**PROCESS DESCRIPTION**

Petroleum refining is the physical, thermal and chemical separation of crude oil into its major distillation fractions which are then further processed through a series of separation and conversion steps into finished petroleum products. The primary products of the industry fall into three major categories:

- Fuels (eg: motor gasoline, diesel and distillate fuel oil, liquefied petroleum gas, jet fuel, residual fuel oil, kerosene and petroleum coke);

- Finished nonfuel products (eg solvents, lubricating oils, greases, petroleum wax, petroleum jelly, bitumen and petroleum coke);

- Chemical industry feedstocks (eg naphtha, ethane, propane, butane, ethylene, propylene, butylenes, butadiene, benzene, toluene, and xylene).

Crude oil, from which petroleum is derived, is a mixture of many different hydrocarbons and small amounts of impurities – such as oxygen, nitrogen, sulphur, salt and water. Its composition varies significantly depending on source. Refineries are a complex system of multiple operations and the operations used at a given refinery depend upon the properties of the crude oil to be refined and the desired products.

Refining can be separated into two stages and a number of supporting processes.

- Stage 1: Desalting and subsequent distillation into its various components or "fractions";

- Stage 2: Conversion of some of the distillation fractions into petroleum products through a range of cracking, coking, reforming, and alkylation processes;

- Supporting operations may include wastewater treatment, heat and power generation, sulphur recovery, additive production, heat exchanger cleaning, blowdown systems, product blending and storage.
The refinery comprises a complex system of stills, crackers, processing and blending units and vessels in which the various reactions take place, bulk storage tanks and packaging units for products for immediate distribution to the retailer. Bulk storage tanks are usually grouped together in bunded tank farms. These “farms” are used for storage of both crude and refined products.

Crude oil can be transferred into the refinery by different modes of transport which include: pipeline, roads, rail and costal or by a combination of these modes such as pipeline and marine tanker. Finished products are transferred out of a refinery to smaller distribution terminals by direct pipeline, marine tanker, road or rail.

Crude oil refineries process large amounts of raw materials and consume substantial amounts of energy. They may also use large quantities of water. Emissions to air and water are generated as well as various solid and liquid waste streams.
KEY ENVIRONMENTAL, HEALTH AND SAFETY RISK/LIABILITY ISSUES

Air Emissions

Introduction

The petroleum refining industry employs a wide variety of processes and associated operations that release emissions to the surrounding environment.

Atmospheric emissions in a petroleum refinery arise from the following refinery processes: separation processes, petroleum conversion processes, and from auxiliary facilities.

Atmospheric emissions arising from separation processes (employing vacuum distillation) are associated with the steam ejectors or vacuum pumps. A major portion of the vapours withdrawn from the column by ejectors or pumps is recovered in condensers. Fugitive hydrocarbon emissions from leaking seals and fittings are also associated with vacuum distillation unit, but these are minimised by the low operating pressures and low vapour pressures in the unit.

Atmospheric emissions from conversion processes employing catalytic cracking include: combustion products from process heaters and flue gas from catalyst regeneration.

Atmospheric emissions arise from process heaters (furnaces), which are used extensively in refineries to supply the heat necessary to raise the temperature to feed materials to reaction or distillation level, as well as, and compressor engines include emissions of sulphur and nitrogen oxides, aldehydes, ammonia, Carbon monoxide (CO) and hydrocarbons.

Summary of Atmospheric Emissions

The principal emissions to air include:

- carbon dioxide, carbon monoxide, oxides of sulphur, oxides of nitrogen, particulates, volatile organic compounds (VOCs) and ammonia;
exhaust gases from the combustion of fuels to generate power, heat and steam;

• flue gases;

• venting and flaring as operational and safety measures;

• fugitive emissions from large numbers of plant items, flanges, pumps and valves with seals, storage tanks, tanker connections, sample points; and

• particulate matter from flue gases, catalyst fines, coke handling, sludge incineration.

Control Technologies

Control technologies applicable to the non-condensable emissions vented from the vacuum ejectors or pumps include venting into blowdown systems or fuel gas systems, and incineration in furnaces or waste heat boilers. These techniques are generally efficient in the control of hydrocarbon emissions.

Some plants will have large numbers of permitted routine process release points, and they vary in size and throughput from the very small to stacks for the discharge of combustion gases from large combustion plant. Permits stipulate limits for specific, named pollutants. In order to control these emissions, the facility is usually required to monitor emissions and submit findings to the authorities. In most instances, it will be illegal to operate and emit pollutants to the atmosphere without a valid permit.

Emission Factors

• Industry emission factors for fugitive leaks arising from the following types of process equipment are given below:

• Valves: (pipeline, open ended, vessel relief) 3,100 kg/day of VOC for approx. 11,500 valves;

• Flanges: 300 kg/day of VOC for approx. 46,500 flanges;

• Seals: (pump, compressor) 590 kg/day of VOC for approx. 350 pump seals 70 kg/day of VOC for approx. 70 compressor seals;

• Process drains: 450 kg/day of VOC from approx. 650 process drains.

Sulphur Recovery

• Sulphur emissions can be minimised by installing high efficiency sulphur recovery units (Claus plants) in refineries and Claus tail gas treating process to bring sulphur recovery yield to 99% or more;

Carbon

CO₂ Capture

In practice, refineries have a large number of process heaters scattered around the site. This makes capture of carbon dioxide (CO₂) capture difficult, extremely expensive or even


2 Recommendations by Expert Group on Techno-Economic Issues (EGTEI)
impractical. However, there is potential for capture of CO$_2$ produced from power generation, hydrogen production and utilities, which represents half the refinery CO$_2$ emission.

**CO$_2$ Abatement. Potential methods for abating CO$_2$**

- Switching refinery fuels away from heavy high sulphur fuel oil towards fuel/natural gas;
- Employing hydrogen pinch analysis techniques to optimise use and CO$_2$ sequestration for Enhanced Oil Recovery (EOR);
- Gasification can be used to provide utilities and hydrogen, whilst at the same time allowing a single point source for CO$_2$ capture.

**Wastewater**

**Introduction**

Large volumes of water are used as process water and for cooling purposes. The largest volume effluents arising from process operations are “sour” water and highly alkaline water.

**Sources of wastewater are discussed below**

Wastewater from the distillation, catalytic cracking, and catalytic reforming processes accounts for the largest amount of wastewater$^3$. Other waste water pollutants include spent potassium hydroxide steam from alkylation, and sour water from thermal cracking / “Visbreaking”.

The wastewater from distillation includes condensed steam from the tower (called oily sour water), which contains hydrogen sulphide and ammonia, and oily wastewater if barometric condensers are used for vacuum distillation.

**Control Technologies for Removal of Contaminants**

In primary treatment the wastewater is separated from free oil and solids are allowed to settle. At this point the water could be discharged to a municipal treatment works for secondary treatment or treated onsite.

In secondary treatment a variety of physical and/or chemical methods are used to separate emulsified oils and remove impurities. A final polishing step may also be included.

Petroleum refineries treating process wastewater on site typically use the following technologies:

- Steam strippers to remove hydrogen sulphide, other sulphur compounds, and ammonia for sour water treatment. It is passed to a sour water stripper unit to remove these contaminants before recycling for onsite use or disposal through an onsite wastewater treatment unit;
- Oil and solids separation using API separator, corrugated plate interceptor, or other type of separator followed by Dissolved Air Flotation (DAF) or settling ponds to remove emulsified oils;
- Biological treatment or aerobic biological treatment (activated sludge or aerated basins) can be used to reduce wastewater organic carbon Biological Oxygen Demand (BOD and COD) “pollution” load. Biological treatment can also remove phenolic compounds;

$^3$ approximately 44% of total wastewater flow rate attributed to distillation process, 26% to fluid catalytic cracking and 10% to catalytic reforming
• Polishing – sand, dual media, or multimedia filtration to remove fine particulates;

• The non-oily/non-sour highly alkaline water must be neutralised before disposal to the wastewater treatment plant.

Liquid effluent also arises from leaks of small quantities of product from equipment, machinery and storage areas.

Flow Rates and Permits

Refinery process wastewater flow rates range between 0.4 to 8.1 Million Gallons per day (MGD)\(^4\). Refinery permits include limitations for Biological Oxygen Demand (BOD) or ammonia. Flow rates from outfalls with nonzero discharges range from 0.09 to 1,240 MGD, with a median flow rate of 2.1 MGD.

**Hazardous Materials and Fire risks**

Petroleum refineries manufacture, use and store large quantities of hazardous materials thereby creating the potential for leaks or accidental releases from equipment, tanks, pipes etc. These materials also pose a risk of fire and explosion due to the flammable and combustible nature of the products.

Processing and storage equipment should meet international standards for structural design integrity and operational performance to avoid catastrophic failure\(^5\). Storage tanks should have appropriate secondary containment. All infrastructure and associated components should undergo regular inspection and maintenance and there should be capital investment programme to support the replacement, upgrade and maintenance of assets.

Equipment should meet international standards for structural design, integrity and operational performance to avoid catastrophic failure and to prevent the build up of static.

Storage tanks should have appropriate secondary containment. All infrastructure and associated components should undergo regular inspection and maintenance.

The American Petroleum Institute (API) Standards 650, 653, and 620 are the primary industry standards by which most above ground welded storage tanks are designed, constructed and maintained. These standards prescribe provisions for leak prevention, leak detection and leak containment.

Organisations should have robust fire risk management systems and emergency response plans in place. Further guidance is provided by the UK’s Health and Safety Executive and the API.

**Improvements**

• Installation of abatement technologies to minimise exposure to toxic raw materials and products, volatile gas emissions and dust, e.g. enclosure of equipment, appropriate ventilation with filters, gas-balancing systems and scrubbers. Recovered material should be recycled into the production process where possible;

• Maintain an up-to-date inventory of all substances present or likely to be present which could be hazardous to health or the environment;

\(^4\) Technical Support Document for the 2004 Effluent Guidelines Program Plan

\(^5\) API Standards 620 & 2610 (2005)
Soil and Groundwater Contamination

Contamination of soil and groundwater may arise due to the loss of crude, refined products or water containing hydrocarbons as a result of storage and transfer operations. Small quantities of contaminated soils or liquids may be managed as hazardous wastes and either treated on site or removed off site for treatment and/or disposal. Larger quantities and gross contamination may require more significant intervention and clean up, especially where it is a hazard or migrating off site.

Potential areas where there is a high risk of contamination include, for example, areas used to load and unload petroleum product, “older” areas of the site (which “historically” stored petroleum product) and where management practices and storage standards may not have been as good as modern day requirements. Also there is a higher risk of contamination of ground and ground-waters from lagoons which are or were used to store waste sludges.

Waste

Refineries produce significant quantities of solid waste including:

- Sludges: Oily sludge from tank bottoms and desalters, non-oily form wastewater treatment;
- Spent catalysts containing a range of metals;
- Sulphur cake from the sulphur recovery unit;
- Solvents;
- General non-refinery wastes, e.g. domestic, demolition, construction.

Petroleum sludge wastes typically are water-in-oil emulsions that are stabilized by fine solids. Sludge usually accumulates in refineries because of pump failures, desalter failure, oil draining from tanks and operation units, periodic cleaning of storage tanks and pipeline ruptures.

Waste Treatment Technologies

Several process technology options for treating petroleum sludge have emerged during the past several years in response to the enhancement of environmental regulation governing these wastes. Some of these technologies are centrifugation, thermal desorption, solvent extraction, and hydrothermal processing. Electrokinetics is a developing technology that is used for in situ remediation of heavy metals and organic contaminants from saturated or unsaturated soils and sediments.

Process wastes should be tested and classified as hazardous or non-hazardous based on local regulatory requirements and international good practice and disposed of appropriately using authorised and licensed waste disposal operators.

A significant proportion of the non-petroleum outputs can be recovered and sold as by-products, e.g. sulphur, acetic acid, phosphoric acid and recovered metals from catalysts.

Improvements

Recommended strategies for management of catalysts:

- Use long-life catalysts and regeneration to extend catalyst life;
- Return spent catalysts (e.g. in desulphurisation and cracking units) to manufacturer for regeneration or off-site specialist companies for material recovery/recycling and correct disposal.
Recommended management strategies for hazardous waste:

- Use delayed coking technologies to recover hydrocarbons from oily sludges;
- Using gravity separators and centrifuges to maximise recovery of oil from oily wastewaters and sludges.

**Energy Consumption & Efficiency**

Refineries consume large amounts of energy to generate electricity, heat and steam. Some refineries have installed combined heat and power plants. Typically more than 60% of refinery air emissions are related to the production of energy.

A number of key processes are the major energy consumers in a typical refinery. These include: crude distillation, hydrotreating, reforming, vacuum distillation and catalytic cracking. Realising measures and opportunities in plants to improve energy efficiency can be carried out using a systematic approach of process integration or pinch technology.

Typical resource and energy consumption of process crude oil for an oil refinery utilising between 200 – 500 hectares for land-use would require:

- Total Energy between 2,100 – 2,900 Maga Jewels per Metric Ton of processed crude oil;
- Electric power between 25 – 48 KWh per Metric Ton of processed crude oil; and
- Fresh make-up water between 0.07 – 0.14 m³ per Metric Ton of processed crude oil.

**Energy Goals**

Overarching energy efficiency goals for oil refineries would be the implementation of more efficient energy technologies as well as to develop innovative partnerships between utilities and refineries to maximise overall electrical and fuel supply system, and taking advantages of the large heat sink that refineries may present.

Innovative energy resources include: building coke gasification plants; make stationary fuel cells and alternative sources available at refinery sites; and taking advantage of gas expansion in refineries (e.g., to generate power).

The off-gases from various refinery unit operations could be converted into valuable chemicals such as hydrogen instead of being sent to flare which contributes to energy loses and greenhouse gas emissions.

However, the refinery off-gases contain large concentrations of sulphur and other impurities such as arsenic that must be removed through desulfurization to prevent the poisoning catalysts used in hydrogen production.

**Fire and Explosion**

The accidental release of syngas, oxygen, methanol and refinery gases during process operations generates fire and explosion hazards. Explosive hazards may also be associated with the accumulation of vapours in storage tanks. Using Vapour Recovery Units for storage tanks as well as for flaring and venting gas should be installed which will reduce the risk of fire and explosions from vapours in refineries.

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European Commission 2003a

International Finance Corporation, Environmental, Health and Safety Guidelines for Petroleum Refining
**Improvements**

- Control the effect of fires and explosions by segregating distancing or process, storage, utility and safe areas;
- Use explosion-proof equipment and conductive materials and ensure that equipment is grounded and bonded;

**Site Security**

Oil refineries could be targets for criminal or terrorist attack and therefore appropriate security measures must be implemented to minimise this hazard.

A site threat and vulnerability assessment analysis should be undertaken and security counter measures should be developed as part of a Security Management Plan. API have developed Security Guidelines for the Petroleum Industry that should be considered.

**Improvements**

- Consider need for upgrades to security measures.

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**Burns and heat stress**

Working at high temperatures can increase the temperature of the working environment which can lead to heat stress for those working in the vicinity. Contact burns can result from contact with hot equipment especially during maintenance activities.

Heat stress injuries can be prevented through the implementation of an effective heat stress program as described in the The American Conference of Governmental Industrial Hygienists (ACGIH).

Using Wet Bulb Globe Temperature (WBGT) to evaluate the environment, a WBGT Index gives work/rest regimens based on the WBGT and the metabolic rate of the worker. The ACGIH guidelines identify several measurable indicators of excessive heat strain for healthy working adults. Body core temperature should not exceed 38°C for unacclimatied workers or 38.5°C for medically selected acclimatized workers. Sustained heart rate should not exceed 180 beats per minute (bpm) minus the worker’s age and the one-minute recovery heart rate should not exceed 110 bpm. Weight loss from sweating should not exceed 1.5% of body weight. Other non-measurable indicators include severe fatigue, nausea, dizziness, or light-headedness.

**Chemical Exposure**

Workers may be subject to potential inhalation hazards (e.g. hydrogen sulphide, carbon monoxide, VOCs, polycyclic aromatic hydrocarbons) during routine plant operations. The use of certain chemical substances in the refining process may lead to chemical burns.

Protective and preventative measures should be introduced to eliminate or disrupt source-
pathway-receptor relationships. This can be achieved by eliminating the hazard, controlling the hazard, minimizing the hazard and providing appropriate personal equipment (PPE).

An Occupational Health and Safety Plan that should include specific job related risk (maintenance of air quality levels of contaminant, dust vapours and gases for workers in close proximity to storage tanks and recommend limits). In addition, the Management Plan should provide a means of training workers in the use of the available information on substances from Materials Safety Data Sheet.

Protection measures should include worker training, work permit systems, use of PPE, and toxic gas detection systems with alarms.

Time-weighted average (TLV-TWA) and short-term exposure limit (TLV-STEEL) Threshold Limit Values (TLVs) should be used as recommended by ACGIH.

**Confined Spaces**

Confined spaces at refineries typically include storage tanks, secondary containment areas and wastewater management infrastructure. Such spaces are dangerous and entry to them must be strictly controlled and avoided wherever possible. The health and safety system should control access to confined spaces via what is termed a permit to work system (which is an internal control process operated by companies rather than an external authorisation). Workers entering storage tanks for cleaning and inspection purposes must be provided with appropriate personal protective and respiratory equipment

**Machinery**

All equipment should have safety guarding and workers should be issued with appropriate personal protective equipment to protect them and to avoid sharp items and edges and avoid workers becoming trapped and/or injured.

**Manual Handling and Repetitive Work**

Lifting and carrying heavy or awkwardly shaped objects, such as equipment or bags, can result in manual handling injuries.

**Noise and Vibration and Odour**

The principal noise sources are:

- Heavy rotating machinery such as turbines, pumps, compressors, motors;
- Pressure release through flaring or steam valves;
- Coolers and furnaces;
- Truck movements.

**Odour**

Emissions of VOCs and sulphur compounds can cause odour problems at the site and in the surrounding area.

**Permitting**

Refineries in the EU are subject to national regulations under the Integrated Pollution Prevention and Control Directive (2008/1/EC) and the Seveso II (1996/82/EC), which aims to control the major accident hazard from dangerous substances. Operations outside the EU will still be subject to local regulation and
will require an environmental and/or operating permit.

Legal entities in the EU manufacturing, importing or using certain chemical substances (including petroleum and petroleum bi-products as well as fuel additives) may be subject to a new EU regulation called the Registration, Evaluation and Authorisation of Chemicals (REACH) (1907/2006). This legislation may also apply to companies exporting petroleum and refinery products directly to the EU. This regulation places potentially new requirements on “users/manufacturers” to evaluate and control the health and environmental risks associated with certain substances.

**Polychlorinated Biphenyls (PCBs) and Asbestos**

- PCBs are a group of substances which are good electrical insulators. Typically, PCBs may be present as constituents of hydraulic oils or dielectric fluids in electrical switchgear, transformers and fluorescent light starters;

- Asbestos has been used on a large scale for many years as a fireproofing and insulation material and may be encountered in a wide range of forms including asbestos cement boards, as fire retardant gaskets in pipe work and as fire retardant insulation around boilers and furnaces.

Both PCBs and asbestos are hazardous to health and an organisation’s existing management systems and practices should recognise these risks and potentially have programmes in place to mitigate or remove risks associated with these materials.

Particular attention should be given to buildings constructed before the 1980s.

**Storage Tanks**

Storage tanks are used through the process to store crude oil, intermediate and final products. The contents of tank bottoms (a sludgy mixture of iron rust, sand, oil, water, emulsified oil and wax) are periodically removed to prevent build-up and during cleaning. These tanks may be fitted with fixed or floating roofs depending on their volatility and account for considerable VOC emissions at refineries through seals and vents.

**Slips, Trips and Falls**

This often takes the form of people being hit by moving, flying or falling objects.

Slips, trips and falls are primarily caused by uneven surfaces, inappropriate footwear, lighting, weather conditions, trailing cables and pipe work especially during unblocking, maintenance and cleaning activities.

There are many ways to protect from slips, trips, and falls. Even so, they still happen and the following measures are means to either prevent slips, trips, and falls or to minimize the consequences if they should happen.

- Wear personal protective equipment (such as hard hats, work gloves, safety shoes, and eye protection).

- Be aware of the slipping and falling hazards when working on the drilling floor, servicing rig floors or other platforms.

- Keep all work areas clean and clear of oil, tools, and debris.

- Use non-skid surfaces where appropriate.
• Provide guardrails and guards around work areas that are prone to slips, trips, and falls.

• Install, inspect, and secure stairs and handrails.

• Instruct workers on proper procedures for using and installing ladders.

• Use only ladders in good repair that do not have missing rungs.

• Do not install stairs with missing or damaged steps. Repair them before installing them.

• Keep walkways clean and free of debris and tripping hazards.

• Keep all cords and hoses orderly and clear of walking spaces.

• Cover open cellars.

• Conduct a pre-job inspection to identify, then eliminate or correct hazardous work surfaces.

• Keep aisles and passageways clear and in good repair, with no obstruction across or in aisles that could create a hazard. Provide floor plugs for equipment so power cords need not run across pathways.

• Use waterproof footwear to decrease slip/fall hazards.

**Water Abstraction / Consumption and Efficiency**

Refineries consume significant quantities of fresh water. Where water is abstracted it is typical for abstraction or water use permits to detail volumes of water abstraction allowed, as over abstraction can impact local communities and also natural resources.

Drinking water sources, whether public or private, should be protected so that they meet or exceed applicable national standards or in their absence the current edition of World Health Organisation (WHO) Guidelines for Drinking-Water Quality.

Water requirements for site workers and staff can be utilised through groundwater and surface water abstraction and should be properly assessed using testing techniques/lab analysis and water drawdown modelling. Guidelines for water availability should follow World Health Organization (WHO) Standards of 100 litres/day as the amount required to meet all consumption and hygiene needs.

**Improvements**

• Using a high pressure power washer instead of a chlorinated solvent degreaser;

• Use flow reduction equipment to control the volume of water used in cleaning operations, e.g. spray nozzles, high-pressure/low-volume washers;

• Reuse hydro test waters (water used for leak testing pressurised systems) for multiple tests.
**KEY SOCIAL, LABOUR AND COMMUNITY RISK/LIABILITY ISSUES**

**Major Accidents**

Accidental leaks of toxic compounds and the presence of flammable gases and liquids pose the most critical hazards to community health and safety during product handling/processing and transport outside the processing facility.

Major accidents from explosions, fires, and emissions of dangerous substances can lead to fatalities, injury, and production downtimes and must be managed to improve hazard incident rates. An integrated approach to HSE and Asset Management should be used to improve safety. A detailed risk-based process safety management (PSM) program should be implemented with the following recommendations:

**Improvements**

- Conduct a facility wide risk assessment, including detailed consequence analysis for events with a likelihood above $10^{-4}$/year.

- Maintain on site abatement equipment and treatment plant.

- Good housekeeping should be maintained at all times in all areas.

- Provision of personal protective equipment (PPE) that is fit for the task to prevent injury and maintain hygiene standards. Staff should be trained in the correct selection, use and maintenance of PPE.

- Train workers in correct use of machinery and safety devices.

- Redesign manual processes to avoid heavy lifting/repetitive activities.

- Install mechanical lifting aids where possible and rotate work tasks to reduce repetitive activities.

- Separate people from moving equipment:
  - Ensure that the process layout reduces opportunities for process activities to cross paths;
  - Install safeguards on moving parts of conveyor belts to reduce risk of entrapment of employees;
  - Install walkways to separate people from vehicle movements so as to reduce risk of collision;

- Establish formal communication channels and procedures with the emergency services and other relevant authorities for use in the event of an accident.

- Provide local fire department with list of products and volumes stored on the premises.

- Construct walkways of non slip materials.

- Provide a good standard of lighting.

- Install automatic alarms and shut off systems.

- Implement a programme of assessment of routine monitoring of worker health.

- Involve the neighbouring community in the creation and practice of plans to respond to major incidents at the installation.
**Public Anxiety**

Public anxiety, particularly from neighbouring residents, can be caused by a lack of knowledge regarding the nature of the chemicals and products being stored on the site, odours from the site, the potential for fires and explosions and the action that will be taken in the case of an accidental release. This public anxiety can result in significant planning constraints being imposed on this type of facility.

A Stakeholder Management would highlight concerns of the project area/site from residents and the community. Consultations through early communication program and exhibition concept programs can be carried out whereby the environment, social, and community issues of the project are highlighted.

A health and safety management plan that would includes hazard incident reporting, emergency preparedness and response for the prevention and control of fires and explosion hazards should be developed to allay any resident fears and anxieties. Management should also have a system to record and act on complaints from the community and wider stakeholders.

**OTHER SOCIAL, LABOUR AND COMMUNITY RISK/LIABILITY ISSUES**

**Nuisance**

Nuisance caused by noise, light and smoke emissions (flaring) and smell may directly impact the local population and may become issues for discussion and unrest.

**FINANCIAL IMPLICATIONS**

- Many countries are signatories to the Kyoto Protocol and have adopted targets for the reduction of CO\textsubscript{2} emissions. Where Governments have set up carbon emission reduction programmes industrial processes have been required to reduce their CO\textsubscript{2} emissions through the setting of targets. This can result in a need for substantial investment in new/clean technologies to achieve the emission targets. These targets may be reflected in environmental permits or fiscal measures such as environmental and/or energy related taxes;

- Under the EU Emissions Trading Scheme (ETS) Member States of the EU, allocate allowances for carbon emissions to industrial sites, including refineries. The scheme can create both financial assets (refineries have emitted less carbon than set) and liabilities (refineries have emitted more carbon than set) and entities can trade their carbon allowances.

- In many countries, new standards for fuels are being set, for example, the amount of sulphur permitted in fuel. This regulation is being set to reduce the amount of air pollution from vehicles. New standards for fuels may be set in permits and/or contracts with customers and may require investment in new technology or lead to increases in the cost of operating plant.

- Injuries may lead to increased payroll costs to replace skilled workers and lost production time.

- Capital investment may be required to comply with new environmental, health and safety requirements.
• There is a relatively high potential for soil and groundwater contamination to be present which can be very costly to remediate.

• Fines, penalties and third party claims may be incurred for non-compliance with environment, health and safety regulations.

• The value of assets on balance sheets may be impaired by pollution and financial provisions may have to be set aside to address these.

**IMPROVEMENTS**

This section considers potential measures which may be considered to improve the EHS performance of an organisation. This section is intended to be a checklist of issues to be considered rather than providing detailed specifications on design characteristics which can be found in supporting references attached to this guide.

**Environmental, Health and Safety**

**General Guidelines**

• Management systems should be in place for EHS, which will include EHS training to employees.

• Good housekeeping should be maintained at all times in all areas to reduce the likelihood of incidents and accidents.

• EHS and fire risk management systems and asset management plans should be subject to frequent and proper inspection.

• Routine plant maintenance to keep small leaks and spills to a minimum and maintain plant efficiency.

• Facility wide risk assessments, including detailed consequence analysis for significant risk events such as fire, explosions and potential structural collapse of storage containers should be in place. Ensure the risks are addressed in the relevant management systems and the emergency response plan.

**Air Emissions**

• Implement a formal Leak Detection and Repair (LDAR) programme and where necessary, replace with higher quality items, any equipment which generate significant fugitive emissions.

• A vapour recovery system should also be used to reduce and/or capture VOC and other fugitive and exhaust emissions.

• Minimise storage and working evaporative losses of VOC by installing floating roofs and seals. When feasible upgrade tank systems by installing variable vapour space tanks such as flexible diaphragm tanks.

• Improve systems to control VOC emissions when handling and storing liquids.

• Minimise leakages and fugitive releases from pipe work through use the use of appropriate corrosive resistant materials and leak proof valve and pump design.

• Regular inspection should be carried out of all infrastructure on site to prevent leakage and product loss.
**Energy Management**

- Use heat exchangers to heat crude oil prior to distillation and cool steams after distillation.

- Recover waste oils, oily sludges from tank bottoms and desalters and hydrocarbon vapours and recycle into process where possible.

- Use *excess/or recover* gases to generate electricity.

**Health, Safety and Fire Risk Management**

- Ensure there is strict enforcement of a no naked flame/no smoking policies.

- Potentially install abatement technology to minimise employee exposure to petroleum liquid and volatile organic gas emissions and dust, e.g. enclosure of equipment, appropriate ventilation and recovery systems with filters and gas-balancing systems. Recovered material should be recycled into the production process where possible.

- There should be provision of personal protective equipment (PPE) that is fit for the task to prevent injury and maintain hygiene standards. Staff should be trained in the correct selection, use and maintenance of PPE.

- Redesign manual processes to avoid heavy lifting/repetitive activities.

- Install mechanical lifting aids where possible and rotate work tasks to reduce repetitive activities.

- Have systems in place which separate people from moving equipment, wherever possible, for example:
  - Ensure that the layout of the site and activities reduces opportunities for processes and activities to cross paths;
  - Install walkways to separate people from vehicle movements to reduce risk of collision.

- Maintain an up-to-date inventory of all substances present or likely to be present which could be hazardous to health or the environment. Document the risks associated with each substance and how it should be handled.

- Provide the local fire department with list of products stored on the premises and their volume. Provide them with an agreed copy of the emergency response plan.

- Emergency storage lagoons may be needed to prevent contaminated firewater reaching controlled waters.

- Establish formal communication channels and procedures with the emergency services and other relevant authorities for use in the event of an accident;

- Control the effect of fires and explosions by segregating distancing or process, storage, utility and safe areas.

- Use explosion-proof equipment and conductive materials and ensure that equipment is grounded and bonded.

- Ensure fire suppression equipment meets internationally recognised specifications for the type and quantity of products held.

- Consider need for upgrades to security measures.
• Implement a programme of assessments and routine monitoring of worker health.

**Noise**

• To reduce the risk of noise exposure isolate noisy equipment and rotate tasks to minimise time spent in a noisy areas over time and provide personal protective equipment where people have to enter noisy areas.

**Soil and Groundwater Contamination**

• Contaminated or potentially contaminated storm water should be collected and routed to a treatment plant;

• Provision of secondary spill containment for bulk storage tanks and silos;

• Regular inspection should be carried out of all bulk containment on site to prevent leakage and product loss;

• Emergency storage lagoons may be needed to prevent contaminated firewater reaching controlled waters;

**Slips, Trips and Falls**

• Route cables and pipe work under walkways to prevent slips, trips and falls;

• Construct walkways of non slip materials;

• Provide a good standard of lighting;

• Install walkways to separate people from vehicle movements to reduce risk of collision;

• Ensure that the process layout reduces opportunities for process activities to cross paths.

**Water and Wastewater**

• Use of process water as desalter wash water:

• Desalting and dewatering of crude oil upstream of the crude distillation unit is a key process operation for the removal of undesirable components from crude oil before it reaches any of the major unit operations. Crude oil is heated to a temperature of 230-300°F/110-149°C. Water containing low levels of impurities is injected into the crude oil. Next, this stream of oil and water is subjected to high shear in order to thoroughly mix the wash water into the crude oil, thereby diluting the impurities. This shearing action produces a relatively stable water-in-oil emulsion. The emulsion enters a desalting vessel where the emulsion is resolved with the assistance of residence time and an electric field. Ideally, the process results in crude oil that is relatively free of water soluble impurities and a brine stream that is free of oil

• Control the temperature of the wastewater to reduce volatilisation and to secure the performance of the biological treatment.

• Reuse heated wastewater to warm the cold water supply.

• Reduce the need for additives in hydro test waters by minimising time water is in equipment or pipe. Use additives with lowest environmental impact.

• Control the surfactants entering the waste water.

• Source segregate and pre-treat concentrated wastewaters.
• Water containing additives (corrosion inhibitors, dyes etc) is used to pressure test equipment and pipelines. This water should be reused for multiple tests prior to disposal.

• Some of the wastes associated with water treatment will be hazardous. Wastewater treatment plants are significant sources of air emissions and discharge limits will be regulated;

• Cooling water does not normally come into direct contact with process oil streams and contains less contaminants than process water and can be recycled.

Social, Labour and Community Improvements

• Involve the neighbouring community in the creation and implementation of EHS and emergency response plans, especially proposals to respond to major incidents at the installation.

GUIDE TO INITIAL DUE DILIGENCE

SITE VISITS

During the initial site visit, the issues will vary according to the type of product being produced and depending on the level of environment, health and safety management already introduced. While visiting the site it is important to discuss and review the following:

Environmental, Health and Safety

General Guidelines

• Confirm organisational responsibilities and systems for EHS and social issues and check that EHS systems cover both all employees and contractors.

Air Emissions Management

• What systems and resources are in place to ensure the facility complies with permitted air emission limits (including air emission limits related to occupational health)? If relevant, is the facility compliant with permitted air emission limits and if not, what measures and investments are required to ensure compliance?

Health Safety and Fire Risk Management

• Are staff wearing Personal Protective Equipment?

• Check signage around the site:
Does the signage convey the health and safety risks?

Are fire exits and/or evacuation routes clearly marked?

Are there demarcated routes for pedestrians and vehicles?

Is fire fighting and first aid equipment available? Is there trained and competent fire fighting resource on site?

Check the age and condition of equipment, look for signs of wear and tear, degradation, leaks and breaks.

**Inspections and Incidents**

Check the conditions and duration of validity for all permits.

Take note/ask questions relating to any activities that address the improvements listed in the improvements section of this document.

Have the premises been inspected recently by the regulatory authorities for health, hygiene and environment? What were their findings?

Has the organisation been subject to environment, safety or quality audits by customers/insurers? What was the outcome of these audits?

Does the organisation have insurance in place to cover the recall of contaminated/faulty product? Have there been any recent product recall incidents?

Does the organisation have insurance to cover any significant damage to the environment/community/operations? Review the terms of the insurance cover?

Have there been any recent incidents on site such as fatalities, fires/explosions, spills? Is insurance in place to cover such incidents? Is any legal action likely?

Does the business plan have line items for Environment, Health and Safety improvements as well as asset management and maintenance?

**Investment**

Where are the organisations main markets? Are they manufacturing or exporting to the EU? Will new product standards such as REACH regulation be relevant? Could the organisations markets and hence revenue be impacted by REACH? Is investment required?

Review budgets for capital expenditure (capex) and operational expenditure to cover EHS matters. Does the business plan have line items for environment, health, safety and social improvements as well as asset management and maintenance?

If investment or refinancing will lead to restructuring of the organisation what will be the potential impacts on health and safety at the operation and wider community? Have these been considered and assessed by the company?

If the company plans to invest in new technology, what will be the impacts and benefits for human resources?
**Noise and Odour**

- Note the noise levels at the site. Is there any evidence of noise abatement measures deployed?
- Note any odours that might cause a nuisance;

**Storage**

- Check the condition of storage facilities for raw materials and finished products;
- Check whether audits are undertaken to monitor the condition of storage equipment. If they are, review findings of the most recent audits;
- Discuss procedures to check the source of raw materials and/or materials for waste incineration;
- Check for automatic safeguards on machinery to prevent accidental injury;

**Water Abstraction & Management**

- What amounts and quality of water are required? Where is the water obtained from? Is the water recycled? If changes are proposed will there be adequate water resources to meet any planned increases in production? Have the potential impacts been Assessed?

**Waste Water Management**

- What liquid effluents are produced? What discharge control measures are employed?
- Check the condition of the wastewater treatment plant and location of discharge points for wastewater from the facility. Note the colour and appearance of adjacent watercourses;
- Note whether the wastewater treatment plant discharges to a local watercourse or the municipal wastewater treatment works. Higher environmental risks will be associated with facilities discharging to water courses;
- Is effluent and wastewater treated before discharge? If so, check the condition of the treatment plant and location of discharge;
- What does the quality of these discharges look like? Note the colour and appearance of adjacent watercourses;
- Is the water quality tested? What are the waters tested for? Where are the samples taken from, how often? Do the discharges have to meet set standards? Does the waste water treatment plants have the capacity to deal with any planned expansion at the site?

**Waste Storage**

- Check that solid waste storage and disposal (storage equipment) is in a good condition;
- Check that waste storage areas are clear of debris and that skips are covered to prevent waste escaping, for example, check that waste containers have lids or are stored in an area with a roof;
- Does the organisation have lagoons on site to store oil contaminated waste? Have these lagoons been on site for some time or are they been developed relatively recently?

**Financials and Risk Management**

- Does the organisation have insurance to cover any significant damage to the environment/community/operations (this
may be covered by public liability insurance or the organisation may be party to an industry insurance scheme). Review the terms of the cover.

- Does the organisation have insurance in place to cover the recall of “contaminated” oil products? Have there been any recent product recall incidents?

- Does the business plan have line items for environment, health and safety improvements as well as asset management/maintenance? Are financial provisions set aside to meet the organisations environmental obligations? If yes are these provisions appropriate?

- If the company plans to invest in new technology, what will be the impacts and benefits for human resources?

- Check the conditions and duration of validity for all permits. Is the company required to comply or implement any EHS improvement plans?

**Social, Labour and Community**

- Check that labour standards, contracting and remuneration are in line with national law and are consistent with the average for the sector.

- Check that hours worked, including overtime, are recorded and staff should receive written details of hours worked and payment received.

- Check that wages and working hours are consistent with the average for the sector and national standards.

- Has the Company received inspections from the local labour inspectorate in the previous three years? Have these resulted in any penalties, fines, major recommendations or corrective action plans?

- Does the organisation have a grievance mechanism which allows employees to raise workplace concerns?

- Are employees free to form, or join, a worker’s organisation of their choosing?

**ACTION PLANS**

**Environmental, Health and Safety**

Dependent on the individual business, select appropriate improvements from the list above to include in the action plan. As a minimum, any business should be required to have the following in place:

- Operational procedures to manage environmental, health and safety and social risks;

- Monitoring programmes;

- Improvement objectives, targets and project plans;

- Training for personnel;

- Plans for asset management;

- Regular inspections, checks and audits with records to demonstrate achievement of the required level of performance against legal requirements and improvement action.
• Emergency plans for environment, health and safety accidents or hygiene non-compliance.

• Waste management plans.

• Plans to deal with closure and remediation and/or decommissioning of the site.

• Management review/demonstrated involvement in environment, health, safety and hygiene management.

• Strategic and operational plans which account for EHS issues.
REFERENCES AND ADDITIONAL SOURCES


