Multilateral Investment Guarantee Agency

Environmental Guidelines for

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 being 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 which control the size and quality of the feed) into a series of ovens; the ovens are sealed and heated at high temperatures in the absence of oxygen, usually 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 byproducts. The solid carbon remaining in the oven is coke which is taken to the quench tower, where it is cooled with a water spray, or alternatively cooled by circulating an inert-gas (nitrogen), also known as dry quenching. Coke is screened and sent to a blast furnace or for storage.

Coke oven gas is cooled and by-products are recovered. Flushing liquor is formed from the cooling of coke oven gas and it contains tar. Liquor from primary coolers and flushing contains tar which is sent to a tar decanter. Further removal of tar from coke oven gas is by using an electrostatic precipitator. It is sent for storage. Ammonia liquor is also separated from the tar decanter and sent for 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 and then light oil is removed from the coke oven gas. Light oil is fractionated to recover benzene, toluene, and xylene. Some facilities may include an on-site tar distillation unit. The Claus process is normally used for sulfur recovery from coke oven gas.

During the coke quenching, handling, and screening operation, coke breeze is produced which is either reused on-site (e.g., 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 (approximately 100 grams per metric ton (g/t) of coke), ammonia, carbon monoxide, hydrogen sulfide (from 50 to 80 g/t of coke from pushing operations), hydrogen cyanide, and sulfur oxides (SO_x) (30% of sulfur in the feed). Significant amount of VOCs may also be released from 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 (with a range of 0.2 to 6.5 kg SO_x), 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 without a vapor recovery systems. 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 0.3-4 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 measured over five days (BOD_5) (4 kg/t of coke), 1,500-6,000 mg/L of chemical oxygen demand (COD), 200 mg/L of total suspended 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/ton of coke).

Coke production facilities generate process solid wastes excluding coke breeze (averaging 1 kg per metric ton of product), most of which contain hazardous components such as benzene and PAHs. Waste streams of concern include residues from coal tar recovery (typically 0.1 kg/t coke), tar decanter (0.2 kg/t coke), tar storage (0.4 kg/t coke), light oil processing (0.2 kg/t coke), wastewater treatment (0.1 kg/t coke), naphthalene collection and recovery (0.02 kg/t coke), tar distillation (0.01 kg/t 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 which 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 wind breaks where feasible. Store materials in bunkers or warehouses. Reduce drop distances.
- Pre-heat and use 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 of doors, door frames, and hole lids. Seal lids using a slurry. Use a low leakage door construction preferably with gas sealings.
- *Pushing*. Emissions from coke pushing can be reduced by maintaining a sufficient coking time thus avoiding the so-called "green push." Use sheds and enclosed cars. Alternatively, consider 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/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 coke oven gas system.

Target Pollution Loads

Implementation of cleaner production processes and pollution prevention measures can provide both economic and environmental benefits. The following production-related targets can be achieved by adopting Good Industrial Practices.

Air Emissions

Emissions should be reduced to the following target levels:

Air Emissions Per Unit of Production

Parameter	*Maximum value (kg/t of coke)*
VOCs	0.3
Benzene	0.1
Particulate matter	0.15
Sulfur oxide (SO_x)	0.5
Nitrogen oxide (NO_x)	0.6

Wastewater

The Generation rate for wastewater should be less than 0.3 m^3 per metric ton 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 metric ton of coke.

Treatment Technologies

Air Emissions

Air emission control technologies include scrubbers (removal efficiency of 90%), and baghouses/electrostatic precipitators (ESPs) (with removal 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 following levels should be achieved:

Target Wastewater Loads per Unit of Production

Parameter	*Maximum value (grams/t of coke produced unless otherwie noted)*
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^3/t of coke produced

Solid Waste Treatment

All process hazardous wastes (except 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.

Emission Guidelines

Emission levels for the design and operation of each project must be established through the Environmental Assessment (EA) process, based on country legislation and the *Pollution Prevention and Abatement Handbook* as applied to

local conditions. The emission levels selected must be justified in the EA and acceptable to MIGA.

The following guidelines present emission levels normally acceptable to the World Bank Group in making decisions regarding provision of World Bank Group assistance, including MIGA guarantees; any deviations from these levels must be described in the project documentation.

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

Liquid Effluents

The following effluent levels should be achieved:

Effluents from the Coke Manufacturing Industry

Parameter	*Maximum value milligrams per liter (mg/L)*
BOD_5	30
COD	150
Total suspended solids	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	less than or equal to 3°C[1]

[1] The effluent should result in a temperature increase of no more than 3 degrees Celsius at the edge of the zone where initial mixing and dilution takes place. Where the zone is not defined, use 100 meters from the point of discharge.

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

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 in a secure landfill.

Ambient Noise

Noise abatement measures should achieve either the following levels or a maximum increase in background levels of 3 dB(A). Measurements are to be taken at noise receptors located outside the project property boundary.

Ambient Noise

	Maximum Allowable L_{eq} (hourly), in dB(A)	
Receptor	Daytime 07:00 - 22:00	Nighttime 22:00 - 07:00
Residential; institutional; educational	55	45
Industrial; commercial	70	70

The emission requirements given here can be consistently achieved by well-designed, well-operated and well-maintained pollution control systems.

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 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. These should be reported to the responsible authorities and relevant parties, as required, and provided to MIGA if requested.

Key Issues

The following box summarizes the key production and control practices that will lead to compliance with emission guidelines:

- 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 on light oil processing, tar processing/storage, naphthalene processing, and phenol and ammonia recovery operations
- Segregate process and cooling water..
- Recycle process solid wastes to the coke oven
- Recover sulfur from coke oven gas.

Further Information

The following are suggested as sources of additional information (these sources are provided for guidance and are not intended to be comprehensive):

Bounicore, A.J. and W.T. Davis. 1992. *Air Pollution Engineering Manual*. New York: Van Nostrand Reinhold.

Technical Note on the Best Available Technologies to Reduce Emissions into Air from Coke Plants. 1993.

Study on the Technical and Economic Aspects of Measures to Reduce the Pollution from the Industrial Emissions of Cokeries. 1992.

US Environmental Protection Agency (EPA). 1982. *Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Subcategory*. EPA 440/1-82/024.

US General Printing Office (GPO). August 18, 1992. *Federal Register*. Vol. 57, No. 160.

World Bank, Environment Department. 1995. "Industrial Pollution Prevention and Abatement: Coke Manufacturing." Draft document.

World Health Organization (WHO). 1989. *Management and Control of the Environment*. Publication No. WHO/PEP/89.