Multilateral Investment Guarantee Agency

Environmental Guidelines for

Oil and Gas Development (Onshore)

Industry Description and Practices

This document addresses *onshore* oil and gas exploration, drilling, and production operations. Refining operations are covered in a separate document. Testing, delineation and production drilling are integral to hydrocarbon reservoir development. This involves the use of drilling rigs (and associated equipment such as casing and tubing), large quantities of water, and drilling muds. In the process, oil and gas are moved to the surface through the well bore either through natural means (the reservoir has enough pressure to push the oil and gas to the surface) or through induced pressure (by means of a pump or other mechanism). At the surface, oil, gas, and water are separated. Crude oils with associated gas containing more than 30 milligrams per cubic meter (mg/m^3) of hydrogen sulfide are normally classified as "sour crude". The crude oil may require further processing including the removal of associated gas. Oil produced at the wells is piped or shipped for use as feedstock in petroleum refineries.

Natural gas is predominantly methane with smaller amounts of ethane, propane, butanes, pentanes, and heavier hydrocarbons. Gas wells produce small quantities of condensate which may require processing. Separation processes generally use pressure reduction, gravity separation, and emulsion "breaking" techniques. Gas that is produced may be used directly as fuel or as feedstock for the manufacture of petrochemicals. It may also contain small amounts of sulfur compounds such as mercaptans and hydrogen sulfide. Sour gas is sweetened by processes such as amine scrubbing.

Waste Characteristics

The major environmental concerns associated with onshore oil and gas production are drilling waste fluids or muds, drilling waste solids, produced water, and volatile organics. The drilling waste muds may be fresh-water gel, salt water (potassium chloride or sodium chloride), or oil invert-based systems. The oil invert mud systems may contain up to 50 percent by volume of diesel oil.

The drilling waste may contain drilling muds (bentonite), bore-hole cuttings, additives (polymers, oxygen scavengers, biocides, surfactants, lubricants, diesel oil, emulsifying agents, and various other wastes that are specifically related to the drilling activities.

The drilling waste solids, which are made up of the bottom layer of drilling mud sump materials, may contain drill cuttings, flocculated bentonite, weighting materials and other additives. Additional wastes from the drilling process include used oils, cementing chemicals, and toxic organics.

Field processing of crude oil will generate several waste streams including contaminated wastewater, tank bottoms which may contain lead, emulsions, and heavy hydrocarbon residues which may contain polynuclear aromatic hydrocarbons (PAHs). Cooling tower blowdown, boiler water, scrubber liquids, and steam production wastes are also generated, as well as contaminated soil, used oil, and spent solvents.

Wastewaters that are generated typically contain suspended solids. To control the growth of micro-organisms in sour water, usually a biocide or hydrogen sulfide scavenger (for example, sodium hypochlorite) is used prior to its reinjection or disposal. Crude pipelines are routinely cleaned by pigging operations which can lead to spills and to the generation of sludge containing heavy metals. Solid wastes which do not contain toxics are used as back-fill material.

The following is a characterization of the overall wastewater stream from crude processing:

Crude Processing Wastewater

Parameter	*Typical values (average) milligrams per liter (mg/L)*
Oil and grease	7-1,300 (200)
Total organic carbon	30-1,600 (400)
Total suspended solids (TSS)	20-400 (70)
Total dissolved solids (TDS)	30,000-200,000 (100,000)
Biochemical oxygen demand (BOD_5)	120-340
COD	180-580
Phenols	50
Cadmium	0.7
Chromium	2.3
Copper	0.4
Lead	0.2
Mercury	0.1
Nickel	0.4

Major sources of air emissions include fired equipment, vents, flares (including those from compressor stations), and fugitive emissions. These may contain volatile organic compounds (VOCs), sulfur oxides, hydrogen sulfide, and nitrogen oxides.

Air Emissions from Oil and Gas Production

<u>*Gas Production*</u>	
Sulfur Oxides	Less than 0.1 grams per cubic meter (g/m^3) of gas produced
Nitrogen Oxides	10-12 g/m^3 of gas produced
VOCs	0.1-14 g/m^3 of gas produced
Methane	0.2-10 g/m^3 of gas produced
<u>*Oil Production*</u>	
Nitrogen Oxides	3.7 grams per kilogram (g/kg) oil produced
VOCs	3.3-26 g/kg oil produced

Pollution Prevention and Control

Pollution prevention programs should focus on reducing the impacts of wastewater discharges, oil spills and soil contamination and on minimizing air emissions. Minimizing the quantity of discharge should be stressed. Process changes might include the following:

- Maximize the use of freshwater gel-based mud systems.
- Eliminate the use of invert (diesel based) muds. In case where the use of diesel-based muds is necessary, reuse the muds.
- Recycle drilling mud decant water.
- Prevent degradation of sweet wells by sulfate reducing bacteria by the use of hydrogen sulfide scavengers.
- Select less toxic biocides, corrosion inhibitors, and other chemicals.
- Minimize gas flaring. However, flaring is preferred to venting.
- Store crude oil in tanks with the large ones (greater than 1,590 m^3) having secondary (double) seals.
- Minimize and control leakage from tanks and pipelines.
- Practice corrosion prevention and monitor above and below ground tanks, vessels, pipes etc.
- Remove hydrogen sulfide and mercaptans from sour gases (releasing greater than 1.8 kg of reduced sulfur compounds per hour) before flaring.
- Use knock-out drums on flares to prevent condensate emissions.
- Regenerate spent amines and spent solvents or send off-site for recovery.
- Use low nitrogen oxides (NO_x) burners in process heaters (especially in those with a design heat input of $4.2X\ 10^{10}$ Joules per hour).
- Provide spill prevention and control measures (bunds/berms and hard surfacing for storage tanks; pressure relief valves; and high-level alarms).
- Recover oil from process wastewaters.
- Segregate storm water from process water.
- Implement leak detection and repair programs.

Practice good house keeping, and ensure that appropriate operating and maintenance programs are in place.

A reclamation and closure plan for the site is required. This plan should be developed early in the project and should address the removal and disposal of production facilities in an environmentally sensitive manner, the restoration of the site, and provisions for any ongoing maintenance issues. Where possible, progressive restoration should be implemented.

Target Pollution Loads

Implementation of cleaner production processes and pollution prevention measures can provide both economic and environmental benefits. In drilling operations, the use of fresh water should be minimized by maximizing the use of drilling mud pond decant water. Eliminate sour gas emissions by sweetening and reuse.

Treatment Technologies

Typically, air emissions of toxic organics are minimized by routing such vapors to recovery systems, flares, or boilers. Tail gases are scrubbed to remove sulfur compounds.

The decant from the drilling mud disposal sump is treated by coagulation and settling before discharge. Alternatively, the sump fluids may be injected downhole into an approved disposal formation.

The drained and settled drilling mud solids are disposed on land: capping; mixing, burying, and covering; trenching; or encapsulating. Other options include land spreading, land filling, incineration (for destruction of toxic organics), or in-situ solidification/fixation.

Effluents from the crude process may be treated using coagulation, de-emulsification, settling, and filtration.

Storm water is settled and if necessary, treated (coagulation, flocculation, and sedimentation) before discharge.

Emission Requirements

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 World Bank Group 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

The following emissions levels should be achieved:

Emissions from Oil and Gas Production (Onshore)

Parameter	*Maximum value milligrams per normal cubic meter (mg/Nm^3)*
VOCs (including benzene)	20
Hydrogen sulfide	30
Sulfur oxides (for oil production)	1,000
Nitrogen oxides	
Gas-fired	320 mg/Nm^3 (or 86 ng/J)
Oil-fired	460 mg/Nm^3 (or 130 ng/J)
Odor	Not offensive at the receptor end*

*H_2S at the property boundary should be less than 5 μg/m^3

Liquid Effluents

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

The following effluent levels should be achieved:

Liquid Effluents from Onshore Oil and Gas Production

Parameter	*Maximum value milligrams per liter (mg/L)*
pH	6-9
BOD_5	50
Total suspended solids (TSS)	50
Oil and grease*	20
Phenol	1
Sulfide	1
Total toxic metals**	5
Temperature increase	less than 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.

* Up to 40 mg/L is acceptable for facilities producing less than 10,000 tpd.

** Includes antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, vanadium, and zinc.

Note: For direct discharge to surface waters.

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 Leq (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

Frequent sampling may be required during start-up and upset conditions. Once a record of consistent performance has been established, sampling for the parameters listed above should be as detailed below.

Air emissions of above listed parameters should be assessed on an annual basis. Liquid effluents from production operations should be analyzed for the above listed parameters on a daily basis, except for metals which can be monitored on a monthly basis or when there are significant process changes.

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 requirements:

- Maximize the use of freshwater gel-based mud systems.
- Dispose drilling muds in a manner which minimizes the impacts on the environment. Reuse invert (diesel-based) muds.
- Reuse drilling mud pond decant water.
- Encourage the reuse of produced water for steam generation where steam is used to stimulate reservoir production.
- Minimize gas flaring.
- Scrub sour gases.

Further Information

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

American Petroleum Institute (API). 1989. API Environmental Guidance Document: *Onshore Solid Waste Management in Exploration and Production Operations.*

Her Majesty's Inspectorate of Pollution 1992. United Kingdom. *Chief Inspector's Guidance to Inspectors*. Environment Protection Act 1990. Process Guidance Note IPR 1/16: Petroleum Processes Onshore Oil Production.

Alberta Land Conservation and Reclamation Council. 1990. Literature Review on the Disposal of Drilling Waste Solids. Alberta Land Conservation and Reclamation Research Technical Advisory Committee. Report No. 90-9. Edmonton, Alberta, Canada.