Basic Industrial Fire Protection:

Part 1

Active and Passive Fire Protection

Anthony Cole, P.E., CFPS, CFEI

Basic and Advance Industrial Fire Protection Course

- **Basic Industrial Fire Protection (IFP)**
  - Prescriptive-based on various API Documents
  - Active and passive fire protection
  - Management of hazards and risk
- **Advance Industrial Fire Protection (IFP)**
  - Performance-based using the Thomas Barry's book and other various AICHE/CCPS references
  - Involves the aid of computer modeling

Course Outline: Basic IFP

- **Part 1: Active and Passive Fire Protection**
  - **API RP 2001**, *"Fire Protection In Refineries"*
  - **API 2021**, *"Management of Atmospheric Storage Tanks"*
  - **API 2510A**, *Fire Protection considerations for the Design and Operation of Liquefied Petroleum Gas (LPG) Storage Facilities"*
  - **API 2030**, *"Application of Fixed Water Spray Systems for Fire Protection in the Petroleum Industry"*
  - **API 2218**, *"Fireproofing Practices in the Petroleum and Petrochemical Processing Plants"*

Course Outline: Basic IFP

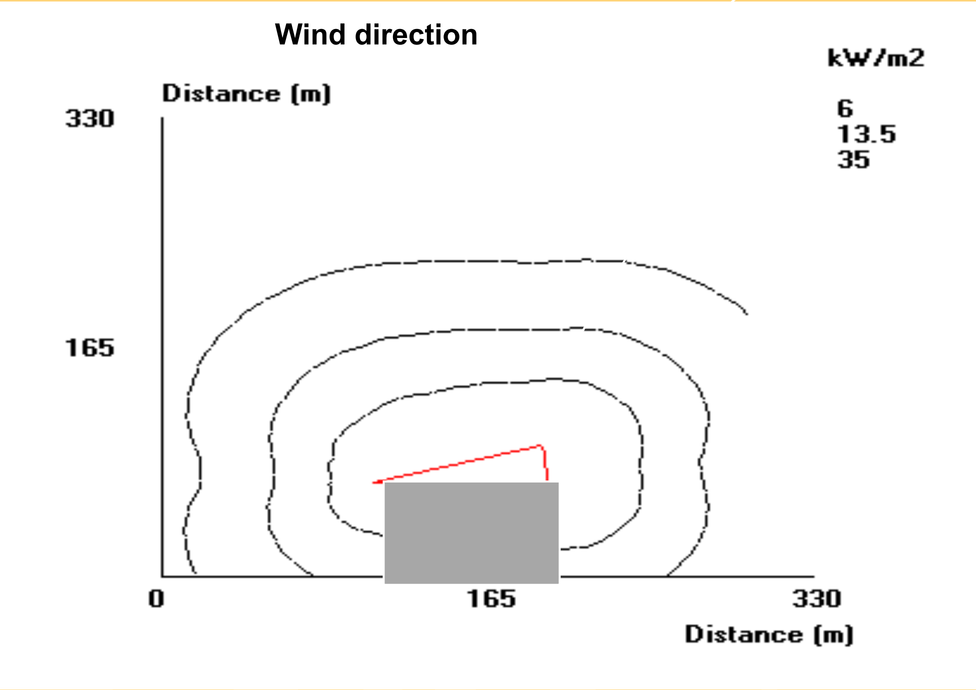
- **Part 2: Advance Hazard Control**
  - **API 521**, *"Pressure-relieving and Depressuring Systems"*
  - **API 2028**, *"Flame Arresters in Piping Systems"*
  - **API 2210**, *"Flame Arresters for Vents of Tanks Storing Petroleum Products"*
  - **API 750**, *"Management of Process Hazards"*
  - **API 752**, *"Management of Hazards Associated with Location of Process Plant Buildings"*

Course Outline: Basic IFP

- **Part 3: Managing Risk**
  - **API 760**, "*Model Risk Management Plan Guidance for Petroleum Refineries*"
  - **AICHE/CCPS**, *"Guidelines for Hazard Evaluation Procedures"*
  - ***AICHE/CCPS**,* "Guidelines for Chemical Process Quantitative Risk Analysis"

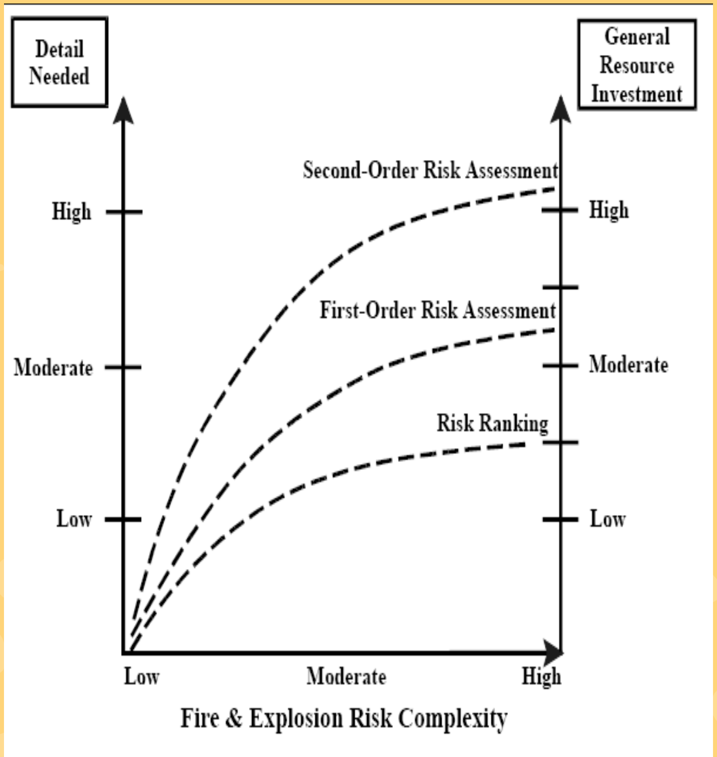
Course Outline: Advance IFP

- **Part 1:**
  - Industrial Application of Computer Modeling Programs



Course Outline: Advance IFP

- **Part 2:**
  - Risk-Informed, Performance-Based Industrial Fire Protection



Today's Objectives

- Discuss the basic principles of active and passive fire protection
- Introduce/review the five (5) "core" API Standards
- Application of the API Standards to real life situations
- Question and answers
- Conclusion

Active and Passive Fire Protection

- What is active fire protection?

  A fire protection method that employs manual or automated means of activation, initiation, alerting, or opening by use of mechanical or electrical devices to deliver, remove, isolate, or otherwise detect and/or suppress a hazard.

Active and Passive Fire Protection

- Examples include:
  - Sprinkler systems
  - Clean agent gas systems
  - Fire detection systems
  - Smoke control and management systems
  - Portable Equipment (fire extinguishers/hose cabinets)

Active and Passive Fire Protection

- Physical Principles in Use:
  - Cooling
  - Smothering/reduction
  - Dilution
  - Suppression
  - Inerting
  - Chain breaking

Active and Passive Fire Protection

Critical Point #1:

In the process industry, the prime objective or purpose of applying water streams in a fire situation is to provide cooling and containment…….

NOT Extinguishment

Active and Passive Fire Protection

- What is passive fire protection?

  A fire protection method that prolongs the fire resistance and/or reduces the effects of thermal radiation for building components, super-structures, vessels, pumps, cable trays, pipes, or similar from failure prior to occupants escape or manual fire firefighting intervention.

Active and Passive Fire Protection

- Examples include:
  - Fireproofing (coatings or insulation)
  - Non-combustible construction
  - Partitions or walls
  - Compartmentation
  - Spacing and layout (Part 2)
  - Drainage and containment (Part 2)
  - Electrical area classification (Part 2)

Active and Passive Fire Protection

- Physical Principles in Use:
  - Delay of effects created by the three modes of energy transfer

Active and Passive Fire Protection

Critical Point #2:

The principle value of passive fire protection …..initial stages of a fire, when efforts are primarily directed at shutting down units, isolating fuel sources, and setting up fire fighting equipment.*

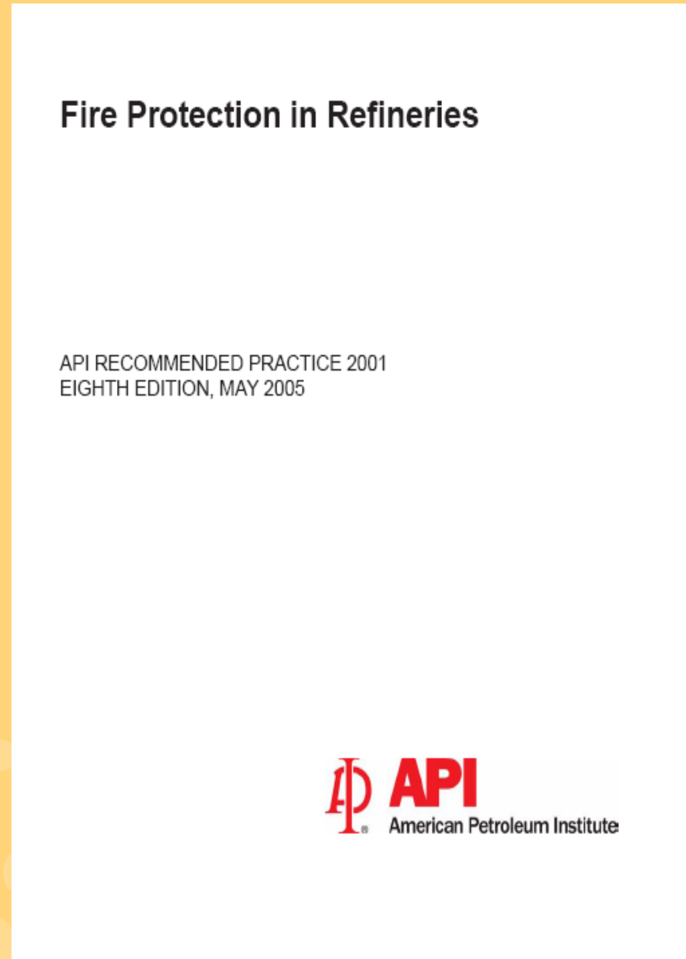
**or to permit the escape and/or protection of occupants in a building or structure.*

The "Core" API Standards

- **API RP 2001**, *"Fire Protection In Refineries"*
- **API 2021**, *"Management of Atmospheric Storage Tanks"*
- **API 2510A**, *Fire Protection Considerations for the Design and Operation of Liquefied Petroleum Gas (LPG) Storage Facilities"*
- **API 2030**, *"Application of Fixed Water Spray Systems for Fire Protection in the Petroleum Industry"*
- **API 2218**, *"Fireproofing Practices in the Petroleum and Petrochemical Processing Plants"*

The "Core" API Standards: API RP 2001

- **API RP 2001**, *"Fire Protection In Refineries"*
- ***Purpose****: Better understanding of refinery fire protection…promote a safe plant.*
- ***Scope****: Basics of fires, control and extinguishment, emergency response.*


Fire Protection in Refineries

API RECOMMENDED PRACTICE 2001
EIGHTH EDITION, MAY 2005

API
American Petroleum Institute

API RP 2001

- **Hazards** – Conditions or properties of materials with the inherent ability to cause harm
- **Risk** – the probability of exposure to a hazard which could result in harm or damage
- **Risk Assessment** – Identification and analysis with judgments of probability and consequences, either qualitative or quantitative

API RP 2001

- Guide to good engineering practice
- Not a design manual (still need NFPA)
- Involve all engineering disciplines
- Should be considered during the earliest stages of refinery design

API RP 2001

- Proper equipment design
- Conditions that lead to fires or explosions*:
  - Vapor clouds
  - Spill/release of flammable liquids
  - Loss of inerting
  - Vibration
  - Incompatible mixing
  - corrosion

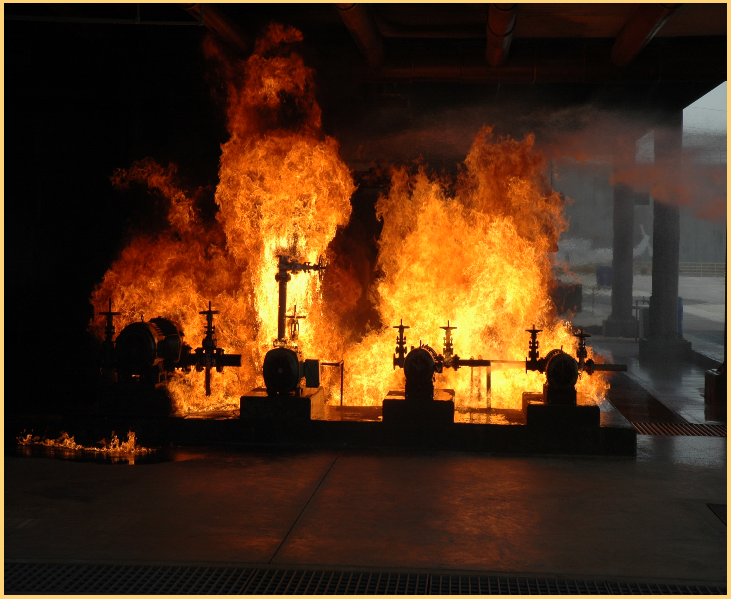
*Section 5.4

API RP 2001

- Where can I expect to see these failures??
- While conducting a walk-through, what should I be looking at?
- How should I be looking at a piece of equipment? A process?
- What are the “red flags”?

API RP 2001

- Where can I expect to see these failures??
  - Pumps/Compressors
  - Pipe Racks/Piping
  - Control Cables
  - Finfan Coolers
  - Pressure Vessels/ Exchangers/Columns
  - Transformers



API RP 2001

- While conducting a walk-through, what should I be looking at?
  - Left
  - Right
  - Above
  - Behind
  - Under
  - And around………

API RP 2001

- How should I be looking at a piece of equipment? A process?
  - Eyes open
  - Mind engaged
  - Liquid inventory
  - Exposures
  - High pressure
  - Physical state of the product
  - Man…this looks weird?!?!

API RP 2001

- What are the “red flags”?
  - Items from “the list” (section 5.4)
  - Closed valves
  - Hot/cold permits
  - Alarms
  - Fire extinguishers laying around
  - Hose cabinets in use
  - “pee-yew”!
  - “I think I stepped in something”!

API RP 2001

Table 1—Example Water Flow Rates for Manual Fire Fighting[1]

Scenario Area of Interest	Firewater Flow Ranges, Per Minute in Thousands of Gallons (Thousands of Liters)	Example Flow Rate, Ranges Based on Protected Area GPM/Ft^2 or LPM/M^2
Radiant heat protection		0.1 gpm/ft^2 (4.1 lpm/m^2)
Process areas handling flammable liquids or high pressure flammable gases	4,000 to 10,000 gpm (15,000 to 38,000 lpm)	Cooling: 0.2 to 0.3 gpm/ft^2 (8.2 to 12.3 lpm/m^2) Suppression: 0.3 to 0.5 gpm/ft^2 (12.3 to 20.4 lpm/m^2)
Process areas handling gases or combustible liquids	3,000 to 5,000 gpm (11,000 to 19,000 lpm)	0.20 to 0.30 gpm/ft^2 (8.2 to 12.3 lpm/m^2)
Tank storage of flammable and combustible liquids in atmospheric tanks		See API 2021 & NFPA 11
LPG Storage tanks and vessels		See API 2510, API 2510A and NFPA 58 *[250 to 500 gpm at point of impingement by a high-velocity jet flame—API RP 2510A]*
Warehouses		See applicable NFPA Fire Codes
Buildings, offices, laboratories, and similar structures		See applicable NFPA Fire Codes

Note: [1]The total (gpm or lpm) flow required will depend on size, congestion and the needs of the exposed facilities being protected. The specific flow rate (gpm/ft^2 or lpm/m^2) chosen will depend on the definition of the fire area and the fuel loading in the area.

Section 6.2.1.4 Maximum flow for 4 to 6 hours

API RP 2001

Critical Point #3:

Refinery fire protection is not like baking a cake, you don’t use a cookbook…….it is done using a thorough and properly executed hazard identification methodology.

The "Core" API Standards: API 2021/2021A

- **API 2021,** *"Prevention and Suppression of Fire in Large Aboveground Atmospherics Storage Tanks"*
- ***Purpose:*** *Provide an experienced-based information to enhance the understanding of fire in atmospheric storage tanks*
- ***Scope:*** *…mange the needs associated with fires in atmospheric storage tanks*

Management of Atmospheric Storage Tank Fires

API RECOMMENDED PRACTICE 2021
FOURTH EDITION, MAY 2001

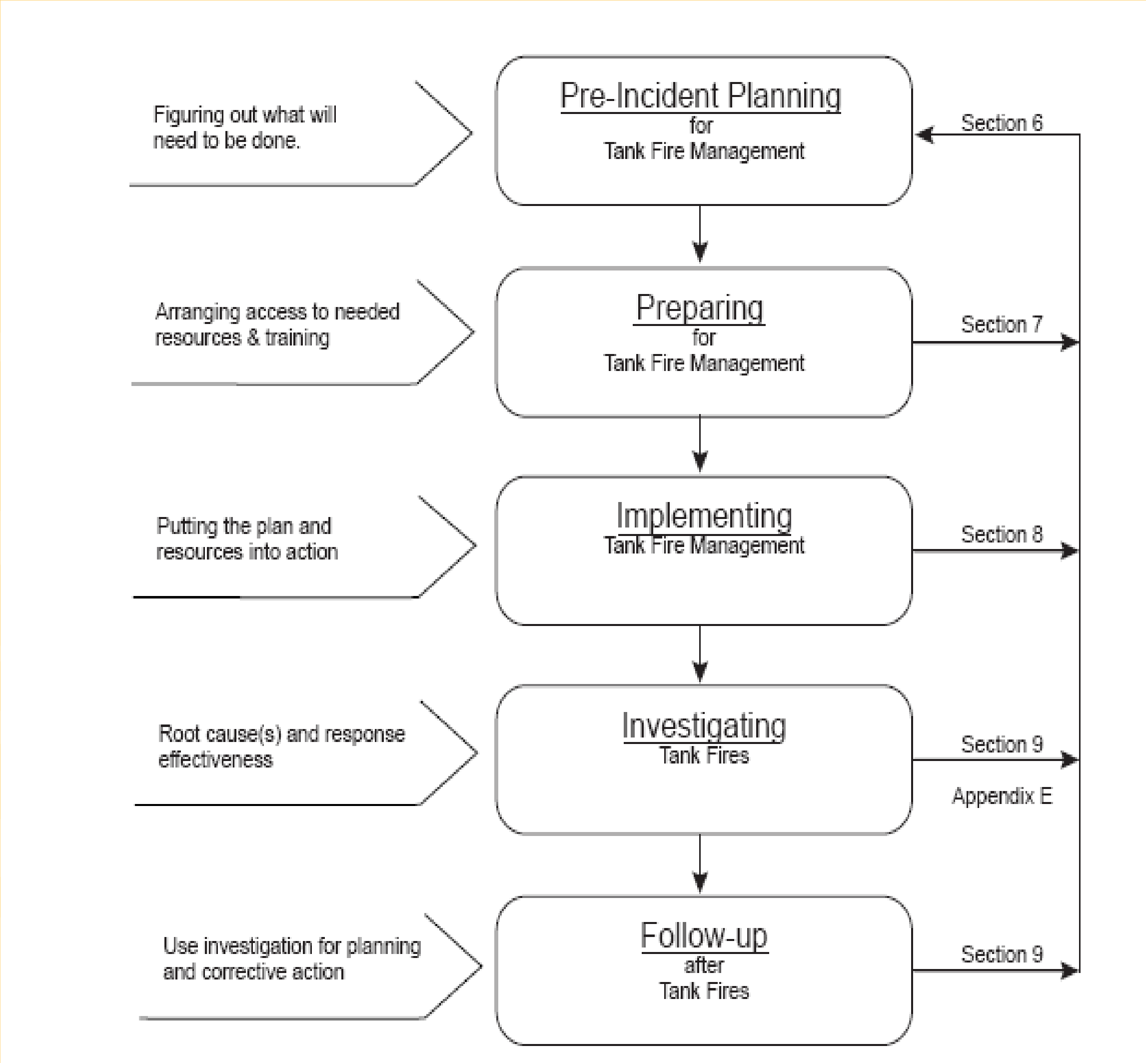
American Petroleum Institute

Helping You Get The Job Done Right.℠

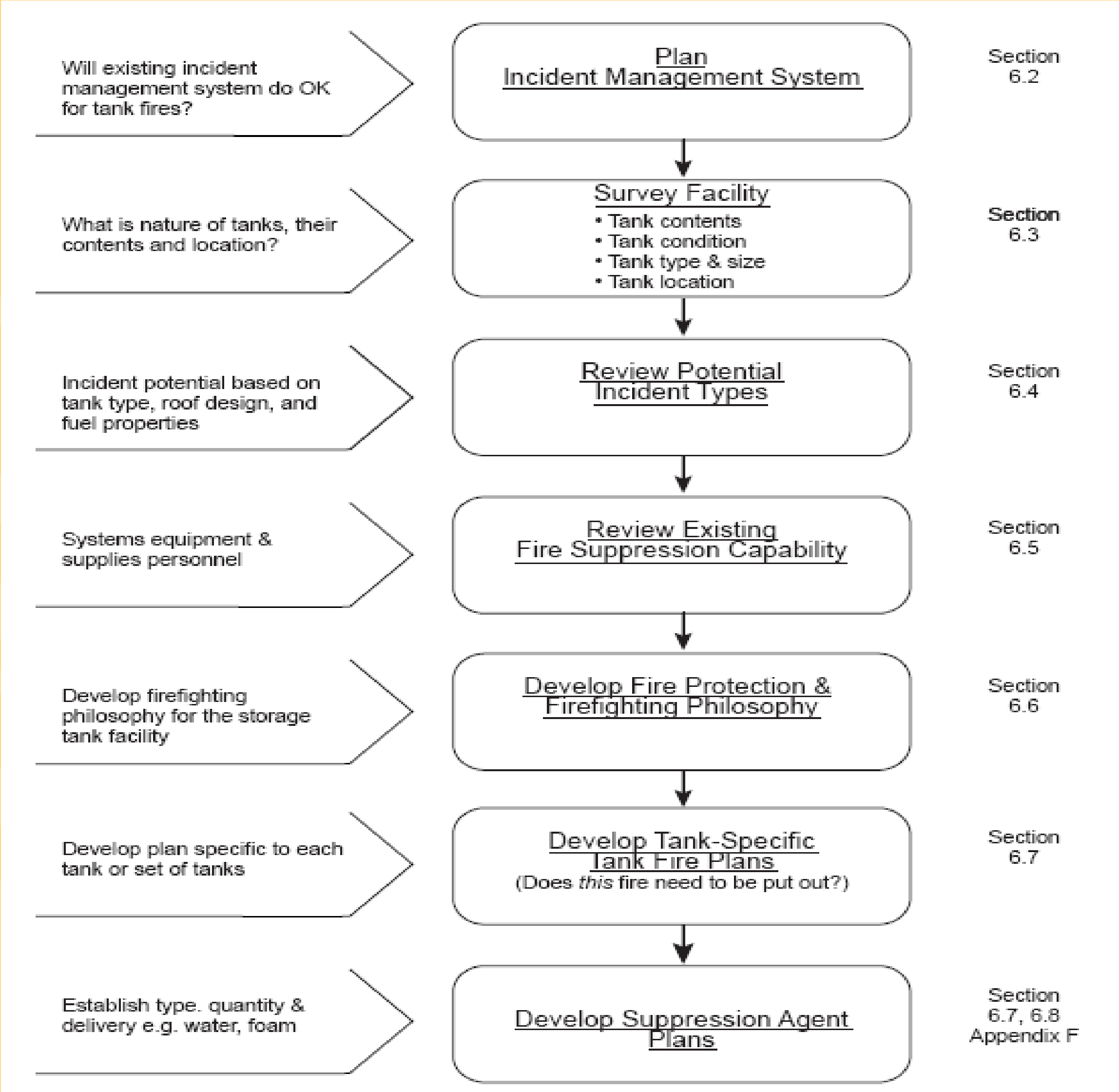
API 2021/2021A

- Interim study that coincides with API 2021
  - **API 2021A**, *“Interim Study – Prevention and suppression of Fires in Large Aboveground Atmospheric Storage tanks”*
- **New Documents:**
  - FOAMSPEX
  - LASTFIRE

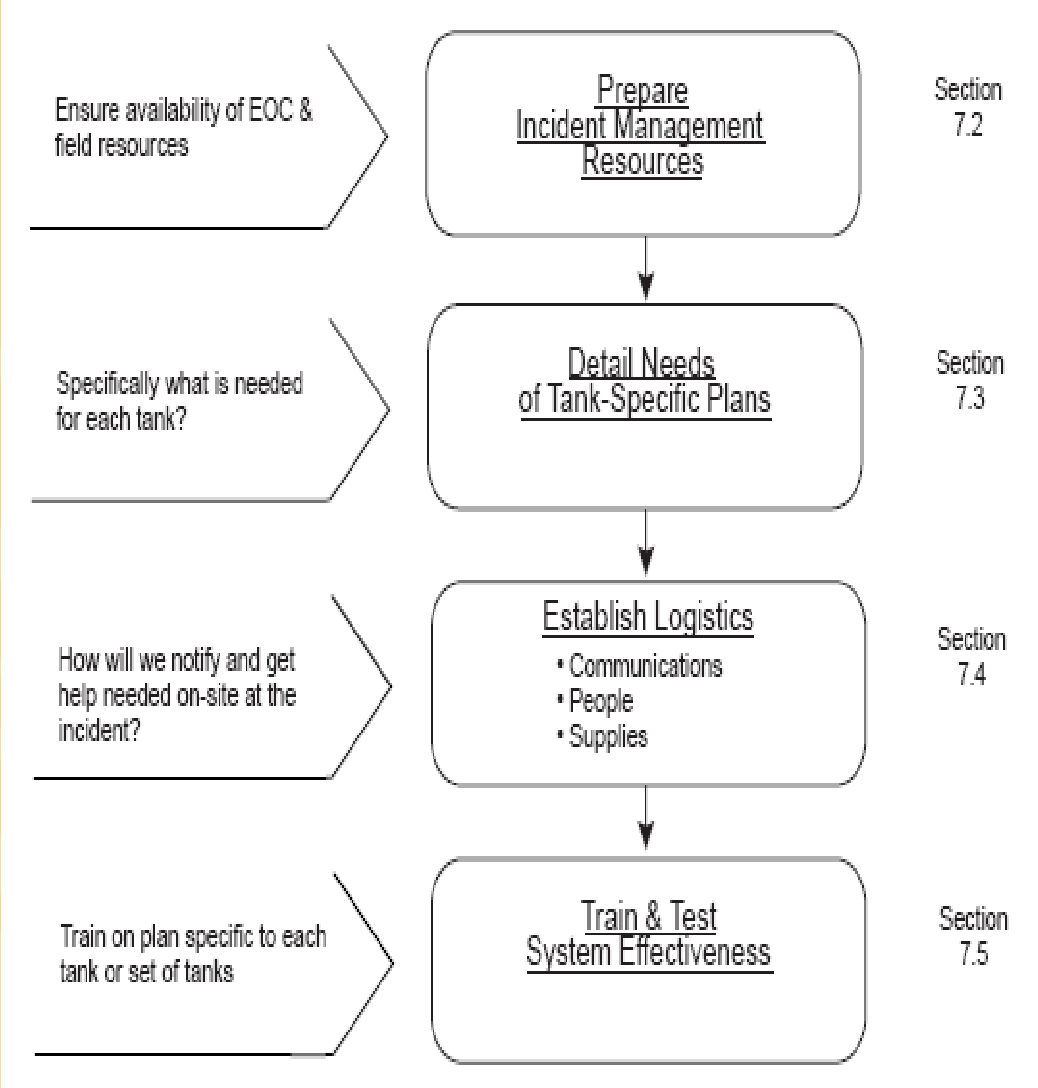
API 2021/2021A



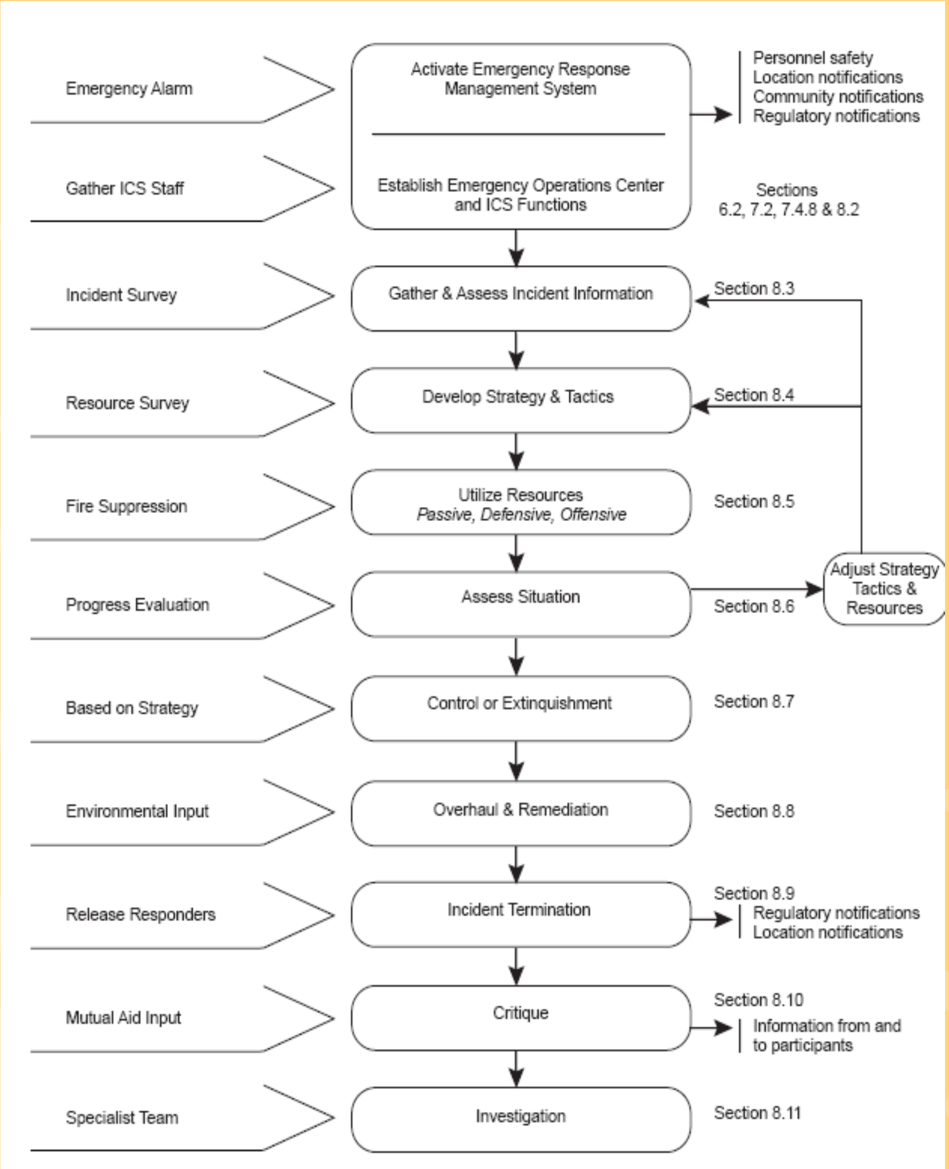
API 2021/2021A



API 2021/2021A



API 2021/2021A

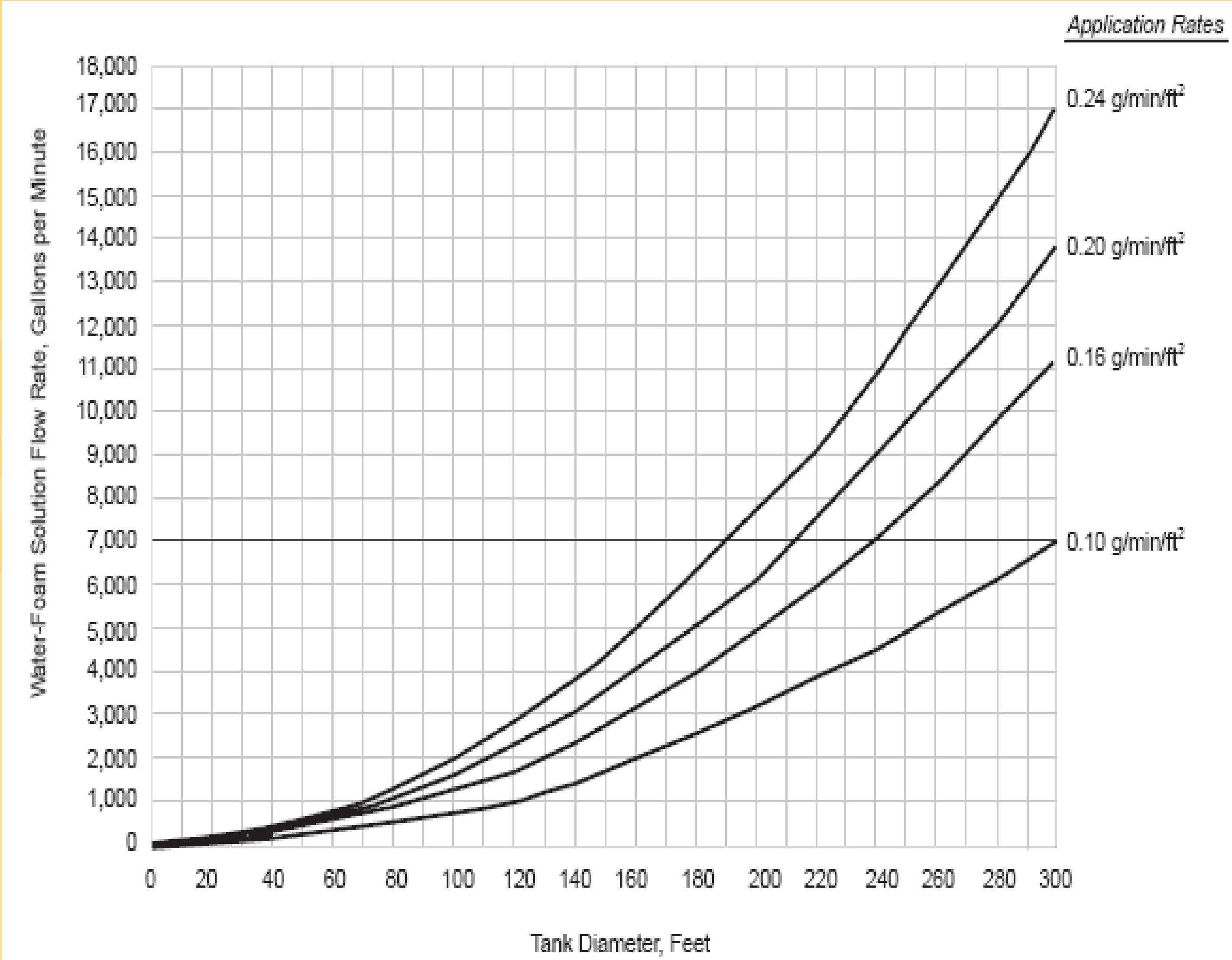


API 2021/2021A

Tank Type [a]	Potential Type(s) of Fire	Comments
Fixed (Cone) Roof Tanks	Vent Fire Overfill Ground Fire Unobstructed Full Liquid Surface Area Obstructed Full Liquid Surface Fire if frangible roof remains partially in tank	For volatile liquids, the rich vapor space typically prevents ignition within the tank. Environmental regulations typically prevent storage of Class I flammable liquids in larger fixed roof tanks
Vertical, Low-Pressure Fixed Roof Tanks without Frangible Roof Seams	Vent Fire Overfill ground fire Tank Explosion and failure with subsequent ground fire	Rich vapor space inside of tank typically prevents ignition within tank. Lack of frangible roof seam can result in failure of tank at bottom or side, resulting in significant or total loss of tank integrity, and/or launching of tank.
Internal (or Covered) Floating-Roof Tanks	Vent Fire Overfill ground fire Obstructed Rim Seal Fire Obstructed Full Liquid Surface Fire	Many fires in this type of tank occur as a result of overfilling. Tank will be extremely difficult to extinguish if entire liquid surface becomes involved. Fires in tanks with pan type covers can be expected to develop into obstructed full liquid surface fires.
Domed (or covered) External Floating-Roof Tanks	Vent Fire Overfill ground fire Obstructed Rim Seal Fire Obstructed Full Liquid Surface Fire	Fires in this type of tank most often occur as a result of overfilling. Tank will be extremely difficult to extinguish if entire liquid surface becomes involved.
Open Floating-Roof Tanks	Rim Seal Fire Overfill ground fire Obstructed Full Liquid Surface Fire Unobstructed Full Surface Fire	Application of fire water to the roof area should be carefully controlled to prevent overloading and sinking the roof when fighting a rim seal fire.
Horizontal Tanks	Vent Fire Overfill ground fire Tank Explosion and failure with subsequent ground fire	Rich vapor space inside of tank typically prevents ignition within tank. Explosion of vapor/air mixture in tank can result in catastrophic failure, with tank ends travelling significant distances. Exposure of unwetted surface of tank to fire can result in a Boiling Liquid Expanding Vapor Explosion (BLEVE).

[a] Appendix E provides pictures and information for various types of storage tank.

API 2021/2021A



API 2021/2021A

K.2 Primary protection

Foam concentrate requirements are determined by the following equation:

$$C = RSTF$$

Where:

C = concentrate required, in gallons.

R = rate of foam solution application, in gallons per minute per square foot.

S = liquid surface area, in square feet.

T = application time, in minutes (see NFPA 11).

F = foam concentrate, as a percent of foam solution.

K.3 Supplemental protection

For protection in addition to the requirements listed in K2, the following equation is used:

$$C = NLTF$$

Where:

C = foam concentrate required, in gallons (liters).

N = nozzle application rate of foam solution, in gal lons per minute (liters per minute).

L = number of lines needed at 50 g/min (190 l/min) per hose line (see NFPA 11).

T = application time, in minutes (see NFPA 11 requirements shown in Table K-3).

F = foam conentrate, as a percent of foam solution.

API 2021/2021A

Table K-1—NFPA Full Surface Fire Minimum Application Rate Based on Fuel and Application Method

Fuel Type	Type II Foam Chambers	Subsurface Injection	Handlines or Monitors
Hydrocarbon	0.10 g/min/ft^2 (4 l/min–m^2)	0.10 g/min/ft^2 (4 l/min-m^2)	0.16 g/min/ft^2 (6.5 l/min-m^2)
Alcohols & Oxygenates[a]	0.10– 0.16 g/min/ft^2 (4–6.5 l/min-m^2)	Not Applicable[b]	0.16 - 0.20 g/min/ft^2 (6.5 - 8 l/min-m^2)
Wide Boiling Range (Crude) Initial	0.10 g/min/ft^2 (4 l/min-m^2)	0.10 g/min/ft^2 (4 l/min-m^2)	0.16 g/min/ft^2 (6.5 l/min-m^2)
After prolonged burning -- if heat wave established	0.20 or more g/min/ft^2 (8 l/min-m^2)	0.20 or more g/min/ft^2 (8 l/min-m^2)	0.20 or more g/min/ft^2 (8 l/min-m^2)

[a] Application rates and foam concentrate percentage for specific oxygenates can vary widely and should be determined in consultation with the foam concentrate supplier.
[b] Subsurface injection is not recommended by NFPA 11 for strong polar solvents requiring alcohol-type foam. MTBE, ETBE and similar weak polar solvent materials should be reviewed with the foam supplier as special cases based on their water solubility, volatility and physical characteristics.

Table K-2—NFPA Full Surface Fire Minimum Application Time in Minutes Based on Application Method

Hydrocarbon Type	Type II Foam Chambers 0.10 g/min/ft^2 (4 l/min-m^2)	Subsurface Injection 0.10 g/min/ft^2 (4 l/min-m^2)	Handlines or Monitors 0.16 g/min/ft^2 (6.5 l/min-m^2)
Flash Point between 100°F and 140°F (38°C and 60°C)	30	30	50
Flash Point below 100°F (38°C) or liquids heated above their flashpoints	55	55	65
Crude Petroleum	55	55	65
Products requiring alcohol resistant foam	55	not recommended	65

Table K-3—Supplemental Hose Streams Recommended by NFPA 11

Largest Tank Diameter	Supplemental Hose Streams 50 g/min (190 l/min) each	Minimum Operating Time Minutes
Up to 35 ft (10 m)	1	10
35 to 65 ft (10– 20 m)	1	20
65 to 95 ft (20–29 m)	2	20
95 to 120 ft (29–36 m)	2	30
Over 120 ft (36 m)	3	30

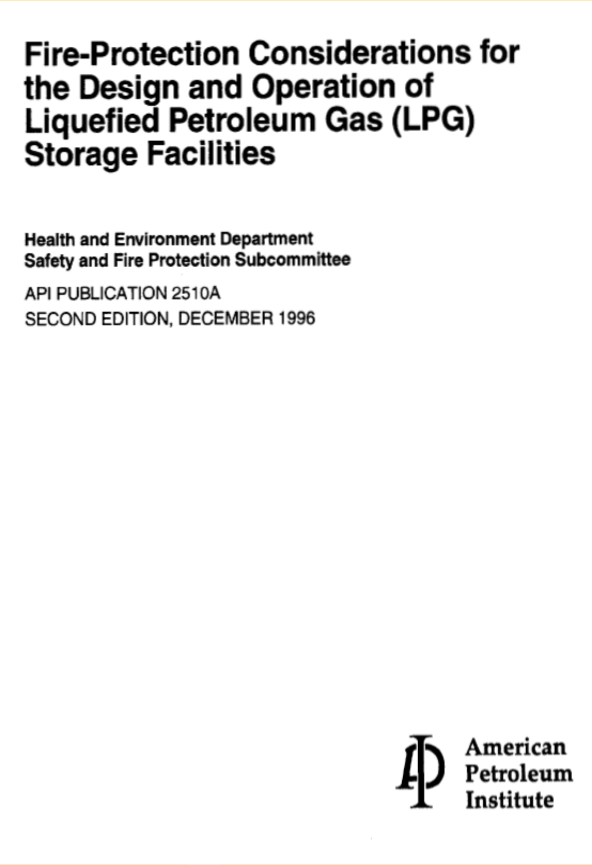
API 2021/2021A

Critical Point #4:

Planning phase starts with a scenario analysis….logistics associated with major tank fire incidents can be very complex. Plan now…save later!

The "Core" API Standards: API 2510/2510A

- **API 2510,** *"Design and Construction of LPG Installations"*
- **Purpose:** To ensure safe storage and operations of LPG installations
- **Scope:** Design, construction, and location of LPG facilities


Fire-Protection Considerations for the Design and Operation of Liquefied Petroleum Gas (LPG) Storage Facilities

Health and Environment Department
Safety and Fire Protection Subcommittee

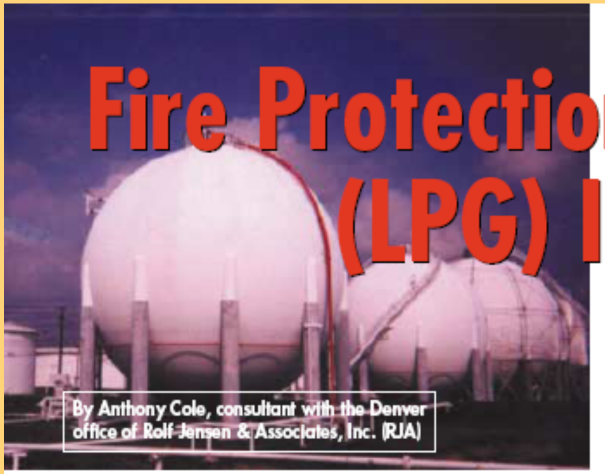
API PUBLICATION 2510A
SECOND EDITION, DECEMBER 1996

American Petroleum Institute

API 2510/2510A

- Publication that coincides with API 2510
  - **API 2510A**, *"Fire-Protection Considerations for the Design and Operation of Liquefied Petroleum Gas (LPG) Storage Facilities"*

Fire Protection for Liquefied Petroleum Gas (LPG) Installations: The Basics



By Anthony Cole, consultant with the Denver office of Rolf Jensen & Associates, Inc. (RJA)

Pic courtesy of RJA

IN DEVELOPING FIRE PROTECTION METHODS and guidelines for liquefied petroleum gas (LPG) storage facilities, the chief concern is a massive failure of a vessel containing a full inventory of LPG. The probability of this type of failure occurring can be mitigated or at least controlled to a reasonable and tolerable figure with appropriately designed and operated facility. Since most LPG fires originate as smaller fires that become increasingly more dangerous, this article will focus on fire protection methods and guidelines in relation to small leaks and fires in LPG spheres. Of greater importance to the fire protection engineer is the more likely event of a leak from a pipe, valve, or other attached component leading to ignition, flash fire, pool fire, and eventually to a pressure fire at the source.

DEFINITION AND PROPERTIES

LPG was first discovered in the 1900s. The applications and uses of LPG, which range from cooking and refrigeration to transportation, heating, and power generation, make it an all-purpose, portable, and efficient energy source. LPG consists of light hydrocarbons (propane, butane, propylene, or a mixture) with a vapor pressure of more than 40 psi at 100°F. At standard temperature and pressure, LPG is in a gaseous state. LPG is liquefied by moderate changes in pressure (i.e. in a process vessel) or a drop in temperature below its atmospheric boiling point. The unique properties of LPG allow for it to be stored or transported in a liquid form and used in a vapor form. LPG vapors are heavier than air and tend to collect on the ground and in low spots. After LPG is released, it readily mixes with air and could form a flammable mixture. As a release occurs, there will be an area closest to the release that is above the flammable range, an intermediate area that may be in the flammable range, and areas that will be below the flammable range. Mixing, natural currents, and diffusion of LPG vapors affect the size and extent of these areas. If these processes continue, eventually the mixture is diluted to below the lower flammable limits (LFL).

Other characteristics of LPG include:

- LPG exerts a cooling effect as a result of vaporization due to releases at low pressure (as called autorefrigeration).
- The density of LPG is almost half that of water, therefore water will settle to the bottom in LPG.
- Very small quantities of liquid will yield large quantities of vapor.
- When vaporized, LPG leaves no residue.
- When LPG evaporates, the autorefrigeration effect condenses the surrounding air, causing ice to form. This is usually a good indication of a leak.
- LPG is odorless, therefore, agents such as ethyl mercaptan are added to commercial grades in most countries for better detection.

Properties of Two Common LPGs

PROPERTY	PROPANE	n-BUTANE
Specific Gravity	1.5	2.p
Vapor Pressure (at 60°F)	105 psia	26 psia
Boiling Point	–44°F	+31°F
Cubic feet of gas/gallon of LPG at 60°F	36.4 ft^3	31.8 ft^3
Lower flammable limit (LFL) % in air	2.0	1.5
Upper flammable limit (UFL) % in air	9.5	9.0
Gross Btu/ft^3 of gas at 60°F	2,516 Btu/ft^3	3,262 Btu/ft^3

Table 1 from 1996 edition of API 2510A

Tank Pressures for Two Common LPGs

LIQUID	QUANTITY	VAPOR VOLUME (gal.)	VAPOR VOLUME (ft^3)	VOLUME of GAS/AIR MIXTURE at LFL (ft^3)
Propane	1 gal.	270	36	1,680
n-Butane	1 gal.	230	32	1,630

Table 2 from 1996 edition of API 2510A

Vapor Volumes Obtained for Two Common LPGs

LIQUID TEMPERATURE	PROPANE	n-BUTANE
31°F	50 psig	0 psig
60°F	90 psig	11 psig
100°F	175 psig	37 psig
130°F	250 psig	65 psig
140°F	290 psig	80 psig

Table 3 from 1996 edition of API 2510A

Pic courtesy of RJA

PRODUCTION AND OPERATIONS

LPG is derived from two main energy sources: natural gas processing and crude oil refining.

When natural gas wells are drilled into the earth, the gas released is a mixture of several components. For example, a typical natural gas mixture may be (90%) methane or "natural gas", while the remaining percentage of components (10%) is a mixture of propane (5%) and other gases such as butane and ethane (5%). From there the gas is shipped in tankers or via pipeline to secondary production facilities for further treatment and stabilization. From these facilities it is sent by bulk carrier or pipeline to various industrial plants and gas filling facilities or used for power generation.

LPG is also collected in the crude oil drilling and refining process. LPG that is trapped inside the crude oil is called associated gas. The associated gas is further divided at primary separation sites or Gas Oil Separation Plants (GOSP's), Central Processing Facilities (CPF's) for offshore installations or Drilling, Production, and Quarter's Platforms (DPQ's). At these facilities, the produced fluids and gases from the wells are separated into individual streams and sent on for further treatment.

At refineries, LPG is collected in the first phase of refinement or crude distillation. The crude oil is then run through a distillation column where a furnace heats it at high temperatures. During this process, vapors will rise to the top and heavier crude oil components will fall to the bottom. As the vapors rise through the tower, cooling and liquefying occurs on "bubble trays," aided by the introduction of naptha. Naptha is straight run gasoline and generally unsuitable for blending with premium gasolines. Therefore, it is used as a feedstock in various refining processes. These liberated gases are recovered to manufacture LPG.

In commercial applications, LPG is usually stored in large horizontal vessels called "bullets." These bullets can range in volume size from 150 to 50,000 gallons. In industrial applications, LPG is typically stored in large vessels that are sphere or spheroid shaped. These are the large "golf ball" shaped and oval vessels commonly seen at refineries and other similar occupancies. In this article, we will deal primarily with the protection of LPG spheres.

STANDARDS

Various sources of standards and codes exist for dealing with LPG facilities and proper fire protection. Some of these sources include:

- NFPA 54, *National Fuel Gas Code.*
- NFPA 58, *Liquefied Petroleum Gas Code.*
- NFPA 59, *Utility LP-Gas Plant Code.*
- American Petroleum Institute (API) 2510, *Design and Construction of LPG Installations.*
- American Petroleum Institute (API) 2510A, *Fire-Protection Considerations for the Design and Operation of Liquefied Petroleum Gas (LPG) Storage Facilities.*
- IP Code of Practice for LPG

Additional sources of information can be obtained from various organizations such as the British Standards Institute, the World LP Gas Association, The LP Gas Association, and industry producers and suppliers. For the purpose of this article, we will focus on some of the above-mentioned sources that are typically accepted as the industry standard.

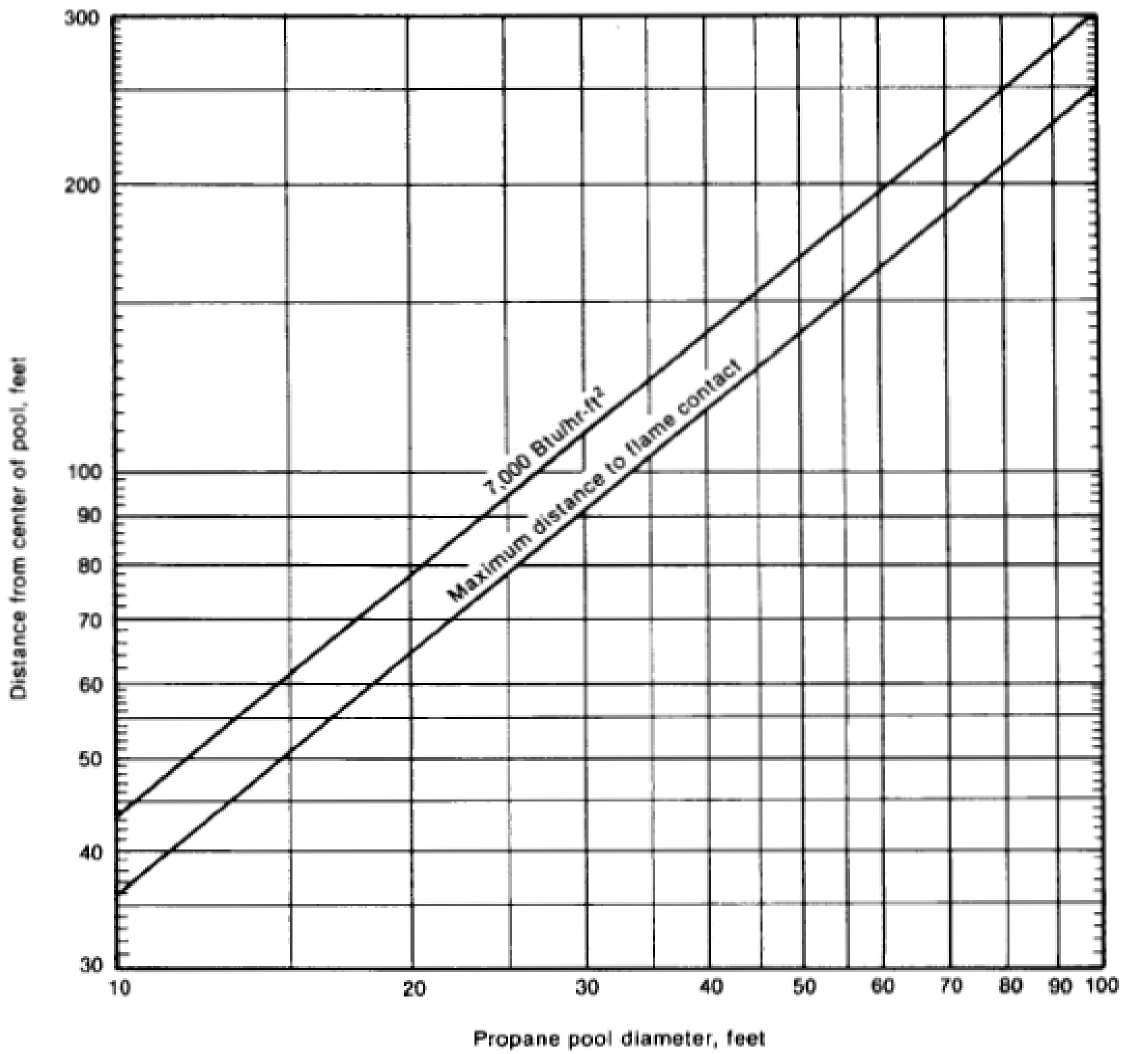
FIRE PROTECTION DESIGN CONSIDERATIONS

In order to reduce the fire risk at LPG facilities, adherence to various design considerations and requirements such as layout, spacing, distance requirements for vessels, drainage, and containment control will help to limit the extent of fire damage. Additional considerations such as fireproofing, water draw systems, and relief systems are also important with respect to the integrity of the installation and the reduction of risk. These considerations address the various ways to prevent leaks or releases that may lead to a fire.

Equally as important to the prevention of a leak or release is properly designed, installed, and maintained fire protection systems. These systems attempt to minimize or limit the fire damage once a fire occurs. In the situation that a fire does occur, the levels of required fire protection are affected by several factors such as location and remoteness of the fire and the availability of water.

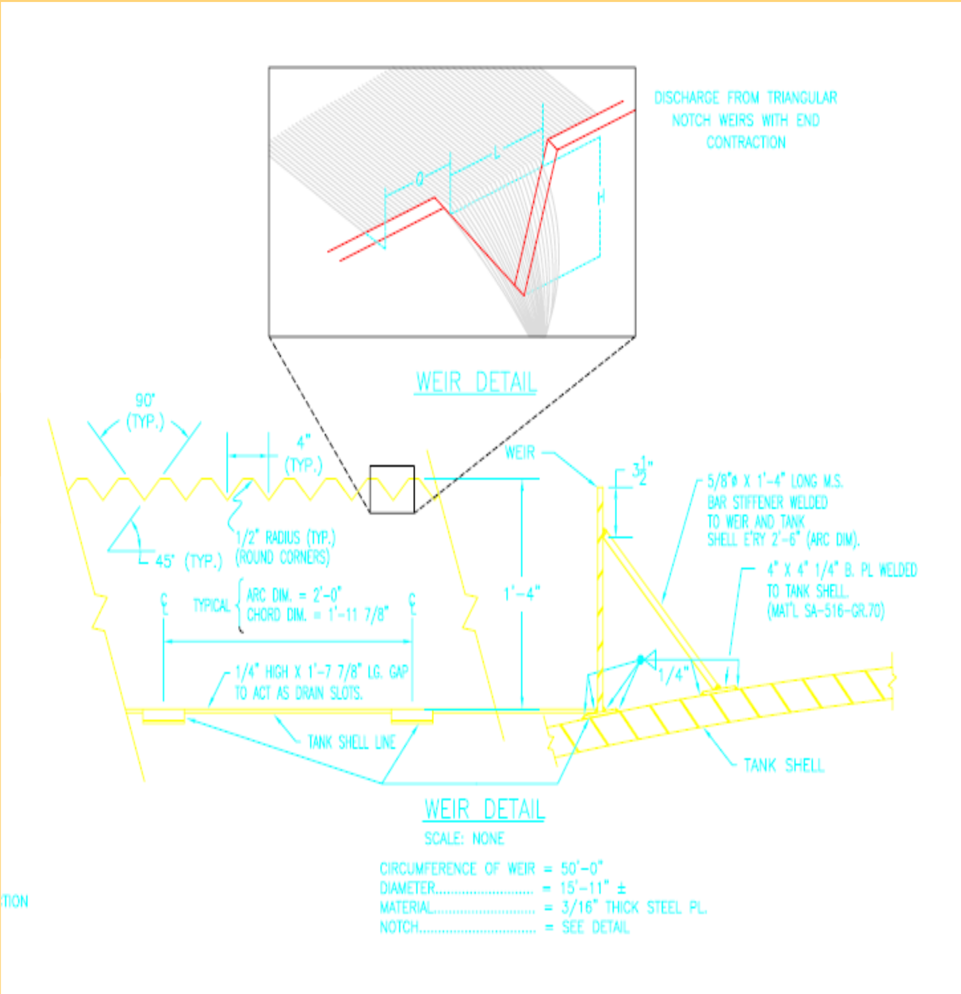
To determine if cooling water is required, the anticipated radiant heat flux from an adjacent tank, maximum tank shell temperatures if the vessel shell is not cooled, and other specific risk management guidelines must be analyzed. API 2510A contains a procedure to identify the point at which cooling water should be applied based on the size of the pool fire and the distance between the vessel and the center of the fire (Figure 1.) Additionally, an analysis of the relief valve parameters is necessary to maintain certain internal vessel pressures. Although computer models

API 2510/2510A



Note: This chart assumes a 20-mile-per-hour wind blowing toward the vessel.

API 2510/2510A



- Consider use of water sprays (Section 5.3.4)
- Fire and hydrocarbon detection systems (Section 5.5.1)

API 2510/2510A

Table 4—Fire Emergency Situations Requiring Special Consideration

Fire Exposure	Water Application Rate
Exposure to radiant heat and no flame contact	0-0.1 gpm/ft^2 [a]
Exposure to fire with direct flame contact	0.1-0.25 gpm/ft^2
Exposure to a high-velocity jet flame	250-500 gpm[b] at point of jet contact

[a] gpm/ft^2 = gallons per minute per square foot.
[b] gpm = gallons per minute.

API 2510/2510A

Application Method	Advantages	Disadvantages
Water Deluge	1. Rapid activation 2. Can be automatic 3. Lack of plugging	1. Problems with wettability 2. Possible water spray supplement for legs 3. Effectiveness with jet fires
Fixed Monitors	1. Ease of activation 2. Can be automatic 3. Effective for jet fires	1. Exposure to operators 2. Wind 3. Large water demand 4. Monitors may be changed unknowingly
Water Spray	1. Rapid activation 2. Wettability and run down 3. Can be Automatic activation	1. VCE damage 2. Plugging 3. Effectiveness with jet fires
Portable Equipment	1. VCE damage not an issue 2. Specific application to area 3. Portability for multiple hazards	1. Prolong set-up times 2. Manual 3. Exposure to operators

Section 5.3.1 – Three methods of water application

API 2510/2510A

Critical Point #5:

Controlling the fuel source prior to any attempt of applying fire water is a must!*

Use a one or more of the three primary methods of water application!!

The "Core" API Standards: API 2030

- **API 2030** *"Application of Fixed Water Spray Systems for Fire Protection in the Petroleum Industry"*
- **Purpose/Scope:** Provide guidance for the petroleum industry in determining where water spray systems might be used.

Application of Fixed Water Spray Systems for Fire Protection in the Petroleum Industry

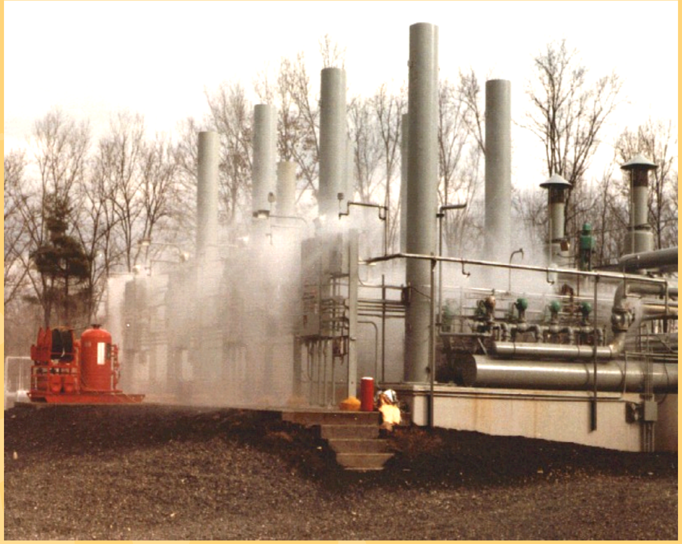
Health and Environmental Affairs Department
Safety and Fire Subcommittee

API PUBLICATION 2030
SECOND EDITION, AUGUST 1998

American Petroleum Institute

Helping You Get The Job Done Right.℠

API 2030



Fixed water spray systems are designed to provide fire (ignition) prevention, exposure protection, control of burning, or extinguishment. They can be independent of other forms of protection, or they may supplement them. Gas fires should be extinguished by isolation. Water spray systems are neither intended nor suitable for extinguishment of pressurized jet fires.

3.3 deluge system: Defined in NFPA 15, an installation equipped with multiple open nozzles connected to a water supply by means of a deluge valve, which allows water to flow from all nozzles simultaneously. This is similar to a water spray system, but does not use directional water spray nozzles to achieve a specific water discharge and distribution. In the refining industry, the term deluge system is generally a system without nozzles in which all the water is applied from an open pipe. API 2510 and API 2510A describe such a system at the top of a vessel which allows water to run down the sides in a thin film, frequently using a weir to improve distribution and assist the even flow of water over the protected vessel.

3.16 water spray system: An automatic or manually actuated fixed pipe system connected to a water supply and equipped with water spray nozzles designed to provide a specific water flow rate and particle size discharge and distribution over the protected surfaces or area.

3.17 water spray nozzle: An open or automatic (self-actuating) device that, when discharging water under pressure, will distribute the water in a specific, directional pattern.

API 2030

Table 1–Water Spray Application Rates for Exposed Surface Area

Item	Section in API 2030 or Other Indicated Reference	Application Rate: Gallons per Minute per Square Foot	Application Rate: Liters per Minute per Square Meter
Exposure Protection General	7.2.1	0.10–0.25	4.1–10.2
Exposure Protection for Specific Applications			
Air -fin coolers[a]	7.3.4	0.25	10.2
Compressors			
General	7.3.6	0.25	10.2
Compressors in building	7.3.6	0.30	12.2
Cooling Towers	7.3.10; NFPA 214	0.15–0.50	6.1–20.4
Fired heater supports	7.3.9	0.25	10.2
LPG loading racks	7.3.11	0.25	10.2
Motors	7.3.8	0.25	10.2
Pipe Racks[a]	7.3.2	0.25	10.2
Pressurized storage tanks	7.3.5; API 2510 and 2510A		
Radiant Exposure	–Distance related	0–0.10	0–4.1
Nonpressure	–Design related	0.10–0.25	4.1–10.2
Impingement Pressure Impingement	–Prefer direct 250 to 500 gpm fire water stream at point of impingement	0.50 minimum	20.4 minimum
Process Buildings & Structures	7.3.14; NFPA 13	0.15–0.30	6.1–23.3
Pumps	7.3.1	0.50	20.4
Atmospheric Storage Tanks	7.3.13	0.10	4.1
Pressure Vessels, Exchangers & Towers	7.3.5	0.25	10.2
Transformers	7.3.3	0.25	10.2
Turbines	7.3.7	0.25	10.2
Well Heads	7.3.12	0.50	20.4
Control of Burning	7.2.2	0.30–0.50	12.2–20.4
Extinguishment[c]			
Combustible Solid	7.2.3	0.15–0.30	6.1–12.2
Combustible Liquid	7.2.3	0.35–0.50	14.6–20.4
Flammable Liquid	7.2.3	(May not be desirable or possible; see text)	

Note:
[a] While NFPA 15 does not specifically address air-fin heat exchangers, it recommends 0.25 for protection of vessels (4–5.2.1) and piping (4–5.3.3). Where the temperature of the vessel or its contents should be limited, higher application rates may be required (NFPA 15 A-4–5.2).
[b] Water spray density for the upper level of multilevel pipe racks can be reduced in accordance with NFPA 15.4–5.3.3.2.
[c] Rates should be established by review of relevant test data for the specific materials (NFPA 15 A-4-3.1.3).

- Values from Table 1 are intended for use by fire protection engineering personnel with the explanatory material in the text references.

API 2030

- Pumps (Section 7.3.1)
  - Significant potential or risk of spreading
  - Fluid being handled 40 F above flash point
  - Pump proximity to other equipment
  - Other means of protection are not practical

Minimum of 0.50 gpm/ft^2

API 2030

- Compressors (Section 7.3.6)
  - Around 300 hp…same as pumps handling flammable liquids

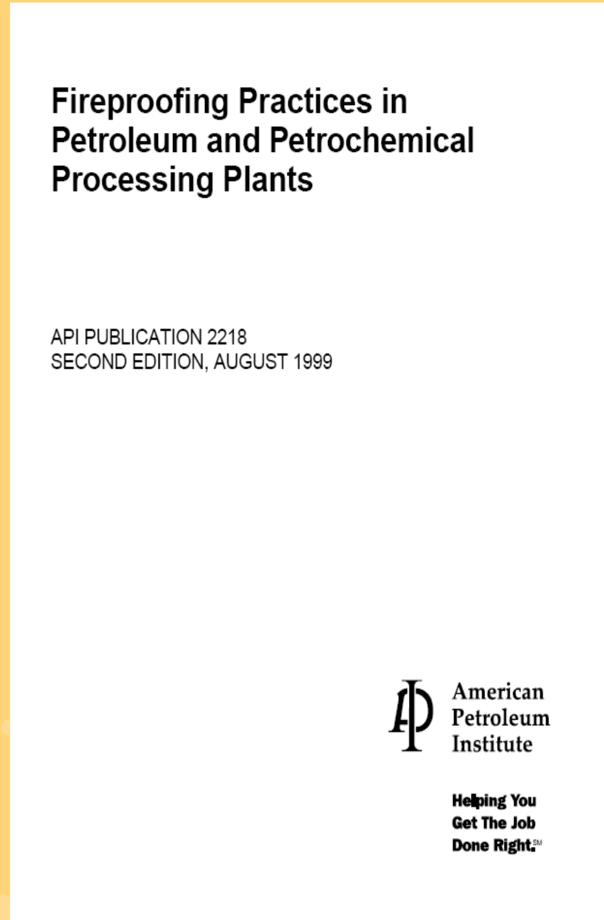
API 2030

Critical Point #6:

Water spray systems should be *designed, installed, tested, and maintained by highly-trained professionals in their field.*

The "Core" API Standards: API 2218

- **API 2218** *"Fireproofing Practices in the Petroleum and Petrochemical Processing Plants"*
- **Purpose:** Provide guidance for selecting, applying, and maintaining fireproofing systems.
- **Scope:** Risk-base approach to evaluate fireproofing needs for the Petroleum and Petrochemical Processing Plants.


Fireproofing Practices in Petroleum and Petrochemical Processing Plants

API PUBLICATION 2218
SECOND EDITION, AUGUST 1999

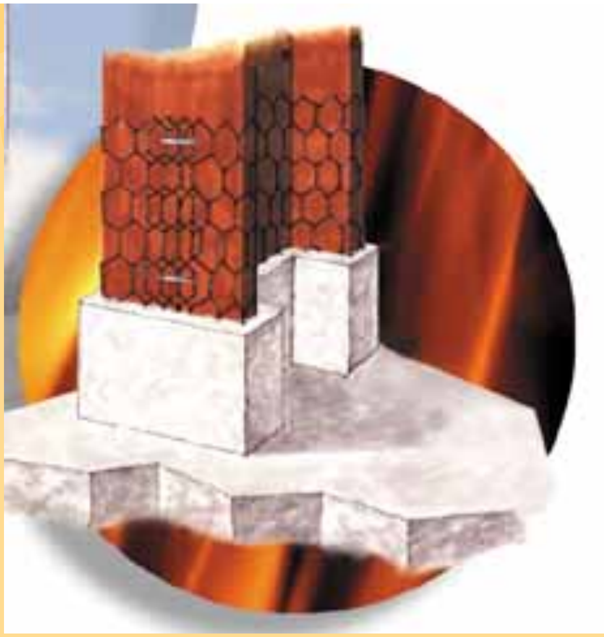
American Petroleum Institute

Helping You Get The Job Done Right.SM

API 2218

3.8 **fireproofing:** A systematic process, including materials and the application of materials, that provides a degree of fire resistance for protected substrates and assemblies.

3.9 **fire-resistance rating:** The number of hours in a standardized test without reaching a failure criterion.



3.3 **cementitious mixtures:** As defined by UL in "Spray Applied Fire Resistive Materials" (SFRM), cementitious mixtures are binders, aggregates and fibers mixed with water to form a slurry conveyed through a hose to a nozzle where compressed air sprays a coating; the term is sometimes used for materials (such as sand and cement) applied by either spray or trowel.

3.18 **perlite:** Natural volcanic material that is heat-expanded to a form used for lightweight concrete aggregate, fireproofing, and potting soil.

3.26 **sprayed fiber materials:** Binders, aggregates and fibers conveyed by air through a hose to a nozzle, mixed with atomized water and sprayed to form a coating; included by UL in "Spray Applied Fire Resistive Materials" (SFRM).

3.30 **vermiculite:** Hydrated laminar magnesium-aluminum-iron silicate which is heat-expanded 8 to 12 times to produce a light noncombustible mineral material used for fireproofing and as aggregate in lightweight concrete.

API 2218

- What needs to be fireproofed?
  - High Fire-Potential Equipment
    - Fired heaters
    - Pumps over 200 gpm
    - Reactors
    - Compressors
    - Vessels and heat exchangers

API 2218

- What needs to be fireproofed?
  - Medium Fire-Potential Equipment
    - Accumulators/feed drums
    - Towers
    - Air-cooled fin fans

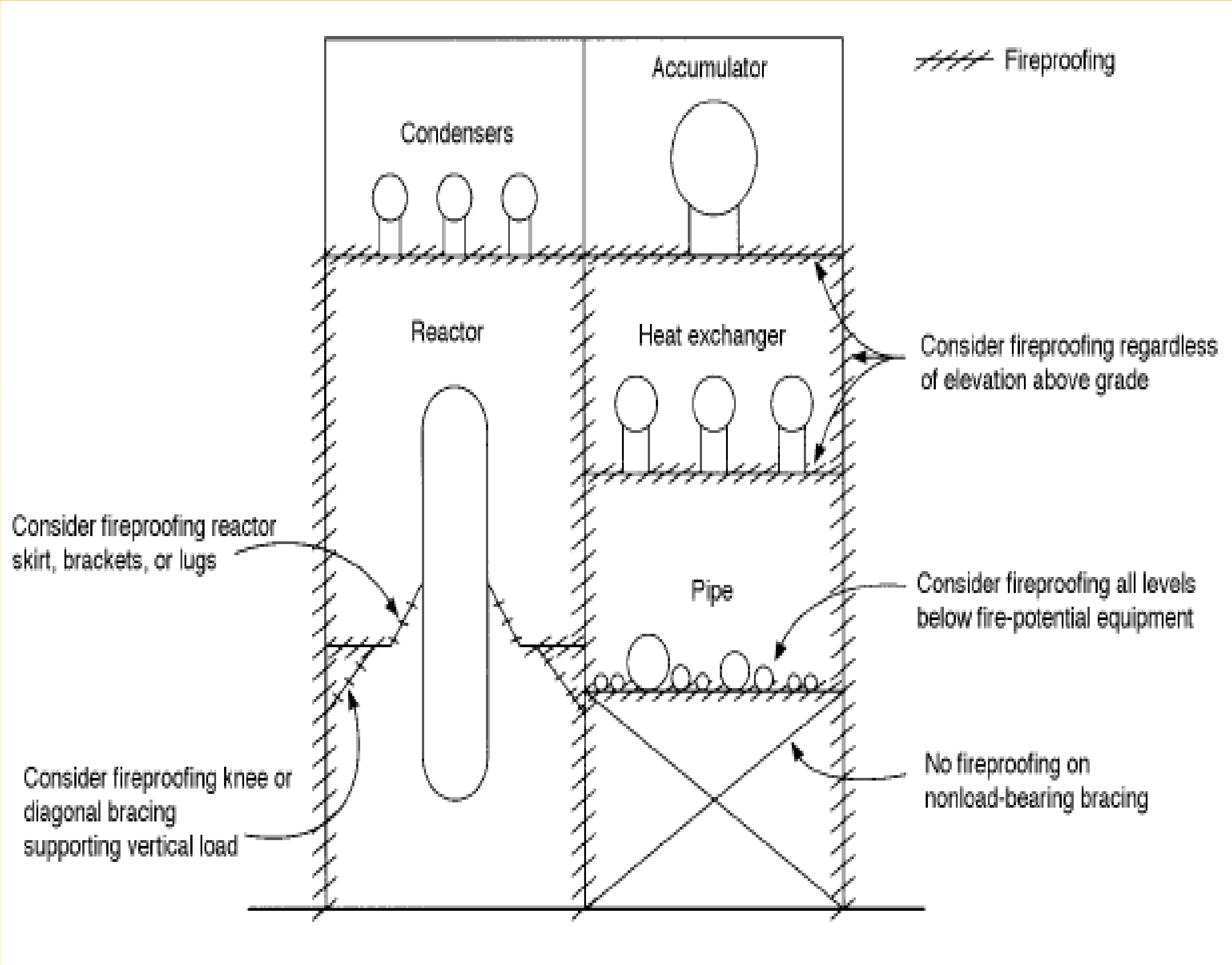
API 2218

- What needs to be fireproofed?
  - Low Fire-Potential Equipment
    - Small pumps
    - Piping

API 2218

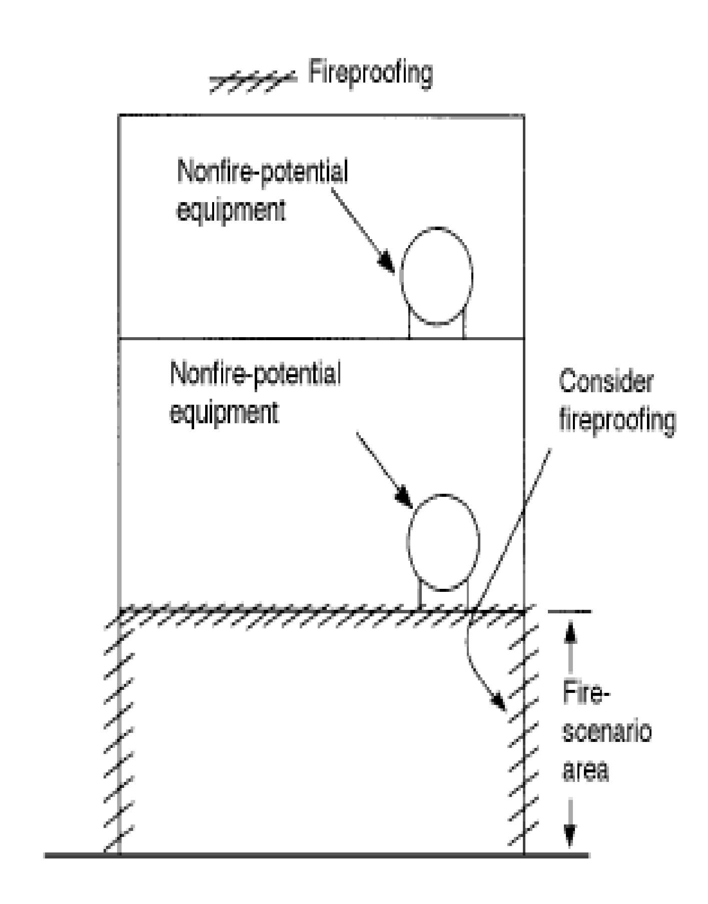
- Power and control cables (Section 6.1.8)
  - 15 to 30 minutes

API 2218

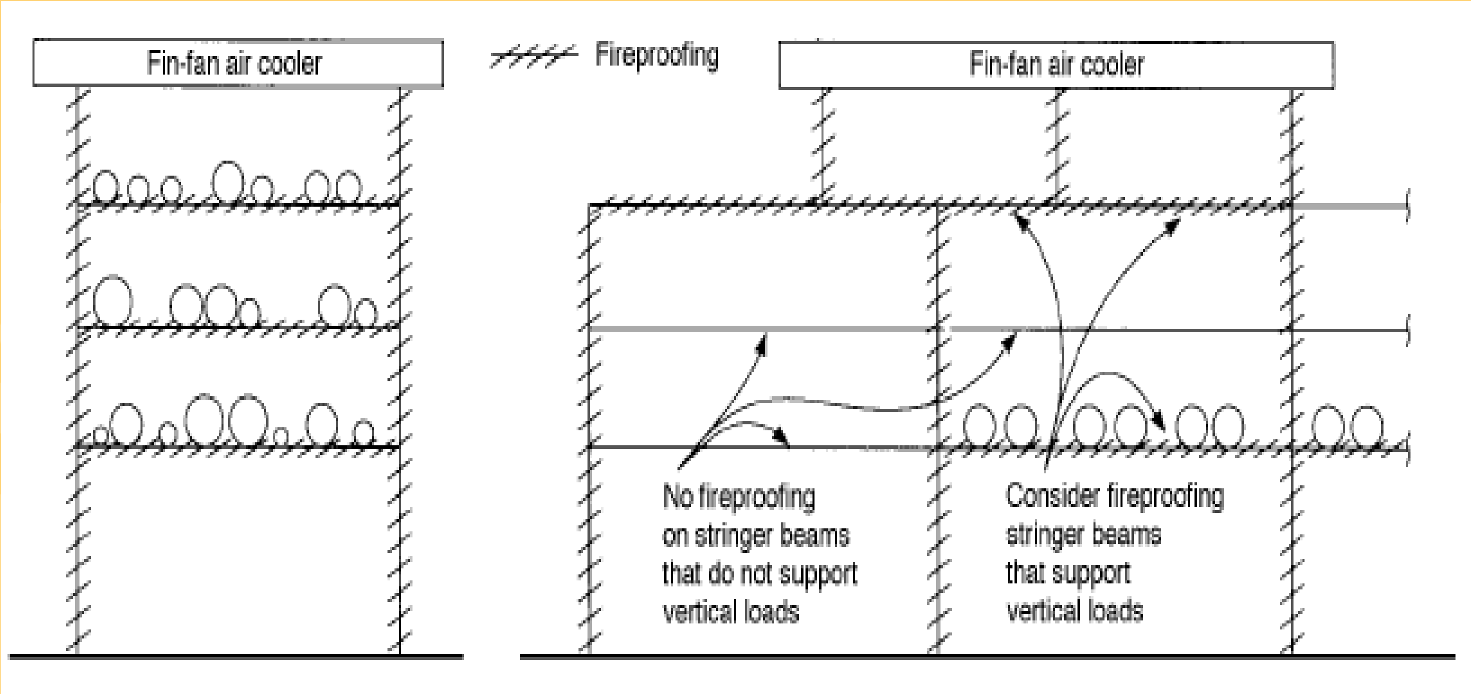


Fireproofing
Accumulator
Condensers
Reactor
Heat exchanger
Consider fireproofing regardless of elevation above grade
Consider fireproofing reactor skirt, brackets, or lugs
Pipe
Consider fireproofing all levels below fire-potential equipment
Consider fireproofing knee or diagonal bracing supporting vertical load
No fireproofing on nonload-bearing bracing

API 2218


Fireproofing
Nonfire-potential equipment
Nonfire-potential equipment
Consider fireproofing
Fire-scenario area

API 2218

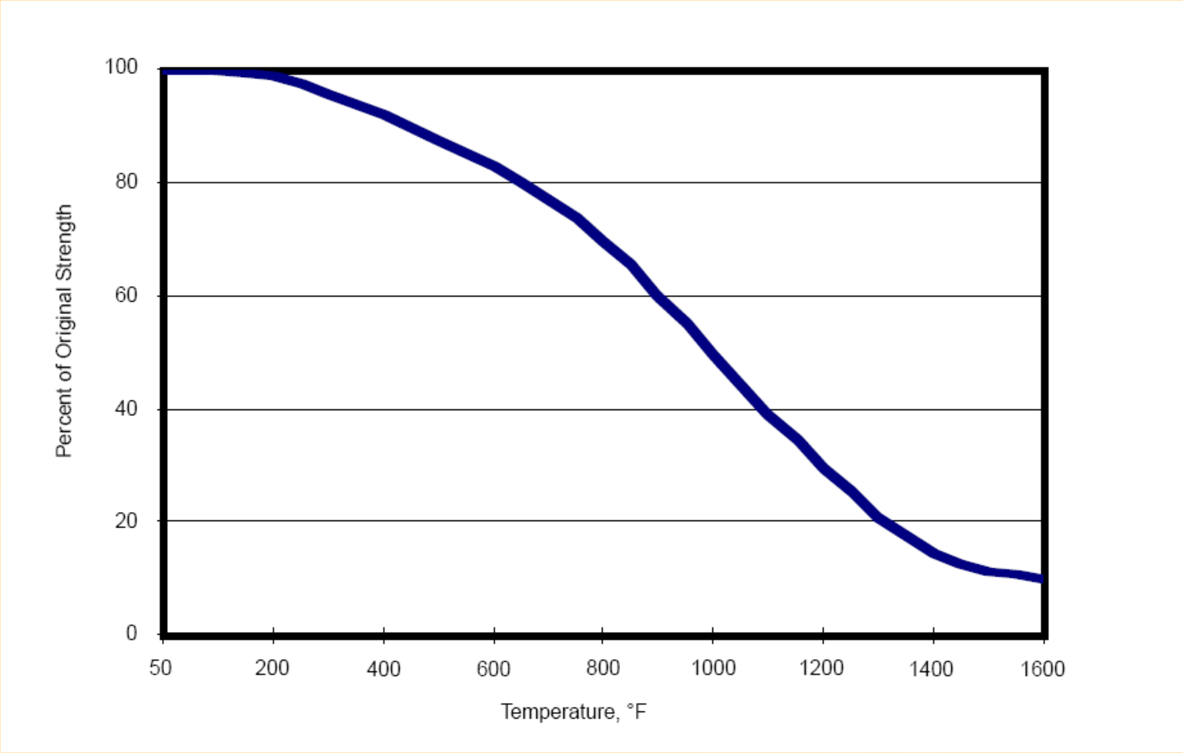


Fin-fan air cooler
Fireproofing
Fin-fan air cooler
No fireproofing
on stringer beams
that do not support
vertical loads
Consider fireproofing
stringer beams
that support
vertical loads

API 2218

Critical Point #7:

*Above 1000ºF, steel's strength (tension and compression) is approx. half and can absorb up to 30,000 Btu/hr/sq.ft. and **will fail** after 10 to 15 minutes of exposure*



Application of API Standards to Real Life

- **Question 1:**
  - **What are three important characteristics about a water supply system?**
  - **Answer: API 2001, section 6.2.1**

Application of API Standards to Real Life

- **<u>Question 2:</u>**
  - **Where would I refer to for information about refinery pre-fire incident planning?**
  - **Storage Tank?**
  - **Answer: API 2001, section 11.2**

    API 2021, section 6, 7, and 8

Application of API Standards to Real Life

- <u>**Question 3:**</u>

  - **How would I determine the flow rate for foam solution in a 250 ft diameter tank?**

  - **Answer: API 2021, Appendix K**

Application of API Standards to Real Life

- **<u>Question 4:</u>**
  - **How would I determine the distance between a LPG vessel and the center of a pool fire at which cooling will be come necessary?**
  - **If the pool fire is 30 ft. in diameter, what is the distance at which cooling water should be applied?**
  - **Answer: API 2510A, Table 1**

    110 ft

Application of API Standards to Real Life

- **Question 5:**

  - **Where would I find the advantages and disadvantaged of water application in the storage of LPG?**

  - **Answer: API 2510A, Table 5**

Application of API Standards to Real Life

- **Question 6:**
  - **Where would I find exposure protection data?**
  - **Answer: API 2030, section 7.2.1**

Application of API Standards to Real Life

- **Question 7:**

  - **Where would I find out details about how to protect Air-fin coolers?**

  - **Answer: API 2030, section 7.3.4**

Application of API Standards to Real Life

- **Question 8:**
  - **Where would I find out information about fireproofing for LPG Spheres?**
  - **Answer: API 2510A, section 5.8**

Application of API Standards to Real Life

- **Question 9:**
  - **What is the dimensions of the fire-scenario envelope for liquid fuel release?**
  - **Above fire-potential equipment?**
  - **Answer: API 2218, section 5.2.3 Table 1**

Application of API Standards to Real Life

- **Question 10:**

  - **What is the fireproofing considerations for equipment?**

  - **Answer: API 2218, Appendix C, C.3**

Questions???

Conclusion

Critical Points

Critical Point #1:

In the process industry, the prime objective or purpose of applying water streams in a fire situation is to provide cooling and containment…….

NOT Extinguishment

Critical Points

Critical Point #2:

The principle value of passive fire protection …..initial stages of a fire, when efforts are primarily directed at shutting down units, isolating fuel sources, and setting up fire fighting equipment.*

**or to permit the escape and/or protection of occupants in a building or structure.*

Critical Points

Critical Point #3:

Refinery fire protection is not like baking a cake, you don't use a cook book…….it is done using a thorough and properly executed hazard identification methodology.

Critical Points

Critical Point #4:

Planning phase starts with a scenario analysis….logistics associated with major tank fire incidents can be very complex. Plan now…save later!

Critical Points

Critical Point #5:

Controlling the fuel source prior to any attempt of applying fire water is a must!*

***Use a one or more of the three primary methods of water application!!**

Critical Points

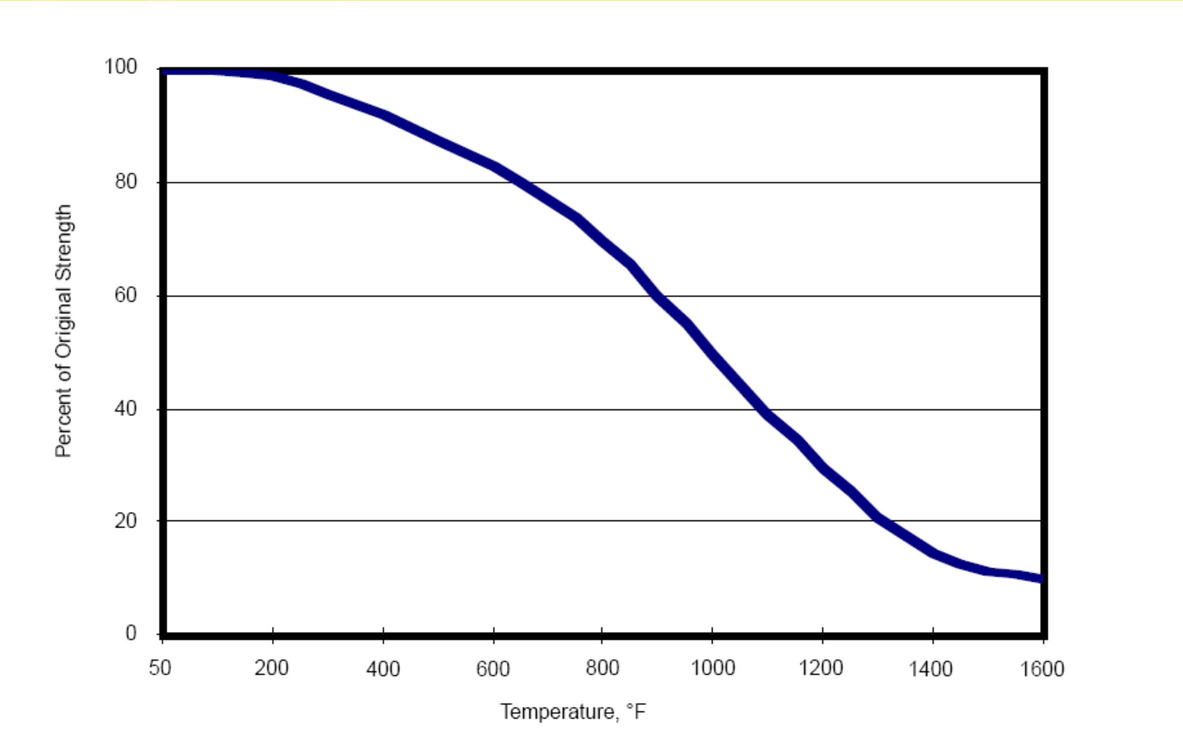
Critical Point #6:

Water spray systems should be designed, installed, tested, and maintained by highly-trained professionals in their field.

Critical Points

Critical Point #7:

*Above 1000ºF, steel's strength (tension and compression) is approx. half and can absorb up to 30,000 Btu/hr/sq.ft. and **<u>will fail</u>** after 10 to 15 minutes of exposure*



Thank you