Case Study Four

Egyptian Case Study: Field Petroleum Company, May 1998

Major General (ret.) Salah Eldin Selim Mohamed

Abstract

This paper explains a fire accident that occurred in May 1998, at an Egyptian field petroleum company in the Egyptian eastern desert, on the shore of the Gulf of Suez. This fire was the result of a lightning strike on a crude oil processing plant. Other contributing factors to the fire included defects in the ability to detect a fire quickly, a delay in the alarm system, a failure within the firefighting network, and hesitation in calling the professional firefighting teams. As a consequence, five degassing, operational and storage tanks were burned and some firefighting personnel were injured, including two seriously. The consequences included the closure of the oil production plant due to the devastation caused by the fire, as well as the environmental damage that was sustained.

The Egyptian Ministry of Petroleum has generally used lightning protection as a means of diminishing the risk of fire and the explosion of petroleum tanks and equipment in its companies and refineries. Since the incident, an alternative, modern and more secure processing unit has been installed to replace the damaged plant. This has incorporated new technology, which enables the heater to increase the crude oil temperature. Investigation teams have also recommended updating meteorological maps, carrying out regular inspections of the processing plants and their steel structures, implementing fire prevention and lightning protection

Major General Salah is an Advisor to the National Center for Middle East Studies in Cairo. His military career included posts as a consultant at the General Headquarters in Abu Dhabi, a professor of NBC warfare and Deputy Commandant of the High War College in the Nasser High Military Academy, Chief of the Chemical Warfare Branch in the Third Field Army, Chief of the Military Research Branch in the Chemical Warfare Department, Defense Attache in Kinshasa, Zaire, and Commander of an Independent Chemical Warfare Battalion.

measures in the plants, and establishing a well-trained group for crisis management within these petroleum companies.

Introduction

Oil and gas are not usually salable as they come from the wellhead. Crude oil is often produced in conditions that make handling it difficult such as high velocity, high-pressure, turbulence, high viscosity, and the use of a variety of hydrocarbon liquids and gases mixed with water, and water vapor. Crude oil contaminants make oil and gas costly to process and transport. These include water, wax, solids (sand and shale sediments), and sour gases (carbon dioxide and hydrogen sulfide). This makes it vital to prepare the oil or gas for transportation from the production site to the refinery, or for sale. The main reasons for processing oil are:

- To remove and/or dissolve gases through depressurization and by increasing the temperature of the rude oil to stabilize it. This then facilitates both the storage and the transportation process.
- To remove and/or emulsify water, which is often produced with crude oil. This will then reduce the transportation costs of the pipelines and shipping.
- To decrease the salt content of crude oil to avoid corrosion and problems of scale deposition in the tankers and refineries.
- To carry out a de-oiling process on the removed (separated) water for economic and environmental reasons.

Description of the Plant

How the treatment plant operates

The well stream (about 30,000 bbl/d) was collected and transported from 6 different fields, located in nearby areas. It was first passed through a series of devices to separate the crude oil and water from the gases and to treat the emulsions for removing water, solids, and undesirable contaminants. The oil was then stabilized, stored and tested in the laboratory for purity. A portion of the produced gas was adjusted to feed a series of direct heater tubes used to raise the crude oil temperature. The remaining portion is then burned through the flare.

The region surrounding the gas and oil processing plant

The gas and oil processing plant was surrounded by artificially producing wells and an administration building. Here oil was produced with the help of the sucker rod pumps. Figure (1) shows the area surrounding the burned plant.

Process for the treatment of crude oil in the plant

The collected stream of untreated crude oil was chemically injected using de-emulsifiers through the injection line in the main header manifold. The liquid mixture (gas and oil) then entered the two interconnected degassing units (A & B) as

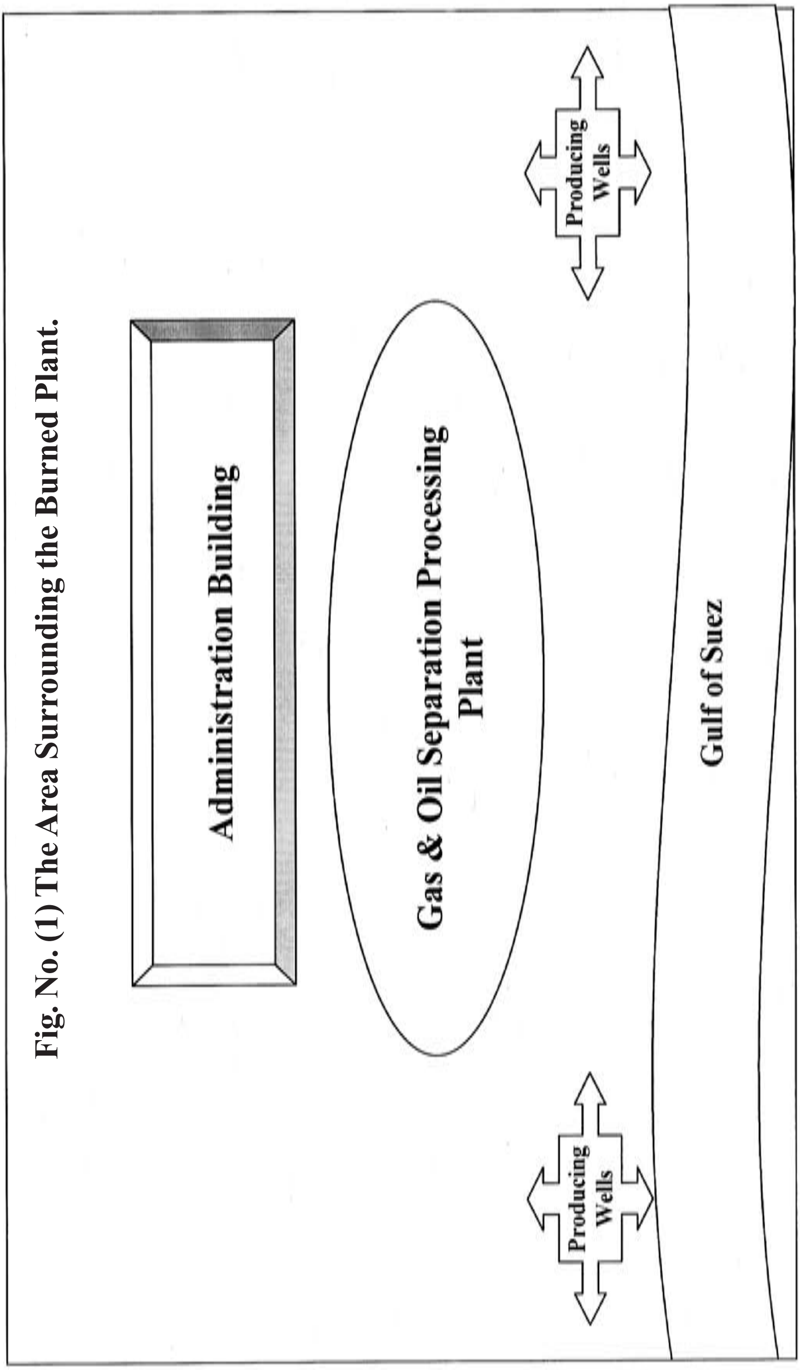


Fig. No. (1) The Area Surrounding the Burned Plant.

shown in figure (2). The degassing units were considered as vertical separator tanks (6 meters high) and were mounted on a 6 meter high skid. The oil was then separated from gas the in the degassing unit by the force of gravity. Oil, which is heavier than gas, fell to the bottom of the degassing tanks and was then removed and sent to the heater, which increased its temperature. The lighter element, the gas, was removed from the top of the degassing tanks and a portion of the separated gas was burned in the direct heater, with the remaining portion being burned through the plant flare.

The cold incoming oil emulsion was passed through a fire tube in the direct heater to heat the oil. The emulsion was then flown to the top of the two interconnected atmospheric degassing tanks (C & D). Here, the gas broke out of the emulsion as it splashed over the pan and was atmospherically vented into the air. The degassing units were also vertical separator tanks (6 meters high) and were mounted on a 6 meter high skid, with a one-meter high crude oil level.

The crude oil emulsion was then sent to two operational tanks (E & F), which were vertical tanks of 30,000-bbl capacity and 9 meters high. In the operational tanks free water and sediment fell out and the oil-water emulsion settled and was then separated. The water fell to the bottom of the operation tanks, while the crude oil rose upwards (due to the difference in specific gravity). It was then passed through an oil outlet located at a height of 7.8 meters, into two storage tanks of 15,000 bbls and 30,000 bbls capacity (G & H). The storage tanks were located at the shipping area, and one tank was filled, while oil was run from the other.

Fire protection equipment

The gas and oil processing plant was equipped with a firefighting system, which had access to the operational and storage tanks. A 6% fluoroprotein foam and water fire protection loop surrounded the process area. This meant that the operational tanks and storage tanks were equipped internally to inject foam above the level of the crude oil and externally, with the use of a cooling shower, to cool the unfired tanks. On top of this the plant was equipped with water monitors, safety hoses and dry powder extinguishers. Figure (3) shows the flow chart for the fire fighting system at the plant.

The processing plant's manpower

The permanent labor in the plant consisted of two operators per shift (day/night). The maintenance and other work was carried out during the day shifts as a safety measure, while the night shift concentrated solely on monitoring the operation process.

The Nature of the Fire and the Scenario of the Accident

How the fire began

At 5:40 a.m. on May 3, 1998 one of the two plant operators observed a sudden fire that began in the two degassing tanks (C & D). The operator called the company firefighting team. The operator then shut down the processing plant, changed the flow direction and sent the crude oil to another plant, exactly as he had been trained to do in the case of an emergency. Figure (4) shows the sequence of the fire in the processing plant.

The company firefighting team arrived at the plant at 6:00 a.m. and started to fight the fire using water and 6% fluoroprotein foam. At 7:12 a.m., degassing tank C exploded and the fire spread to the operational Tank F.

Firefighting teams at nearby petroleum companies along with the civil defense arrived at the scene to cooperate with the company firefighting team. They began to fight the fire in tank F by isolating oxygen above the crude oil. This was done by an injection of foam through a foam box and cooling the water in the undamaged tanks. Unfortunately, they failed to inject the foam as they failed to break the case on the box (the foam box materials are usually made from Fiberglas). Consequently they proceeded to use a firefighter in a basket, hung in a crane to ensure that the foam reached the surface of the crude oil inside the tank on fire. Bad weather conditions however restricted the efficiency of fighting the fire due to strong winds.

At 1:27 a.m. on the second day, the tank exploded, and the fire extended to the storage tanks (G & H). Consequently the fire moved closer to the administration building.

Steps followed to fight the fire

The fire teams worked in relays and concentrated their efforts on the storage tanks. This was achieved by:

a. The injection of foam above the crude oil through a foam box designed for this purpose.

b. Draining crude oil stored in the storage tanks to the Gulf of Suez.

At 1:41 p.m. the fire had been successfully put out in tank G, and at 8:24 p.m. this was repeated for storage tank H, while continuously cooling tank G.

At 9:50 a.m. on the third day, the fire in the operational and degassing tanks was under control.

By 11:45 the fire had been put out. The processing plant remained under observation for the next 24 hours. Many investigation teams visited the accident site to gather the required information to understand the causes of the accident. Company technical teams, safety and administration committees also arrived at the site to evaluate the total losses, safety precaution measures and the technical procedure required to rehabilitate the damaged plant. See appendix (1).

Losses, Casualties and Environmental Damage Caused

The losses can be summarized in the following:

Direct losses

- Two degassing tanks.

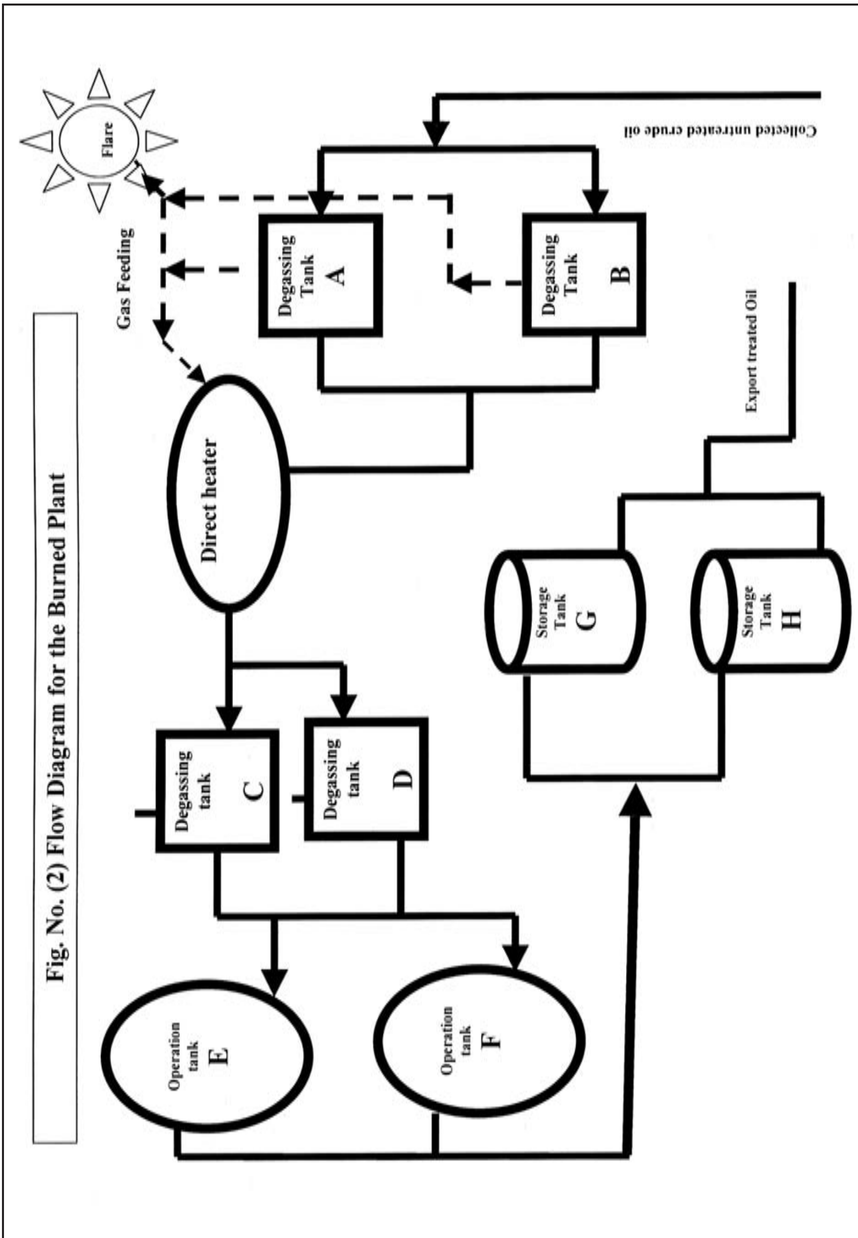


Fig. No. (2) Flow Diagram for the Burned Plant

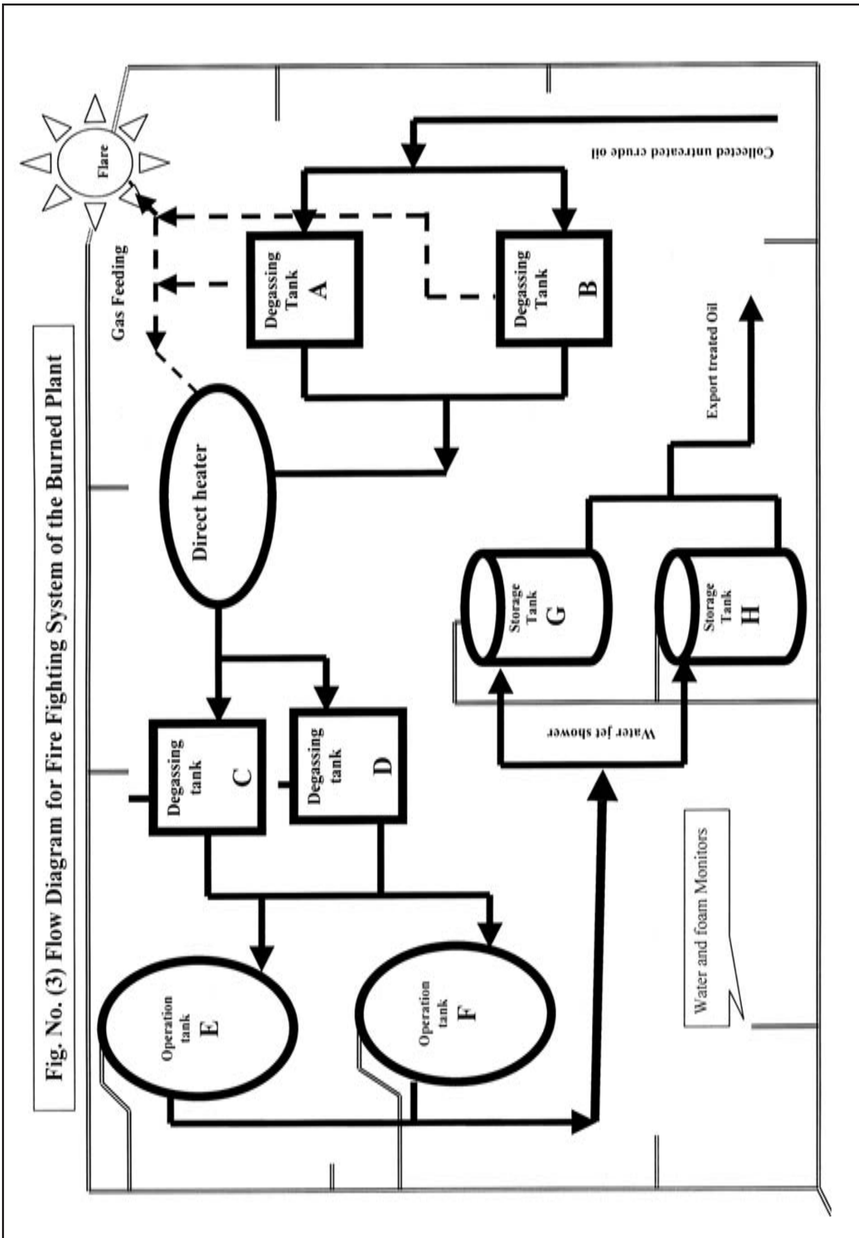
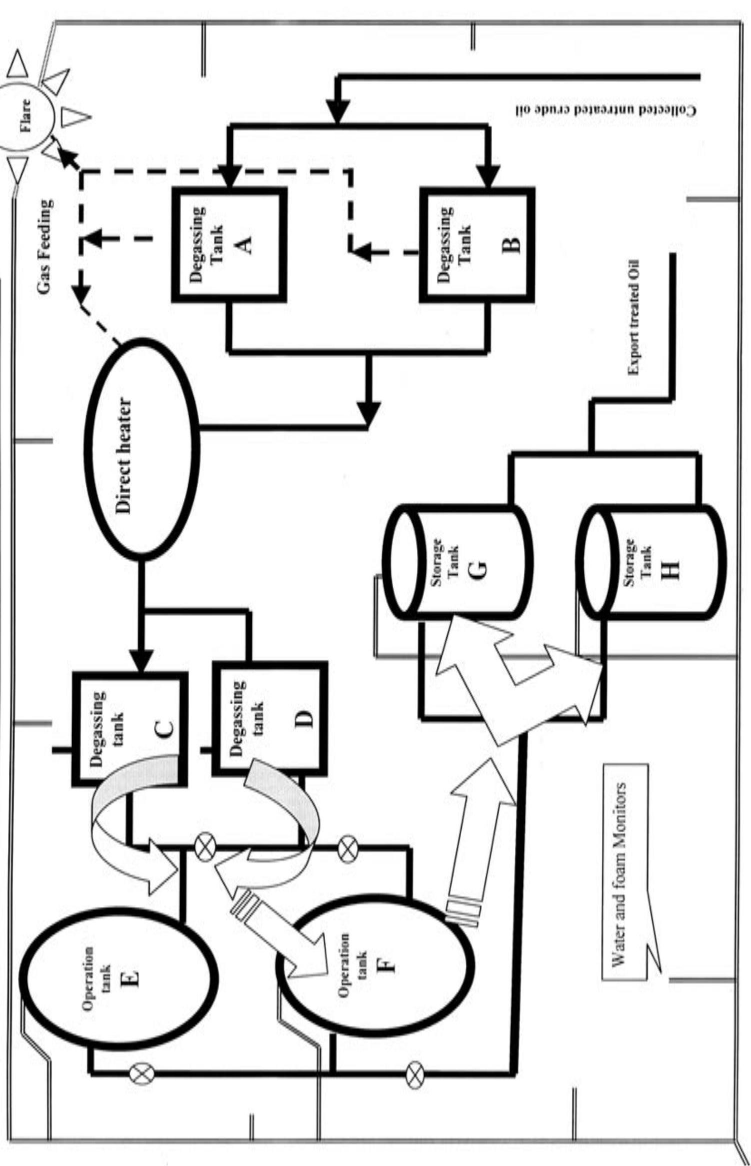


Fig. No. (3) Flow Diagram for Fire Fighting System of the Burned Plant

Fig. No. (4) Sequence of Fire in the Processing Plant



- One operational tank of 30,000 bbl capacity.
- Two storage tanks of 15,000 & 30,000 bbl capacity.
- One newly equipped firefighting car.
- One car equipped with a crane.
- The exterior of the administration building.
- Many tons of foam materials.
- Minor injuries for some firefighting personnel and serious injuries of two firefighting personnel.

Indirect losses

- Complete shutdown of the plant and the transfer of untreated crude oil to another treatment and processing plant.
- Cost of reconstructing an alternative, modern and secure processing plant.
- Cost of the cleaning and the rehabilitation of the polluted area.

Environmental damage

This accident also affected the environment in many ways. For example:

Black clouds, soot and fine dust were formed from the incomplete combustion of crude oil. These spread in the atmosphere and to the surrounding areas. The calm wind assisted the stagnation of the black clouds and reflected a feeling of suffocation and darkness for several days after the fire had ended. Fortunately, the burned plant was in the desert far from urban areas (the nearest city was almost 40 km away).

A wide area of soil, both at the plant's location and in the surrounding terrain (about 7.5 km2) was polluted with spilled crude oil. A huge number of vacuum trucks and heavy equipment were needed to remove and clean up the polluted area.

A wide area of the coast and seawater was also polluted with crude oil, which was drained from the storage tanks into the Gulf of Suez in order to starve the fire. The polluted seawater was encircled with a boom, skimmed, collected and pumped for re-treatment again.

Root and Contributing Causes of the Fire and Expert Analysis

Many investigations have been carried out by the police and other specialized authorities to determine the root causes of the fire. They concluded that the main cause of the fire was lightning. The other contributing causes included:

- Inefficient fire detection facilities (heat and smoke detectors), which was made worse by a delay in the alarm system.
- The failure of the equipment used to fight the fire.
- The delay in calling the highly equipped and professional firefighting teams (especially the armed forces' team).

Recommendations for Protection Against Lightning

There are two basic approaches to lightning strike protection, the remedial and the preventive. The remedial or collective approach is commonly used in the Russian Federation and Norway.

Remedial or collective option

It is designed to divert the stroke channel in order to function and achieve the following:

- Capturing the stroke leaders.
- Diverting all energy away from the equipment.
- Establishing a low impedance interface with the ground.
- Eliminating any secondary effects (electromagnetic fields).

Within all lightning stroke characters, the collective method depends on three main items:

- *Air terminal:* This determines the protected zone according to its height, in the form of a "cone of protection." Its head is located at the tip of the top terminal and then slips with an angle of 45° with the terminal, to form a base or radius equal to the terminal height. The efficiency would not exceed 90% if the terminal height is less than 100 meters.
- *Down conductor and ground conductor:* This is usually a length of open wire running from the air terminal to the earth. The resulting impedance can vary from 500 to over 5,000 ohms, depending on the physical parameters. The average lightning current rises at the rate of 100,000 ampere per microsecond. This rate represents a high impedance to a lightning current and will develop a voltage difference of over one million volts.
- *Grounding:* The grounding provides the protection for personnel against the electric shock. This is ensured by a common reference plan for the electrical circuit, a sink for lightning energy and a return for fault current in the power system. Grounding resistance could be a problem as grounding resistance of less than 1 ohm may be obtained by using individual electrodes connected together. Such a low resistance may only be required for large sub-stations or generating stations. Resistance in a 2-5 ohm range is generally suitable for industrial plant sub-stations, buildings and large commercial installations. A resistance of 25 ohm is the maximum resistance for a single electrode. If a higher resistance is expected, more than a single electrode would be required.

The collector systems' drawbacks include secondary effects that relate to the close proximity of the electrostatic and electromagnetic fields. They can be dangerous to flammable items, explosives and electronics.

Preventive option
To prevent lightning strikes in a given area, a system is needed to reduce the potential between the specific site and the cloud cell.

Protection may also be achieved by tampering with the induced charge created. A lightning protection system would then reduce the charge induced by a strike of lightening, to a level that would make a lightning stroke impractical.

This is best achieved by installing a multipoint ionizer as a dissipation device. As the potential for a lightening stroke increases, the ion current would also increase exponentially.

The electrostatic field created by the storm cell will then draw the charge away from the site, leaving that site with a lower probability of a lightening strike than its surroundings.

The dissipation array system consists of three basic elements, the dissipater (or ionizer), a ground current collector and service wires.

The protection of storage tanks
Tanks containing flammable and combustible liquids, or gases stored at atmospheric pressure can be set on fire by a lightning strike. A direct hit would ignite the vapors that escape from the tank and this may then cause a fire on the upper surfaces of the wood-roof tanks.

Externally ignited vapors may carry flames inside the tank. This could then result in an explosion or a fire if the tank contains a mixture of flammable or combustible air vapor.

The tanks situated above ground storing flammable or combustible liquids or gases, are at present thought to be protected against lightning as they are made out of carbon-steel.

However the following are also necessary:
- All joints between steel plates should be riveted, bolted or welded together.
- All pipes entering the tanks should be metallically connected to the tank using isolating flanges.
- All vapor openings should be closed or protected using flame arrestors.
- The tank and the roof should be constructed using a minimum of 3/16 inches thick steel sheets. This would ensure that a lightening strike would not be able to penetrate the roof of the tanks.
- The roof should be continuously welded, bolted or riveted to the body of the tank. It should also be caulked ensure that all seams are vapor-tight. The tanks should also be securely earthed.

Recommendations
- Meteorological maps and thunder distribution should be reviewed.
- There is a greater need for lightning protection of crude oil storage tanks (with a

fixed or a floating roof) and for periodic inspections to be carried out of all rim seals.

- All equipment, tanks, vessels and buildings should be securely grounded. The control room should also carry out periodic measurements, and regularly review and renew all resistance records.
- All processed steel structures should be protected against lightning, making sure these structures are connected and earthed to the overall network.
- There should be rigorous fire prevention and protection measures installed in all plants. These safety regulations have to be based on laws, municipal legislation and technical recommendations. The fire prevention regulations are usually drafted in one of two forms, in detail or by reference. These safety regulations should be revised periodically by the Civil Defense Authorities, to ensure that they are kept up to date. All oil and gas plants should have reliable, operational and well-designed fire and gas detectors, instantaneous alarm systems and fire extinguishing systems. These safety and operational procedures should be taught to and practiced by all personnel at the plant.
- There is little need for fixed roof tanks for petroleum products if all beating and venting points are equipped with working flame arrestors. However, it is possible to enhance the protection of floating roof tanks (oil storage tanks) through the installation of wire-mesh panels along the external circumference of the tanks.
- There should also be cable land terminations in all control cubicle bodies. These should also be joined to the grounding network.
- It is recommended that clean and dirty earth is mixed together, or that spark gaps are properly maintained within the digital control system (DCS).
- The installation of a local lightning air termination may be necessary to protect valves and vents on the top of the tanks and process vessels, through the installation of steel rods well connected to the grounding network.
- It is advised that there should be a metallic structure for the control room including the proper grounding of the building.
- Telecommunication links connecting the high towers to the nearby control room should be protected, and the conductivity of the metallic structure should be maintained and well grounded.

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