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L. J. Estey

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Résumé de l'article

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Designing petroleum and petrochemical plants from an insurance standpoint

by

L. J. ESTEY, P. ENG. [1]

Dans un excellent article, M. Estey pose le problème de l'industrie du pétrole et de la pétrochimie devant le risque d'incendie ou d'explosion. Il précise les questions qui se posent en vue de la prévention des sinistres et auxquelles il faut voir avant la construction de l'usine, sans attendre que les solutions deviennent extrêmement coûteuses, une fois les travaux en marche ou exécutés.

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The petroleum and petrochemical industries represent two of the more important and progressive industries in Canada today.

With the importance placed on energy, as it has been in recent years, these industries have grown very rapidly. Before, plants were built to serve localized markets but now with the worldwide interest in our oil supply, several "world-scale" size plants are already operating or under construction across Canada. The cost to construct these plants is in the several hundred millions of dollars range so the potential for a catastrophic loss has grown proportionately with the increase in the size and value of these plants.

Loss prevention should always be an important consideration in the construction of any plant but in these huge plants it is imperative. Loss prevention must be foremost in the minds of the planners of these plants and that interest continued throughout the design, construction and operational stages.

If this is not the case and loss prevention becomes an afterthought, the cost to provide the necessary protection at a later date may well become prohibitive, necessitating acceptance of lesser protection.

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[1] Mr. Estey is Vice President – Engineering Department – of Dale & Company Limited, member of the Sodarcan Group.

Consideration of protection at the initial stages is the only practical time to approach the subject in these rapidly growing industries.

When it was stated that protection and prevention must be considered by the planner, this applies right at the choice of the property on which the plant is to be constructed.

If a site is chosen strictly by economic considerations, it could present problems from a loss prevention standpoint. The property could present adverse climatic conditions (windstorm, floods, or earthquakes), undue exposure from neighbouring plants, inadequate fire fighting services or drainage problems.

The land should preferably be level or one with a slight slope at worst. When an installation has to be made on hilly or rolling terrain, special consideration has to be given to layout. For instance, the storage and loading facilities should be located below the elevation of the process area such that a flow of flammables accidently released in the storage or loading areas will not involve the process area.

Flammables flowing from the storage or loading areas into the process area has been the source of catastrophes in the past and the possibility of this happening should be avoided.

Special consideration has to be given to the layout in the storage area. With these "world-scale" plants there is also a trend towards "Jumbo" tanks of 600,000 barrel capacity and larger. It must be ensured that the contents of one of these tanks does not expose another tank. Natural drainage is important and if diversionary or deflection dykes have to be provided, then the property may not be as economically feasible as first thought.

Detachment of these tanks from one another and from process units, other facilities and neighbouring properties creates the requirement for the property to be large in size – often 200 to 300 acres.

Once the property is chosen, then the layout of the plant itself is most important. Definite vehicular traffic patterns should be established to keep traffic in important areas of the plant to a minimum. A truck carrying large volumes of flammables having an accident within the important areas of a plant can spell disaster.

As just mentioned, adequate spacing within the plant is essential to eliminate congestion. Congested plants have resulted in major losses and adequate spacing tends to minimize these losses. The trend is to design plants in blocks utilizing roadways between process areas, tank dykes and other major areas to allow access for fire fighting and emergency equipment. Traffic on roadways in these important areas is usually restricted and a "permit" system utilized to enforce the restriction.

Service Buildings such as offices, warehouses, cooling towers, utilities, and flares can be located toward the perimeter thus maintaining the all important efficient operation of the plant and keeping congestion to a minimum.

The design of the actual process units and storage areas are usually very detailed making it impractical to go into details of every item in this article, but some of the items for consideration when designing these plants are highlighted below.

The process units are the most hazardous areas within the plant and certainly demand special consideration in design and construction. Drainage is one major concern, as piping or open trenches must be of adequate size to safely remove all flammable spills, plus fire water and surface water (rain, etc.) that can be expected in an emergency. The flow in these instances can be in the area of 10,000 g.p.m. and providing drainage for flows of this magnitude is quite a task. Inadequate drainage can cause flammable spills to flow outside the trenches or back-up in the piping and flaming liquids can flow throughout an entire unit.

Fireproofing of structural supports for piping and equipment is essential. Concrete is still the most common material used for fireproofing. Now there are several materials being sold for this purpose and care must be exercised to ensure that these materials will perform in an emergency as well as retain their integrity so that it will not become a maintenance problem in future years. One thing to establish is that the material, whether it is concrete or one of the newer materials, is that it is installed by an experienced installer. If cracks or spalling develops, you might just as well not have fireproofing and the excessive corrosion can certainly be detrimental to the column. There have been large losses when towers without protection have toppled in a relatively minor fire.

The equipment should be designed to safely contain and control the material being processed and should an upset occur, safety valves (vents or pressure relief valves) will automatically operate to relieve the pressure to flare or atmosphere depending on circumstances. Obviously this is to protect the equipment from failing and prevent dumping flammables in an area that could have disastrous results.

When there is an upset condition, the only way to prevent a serious loss, is to get the flammable out of the area and relieve the pressure. This is achieved by providing an Emergency Shutdown System. This System is manually operated usually from several locations within the unit and from the Control Room. It will comprise a system of buttons that will shut down specific equipment, close valves to isolate areas, dump the product to a safe location such as a flare and most importantly reduce the pressure as quickly as possible. There will be buttons to perform certain of these functions depending on the degree of upset, but in a total shut down situation one button will do just that – shut the area down and remove the flammables and pressure – usually in less than 10 minutes.

Due to the size, automation of these plants is absolutely necessary for their efficient operation. The time for decisions and action in the event of an emergency has been greatly reduced to the point that protective steps must be forecast and designed into the equipment and minds of the plant personnel long before that emergency ever arises. Therefore, the personnel in the areas must be trained to very quickly assess the situation and react accordingly to set the Emergency Shutdown System in operation. This is one of the many areas where training of personnel is essential.

Water, and in an abundance, is the prime fire fighting material in these plants although other materials may be better in specific areas. These plants, by their hazard and size, are not usually located in built-up areas. They are generally on the outskirts of municipalities and sometimes very remote, so they must supply their own facilities for providing fire fighting water. The supply must be reliable and in sufficient quantities to meet demands determined by either hydraulic calculations for deluge systems or estimations of the water required for hose streams in an area – whichever is larger.

A good grid system of mains is required in the process and storage areas. A minimum of 8" mains should be used and 10" or 12" mains should be used in the higher hazard areas. Depending on the size of the plant these mains are supplied by anywheres from two to four pumps of about 2500 g.p.m. capacity. The pumps will be divided so half are electric and half are diesel engine driven for reliability. When four pumps are provided, they will be separated in groups of two, again for reliability.

Monitors are required in the Process Units and pressurized Storage Areas. Ordinary hydrants can generally be utilized elsewhere. The monitor location is determined by drawing 75' circles on an equipment layout and ensuring that all equipment that can contain flammables is within a circle. The centre of each circle represents a monitor and you proceed from there to located monitors so that they are not obstructed. You will also find monitors may be required on elevated equipment platforms to be effective. Hydrants are required in the process area as well, so a combination of hydrants with monitors can be utilized and be quite effective.

Pumps and compressors are vital to the operation to move product from one vessel to another. One common problem is failure of packing glands. Serious fires have been caused in such failures and protection is required.

Automatic spray protection should be provided over all pumps transferring flammables. All the pumps in one area can be on the one system to cool neighbouring pumps should a fire occur at one. Pumps should not be located beneath equipment or pipe racks so they are not exposed to a pump fire. Pumps should also have remotely controlled switches to control the flow of fuel during an emergency.

Compressors should have a full complement of automatic alarms and shut downs as they can be susceptible to various malfunctions of both the drivers and compressors. Temperatures and pressures of product, water coolants and lubricating oil should be carefully monitored and arranged to shut down automatically in many instances. Overspeed monitoring is important.

Permanently installed gas leak detectors should be provided for compressors. As gases can be either lighter or heavier than air then these detectors should be installed above and below the compressors. These detectors are generally arranged to alarm at about

25% of the lower explosion limit of the gas and shut the compressor down at 55-60% of the lower explosion limit. In large plants, compressors are huge and comprise several stages making them worth several millions of dollars. Also, the lubricating systems are large, so automatic sprinklers are required over the oil reservoir, consul and piping. This is one installation that is sometimes met with resistance but the actual compressor and driver can be shielded from the water spray if desired.

If a plant does have generators, the lubricating system should be likewise protected by automatic sprinklers. In addition, automatic CO_2 may be required in the generator housing.

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The trend today is to have one Central Control Building even though the plant might comprise several different units. When this is the case, the continued operation of the plant relies on the existence of this Control Building. Economics dictate that the equipment in this building have ordinary electricals whereas the units have electricals suitable for Class I Group D locations. Therefore, this building must be detached from hazardous areas. Too close and you risk flammable vapors getting into the building and causing severe damage. If that danger exists then the building should be pressurized to .2 inches of water and be equipped to alarm when the pressure drops. The Control Building, as well as all other buildings in the hazardous areas should be constructed of noncombustible materials throughout and devoid any other occupancies that would create an additional fire loading in this essential building. Blank walls should face the units so that the control room will not be exposed should a fire occur in the unit,

This building requires automatic protection for the room and under the raised floors that these buildings generally have.

Electrical cables are installed throughout the plant in trays that are generally stacked one above the other. These trays can be extensive in size, particularly where they leave the Control Building, and are very vulnerable to fires and explosions. As these cables are generally polyvinylchloride covered, a small fire can do minor damage to the unit but do extensive damage to the cables and result in a long shut down of the plant.

In recent years much research has been done to develop a system to provide a fire resistance rating for cable trays. There are several methods that have now proven to effectively protect these cable trays for the period of time necessary to shut the plant down in an orderly manner in a large loss, or not shut the plant down at all in a small fire.

One popular method right now seems to be to box the trays and coat the box with an intumescent mastic. Spraying the cables direct with a fire retardent material has proved to be messy and difficult to maintain.

Water in abundant quantities is required to cool process equipment, therefore most large plants have large cooling towers. Unfortunately these towers are constructed of wood even though they might have non-combustible exteriors. They appear that they would not burn considering all the water that can be seen cascading down through them, but there have been fires. Cells are shut down from time to time for maintenance purposes or at certain times of the year process may not require the cooling. The wood dries quickly and fires do occur. Automatic sprinkler protection should be installed in these towers. Cooling towers should be located away from the hazardous areas preferably on the perimeter of the plant.

In addition to the cooling towers, there will normally be fin fan coolers located within the united for localized cooling. The piping in these fin fans contain hydrocarbons so the supports for the fin fan should be fireproofed and an automatic water spray system installed to control a fire on the ground should a tube leak and also protect the fin fan itself.

Most materials are received and shipped by underground pipeline but usually there are tank truck and rail car facilities as well. These facilities should be located on the perimeter of the plant due to traffic involved and also the hazards involved. Static grounding should be provided to bond the racks, the cars and rails at the same potential.

In recent years, unit trains have come into use. This is a system of 20 -30 cars connected together and all filled at once. One fill line is inserted at the centre car and product flows to both ends. In some instances when very flammable liquids are being loaded, deluge systems have been required with two lines of sprinklers above the car and one line beneath the car running the length of the unit train. Otherwise monitor protection should be provided.

Storage of finished product is generally in tanks, however, storage can also be found in warehouses. When this is the case, the conventional standards for the design and protection of warehouse apply. Automatic sprinklers should be installed and designed according to the configuration of the warehouse and goods stored.

The tank farm should be in a detached area. A general rule of thumb for electing detachment distances from open flame and sources of ignition is one and one half times the diameter of the largest tank under consideration but not less than 250'. Generally each tank should be in its' own dyke. Common dyking is considered undesirable. Experience has shown that it is difficult to prevent the spread of fire to other tanks within a common dyke compound. However, it is appreciated that it is not always practical to avoid common dyking and providing the total contents within a single dyke does not exceed 600,000 bbls. then this is generally accepted with 3' spill dykes around each tank.

From a loss control viewpoint there is a strong preference for floating roof tanks of either the open or hard top variety. With the environmental regulations enacted by the Government, there are many cone roof tanks being converted to floating roof tanks. Pontoon floating decks are preferred due to their buoyance. Less desirable floating roofs utilize foamed polyurethane sandwiched by metal. Aluminum pans are also being used but not recommended due to their rapid burn-out characteristics.

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Heated tanks need insulation and foam glass is the recommended material. Polyurethane foam has been accepted in some instances where the foam is protected by fireproofing material.

Besides the hydrant protection already mentioned, the provision of fixed or semi-fixed foam protection facilities are recommended except for boil over products such as bunker and asphalt.

The old established method of providing foam protection was by surface application through foam chambers attached to the tank shell using protein base foam concentrates. A limiting factor in its use for protection of cone roof tanks, however, was the distance foam could travel effectively across the surface of a burning liquid and about 150' is considered the maximum diameter for a tank to be effectively protected by this method.

Quite recently sub-surface foam injection has come to the fore and is now a common method of application. "Jumbo" tanks are well in excess of 150' and a combination of surface and sub-surface injection is being provided. The subsurface foam system offers the advantage of less chance for foam generation equipment disruption as the result of an initial tank explosion and can inject the foam to the centre of larger tanks. However, sub-surface foam injection is not without limitations in that the more expensive fluoroprotein foam concentrate is recommended for pan type floating roofs. Sub-surface foam injection can be installed by providing a valved connection on the fill line from the tank and extending the line into the centre of tank. Recently aquous film forming foam (AFFF) is being used for sub-surface injection and is becoming quite popular for usage in Petrochemical Plants.

Liquified petroleum gases are stored in pressurized spheres and horizontal tanks called "bullets". Hydrants with monitors should be located around these vessels for cooling purposes and always be accessible not depending on which way the wind is blowing. These tanks should always be remote from other storage tanks and process units usually on the perimeter of the property but not exposing neighbours. "Bullets" when subjected to severe fire exposure tend to fail at the ends and take off like rockets travelling considerable distances. For this reason, bullets should be installed in a single row with their longitudinal axis parallel and pointed away from major value concentrations. Spheres and bullets should be located in diversion areas rather then enclosed dykes. The diversion area is an area bounded on three sides by an approximately 3' high dyke with the fourth side open and graded to direct the contents and fire water to a "burn pit" safely away from any exposure.

These pressure tanks pose a special control problem due to the possibility of a large vapour relase so their remote locations and lower elevation downwind from the plant cannot be overstressed.

These vessels should be protected by deluge systems automatically activated, and hydraulically designed to provide a density of at least 0.25 g.p.m./sq. ft. of surface area. Monitors should be provided to supplement the water spray system.

The provision of internal water flooding facilities is considered highly desirable as this will permit introducing a water leg to block off a hydrocarbon leak and permit repair work to be conducted, under perhaps rather wet conditions, but free of hydrocarbons. This may be accomplished by a double valved and plugged connection outside the diversion area on a line to the bottom of the sphere or bullet.

The supports for these vessels should be fire-proofed to the full load bearing height. Several years ago a fire occurred involving spheres at Fayzen, France, where bare legs on three spheres collapsed. It is quite an impressive sight to see three spheres rolling around like giant balls.

192 In conclusion, it would be remiss not to mention the personnel that administer the Loss Prevention Programme at these plants. They are required to be very dedicated people, completely committed to establishing and making the programme a success. You will not find a more dedicated group who are aware of the hazards involved in these plants. They must be prepared to do everything in their power to ensure that all protection devices are functional and train everyone for their special function in an emergency.