1 grains per dry standard cubic foot (gr/dscf) hydrogen sulfide (H<sub>2</sub>S) in fuel gas to be burnt in combustion device except for fuel gas being flared, and

1. *For Oxidation or Reduction System followed by incineration:*

Less than or equal to 250 ppmv dry basis sulfur dioxide (SO<sub>2</sub>) at zero percent excess air

2. *For Oxidation or Reduction System not followed by incineration:*

- Less than or equal to 300 ppmv dry basis total reduced sulfur (TRS) (measured as SO<sub>2</sub>) at zero percent excess air, and
- 
- Less than or equal to 10 ppmv dry basis H<sub>2</sub>S (measured as SO<sub>2</sub>) at zero percent excess air

B. New Sources: SOTA will be case-by-case.

### 3.3.2.4 Wastewater Treatment Equipment

- A. New Sources (performance levels based on 40 CFR 60 Subpart QQQ adopted 11/23/88)
1. Vent all oil-water separator tanks or auxiliary equipment to a closed vent system (CVS) with a control device.
  2. The closed vent system shall be designed and operated to reduce VOC emissions by 95% or greater or provide a minimum residence time of 0.75 seconds at a minimum temperature of 1500 °F.
- B. Existing Sources (performance levels based on 40 CFR 63 Subpart CC)
1. For each waste stream that contains benzene,
    - a) remove and destroy the benzene contained in the waste using a treatment process or wastewater treatment system that reduces the benzene concentration to less than 10 parts per million by weight (ppmw) on a flow weighted annual basis, or
    - b) remove 99% of the benzene on a mass basis, and comply with the following for each listed source:
      - i. Waste Tanks: Fixed roof with a closed-vent system (CVS).
      - ii. Surface Impoundments: Maintain a cover with a CVS.
      - iii. Containers: Maintain a sealed cover.
      - iv. Individual Drain Systems: Maintain a cover with a CVS.
      - v. Oil-water Separators: Fixed roof with a CVS.
  2. The owner or operator may elect to manage and treat the facility waste as follows:
    - a) Treat process wastewater to achieve a total annual benzene quantity from facility process wastewater less than 1 megagram per year (Mg/yr), and
    - b) Manage and treat facility waste with a flow-weighted annual average water content of less than 10%.
  3. For each CVS and control device, the system must reduce emissions by 95% or

achieve a less than 20 ppmv (dry basis) concentration of organic material in the vented emissions.

### 3.3.2.5 Process Heaters

The SOTA performance emission levels, in Tables 1 and 2 below, are for natural draft (ND) process heaters. For gaseous fuel, the hydrogen content of refinery fuel gas (RFG) is assumed to be not greater than 50%. Mechanical draft (MD) heaters with preheated air, and/or RFG with hydrogen content greater than 50%, will be evaluated on a case-by-case basis if the limits in Tables 1 and 2 cannot be met.

The limits in Tables 1 and 2 are to be achieved by initial stack testing. In the case where continuous monitoring is required (continuous emission monitoring for sources greater than 250 million British thermal units per hour (MMBtu/hr) and operational monitoring for other sources) these limits shall be 24-hour averages.

Control of CO and NO<sub>x</sub> emissions is usually accomplished by the use of combustion controls. Flue gas control for NO<sub>x</sub> for large units may be appropriate under some circumstances.

Since additional controls are generally not required for other pollutants, SOTA performance limits are included only for CO and NO<sub>x</sub>.

**Table 1**  
(Fuel type - **refinery fuel gas** or **natural gas**)  
Maximum Emission Rates in lb/MMBtu (High Heating Value - HHV)

|                                    | <u>New Unit</u> | <u>Burner Replacement</u> |
|------------------------------------|-----------------|---------------------------|
| Nitrogen Oxides (NO <sub>x</sub> ) | 0.05            | 0.07                      |
| Carbon Monoxide (CO)               | 0.06            | 0.10                      |

**Table 2**  
(Fuel type - **Fuel oil**<sup>1</sup>)  
Maximum Emission Rates in Lb/MMBtu (HHV)

|                                    | <u>New Unit</u> | <u>Burner Replacement</u> |
|------------------------------------|-----------------|---------------------------|
| Nitrogen Oxides (NO <sub>x</sub> ) | 0.10            | 0.12                      |
| Carbon Monoxide (CO)               | 0.10            | 0.10                      |

<sup>(1)</sup> These levels are achievable with distillate fuel oil. If residual fuel oil is burned, and these levels cannot be met, and if flue gas control is not feasible, case-by-case determinations will be made.

### 3.3.2.6 Flares

Flares shall only be used for emergencies, startup/shutdowns, malfunctions and other non-steady state operations.

#### A. Standards based on 40 CFR 60.18 adopted 11/17/75, as amended 12/13/90 & 3/16/94

1. No visible emissions except for periods not to exceed a total of five (5) minutes during any two consecutive hours.
2. Shall be operated with flame present at all times.
3. Net heating value (NHV) of the gas being combusted, as calculated using the formula in this section, shall be
  - a) 300 British thermal units per standard cubic foot (Btu/scf) or greater if the flare is steam-assisted or air-assisted, and
  - b) 200 Btu/scf or greater if the flare is nonassisted.
4. Steam-assisted and nonassisted flares shall be designed and operated with an exit velocity less than 60 feet per second (ft/sec). Exit velocities greater than 60 ft/sec but less than 400 ft/sec are allowed if the NHV of the gas being combusted is greater than 1000 BTU/scf.
5. Steam-assisted and nonassisted flares designed for and operated with an exit velocity less than  $V_{\max}$  (as determined using the formula in 40 CFR 60.18(b)6) and less than 400 ft/sec are allowed.
6. Air-assisted flares shall be designed and operated with an exit velocity less than  $V_{\max}$ .
7. Shall be operated at all times when emissions may be vented to them.

#### B. Other Standards

1. Ground Flares
  - a) Enclosed
  - b) Reduce VOC emissions by 95%
  - c) Achieve a residence time of 0.5 seconds
  - d) Achieve a temperature of 1500 °F
  - e) Be operated and maintained in accordance with the manufacturer's

specifications.

- f)
- 2. Candle Flares: Be operated and maintained in accordance with the manufacturer's specifications.

### 3.3.3 Technical Basis and References

The emission limits and associated control technologies were obtained by surveying data from refineries operating in New Jersey and in this country.

For Process heaters, the basis for developing this guidance is the information contained in EPA Document EPA-453/R-93-015 (Alternate Control Techniques Document - NO<sub>x</sub> Emissions from Process Heaters), vendor information and information contained in permits approved by the Department.

The following are available control technologies that would achieve the limits outlined in Section 3.3.2, above.

#### A. Storage Vessels

- 1. Volatile Organic Compounds

Refer to Section 3.1 of the SOTA Manual for Storage Tanks

#### B. Fluidized-Bed Catalytic Cracking Units

- 1. Particulate Matter

- a) Wet scrubbers including venturi, jet, and EDV scrubbers
- b) Electrostatic precipitators

- 2. Sulfur Dioxide

- a) Wet scrubbers including venturi, jet, packed and spray towers
- b) SO<sub>2</sub> reduction catalyst
- c) Sulfur removal from the feed

- 3. Oxides of Nitrogen

- a) New sources with CO Boiler: Selective Non-Catalytic Reduction (SNCR) or equivalent
- b) Other sources: NO<sub>x</sub> is controlled by coke burnoff and other regenerator

performance factors

4. Carbon Monoxide

- a) Complete burn in the regenerator
- b) CO Boiler

C. Sulfur Recovery Units

- 1. Claus Sulfur Recovery Unit with Beavon Stretford Tail Gas Unit
- 2. Claus Sulfur Recovery Unit with Selective Amine Tail Gas Unit
- 3. Claus Sulfur Recovery Unit, in 1 or 2 above, followed by incineration

D. Process Heaters

1. Carbon Monoxide

Carbon monoxide emission limits are generally achieved with good combustion control and proper operation of SOTA equipment. If additional control is necessary, oxidation catalysts are available for reducing emissions of CO.

2. NO<sub>x</sub> Control

Combustion controls are used to control NO<sub>x</sub> formation, and the emission limits in Tables 1 and 2 can generally be met with the use of ultra-low NO<sub>x</sub> burners (ULNB). Flue gas control for large units may be appropriate in some circumstances.

The following combustion and post combustion technologies are available for controlling NO<sub>x</sub>:

- a) Low NO<sub>x</sub> Burners (LNB) - Staged fuel LNB for gaseous fuel, instead of conventional burners, can achieve NO<sub>x</sub> reductions of 60%, and reductions of 40% with liquid fuel can be achieved with staged air LNB.
- b) Ultra-Low NO<sub>x</sub> Burners - Ultra-low NO<sub>x</sub> burners (ULNB) incorporate internal flue gas recirculation (IFGR), and are effective in controlling NO<sub>x</sub> emissions for heaters firing either gaseous or liquid fuels.

NO<sub>x</sub> reductions in the order of 75% have been achieved for both gaseous and liquid fuels, when using ULNB instead of conventional burners.

- c) Selective Non-Catalytic Reduction - Selective non-catalytic reduction (SNCR) is a post combustion method of controlling NO<sub>x</sub> emissions, in which ammonia or urea is mixed with air or steam and injected into the combustion chamber at high temperatures where it reacts at high temperature with NO<sub>x</sub> to produce nitrogen and water. The reaction temperature can be lowered somewhat by adding hydrogen to the ammonia, such as from the hydrogen-rich catalytic reformer off-gas stream.

NO<sub>x</sub> reductions in the orders of 60% can be achieved with SNCR alone, and 80% when SNCR is used in combination with LNB.

- d) Selective Catalytic Reduction - Selective catalytic reduction (SCR) is another post combustion NO<sub>x</sub> control technology. Ammonia is injected in the flue gas where it reacts with NO<sub>x</sub> in the presence of a catalyst, such as titanium or vanadium, to produce nitrogen and water.

NO<sub>x</sub> reductions in the order of 75% can be achieved with SCR alone and 85 to 90% in combination with LNB.

### **3.3.4 Recommended Review Schedule**

The Department anticipates opening this manual for review every five (5) years or whenever a new applicable rule or regulation is promulgated, whichever comes first.