FIRE PROTECTION FOR PETROCHEMICAL PLANT

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Since 1970s, The Petrochemical Industry in Korea has grown rapidly by the successful economic growth. While the process became larger and more complex, hazardous chemicals have been used in large quantity. Therefore, the risk of a major accident such as fire, explosion and toxic material release has been increased.
Korea has been ranked the fifth in petrochemical product capacity worldwide, also required to meet international standards on process safety management.
Fire Protection System integral part of safety management in Petrochemical Plants, will be reviewed.

INTRODUCTION

As a part of the second economic development plan, the petrochemical industry in Korea was initiated in 1968 at the Ulsan petrochemical industrial complex. Continuous economic growth led to the construction of Yeochun petrochemical complex in the late 1970s and Daesan petrochemical complex in the mid-1980s. Korea exports nearly $6 billion worth of petrochemical product annually and ranked fifth worldwide in petrochemical production capacity now. The petrochemical industry has greatly contributed to Korea's successful economic growth.

RISK IN THE PETROCHEMICAL INDUSTRY

Production processes of the petrochemical industry are unique. All products result from the some raw material and end products produced by one plant can be used as raw material in other plants. It makes sense, therefore, that petrochemical complexes has been designed to house many petrochemical plants in one area so that supply and production can be integrated and companies large scale equipment and advanced technology. Automatic control systems are used to control the production processes. Petrochemical plants use a large quantity of hazardous chemicals and the potential for accidents is significant. As witnessed through real life incidents, storage and containment failures can result in many casualties, serious loss of property and environmental damage.

Since petrochemical plants are usually located together and linked through production stream, an incident in one plant can cause plant shutdowns both upstream and downstream plants. This situation can have a serious impact on the national economy and related industries. This is why we must consider safety from the early plant design phase to the discommissioning stage. No matter how much attention is given to safety management, it is impossible to cut the risk to zero. Thus, it is necessary to be prepared for possible incidents by developing detailed emergency response plan and implementing training programs.

SAFETY MANAGEMENT FOR THE PETROCHEMICAL INDUSTRY

Since most Korean petrochemical industries imported technology from technically advanced countries, process technologies and facilities have been maintained at the same level of safety as those of exporting countries. In order to control these technically complicated processes, however, we have needed specialized technology and experience. As a result of the booming petrochemical industry in Korea, these specialized experts were difficult to hire. Thus, we have not been able to maintain facilities systematically and to maintain plant at low operability. Since process safety management was weak and process technology management, facility management and construction and maintenance management were not integrated, many incidents occurred in the early start up stage.

In recent times, the petrochemical industry has experienced large scale accidents and incidents worldwide resulting in both loss of life and property. Insurance companies have also assessed high risk associated with the petrochemical industry. As a result, process safety management has become a hot issue within the petrochemical industry. An analysis of petrochemical industry incidents presents some common causes.

They include;

- No identification and control of potential process hazard s
- Poor maintenance
- Weak safety and fire fighting facilities

It is absolutely necessary to integrate process operation, and facility maintenance, and improve fire safety to make process safety management successfully in a petrochemical plant.

The concept of process safety management includes the identification and control of process hazards and all of the related activities to operate the process safely. The process safety management would cause some change in the petrochemical industry by making the existing safety management system more scientific and systematic. The petrochemical industry would also require to assess their process hazard and to develop and improve their ability to control these hazards. The scale of petrochemical plants and the amount of energy and chemicals used for production is increasing. Existing safety management in petrochemical industry are not adequate and a more scientific and systematic safety management method must be developed to control plant safety more effectively.

FIRE PROTECTION FOR PERTOCHEMICAL PLANT

Various chemical products and intermediates are now produced and the great number of materials and processes presents a wide range of hazards from fires and explosions in petrochemical plants.

In petrochemical plants, flammable solids, liquids, and gases are usually confined within closed equipment, such as piping, tanks, process vessels. The hazard of fire is greatest where flammable liquids or gases are released through leakage, explosion, or other accident. The fire and resulting heat can cause the release of further fuel if proper protection is no provided. For protection against fire, the same basic needs usually exist for petrochemical plants as would be required for others where there is combustible occupancy. However, special consideration maybe needed when the flammable materials is present in unusually large quantities, is chemically unstable, reacts with the extinguishing medium, or when the protective equipment is exposed by an explosion hazard in the process.

DELUGE SYSTEM (WATER SPRAY FIXED SYSTEM)

In the petrochemical plants, deluge system are most commonly used to protect processing equipment and structures, flammable liquid and gas vessels, piping and equipment such as transformers, oil switches, and motors.

Automatic water spray systems are used where it is necessary to provide water spray coverage over an entire process area and process equipment, with being required up to 11,000 LPM of water at a minimum of 3.8 kg/cm^2 residual pressure. Deluge systems are a dry pipe, open nozzle type of system which discharge water out of all nozzles when system is activated.

Deluge systems are effective in any one or a combination.

- Extinguishment - cooling, smothering emulsification or dilution of some materials.
- Control of burning - control burning rate / limit heat release.
- Exposure protection - reduce absorption of heat / minimize damage from external fire exposure
- Fire prevention - dissolve, dilute, disperse or cool flammable liquids
  - reduce flammable vapor concentration below Low Explosion Limit.

Slop-over or frothing hazard of a material shall be considered where water spray may contact these materials at a high temperature or water spray should not be used for direct application to material that react with water. Such as alkyls or metallic sodium or for liquefied gases at cryogenic temperatures, such as LNG, which boil violently and release large volumes of vapor when contracted by water spray.

Spray density of water spray system.

- Area protection : process structure - 8~20 LPM/㎡
- Specific protection : vessel, pump, cable tray
  pipe rack, compressor - 6~12 LPM/㎡
- Water curtain between a potential flammable vapor release area and fired equipment -
  water density is not as important as velocity and water particle size.

The deluge valve should be arranged so that visual examination is possible and remote trip station are required to actuate the system manually from strategic points such as control room. The design criteria is based on what the system is expected to do.

The following data is required.

- Type of nozzle : full cone, high velocity, fog, Air aspirating, wide angle, water particle
- Rate of application : density of water application
- Pressure required : nozzle operating pressure (1 kg/㎠ ~ 2.8 kg/㎠)
- Location of nozzle : number of nozzle ring on a column
  : nozzle location
  : nozzle distance

Hydraulic calculations are required for all deluge systems, the use of angle control valves with less friction loss may be more suitable. Strainers are required in the supply line upstream of the deluge valve, and the deluge valve should be located a reasonable distance from the facility being protected, in high hazard area, the valve should be protected by a blast and/or fire wall. Also selection of the right type nozzle is important. In general, nozzles having a spray pattern formed by a jet of water impinging on a deflector surface have a fine spray. All above ground piping shall be galvanized ASTM A53 minimum, in high hazard plants, all piping larger than 2 ½ ″ shall be welded flange and galvanized and all pipe support hangers should be installed with galvanized.

A significant feature of a deluge system is the capability of actuating the system prior to a fire starting. This can be done manually or automatically.

The most common type of automatic activation systems are;

- Thermo-pneumatic rate of rise systems
- Fixed temperature or pilot head system
- Combustible gas sensors tied into an electrical release with a solenoid

Manual Activation of a deluge system is accomplished by;

- Releasing the supervisory air pressure off the control cabinet
- Releasing the air from the pilot head system
- Manual pull at the control box

. All deluge systems shall have a manual, as well as automatic means of tripping.

FIRE WATER SUPPLIES AND FIRE PUMPS

The main line of defense against fire in petrochemical plants is water spray protection of building, processing equipment, and supporting structures. A base requirement is to be satisfied that fire water supply system - pumping and distribution - are sufficient to meet the maximum demand for the site. This requires as a first step that these must be an estimate of the maximum demand.

Where a site has several fire protection systems, spread over various plant blocks which are well separated, it is not realistic to assume that every system will need to be operated simultaneously.

The maximum demand should consider the worst likely single fire incident - worst in term of fire water capacity / flow requirements. If a single plant has two or more deluge or sprinkler systems in closely adjacent areas, it is possible that these could need to operate simultaneously. The maximum demand should consider also any adjacent fire hose or monitor guns which would likely be used in addition to a deluge or sprinkler system in the same incident. The thing of the most importance to all of the fire water systems which use water to put out the fire that is the supply of water itself.

Sprinklers, hydrants and monitor guns that these installed systems requiring water can be useless if we are not able to deliver to them enough flow at high enough pressure and for a long enough period to do the job. If we look at the static pressure in the fire main system or open up a hydrant and see the pressure and flow from that we think that there is plenty of pressure and flow. But, this is not the full picture. The sprinkler systems may need to have many times the flow you get from an open hydrant and then pressure losses in the fire mains because important. In fire pumps, we must first make an estimate of the largest flow rate we believe will be requires by the systems we have installed.

For this we do not assume that every sprinkler system and every hydrant in the plant will need to operate at the same time. But we look at the worst case involving a single plant area and add up the flows need to operate one or more sprinkler systems plus any nearby monitor guns or hydrant also be used. This will be the design basic for the fire pump capacity.

We must provide standby pumping capacity so that we can deliver the design flow with any one fire pump out of service. We have had many different problems with the reliability of the fire pumps. For the reliability at power fail, engine pump installation should be considered to cover maximum demand capacity. It is necessary that fire water pumps should be subjected to a full performance test at regular intervals. The recommended frequency is at least once every 6 months. Pump should be tested over the full capacity range up to 150% of nominal rated capacity, as requires by NFPA standards. This performance test is necessary so that pump and drive can be checked under loaded condition. Pump performance must be assessed in relation to the performance curve provided by the vendor.

Looping of firewater distribution main is recommended so that at cease on alternate flow path maybe available to keep most system on line when it is necessary to isolate any portion on the system. This also has the effect that flow will be distributed over several flow path when all loops are available and this will greatly reduce overall pressure drop. However, the calculation of pressure drops in such systems become very complex if there are multiple loops, the calculation may require two or more starting assumptions for an interactive procedure with very slow convergence.

A final point on fire water supplies is the storage quantity needed. The insurance company recommendation is that we should be able to pump water at the design rate for a minimum of 4 Hrs because a large fire can frequently burn for hours.

FOAM SYSTEM

You need to realize that water spray is unlikely to extinguish a well established flammable liquid fire. However, the water does provide cooling and can have a significant effect in limiting the intensity of the fire and in minimizing damage to nearby equipment. If we can limit the fire duration by isolating the fuel and if we have good drainage to divert the fuel to a safer location then water spray can provide fairly effective protection. In other cases an extinguishing system using foam may be the answer. In these systems foam concentrate is metered into the water stream in the correct ratio to produce foam which forms a stable and fire smothering layer on the flammable liquid face. There is a range of foam products available and some care and experience is needed to choose the best one for the material or combination of materials which is the potential hazard.

In choosing the foam we need to give thought to reaction between the foam and the plant materials, reaction which could destroy the foam-forming properties. Shelf life of the foam compound is usually of long duration but can deteriorate with some materials if contaminated with water of if stored at too high a temperature. Stocks must be sampled and tested annually. In most systems foam will be effective where it can be used on a pool of burning liquid but the surface cover may be easily broken if the liquid is agitated too much. For this reason, the traditional use of foam has been in storage tanks or on diked areas or ponds. Foam chambers mounted near the top of tank walls may be used for internal addition to tanks. It will be common to install a single foam storage to serve a number of tanks in a single tank farm and this will utilize a valving manifold and a schematic to assist in operation. An alternate arrangement is to provide connections for a fire trunk to deliver foam.

In recent years there has been a trend towards use of foam in deluge systems for process areas.

The usual arrangement here is to provide for automatic activation of the water spray with ability to turn the foam on manually if needed. And foam can also be delivered via monitor guns or hydrant hoses. Large stocks of foam compound are expensive and if is usual to provide for only a limited period of operation with foam normally about 10 minutes. It is important that the system is designed for a rate of foam application which will ensure that the fire is controlled within this time.

If the rate is too low the fire will destroy the foam at the leading edge of the foam blanket as fast as it is being applied. The main problem in fighting fires which occur in very large oil tanks in the difficulty of delivering the foam into the tank at a fast enough rate. Any attempts at a low rate simply use up foam stocks to no benefit. Another type of form system which might interest you is high expansion foam, which uses about 100 times as much air to produce a large volume of very light foam. The usual applications for this have been in warehouses storing drums or smaller containers of various agricultural chemicals formulated with flammable solvents such as xylene.

The aim of this system is to completely fill the warehouse with foam - at least up to the height of the storage - and smother the fire. Fires in stacked drums of flammable liquids are very hard to extinguish and this is one way to do it. There is another advantage as well - that there is minimum liquid runoff which should be a problem with certain chemicals toxic to plant life or to fish.

FIRE PROOFING OF STRUCTURES

Most of our structures are steel and the strength of steel starts to drop sharply when its temperature increases above about 400 ℃. This is a temperature which can be reached fairly quickly when there is direct exposure to a large fire. Collapse of the structure can itself cause much property damage and can also cause release of more material to feed the fire. There are a number of different material which are used as coating on structural steel and these provide a heat insulating effect that longer fire exposure is needed to heat the steel to the critical temperature. It is usual to provide a coating thickness which gives a rating of from one to three hours protection. Fire proofing coating seems that the proper preparation of the steel surface and application of the coating are very critical. The problem we have experiences are spalling and cracking of the coating and also penetration of water between the steel and the coating which corrodes the steel and also probably causes the coating to crack. In addition to this the coatings often get damaged at exposed edges or are broken in spots where we attach things to the structure for plant modifications.

It may be much easy to achieve proper coating when this is done during the original plant construction than it is to add protection to an existing structure. These problems have been so bad that we have been looking at alternate ways to protect structures. Water spray direct onto the steel is an effective way to keep the steel cooled. It is relatively easy to install and cost can be comparable or even lower than protective coatings, particularly if there is other water spray in the plant and the steel protection sprays can be added as an extension of that. This is not usually favored by the insurance people because

- There is a risk that he water spray system can be knocked out by an explosion. We would not recommend this form of structure protection in a plant which has an explosion potential.
- It is dependent also on the fire water supply, which may fail.

The plant structure can also be secured against fire by using concrete construction and we have done this is some plants where it has been competitive in cost with a steel structure. A concrete structure may suffer some spalling and damage in a fire but I do not know of any case where has been general collapse.

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