

# Coke Manufacturing

## Industry Description and Practices

Coke and coke by-products, including coke oven gas, are produced by the pyrolysis (heating in the absence of air) of suitable grades of coal. The process also includes the processing of coke oven gas to remove tar, ammonia (usually recovered as ammonium sulfate), phenol, naphthalene, light oil, and sulfur before the gas is used as fuel for heating the ovens. This document covers the production of metallurgical coke and the associated by-products using intermittent horizontal retorts.

In the coke-making process, bituminous coal is fed (usually after processing operations to control the size and quality of the feed) into a series of ovens, which are sealed and heated at high temperatures in the absence of oxygen, typically in cycles lasting 14 to 36 hours. Volatile compounds that are driven off the coal are collected and processed to recover combustible gases and other by-products. The solid carbon remaining in the oven is coke. It is taken to the quench tower, where it is cooled with a water spray or by circulating an inert gas (nitrogen), a process known as dry quenching. The coke is screened and sent to a blast furnace or to storage.

Coke oven gas is cooled, and by-products are recovered. Flushing liquor, formed from the cooling of coke oven gas, and liquor from primary coolers contain tar and are sent to a tar decanter. An electrostatic precipitator is used to remove more tar from coke oven gas. The tar is then sent to storage. Ammonia liquor is also separated from the tar decanter and sent to wastewater treatment after ammonia recovery. Coke oven gas is further cooled in a final cooler. Naphthalene is removed in the separator on the final cooler. Light oil is then removed from the coke oven gas and is fractionated to recover benzene, toluene, and xylene. Some facilities may include an onsite tar

distillation unit. The Claus process is normally used to recover sulfur from coke oven gas.

During the coke quenching, handling, and screening operation, coke breeze is produced. It is either reused on site (e.g., in the sinter plant) or sold off site as a by-product.

## Waste Characteristics

The coke oven is a major source of fugitive air emissions. The coking process emits particulate matter (PM); volatile organic compounds (VOCs); polynuclear aromatic hydrocarbons (PAHs); methane, at approximately 100 grams per metric ton (g/t) of coke; ammonia; carbon monoxide; hydrogen sulfide (50–80 g/t of coke from pushing operations); hydrogen cyanide; and sulfur oxides,  $SO_x$  (releasing 30% of sulfur in the feed). Significant amount of VOCs may also be released in by-product recovery operations.

For every ton of coke produced, approximately 0.7 to 7.4 kilograms (kg) of PM, 2.9 kg of  $SO_x$  (ranging from 0.2 to 6.5 kg), 1.4 kg of nitrogen oxides ( $NO_x$ ), 0.1 kg of ammonia, and 3 kg of VOCs (including 2 kg of benzene) may be released into the atmosphere if there is no vapor recovery system. Coal-handling operations may account for about 10% of the particulate load. Coal charging, coke pushing, and quenching are major sources of dust emissions.

Wastewater is generated at an average rate ranging from 0.3 to 4 cubic meters ( $m^3$ ) per ton of coke processed. Major wastewater streams are generated from the cooling of the coke oven gas and the processing of ammonia, tar, naphthalene, phenol, and light oil. Process wastewater may contain 10 milligrams per liter (mg/l) of benzene, 1,000 mg/l of biochemical oxygen demand (BOD) (4 kg/t of coke), 1,500–6,000 mg/l of chemical oxygen demand (COD), 200 mg/l of total sus-

pended solids, and 150–2,000 mg/l of phenols (0.3–12 kg/t of coke). Wastewaters also contain PAHs at significant concentrations (up to 30 mg/l), ammonia (0.1–2 kg nitrogen/t of coke), and cyanides (0.1–0.6 kg/t of coke).

Coke production facilities generate process solid wastes other than coke breeze (which averages 1 kg/t of product). Most of the solid wastes contain hazardous components such as benzene and PAHs. Waste streams of concern include residues from coal tar recovery (typically 0.1 kg/t of coke), the tar decanter (0.2 kg/t of coke), tar storage (0.4 kg/t of coke), light oil processing (0.2 kg/t of coke), wastewater treatment (0.1 kg/t of coke), naphthalene collection and recovery (0.02 kg/t of coke), tar distillation (0.01 kg/t of coke), and sludges from biological treatment of wastewaters.

### Pollution Prevention and Control

Pollution prevention in coke making is focused on reducing coke oven emissions and developing cokeless iron- and steel-making techniques. The following pollution prevention and control measures should be considered.

#### General

- Use cokeless iron- and steel-making processes, such as the direct reduction process, to eliminate the need to manufacture coke.
- Use beneficiation (preferably at the coal mine) and blending processes that improve the quality of coal feed to produce coke of desired quality and reduce emissions of sulfur oxides and other pollutants.
- Use enclosed conveyors and sieves for coal and coke handling. Use sprinklers and plastic emulsions to suppress dust formation. Provide windbreaks where feasible. Store materials in bunkers or warehouses. Reduce drop distances.
- Use and preheat high-grade coal to reduce coking time, increase throughput, reduce fuel consumption, and minimize thermal shock to refractory bricks.

#### Coke Oven Emissions

- *Charging*: dust particles from coal charging should be evacuated by the use of jumper-pipe

systems and steam injection into the ascension pipe or controlled by fabric filters.

- *Coking*: use large ovens to increase batch size and reduce the number of chargings and pushings, thereby reducing the associated emissions. Reduce fluctuations in coking conditions, including temperature. Clean and seal coke oven openings to minimize emissions. Use mechanical cleaning devices (preferably automatic) for cleaning doors, door frames, and hole lids. Seal lids, using a slurry. Use low-leakage door construction, preferably with gas sealings.
- *Pushing*: emissions from coke pushing can be reduced by maintaining a sufficient coking time, thus avoiding “green push.” Use sheds and enclosed cars, or consider use of traveling hoods. The gases released should be removed and passed through fabric filters.
- *Quenching*: where feasible, use dry instead of wet quenching. Filter all gases extracted from the dry quenching unit. If wet quenching, is used, provide interceptors (baffles) to remove coarse dust. When wastewater is used for quenching, the process transfers pollutants from the wastewater to the air, requiring subsequent removal. Reuse quench water.
- *Conveying and sieving*: enclose potential dust sources, and filter evacuated gases.

#### By-Product Recovery

- Use vapor recovery systems to prevent air emissions from light oil processing, tar processing, naphthalene processing, and phenol and ammonia recovery processes.
- Segregate process water from cooling water.
- Reduce fixed ammonia content in ammonia liquor by using caustic soda and steam stripping.
- Recycle all process solid wastes, including tar decanter sludge, to the coke oven.
- Recover sulfur from coke oven gas. Recycle Claus tail gas into the coke oven gas system.

### Target Pollution loads

Implementation of cleaner production processes and pollution prevention measures can yield both economic and environmental benefits. The pro-

**Table 1. Air Emissions, Coke Manufacturing***(kilograms per ton of coke produced)*

<i>Parameter</i>	<i>Maximum value</i>
VOCs	0.3
Benzene	0.1
Particulate matter	0.15
Sulfur oxides	0.5
Nitrogen oxides	0.6
TSS	50
Oil and grease	10
Phenol	0.5
Benzene	0.05
Dibenz(a,h)anthracene	0.05
Benzo(a)pyrene	0.05
Cyanide (total)	0.2
Nitrogen (total)	10
Temperature increase	≤ 3° C <sup>a</sup>

Note: Effluent requirements are for direct discharge to surface waters.

a. The effluent should result in a temperature increase of no more than 3° C at the edge of the zone where initial mixing and dilution take place. Where the zone is not defined, use 100 meters from the point of discharge.

duction-related targets described below can be achieved by adopting good industrial practices.

### *Air Emissions*

Emissions should be reduced to the target levels presented in Table 1.

### *Wastewater*

The generation rate for wastewater should be less than 0.3 m<sup>3</sup>/t of coke.

### *Solid and Hazardous Wastes*

New coke plants should not generate more than 1 kg of process solid waste (excluding coke breeze and biosludges) per ton of coke.

## **Treatment Technologies**

### *Air Emissions*

Air emission control technologies include scrubbers (removal efficiency of 90%) and baghouses and electrostatic precipitators (ESPs), with re-

moval efficiencies of 99.9%. Baghouses are preferred over venturi scrubbers for controlling particulate matter emissions from loading and pushing operations because of the higher removal efficiencies. ESPs are effective for final tar removal from coke oven gas.

### *Wastewater Treatment*

Wastewater treatment systems include screens and settling tanks to remove total suspended solids, oil, and tar; steam stripping to remove ammonia, hydrogen sulfide, and hydrogen cyanide; biological treatment; and final polishing with filters.

The levels presented in Table 2 should be achieved.

### *Solid Waste Treatment*

All process hazardous wastes except for coke fines should be recycled to coke ovens. Wastewater treatment sludges should be dewatered. If toxic organics are detectable, dewatered sludges are to be charged to coke ovens or disposed in a secure landfill or an appropriate combustion unit.

## **Emissions Guidelines**

Emissions levels for the design and operation of each project must be established through the environmental assessment (EA) process on the basis of country legislation and the *Pollution Prevention and Abatement Handbook*, as applied to local conditions. The emissions levels selected must be

**Table 2. Target Wastewater Loads per Unit of Production, Coke Manufacturing***(grams per ton of coke produced, unless otherwise specified)*

<i>Parameter</i>	<i>Maximum value</i>
COD	100
Benzene	0.015
Benzo(a)pyrene	0.009
Naphthalene	0.0008
Nitrogen (total)	12
Cyanide (free)	0.03
Phenol	0.15
Wastewater	0.3 m <sup>3</sup> /t of coke produced

justified in the EA and acceptable to the World Bank Group.

The guidelines given below present emissions levels normally acceptable to the World Bank Group in making decisions regarding provision of World Bank Group assistance. Any deviations from these levels must be described in the World Bank Group project documentation. The emissions levels given here can be consistently achieved by well-designed, well-operated, and well-maintained pollution control systems.

The guidelines are expressed as concentrations to facilitate monitoring. Dilution of air emissions or effluents to achieve these guidelines is unacceptable.

All of the maximum levels should be achieved for at least 95% of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours.

#### *Air Emissions*

Benzene emissions should not be more than 5 milligrams per normal cubic meter ( $\text{mg}/\text{Nm}^3$ ) in leaks from light oil processing, final cooler, tar decanter, tar storage, weak ammonia liquor storage, and the tar/water separator. VOC emissions should be less than  $20 \text{ mg}/\text{Nm}^3$ . Particulate matter emissions from the stacks should not exceed  $50 \text{ mg}/\text{Nm}^3$ . Sulfur recovery from coke oven gas should be at least 97% but preferably over 99%.

#### *Liquid Effluents*

The effluent levels presented in Table 3 should be achieved.

#### *Solid and Hazardous Wastes*

Solid hazardous wastes containing toxic organics should be recycled to a coke oven or treated

in a combustion unit, with residues disposed of in a secure landfill.

#### *Ambient Noise*

Noise abatement measures should achieve either the levels given below or a maximum increase in background levels of 3 decibels (measured on the A scale) [dB(A)]. Measurements are to be taken at noise receptors located outside the project property boundary.

<i>Receptor</i>	<i>Maximum allowable log equivalent (hourly measurements), in dB(A)</i>	
	<i>Day</i>	<i>Night</i>
	<i>(07:00–22:00)</i>	<i>(22:00–07:00)</i>
Residential, institutional, educational	55	45
Industrial, commercial	70	70

#### **Monitoring and Reporting**

Stack air emissions should be monitored continuously for particulate matter. Alternatively, opacity measurements of stack gases could suffice. Fugitive emissions should be monitored annually for VOCs. Wastewater discharges should be monitored daily for flow rate and for all parameters, except for dibenz(a,h)anthracene and benzo(a)pyrene. The latter should be monitored at least on a monthly basis or when there are process changes. Frequent sampling may be required during start-up and upset conditions.

Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Records of monitoring results should be kept in an acceptable format. The results should be reported to the responsible authorities and relevant parties, as required.

#### **Key Issues**

The key production and control practices that will lead to compliance with emissions guidelines can be summarized as follows:

**Table 3. Effluents, Coke Manufacturing**

(milligrams per liter, unless otherwise specified)

<i>Parameter</i>	<i>Maximum value</i>
BOD	30
COD	150

- Use cokeless iron- and steel-making processes, such as the direct reduction process for iron-making, to eliminate the need for coke manufacturing.
- Where feasible, use dry quenching instead of wet quenching.
- Use vapor-recovery systems in light oil processing, tar processing and storage, naphthalene processing, and phenol and ammonia recovery operations.
- Recover sulfur from coke oven gas.
- Segregate process and cooling water.
- Recycle process solid wastes to the coke oven.

### Sources

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