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”
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
  - 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 2021, “Management of Atmospheric Storage Tanks”
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.
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”? 
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………
• 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”!
### Table 1—Example Water Flow Rates for Manual Fire Fighting

<table>
<thead>
<tr>
<th>Scenario Area of Interest</th>
<th>Firewater Flow Ranges, Per Minute in Thousands of Gallons (Thousands of Liters)</th>
<th>Example Flow Rate, Ranges Based on Protected Area GPM/ft² or LPM/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiant heat protection</td>
<td>4,000 to 10,000 gpm (15,000 to 38,000 lpm)</td>
<td>0.1 gpm/ft² (4.1 lpm/m²)</td>
</tr>
<tr>
<td>Process areas handling flammable liquids or high-pressure flammable gases</td>
<td>Cooling: 0.2 to 0.3 gpm/ft² (8.2 to 12.3 lpm/m²) Suppression: 0.3 to 0.5 gpm/ft² (12.3 to 20.4 lpm/m²)</td>
<td></td>
</tr>
<tr>
<td>Process areas handling gases or combustible liquids</td>
<td>3,000 to 5,000 gpm (11,000 to 19,000 lpm)</td>
<td>0.20 to 0.30 gpm/ft² (8.2 to 12.3 lpm/m²)</td>
</tr>
<tr>
<td>Tank storage of flammable and combustible liquids in atmospheric tanks</td>
<td>See API 2021 &amp; NFPA 11</td>
<td></td>
</tr>
<tr>
<td>LPG Storage tanks and vessels</td>
<td>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]</td>
<td></td>
</tr>
<tr>
<td>Warehouses</td>
<td>See applicable NFPA Fire Codes</td>
<td></td>
</tr>
<tr>
<td>Buildings, offices, laboratories, and similar structures</td>
<td>See applicable NFPA Fire Codes</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** 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/ft² or lpm/m²) 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**
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**: …manage the needs associated with fires in atmospheric storage tanks
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:**
  ▪ FOAMSPLEX
  ▪ LASTFIRE
API 2021/2021A

Pre-incident Planning
for
Tank Fire Management

Section 6

Preparing
for
Tank Fire Management

Section 7

Implementing
Tank Fire Management

Section 8

Investigating
Tank Fires

Section 9

Follow-up
after
Tank Fires

Section 9

Figuring out what will need to be done.

Arranging access to needed resources & training

Putting the plan and resources into action

Root cause(s) and response effectiveness

Use investigation for planning and corrective action
API 2021/2021A

1. Will existing incident management system do OK for tank fires?
2. What is nature of tanks, their contents and location?
3. Incident potential based on tank type, roof design, and fuel properties
4. Systems equipment & supplies personnel
5. Develop firefighting philosophy for the storage tank facility
6. Develop plan specific to each tank or set of tanks
7. Establish type, quantity & delivery e.g. water, foam

- Plan Incident Management System
  - Survey Facility
    - Tank contents
    - Tank condition
    - Tank type & size
    - Tank location
  - Review Potential Incident Types
  - Review Existing Fire Suppression Capability
  - Develop Fire Protection & Firefighting Philosophy
  - Develop Tank-Specific Tank Fire Plans (Does this fire need to be put out?)
  - Develop Suppression Agent Plans

Section 6.2
Section 6.3
Section 6.4
Section 6.5
Section 6.6
Section 6.7
Section 6.7, 6.8 Appendix F
API 2021/2021A

- Ensure availability of EOC & field resources
- Specifically what is needed for each tank?
- How will we notify and get help needed on-site at the incident?
- Train on plan specific to each tank or set of tanks

1. Prepare Incident Management Resources
2. Detail Needs of Tank-Specific Plans
3. Establish Logistics
   - Communications
   - People
   - Supplies
4. Train & Test System Effectiveness

Section 7.2
Section 7.3
Section 7.4
Section 7.5
<table>
<thead>
<tr>
<th>Tank Type</th>
<th>Potential Type(s) of Fire</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed (Cone) Roof Tanks</td>
<td>- Vent Fire</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>- Overfill Ground Fire</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Unobstructed Full Liquid Surface Area</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Obstructed Full Liquid Surface Fire if flammable roof remains partially in tank</td>
<td></td>
</tr>
<tr>
<td>Vertical, Low-Pressure Fixed Roof Tanks without Frangible Roof Seams</td>
<td>- Vent Fire</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>- Overfill ground fire</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Tank Explosion and failure with subsequent ground fire</td>
<td></td>
</tr>
<tr>
<td>Internal (or Covered)</td>
<td>- Vent Fire</td>
<td>Many fires in this type of tank occur as a result of overfilling. Task 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.</td>
</tr>
<tr>
<td>Floating-Roof Tanks</td>
<td>- Overfill ground fire</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Obstructed Rim Seal Fire</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Obstructed Full Liquid Surface Fire</td>
<td></td>
</tr>
<tr>
<td>Domesd (or covered)</td>
<td>- Vent Fire</td>
<td>Fires in this type of tank most often occur as a result of overfilling. Task will be extremely difficult to extinguish if entire liquid surface becomes involved.</td>
</tr>
<tr>
<td>External Floating-Roof Tanks</td>
<td>- Overfill ground fire</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Obstructed Rim Seal Fire</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Obstructed Full Liquid Surface Fire</td>
<td></td>
</tr>
<tr>
<td>Open Floating-Roof Tanks</td>
<td>- Rim Seal Fire</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>- Overfill ground fire</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Obstructed Full Liquid Surface Fire</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Unobstructed Full Surface Fire</td>
<td></td>
</tr>
<tr>
<td>Horizontal Tanks</td>
<td>- Vent Fire</td>
<td>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).</td>
</tr>
<tr>
<td></td>
<td>- Overfill ground fire</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Tank Explosion and failure with subsequent ground fire</td>
<td></td>
</tr>
</tbody>
</table>

*Appendix E provides pictures and information for various types of storage tank.*
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:

\[ C = NLT \]

Where:

- \( C \) = foam concentrate required, in gallons (liters).
- \( N \) = nozzle application rate of foam solution, in gallons 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 concentrate, as a percent of foam solution.
## Table K-1—NFPA Full Surface Fire Minimum Application Rate Based on Fuel and Application Method

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Type II Foam Chambers</th>
<th>Subsurface Injection</th>
<th>Handlines or Monitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrocarbon</td>
<td>0.10 g/min ft²</td>
<td>0.10 g/min ft²</td>
<td>0.16 g/min ft²</td>
</tr>
<tr>
<td>(4 l/min-m²)</td>
<td>(4 l/min-m²)</td>
<td>(4 l/min-m²)</td>
<td>(6.5 l/min-m²)</td>
</tr>
<tr>
<td>Alcohols &amp; Oxygenates&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.10—0.16 g/min ft²</td>
<td>Not Applicable&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.16 - 0.20 g/min ft²</td>
</tr>
<tr>
<td>(4—6.5 l/min-m²)</td>
<td></td>
<td></td>
<td>(6—8 l/min-m²)</td>
</tr>
<tr>
<td>Wide Boiling Range (Crude)</td>
<td>0.10 g/min ft²</td>
<td>0.20 or more g/min ft²</td>
<td>0.16 g/min ft²</td>
</tr>
<tr>
<td>Initial</td>
<td>(4 l/min-m²)</td>
<td>(8 l/min-m²)</td>
<td>(6.5 l/min-m²)</td>
</tr>
<tr>
<td>After prolonged burning—</td>
<td>0.20 or more g/min ft²</td>
<td>0.20 or more g/min ft²</td>
<td>0.20 or more g/min ft²</td>
</tr>
<tr>
<td>if heat wave established</td>
<td>(8 l/min-m²)</td>
<td>(8 l/min-m²)</td>
<td>(8 l/min-m²)</td>
</tr>
</tbody>
</table>

<sup>a</sup> Application rates and foam concentrate percentages for specific oxygenates can vary widely and should be determined in consultation with the foam concentrate supplier.

<sup>b</sup> 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

<table>
<thead>
<tr>
<th>Hydrocarbon Type</th>
<th>Type II Foam Chambers</th>
<th>Subsurface Injection</th>
<th>Handlines or Monitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash Point between 100°F and</td>
<td>30</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>140°F (38°C and 60°C)</td>
<td>(4 l/min-m²)</td>
<td>(4 l/min-m²)</td>
<td>(6.5 l/min-m²)</td>
</tr>
<tr>
<td>Flash Point below 100°F (38°C)</td>
<td>55</td>
<td>55</td>
<td>65</td>
</tr>
<tr>
<td>or liquids heated above their</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>flashpoints</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude Petroleum</td>
<td>55</td>
<td>55</td>
<td>65</td>
</tr>
<tr>
<td>Products requiring alcohol</td>
<td>55</td>
<td>not recommended</td>
<td>65</td>
</tr>
<tr>
<td>resistant foam</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Largest Tank Diameter</th>
<th>Supplemental Hose Streams</th>
<th>Minimum Operating Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50 g/min (180 l/min) each</td>
<td>Minutes</td>
</tr>
<tr>
<td>Up to 35 ft (10 m)</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>35 to 65 ft (10—20 m)</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>65 to 95 ft (20—29 m)</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>95 to 120 ft (29—36 m)</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>Over 120 ft (36 m)</td>
<td>3</td>
<td>30</td>
</tr>
</tbody>
</table>
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
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 Halsted & Associates, Inc. (HAI)

In developing fire protection methods and guidelines for liquefied petroleum gas (LPG) storage facilities, the chief concern is the possible 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 by a reasonably feasible-fire safety program that is supported and operated by the facility. Since most LPG storage operations will be located in areas where fires from other sources are not common, this article will focus on fire protection methods and guidelines in relation to small tanks and fires in LPG systems. Of greater importance to the fire protection program is the main source of fuel, either liquid or gas, as it is part of a primary component or fire protection system.

IN DESCRIPTION AND PROPERTIES

LPG was first discovered in the 1960s. The application 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, primarily propane, butane, propane, and butane, with a higher vapor pressure of about 40 psig at 68°F. At normal temperature and pressure, LPG is a gaseous state. LPG is liquefied by moderate changes in pressure (i.e., in a process vessel or a storage tank) or by cooling the temperature below atmospheric boiling point. Two 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 or in low areas. After LPG is released, it readily mixes with air and could form a flammable mixture. As a release occurs, there will be an increase in the release that is above the flammability range in an indoor area that may have the flammability range.

Two main types of LPG are:
- Propane
- Butane

These types can be found in different applications such as:
- Cooking
- Heating
- Power generation

LPG is derived from many sources, including natural gas processing and oil refining. When natural gas wells are drilled, the methane released is collected and sent to a mixture of several components. For example, a typical natural gas mixture may be composed of about 80% methane and 10% ethane (with the remaining percentage of components that include carbon monoxide, nitrogen, and other gases). This mixture is then processed to remove impurities and other gases before being sent to customers. LPG is also used in various industries, including:
- Transportation
- Heating
- Power generation

LPG storage and handling can be complex and requires careful planning and design. In this article, we will discuss the basics of fire protection for LPG systems.

PRODUCTION AND OPERATIONS

LPG is derived from two main energy sources: natural gas processing and oil refining. When natural gas wells are drilled, the methane released is collected and sent to a mixture of several components. For example, a typical natural gas mixture may be composed of about 80% methane and 10% ethane (with the remaining percentage of components that include carbon monoxide, nitrogen, and other gases). This mixture is then processed to remove impurities and other gases before being sent to customers. LPG is also used in various industries, including:
- Transportation
- Heating
- Power generation

LPG storage and handling can be complex and requires careful planning and design. In this article, we will discuss the basics of fire protection for LPG systems.

IN PROTECTION DESIGN CONSIDERATIONS

In order to reduce the risk of LPG systems, adherence to standard design considerations and procedures such as layout, piping, storage, and containment, critical factor control, and fire protection design must be considered to ensure the safety and effectiveness of the system. The design and installation of LPG systems must be done by licensed professionals.

VOLTAGE SOURCES AND CODES

Various sources of standards and codes for dealing with LPG facilities and proper fire protection. Some of these sources include:
- NFPA 58, National Fuel Gas Code
- NFPA 51A, Liquefied Petroleum Gas Code
- NFPA 30, Flammable and Combustible Liquids Code
- American Petroleum Institute (API) 520, Design and Construction of LPG Installations
- IP Code of Practice for LPG
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)
**Table 4—Fire Emergency Situations Requiring Special Consideration**

<table>
<thead>
<tr>
<th>Fire Exposure</th>
<th>Water Application Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure to radiant heat and no flame contact</td>
<td>0-0.1 gpm/ft²</td>
</tr>
<tr>
<td>Exposure to fire with direct flame contact</td>
<td>0.1-0.25 gpm/ft²</td>
</tr>
<tr>
<td>Exposure to a high-velocity jet flame</td>
<td>250-500 gpm at point of jet contact</td>
</tr>
</tbody>
</table>

a gpm/ft² = gallons per minute per square foot.

b gpm = gallons per minute.
## Section 5.3.1 – Three methods of water application

<table>
<thead>
<tr>
<th>Application Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| 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  
3. Exposure to operators |
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


• Purpose/Scope: Provide guidance for the petroleum industry in determining where water spray systems might be used.
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.
Values from Table 1 are intended for use by fire protection engineering personnel with the explanatory material in the text references.

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

Note:

\(^a\) While NFPA 15 does not specifically address air-fin heat exchangers, it recommends 0.25 gpm 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).
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/ft²
API 2030

- Compressors (Section 7.3.6)
  - Around 300 hp...same as pumps handling flammable liquids
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.
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
Consider fireproofing reactor skirt, brackets, or lugs

Consider fireproofing knee or diagonal bracing supporting vertical load

Consider fireproofing regardless of elevation above grade

Consider fireproofing all levels below fire-potential equipment

No fireproofing on nonload-bearing bracing
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
Critical Point #7:

Above 1000°F, 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

• **Question 2:**

  ▪ 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

• **Question 3:**

  ▪ 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

• Question 4:

  ▪ 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
• **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 cookbook……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 1000°F, 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.
Thank you