Petroleum Storage Tanks

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Accident s of Explosive of Petroleum and Gas Storage Tanks


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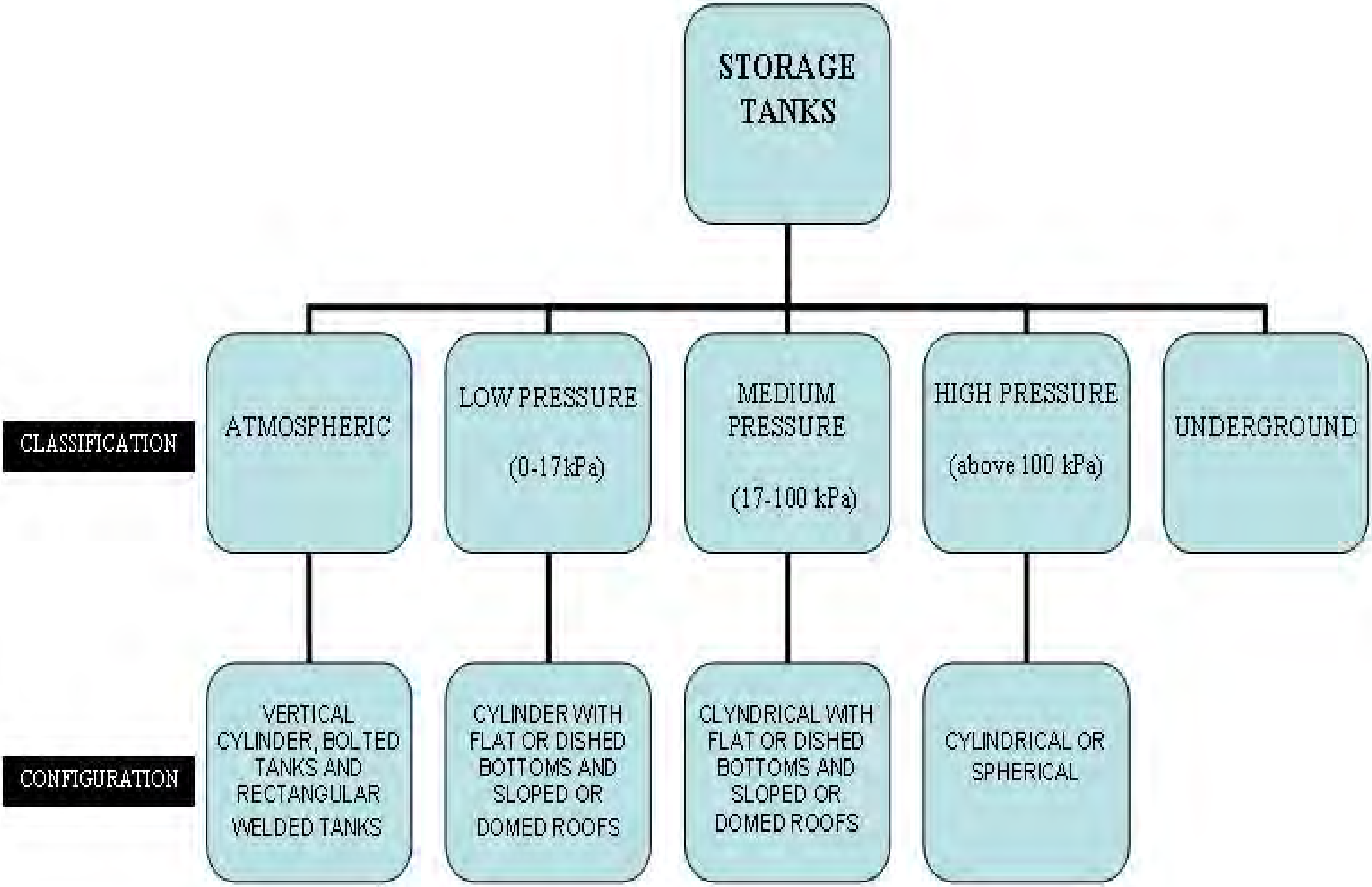
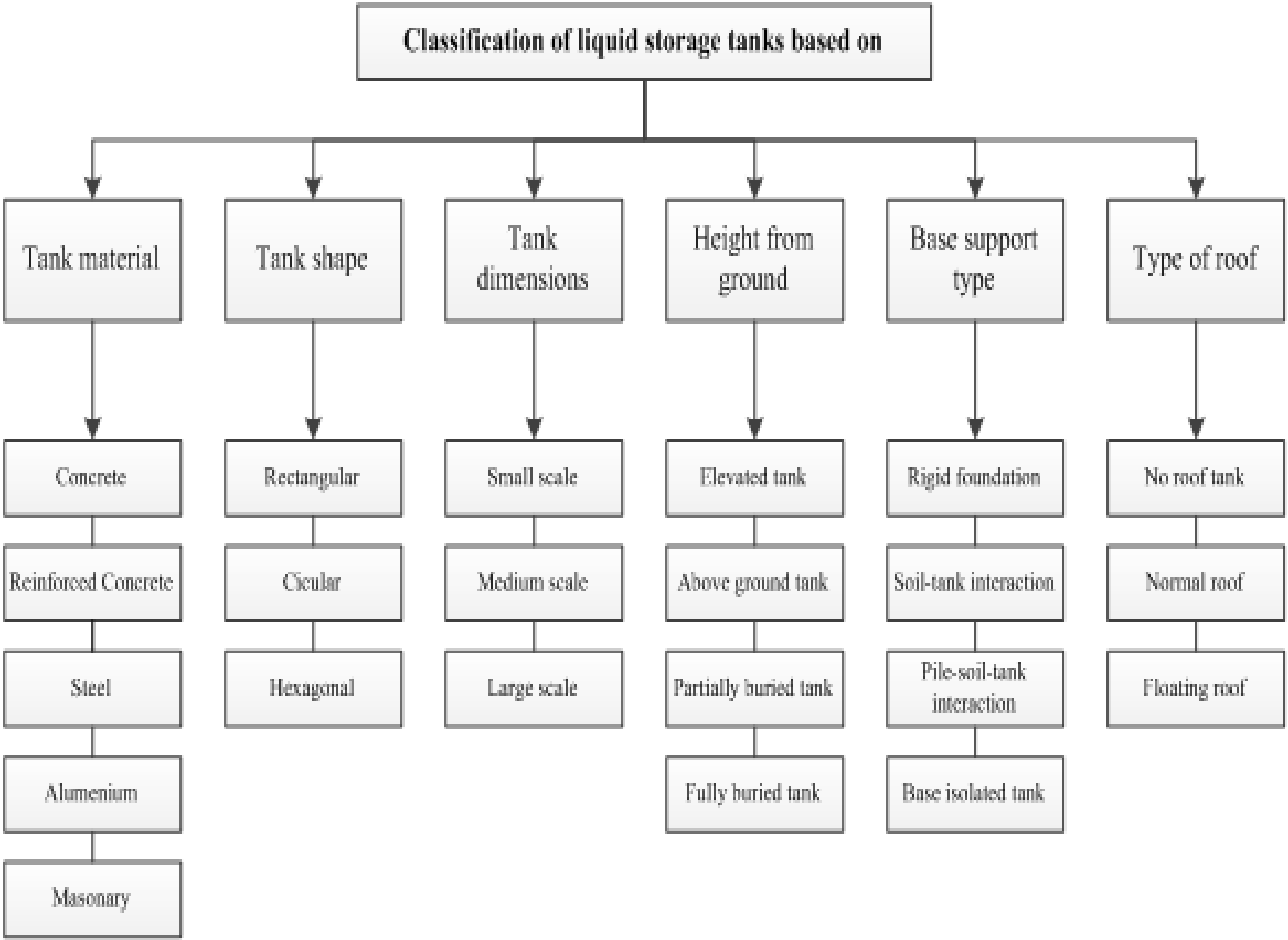
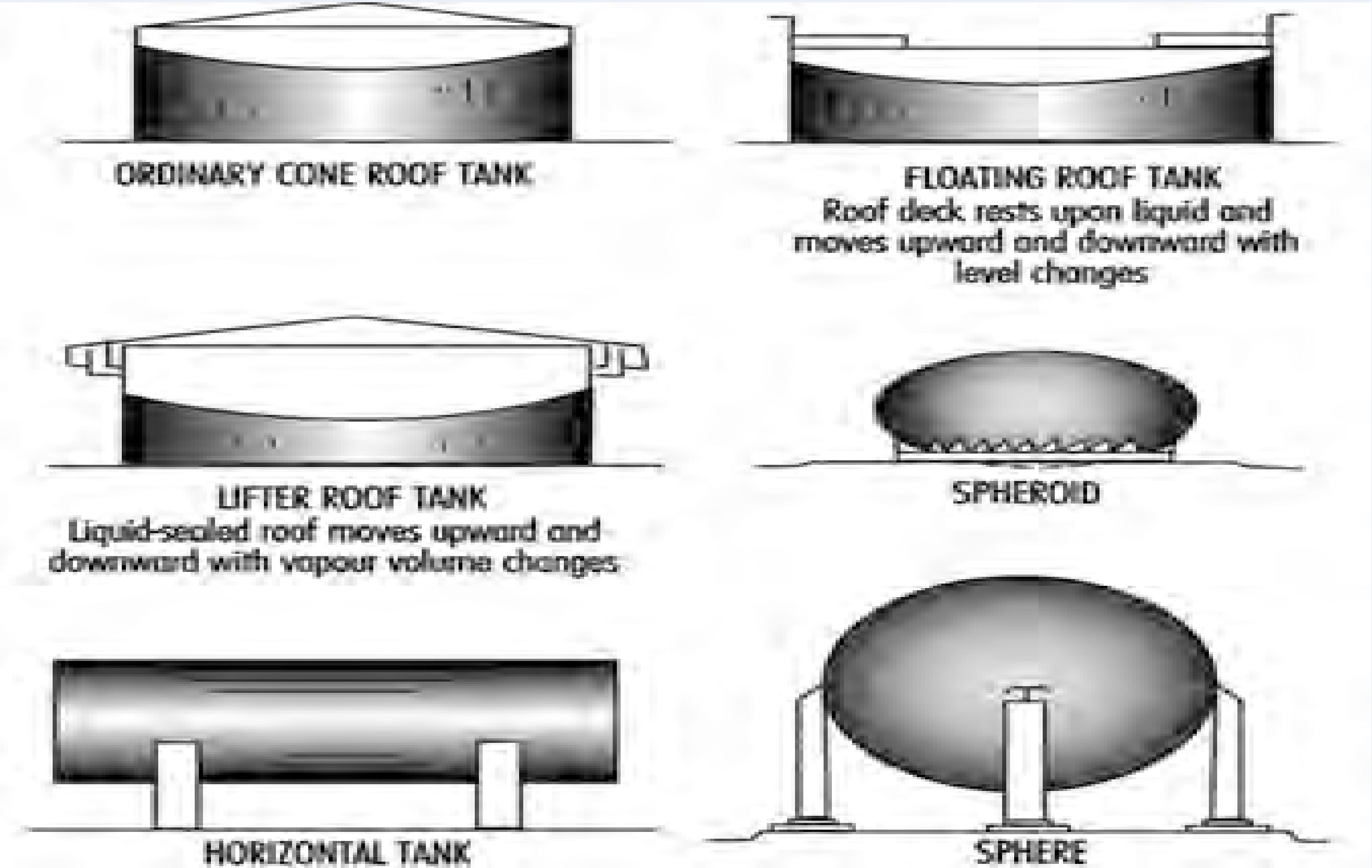
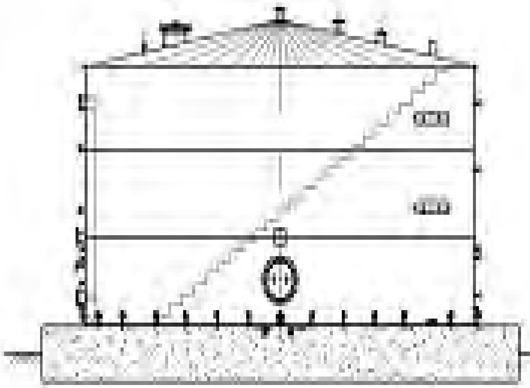
Types of Storage Tanks



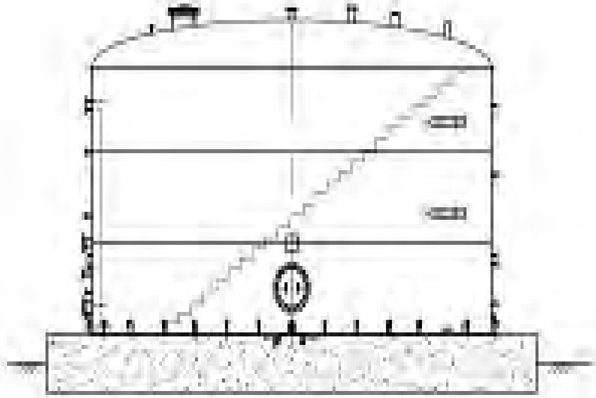

Classification of liquid storage tanks based on
Tank material
Tank shape
Tank dimensions
Height from ground
Base support type
Type of roof
Concrete
Reinforced Concrete
Steel
Alumenium
Masonary
Rectangular
Cicular
Hexagonal
Small scale
Medium scale
Large scale
Elevated tank
Above ground tank
Partially buried tank
Fully buried tank
Rigid foundation
Soil-tank interaction
Pile-soil-tank interaction
Base isolated tank
No roof tank
Normal roof
Floating roof

Common types of tanks for storage of flammable and combustible liquids.



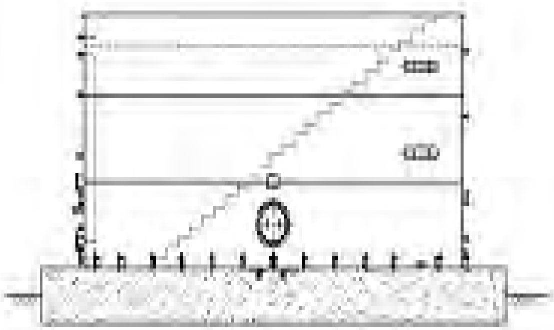


Umbrella Roof

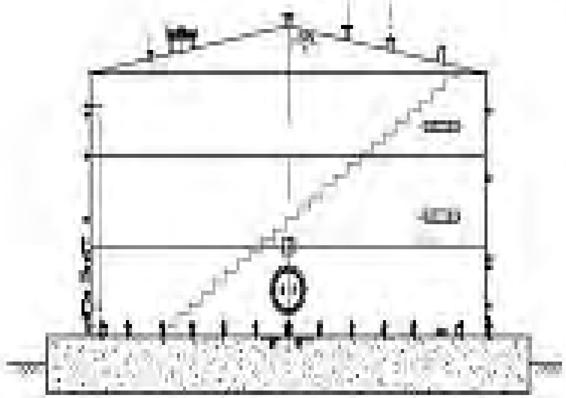


Dome Roof

The major parts in storage tanks to which calculations apply, include shell, roof and bottom plate respectively.



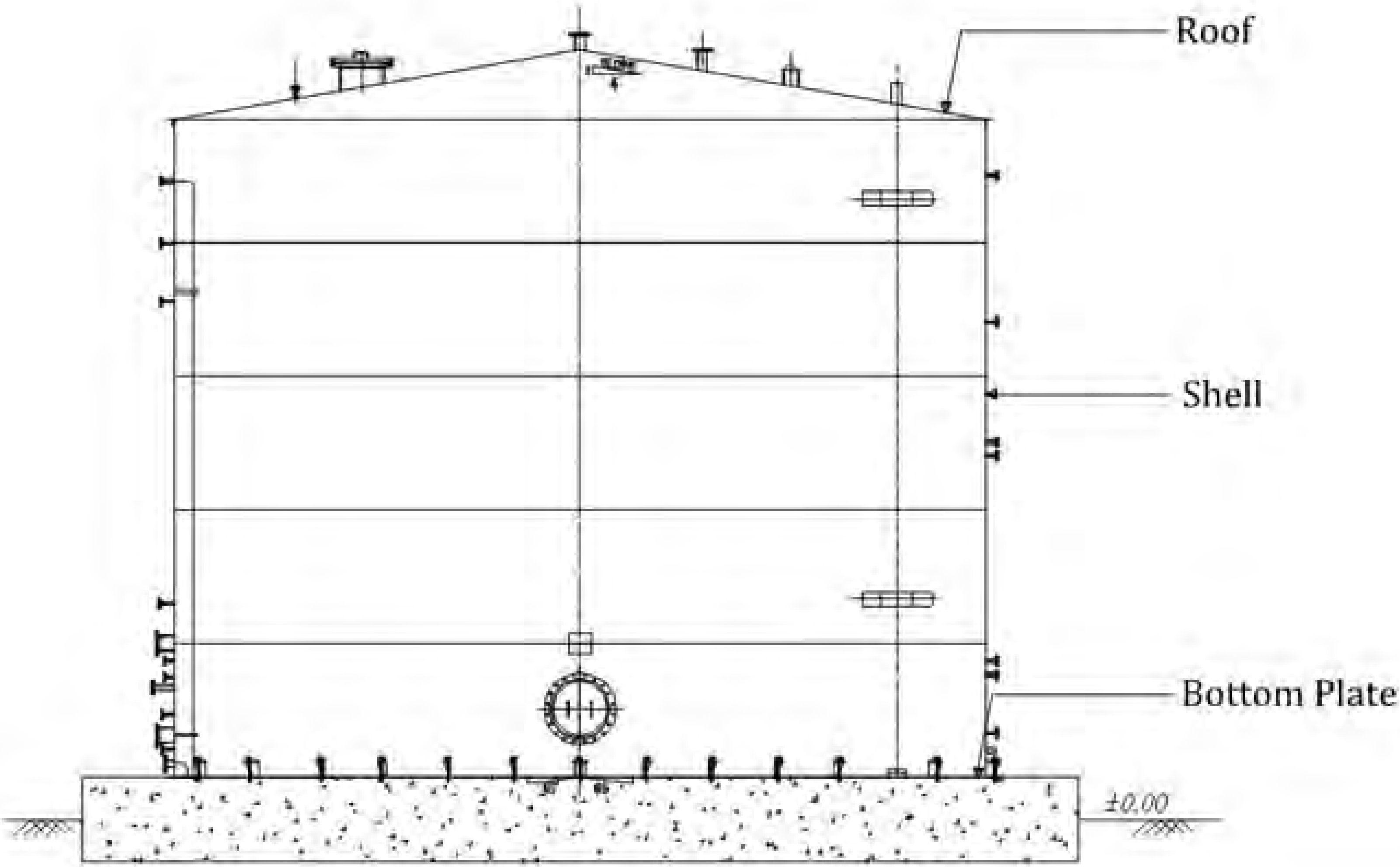
Floating Roof



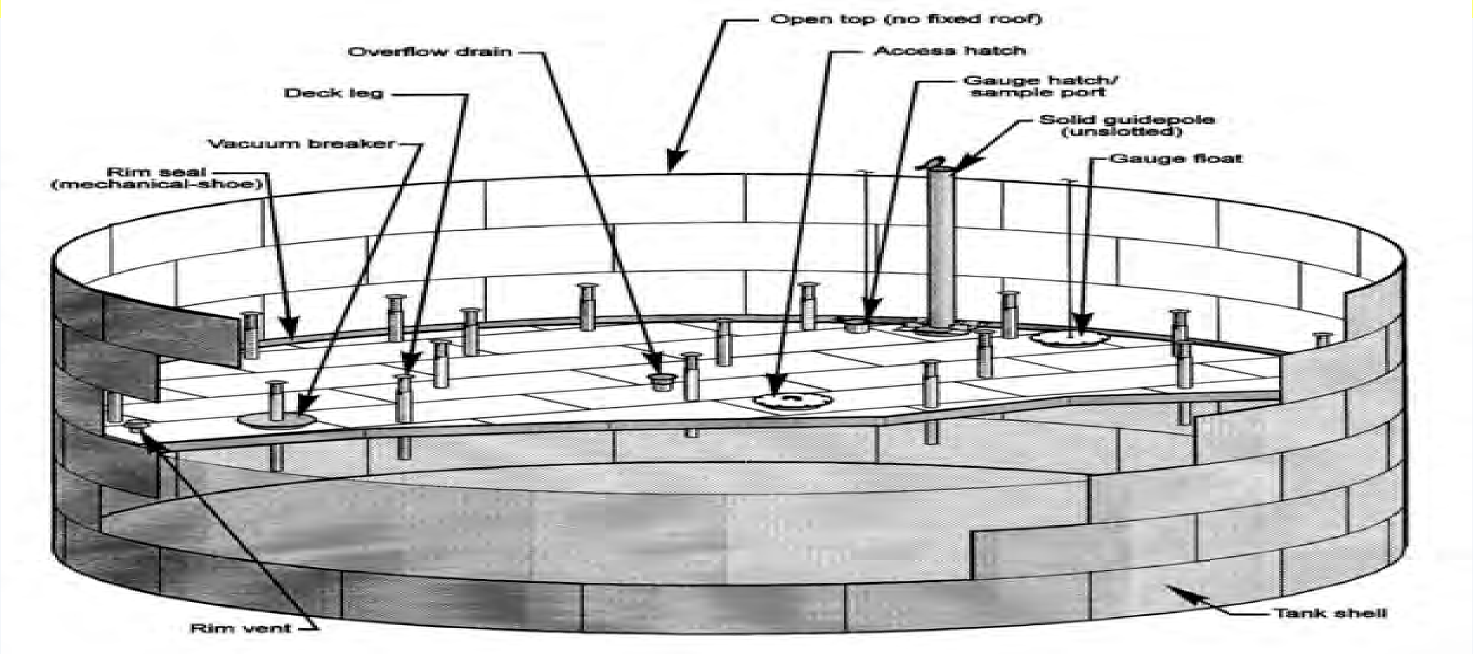
Cone Roof

Based on the shape of the roofs, storage tanks are classified to four major categories as flowing:

Fixed Roof tank



External Floating Roof Tank



Advantages of External Roof Tanks

External roof tanks are usually installed for environmental or economical reasons to limit product loss and reduce the emission of volatile organic compounds (VOC), an air pollutant.

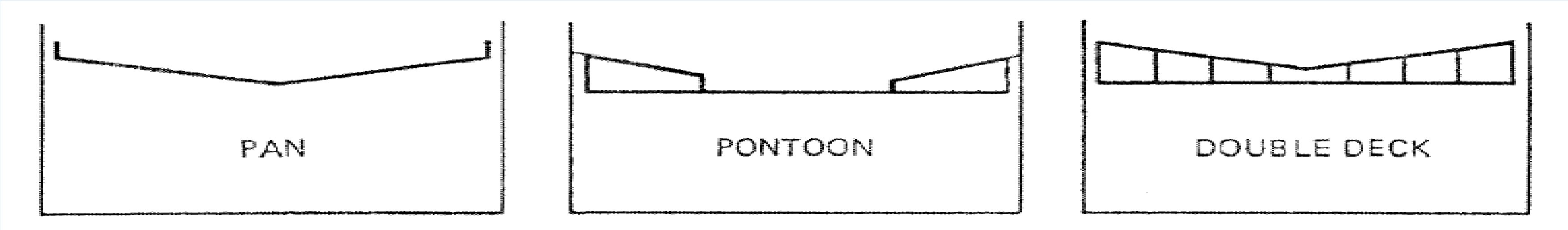
Disadvantages

Rain water and snow can accumulate on the roof; eventually the roof may sink.

Roof Tank Types

- Floating-roofs are completely welded structures, which are fabricated on site.
- The following types can be distinguished:

1- Pan tanks, 2- Pontoon roof, and 3- Double deck roof



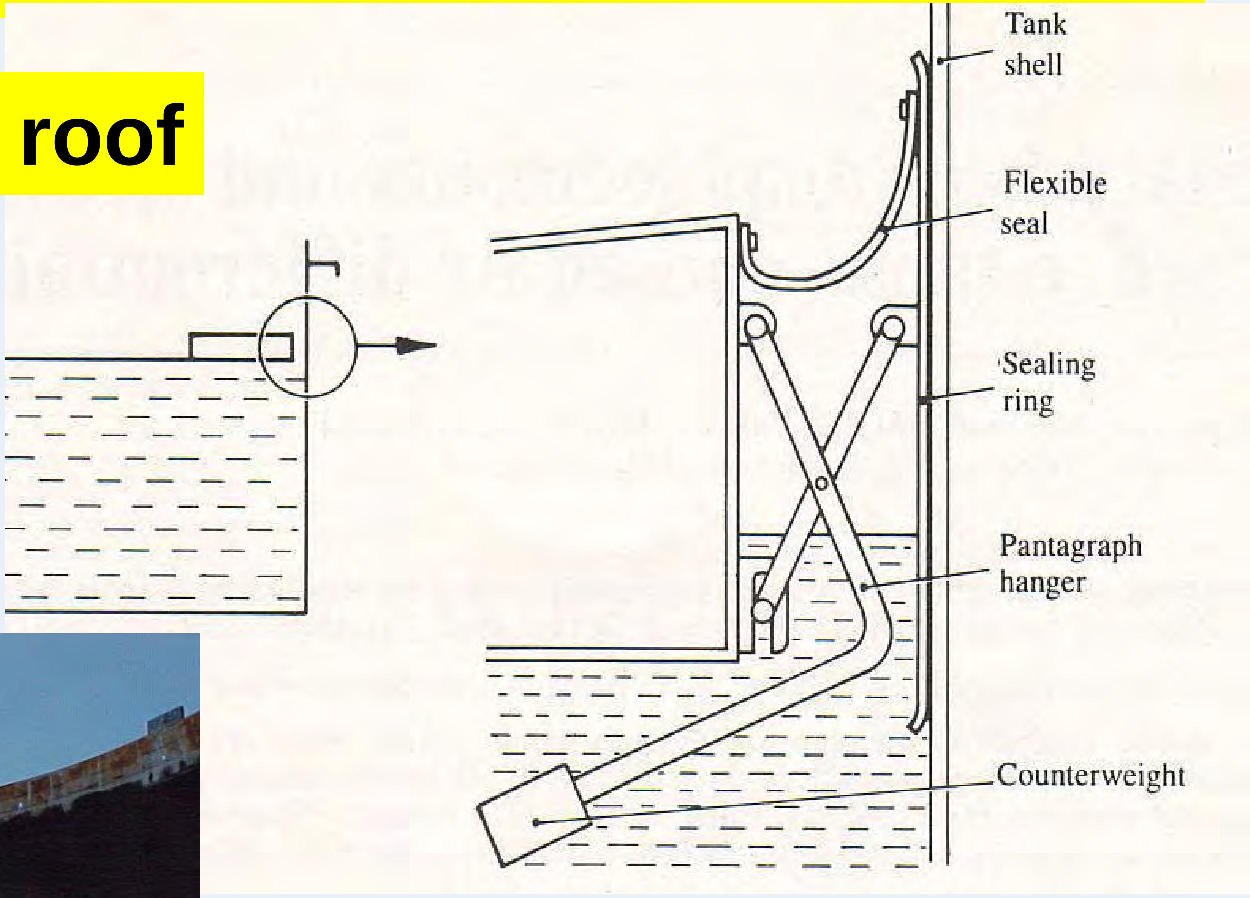
The pan roof was the first type of floating roof tank. Some are still in use in different places. The pan roof is a single layer of metal. The pan is shaped like an upside-down cone. The low point in the center of the roof is a collecting point for rain water.

Pontoon Roof. The outer edge of the pontoon roof is a float, called a *pontoon.* This is a sealed metal air chamber that provides flotation for the roof. As figure 6 shows, the underside of the roof is flat. The pontoon around the roof also provides some air space insulation for part of the liquid surface under the roof.

The double deck floating roof is the most efficient type of floating roof. The air space between the top and bottom of the roof provides insulation from the heat of the sun over the entire surface of the stored liquid. The sloping top forms a collecting point for rain water in the center of the roof.

A floating roof may have a complex mechanism to avoid gases accumulating on top of the fluid by means of a pontoon resting on the fluid. There are various models of sealing rings to allow vertical displacements.

Sealing of the roof



Petroleum Product Classes and Tank Types

Product Class	Standard Tank Diameter in Meters			
	3- 12.5	15-20	22.5-39	42-78
Class I (Flash Point: $F < 21^\circ C$)	Fixed Roof		Preferably Floating Roof	Floating Roof
Class II (Flash Point: $21^\circ C \leq F < 55^\circ C$)		Fixed Roof	Preferably Floating Roof	Floating Roof
Class III (Flash Point: $F \leq 55^\circ C$)	Fixed Roof all Diameters			

Considerations for Engineering Design of Storage Tanks

- Determine the size of tank (volume, i.e. diameter and height).
- Select the best material of construction.
- The Operating, Design, and Testing Pressure.
- The Operating Temperature.
- Types of Roof tanks.
- Safety considerations.
- Maintenance considerations.
- Options for foundation design.

✓ Tanks shall rest on foundations made of concrete or steel.

✓ The foundations shall be designed to minimize the possibility of uneven settling of the tank, and to minimize corrosion to any part of the tank resting on the foundation.

- Check Requirements

The General Standards for Design of Petroleum Storage Tanks

Steel Tank Institute SP-001 Standard for Inspection of Aboveground Storage Tanks
Underwriters Laboratory (UL) Standard 142 Steel Aboveground Tanks for Flammable and Combustible Liquids
National Fire Protection Association (NFPA) Code 30A Automotive and Marine Service Station Code, Chapters 1 and 2
National Fire Protection Association (NFPA) Code 30 Flammable and Combustible Liquids Code,
FIELD ERECTED TANKS
American Petroleum Institute (API) Standard 620 Design and Construction of Large, Welded, Low-Pressure Storage Tanks
API Standard 650 Welded Steel Tanks for Oil Storage
API Recommended Practice 651 Cathodic Protection of ASTs
API Recommended Practice 652 Lining AST Tank Bottoms
API Standard 653 Tank Inspection, Repair, Alteration, and Reconstruction
API Recommended Practice 920 Prevention of Brittle Fracture
API Standard 2015 Safe Entry and Cleaning of Tank
API Recommended Practice 2350 Overfill Protection for Petroleum Tanks
API Standard 2610 Design, Construction, Operation and Maintenance and Inspection of Terminal and Tank Facilities

MATERIALS OF CONSTRUCTION

Following are the common plate material used for construction of tanks,

A 36	upto 40 mm
A 283 Gr C	upto 25 mm
A 285 Gr C	upto 25 mm
A 131 Gr A	upto 12.5 mm
A 131 Gr B	upto 25 mm
A 516 Gr 55,60,65,70	upto 40 mm
A 537 Cl1, Cl2	upto 45 mm

The minimum tensile strength of materials used in construction of tanks are between 55000 psi to 85000 psi.

Carbon content between 0.15% to 0.25%

Pressure Vessel Design

- **Pressure Vessel Design Codes**
- Vessel Geometry & Construction
- Strength of Materials
- Vessel Specifications
- Materials of Construction
- Pressure Vessel Design Rules
- Fabrication, Inspection and Testing

The General Loads in Storage Tanks

- Loading that caused from internal and external pressure
- The weight of vessel and contents
- The weight pump , duct , pipe and etc
- Loading that caused from earth quake , wind and etc

DESIGN OF TANK COMPONENTS

SHELL DESIGN:

Shell thickness is calculated for two conditions, design conditions and hydrotest condition

Design Condition:

$$td = \frac{2.6\ D(H-1)G}{S_d} + CA$$

Hydrostatic Condition:

$$tt = \frac{2.6\ D(H-1)G}{S_t}$$

where, td is the design thickness required in inches

tt is the hydrostatic thickness required in inches

D is the diameter of the tank in feet

H is the height of the tank in feet

G is the specific gravity of the product

CA is the corrosion allowance in inches

S_d is the allowable stress for design condition in psi

S_t is the allowable stress for test condition in psi

WIND GIRDER DESIGN: As per Clause 3.9.7

Tanks of larger diameter may not have the necessary inherent rigidity to withstand wind pressure without deforming and excessively straining the shell. To avoid this suitable stiffening or wind girders are provided.

The maximum height of unstiffened shell H_1 shall be calculated as follows:

$$H_1 = 600{,}000\ t\ ((t/D)^3)^{12}\ (100/V)^2$$ (As per Clause 3.9.7)

where, t = as ordered thickness of the top shell course(in.)

D = nominal tank diameter(ft)

V = wind velocity (mph)

After the maximum height of the unstiffened shell, H_1 has been determined, the height of the transformed shell shall be calculated as follows:

Change the actual width each shell course into a transposed width of each shell course having the top shell thickness:

$$W_{tr} = W((t_{uniform}/t_{act})^5)^{05}$$

where W_{tr} = Transposed width of each shell course, (in.)

W = Actual width of each shell course (in.)

$t_{uniform}$ = ordered thickness of top shell course (in.)

t_{act} = ordered thickness of shell course for which transposed width is calculated (in.)

SEISMIC ANALYSIS

The design procedure considers two response modes of the tanks and its contents:

a. The relatively high-frequency amplified response to lateral ground motion of the tank shell and roof, together with the portion of the liquid contents that moves in unison with the shell.

b. The relatively low-frequency amplified response of the portion of the liquid contents that moves in fundamental sloshing mode.

The design requires the determination of the hydrodynamic mass associated with each mode and the lateral force and overturning moment applied to the shell as a result of the response of the masses to lateral ground motion.

The overturning moment due to seismic forces applied to the bottom of the shell shall be determined as follows:

$$M = ZI\,(C_1 W_s X_S + C_1 W_r X_t + C_1 W_1 X_1 + C_2 W_2 X_2)$$

where, Z = seismic zone factor

I = Importance factor as per Appendix E

$C_1 C_2$ = lateral earth quake force coefficients

W_S = Total weight of the tank shell(lb)

X_S = Height from the bottom of the tank shell to the shell's CG(ft)

W_r = Total weight of the tank roof(lb)

H_t = Total height of tank shell(ft)

W_1 = Weight of the effective mass of the tank contents that move in unison with the tank shell(lb)

X_1 = Height from the bottom of the tank shell to the centroid of lateral seismic force applied to W_1 (ft)

W_2 = Weight of the effective mass of the tank contents that move in unison in first sloshing mode(lb)

X_2 = Height from the bottom of the tank shell to the centroid of lateral seismic force applied to W_2 (ft)

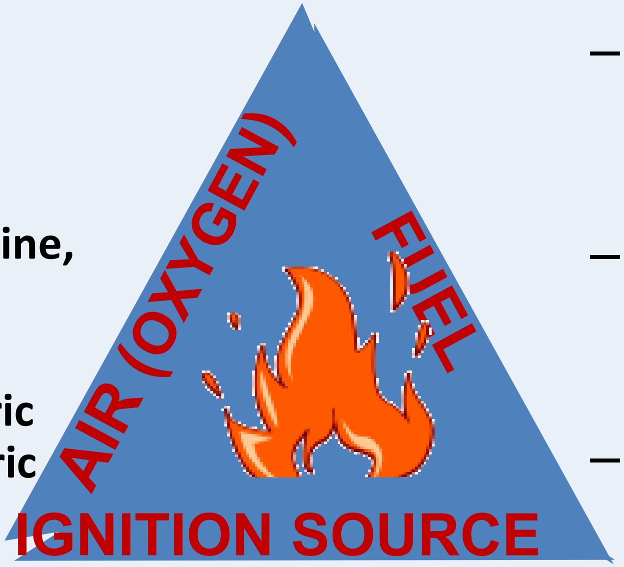
Resistance to the over turning moment at the bottom of the shell may be provided by the weight of the tank shell and by anchorage of the tank shell or for unanchored tanks, the weight of a portion of the tank contents adjacent to the shell.

In Design of Petroleum Storage Tanks:

Three elements must be considered to gate the required Process Safety: 1) Behavior 2) System and 3) Process

The Fire Triangle

- **Oxidizers**
  - Liquids
  - Gases
    - Oxygen, fluorine, chlorine
    - hydrogen peroxide, nitric acid, perchloric acid
  - Solids
    - Metal peroxides, ammonium nitrate



- **Fuels:**
  - Liquids
    - gasoline, acetone, ether, pentane
  - Solids
    - plastics, wood dust, fibers, metal particles
  - Gases
    - acetylene, propane, carbon monoxide, hydrogen

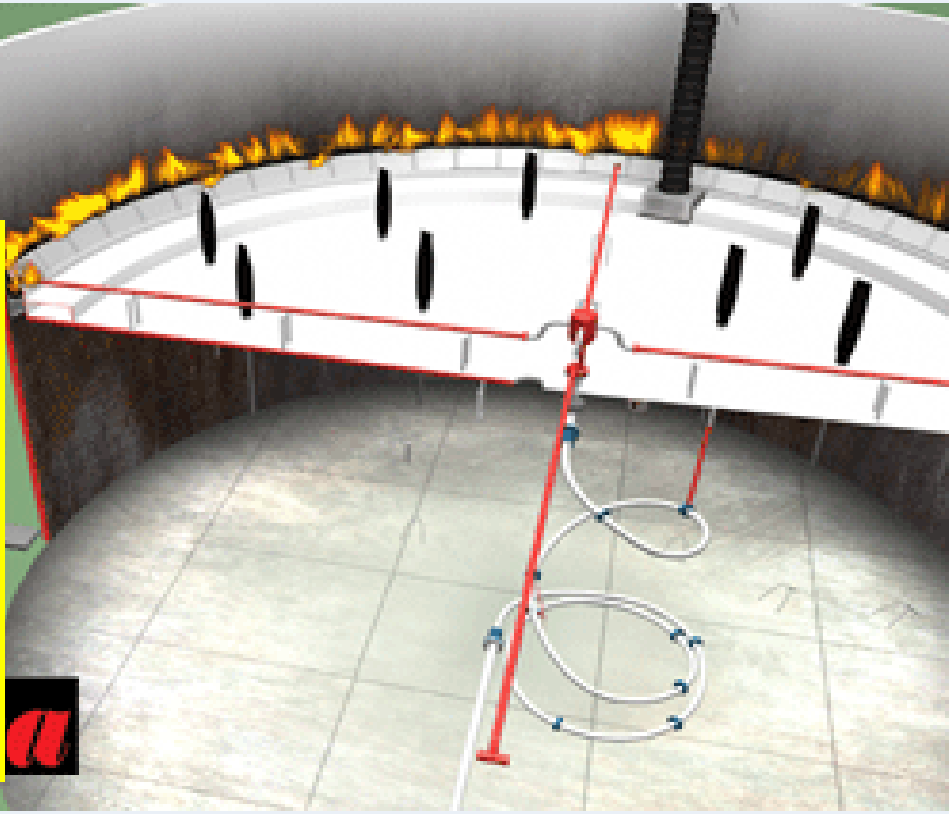
- **Ignition sources**
  - Sparks, flames, static electricity, heat

Fire Protection System for Petroleum Storage Tanks:

This system designed to deliver foam directly to the storage tank rim and prevent extended of fire.

Foam System Advantages

- **Provides economical solution**
- **Ensures rapid response**
- **Directly delivers foam to rim area**
- **Operates with minimal maintenance**
- **Reduces risk**
- **Engineered to NFPA guidelines**
- **Integrates with tank design**



VENTING

Storage Tanks - Cone Roof

Atmospheric tanks shall be adequately vented to prevent the development of vacuum or pressure which exceeds the design pressure of the tank as a result of filling, emptying, or atmospheric temperature changes.

Normal Venting

COMPONENTS OF STORAGE TANK MANAGEMENT PROGRAM

- ✓ Tank and Piping Design and Construction
- ✓ Spill and Overfill Control
- ✓ Venting
- ✓ Tank Location
- ✓ Associated Electrical Equipment
- ✓ Release Detection and Monitoring
- ✓ Fire Control/Emergency Equipment
- ✓ General Requirements
- ✓ Training
- ✓ Inspections/Assessments

Design Pressure

- Excessive design pressure causes equipment to be more expensive than is required

for cylindrical shells

$$t = \frac{P \cdot r_i}{S \cdot E_J - P} + C_c$$

t = metal thickness, P = Design Pressure

C_c = Corrosion Allowance, E_J = Joint Efficiency

S= Tensile strength of the metal,

r_i = Radius of vessel or tank

Recommended Stress Values

Joint efficiencies	Recommended stress values		
	Metal	Temp., °C	S, kPa
For double-welded butt joints	**Carbon steel**	-29 to 343	94,500
If fully radiographed = 1.0	(SA-285, Gr. C)	399	82,700
If spot-examined = 0.85		454	57,200
If not radiographed = 0.70	**Low-alloy steel**	-29 to 427	94,500
	for resistance to	510	75,800
In general, for spot examined	H_2 and H_2S	565	34,500
If electric resistance weld = 0.85	(SA-387, Gr. 12C1.1)	649	6,900
If lap-welded = 0.80	**High-tensile steel**	-29 to 399	137,900
If single-butt-welded = 0.60	for heavy-wall	454	115,800
	vessels	510	69,000
	(SA-302, Gr.B)	538	42,750
	High-alloy steel	-29	128,900
	for cladding and	343	77,200
	corrosion resistance	427	72,400
	Stainless 304	538	66,900
	(SA-240)		
		-29	128,900
	Stainless 316	345	79,300
	(SA-240)	427	75,800
		538	73,100
	Nonferrous metals	38	46,200
	Copper (SB-11)	204	20,700
	Aluminum(SB-209, 1100-0)	38	15,900
		204	6,900

Spherical Tanks

- **Suitable for Design Pressures of**

  # 2 to 15 psig

  # 30 to 220 psig

(Reference: Ludwig, Equipment Design for Chemical & Petrochemical Processes,

$$P = \frac{SEt_p}{R + 0.2t_p} \quad \begin{cases} t \le 0.356 r_i \\ or \ P \le 0.665 SE_J \end{cases}$$

P = internal design gauge pressure *(psig)*
R = Inside Radius *(inch)*
t_p = Minimum required thickness *(inch)*
E = Lowest joint efficiency
S = Max allowable stress *(psi)*


Thank You
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