

PROJECT STANDARD DOCUMENT

Regulations for Pollution Control

REQUIREMENTS FOR POLLUTION CONTROL

The main legislation in Malaysia that deals with pollution control is the Environmental Quality Act (EQA) 1974. The agency responsible for the enforcement of the Act is the Department of Environment (DoE) which is under the Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC). Regulations underneath the EQA 1974 that emphasize on the pollution control such as air emission and effluent discharge are the Clean Air Regulations (CAR) 2014 and Industrial Effluent Regulations 2009.

Based on these regulations, these are basic requirements for application of pollution control equipment for this project:

POLLUTION CONTROL EQUIPMENT	REQUIREMENTS
Industrial Effluent Treatment System (IETS)	<ul style="list-style-type: none"> • Design and construction as specified in Guidance Document on the Design and Operation of Industrial Effluent Treatment System issued by DoE • “as-built drawing” of the system to be approved by professional engineer • monitoring of effluent discharge as per parameter listed under Standard A • operation of IETS shall be maintain in accordance to sound engineering practice • performance monitoring of IETS conducted by competent person as specified in Guidance Document on Performance Monitoring of Industrial Effluent Treatment System • competent person supervises the operation of IETS shall be on-site at any time
Air Pollution Control System (APCS)	<ul style="list-style-type: none"> • APCS shall be designed and construct by professional engineer as specified by Director General • operation of APCS shall be maintained in accordance to sound engineering practice • operation of APCS shall be supervised by competent person who is responsible to conduct performance monitoring and emission monitoring report which to be submitted to DoE • record of maintenance and performance monitoring shall be kept and made available for inspection by authorized officer • competent person supervises the operation of APCS shall be on-site at any time

The International Finance Corporation (IFC) has established the Environmental, Health and Safety (EHS) Guidelines which is a technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP), as defined in the IFC’s Performance Standard 3: Resource Efficiency and Pollution Prevention.

For the purpose of the project, this document will discuss and compare the limit values and standards of air emission and effluent discharge regulated in the National Standard (under the EQA1974) and with the IFC’s EHS Guidelines Standard.

1 LIQUID EFFLUENT SOURCES AND INVENTORY

The main sources of liquid effluent/discharge during the operation of this project are effluent/discharge streams from dilution steam blowdown and blowdown from cooling tower, effluent with aromatic hydrocarbons, sour water, wash water and production of spent caustic. These effluent/discharge will be pre-treated and channelled into the balance tank before it goes

to the on-site waste water treatment plant and finally being discharge to the surface drainage. Estimation quantity of final treated waste water on-site is about 2,400 m³/day.

Inventory of liquid effluents that generated by the PEC facility is presented in *Table 1* below with the exception of effluents that are treated in the spent caustic treatment system or directed to the DHT feed surge drum. Most of these effluents are discharge to the on-site waste water treatment plant.

Table 1: Liquid Effluent Inventory

Source	Nature
Domestic Effluent (Toilet, showers etc)	Domestic effluent
Condensate Fractionation Unit	Sour water
Condensate Fractionation Unit	Brine water
LPG Merox Unit – Caustic heater	Steam Condensate Temperature (max) – 100°C pH – 7 to 9
LPG Merox Unit – Sand Filter	Back wash water – various suspended matter
LPG Merox Unit	Disulphide oil without wash oil SG @ 38°C 1.0 (approx) Sulfur, wt-% 20-50 Color: Water white to pale green
LPG Merox Unit	Spent Caustic (prewash) % Spent: 50-70 Total alkalinity, wt-% NaOH: 6-7 Strong Alkalinity, wt-% NaOH: 2-3 Total S, wt-% 3-4 Mercaptide, wtppm S: trace Sodium Bisulphide (NaHS), wt-% 3-4 Sulphide (Na ₂ S), wt-%: 3-4 Undissolved oil, vol-%: <1 Acid Oils, wt-%: 0-10 (*) Merox Catalyst (from Extract Spent Caustic), wtppm 0-250
LPG Merox Unit	Spent Caustic (extraction) % spent: 10-20 Total alkalinity, wt-% NaOH: 12-16 Strong Alkalinity, wt-% NaOH: 10-12 Total S, wt-%: <1 Na ₂ SxO _y Mercaptide, wtppm S: 100 Sulphide (Na ₂ S), wtppm <1 Disulphide, wtppm S: 50-200 Undissolved Oil, vol-% <1 Acid oils, vol-% 0-10(*) Merox catalyst, wtppm : 0-250
Distillate Union fining (KHT) Unit	Amine waste water Sour Water
Distillate Union fining (DHT) Unit	Amine waste water Sour Water
AROMATICS PROCESS WASTE WATER	
Naphtha Prefractionation Unit	Water with hydrocarbon 18 mg/L propane, 276 mg/L butanes & 8 mg/L pentanes
Naphtha Hydrotreating Unit	Water with 11mg/L NH ₃ max, 2mg/L H ₂ S max, trace NaCl & trace hydrocarbon

Source	Nature
	BOD = 100 mg/L COD = 250 mg/L Waste water with Mercury and Arsenic Condensate from the stripping unit Sour water
CCR Platformer	Water with NH ₄ Cl & trace hydrocarbons BOD = 100 mg/L COD = 250 mg/L
Parex Unit – Raffinate column receiver	Water with aromatic hydrocarbons (0.11 wt%) ¹ BOD = 1,692 mg/L COD = 3,385 mg/L
Parex Unit– Finishing Column receiver	Water with aromatics (0.13wt%) ¹ BOD = 2,000 mg/L COD = 4,000 mg/L
Isomar Unit – Deheptaniser	Water with aromatics (0.32 wt%) ¹ BOD = 4,293 mg/L COD = 9,846 mg/L
Sulfolane Unit – Ejector Condensate Drum	Water with aromatics (0.32 wt%) ¹ BOD = 4,293 mg/L COD = 9,846 mg/L
Sulfolane Unit – Solvent regenerator bottoms	Sulfolane solvent with aromatics, polymers, inorganic solids and water.
Sulfolane Unit	Sour water
Benzene – Toluene Fractionation Unit	Water with aromatics (0.28 wt% Benzene) BOD = 4,000 mg/L COD = 8000 mg/L
Clay Treators Benzene Toluene Area	Water
Tatoray – Regenerator Drier Package	Water
Tatoray Unit	Condensate from stripper and receiver
Clay Treators Xylene Area	Water
Process Tanks in Aromatics Area (Tankfarm Rundown)	SS = Max 100 mg/L Total Oil = 50-500mg/L N-NH ₃ =5-25 mg/L BOD = 100-2,500 mg/L COD = 250-5,000 mg/L
Aromatics Complex (Stormwater)	BOD = 50 mg/L (max)
Aromatics Complex (Firewater)	-
Washdown of Process Paved Areas	-
Maintenance Flows	-
Dumped Condensate	-
Storage Tank Bunds	-

Notes:

¹ Aromatics hydrocarbon content assumed to be Benzene for calculation of Theoretical Oxygen Demand (ThOD)

1.1 Liquid Effluent Discharge Standards

1.1.1 National Standards

The main legislative instruments governing water pollution are the Environmental Quality Act (Part IV – Section 25, 27 and 29) 1974, Environmental Quality (Industrial Effluent) Regulations 2009 and the Environmental Quality (Sewage) Regulations 2009. The Director General of Environmental Quality is responsible for the implementation and administration of these statutory requirements. The provisions given under each of these Acts or Regulations are

described below, whilst a summary of Industrial Effluent or Mixed Effluent Discharge of Standard A applicable to project is presented in *Table 2* below.

Table 2 : Acceptable Conditions for Discharge of Industrial Effluent or Mixed Effluent of Standard A

Parameter	Unit	National Standard (Standard A)
pH	pH	6-9
Total suspended solid (TSS)	mg/l	50
Temperature	°C	40
BOD	mg/l	20
COD	mg/l	80 (industrial effluent) 80 (mixed effluent)
Total Nitrogen	mg/l	N/A
Total Phosphorus	mg/l	N/A
Oil and grease	mg/l	1
Phenols	mg/l	0.001
Sulphide	mg/l	0.50
Sulphates	mg/l	Adopt "Best Management Practice"
Arsenic	mg/l	0.05
Chromium total	mg/l	N/A
Chromium (hexavalent)	mg/l	0.05
Copper	mg/l	0.20
Lead	mg/l	0.10
Mercury	mg/l	0.005
Nickel	mg/l	0.20
Iron	mg/l	1
Zinc	mg/l	2.00
Cyanide (total)	mg/l	N/A
Cyanide (free)	mg/l	0.05
Vanadium	mg/l	Adopt "Best Management Practice"
Benzene	mg/l	N/A
Benzo(a)pyrene	mg/l	N/A
Total Coliform	MPN/100ml	N/A

Source: Fifth Schedule (Sub regulation 11(1), 11(2), 11(3)) of Industrial Effluent Reg. 2009

Environmental Quality Act 1974 (Part IV – Prohibition and Control of Pollution)

Section 25, 27 and 29 under Part IV of this Act includes the following measures to protect water bodies from pollution:

- Section 25 describes that no person shall, unless licensed, emit, discharge or deposit any environmentally hazardous substances, pollutants or wastes into any inland waters;
- Section 27 prohibits the discharge or spill any oil or mixture containing oil into Malaysian waters;
- Section 29 prohibits the discharge of environmentally hazardous substances, pollutants or wastes into the Malaysian waters; and
- Contravenes of these sections shall be guilty of an offence and shall be liable to an amount of fine

This Act also provides the Director General with the power to issue prohibition order to the owner or occupier of any industrial plant or process to prevent its continued operation and release of environmentally hazardous substances, pollutants or wastes either absolutely or conditionally.

Environmental Quality (Industrial Effluent) Regulations 2009

- These regulations are applicable to any premises which discharge or release industrial effluent or mixed effluent, onto or into any soil, or into inland waters or Malaysian waters, other than the premises as specified in the First Schedule of the Regulations.
- Details on effluent quality standards for discharge of wastewater into the watercourses or land are provided in the Industrial Effluent Regulations 2009, however, the discharge of effluent into the public sewer system is not stipulated under these regulations.
- Among the key provisions under these regulations are:
 - prohibition of discharging effluent or mixed effluent into the watercourses or land without obtaining permit or license from the Director General;
 - acceptable conditions of discharging the industrial or mixed effluent are stipulated under Standard A or Standard B of the Regulations. The Standard A have a particularly stringent requirements because of location of discharging watercourses are located within the water catchment areas;
 - all wastewater must be treated and monitored accordingly prior to discharging into the watercourse; and
 - industrial or mixed effluent must be treated by the industrial effluent treatment system and the owner or occupier of the premise must ensure that the treatment system is working in good condition by appointing a competent person to supervise the operation.

Environmental Quality (Sewage) Regulations 2009

- These Regulations is applicable to any premises which discharge sewage onto or into any soil, or into any inland waters or Malaysian waters, other than any housing or commercial development or both having a population equivalent of less than 150.
- As the sewerage system of an industrial plant is self-contained and the sewage discharge are channel to the public sewerage system (IWK), thus these regulations are not explained further here.

1.1.2 IFC's ESH Guideline Standards

General EHS Guidelines

The IFC's General EHS Guidelines stated that industrial wastewater generated from the industrial operations which includes process wastewater, wastewater from utility operations, runoff from process and materials staging areas and others activities. The pollutants in an industrial wastewater may include acids or bases (exhibited as low or high pH), soluble organic chemicals causing depletion of dissolved oxygen, suspended solids, nutrients (phosphorus, nitrogen), heavy metals (e.g. cadmium, chromium, copper, lead, mercury, nickel, zinc), cyanide, toxic organic chemicals, oily materials and volatile materials.

The treatment of industrial wastewater depends on adequacy of its design, equipment selection, as well as operation and maintenance of its installed facilities. This is to ensure that the discharge of wastewater to surface water should not result in contaminant concentration in excess of local ambient water quality criteria or, in absence of local criteria, other sources of ambient water quality.

The IFC's General EHS Guidelines for Effluent can be observed below.

Table 3 : IFC's General EHS Guidelines for Effluent (sanitary wastewater discharged to surface water)

Parameter	Unit	Guidelines Value
pH	pH	6-9
Total suspended solid (TSS)	mg/l	50
Temperature	°C	Temperature of wastewater prior to discharge does not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone
BOD	mg/l	30
COD	mg/l	125
Total Nitrogen	mg/l	10
Total Phosphorus	mg/l	2
Oil and grease	mg/l	10
Total coliform bacteria	MPN ^b /100ml	400 ^a

Notes:

^a Not applicable to centralized, municipal, wastewater treatment systems which are included in EHS Guidelines for Water and Sanitation

^b MPN = Most Probable Number

EHS Guidelines for Petroleum Refining 2016

The IFC's General EHS Guidelines is meant to be complemented by the industry-specific effluent guidelines as presented in the Industry Sector EHS Guidelines.

Based on this document of EHS Guidelines for Petroleum Refining published in 2016, significant volumes of wastewaters in petroleum refining include "sour" process wastewater and non-oily/non-sour process wastewater. Process wastewater that is high in H₂S and/or NH₃ is treated in the Sour Water Stripper Unit (SWSU) to remove the contaminants before recycling for internal process uses, or before final treatment and disposal through an on-site wastewater treatment (WWTP) unit. Source segregation and pre-treatment of concentrated wastewater systems are techniques for treating industrial process wastewater in this sector. Typical wastewater treatment steps are:

- grease trap, oil skimmers, Coalescing Plate Separators (CPS), Dissolved Air Flotation (DAF) or oil water separators for separation of oils and floatable solids;
- filtration for separation of filterable solids;
- flow and load equalization;
- sedimentation for suspended solids reduction using clarifiers;
- biological treatment – typically aerobic treatment – for the reduction of soluble organic matter, measured as Biological Oxygen Demand (BOD);
- chemical or biological nutrient removal for reduction of nitrogen and phosphorus;
- chlorination of wastewater when disinfection is required; and
- dewatering and disposal of residuals in designated hazardous waste landfills.

Through the use of these technologies and good practices techniques for wastewater management, the facility should meet the guideline values for wastewater discharge as indicated in the *Table 4* below.

Table 4 : Wastewater discharge standards for Petroleum Refining Facilities ^a

Parameter	Unit	Guidelines Value
pH	pH	6-9
Total suspended solid (TSS)	mg/l	30
Temperature	°C	Temperature of wastewater prior to discharge does not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone ^b
BOD	mg/l	30 ^c
COD	mg/l	125 ^d
Total Nitrogen	mg/l	10 ^e
Total Phosphorus	mg/l	2
Oil and grease	mg/l	10
Phenols	mg/l	0.2
Sulphide	mg/l	0.2
Arsenic	mg/l	0.1
Chromium total	mg/l	0.5
Chromium (hexavalent)	mg/l	0.05
Copper	mg/l	0.5
Lead	mg/l	0.1
Mercury	mg/l	0.003 ^f
Nickel	mg/l	0.5
Iron	mg/l	3.0
Zinc	mg/l	N/A
Cyanide (total)	mg/l	1.0
Cyanide (free)	mg/l	0.1
Vanadium	mg/l	1.0
Benzene	mg/l	0.05 ^g
Benzo(a)pyrene	mg/l	0.05
Total Coliform	MPN/100ml	N/A

Notes:

^a Assumes an integrated petroleum refining facility

^b at the edge of a scientifically establish mixing zone, which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity. EC JRC, BREF (2015) Table 3.16

^c Guideline value from EC JRC, BREF (2015) Table 3:16; National legislations may have lower values such as China=20mg/L

^d Guideline value from EC JRC, BREF (2015); National legislations may have lower values such as China = 120mg/L

^e the effluent concentration of nitrogen (total) may be up to 40 mg/L in processes that include hydrogenation

^f EC JRC, BREF (2015) Table 3.16

^g Guideline value from EC JRC, BREF (2015)

EHS Guidelines for Large Volume Petroleum-based Organic Chemical Manufacturing 2007

The facility should consider adapting this document as one of its project applicable standard which have relevant limits/parameters such as cadmium that is not available in other project standards. Besides that, this Guidelines are applicable for facilities that produce aromatics as large volume petroleum-based organic chemicals (LVOC).

Process water within aromatics plant is generally operated in closed loops where the main wastewater sources are process water recovered from condensates of the steam jet vacuum pumps and overheated accumulators of some distillation towers.

Wastewater generates from the operations potentially contains small quantities of dissolved hydrocarbons, sulphide and COD (from caustic scrubbers). Other unintentional sources are from

spillages, purge of cooling water, rainwater, equipment wash-water, which may contain extraction solvents and aromatics and water generated by tank drainage and process upsets. Wastewater which contains hydrocarbons should be collected separately, settled and steam stripped prior to biological treatment in the facility's wastewater treatment systems.

Effluent guidelines, as shown in *Table 5* below are applicable for direct discharge of treated effluents to surface waters for general use.

Table 5 : Effluents Guidelines for Large Volume Petroleum-based Organic Chemical Manufacturing

Parameter	Unit	Guidelines Value
pH	S. U	6-9
Temperature increase	°C	=3
BOD ₅	mg/l	25
COD	mg/l	150
Total Nitrogen	mg/l	10
Total Phosphorous	mg/l	2
Sulphide	mg/l	1
Oil and grease	mg/l	10
Total Suspended Solids (TSS)	mg/l	30
Cadmium	mg/l	0.1
Chromium (total)	mg/l	0.5
Chromium (hexavalent)	mg/l	0.1
Copper	mg/l	0.5
Zinc	mg/l	2
Lead	mg/l	0.5
Nickel	mg/l	0.5
Mercury	mg/l	0.01
Phenol	mg/l	0.5
Benzene	mg/l	0.05
Vinyl Chloride (VCM)	mg/l	0.05
1,2 Dichloroethane (EDC)	mg/l	1
Absorbable Organic Halogens (AOX)	mg/l	1
Toxicity	-	Determined on a case specific basis

EHS Guidelines for Crude Oil and Petroleum Product Terminal 2007

This guidelines provide information pertaining land and shore-based petroleum storage terminals receiving and dispatching bulk shipments of crude oil, gasoline, middle distillates, aviation gas, lube oil, residual fuel oil, compressed natural gas (CNG), liquid petroleum gas (LPG) and specially products from pipelines, tankers, railcars, and trucks for subsequent commercial distribution.

Process wastewater generated from these activities are mainly from tank bottom draining and contaminated stormwater runoff, including water from tank leaks and spills that collects in hydrocarbon contaminated secondary containment areas.

There are no specific effluent guidelines value in this document. However, recommendations that are need to be considered by facility in terms of effluent monitoring guidelines are: -

- stormwater runoff should be treated through an oil/water separator system able to achieve oil and grease concentration of 10 mg/l; and

- quality of process effluent discharge should be established on a site-specific basis, taking into account the characteristics of the effluent of the receiving water use.

1.1.3 Comparison of National Standards, IFC's EHS Guideline, and other standards.

Table 2, Table 3, Table 4 and Table 5 list the varying standards of acceptable industrial or mixed effluent discharge to the public sewer or watercourse. When comparing those standards requirements, it can be ascertained that:

- National acceptable condition for industrial effluent or mixed effluent discharge is slightly stringent when compared to the IFC's EHS Guidelines.
- For example, the acceptable condition for BOD in a watercourse by national standard is 20 mg/l whereas the IFC's Guidelines stands at 30 mg/l. The same can be observed for COD limit where national standard is 80 mg/l and IFC's Guidelines is 125 mg/l.
- However, there are certain parameters in the IFC's Guidelines which the acceptable condition for discharge more rigid than the national standards. For example, total suspended solids limit in IFC's Guidelines is 30 mg/l compared to 50 mg/l in the national standard. The same can be noticed for other pollutants such as sulphide, chromium (total), mercury, cyanide (total) and benzene.
- In addition, the limits/parameter value for other pollutants such as cadmium, vinyl chloride (VCM), absorbable organic halogens (AOX), EDC and toxicity are addressed in the EHS Guidelines for Large Volume Petroleum-based Organic Chemical Manufacturing.
- Under the national regulations, industries are required to adopt the "Best Management Practice" for discharge of any industrial effluent or mixed effluent for parameters such as sulphates and vanadium. "Best Management Practice" allows practical, structural or non-structural methods for the purpose of preventing or reducing the discharge of industrial or mixed effluent containing contaminants.

A comparison of Malaysia's national standard and IFC's EHS Guideline Standards requirements for liquid effluents is presented in Table 6 below.

Table 6 : Comparison of National Standard, IFC's EHS Guidelines, and other standard for Liquid Effluent Discharge

Parameter	Unit	National Standard (Standard A)	IFC EHS Guidelines			Suggested Project Design Standard*
			General Guidelines	Petroleum Refining 2016 Guidelines	Large Volume Petroleum-based Organic Chemical Manufacturing 2007	
pH	pH	6-9	6-9	6-9	6-9	6-9
Total suspended solid (TSS)	mg/l	50	50	30	30	30
Temperature	°C	40	Temperature of wastewater prior to discharge does not	Temperature of wastewater prior to discharge does not	Temperature of wastewater prior to discharge does not result in an increase = 3°C	40

Parameter	Unit	National Standard (Standard A)	IFC EHS Guidelines			Suggested Project Design Standard*
			General Guidelines	Petroleum Refining 2016 Guidelines	Large Volume Petroleum-based Organic Chemical Manufacturing 2007	
			result in an increase >3°C of ambient temperature at the edge of a scientifically established mixing zone	result in an increase >3°C of ambient temperature at the edge of a scientifically established mixing zone	of ambient temperature at the edge of a scientifically established mixing zone	
BOD ₅	mg/l	20	30	30	25	20
COD	mg/l	80 (industrial effluent) 80 (mixed effluent)	125	125	150	80
Total Nitrogen	mg/l	N/A	10	10	10	10
Total Phosphorus	mg/l	N/A	2.0	2.0	2.0	2.0
Oil and grease	mg/l	1.0	10	10	10	1.0
Phenols	mg/l	0.001	N/A	0.2	0.5	0.001
Sulphide	mg/l	0.50	N/A	0.2	1.0	0.2
Sulphates	mg/l	Adopt "Best Management Practice"	N/A	N/A	N/A	National standard
Arsenic	mg/l	0.05	N/A	0.1	N/A	0.05
Chromium total	mg/l	N/A	N/A	0.5	0.5	0.5
Chromium (hexavalent)	mg/l	0.05	N/A	0.05	0.1	0.05
Copper	mg/l	0.20	N/A	0.5	0.5	0.2
Lead	mg/l	0.10	N/A	0.1	0.5	0.1
Mercury	mg/l	0.005	N/A	0.003	0.01	0.003
Nickel	mg/l	0.20	N/A	0.5	0.5	0.2
Iron	mg/l	1.0	N/A	3.0	N/A	1.0
Zinc	mg/l	2.0	N/A	N/A	2.0	2.0
Cyanide (total)	mg/l	N/A	N/A	1.0	N/A	1.0
Cyanide (free)	mg/l	0.05	N/A	0.1	N/A	0.05
Vanadium	mg/l	Adopt "Best Management Practice"	N/A	1.0	N/A	1.0
Benzene	mg/l	N/A	N/A	0.05	0.05	0.05
Benzo(a)pyrene	mg/l	N/A	N/A	0.05	N/A	0.05
Total Coliform	MPN/100ml	N/A	400	N/A	N/A	400
Cadmium	mg/l	N/A	N/A	N/A	0.1	0.1
Vinyl Chloride (VCM)	mg/l	N/A	N/A	N/A	0.05	0.05

Parameter	Unit	National Standard (Standard A)	IFC EHS Guidelines			Suggested Project Design Standard*
			General Guidelines	Petroleum Refining 2016 Guidelines	Large Volume Petroleum-based Organic Chemical Manufacturing 2007	
Absorbable Organic Halogens (AOX)	mg/l	N/A	N/A	N/A	1.0	1.0
1,2 Dichloroethane (EDC)	mg/l	N/A	N/A	N/A	1.0	1.0
Toxicity	-	N/A	N/A	N/A	Determined on a case specific basis	LVOC Standard

Note: *suggestion is based on the most stringent value between all applicable standards and guidelines

2 AMBIENT AIR QUALITY STANDARDS

2.1 National Standards (Malaysia Guidelines)

The ambient air quality measurement in Malaysia is described in terms of Air Pollution Index (API). The API is developed in easily understood ranges of values as a means of reporting the quality of air instead of using the actual concentration of air pollutants. The index also reflects its effect on human health ranging from good to hazardous and also can be categorized according to the action criteria as stipulated in the National Haze Action Plan. The Malaysian API system adapts the Pollutant Standard Index (PSI) developed by the United States Environmental Protection Agency (US-EPA).

The older Malaysia's Ambient Air Quality Guideline that established in 1989 has been replaced with the New Ambient Air Quality Standard. Based on this new standard, there are six types of air pollutants criteria which are:

- particulate matter with the size of less than 10 micron (PM₁₀);
- sulphur dioxide (SO₂);
- carbon monoxide (CO);
- nitrogen dioxide (NO₂);
- ground level ozone (O₃); and
- particulate matter with size less than 2.5 micron (PM_{2.5})

The air pollutants concentration limit will be strengthened in stages until full implementation of the standard by year 2020. There are three interim targets set which include interim target 1 (IT-1) in year 2015, interim target 2 (IT-2) in year 2018 and standard implementation in year 2020. The standard limit of ambient air quality is presented in *Table 7* below.

Table 7: New Malaysia Ambient Air Quality Standard

Pollutants	Averaging Time	Ambient Air Quality Standard		
		IT-1 (2015)	IT-2 (2018)	Standard (2020)
		µg/m ³	µg/m ³	µg/m ³
Sulphur Dioxide (SO ₂)	1 year	350	300	250
	24 hours	105	90	80
	1 year	320	300	280

Pollutants	Averaging Time	Ambient Air Quality Standard		
		IT-1 (2015)	IT-2 (2018)	Standard (2020)
		$\mu\text{g}/\text{m}^3$	$\mu\text{g}/\text{m}^3$	$\mu\text{g}/\text{m}^3$
Nitrogen Dioxide (NO ₂)	24 hours	75	75	70
Carbon Monoxide (CO) (mg/m^3)	1 year	35	35	30
	24 hours	10	10	10
PM ₁₀	1 year	50	45	40
	24 hours	150	120	100
PM _{2.5}	1 year	35	25	15
	24 hours	75	50	35

2.2 International Standards

IFC's General EHS Guidelines: Environmental - Air Emissions and Ambient Air Quality

According to the IFC's General EHS Guidelines on Environment, projects that have significant sources of air emissions, and potential significant impacts to the ambient air quality should prevent or minimize the impact by taking into accounts the following:

- Emission do not exceed the pollutant concentrations of ambient air quality guidelines and standards¹ by applying national legislated standards, or the current World Health Organization (WHO)'s Air Quality Guidelines or other internationally recognized sources such as US EPA or European Council Directives.
- Emission do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards. As general rule, this Guidelines suggested that 25% of the applicable air quality standards to allow additional, future sustainable development in the same airshed.

This means that, impacts should be estimated through quantitative or qualitative assessments by the use of baseline air quality assessments and atmospheric dispersion models to assess potential ground level concentrations. Usage of dispersion model should be internationally recognized, or comparable.

Based on the IFC's EHS Guidelines for Petroleum Refinery 2016, in addition to improve the management of fugitive emissions from the entire petroleum refinery and to protect human health in affected communities, fence line monitoring of benzene concentration should be conducted according to internationally recognized methodologies. The annual average benzene concentrations associated with refinery emissions shall not exceed the guideline given as reference to *Table 8* below. Corrective actions should be taken to reduce the benzene emissions from refinery.

Table 8 : Fence Line Monitoring Action Level

Pollutant	Guideline Value
Benzene	9 $\mu\text{g}/\text{m}^3$ ^a
<i>a. Annual average concentration that is corrected for background contribution. Guideline value from US EPA 40CFR63 Subpart CC – National Emission Standards for Hazardous Air Pollutants from Petroleum Refineries (2015)</i>	

World Health Organization (WHO) Ambient Air Quality Guidelines

¹ Ambient air quality standards are ambient air quality levels established and published through national legislative and regulatory processes, while the ambient quality guidelines refer to ambient quality levels primarily developed through clinical, toxicological and epidemiological evidence (such as those published by the WHO).

The WHO air quality guidelines (AQGs) are intended for worldwide use but have been developed to support actions to achieve air quality that protects public health in different contexts. On the other hand, air quality standard is set by each country to protect the public health of their nationals and are important component to the national risk management and environmental policies.

National standards are often varying as it is being set according to the approach adopted for balancing health risks, technological feasibility, economic considerations and various other political and social factors.

The WHO AQGs are based on the following key findings that emerged in recent years:

- the evidence for ozone (O₃) and particulate matter (PM) indicates that there are risks to health at concentrations currently found in many cities in developed countries;
- increasing range of adverse health effects has been linked to air pollution, and at ever-lower concentrations which is especially true for airborne particulate matter; and
- limitation of controlling air pollution through guidelines for single pollutants have become increasingly apparent. For example, Nitrogen dioxide (NO₂) is a product of combustion processes and generally found in the atmosphere in close association with other primary pollutants. It is itself toxic and is also precursor of ozone, with which it coexists along with a number of other photochemically generated oxidants. Achieving guideline concentrations for individual pollutants such as NO₂ may bring public health benefits.

The WHO Ambient Air Quality Guidelines is presented in *Table 9* below.

Table 9 : WHO Ambient Air Quality Guidelines

Pollutants	Averaging Period	Guideline Value in µg/m ³	
		Interim ^a	Guideline ^b
Sulphur Dioxide (SO ₂)	10 minutes	N/A	500
	24 hours	125 (target 1) 50 (target 2)	20
Nitrogen Dioxide (NO ₂)	1 hour	N/A	200
	1 year	N/A	40
Ozone	8-hour daily maximum	160 (target 1)	100
PM ₁₀	1 year	70 (target 1) 50 (target 2) 30 (target 3)	20
	24 hours	150 (target 1) 100 (target 2) 75 (target 3)	50
PM _{2.5}	1 year	35 (target 1) 25 (target 2) 15 (target 3)	10
	24 hours	75 (target 1) 50 (target 2) 37.5 (target 3)	25

Notes:

^a Interim are proposed as incremental steps in a progressive reduction of air pollution and are intended to use in areas where pollution is high. These targets aim to promote a shift from high air pollutants concentrations, which have acute and serious health consequences, to lower air pollutants concentrations.

^b Progress towards the guideline values should, however be the ultimate objective of air quality management and health risk reduction in all areas

Adopted Project Standards

In addition to the other standards requirements mentioned above, the project proponent may also compare and use the standard requirements of other adopted (e.g. Bahrain, UK, and etc) that have been implemented during the operation period. The ambient air quality standards from adopted projects are presented in *Table 10* below.

Table 10 : Ambient Air Quality Standard from Adopted Projects

Pollutants	Average Period	Bahrain ($\mu\text{g}/\text{m}^3$)	UK/EU ($\mu\text{g}/\text{m}^3$)	WHO ($\mu\text{g}/\text{m}^3$)
SO ₂	10 minutes	N/A	N/A	500
	Hourly	350 ^a	350 ^b	N/A
	Daily	125	125 ^c	20 ^d
	Annual	50	N/A	N/A
NO ₂	Hourly	200	200 ^e	200
	Daily	150	N/A	N/A
	Annual	40	40	40
CO	8-hourly	10 000	10 000	N/A
	Daily	N/A	N/A	N/A
	Annual	N/A	N/A	N/A
PM ₁₀	Hourly	N/A	N/A	N/A
	Daily	340	50 ^f	50
	Annual	N/A	40	20

Notes:

^a Not to be exceeded more than twice in any 30-day period at a given location

^b Not to be exceeded more than 24 times a year

^c Not to be exceeded more than 3 times a year

^d WHO also proposed interim targets of 125 $\mu\text{g}/\text{ml}$ which is equal to the former WHO guidelines (WHO, 2000), and 50 $\mu\text{g}/\text{ml}$, which is viewed as a feasible and achievable goal that would lead to significant health improvements

^e Not to be exceeded more than 18 times a year

^f Not to be exceeded more than 35 times a year

2.3 Monitoring Requirements

Air quality in Malaysia is monitored continuously and manually to detect any changes in the ambient air quality status that may pose risk to human health and the environment. Department of Environment (DoE) is an agency that responsible to monitor the country's ambient air quality through a network of 51 stations nationwide. The location of these monitoring stations is strategically located in residential area (57%), traffic (2%), and industrial area (26%). Other than that, there are 2% of background monitoring and 13% of PM₁₀ stations.

The monitoring locations of Continuous Air Quality Monitoring (CAQM) are chosen based on the following criteria:

- results of past and current monitoring;
- representatives;
- accessibility;
- availability of support services (power, telephone line, etc);
- security; and
- effects of any specific topography

Other than national monitoring requirements, the IFC's EHS Guidelines stated the following requirements for ambient air monitoring:

Table 11 : Monitoring Requirement in IFC's ESH Guidelines

Situation	Requirements
If incremental impacts predicted by environmental assessment are ≥ 25 % of relevant short-term ambient air quality standards or if the plant $\geq 1,200$ MWth	Monitor parameters (e.g. PM ₁₀ / PM _{2.5} / SO ₂ / NO _x to be consistent with the relevant ambient air quality standards) by continuous ambient air quality monitoring system (typically a minimum of two systems to cover predicted maximum ground level concentration point / sensitive receptor / background point)
If incremental impacts predicted by environmental assessment are < 25 % of relevant short-term ambient air quality standards and if the facility $< 1,200$ MWth but ≥ 100 MWth:	Monitor parameters either by passive samplers (monthly average) or by seasonal manual sampling (e.g., one week/ season) for parameters consistent with the relevant air quality standards.

The project proponent shall review the effectiveness of the ambient air quality monitoring regularly. It could be simplified or reduced if alternative program is developed (e.g. local government's monitoring network). Continuation of the program is recommended during the life of the project if there are sensitive receptors or if monitored levels are not far below the relevant ambient air quality standards.

2.4 Comparison of National Standards and IFC'S EHS Guidelines

A comparison of Malaysia and International Guidelines and Standard for ambient air quality is summarized in *Table 12* below.

Table 12 : Comparison Table of Ambient Air Quality Standards and Guidelines

Parameter	Time Weighted Average	Units (unless stated otherwise)	Emissions				Suggested Project Design Standard*
			National Standard	IFC EHS General Guidelines	WHO	Adopted Project standards	
SO ₂	10-minutes	µg/m ³	N/A	Local AQ standards apply where set, i.e. SCE AQ standards	500 (guideline)	N/A	500 (guideline)
	Hourly	µg/m ³	250		N/A	350	250
	Daily	µg/m ³	80		20 (guideline) 125 (interim target 1)	125	20 (guideline)
	Annual	µg/m ³	N/A		N/A	50	50
NO ₂	Hourly	µg/m ³	280		200	200	200
	Daily	µg/m ³	70		N/A	150	70
	Annual	µg/m ³	N/A		40	40	40
CO	8-hourly	µg/m ³	10		N/A	10,000	10
PM ₁₀	Daily	µg/m ³	100		50 (guideline) 150 (interim target 1)	340	50 (guideline)
	Annual	µg/m ³	40		20 (guideline) 70 (interim target 1)	N/A	20 (guideline)
PM _{2.5}	Daily	µg/m ³	35	25 (guideline) 75 (interim target 1)	N/A	25 (guideline)	
	Annual	µg/m ³	15	10 (guideline) 35 (interim target 1)	N/A	10 (guideline)	

Parameter	Time Weighted Average	Units (unless stated otherwise)	Emissions				Suggested Project Design Standard*
			National Standard	IFC EHS General Guidelines	WHO	Adopted Project standards	
Ozone	8-hourly	µg/m ³	100		100 (guideline) 160 (interim target 1)	N/A	100
Benzene	Annual	µg/m ³	N/A	9 (Fence line - Refinery sector guideline)		9 (fence line)	9 (fence line - Refinery Sector Guideline)

3 AIR EMISSION SOURCES AND INVENTORY

According to the Interpretation of Clean Air Regulations 2014, “fuel burning equipment” refers to any furnace, boiler, fire place, oven, retort, internal combustion engine, vessel or any other apparatus, device, mechanism, stack, chimney or structure used in connection with the burning of any combustible materials.

Under the First Schedule of Regulation 6 and 13, oil and gas industries in all sizes, which includes refineries is subjected to “Best Available Techniques Economically Achievable (BAT)”. The guidance document related to this project operation can be referred to guidance document published by the Malaysian Department of Environment (DoE) *BEST AVAILABLE TECHNIQUES GUIDANCE DOCUMENT ON OIL AND GAS INDUSTRY*.

Based on operation of this project, there are two types of air emission points that potentially release air pollutants into the atmosphere which are explained in *Table 13* below:

Table 13: Types of Air Emission Points

EMISSION POINT	DESCRIPTION
Continuous Emission Point	
Flare System	<ul style="list-style-type: none"> Elevated flare system is installed to enable emergency flaring of raw materials No flaring under normal operations but a small pilot flame to ensure combustion of any purge gas and prevent any hazardous gases Example of equipment: LPG Merox Unit disulphide separator, naphtha hydrotreating unit stripper receiver and sulfolane unit
Process equipment stacks	<ul style="list-style-type: none"> Natural gas will be used as fuel for all equipment to minimise emissions Emission from reboilers, heaters and other equipment
Non-continuous Emission Point	
Emergency flaring	<ul style="list-style-type: none"> refer Flare system
Vent gases from regeneration of catalyst	<ul style="list-style-type: none"> vent gases from isomar and tatoray units every two to three years vent out non-controlled gases N₂, CO₂, and H₂O for seven days at a time
Diesel generator	<ul style="list-style-type: none"> Use for emergency in power outage
Fugitive emissions	<ul style="list-style-type: none"> Emission from tanks, pumps, and flanges tanks, tank filling and/or accidental release from filling of

EMISSION POINT	DESCRIPTION
	<p>the tanks and from refining processes if the safety and leak control fail</p> <ul style="list-style-type: none"> Fugitive emissions will be minimized by the use of valves, flanges, and other such equipment

The air emission inventory for this process is as follows:

- three (3) steam boilers
- one (1) flare stack
- ten (10) charge heaters, re-boilers stacks and SRU thermal oxidiser
- two (2) vent gases from process areas
- tankage and fugitives

3.1 Emission from Combustion Process

These sources of potential air emissions shall be monitored continuously or periodically according to the National Standards and adapted International Guidelines i.e. IFC EHS Guidelines. Applicable sources for this Section are:

- flare stack
- diesel emergency generator
- distillate union fining unit

The limit values of emission are different according to the type of pollutants release from each sources of emission as summarized in *Table 14* below.

Table 14 : Emission from Power Generation

Source	Main Air Emission	Applicable Limit Values/Standard
Flare – Combustion	CO ₂ , N ₂ (Continuous emission of purge gas)	Combustion turbines
Flare Stack – Combustion	NO _x , VOC, CO, SO ₂ (Emergency flaring)	Combustion turbines
Diesel emergency generator	NO _x , CO, CO ₂ , SO _x , PM	Generator sets for combined heat and power generation with total thermal output ≥ 3MW _e
Distillate Union fining Unit: Ejector receiver	Vent gas: N ₂ , O ₂ , H ₂ S, C ₁ -C ₄ , NC ₆ , naphtha, diesel	Combustion turbines

3.1.1 National Standards

Emission standards for Malaysia are set by the Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) under the authority of the Department of Environment (DoE). Emission standards for industrial processes, including power generation, are covered in the Environmental Quality (Clean Air) Regulations 2014. The following emission standards apply to power generation boilers and combustion turbines which fuel type includes natural gas, solid and diesel or liquid fuels.

According to the Environmental Quality (EQ) the emission limits from combustion processes of the power generation, turbines the limit value for solid and liquid fuels for Sulphur Dioxide (SO₂), Nitrogen Monoxide (NO) with the thermal capacity larger than 10MWe is 150mg/m³ and 100mg/m³ and for Carbon Monoxide (CO) respectively. For the liquid fuel type with the thermal

capacity larger than 10MWe, the limit for NO and CO is 200 mg/m³ and 100 mg/m³ respectively. Continuous monitoring is required for both types of fuel for all parameters.

The O₂ reference content is 15%. Refer *Table 15* below for Heat and Power Generation for Combustion Turbines.

Table 15 : Combustion Turbines Limit Values

Fuel Type	Pollutant	Capacity at ISO conditions	Limit value			Monitoring
			mg/m ³	*mg/Nm ³	ppm	
Gaseous fuels	Sum of NO and NO ₂ expressed as NO ₂	> 10 MWe	150	150	73.04	continuous
	Carbon monoxide (CO)	> 10 MWe	100	100	80	continuous
Liquid fuels	Sum of NO and NO ₂ expressed as NO ₂	> 10 MWe	200	200	97.39	continuous
	Carbon monoxide (CO)	> 10 MWe	100	100	80	continuous

Note *conversion from unit mg/m³ in National Standard to unit mg/Nm³ as in IFC's EHS Guidelines is based on standard calculation used in the Guidelines which indicated that Nm³ is at one atmosphere pressure (1013hPa), 0 °C.

Source: Third Schedule (Regulation 15) of Clean Air Regulations 2014

3.1.2 IFC'S EHS Guidelines

General EHS Guidelines

Guideline values for process emissions (such as FCCU, SRU and combustion units) and effluents in Petroleum Refining sector are indicative of good international industry practice, as reflected in relevant standards of countries with recognized regulatory frameworks.

Combustion source emissions guidelines associated with steam-and power-generation activities from sources with a capacity **equal to or lower than 50 Megawatt thermal (MWth)** are addressed in the General EHS Guidelines on Air Emissions and Ambient Air Quality.

Meanwhile, the large power source emissions from turbines, boilers and engines are elaborated in the EHS Guidelines for Thermal Power Plants 2008.

Small combustion processes are systems designed to deliver electrical or mechanical power, steam, heat, or any combination of these regardless of the fuel type, with a total, rated heat input capacity of between 3 MWth and 50 MWth. Emission guidelines tabulated below (*Table 16*) are applicable to small combustion process installations which operating more than 500 hours per year, with annual capacity utilization of more than 30 percent. Plants firing a mixture of fuels shall compare emission performance with these guidelines based on the sum of the relative contribution of each applied fuel².

Table 16 : Small Combustion Facilities Emissions Guidelines (3MWth-50MWth) – (in mg/Nm³ or as indicated)

Combustion Technology/Fuel	Particulate Matter (PM)	Sulfur Dioxide (SO ₂)	Nitrogen Dioxide (NO _x)	Dry gas, excess O ₂ Content (%)
<i>Engine</i>				

² The contribution of a fuel is the percentage of heat input (LHV) provided by this fuel multiplied by its limit value.

Combustion Technology/Fuel	Particulate Matter (PM)	Sulfur Dioxide (SO ₂)	Nitrogen Dioxide (NO _x)	Dry gas, excess O ₂ Content (%)
Gas	N/A	N/A	200 (spark ignition) 400 (Dual fuel) 1,600 (compression ignition)	15
Liquid	50 or up to 100 if justified by project specific considerations (e.g economic feasibility of using lower ash content fuel, or adding secondary treatment to meet 50, and available environmental capacity of the site)	1.5 percent Sulfur or up to 3.0 percent Sulfur if justified by project specific considerations (e.g economic feasibility of using lower S content fuel, or adding secondary treatment to meet levels of using 1.5 percent Sulfur, and available environmental capacity of the site)	If bore size diameter (mm) <400:1460 (or up to 1,600 if justified to maintain high energy efficiency) If bore size diameter (mm) > or = 400:1,850	15
Turbine				
Natural gas =3MWth to <15MWth	N/A	N/A	42 ppm (electric generation) 100 ppm (mechanical drive)	15
Natural gas =15MWth to <50MWth	N/A	N/A	25 ppm	15
Fuels other than natural gas =3MWth to <15MWth	N/A	0.5 percent Sulfur (e.g 0.2 percent Sulfur) if commercially available without significant excess fuel cost	96 ppm (electric generation) 150 ppm (mechanical drive)	15
Fuels other than natural gas =15MWth to <50MWth	N/A	0.5% S or lower %S (0.2%S) if commercially available without significant excess fuel cost	74 ppm	15
Boiler				
Gas	N/A	N/A	320	3
Liquid	50 or up to 150 if justified by environmental assessment	2000	460	3
Solid	50 or up to 150 if justified by environmental assessment	2000	650	6

Notes:

N/A-no emissions guidelines. Higher performance levels than these in the table should be applicable to facilities located in urban/ industrial areas with degraded airsheds or close to ecologically sensitive areas when more stringent emissions controls may be needed. MWth is heat input on HHV basis. Solid fuels include biomass. Nm³ is at one atmosphere pressure 0 °C. MWth category is to apply to the entire facility consisting of multiple units that are reasonably considered to be emitted from a common stack except

for NOx and PM limits for turbines and boilers. Guidelines values apply to facilities operating more than 500 hours per year with an annual capacity utilization factor of more than 30 percent.

According to the guidelines limit for small combustion facilities emission guidelines there is no emissions guidelines for particulate matter (PM) and for natural gas fuel type for Sulphur Dioxide (SO₂) parameter.

The limit value for the emissions from the combustion of turbines for SO₂ for the thermal input ranges between 3-15MWth and not larger than 50MWth is 0.5 percent (%) Sulphur (S) of lower percent Sulphur for fuels type other than natural gas. The limit emission value of Nitrogen Oxides (NOx) from natural gas fuel type for the thermal input ranges of 3-15 MWth is 42 ppm for electrical generation and 100 ppm or mechanical drive. While, for thermal input ranges between 15 MWth to no larger than 50 MWth, the emission for NOx is 25ppm. Any emission from the fuels other than natural gas, in the range between 3 to 15 MWth, the emissions limit is 96 ppm for electrical generation and 150 ppm for mechanical drive and 74 ppm for thermal input between 15 MWth and not larger than 50 MWth.

EHS Guidelines for Thermal Power Plant (2008)

These guidelines are a document relevant to combustion processes fuelled by gaseous, liquid and solid fossil fuels and biomass and designed to deliver electrical or mechanical power, steam, heat, or any combination of these, regardless of the fuel type with a total rated heat input **capacity above 50-Megawatt thermal input (MWth)**. It applies to boilers, reciprocating engines, and combustion turbines in new and existing facilities. Combustion turbines' guidelines limit is discussed as per *Table 17* below and the other sources of emission will be elaborated in the next *Section*.

Table 17: Emissions Guidelines (in mg/Nm³ or as indicated) for Combustion Turbine

Combustion Technology/Fuel	Particulate Matter (PM)		Sulfur Dioxide (SO ₂)		Nitrogen Dioxide (NOx)	Dry gas, excess O ₂ content (%)
	NDA	DA	NDA	DA		
Combustion turbine					NDA/DA	
Natural gas (all turbine types of unit >500 MWth)	N/A	N/A	N/A	N/A	51 (25 ppm)	15%
Fuels other than Natural Gas (Unit >> 500 MWth)	50	30	Use of 1% or less S fuel	Use of 0.5% or less S fuel	152 (74 ppm) ^a	15%

Notes:

- MWth = Megawatt thermal input on HHV basis; N/A = not applicable; NDA = non-degraded airshed; DA = degraded airshed (poor air quality); Airshed should be considered as being degraded if nationally legislated air quality standards are exceeded, or in their absence, if WHO Air Quality Guidelines are exceeded significantly; S= sulfur content (expressed as a % by mass); Nm³ is at one atmospheric pressure, 0 degree Celsius; MWth category is to apply to single units; Guideline limits apply to facilities operating more than 500 hours per year. Emission levels should be evaluated on a one-hour average basis and be achieved 95% of annual operating hours.
- If supplemental firing is used in a combined cycle gas turbine mode, the relevant guideline limits for combustion turbines should be achieved including emissions from those supplemental firing units (e.g duct burners).
- ^a Technological difference (for example the use of Aeroderivative) may require different emissions values which should be evaluated on cases-by-case basis through the EA process but which should not exceed 200 mg/Nm³.

Source: EU (LCP Directive 2001/80/EC October 23 2001), EU (Liquid Fuel Quality Directive 1999/32/EC, 2005/33/EC), US (NSPS for Stationary Combustion Turbines, Final Rule – July 6, 2006).

The guidelines limit presented above is applicable for new facilities. During the environmental assessment, justification on more stringent or less stringent limits should be provided. Ambient environment, technical and economic should be taken into considerations where it should be

compliance with applicable ambient air quality standards and incremental impacts are minimized.

3.1.3 Comparison of National Standards and IFC'S EHS Guidelines

The pollutant parameter for emissions combustion from natural gas fuel type which is Nitrogen Oxides (NO_x), Carbon Monoxide (CO), Particulate matter (PM) and Hydrogen Sulfide (H₂S). Emissions limit for NO_x for thermal input ranging between 3-15 MWth, 15-50 MWth and larger than 50 MWth is 150 mg/m³ respectively as in the national standard quoted that any capacity larger than 10 MWe, the emission limit is 150 mg/m³. Whereas, based on IFC EHS Guidelines quoted that the emission limit for NO_x for thermal input ranging between 3-15 MWth is 42ppm for electrical generation and 100ppm for mechanical drive. For the input ranging from 15 to 50 MWth the emissions limit is 25 ppm. While for input larger than 50 MWth the emission limit is 51mg/ Nm³. As per national standard the limit for CO is 100 mg/m³ for all ranges of thermal input and no limit is set for CO in IFC EHS Guidelines.

No emissions guidelines quoted for PM and H₂S content in fuel for both in the national standard and in the IFC guidelines.

The pollutant that put as parameters for emissions limit for the combustion from diesel or liquid fuels type is SO₂, NO_x, CO, PM and unburnt HC. The emission limit for Unburnt hydrocarbon is not set in both national standard and IFC EHS guidelines. No emissions limit is set as in national standard for SO₂ and PM. IFC EHS Guidelines stated the emissions limit for SO₂ is the use of 0.5 % or less Sulphur(S) fuel for both thermal input ranging between 3 to 50 MWth and thermal input ranges larger than 50 MWth. Emission limit for NO₂ according to IFC EHS Guidelines is 96 ppm for electrical generation and 150 ppm for mechanical drive for the thermal input ranging from 3 to 15 MWth, 74 ppm for 15 to 50 MWth and 152 mg/ Nm³ for thermal input larger than 50 MWth respectively. The emission limit for NO₂ 200 mg/m³ for all ranges as quoted in national standard the emissions limit for any capacity larger than 10 MWe is 200mg/m³. Limit value for CO is 100 mg/m³ for all thermal input ranges. No emissions limit as in IFC EHS guidelines for CO. For particulate matter, the emissions limit for both thermal input ranges for 3 to 15 MWTH and 15 to 50 MWth is 50-100 (without specific unit mentioned). While, 30 mg/Nm³ is the emissions limit for the PM that the thermal input is larger than 50 MWth as quoted in IFC EHS guidelines.

The comparison between the National Standard and the IFC EHS Guidelines for power generation, combustion turbines is presented in

Table 18 below:

Table 18 : Comparison of National Standards, IFC's EHS General Guidelines 2007 and IFC's EHS Thermal Power Plant 2008 for Combustion Turbines

Parameter	Thermal input (MWth)	Units (unless stated otherwise)	Emissions				Suggested Project Design Standard*
			National Standard	EHS General Guidelines 2007	EHS Thermal Power 2008	Monitoring requirements	
Natural gas							
NO _x	3 - 15 MWth	mg/m ³	150 (73.04ppm)	42 ppm (electrical generation) 100 ppm (mechanical drive)	-		42 ppm (electrical generation) 100 ppm (mechanical drive)
	15 - 50 MWth	mg/m ³	150 (73.04ppm)	25 ppm	-		25 ppm
	>50 MWth	mg/m ³	150 (73.04ppm)		51 mg/Nm ³ (25ppm)	Continuous or indicative emission monitoring; Annual stack emission testing	51 mg/Nm³ (25ppm)
CO	All	mg/m ³	100 (80ppm)	N/A	N/A		100 mg/m³ (80ppm)
Particulate matter (PM)	>3 MWth	mg/m ³	N/A	N/A	N/A		
H ₂ S (content in fuel)	All	ppm	N/A	N/A	N/A		
Diesel/ Liquid Fuels							
SO ₂	3 - 50 MWth	mg/m ³	N/A	Use of 0.5% or less S fuel			
	>50 MWth	mg/m ³	N/A		Use of 1% or less S fuel (NDA) Use of 0.5% or less S fuel (DA)	Continuous emissions monitoring if FGD is used or monitor by S content; Annual stack emission testing	
NO _x	3 - 15 MWth	mg/m ³	200 (97.39ppm)	96 ppm (electrical generation) 150 ppm (mechanical drive)			96 ppm (electrical generation) 150 ppm (mechanical drive)
	15 - 50 MWth	mg/m ³	200 (97.39ppm)	74 ppm			74 ppm
	>50 MWth	mg/m ³	200 (97.39ppm)		152 mg/Nm ³ (74 ppm)	Continuous or indicative emission	152 mg/Nm³ (74 ppm)

Parameter	Thermal input (MWth)	Units (unless stated otherwise)	Emissions				Suggested Project Design Standard*
			National Standard	EHS General Guidelines 2007	EHS Thermal Power 2008	Monitoring requirements	
						monitoring; Annual stack emission testing	
CO	All	mg/Nm ³	100 (80ppm)				100 (80ppm)
PM	3 - 15 MWth	mg/Nm ³	N/A	N/A			
	15 - 50 MWth	mg/Nm ³	N/A				
	>50 MWth	mg/Nm ³	N/A		50 mg/Nm ³ (NDA) 30 mg/Nm ³ (DA)	Continuous or indicative emission monitoring; Annual stack emission testing	50 mg/Nm³ (NDA) 30 mg/Nm³ (DA)
Unburnt HC		ppm	N/A				

Note: NDA – non-degraded airshed; DA – degraded airshed; *suggestion is based on the most stringent value between all applicable standards and guidelines

Monitoring requirements

A continuous or indicative NOx emissions monitoring and annual stack emission is required for thermal input that larger than 50 MWth for natural gas fuel type of combustion. No emission monitoring guidelines stated for CO and H₂S. Meanwhile, for the PM monitoring quoted for the thermal input that larger than 50 MWth as in the guidelines.

A continuous or indicative emissions monitoring and annual stack emission for parameters such SO₂, NOx and PM are required for thermal input that larger than 50 MWth for fuels type other than natural gas combustions. No emissions monitoring guidelines stated for CO and Unburnt HC.

3.2 Emission from Boiler and Furnaces

These sources of potential air emissions shall be monitored continuously or periodically according to the National Standards and adapted International Guidelines i.e. IFC EHS Guidelines. The limit values of emission are different according to the type of pollutants release from each sources of emission. Applicable sources for this Section are:

- i. heater
- ii. boiler and reboiler
- iii. furnaces
- iv. vent

Table 19 : Emission from Boiler and Furnaces

Source	Main Air Emission	Applicable Limit Values/Standards
Charge Heater – Unit 320-H1	Flue gas: O ₂ , N ₂ , H ₂ O, CO ₂ , SO ₂ , NO _x	Furnaces
Xylene Splitter Reboiler	Flue gas:	Boilers

Source	Main Air Emission	Applicable Limit Values/Standards
	O ₂ , N ₂ , H ₂ O, CO ₂ , SO ₂ , NO _x	
Charge Heater Toluene Column	Flue gas: O ₂ , N ₂ , H ₂ O, CO ₂ , SO ₂ , NO _x	Furnaces
Charge Heater – Unit 200-H1 (NHT)	Flue gas: O ₂ , N ₂ , H ₂ O, CO ₂ , SO ₂ , NO _x	Furnaces
Charge Heater & NO1 Interheater – CCR Unit 300-H1	Flue gas: O ₂ , N ₂ , H ₂ O, CO ₂ , SO ₂ , NO _x	Furnaces
Charge Heater & NO1 Interheater	Flue gas: O ₂ , N ₂ , H ₂ O, CO ₂ , SO ₂ , NO _x	Furnaces
CCR RCR Vent – Unit 312-ME8	Flue gas: O ₂ , N ₂ , H ₂ O, CO ₂ , SO ₂ , NO _x	Furnaces
Feed Fractionator Reboiler – 100-H1 and H2 (combined)	Flue gas: O ₂ , N ₂ , H ₂ O, CO ₂ , SO ₂ , NO _x	Boilers
Combined Feed Heater DHT	Flue gas: O ₂ , N ₂ , H ₂ O, CO ₂ , SO ₂ , NO _x	Furnaces
KHT Furnaces – Units 120-H1 and H2	Flue gas: O ₂ , N ₂ , H ₂ O, CO ₂ , SO ₂ , NO _x	Furnaces
CRP Vent – Unit 230-ME1	Flue gas: O ₂ , N ₂ , H ₂ O, CO ₂ , SO ₂ , NO _x	Furnaces
3 X Steam Boiler	Flue gas: O ₂ , N ₂ , H ₂ O, CO ₂ , SO ₂ , NO _x (Continuous)	Boilers

3.2.1 National Standards

The emission limits value from combustion processes of the power generation boilers as stated in the regulations are:

- solid and liquid fuels for Sulphur Dioxide (SO₂) is 500mg/m³;
- Nitrogen Monoxide (NO) is 500 mg/m³;
- particulate matter (PM) is 50 mg/m³ with the thermal capacity larger than 10MWe respectively; and
- for the gaseous fuels type with the thermal capacity larger than 10MWe, the limit for NO₂ is 350 mg/m³ and CO is 50 mg/m³ and for 5 mg/m³ for particulate matter respectively.

Solid and liquid fuels type emissions is required a continuous monitoring for SO₂, Nox and PM parameters. While for the gaseous fuels type, a continuous monitoring is required for NO₂ and CO. While for PM a periodic monitoring is required.

Table 20 below is the Limit Values for Boilers in Heat and Power Generation. The O₂ reference content is 6% for solid fuels and 3% for others.

Table 20: Limit Values for Boilers

Fuel Type	Pollutant	Capacity	Limit Value ^{1,2}		Monitoring
			mg/m ³	mg/Nm ³	
Solid and liquid Fuels	Sum of SO ₂ and SO ₃ , expressed as SO ₂	>10 MW	500	500	Continuous
	Sum of NO and NO ₂ expressed as NO ₂	>10 MW	500	500	Continuous

Fuel Type	Pollutant	Capacity	Limit Value ^{1,2}		Monitoring
	Hydrogen chloride (HCl)	> 10 – <100 MWe	200	200	periodic
	Hydrogen chloride (HCl)	≥100 MWe	100	100	periodic
	Hydrogen fluoride (HF)	> 10 – <100 MWe	30	30	periodic
	Hydrogen fluoride (HF)	≥100 MWe	15	15	Periodic
	Carbon monoxide (CO)	> 10 MW	200	200	continuous
	Total PM	> 10 MW	50	50	continuous
	Mercury (Hg)	> 10 MW	0.03	0.03	periodic
	PCDD/PCDF	> 10 MW	0.1 ng TEQ/m ³	-	periodic
Gaseous fuels	Sum of NO and NO ₂ expressed as NO ₂	> 10 MW	350	350	continuous
	Carbon monoxide (CO)	> 10 MW	50	50	continuous
	Total PM	> 10 MW	5	5	periodic

Source: Third Schedule (Regulation 15) of Clean Air Regulations 2014

Note: ¹ Limit Values to be adopted for process furnaces; ² conversion from unit mg/m³ in National Standard to unit mg/Nm³ as in IFC's EHS Guidelines is based on standard calculation used in the Guidelines which indicated that Nm³ is at one atmosphere pressure (1013hPa), 0 °C.

3.2.2 IFC'S EHS Guidelines

General EHS Guidelines 2007

Elaboration on guidelines value emission in EHS General Guidelines 2007 are discussed in Section 3.1.2 and the emission standard for boilers and other combustions process are presented in

EHS Guidelines for Thermal Power Plants 2008

The Environmental, Health, and Safety (EHS) Guidelines for Thermal Power Plant (2008) is a document information relevant to combustion processes fuelled by gaseous, liquid and solid fossil fuels and biomass and designed to deliver electrical or mechanical power, steam, heat, or any combination of these, regardless of the fuel type with a total rated heat input capacity above 50 Megawatt thermal input (MWth).

Guidelines limit for boilers is discussed as per Table below.

Table 21: Emissions Guidelines (in mg/Nm3 or as indicated) for Boilers

Combustion Technology/Fuel	Particulate Matter (PM)		Sulfur Dioxide (SO ₂)		Nitrogen Oxides (NO _x)		Dry Gas, Excess O ₂ content (%)
	NDA	DA	NDA	DA	NDA	DA	
Boiler	N/A	N/A	N/A	N/A	NDA	DA	
Natural Gas	N/A	N/A	N/A	N/A	240	240	3%
Other Gaseous Fuels	50	30	400	400	240	240	3%
Liquid Fuels (Plant > 50 MWth to <600 MWth)	50	30	900-1,500 ^a	400	400	200	3%
Liquid Fuels (Plant > /=<600 MWth)	50	30	200-850 ^b	200	400	200	3%
Solid Fuels (Plant > 50 MWth to <600 MWth)	50	30	900-1,500 ^a	400	510 ^c or up to 1, 100 if volatile matter of fuel <10%	200	6%
Solid Fuels (Plant > /=<600 MWth)	50	30	200-850 ^b	200			6%

Note:

- MWth = Megawatt thermal input HHV basis, N/A = not applicable; NDA= Non -degraded airshed; DA= Degraded airshed (poor air quality); Airshed should be considered as being degraded if national legislated air quality standards are exceeded or, in their absence, if WHO Air Quality Guidelines are exceeded significantly; CFB = circulating fluidized bed coal-fired; PC = pulverized coal-fired; Nm³ is at one atmospheric pressure, 0°C; MWth category is to apply to the entire facility consisting of multiple units that are reasonably considered to be emitted from a common stack. Guideline limits apply to facilities operating more than 500 hours per year. Emission levels should be evaluated on one-hour average basis and be achieved 95% of annual operating hours.

- ^a Targeting the lower guidelines values and recognizing issues related to quality of available fuel, cost effectiveness of controls on smaller units, and the potential for higher energy conversion efficiencies (FGD may consume between 0.5% and 1.6% of electricity generated by the plant). ^b Targeting the lower guidelines values and recognizing variability in approaches to the management of SO₂ emissions (fuel quality vs use of secondary controls) and the potential for higher energy conversion efficiencies (FGD may consume between 0.5% and 1.6% of electricity generated by the plant). Larger plants are expected to have additional emission control measures. Selection of the emission level in the range is to be determined by EA considering the project's sustainability, development impact, and cost-benefit of the pollution control performance. ^c stoker boilers may require different emissions values which should be evaluated on a case-by-case basis through the EA process.

3.2.3 Comparison of National Standards and IFC'S EHS Guidelines

The pollutant parameter for emissions combustion from natural gas fuel type boilers which is Nitrogen Oxides (NOx), Sulphur Dioxide (SO₂) and Particulate matter (PM). Emissions limit for PM for both thermal inputs below 50 MWth and larger than 50 MWth is 5 mg/m³ respectively as in the national standard quoted that any capacity larger than 10 MWe, the emission limit is 5 mg/m³. Whereas, based on IFC EHS Guidelines quoted that no emission limit for PM. No emission limit stated in both national standard and IFC EHS guidelines for SO₂. For the NOx with thermal input larger than 50 MWth the emissions limit is 240 mg/m³. While for input below 50 MWth the emission limit is 320 mg/ Nm³. As per national standard EQ the limit for NOx is 350 mg/m³ for capacity larger than 10MWe.

The pollutant that put as parameters for emissions limit for the combustion from diesel or liquid fuels type boilers is SO₂, NOx, CO, and PM. The emission limit for CO is not set in IFC EHS guidelines and emission limit for CO quoted in national standard is 200 mg/m³ for the capacity larger than 10 MWe. IFC EHS Guidelines stated the emissions limit for SO₂ is 2000 mg/Nm³ for thermal input below 50 MWth; 900 to 1500 mg/Nm³ for thermal input ranging between 50-600 MWth for Non-Degraded Airshed (NDA) and 400 mg/Nm³ for Degraded Airshed (DA); and 280 to 850 mg/Nm³ (NDA) and 200 mg/Nm³ (DA) with the thermal input higher than 600 MWth respectively. The emissions limit for NOx is 460 mg/Nm³ for thermal input below 50 MWth; and 400 mg/Nm³ (NDA) and 200 mg/Nm³ (DA) for both thermal input ranging between 50-600 MWth and higher than 600 MWth respectively. National Standard EQ stated the limits for both SO₂ and NOx for capacity larger than 10 MWe is 500 mg/m³. Particulate matter emissions limit as in national standard for all thermal input ranges <50 MWth; 50-600 MWth and >600 MWth is 50 mg/m³. While for IFC EHS Guidelines stated the emissions limit for PM is 50-100 mg/Nm³ for thermal input below 50 MWth; 50 mg/Nm³ (NDA) and 30 mg/Nm³(DA) for both thermal input ranging between 50-600 MWth and higher than 600 MWth respectively.

The comparison between the EQ National Standard and the IFC EHS Guidelines for power generation, boilers is presented in the as Table 22 below:

Table 22 : Comparison of National Standard, IFC's EHS General Guidelines 2007 and EHS Guidelines for Thermal Plant 2008 for Boilers

Parameter	Thermal input (MWth)	Units (unless stated otherwise)	Emissions			Monitoring requirements	Suggested Project Design Standard*
			National Standard	EHS General Guidelines 2007	EHS Guidelines for Thermal Power Plant 2008		
Natural gas							
PM	<50MWth	mg/m ³	5	N/A	N/A	Annual stack emission testing	5 mg/m ³

Parameter	Thermal input (MWth)	Units (unless stated otherwise)	Emissions			Monitoring requirements	Suggested Project Design Standard*
			National Standard	EHS General Guidelines 2007	EHS Guidelines for Thermal Power Plant 2008		
	>50MWth	mg/m ³	5	N/A	N/A	Annual stack emission testing	5 mg/m³
SO ₂	<50MWth	N/A	N/A	N/A	N/A	Annual stack emission testing	N/A
	>50MWth	N/A	N/A	N/A	N/A	Annual stack emission testing	N/A
NO _x	<50MWth	mg/m ³	350	320 mg/Nm ³	-	Annual stack emission testing	320 mg/Nm³
	>50MWth			-	240 mg/Nm ³ (NDA & DA)	Continuous or indicative	240 mg/Nm³
Diesel / Liquid fuels							
PM	<50MWth	mg/m ³	50	50 mg/Nm ³ or up to 150 mg/Nm ³ if justified by environmental assessment	-	No prescriptive standard	50 mg/m³
	>50 to <600 MWth	mg/m ³	50	-	50 mg/Nm ³ (NDA); 30 mg/Nm ³ (DA)	Continuous or indicative and an annual stack emission testing	50 mg/m³
	>= 600 MWth			-	50 mg/Nm ³ (NDA); 30 mg/Nm ³ (DA)		50 mg/m³
SO ₂	<50MWth	mg/m ³	500	2,000 mg/Nm ³	-	No prescriptive standard	500 mg/m³
	>50 to <600 MWth			-	900 – 1,500 mg/Nm ³ (NDA); 400 mg/Nm ³ (DA)	Continuous if FGD is used to monitor by S content, and an annual stack emission testing	500 mg/m³
	>= 600 MWth			-	200 – 850 mg/Nm ³ (NDA); 200 mg/Nm ³ (DA)	Continuous, and an annual stack emission testing	200 mg/Nm³
NO _x	<50MWth	mg/m ³	500	460 mg/Nm ³	-	No prescriptive standard	460 mg/Nm³
	>50 to <600 MWth			-	400 mg/Nm ³ (NDA); 200 mg/Nm ³ (DA)	Continuous or indicative, and an annual stack emission testing	400 mg/Nm³ (NDA); 200 mg/Nm³ (DA)

Parameter	Thermal input (MWth)	Units (unless stated otherwise)	Emissions			Monitoring requirements	Suggested Project Design Standard*
			National Standard	EHS General Guidelines 2007	EHS Guidelines for Thermal Power Plant 2008		
	>/= 600 MWth			-	400 mg/Nm ³ (NDA); 200 mg/Nm ³ (DA)	Continuous, and an annual stack emission testing	400 mg/Nm³ (NDA); 200 mg/Nm³ (DA)
CO	All	mg/m ³	200	N/A	N/A	N/A	200 mg/m³

Note:

- MWth = Megawatt thermal input HHV basis, N/A = not applicable; NDA= Non -degraded airshed; DA= Degraded airshed (poor air quality); Airshed should be considered as being degraded if national legislated air quality standards are exceeded or, in their absence, if WHO Air Quality Guidelines are exceeded significantly; Nm³ is at one atmospheric pressure, 0°C; MWth category is to apply to the entire facility consisting of multiple units that are reasonably considered to be emitted from a common stack. Guideline limits apply to facilities operating more than 500 hours per year. Emission levels should be evaluated on one-hour average basis and be achieved 95% of annual operating hours. *suggestion is based on the most stringent value between all applicable standards and guidelines

Monitoring requirements

An annual stack test is required for emissions monitoring for PM, SO₂ and NO_x for the thermal input larger than 50 MWth. No monitoring is quoted in IFC EHS Guidelines for both PM and SO₂ parameter for the thermal input below 50 MWth. Meanwhile, a continuous or indicative monitoring is required for NO_x emissions with thermal input lower than 50 MWth.

For emission monitoring from liquid fuels type, no prescriptive standard is quoted in IFC EHS guidelines for PM, SO₂ and NO_x emission monitoring for thermal input below 50 MWth. A continuous or indicative plus annual stack test is required for emissions monitoring for PM, SO₂, NO_x with thermal input ranges of 50 to 600 MWth. For the thermal input larger than 600 MWth a continuous plus annual stack test is required for both SO₂ and NO_x. No emission monitoring requirement quoted for CO in the guidelines.

3.3 Other Process Emission

Descriptions

Sources: Environmental Quality (Clean Air) Regulations of Malaysia, 2014; IFC EHS Guidelines for Petroleum Refining, 2016; WHO air quality guidelines for Europe, 2nd edition, 2000; and National Framework for Petroleum Refinery, Emission Reduction, CCME, 2005.

The largest sources of emissions at petroleum refineries are stationary fuel combustion units (e.g. steam boilers, process furnaces, and process heaters). The Petroleum Refineries Sector also reports process emissions from catalytic cracking units, fluid coking units, delayed coking units, catalytic reforming units, coke calcining units, asphalt blowing operations, blowdown systems, storage tanks, equipment leaks, loading operations, flares, and sulphur recovery plants.

Hazardous Air Pollutants (HAPs) which may come from the emissions of petroleum refineries are known to cause or suspected of causing cancer or other serious health problems. Health concerns may be associated with both short- and long-term exposures to these pollutants. Many are known to have respiratory, neurological, immune or reproductive effects, particularly for more susceptible sensitive populations such as children. General pollutants from refinery activities are as follows:

- **Ammonia**

Ammonia gas (NH₃) is a colourless, acrid-smelling gas that is volatile and highly water soluble. It originates from both man-made and natural sources. Gaseous ammonia reacts

chemically with other gases and particles and can produce secondary particulate matter with diameters less than 2.5 μm (i.e. PM_{2.5}). These fine particles cause the greatest concern for human health. Particulate matter and ammonia are also linked to air quality issues such as reduced visibility

- **Carbon monoxide (CO)**

A colourless, odourless, tasteless, non-corrosive, highly poisonous gas of about the same density as air. When it enters the bloodstream, CO inhibits the blood's capacity to carry oxygen. CO is a product of incomplete burning of fuels.

- **Nitrogen oxides (NO_x), or oxides of nitrogen**

Include both nitric oxide (NO) and nitrogen dioxide (NO₂). Since NO_x are a mixture, the combination of NO and NO₂ is normally reported on an NO₂-equivalent basis. NO_x is produced in all combustion processes and is formed from the nitrogen in both the air and in fuel. NO_x plays an important role in the formation of ground-level ozone, can react with other contaminants such as ammonia to form secondary particulate matter, and contribute to the formation of acid rain.

- **Particulate matter**

Refers to microscopic bits of solid and liquid that remain suspended in the air for some time. Particles give smog its colour and cause the reductions in visibility. Direct particulate matter (PM) enters the outdoor air from many sources, principally from fossil fuel combustion by industrial and non-industrial sources, from the transportation sector, and from forest fires and wood-burning stoves. Indirect or secondary formation of PM results when particulates are formed by chemical and physical reactions of precursor substances (NO_x, SO_x, VOC and ammonia). Particles range in size, shape and chemical composition but are typically grouped into PM₁₀ (inhalable, less than 10 microns in diameter), PM_{2.5} (respirable, less than 2.5 microns in diameter) and ultra fine particles of less than 1.0 micron. There is increasing evidence that not only the mass, but also the surface area, shape and chemical nature of these particles play a role in the health outcomes of individuals exposed to particulate matter.

- **Sulphur oxides (SO_x)**

Include SO₂ and SO₃ and sulphate (SO₄) forms. SO₂ (sulphur dioxide) is a non-flammable, non-explosive, colourless gas which is produced during the combustion of fossil fuels that contain sulphur. Like NO_x, SO_x are a precursor to the formation of secondary particulate matter and are an important contributor to acid rain.

- **Volatile organic compounds (VOC)**

A loosely defined group of compounds containing at least one carbon atom that are volatile (evaporate readily) and organic in origin. They are substances that can photochemically react in the atmosphere. In addition, VOC are precursors to the formation of secondary particulate matter and ground-level ozone. The National Pollutant Release Inventory (NPRI) of Canada defines them as "volatile organic compounds that participate in atmospheric photochemical reactions," but excludes a number of individual substances or groups of substances such as methane and ethane from the definition. They are emitted through combustion processes and from the evaporation of materials with volatile organic content, such as petroleum products, paints and solvents, and from naturally occurring sources.

- **Hydrogen Sulphide (H₂S)**

H₂S is a colourless, flammable and extremely dangerous gas. It is found in many refinery streams such as crude oil, asphalt, residual fuel, mid distillate, gasoline and blend components. As well as natural gas, propane and LPG. It is heavier than air and can travel along the ground.

- **Vanadium (V)**

Vanadium is a bright white ductile metal belonging to group V of the periodic system of elements. It forms compounds mainly in valence states +3, +4 and +5. In the presence of oxygen, air or oxygenated blood, or oxidizing agents, vanadium is always in the +5-oxidation state. In the presence of reducing agents, vanadium compounds are in the +4-oxidation state. Vanadium forms both cationic and anionic salts, and can form covalent bonds to yield organometallic compounds which are mostly unstable.

- **Nickel (Ni)**

Nickel is a silvery-white hard metal which forms compounds in several oxidation states, the divalent ion seems to be the most important for both organic and inorganic substances, but the trivalent form may be generated by redox reactions in the cell. Nickel compounds that are practically insoluble in water include carbonate, sulphides (the main forms being amorphous or crystalline monosulphide, NiS, and subsulphide Ni₃S₂) and oxides (NiO, Ni₂O₃). Water-insoluble nickel compounds may dissolve in biological fluids.

- Particles of the same chemical entity (oxides and sulphides) have different biological activity depending on crystalline structure and surface properties. Soluble nickel salts include chloride, sulphate and nitrate. Nickel carbonyl (Ni (CO)₄) is a volatile, colourless liquid with a boiling-point of 43 °C; it decomposes at temperatures above 50 °C. In biological systems, nickel forms complexes with adenosine triphosphate, amino acids, peptides, proteins and deoxyribonucleic acid.

3.3.1 Emission Sources

These sources of potential air emissions shall be monitored continuously or periodically according to the National Standards and adapted International Guidelines i.e. IFC EHS Guidelines. The limit values of emission are different according to the type of pollutants release from each sources of emission. Applicable sources for this Section are:

i. Fluid Catalytic Cracking Units (FCCU)

ii. Sulphur Recovery Units (SRU)

Source	Main Air Emission	Applicable Limit Values/Standards
Isomar Unit: Vent gas – regeneration waste gas from Isomar Unit	Vent gas: N ₂ , CO ₂ , H ₂ O (once every three years only)	Fluid Catalytic Cracking Units (FCCU)
Tatoray Unit: Vent gas – regeneration of waste gas	Vent gas: N ₂ , CO ₂ , H ₂ O (once every two years only)	Fluid Catalytic Cracking Units (FCCU)
LPG Merox Unit: Disulfide separator vent	Vent gas: N ₂ , O ₂ , disulfide, mercaptan, hydrocarbon	Sulphur Recovery Units (SRU)
SRU Thermal Oxidiser – Unit 610-ME1	Flue gas: O ₂ , N ₂ , H ₂ O, CO ₂ , SO ₂ , NO _x	Sulphur Recovery Units (SRU)

Source	Main Air Emission	Applicable Limit Values/Standards
Fugitive emissions	VOC	Based on Guidance Document on Fugitive Emission Control

3.3.2 National Standards

Environmental Quality (Clean Air) Regulations 2014 of Malaysia, regulates the threshold of parameters which related to PEC activities as follows:

Table 23 : Threshold Parameter

Parameter	Units (unless stated otherwise)	Emissions	
		National Standard	^a Conversion to mg/Nm ³
NH ₃	mg/m ³	76	76
SO _x	mg/m ³	100	100
NO _x	mg/m ³	700	700
CO	mg/m ³	N/A	N/A
Total PM	mg/m ³	50*	50
H ₂ S	mg/m ³	7.5	7.5
**VOC	mg/m ³	20 (halogenated hydrocarbons) 150 (non-halogenated hydrocarbons)	20 (halogenated hydrocarbons); 150 (non-halogenated hydrocarbons)
Vanadium	mg/m ³	0.5	0.5
Nickel	mg/m ³	0.5	0.5

Notes: * Adopted from Environmental Quality (Clean Air) Regulations 2014 of Malaysia standard for Chemical and Petrochemical Industry in all sizes

**Second Schedule (Regulation 13) of Clean Air Regulations 2014

^aConversion from unit mg/m³ in National Standard to unit mg/Nm³ as in IFC's EHS Guidelines is based on standard calculation used in the Guidelines which indicated that Nm³ is at one atmosphere pressure (1013hPa), 0°C.

3.3.3 IFC'S EHS Guidelines

EHS Guidelines for Petroleum Refining 2016

Flue gas emissions to the atmosphere in the petroleum refining sector result from the combustion of gas and oil in gas turbines, boilers, engines, and process heaters for power, steam, and heat generation. Flue gas can also be emitted from waste heat boilers associated with some process units during continuous catalyst regeneration (CCR) or fluid petroleum coke combustion. Air emission levels for petroleum refining facilities based on IFC requirements which are applicable to direct release of emission such as NH₃, SO_x, NO_x, CO, PM₁₀, H₂S, VOC, Vanadium, and Nickel to atmosphere are as follows:

Table 24: Air Emissions Levels for Petroleum Refining Facilities^a

Pollutant	Units	Guideline Value
NO _x ^b	mg/Nm ³	300 100 for FCCU
SO _x ^c	mg/Nm ³	150 for SRU; 300 for FCCU 500
Particulate matter (PM10) ^d	mg/Nm ³	25
Vanadium ^e	mg/Nm ³	5
Nickel	mg/Nm ³	1

Pollutant	Units	Guideline Value
H ₂ S ^e	mg/Nm ³	5

Note: ^a dry gas at 3% O₂; ^b NO_x means NO + NO₂ expressed in NO₂ equivalent. Guideline value from European Commission Joint Research Centre (EC JRC), "Best Available Techniques Reference (BREF) Document for the Refining of Mineral Oil and Gas" (2015); ^c SO_x means SO₂ + SO₃ expressed in SO₂ equivalent; ^d Guideline value from EC JRC, "BREF document for the Refining of Mineral Oil and Gas" (2015). Particulate matter guidance value is also valid for FCCU; ^e From GSR 186(E) and 820(E), India Ministry of Environment and Forests Notification http://envfor.nic.in/legis/env_stand.htm

EHS Guidelines for Large Volume Petroleum-based Organic Chemical Manufacturing 2007

Emissions from aromatics plants are to a large extent due to the use of utilities (e.g. heat, power, steam and cooling water) needed by the aromatic's separation processes. Guideline values for process emissions are indicative of good international industry practice as reflected in relevant standards of countries with recognized regulatory framework. These guidelines are achievable under normal operating conditions in appropriately designed and operated facilities through the application of pollution prevention and control techniques.

The air emissions guidance value for these guidelines are presented in Table 25 below:

Table 25: Air Emissions Guidelines^a for Large Volume Petroleum-based Organic Chemicals Manufacturing

Pollutant	Unit	Guideline Value
Particulate matter (PM)	mg/Nm ³	20
Nitrogen Oxides	mg/Nm ³	300
Hydrogen Chloride	mg/Nm ³	10
Sulfur Oxides	mg/Nm ³	100
Benzene	mg/Nm ³	5
1,2-Dichloroethane	mg/Nm ³	5
Vinyl Chloride (VCM)	mg/Nm ³	5
Acrylonitrile	mg/Nm ³	0.5 (incineration) 2 (scrubbing)
Ammonia	mg/Nm ³	15
VOCs	mg/Nm ³	20
Heavy metals (total)	mg/Nm ³	1.5
Mercury and compounds	mg/Nm ³	0.2
Formaldehyde	mg/m ³	0.15
Ethylene	mg/Nm ³	150
Ethylene Oxide	mg/m ³	2
Hydrogen Cyanide	mg/m ³	2
Hydrogen Sulfide	mg/m ³	5
Nitrobenzene	mg/m ³	5
Organic sulfide and mercaptans	mg/m ³	2
Phenols, Cresols and Xylols (as Phenol)	mg/m ³	10
Caprolactam	mg/m ³	0.1
Dioxins/Furans	ng TEQ/Nm ³	0.1

Note: ^a Dry, 273K (0°C), 101.3 kPa (1 atmosphere), 6% O₂ for solid fuels; 3% O₂ for liquid and gaseous fuels.

EHS Guidelines for Crude Oil and Petroleum Product Terminal 2007

Volatile Organic compounds (VOCs) emitted during crude oil and petroleum product terminal storage activities have the potential to be significant from an environment and an economic perspective. Emissions of VOCs may result from evaporative losses during storage (typically referred to as "breathing, storage, or flash losses"), from operational activities such as filling, withdrawal, additive blending, and loading/unloading of transport links (referred to as "working

losses”), and due to leaks from seals, flanges, and other types of equipment connections (known as “fugitive losses”).

There is no specific guidelines value for emission of VOCs from these guidelines, however, necessary control techniques should be adapted by the facilities to control the emissions.

3.3.4 Comparison of National Standards and IFC’s EHS Guidelines

Comparison data between Environmental Quality (Clean Air) Regulations 2014 of Malaysia and IFC ‘s Air Emission Levels for Petroleum Refining Facilities, and the IFC’s EHS Guidelines for Large Volume Petroleum-based Organic (LVPO) Chemical Manufacturing are tabulated below:

Table 26: Comparison of National Standard, EHS Guidelines for Petroleum Refining Facilities and EHS Guidelines for LVPO Chemical Manufacturing for Air Emissions

Parameter	Units (unless stated otherwise)	Emissions			Suggested Project Design Standard*
		National Standard	EHS Guidelines for Petroleum Refining 2016	EHS Guidelines for LVPO Chemical Manufacturing 2007	
NH ₃	mg/m ³	76	N/A	N/A	76 mg/m³
SO _x	mg/m ³	100	500 mg/Nm ³	100 mg/Nm ³	100 mg/m³
NO _x	mg/m ³	700	300 mg/Nm ³	300 mg/Nm ³	300 mg/Nm³
CO	mg/m ³	N/A	N/A	N/A	N/A
PM ₁₀	mg/m ³	50 ^c	25 mg/Nm ³	20 mg/Nm ³	20 mg/Nm³
VOCs	mg/m ³	20 (halogenated hydrocarbons) 150 (non-halogenated hydrocarbons)	N/A	20 mg/Nm ³	20 (halogenated hydrocarbons) 150 (non-halogenated hydrocarbons)
Vanadium	mg/m ³	0.5 ^a	5 mg/Nm ³	N/A	0.5 mg/m³
Nickel	mg/m ³	0.5 ^a	1 mg/Nm ³	N/A	0.5 mg/m³
H ₂ S	mg/m ³	7.5 ^b	5 mg/Nm ³	N/A	5 mg/Nm³

Notes :^a Adopted from Environmental Quality (Clean Air) Regulations 2014 of Malaysia standard for Waste Incinerators in all sizes

^b Adopted from Environmental Quality (Clean Air) Regulations 2014 of Malaysia standard for Chemical and Petrochemical Industry in all sizes

^c Total PM as required in Environmental Quality (Clean Air) Regulations 2014 of Malaysia standard for Chemical and Petrochemical Industry in all sizes

*suggestion is based on the most stringent value between all applicable standards and guidelines

3.3.5 Sulphur Recovery Units (SRU) and Fluid Catalytic Cracking Units (FCCU)

Sources: Environmental Quality (Clean Air) Regulations of Malaysia, 2014; IFC EHS Guidelines for Petroleum Refining, 2016; and Emissions Estimation Protocol for Petroleum Refineries, RTI International, 2015.

SRU Descriptions

All crude oils contain some sulphur compound impurities. Sulphur compounds in crude oil are converted to H₂S in the cracking and hydrotreating processes of the refinery. The H₂S in the generated gas streams is removed from the process vapours using amine scrubbers. The amine scrubbing solution is subsequently heated to release the H₂S to form an H₂S rich “acid gas” that is treated in the sulphur recovery plant to yield high-purity sulphur that is then sold as product.

Most sulphur recovery plants use the Claus reaction and are commonly referred to as Claus units or Claus sulphur recovery plants. There are a couple of other types of sulphur recovery plants at smaller refineries, but all larger sulphur recovery plants employ Claus units. The

exhaust gas from the sulphur recovery unit (SRU) is commonly referred to as “tail gas.” The sulphur recovery plant consists of one or more SRU operated in parallel and may also contain one or more catalytic tail gas treatment units and/or a thermal oxidizer to combust the tail gas.

Sulphur recovery plant vents are commonly controlled by a thermal oxidizer to oxidize unreacted H₂S or H₂S in sweep gas from the sulphur pits to SO₂. Some sulphur recovery plants use reducing controls and thus emit H₂S rather than SO₂. The sulphur plant sour gas feed may also contain small amounts of light organics. Therefore, it is important to account for the hydrocarbons in the sulphur recovery plant feed when estimating emissions from the sulphur recovery plant that may have atmospheric vents without thermal destruction.

FCCU Descriptions

The Catalytic Cracking Unit (CCU) catalyst regenerator vent is often the single largest emissions vent at the refinery. The CCU is a catalytic process used to upgrade (crack) heavy distillates to form lighter, more useful distillates such as heating oils or gasoline. The CCU system consists of a reactor, a catalyst regenerator (commonly referred to as the “regenerator”), vent gas process equipment for energy recovery and emissions control, and an exhaust stack. Nearly all refinery CCU systems operate as fluidized-bed reactors and use air or oil gas flow to transport the very small catalyst particles between the CCU reactor and regenerator. These fluidized CCU systems are commonly referred to as fluid catalytic cracking units (FCCU).

There are two basic types of CCU regenerators which are complete combustion regenerators and partial combustion regenerators that operated as follows:

- In a complete combustion regenerator, the regenerator is typically operated at approximately 1,200°F to 1,400°F with excess O₂ and low levels (< 500 ppmv) of CO in the exhaust flue gas.
- In a partial (or incomplete) combustion regenerator, the regenerator is typically operated at approximately 1,000°F to 1,200°F under O₂-limited conditions and relatively high levels (1% to 5%) of CO. Prior to exiting the regenerator, catalyst particles entrained with the flue gases are initially removed by internal cyclone separators and returned to the regenerator catalyst bed for recirculation to the reactor.

3.3.5.1 National Standards for SRU and FCCU Operations

Based on the Environmental Quality (Clean Air) Regulations 2014 of Malaysia, the refineries of oil and gas industries are fall under Activities and Industries Subject to The Best Available Techniques Economically Achievable (BAT). The refinery’s activity is also fall under schedule 3 (Regulation 13) which regulates the threshold of particulates and SO_x in oil and gas industries. The threshold is described as below:

Source	Pollutant	Limit value	Monitoring
SRU			
Claus plant	Sulphur	Recovery > 95%	Periodic
FCCU			
Catalytic cracking	Total PM	40 mg/m ³	Continuous*
	Sum of SO ₂ and SO ₃ , expressed as SO ₂	1200 mg/m ³	Continuous*

*averaging time for continuous monitoring is 30 minutes

Gases and vapours of organic substances which escape from pressure relief fittings and blow-down systems shall be fed in to a gas collecting system. The collected gases shall be combusted in process furnaces if this is feasible. If this is not feasible, the gases shall be fed into a flare. Waste gases continually produced by processing systems and waste gases occurring during the

regeneration of catalysts, inspections and cleaning operations shall be fed into a post-combustion facility, or equivalent measures to reduce emissions shall be applied.

Gaseous and volatile organic compounds shall be indicated as total organic carbon. Fugitive emissions of volatile organic substances shall be minimized according to the respective Best Available Techniques Economically Achievable Guidance Document. For compliance check a “Leakage Detection and Repair Programme” shall be implemented as outlined in the Guidance Document on Leak Detection and Repair in a manner as specified and approved by the Director General. Combustion installations using refinery gas or other by-products shall comply with the standards of Fuel Burning Equipment in the Second Schedule or Third Schedule, depending on the thermal output.

3.3.5.2 IFC’s EHS Guidelines for SRU and FCCU Operations

The IFC EHS Guidelines for Petroleum Refinery states that the emissions in this sector are indicative of good international industry practice, as reflected in relevant standards of countries with recognized regulatory frameworks. The guideline values are assumed to be achievable under normal operating conditions in appropriately designed and operated facilities through the application of pollution prevention and control techniques discussed in the preceding sections of this document.

Emissions guidelines are applicable to direct release of emission to atmosphere. Flue gas emissions to the atmosphere of metals, carbon dioxide (CO₂), nitrogen oxides (NO_x), sulphur oxides (SO_x), carbon monoxide (CO), and particulate matter (PM) in the petroleum refining sector result from the combustion of gas and oil in gas turbines, boilers, engines, and process heaters for power, steam, and heat generation. Flue gas can also be emitted from waste heat boilers associated with some process units during continuous catalyst regeneration (CCR) or fluid petroleum coke combustion. Air emission levels for petroleum refining facilities based on IFC requirements are as follows:

Parameter	Units (unless stated otherwise)	Emissions
		IFC Guidelines for Refineries (2016)
SRU		
SO ₂	mg/Nm ³	150
FCCU		
SO _x	mg/Nm ³	300
NO _x	mg/Nm ³	100
CO	ppm	N/A
PM ₁₀	mg/Nm ³	25
Vanadium	mg/Nm ³	5
Nickel	mg/Nm ³	1
H ₂ S	mg/Nm ³	5

Fugitive emissions in petroleum-refining facilities may occur from leaking tubing, valves, connections, flanges, gaskets, steam traps, packing, open-ended lines, floating roof storage tanks and pump seals, gas conveyance systems, compressor seals, pressure relief valves, breathing valves, tanks or open pits/containments, oil-water separators, and in the storage, loading, and unloading operations of hydrocarbons. Depending on the refinery process scheme, fugitive emissions may comprise:

- Hydrogen;

- Methane;
- Volatile organic compounds (VOCs), (e.g., ethane, ethylene, propane, propylene, butanes, butylenes, pentanes, pentenes, C6-C9 alkylate, benzene, toluene, xylenes, phenol, and C9 aromatics);
- Polycyclic aromatic hydrocarbons (PAHs) and other semi-VOCs;
- Inorganic gases, including ammonia (NH₃), CO, CO₂, SO₂ and sulphur trioxide (SO₃) from sulfuric acid regeneration in the sulfuric acid alkylation process, NO_x, methyl tertiary butyl ether (MTBE), ethyl tertiary butyl ether (ETBE), t-amylmethyl ether (TAME), methanol, and ethanol; and
- If occurring, hydrofluoric acid (HF) from hydrogen fluoride alkylation and H₂S.

Recommendations to prevent and limit fugitive emissions include the following:

- A structured leak detection and repair (LDAR) program should be implemented; based on a systematic review of Process and Instrumentation Diagrams (P&IDs), this program should identify streams and equipment (e.g., pipes, valves, seals, tanks, and other infrastructure components) where fugitive VOC emissions are a possibility (through component degradation, for example) and prioritize their monitoring with vapor detection equipment, followed by maintenance or replacement of components, as needed.
- When selecting appropriate valves, packings, flanges, fittings, and seals, consideration should be given to their effectiveness to reduce gas leaks and fugitive emissions.
- To minimize their release to the atmosphere, hydrocarbon vapours should be either contained (e.g., using a nitrogen blanketing system an internal floating roof for tanks, or a cover system for separator) or routed back to the process.
- Installing a Vapours Recovery Unit, in lieu of open venting or flaring. Use of vent gas scrubbers should be considered to remove oil and other oxidation products from overhead vapours in specific units (e.g., bitumen production, loading racks).
- The incineration of gas should be conducted at a high temperature (approximately 800°C) to ensure complete destruction of minor components (e.g., H₂S, aldehydes, organic acids, and phenolic components) and to minimize emissions and odour impacts.
- With regard to emissions from HF, alkylation plant vents should be collected and neutralized for HF in a scrubber before being sent to flare.
- With regard to naphtha, gasoline, methanol/ethanol, and ethers—including MTBE, ETBE, and TAME—loading/unloading racks should be provided with vapor controls, e.g. vapor recovery units.
- Additional guidelines for the prevention and control of fugitive emissions from storage tanks are provided in the EHS Guidelines for Crude Oil and Petroleum Product Terminals.

Environmental monitoring programs for the Petroleum Refining sector should be implemented to address all activities that have been identified to have potentially significant impacts on the environment, during both normal operations and upset conditions (emergencies and consequent flaring). Environmental monitoring activities should be based on direct or indirect indicators of emissions, wastewater, and resource use applicable to the particular project, and for point sources of emissions this should include both concentration and mass flow rate of pollutants.

Monitoring frequency should be sufficient to provide representative data for the parameter being monitored. Monitoring should be conducted by trained individuals following suitable and appropriate monitoring and record-keeping procedures and using regularly calibrated and suitably maintained equipment. Monitoring data should be analysed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken.

3.3.5.3 Comparison of National Regulation and IFC Requirements for SRU and FCCU Operations

Comparison data between Environmental Quality (Clean Air) Regulations 2014 of Malaysia and IFC 's Air Emission Levels for Petroleum Refining Facilities, and the suggested project design standard for the operations of SRU and FCCU are tabulated below:

Parameter	Units (unless stated otherwise)	Emissions		
		National Standard	IFC Guidelines for Refineries (2016)	Suggested Project Design Standard
SRU				
SO ₂	mg/Nm ³	Recovery >95%	150	150
FCCU				
SO _x	mg/Nm ³	1200	300	300
NO _x	mg/Nm ³	N/A	100	100
CO	ppm	N/A	N/A	N/A
PM ₁₀	mg/Nm ³	40***	25	25
Vanadium	mg/Nm ³	0.5*	5	5
Nickel	mg/Nm ³	0.5*	1	1
H ₂ S	mg/Nm ³	7.5**	5	7.5****

* Adopted from Environmental Quality (Clean Air) Regulations 2014 of Malaysia standard for Waste Incinerators in all sizes

** Adopted from Environmental Quality (Clean Air) Regulations 2014 of Malaysia standard for Chemical and Petrochemical Industry in all sizes

*** Total PM as required in Environmental Quality (Clean Air) Regulations 2014 of Malaysia standard for Oil and Gas Industries: Refineries (All Sizes); Natural Gas Processing and Storage; Storage and Handling of Petroleum Products

**** Chosen as suggested project design standard as required in Environmental Quality (Clean Air) Regulations 2014 of Malaysia standard for Chemical and Petrochemical Industry in all sizes

4 NOISE EMISSION AND SOURCES

Primary noise sources that is identified within the production facilities are:

- Flare;
- Coolers;
- Condensers;
- Compressors and steam turbines

Noise limits are stipulated under the Occupational Safety and Health (Noise Exposure) Regulations 2019 which are regulated and authorized by the Department of Occupational Safety and Health (DOSH). These regulations are mainly to protect and monitor the safety and health of workers working in the operation facilities. Meanwhile, boundary noise monitoring limit are specified under a Guidelines that is published by the Department of Environment (DoE). The general coverage and complimentary Regulations are outlined in sub-section below.

4.1 National Standards

Occupational Safety and Health (Noise Exposure) Regulations 2019

PEC shall ensure to identify whether their employee may be exposed to excessive noise in the place of work by doing noise risk assessment. The risk assessment shall be carried out by certified noise risk assessor every five years. It is also the responsibility of the employer to: -

- a. provide adequate information relating the effects of noise exposure on hearing of a person and the requirement to undergo audiometric testing to such employees;
- b. give training (at least once a year) and instruction on proper usage of PPE; and
- c. supervise implementation of noise exposure control at the place of work.

Noise exposure limit is elaborated in the Regulation 6 where every employer shall ensure that none of his employee is exposed to: -

- i. the daily noise exposure level exceeding 85dB(A) or daily personal noise dose exceeding 100%;
- ii. the maximum sound pressure level exceeding 115dB(A) at any time; or
- iii. the peak sound pressure level exceeding 140dB(A).

Guidelines for Environmental Noise Limits and Control (Third Edition) 2019

These guidelines present noise acceptance criteria upon which a quantitative assessment of noise could be made. The purpose of this guidelines is:

- a. for planning required or parties involved in planning process;
- b. for noise impact assessments, pre- and post-EIA compliance verification;
- c. for quantifying noise disturbance on a quantitative basis; and
- d. for guidance in environmental noise mitigation through planning and control.

Ambient noise in the environment are dependent on the noise sources that pre-exist and/or additional noise source(s) that may be introduces to a location of concern. The limits to be set should be consistent with the environmental noise climate that currently exists at this location – such that an adverse impact on the environment and adjacent affected land use are avoided, and at the same time maintain a reasonable balance with physical development and/or activities that shall or had taken place.

Recommended maximum permissible sound levels for different noise sources measured at the real property boundary and assessed based on receiving land use. *Table 27* below prescribes recommended sound level (L_{Aeq}) for planning purposed and new development which to be used for new industrial, commercial or housing areas; and/or development in undeveloped areas (rural and/or ungazetted areas).

Table 27 : Recommended Permissible Sound Level (L_{Aeq}) by Receiving Land Use for New Development

Receiving Land Use Category	L_{Aeq} Day 07:00-22:00	L_{Aeq} Night 22:00-07:00
Low density residential, noise sensitive receptors, institutional (school, hospital, worship)	55 dBA	50 dBA
Suburban residential (medium density), recreational	60 dBA	55 dBA

Receiving Land Use Category	L _{Aeq} Day 07:00-22:00	L _{Aeq} Night 22:00-07:00
Urban residential (high density), mixed development	65 dBA	60 dBA
Commercial Business Zones	65 dBA	60 dBA
Industrial Zones	70 dBA	65 dBA

Construction Noise

Based on the Guidelines for Environmental Noise Limits and Control, major items to be considered to be included in the Environmental Impact Assessment (EIA) for noise are:

- identification of sensitive receptors;
- establishing noise acceptance criteria;
- baseline noise monitoring;
- noise modelling;
- noise impact assessment;
- noise mitigation; and
- Environmental Management Plan requirements.

The modelling, impact assessment and mitigation shall cover 1) constructions (and demolition works where applicable); and 2) operations.

The construction noise measurement procedure is referred to the measurement of construction noise from construction sites which includes demolition works at work site boundaries and at specific receptor locations. The construction noise measurements are stipulating noise compliance monitoring and mitigation during construction works for the project.

The construction noise may vary and change over time depending on the phase of the construction works activities. The measurements may be required to be undertaken over the entire construction period either involves continuously monitoring on long term or specific duration or involve periodic monitoring over a typical workday night that may be repeated weekly or monthly.

Construction and demolition work' measurements shall require noise levels to be measured continuously over a 24 hours day night that is divided into three time periods:

- Day 7:00am to 6:00pm
- Evening 6:00pm to 10:00pm; and
- Night 10:00pm to 7:00am the following day

However, where the construction works may not be undertaken for such on weekends and public holidays, some changes may occur.

An additional measurement without the construction noise or work activities should be undertaken for comparison if there is a need to investigate complaints against the construction works. In most applications, prior baseline noise measurement should be undertaken at locations of concern before the commencement of the construction works.

4.2 IFC's EHS Guidelines

EHS General Guidelines on Environmental Noise Management

These guidelines addressed the impacts of noise beyond the property boundary of the facilities. Predicted or measured noise impacts from a project facility or operation which exceed the applicable noise level guideline at the most sensitive point of reception should be prevented using effective mitigation measures. The most preferred method of controlling noise from stationary sources is to implement noise control measures at source. Other noise reduction options to be considered are:

- selecting equipment with lower sound power levels
- installing silencers for fans
- installing suitable mufflers on engine exhausts and compressor components
- installing acoustic enclosures for equipment casing radiating noise
- improving the acoustic performance of constructed buildings, apply sound insulation
- installing acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/m² in order to minimize the transmission of sound through the barriers. Barriers should be located as close to the source or to the receptor location to be effective
- installing vibration isolation for mechanical equipment
- limit the hours of operation for specific pieces of equipment or operations, especially mobile sources operating through community areas
- re-locating noise sources to fewer sensitive areas to take advantage of distance and shielding
- siting permanent facilities away from community areas if possible
- take advantage of the natural topography as a noise buffer during designing
- reduce project traffic routing through community areas wherever possible
- planning flight routes, timing and altitude for aircraft (airplane and helicopter) flying over community areas
- develop mechanism to record and respond to complaints.

Noise impacts should not exceed the levels presented in *Table 28* below, or result in maximum increase in background levels of 3dB at the nearest receptor location off-site.

Table 28: Noise Level Guidelines¹

Receptor	One-hour L _{Aeq} (dBA)	
	Daytime 07:00 – 22:00	Night time 22:00-07:00
Residential; institutional; Educational ²	55	45
Industrial; commercial	70	70

Note: ¹ Guidelines value are for noise levels measured out of doors. Source – Guidelines for Community Noise, World Health Organization (WHO), 1999.

² For acceptable indoor noise levels for residential, institutional, and educational settings refer to WHO (1999)

EHS Guidelines for Large Volume Petroleum-based Organic (LVPO) Chemical Manufacturing 2007

According to these guidelines, typical noise generation for this type of manufacturing include large size rotating machines, such as compressors and turbines, pumps, electric motors, air

coolers, fired heaters, flares and from emergency depressurization. Guidance on noise control and minimization is referred to *Table 28* in EHS General Guidelines.

EHS Guidelines for Petroleum Refining 2016

The principal sources of noise in petroleum refining facilities include large rotating machines, such as compressors and turbines, pumps, electric motors, air coolers (if any), blowers, fans and heaters. In addition, steam leaks, if significant, can be noisy. During emergency depressurization, high noise levels can be generated due to high-pressure gases released to flare and/or steam release into the atmosphere. Guidance limit can be referred to the General EHS Guidelines.

4.3 Comparison of National Standards and IFC’s EHS Guidelines

Noise limit values between the national standards and IFC’s EHS Guidelines are tabulated below. The suggested project design standards are based on the most stringent value between all applicable standards and guidelines.

Table 29 : Comparison of National Standards and IFC’S EHS General Guidelines for Environmental Noise

Land Use Category	L _{Aeq} Day (dBA) 07:00-22:00		L _{Aeq} Night (dBA) 22:00-07:00		Suggestion Project Design Standard		
	National Standard	EHS General Guidelines	National Standard	EHS General Guidelines	L _{Aeq} Day (dBA) 07:00-22:00	L _{Aeq} Night (dBA) 22:00-07:00	
Low density residential, noise sensitive receptors, institutional (school, hospital, worship)	55	55	50	45	55	45	
Suburban residential (medium density), recreational	60		55		55	45	45
Urban residential (high density), mixed development	65		60		55	45	45
Commercial Business Zones	65	70	60	70	65	60	
Industrial Zones	70	70	65	70	70	65	

5 INDUSTRY BENCHMARKING INDICATORS

Resources Use, Energy Consumption, Emission and Waste Generation

These are the guidelines that provide industry benchmarking indicators for resources use, energy consumption, emission and waste generation.

- **EHS Guidelines for Large Volume Petroleum-based Organic Chemicals Manufacturing 2007**

Table below (*Table 31*) provides examples of resources consumption indicators and energy for main products, whereas the next Table (*Table 32*) provides examples of emission and waste generation indicators. Industry benchmark values are provided for comparative purposes only and individual projects should target continual improvement in those areas.

Table 30: Resource and Energy Consumption

Product	Parameter	Unit	Industry Benchmark
Lower Olefins	Energy consumption Ethane feedstock	GJ/t ethylene	15-25
	Energy consumption Naphtha feedstock	GJ/t ethylene	25-40
	Energy consumption Gas oil feedstock	GJ/t ethylene	40-50
Aromatics	Steam	Kg/t feedstock	0.5-1.0
Formaldehyde Silver/Oxide process	Electricity	Kwh/t formaldehyde	100/200-225
VCM	Power	MWh/t VCM	1.2-1.3

Source: EIPPCB BREF (2003)

Table 31: Emissions, Effluents Waste/Co-Products Generation

Product	Parameter	Unit	Industry Benchmark
Lower Olefins	Alkenes	t/y	2500
	CO, NOx	t/y	200
	SOx	t/y	600
	VOC	kg/t ethylene	0.6-10
	Waste Water Flow	m ³ /h	15
	Total Hydroc. losses	% feed/kg/t ethylene	0.3-0.5/5-15
Aromatics	NOx	kg/t feedstock	0-0.123
	SOx	kg/t feedstock	0.0.146
	Hydrogen cyanide	kg/t acrylonitrile	90-120
Acrylonitrile	Acetonitrile	kg/t acrylonitrile	5-32
	Ammonium sulfate	kg/t acrylonitrile	115-200
Caprolactam Basf/Rashig proc.	Ammonium sulfate	t/t caprolactam	2.5-4.5
TDI	COD/TOC	Kg/t TDI	6/2
	Nitrate, Nitrite/ sulfate	Kg/t TDI	15,10/24
VCM	Liquid residues	Kg/t VCM	25-40
	Oxy Catalyst	Kg/t VCM	10-20
	Iron Salts	Kg/t VCM	10-50
	Coke	Kg/t VCM	0.1-0.2

Source: EIPPCB BREF (2003)

- **EHS Guidelines for Petroleum Refining 2016**

These guidelines provide examples of resource consumption, and emission/waste quantities generated per millions of tons of proceeded crude oil. Industry benchmark values are provided for comparative purposes only, and individual projects should target continuous improvement in these areas. *Table 32* and *Table 33* presented those examples in the guidelines.

Table 32 : Resource and Energy Consumption

Parameter	Definition of Parameter	Unit	Industry Benchmark
Total Energy Consumption¹	Total energy consumed by the process, including direct combustion, steam, electricity, etc	MJ per metric ton of processed crude oil	2,300-3,300
Electric Power Consumption¹	Total electricity consumed by the process	kWh per metric ton of processed crude oil	22-31
Fresh Make-up Water²	The supply of eraw filtered water that integrates drift and epeporation losses as well as blowdown	m ³ per metric ton of processed crude oil	0.07-0.66

Note : ¹Based on CONCAWE, EU refinery energy systems and efficiency, Report No. 3/12. (2012);

CONCAWE, Oil Refining Report No. 1/13 (2013); U.S. Energy Information Administration (EIA), Short Term Energy Outlook (2013).

². Based on EC JRC, "BREF Document for the Refining of Mineral Oil and Gas" (2015).

Table 33: Emission and Waste Generation

Parameter	Unit	Industry Benchmark
Wastewater	m ³ /metric ton crude oil	0.1–1.5 ¹
Emissions	Metric ton /million metric tons of processed crude oil	105,000–276,000
CO ₂ ²		70–450
NO _x ³		60–150
Particulate matter		60–300
SO _x ⁴		65–300
Solid waste		10–100

Notes: ¹. Based on European Commission Joint Research Center (EC JRC), "Best Available Techniques Reference (BREF) Document for the Refining of Mineral Oil and Gas" (2015). ². Not all GHGs, only total CO₂. Based on EC JRC, "BREF Document for the Refining of Mineral Oil and Gas" (2015). ³. NO+NO₂ expressed in NO₂ equivalent. ⁴. SO₂+SO₃ expressed in SO₂ equivalent.