

36 OIL REFINERIES AND PETROCHEMICAL PLANTS

Oil Refineries

Because of their inherent hazards, especially from explosion, fire, and chemicals, oil refineries are tightly regulated places in which to work. Work permits must always be obtained and followed. Plant practices, warnings, and emergency procedures must be observed at all times. When in doubt, remember to exercise your “right to know” under WHMIS legislation. Check labels and MSDSs. Any required protective equipment and procedures must be explained and available when hazardous exposure is possible.

Introduction

Crude oil is a complex mixture of thousands of different hydrocarbons and varying amounts of other compounds containing sulphur, nitrogen, and oxygen as well as salts, trace metals, and water. Crude oils can vary from a clear liquid, similar to gasoline, to a thick tar-like material needing to be heated to flow through a pipeline.

A petroleum refinery's main job is to split crude oil into its many parts (or fractions) which are then reprocessed into useful products. The type, number, and size of process units required at a particular refinery depends on a variety of factors including the type of crude oil and the products required. The interconnected units making up a refinery are a maze of tanks, furnaces, distillation towers (fractionating columns), reactors, heat exchangers, pumps, pipes, fittings, and valves.

Products of crude oil refineries include

- **fuels** such as gasoline, diesel fuel, heating oil, kerosene, jet fuel, bunker fuel oil, and liquified petroleum gas
- **petroleum solvents** including benzene, toluene, xylene, hexane, and heptane, which are used in paint thinners, dry-cleaning solvents, degreasers, and pesticide solvents
- **lubricating oils** produced for a variety of purposes, and insulating, hydraulic, and medicinal oils
- **petroleum wax**
- **greases**, which are primarily a mixture of various fillers
- **asphalt**.

These products can be hazardous not only in their final state but as they are being processed and refined.

Health and Safety Hazards

The plant and equipment of refineries are generally modern, and the processes are largely automatic and totally enclosed. Routine operations of the refining processes generally present a low risk of exposure when adequate maintenance is carried out and proper industry standards for design, construction, and operation have been followed. The potential for hazardous exposures always exists, however.

Because of the wide variety of hydrocarbon hazards and their complexity, it is impossible to identify all of the hazards here – and impossible for construction crews to know

everything they may need for protection when performing maintenance, repair, or installation work in an oil refinery.

As a worker you must depend on the knowledge available from the plant operating and maintenance staff, normally available through your employer. If there is reasonable doubt about a situation in which you find yourself, exercise your “right to know” and make use of WHMIS to obtain the information, equipment, and procedures necessary to protect yourself and your fellow workers.

Hazardous Chemicals

In a refinery, hazardous chemicals can come from many sources and in many forms. In crude oil, there are not only the components sought for processing, but impurities such as sulphur, vanadium, and arsenic compounds. The oil is split into many component streams that are further altered and refined to produce the final product range.

Most, if not all, of these component stream chemicals are inherently hazardous to humans, as are the other chemicals added during processing.

Hazards include fire, explosion, toxicity, corrosiveness, and asphyxiation. Information on hazardous materials manufactured or stored in a refinery should be supplied by the client's representative when a work permit is issued.

Fire and Explosion

The principal hazards at refineries are fire and explosion. Refineries process a multitude of products with low flash points. Although systems and operating practices are designed to prevent such catastrophes, they can occur. Constant monitoring is therefore required. Safeguards include warning systems, emergency procedures, and permit systems for any kind of hot or other potentially dangerous work. These requirements must be understood and followed by all workers.

The use of matches, lighters, cigarettes, and other smoking material is generally banned in the plant except in specially designated areas.

Health and Hygiene Hazards

Table 1 highlights major potential air contaminants which can escape from a typical refinery operation and their major sources. It does not attempt to identify all such possible hazards.

Table 2 reviews common hazardous chemicals and chemical groups typically present and their most significant hazards to workers.

Care should be exercised at all times to avoid inhaling solvent vapours, toxic gases, and other respiratory contaminants. Because of the many hazards from burns and skin contact, most plants require that you wear long-sleeved shirts or coveralls.

Major Shutdown and Maintenance

The principal exposures to hazardous substances occur during shutdown or maintenance work, since these are a deviation from routine operations. Plant turnarounds require careful planning, scheduling, and step-by-step procedures to make sure that unanticipated exposures do not occur. Any plant shutdown requires a complete plan in writing to cover all activities, the impact on other

Table 1 – Major potential air contaminants

Air Contaminants	Major Sources
Hydrocarbon vapours — compounds of carbon (C) and hydrogen (H)	<ul style="list-style-type: none"> • transfer and loading operations • storage tanks • crude unit, atmospheric, and vacuum towers • cracking units (“cat”, hydrocracking, coking–polynuclear aromatic hydrocarbons [PAHs] and high-boiling aromatic hydrocarbons [HBAHs] are of concern because of their carcinogenic potential) • rearranging and combining processes such as reformers and alkylation units • treating operations • cracking unit regeneration • heat exchangers • boilers and heaters • pumps, valves • cooling towers
Sulphur dioxide (SO ₂)	<ul style="list-style-type: none"> • boilers • cracking unit regeneration • treating operations • flares
Carbon monoxide (CO)	<ul style="list-style-type: none"> • rearranging and combining processes such as reformers and alkylation units • catalyst regeneration • flares • boilers • furnaces
Nitrogen dioxide (NO ₂)	<ul style="list-style-type: none"> • flares • boilers
Hydrogen sulphide (H ₂ S)	<ul style="list-style-type: none"> • sour crudes • liquid wastes • pumps • crude tower • cracking operations • rearranging and combining processes such as reformers and alkylation units • hydrogenation
Particulates	<ul style="list-style-type: none"> • catalyst dusts – cracking units, catalyst regeneration, and rearranging and combining processes such as reformers and alkylation units • petroleum coke dust – cracking units
Chlorine (Cl or Cl ₂)	caustic unit
Ammonia (NH ₃)	compressors

operations, and emergency planning. Plans are normally formulated by plant personnel in conjunction with contractors.

Construction personnel should always keep in mind the responsibilities of the various workplace parties under the *Occupational Health and Safety Act*, the regulations for construction projects, and WHMIS legislation. This should especially be considered in the bidding and planning stages of any contract to ensure that the refinery provides all of the required health and safety information.

Common Hazardous Materials

Table 2 lists common hazardous materials that may be encountered on a refinery site. Note, however, that the table is not all-inclusive. See the chapters on WHMIS and Basic Occupational Health in this manual. WHMIS labels and MSDSs provide detailed information for specific products.

Table 2: Common Hazardous Materials

Material	Dominant Hazard
Additives	– usually skin irritants
Ammonia	– toxic on inhalation
Asbestos	– designated substance under construction regulations. See chapter on asbestos in this manual.
Asphalt	– dermatitis (can be photosensitizer)
Benzene	– designated substance under industrial regulations
Carbon monoxide	– toxic on inhalation
Caustic soda	– corrosive to skin and eyes
Chlorine	– corrosive to skin and tissue on contact or inhalation
HBAHs (high boiling aromatic hydrocarbons)	– potential carcinogens
Hydrofluoric acid	– corrosive to skin and tissue on contact or inhalation
Hydrogen sulphide	– toxic on inhalation
MEK (methyl ethyl ketone)	– corrosive to skin
Nitrogen	– asphyxiant
PAHs (polynuclear aromatic hydrocarbons)	– potential carcinogens
Phenol-acid	– corrosive to skin and tissue
Silica	– designated substance under industrial regulations
Sulphuric acid	– corrosive to skin and tissue on contact or inhalation
Sulphur dioxide	– toxic on inhalation

Maintenance Hazards and Precautions

Tank Cleaning

Hydrogen sulphide is a potential problem in the transport and storage of crude oil. The cleaning of storage tanks presents a high hazard potential. Many of the other classic confined-space entry problems can occur here, including oxygen deficiency resulting from previous inerting procedures, rusting, and oxidation of organic coatings. Carbon monoxide can be present in the inerting gas. In addition to H₂S, depending on the characteristics of the product previously stored in the tanks, other chemicals that may be encountered include metal carbonyls, arsenic, and tetraethyl lead.

“Alky” (Alkylation) Unit

The lightest fraction from the crude unit is first processed in the gas plant. Some of the liquid hydrocarbons from the wet gas are run straight to the gasoline blending plant, but others go through the alkylation process. These light parts are put together using hydrofluoric acid or sulphuric acid as catalysts.

The main hazards in this process come from possible exposure to the catalysts, hydrofluoric acid or sulphuric acid, and their dusts, byproducts, and residues as well as hydrogen sulphide, carbon monoxide, heat, and noise.

Other processes utilize acid catalysts and caustic “washes.” These can lead to hazardous situations, especially in shutdowns where a contractor’s personnel may be exposed to residues or other contaminants. Information is required from refinery personnel and specialized training is required in the necessary

procedures and personal protective equipment, including its care and use.

Confined Spaces

On most jobsites there are potential confined space hazards. These hazards are multiplied, however, on a refinery site because of the complex collection of tanks, reactors, vessels, and ducts combined with a wide variety of hazardous chemicals and emissions, often in enclosed areas. Many of these chemicals can produce oxygen-deficient, toxic, or explosive atmospheres. Knowledge of general confined space procedures and specific in-plant requirements are both critical in refinery work. For more information, refer to the chapter on Confined Spaces in this manual.

Safe Work Practices and Procedures

Personnel

- Hearing protection and safety glasses must be worn in all operating areas or as posted.
- Respiratory protection or equipment must be fit-tested. Facial hair is unacceptable where the mask must make an airtight seal against the face.
- Shirts must be long-sleeved and worn with full-length pants or coveralls.
- Clothing must not be of a flammable type such as nylon, Dacron, acrylic, or blends. Fire-resistant types include cotton, Nomex, and Proban.
- Other PPE required may include acid hood, impervious outerwear, rubber boots, face shields, rubber gloves, disposable coveralls, monogoggles, and fall-arrest equipment.
- Smoking is allowed only in designated areas.

Vehicles

- Vehicle entry is by permit only and keys are to be left in parked vehicles.
- Vehicles must be shut down at the sound of any emergency alarm.
- Vehicles must be equipped with ground straps or cables.

Permit Systems

No work takes place in a refinery without a safe work permit. A safe work permit is a document issued by an authorized representative of the client permitting specific work for a specific time in a specific area. Work permits should indicate the date and time of issue, the time of expiry, a description of the work to be done, and the name of the company performing the work. Permits also specify any hazards and controlled products under WHMIS and any protective equipment needed for the job. The permit will advise you of any steps required to make the area or equipment safe for work, tell you the results of any gas tests, advise you of any electrical lockouts that have been done, and tell you of any work practices required for the specific job.

Safe work permits are valid only for a limited time and **must be renewed** following expiry or normally after any one-hour stoppage, after an emergency warning on the site, or for other safety reasons. After such an event, any required gas testing or other testing must be repeated to ensure a safe return to the work.

The types of safe work permits required typically include the following. Specific categories may vary from site to site.

- **Hot work** – covers any work that involves heat or an ignition source, including welding, grinding, and the use of any kind of motor. In high-risk areas, a spark watch may be required.
- **X-ray and radiation**
- **Benzene** – required when a benzene exposure hazard exists.
- **Confined space entry hot work** – involving potential ignition hazards.
- **Confined space entry cold work** – involving work that will not produce a spark.
- **Hoisting** – permit.
- **Electrical** – for other than routine work.
- **Camera** – typically requires a hot work permit when lighting is required.
- **Asbestos** – required whenever an asbestos exposure hazard exists.
- **Vehicle movement**
- **Hydrant** – permits the use of plant fire hydrants.

Special Authorization Permits

In addition to safe work permits, special authorization permits are normally required for the following operations:

- excavation
- hoisting with major mobile equipment
- hot tap and non-conventional repairs
- opening live flare lines
- temporary electrical facilities.

Emergency Warning System and Procedures

In oil refineries there will be both plant alarms or whistles and individual unit alarms. All workers must receive training in recognizing and responding to these alarms. Verbal messages usually accompany the alarms.

There will be different alarms for a fire emergency and toxic alarms.

- When an alarm sounds, secure all equipment and shut down all vehicles.
- Note the wind direction (wind socks) and proceed to the appropriate assembly area (or safe haven).
- Do a head count to make sure all personnel are accounted for and report the result to a client contact person.
- Know the local designated safety areas or safe havens and emergency phone number(s).

If you are the one who is first aware of an emergency, then call the emergency number.

- Report your name.
- Describe the emergency.
- Identify its location.
- Indicate whether anyone is injured.
- Proceed to the assembly area.

Electrical Precautions

- Electrical tagging and lockout procedures must be understood and followed by all workers.
- All electric tools, cords, and equipment must be grounded or double-insulated.
- Use explosion-proof fixtures where required.

Sewers

- Sewers must be covered when hot work is being done in the vicinity.
- Sewer covers must be in good condition with no openings for vapour flow.
- Sewer covers are to be removed when hot work is discontinued at the end of the job or overnight to accommodate drainage.

Blinding or Blanking-off

- Piping connected to a work area from vessels, pumps, and other sources is isolated or blinded with a solid plate prior to the start of work.
- Blanking can sometimes be done with two valves and a bleeder valve between them. In this case the valves should be closed, chained, locked, and tagged.

Petrochemical Plants

Petrochemicals refers to a group of chemicals that are manufactured using crude petroleum and natural gas feedstocks as raw materials.

Petrochemicals are versatile starting points for the production of thermoplastic and thermosetting materials. Thermoplastics are materials that can be softened repeatedly by the application of heat. The most important thermoplastics are high and low density polyethylene, polypropylene (polyolefins), polyvinyl chloride, and polystyrene.

Thermosetting materials are those that undergo a chemical change when heated and shaped and therefore cannot be reshaped by another application of heat. Some thermosetting plastics are thermosetting resins (including phenol and urea formaldehydes), epoxy resins, unsaturated polyesters and polyurethanes, and engineered plastics such as polyacetyls, polyamides, and polycarbonates.

The hazards of the petrochemical industry are closely related to those of oil refining, particularly in the raw material stages.

Atmospheric contamination hazards in the petrochemical industry can be complex, particularly when substances or processes combine. These combined effects are often much more toxic and dangerous than individual effects.

As they do in oil refineries, construction crews in petrochemical plants must comply with regulations as well as in-plant procedures. Cooperation between contractor and client is essential for safe work, from the bidding stage until the contract is completed.