OIL AND CHEMICAL PLANT LAYOUT AND SPACING

INTRODUCTION

Loss experience clearly shows that fires or explosions in congested areas of oil and chemical plants can result in extensive losses. Wherever explosion or fire hazards exist, proper plant layout and adequate spacing between hazards are essential to loss prevention and control. Layout relates to the relative position of equipment or units within a given site. Spacing pertains to minimum distances between units or equipment.

AXA XL Risk Consulting layout and spacing recommendations are for property loss prevention purposes only and are intended for existing and new oil and chemical facilities. These guidelines are intended to limit explosion overpressure and fire exposure damage. They do not address shrapnel damage. If these guidelines cannot be followed, then additional loss control measures, such as fire proofing, waterspray or blast hardening will be necessary.

Property Risk Consulting Guidelines only address spacing and layout within a plant and are mostly applicable to open structures. An open-air design favors vapor dissipation, provides adequate ventilation, reduces the size of the electrically classified area, and increases firefighting accessibility. Additional information can be found in several publications, Hazard Survey of the Chemical and Allied Industries, Technical Survey No. 3, 1968, *An Engineer's Guide To Process-Plant Layout* by F.F. House, *Process Plant Layout* by J.C. Mecklenburgh, *Loss Prevention In The Process Industries* by F. P. Lees, Volumes 1 & 2, Loss Prevention Fundamentals For The Process Industry, Loss Prevention Symposium, March 1988, NFPA 30, and NFPA 58.

POSITION

Management Programs

Management program administrators should report to top management through the minimum number of steps. They should also institute loss prevention inspection and audit programs to communicate program effectiveness to top management. This management feedback is a key feature of PRC.1.0.1 (*OVERVIEW*). In developing a program, pay particular attention to the following important areas:

Hazard Identification and Evaluation Program

Determine the plant layout and spacing necessary to limit loss size based on worst-case scenarios for vapor cloud, vessel and building explosions, and for fires. Calculate overpressure circles. See PRC.8.0.1.1 for hazard analysis and evaluation methods applicable to various explosion or fire scenarios. This analysis can be completed in coordination with AXA XL Risk Consulting loss prevention personnel.

Management of Change

Evaluate the impact of all modifications to equipment and procedures to the plant process safety using the Management of Change program Conduct a Hazard Identification and Evaluation program for all new processes or for any modification to an existing process prior to completing final site selection and equipment layout. Determine the need for changes to spacing or layout.

Duplication of Facilities

For large-scale chemical and petrochemical plants, provide multiple process trains. In large scale plants, duplicate, with installed spares, equipment that is highly susceptible to loss or important for continued operations. For smaller scale or batch type plants, install processes important to production in the form of multiple small-scale units rather than a single large unit.

Physically separate duplicated units, process trains or equipment with adequate spacing in accordance with this section or compartmentalize with blast resistant construction.

General

Consider the following when determining the layout and the separation required:

- High hazard operations (see Appendix A)
- Grouped operations
- Critical operations
- Number of personnel at risk
- Potential environmental damage
- Concentration of property and business interruption values
- Importance of facility for continuing operations
- Equipment replacement and installation time
- Interdependency of facilities
- Critical customer or supplier relationships
- Market share concerns
- Fire and explosion exposures
- Corrosive or incompatible materials exposures
- Vapor cloud explosions
- Potential to damage of building components and outdoor equipment
- Sources of ignition
- Maintenance and emergency accessibility
- Drainage and grade sloping of surrounding land
- Prevailing wind conditions
- Natural hazards and climate
- Future expansions
- External exposures including other plants, pipelines and transportation (rail, motor vehicle, aircraft, ship)

Review the various hazards and loss potentials to establish the degree of separation required between units and equipment. Consult Tables 1, 2 and 3 in this guide for minimum spacing guidelines based on fire and vessel explosion hazards. Increase spacing where appropriate.

	Service Buildings	Motor Control Centers And Electrical Substations	Utilities Areas	Cooling Towers	Control Rooms	Compressor Buildings	Large Pump Houses	Process Units Moderate Hazard	Process Units Intermediate Hazard	Process Units High Hazard	Atmospheric Storage Tanks	Pressure Storage Tanks	Refrigerated Storage Tanks Dome Roof	Flares	Unloading And Loading Racks	Fire Water Pumps	Fire Stations
Service Buildings	/																
Motor Control Centers And Electrical Substations	/	/															
Utilities Areas	50	50	/														
Cooling Towers	50	50	100	50 ①													
Control Rooms	/	/	100	100	/												
Compressor Buildings	100	100	100	100	100	30											
Large Pump Houses	100	100	100	100	100	30	30										
Process Units Moderate Hazard	100	100	100	100	100	30	30	50									
Process Units Intermediate Hazard	200	100	100	100	200	50	50	100	100								
Process Units High Hazard	400	200	200	200	300	100	100	200	200	200							
Atmospheric Storage Tanks	250	250	250	250	250	250	250	250	300	350	*						
Pressure Storage Tanks	350	350	350	350	350	350	350	350	350	350	*	*					
Refrigerated Storage Tanks Dome Roof	350	350	350	350	350	350	350	350	350	350	*	*	*				
Flares	300 ②	300	300	300	300	300	300	300	300	300	300	400	400	/			
Unloading And Loading Racks	200	200	200	200	200	200	200	200	200	300	250	350	350	300	50		
Fire Water Pumps	50	50	50	50	50	200	200	200	300	300	350	350	350	300	200	/	
Fire Stations	50	50	50	50	50	200	200	200	300	300	350	350	350	300	200	/	/

1 ft = 0.305 m
/ = no spacing requirements
* = spacing given in Table 3

Examples:

① 50 ft separation between two cooling towers

② 300 ft separation between service building and flare

TABLE 1. Inter-Unit Spacing Recommendations For Oil And Chemical Plants.

	Compressors	Intermediate Hazard Pumps	High Hazard Pumps	High Hazard Reactors	Intermediate Hazard Reactors	Moderate Hazard Reactors	Columns, Accumulators, Drums	Rundown Tanks	Fired Heaters, Incineraors, Oxidizers	Air Cooled Heat Exchanger	Heat Exchangers	Pipe Racks	Emergency Exchangers	Unit Block Valves	Analyzer Rooms
Compressors	30														
Intermediate Hazard Pumps	30	5													
High Hazard Pumps	50	5	5												
High Hazard Reactors	50	10	15	25											
Intermediate Hazard Reactors	50	10	15	25	15										
Moderate Hazard Reactors	50	10	15	25	15	15									
Columns, Accumulators, Drums	50	10	15	50	25	25	15								
Rundown Tanks	100	100	100	100	100	100	100	100							
Fired Heaters, Incineraors, Oxidizers	50	50	50	50	50	50	50	100	25						
Air Cooled Heat Exchanger	30	15	15	25	15	15	15	100	50	/					
Heat Exchangers	30	10	15	25	15	10	10	100	50	15	5				
Pipe Racks	30	10	15	25	15	10	10	100	50	/	10	/			
Emergency Exchangers	50	50	50	100	50	50	50	100	50	50	50	50	/		
Unit Block Valves	50	50	50	100	50	50	50	100	50	50	50	50	/	/	
Analyzer Rooms	50	50	50	50	50	50	50	100	50	50	50	50	/	/	/

1 ft = 0.305 m
/ = no spacing requirements

TABLE 2. Intra-Unit Spacing Recommendations For Oil And Chemical Plants.

	FLOATING & CONE ROOF TANKS < 3000 BARRELS	FLOATING & CONE ROOF TANKS > 3000 < 10,000 BARRELS	FLOATING ROOF TANKS > 10,000 < 300,000 BARRELS	JUMBO FLOATING ROOF TANKS > 300,000 BARRELS	CONE ROOF TANKS CLASS II, III PRODUCT > 10,000 < 300,000 BARRELS	CONE ROOF TANKS INERTED CLASS I PRODUCT** > 10,000 < 150,000 BARRELS	PRESSURE STORAGE VESSELS SPHERES AND SPHEROIDS	PRESSURE STORAGE VESSELS DRUMS AND BULLETS	REFRIGERATED DOME ROOF STORAGE TANKS
FLOATING & CONE ROOF TANKS < 3000 BARRELS	0.5 D*								
FLOATING & CONE ROOF TANKS > 3000 < 10,000 BARRELS	0.5 D	0.5 D							
FLOATING ROOF TANKS > 10,000 < 300,000 BARRELS	1 X D	1 X D	1 X D						
JUMBO FLOATING ROOF TANKS > 300,000 BARRELS	1 X D	1 X D	1 X D	1 X D					
CONE ROOF TANKS CLASS II, III PRODUCT > 10,000 < 300,000 BARRELS	0.5 D	0.5 D	1 X D	1 X D	0.5 D				
CONE ROOF TANKS INERTED CLASS I PRODUCT** > 10,000 < 150,000 BARRELS	1 X D	1 X D	1 X D	1 X D	1 X D	1 X D			
PRESSURE STORAGE VESSELS SPHERES AND SPHEROIDS	1.5 D 100' MIN	1.5 D 100' MIN	1.5 D 100' MIN	2 X D	1.5 D 100' MIN	1.5 D 100' MIN	1 X D 50' MIN		
PRESSURE STORAGE VESSELS DRUMS AND BULLETS	1.5 D 100' MIN	1.5 D 100' MIN	1.5 D 100' MIN	2 X D	1.5 D 100' MIN	1.5 D 100' MIN	1 X D 100' MIN	1 X D	
REFRIGERATED DOME ROOF STORAGE TANKS	2 X D 200' MIN	2 X D 200' MIN	2 X D 200' MIN	2 X D	2 X D 200' MIN	2 X D 200' MIN	1 X D 100' MIN	1 X D 100' MIN	1 X D 100' MIN

D = Largest Tank Diameter
1 barrel = 42 gallons = 159 L
°C = (°F-32) x 0.555
1 ft = 0.305 m

*For Class II, III products, 5 ft spacing is acceptable.
**Or Class II or III operating at temperatures > 200°F.

TABLE 3. Storage Tank Spacing Recommendations For Oil And Chemical Plants.

Where large amounts of flammable vapors could be released and a vapor cloud explosion could occur, perform a more detailed hazard analysis and evaluation per PRC.8.0.1.1. Calculate the vapor cloud explosion overpressure circles. Where applicable, base the minimum spacing required between units upon the following criteria:

- Do not locate critical equipment of adjacent units within the 3-psi (0.21 bars) overpressure circle.
- Design equipment or structures of adjacent units within the 1-psi (0.07 bars) overpressure circle to withstand the calculated vapor cloud overpressure.

If the minimum spacing requirements based on a vapor cloud explosion differ from the minimum spacing required by the spacing tables, use the greater of the two.

Overall Plant Layout

Initially, base site selection on exposure from uncontrollable factors, such as floods, earthquakes, tidal waves, subsidence, hurricanes, and adjacent oil and chemical plants.

Once a site has been selected, arrange layout and spacing to reduce the effect of some of the following controllable and uncontrollable factors that contribute to losses:

- Uncontrollable factors include site slope, climate, exposure to natural hazards, wind direction and force. However, locating ignition sources upwind of potential vapor leaks or locating the tank farm downhill of essential units may reduce the loss potential from an explosion or fire. Figure 1 illustrates a good layout based on the prevailing wind.
- Controllable factors include process design parameters, process equipment design, unloading facilities, maintenance, spare parts supply, control logic and automation, ignition sources, fire protection design, spare production capacity, flammable liquid holdups, spill control and the type of process. Use proper drainage and separation to control spills and fire spread. Refer to PRC.2.5.3 and PRC.8.0.1.2.

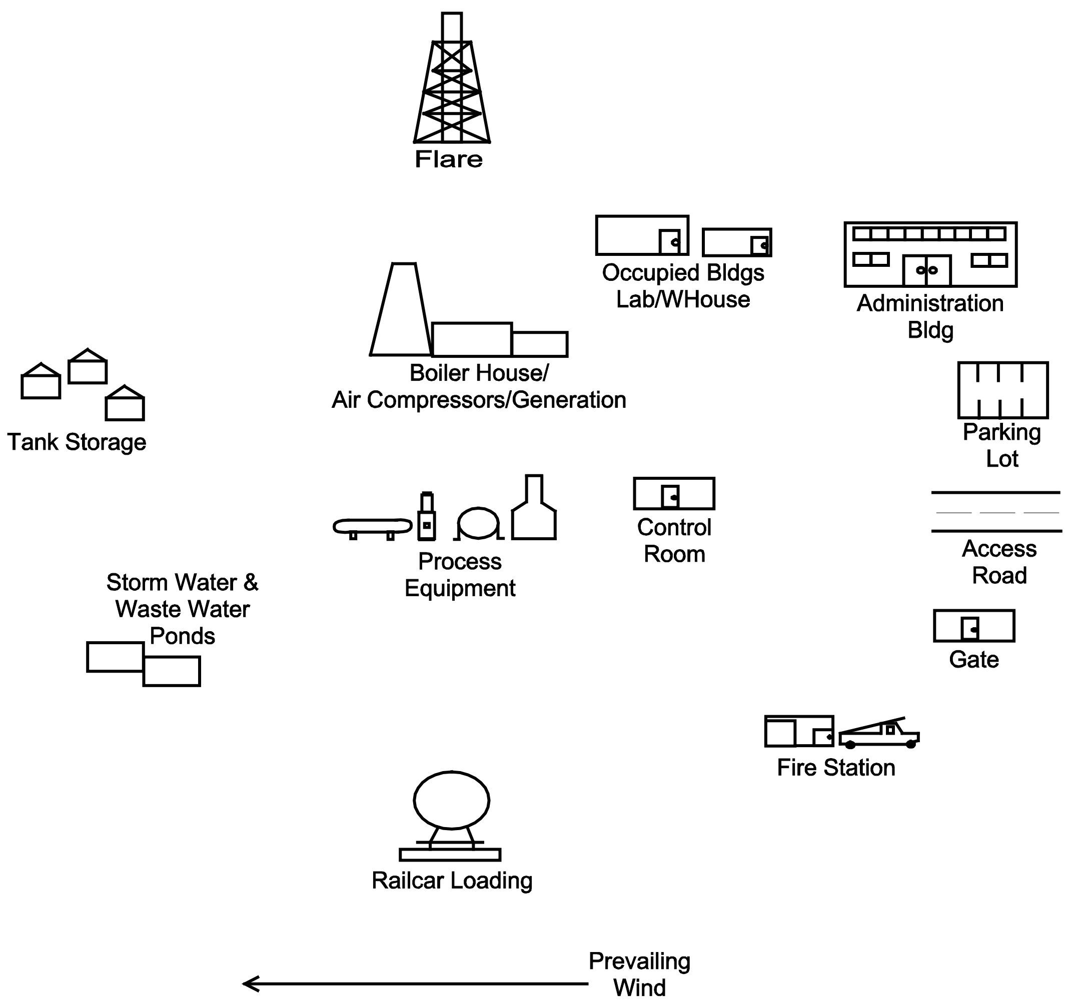

Figure 1. Good Layout Example.
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Use a hazard assessment of each plant operation to help establish the layout or orientation of blocks or unit battery limits within the plant. Review the possible loss events and the consequences for each proposal. Select a layout which will minimize the overall property damage and related business interruption should an incident occur.

Subdivide the overall site into general areas dedicated to process units, utilities, services and offices. Since each area or unit block generally has a rectangular shape, keep the maximum unit size to 300 ft × 600 ft (92 m × 183 m) for firefighting purposes.

Provide access roadways between blocks to allow each section of the plant to be accessible from at least two directions.

- Avoid dead end roads.
- Size road widths and clearances to handle large moving equipment and emergency vehicles or to a minimum of 28 ft (8.5 m), whichever is greater.
- Maintain sufficient overhead and lateral clearances for trucks and cranes to avoid hitting piping racks, pipe ways, tanks or hydrants.
- Do not expose roads to fire from drainage ditches and pipeways.
- Slightly elevate roads in areas subject to local flooding.
- Locate hydrants and monitors along roads to allow easy hook-up of firefighting trucks.
- Provide at least two entrances to the plant for emergency vehicles to prevent the possibility of vehicles being blocked during an incident, e.g., open bridge, railway.
- Plan and implement a “Roadway Closure” permit system authorized and controlled by site Emergency Response personnel as part of the site impairment handling system.

Provide spacing between units based upon the greater of either Table 1 or a hazard assessment. The space between battery limits of adjoining units should be kept clear and open. **Do not consider the clear area between units as a future area for process expansion**.

Process Units

Evaluate the process hazards and, depending on the results of such review, classify them in high, intermediate and moderate hazard groups as shown in PRC.2.5.2.A. Consult the table in this section to determine the spacing required between the various blocks based upon the relative hazard of each process.

Separate hazardous units from other hazardous units to avoid fire spread. “Separate” or “buffer” high hazard units by using moderate or even lower hazard units as a way to reduce such exposure, e.g., separate a DNT plant from a TDA plant by placing a sulfuric or nitric acid unit between them.

Locate equipment or structures common to multiple process units, such as large compressors and turbines, central control rooms and fired heaters, to prevent a single event from impairing the overall operation and causing extensive business interruption.

Lay out the equipment within a unit in one of two general ways.

- Use grouped layout, where similar equipment is grouped together to ease operation, maintenance and control.
- Use flow line layout, where equipment is arranged in a sequence similar to the process flow diagram.

Wherever it does not conflict with loss control, consider accessibility for maintenance and operations in determining spacing and layout. Locate equipment needing frequent overhaul, maintenance or cleaning at unit boundaries. Locate large vessels or equipment close to unit boundaries to allow easy access of cranes.

Use Table 2 for minimum spacing guidelines for spacing within process units. The recommended separations are the clear, horizontal distances between adjacent edges of equipment.

Hazard Classification

The following hazard classifications are for equipment and processes:

- Reactors:
- Classify process reactors as moderate, intermediate or high hazard. The relative hazard classification is detailed in PRC.2.5.2.A.
- Fire heaters that process hydrocarbons at high temperatures and flow rates. Operation can cause coking of tubes or cause large spills
- High hazard pumps:
  - Handle flammable and combustible liquids operate at temperatures above 500°F (260°C) or above the product autoignition temperature.
  - Handle flammable and combustible liquids and operate at pressures above 500 psi (34.5 bar).
  - Handle liquefied flammable gases.
- Intermediate hazard pumps:

  All other pumps handling flammable or combustible liquids. Canned and magnetic pumps have a lower fire hazard, and therefore, there are no specific spacing requirements.

Intra-Unit Spacing

For proper intra-unit layout, include the following principles:

- Do not group pumps and compressors handling flammable products in one single area. Do not locate them under piperacks, air cooled heat exchangers and vessels. Orient pump and driver axes perpendicular to piperacks or other equipment to minimize fire exposure in case of a pump seal failure. Separate high-pressure charge pumps from any other major process equipment and other pumps by at least 25 ft (7.5 m).
- Locate compressors at least 100 ft (30 m) downwind from fired heaters and at least 30 ft (7.5 m) from any other exposing equipment. To avoid unnecessary exposure, do not locate lube oil tanks and pumps directly under any compressor.
- Detach heaters and furnaces from the unit or at least locate them at one corner of the unit. Locate continuous ignition sources upwind of the process units.
- If increased spacing for very high hazard equipment susceptible to explosions, such as reactors, is not possible, separate them from other areas by blast resistant walls.
- Keep flammable products storage to a minimum within the process unit boundaries. Install tanks, accumulators or similar vessels with flammable liquid holdups at grade, if possible.

The preferred layout of a process unit is a piperack located in the center of the unit with large vessels and reactors located outwards of the central piperack. Place pumps at the outer limits of the process area. Limit the stacking of equipment in process structures to equipment with no fire potential. Slope the ground surface so that liquids drain away from the center of the unit. Do not put drainage trenches under piperacks. Put cable trays in the top tier of the piperacks.

Utilities

Locate central services, such as cooling towers, boilers, power stations and electrical substations, away from hazardous areas so they will not be affected by a fire or explosion within the plant nor be a source of ignition for any potential flammable liquid or gas release. Maintain adequate separation between different utility services because utility losses could then lead to unsafe conditions in other plant units, possibly creating fires or explosions. Increase the reliability of the utilities by keeping adequate spacing between boilers or generators.

Properly pressurize in accordance with NFPA 496 or separate electrical substations and motor control centers. Locate substations away from hazardous areas to increase the reliability of the power supplies should a loss occur. Bury electrical distribution cables to limit their exposure to explosions, fires, storms and vehicles, and to ease firefighting accessibility.

Control Rooms

Locate and construct control rooms, motor control centers, and other essential facilities to allow operators to safely shut down units under emergency conditions. Locate the control building where it will not be exposed by fires or explosions. If separation is not feasible, design the building to withstand potential explosion overpressure. Where control rooms are exposed to fires or blast overpressures, locate the emergency loss control coordination center in a safe area.

Consider unmanned satellite computer rooms, terminal rooms and I/O rack rooms equivalent to motor control centers for the purpose of this guideline.

Services

Keep warehouses, laboratories, shops, fire brigade stations and offices away from process areas. Welding equipment, cars and trucks as well as large numbers of people can become “uncontrollable ignition sources.”

Loading and Unloading

Space loading racks, piers and wharves well away from other areas due to large numbers of trucks, rail cars, barges or ships carrying large amounts of flammable or combustible liquids. Reduce plant traffic to ease emergency vehicle movement and limit accident hazards by locating loading and off-loading operations at the plant perimeter close to the entry gate.

Locate flares according to Table 1 or to API 521, whichever is greater.

Tank Farms

Consult Table 3 for general recommendations for spacing aboveground storage tanks in the oil and chemical industry. The spacing is given as a distance from tank shell to tank shell and is a function of the largest tank diameter. If there are adverse conditions, such as poor fire protection water supply, difficult firefighting, poor accessibility, poor diking or poor drainage, increase the spacing by at least 50%. Treat crude oil as a flammable liquid.

See Table 1 for minimum spacing between tank farms and other units.

Do not group or dike different types of tanks and contents together.

Locate storage tanks at a lower elevation than other occupancies to prevent liquids or gases from flowing toward equipment or buildings and exposing them. Locate tanks downwind of other areas.

Arrange atmospheric storage tanks and pressure vessels in rows not more than two deep and adjacent to a road or accessway for adequate firefighting accessibility.

Since piping involved in ground fires usually fails within 10 or 15 min of initial exposure, locate an absolute minimum amount of piping, valves and flanges within dikes. Install pumps, valve manifolds, and transfer piping outside dikes or impounding areas.

Provide tanks with proper dikes or drainage to a remote impounding facility.

Where tanks over 500,000 bbl (80,000 m^3) are present, increase minimum distances to 1000 ft (305 m) spacing between them.

Space tanks so the thermal radiation intensity from an exposing fire is too low to ignite the contents of the adjacent tanks. Tolerances of tanks to thermal radiation can be increased by:

- Painting vessels a reflective color (generally white or silver).
- Providing a fixed water spray or tank shell cooling system. Refer to PRC.12.2.1.2 for additional guidance.

- Insulating or fireproofing the tank shell. Guidance can be found in PRC.2.5.1.

Atmospheric Storage Tanks

Classify internal floating roof tanks as floating roof tanks when pontoon internal floaters are provided. When plastic, aluminum or a steel pan are used in the construction of the internal floater, classify the tank as a cone roof tank for spacing purposes.

- Floating roof tanks: Store crude oil and flammable liquids (Class I) in floating roof or internal floating roof tanks. Arrange floating roof tanks in excess of 300,000 barrels (47,700 m3) in a single row. If multiple rows are necessary, space tanks farther than one diameter apart.
- Cone roof tanks: Combustible liquids (Class II and III) may be stored in cone roof tanks with the following limitations or exceptions:
  - Cone roof tanks in excess of 300,000 barrels (47,700 m^3) present an unacceptable amount of potentially explosive vapor space, even if storing heavy oils. In such cases, use only floating roof tanks.
  - Do not store liquids with boil over characteristics in cone roof tanks larger than 150 ft (45.8 m) in diameter, unless an inerting system is provided.
  - Avoid storage of flammable liquids (Class I) in cone roof tanks. If cone roof tanks are used for flammable liquids storage, restrict the tank size to less than 150,000 barrels (23,850 m^3), provide an inert gas blanket, and increase the spacing.
  - Space cone roof tanks storing Class IIIB liquids, operating at ambient temperatures, as "floating and cone roof tanks smaller than 3000 barrels (480 m^3)."
  - Increase separation of cone roof tanks in excess of 10,000 barrels (1590 m^3) containing combustible liquids stored at a temperature higher than 200°F (93°C).

Pressurized and Refrigerated Storage Tanks

Spheres and spheroids: Provide spacing between groups of vessels of at least 100 ft (30 m) or the largest tank diameter. Limit each tank group to a maximum of six vessels. See Table 3 for the minimum spacing between vessels.

Drums and bullets: Limit horizontal pressurized storage vessels to not more than six vessels or 300,000 gal (1136 m^3) combined capacity in any one group. Provide at least 100 ft (30 m) or the largest tank diameter between groups. Align vessels so that their ends are not pointed toward process areas or other storage areas, as these vessels tend to rocket if they fail during a fire. Avoid multiple row configurations. Do not locate pressurized storage vessels above each other. See also PRC.8.2.0.1.

Refrigerated dome roof tanks: Provide spacing between groups of vessels of at least 100 ft (30 m) or the largest tank diameter. Limit each tank group to a maximum of six vessels. Provide greater spacing if exposed combustible insulation is used on the tanks.

DISCUSSION

A good layout and sufficient spacing between hazards, equipment and units will have the following benefits:

- Less explosion damage. Overpressures created by an explosion decrease rapidly as the distance from the center of the explosion increases. The mathematical relationship between overpressures and their distances from the explosion center is given in PRC.8.0.1.1.
- Less fire exposure. Radiation intensity from a fire decreases as the square of the separation distance.
- Higher dilution of gas clouds or plumes. Gas concentration decreases as the distance from the emission source increases.
- Easier access to equipment for maintenance, inspection and firefighting purposes.

- Easier spill and spill fire control in open areas.
- Lower concentration of values, resulting in a lower property damage loss estimates should a given incident occur. AXA XL Risk Consulting typically establishes a probable maximum loss (PML) and maximum foreseeable loss (MFL) estimates based upon a vapor cloud explosion where such a hazard exists. An adequate spread of values and good spacing between explosion hazard areas will lower the PML and MFL.

Extensive spacing might increase the initial investment required to build a given plant. More land will be required. More piping, cabling, roads and larger drainage systems will be required. Additional or larger pumps or compressors might be required as friction loss increases with the piping length and, therefore, operating costs increase. However, the loss control benefits outweigh the additional costs due to less disruption to production when the incident occurs.

Proper layout and separation distances should be designed into a plant during the very early planning stages of the project. This will require preliminary identification of hazards inherent to the operations and of the natural hazards. A good layout may not automatically increase the construction cost because proper separation between hazards can decrease the exposure protection required. For example, a control room unexposed by a process unit would have no need to be explosion resistant. Optimum layout will achieve a balance among loss prevention, construction, maintenance and operation requirements.

Computer-aided design (CAD) generates three-dimensional layouts, which have proven effective for visualizing the proposed spatial arrangement of a unit or plant. High equipment concentration and plant congestion are spotted easily by these computer-generated techniques. The use of CAD allows operators, maintenance and loss prevention personnel to easily comment and make appropriate recommendations. Scale models offer similar benefits.

Vapor cloud calculations could indicate that an even greater separation between some units is needed because of higher than normal explosion damage potential and business interruption.

Other hazard assessment methods can provide good loss potential evaluations and are described in various Center for Chemical Process Safety publications, in the DOW Fire & Explosion Index, or in API RP 752.

Table 1 provides minimum inter-unit spacing, which should be increased where a hazard analysis shows that larger separation distances are required. Unfavorable conditions, such as inadequate sloping, poor drainage and critical operations, can increase the exposure between units, thus requiring higher separation distances. All distances between units are measured from battery limits. “Battery limits” as defined by AXA XL Risk Consulting are imaginary lines surrounding a unit. This line is typically box shaped and encloses equipment required for the operation of the unit. Cooling towers, maintenance buildings or other structures not integral to the unit are considered to be independent and should not be included in the battery limits. This line crosses utility, service, raw material and finished product piping.

The processing units are generally the most hazardous operations in a plant. For operational purposes, the process units are generally grouped together and arranged in accordance with the general process flow.

Often, fire protection spacing requirements will exceed maintenance accessibility requirements. The relative location of equipment depends on its probable release of flammable materials, its flammable liquid holdup, and its potential to be a source of ignition. A domino effect loss is possible within process units.

NFPA 30 defines flammable liquids as Class I materials, and combustible liquids as Class II and III materials. The classification depends on the flash point and boiling point of the product. In some very hot climates, Class II liquids could behave as flammable liquids because the storage temperature could exceed the flashpoint temperature. Unstable liquids or gases and monomer storage require special precautions and are not addressed in Table 3.

HAZARD CLASSIFICATION OF PROCESS OPERATIONS FOR SPACING REQUIREMENTS

INTRODUCTION

Processes differ from each other because of their inherent hazards. Processes and operations can be empirically classified into one of the three classes according to their explosion and fire hazards:

- Moderate
- Intermediate
- High

These classifications do not substitute for a proper hazard identification or analysis method. They are intended only to be used in determining spacing requirements. Many additional factors and judgments can still affect the class to which the process is assigned such as:

- Process Unit size
- Process Vessel size
- Hazards of Materials: Flammability, explosivity, reactivity
- Hazardous Material holdup
- Physical State: Gas vs. liquid phase
- Operating Pressures
- Operating Temperatures
- Potential risk from fire or explosion: probability and consequence
- Unit importance to continuity of operations
- Loss history
- Interdependency
- Lead time to rebuild
- Market share

Therefore, if any of the above features of a process are higher than normal, raise it to a higher class. Typical process examples are given for each classification.

See PRC.8.0.1.1 for an evaluation method to estimate damage from a vapor cloud or vessel explosion.

FIRE AND EXPLOSION HAZARD CLASSIFICATION

Moderate

This category includes processes, operations, or materials having a limited explosion hazard and a moderate fire hazard. This class generally involves endothermic reactions and nonreactive operations, such as distillation, absorption, mixing and blending of flammable liquids. Exothermic reactions with no flammable liquids or gases also fit in this hazard group. Typical examples include:

- Acetic anhydride (carbonylation of methyl acetate)
- Acetone (dehydrogenation of alcohol)
- Adiponitrile
- Ammonia

- Crude distillation
- Dimethyl formamide
- Chloromethanes
- Ethanol (from methanol)
- Ethylene glycol
- Formaldehyde (methanol oxidation)
- Methyl amines
- Methyl ethyl ketone (dehydrogenation of alcohol)
- Solvent extraction
- Styrene
- Urea
- Visbreaking

Intermediate

This category includes processes, operations, or materials having an appreciable explosion hazard and a moderate fire hazard. This class generally involves mildly exothermic reactions. Typical examples include:

- Acetic anhydride (from acetic acid)
- Alkylation (Refinery)
- Benzene (from toluene-xylene)
- Benzene-Toluene-Xylene (BTX)
- Cumene
- Cyclohexane
- Ethyl benzene
- Hydrogenation
- Methanol (Reforming)
- Natural Gas Liquefaction Plants
- Natural Gas Liquids Extraction Plants
- Organic Peroxides
- Polyethylene HD (small units)
- Polypropylene
- Polystyrene
- Polyvinylchloride
- Reforming (Refinery)
- Terephtalic Acid

High

This category includes processes, operations, or materials having a high explosion hazard and moderate to heavy fire hazard. This class involves highly exothermic or potential runaway reactions and high hazard products handling. Typical examples include:

- Acetic acid
- Acetaldehyde (oxidation)
- Acetone (cumene oxidation)
- Acrolein
- Acrylic acid (propylene oxidation)

- Acrylonitrile
- Butadiene (oxidation)
- Caprolactam
- Cyclohexanone (cyclohexane oxidation)
- Cumene hydroperoxide
- Dimethyl terephtalate
- Dinitrotoluene (nitration)
- Ethylene
- Ethylene oxide
- Hydrocracking (Refinery)
- Maleic anhydride (butane oxidation)
- Methyl metacrylate
- Organometallics (Alkyla-luminums)
- Phenol (cumene oxidation)
- Phtalic anhydride
- Polyethylene LD (high pressure)
- Polyethylene HD (large units)
- Polyglycol ethers (polyols)
- Propylene oxide
- Trinitrotoluene (nitration)
- Vinyl acetate
- Vinyl chloride (VCM-EDC)