Chapter 16

Fire and Explosion Resistant Systems

The petroleum and related industries deal with tremendous bulk quantities of flammable and combustible materials daily. These materials are handled at extremely high pressures and temperatures where explosive, corrosive and toxic properties may also be present. It is therefore imperative not to become complacent about their destructive natures and the required protective arrangements that must be instituted whenever they are handled.

Fire and explosion resistant materials and barriers for critical equipment or personnel protection should always be considered whenever petroleum operations are involved. They prolong or preserve the integrity of a facility critical features to ensure a safe and orderly evacuation and protection of the plant is accomplished.

Ideally most oil or gas incidents will be controlled by the process shut down systems (ESD, depressurization, drainage, etc.) and hopeful the fire protection systems (fireproofing, water deluge, etc.), will not be required. However these primary fire defense systems may not not be able to control fire incidents if previous explosions have previously occurred. Before any consideration of fire suppression efforts, explosion effects must first be analyzed to determine the extent of protection necessary. Most major fire incidents associated with hydrocarbon process incidents are preceded by explosion incident.

Explosions

Explosions are the most destructive occurrence that can transpire at a hydrocarbon facility. Explosions may happen too quickly for conventional fire protection systems to be effective. Once an explosion occurs damage may result from several events:

1. Overpressure - the pressure developed between the expanding gas and it's surrounding atmosphere.
2. Pulse - the differential pressure across a plant as a pressure wave passes might cause collapse or movement.
3. Missiles - items thrown by the blast of expanding gases might cause damage or escalation.

Explosion overpressure levels are generally considered the most critical measurement at this time. Estimates are normally prepared on the amount of overpressure that can be generated at various damaging levels.
These levels are commonly referred to as overpressure circles. Overpressure circles are normally drawn from the point of ignition that is typically taken for sake of expediency and highest probability as the point of leakage or release unless other likely ignition points are identified.

**Definition of Explosion Potentials**

The first step in protection against explosions is to identify if they have the possibility of occurring at the facility and to acknowledge that fact. This may be for both internal and open air explosions. Once it is confirmed an estimate of their probability and severity should be defined by a risk analysis. If the risk level is indicated as unacceptable additional measures for prevention and mitigation should be implemented.

Typical locations where explosion overpressure potentials should be considered or evaluated are:

- Gases stored as liquid due to the application of refrigeration or pressure.
- Flammable or combustible liquids existing above atmospheric boiling point and maintained as a liquid because of the application of pressure.
- Gases contained under a pressure of 3,448 kPa (500 psi) or more.
- Any combination of vessels and piping that has the potential to release a total volume containing more than 907 kg (2,000 lbs.) of hydrocarbon vapors.
- Onshore areas that are considered to have confinement (fully or partially) and may release commodities meeting the above criteria.
- Locations which may have a manned control room less than 46 meters (150 ft.) from a process area meeting the above criteria.
- Gas compressor buildings that may be fully or partially enclosed.
- Enclosed buildings handling fluids that have the potential to accumulate flammable gases (e.g., produced water treating facilities).
- Offshore structures that handle or process hydrocarbon materials.

The objective in calculating explosion overpressure levels is to determine if a facility has the potential to experience the hazardous effects of an explosion and, if so, to mitigate the results of these explosions. The calculations can also serve to demonstrate where mitigating measures are not needed due to the lack of a potential to produce damaging overpressures either because low explosion effects or distance from the explosion for the facility under evaluation.

As an aid in determining the severity of vapor cloud explosions, overpressure radius circles are normally plotted on a plot plan from the source of leakage or ignition. These overpressure circles can be determined the levels at which destructive damage may occur to the facility from the worst case credible event (WCCE). Facilities that are deemed critical or highly manned should be relocated out of the overpressure circles from which the facility cannot withstand the explosive blast or provided with other explosion protective measures. Other systems within these overpressure zones should be evaluated for the benefits of providing explosive protective design arrangements. Figure 8 shows an example of a typical plot of overpressure circles for a hydrocarbon processing facility.
OVERPRESSURE CONSEQUENCE DIAGRAM

Figure 8
Explosion Protective Design Arrangements

Explosion suppression systems are being offered on the commercial market for small enclosures, based on powder and Halon extinguishing agents. These systems have some disadvantages that must be considered before being applied at any facility. A leak may continue for some time and the ignition source is usually not likely to dissipate. Re-ignition of the gas cloud is a high risk with "one shot" systems. For large enclosures, a tremendous volume of the suppression agent is necessary and therefore there is point of diminishing return for the protection system (i.e., cost versus benefit).

Research on water explosion inhibiting systems is providing an avenue of future protection possibilities against vapor cloud explosions. British Gas experimentation on the mitigation of explosions by water sprays, shows that flame speeds of an explosion may be reduced by this method. The British Gas research indicates that small droplet spray systems can act to reduce the rate of flame speed acceleration and therefore the consequential damage that could be produced. Normal water deluge systems appear to produce too large a droplet size to be effective in explosion flame speed retardation and may increase the air turbulence in the areas.

The following are typical design practices that are employed to prevent vapor cloud explosions.

a. All hydrocarbon areas should be provided with maximum ventilation capability. Specific examinations should be undertaken at all areas where the hazardous area classification is defined as Class 1 Division 1 or Class 1 Division 2. These are areas where hydrocarbon vapors are expected to be present, so verification that adequate ventilation is provided to aid in the dispersion of combustible vapors is a necessity.

The following practices are preferred:

- Enclosed spaces are avoided.

  Enclosed locations will not receive adequate ventilation and could allow the build-up of combustible vapors or gases. Vapors with heavy densities can be particularly cumbersome as they will seek the low areas that are normally not provided with fresh air circulation.

- Installation of walls and roofs are used only where necessary (including firewalls).

  Walls or roofs tend to block vision and access, trap sand, debris, and reduce ventilation so that flammable vapors are not as quickly dispersed. They may also collapse if there is an explosion or deflagration. They can therefore contribute to secondary effects by falling onto pipes an equipment that may substantially exceed damage from the original explosion or deflagration. They can also lead to a false sense of security.

- A minimum of six air changes per hour are provided to enclosed areas.

- Generally hydrocarbon floors areas are open grated construction when elevated, unless solid floors are provided where there is a need for spill protection or a fire or explosion barrier, otherwise ventilation requirements will prevail.

b. Area congestion should be kept to a minimum.

- Vessels should be orientated to allow maximum ventilation or explosion venting.
- Bulky equipment should not block air circulation or dispersion capability.
c. Release or exposure of flammable vapors to the atmosphere should be avoided.

- Waste hydrocarbon gases (process vents, relief valves, and blowdowns) should be routed to the flare or returned to the process through a closed header where practical.
- Sampling techniques should use a closed system.
- Process equipment liquid drains should use a sealed drainage system.
- Open drain ports should be avoided and separate sewage and an oily water drain system should be provided.
- Surface drainage should be provided to remove spills immediately and effectively from the process area.

d. Gas Detection is provided, particularly to areas handling low flash point materials with a negative or neutral buoyancy (i.e., vapor density is 1.0 or less), since these have the highest probability to collect or resistance to dispersion.

e. Air or oxygen is eliminated from the interior of process systems, i.e., vessels, piping and tanks. Combustible gasses and vapors will exist in the interior of process systems by the nature of work. Inclusion of air inside a process will as some time for a flammable atmosphere that will explode once an ignition source is available.

f. Protective devices are located outside hazardous areas or behind protective barriers.

g. Semi or permanently occupied buildings required in or adjacent process areas are constructed to withstand expected explosion overpressures. Nonessential personnel or facilities are relocated areas which are not vulnerable to explosions.

Vapor Dispersion Enhancements

Water Sprays

Water spray systems have been demonstrated to assist in the dispersion of vapor releases. The sprays assist in the dilution of the vapors with the induced air currents created by the velocity of the projected water particles. They cannot guarantee that a gas will reach an ignition source but do improve that probabilities that dispersion mechanisms will be enhanced.

Air Cooler Fans

Large updraft air cooler fans create induced air currents to provide cooling for process requirements. These air coolers create a considerable updraft that ingests the surrounding atmosphere and disperses it upwards. Judicious placement of fans during the initial plant design can also serve a secondary purpose of aiding the dilution of combustible vapors during an accidental release.

Location Optimization Based on Prevailing Winds

Equipment that normally handles large amounts of highly volatile products should be placed so that the prevailing wind direction will disperse releases to locations that would not endanger other equipment or provide for an ignition source for the released material.

Supplemental Ventilation Systems

Enclosed locations that may be susceptible to build up of combustible gases are typically provided with ventilation systems that will disperse the gases or provide sufficient air changes to the enclosures
such that gas leakages will not accumulate. Typical examples are battery rooms, gas turbine enclosures, offshore enclosed modules, etc.

**Damage Limiting Construction**

Various methods are available to limit the damage from the effects of an explosion. The best options are to provide some pre-installed or engineered features into the design of the facility or equipment that allow for the dissipation or diversion of the effects of a blast to nonconsequential areas. Wherever these mechanisms are used the overpressure levels utilized should be consistent with the risk analysis estimates of the WCCE incident.

Where enclosed spaces may produce overpressures blow out panels or walls are provided to relieve the pressure forces. The connections of the panel are specified at a lower strength that normal panels so it will fail at the lower level and relieve the pressures. Similarly, combustible or flammable liquid storage tanks are provided with weak roof to shell seams so that in case of an internal explosion, the built-up pressure is relieved by blowing off the roof and the entire tank does not collapse.

For exposed buildings at onshore facilities, heavy monolithic concrete construction is used. Entranceways are provided with heavy blast resistance doors that do not face the exposed area.

**Fireproofing**

Following an explosion incident, local fires develop which it left uncontrolled, result in a conflagration of the entire facility and its destruction. Fire protection measures are provided as required to control these occurrences. The ideal fire protection measure is one that does not require addition action to implement and is always in place. These methods are considered passive protection measures and the most familiar is fireproofing.

It has been demonstrated that steel strength decreases rapidly with temperature increases above 260 °C (500 °F). At 538 °C (1000 °F), its strength both in tension and compression is approximately half, at 649 °C (1200 °F) its strength decreases to less than one quarter. Bare steel exposed to hydrocarbon fires may absorb heat at rates from 10,000 to 30,000 Btu/hr/sq. ft., depending on the configuration of the exposure. Due to the high heat conduction properties of steel, it is readily possible for normally loaded steel members or vessels to lose their strength to the point of failure within ten minutes or less of a hydrocarbon fire exposure.

In a strict sense, fireproofing is a misnomer, as nothing is entirely "fireproof". In the petroleum and related industries, the term fireproofing is commonly used to refer to material that is resistive to a certain set of fire conditions for a specified time. The basic objective of fireproofing is to provide a passive means of protection against the effects of fire to structure components, fixed property, or to maintain the integrity of emergency control systems or mechanisms. Personnel shelters or refuges should not be considered adequately protected with fireproofing unless measures to provide fresh air and protection against smoke and toxic vapor inhalation is also provided. In itself fireproofing should also not be considered protection against the effects of explosions, in fact quite the opposite may be true, fireproofing may be just as susceptible to the effects of an explosion, unless specific arrangements have been stipulated to protect it from the effects of explosion overpressures.

Fireproofing for the petroleum and related industries follow the same concept as other industries except that the possible fire exposures are more severe in nature. The primary destructive effects of fire in the petroleum industry is very high heat, very rapidly, in the form of radiation, conduction and convection. This causes the immediate collapse of structures made of exposed steel construction. Radiation and convection effects usually heavily outweigh the factor of heat conduction for the
purposes of fireproofing applications. Fireproofing is not tested to prevent the passage of toxic
vapors or smoke, other barriers must be installed to prevent the passage of these. The collapse of
structural components in itself is not of high concern, as these can usually be easily replaced. The
concern of structural collapse is the destruction of the items being supported and the impact damage
and spread of large quantities of combustible fluids or gases they might release to other portions of
the facility. Where either of these features might occur that would have high capital impact, either in
immediate physical damage or a business interruption aspect, the application of fireproofing should be
considered. Usually where essentially only piping is involved, which would not release enormous
amounts of combustible materials, fireproofing for pipe racks is not economically justified. Common
piping and structural steel normally can be easily and quickly replaced. It is usually limited to
locations where equipment that requires a long replacement time might be damaged if the rack
collapsed or are supportive of emergency incident control function, such as depressuring and
blowdown headers that are routed to the flare.

The primary value of fireproofing is obtained in the very early stages of a fire when efforts are
primarily directed at shutting down processes, isolating fire supplies to the fire, actuating fixed or
portable fire suppression equipment and conducting personnel evacuation. If equipment is not
protected, then it is likely to collapse during this initial period. This will cause further impact damage
and possibly additional hydrocarbon leakages. It may become impossible to actuate ESD devices,
vent vessels, or operate fire suppression devices. During further escalation of the fire larger vessels,
still containing hydrocarbon inventories, can rupture or collapse causing a conflagration of the entire
facility.

It is theoretically possible, based on the assumption of the type of fire exposure (i.e., pool, jet, etc.)
to calculate the heat effects from the predicted fire on every portion of petroleum facility. As of yet
this extremely costly and cannot be performed economically for an entire facility.

What is typically applied, is the standard effects of a petroleum fire (i.e., a risk exposure area is
defined) for a basic set of conditions that is used for most locations in a facility. If necessary
examinations of critical portions of a facility for precise fire conditions are then undertaken by
theoretical calculations. In general the need for fireproofing is typically defined by identifying areas
where equipment or processes can release liquid or gaseous fuel that can burn with sufficient intensity
and duration to result in substantial property damage. In the petroleum industries these locations are
normally characterized by locations with a high liquid holdups or pressures historically having a
probability of release and high pressure gas release sources.

Typical locations where fire risk exposures are considered prevalent are:

(1) Fired heaters
(2) Pumps handling hydrocarbon materials
(3) Reactors
(4) Compressors
(5) Large hydrocarbon inventory vessels, columns, and drums

Additionally whenever equipment is elevated, which could be source of liquid spillage, long down
time for replacement, or supports flare or blowdown headers in a fire exposure risk area, fireproofing
of the supports is normally applied. API Publication 2218 provides further guidance on the exact
nature of items and conditions that the industry considers prudent for protection.

A standard fire duration (e.g., 2 hours) is applied and a high temperature fire (i.e., UL 1709) is
normally assumed from the hydrocarbon release sources.
The following material aspects should be considered when application of fireproofing is contemplated:

- Fire performance data (fire exposure and duration)
- Costs (material, installation labor and maintenance)
- Weight
- Explosion resistance
- Mechanical strength (resistance to accidental impacts)
- Smoke or toxic vapor generation (when life safety is associated with protection)
- Water absorption
- Degradation with age
- Application method
- Surface preparation
- Curing time and temperature requirements
- Inspection method for coated surface
- Thickness control method
- Weather resistance
- Corrosivity
- Ease of repair

**Fireproofing Specifications**

Typically fireproofing materials are specified for either cellulosic (ordinary) or hydrocarbon (petroleum) fire exposures at various durations. The essential feature of the fireproofing is that it does not allow the passage of flame or heat and therefore can protect against structural collapse for certain conditions. Because fireproofing is normally not tested to prevent the passage of smoke or toxic vapors, it's use to provide protection for human habitation should be carefully examined, in particular the effects of the passage of smoke and lack of oxygen in the environment. It should be borne in mind that fireproofing is tested to a set of basic standards. These standards cannot be expected to correlate to every fire condition that can be produced in a petroleum facility. The spacing, configuration, and arrangement of any hydrocarbon process can render the application of fireproofing inadequate for the fire duration if the fire intensity is higher than the rating of the fireproofing. Fire resistance enclosures should not only be rated for protection against the predicted fire exposure but to ensure the continued operation of the equipment being protected. For example if the maximum operating temperature of a valve actuator is only 100 °C (212 °F), ambient temperature limits inside the enclosure should be allowed to rise above, even though the fireproofed enclosure has met the requirements of a standard fire test. The operating requirements for emergency systems must always be borne in mind.

There are a number of fire test laboratories in the world that can conduct fire tests according to defined standards and on occasion specialized tests. Table 17 provides a list of the test agencies recognized by the petroleum and related industries.
Structural steel begins to soften at 316 °C (600 °F) and at 538 °C (1,000 °F) it loses 50% of its strength. Therefore the minimum accepted steel temperature for structural tolerance is normally set to 400 °C (752 °F) for a period of 2 hours, exposed to a high temperature hydrocarbon (i.e., petroleum) fire (Ref. UL Standard 1709).

<table>
<thead>
<tr>
<th>Laboratory</th>
<th>Name</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>FM</td>
<td>Factory Mutual Research Corp.</td>
<td>Norwood, MA, USA</td>
</tr>
<tr>
<td>LPC</td>
<td>Loss Prevention Council</td>
<td>Borehamwood, Herts., UK</td>
</tr>
<tr>
<td>SINTEF</td>
<td>Norwegian Fire Test Laboratory</td>
<td>Trondheim, Norway</td>
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<tr>
<td>SWRI</td>
<td>Southwest Research Institute</td>
<td>San Antonio, TX, USA</td>
</tr>
<tr>
<td>TNO</td>
<td>Dutch Fire Test Laboratory</td>
<td>Delft, Netherlands</td>
</tr>
<tr>
<td>UL</td>
<td>Underwriters Laboratories</td>
<td>Northbrook, IL, USA</td>
</tr>
<tr>
<td>ULC</td>
<td>Underwriters Laboratories, Canada</td>
<td>Ottawa, Canada</td>
</tr>
<tr>
<td>WFRC</td>
<td>Warrington Fire Research Center</td>
<td>Warrington, Cheshire, UK</td>
</tr>
</tbody>
</table>

Table 17

Recognized Fire Testing Laboratories
Figure 9

Time Temperature Curves for Petroleum versus Cellulosic Fires
(Degrees Celsius versus Time in Minutes)
Recent experiential work suggests that heat flux is a more realistic method of determine the heat transmission into fire barriers. Typical heat flux values of 30-50 kW/sq.m (9,375 - 15,625 Btu/sq.ft.) for pool fires and 200-300 kW/sq.m (62,500 - 93,750 Btu/ sq. ft.) for jet fires is normally the basis of heat flux exposure calculations.

Fireproofing Materials

There are numerous fireproofing materials available on the marketplace and the selection of the material involved is based on the application and advantages versus disadvantages of each over an economic factor. Usually no single material is ideally suited for a particular application, and an evaluation of the cost, durability, weatherability, and combination of factors is necessary.

Cementitious Materials

Cementitious materials use a hydraulically setting cement such as Portland cement as a binder with a filler material of good insulation properties, e.g., vermiculite, perlite, etc. Concrete is frequently used for fireproofing because it is easily installed, readily available, is quite durable and generally economical compared to other methods. It is heavy compared to other materials and requires more steel to support that other methods.

Pre-formed Masonry and Inorganic Panels

Brick, concrete blocks, or pre-cast cement aggregate panels have been commonly used in the past. These materials tend to be labor intensive to install and are less economical than other methods.

Metallic Enclosures

Stainless steel hollow panels filled with mineral wool are fabricated in precise dimensions to withstand the specified fire exposure. Typically electrical equipment must operate within a specified level for a period of time when a fire exposure occurs and is protected by such enclosures.

Thermal Insulation

These can be inorganic materials such as calcium silicate, mineral wool, diatomaceous earth or perlite and mineral wool. If provided as an assembly they are fitted with steel panels or jackets. These are woven noncombustible or flame retardant materials the provide insulation properties to fire barrier for the blockage of heat transfer.

Intumenscent Coatings

Intumenscent coatings have an organic base that, when subjected to a fire, will expand and produce a char and underlying insulating layer.

Refractory Fibers

Fibrous materials with a high melting point are used to form fire resistant boards and blankets. The fibers are derived from glass minerals or ceramics. They may be woven into cloths and are used as blankets around the object to be protected.
The principle features of passive protection are summarized below:

**Advantages**

- No initiation required.
- Immediate protection with low conductivity materials, reactive materials respond when threshold temperature is reached.
- No power required.
- Meet regulatory requirements.
- Low maintenance.
- Can be upgraded.
- Certain materials can provide anti-corrosion benefits.
- No periodic testing required.

**Disadvantages**

- Provide only short duration protection when compared to active systems.
- Not renewable during or after a fire.
- Inspection of substrate for permanent materials for corrosion can be difficult.

**Choice - Determined by:**

- Application.
- Protection required.
- Performance.
- Physical properties.
- Costs.
Composite Materials

Lightweight Composite proprietary materials, typically of glass fiber and polyester resins, are available as sheet boards which can be arranged into protective walls or enclosures. They offer light weight, inherent insulation, and can be configured to achieve blast protection. These materials are corrosion free, and wear resistant.

Radiation Shields

In some cases radiation shields are provided to protect against heat effects from fire incidents and operation requirements. The shields usually are of two styles either a dual layer wire mesh screen or a plexy-glass see through barrier. The shields provide a barrier from the effects of radiant heat for specific levels. They are most often used for protection against flare heat and for barriers at fixed firewater monitor devices, most notably at the helidecks of offshore facilities.

Water Cooling Sprays

Water sprays are sometimes used instead of fireproofing where the fireproofing application may be considered detrimental to the situation or uneconomical to achieve. Typical examples are the surface of pressure vessels or piping where metal thickness checks are necessary, structural facilities that cannot accept additional loads of fireproofing materials due to dead weight or wind loads, inaccessibility of the surface for application of fireproofing, or impracticability of fireproofing application.

Normally where it is necessary, fireproofing is preferred over water spray for several reasons. The fireproofing is a passive inherent safety feature, while the water spray is a vulnerable active system that requires auxiliary control to be activated. Additionally the water spray relies on supplemental support systems that may be vulnerable to failures, i.e., pumps, distribution network, etc. The integrity of fireproofing systems is generally considered superior to explosion incidents compared to water spray piping systems. The typical application of water sprays in place of fireproofing is for vessel protection.

The water spray protects the exposure by:

1. Cooling the surface of the exposure.
2. Cooling the atmosphere surrounding the exposure and from the source.
3. Limiting the travel of radiant heat from flames to adjacent exposures.

Vapor Dispersion Water Sprays

Fire water sprays are sometimes employed as an aid to vapor dispersions. Some literature on the subject suggests two mechanisms are involved that assist in vapor dispersions with water sprays. First, a water spray arrangement will start a current of air in the direction of the water spray. The force of the water spray engulfs air and dispenses it further from its normal circulating pattern. In this fashion released gases will also be engulfed and directed in the direction of nozzles. Normal arrangement is to point the water spray upward to direct ground and neutral buoyancy vapors upwards for enhanced dispersion by natural means at higher levels. Second, a water spray will warm a vapor to neutral or higher buoyancy to also aid in its natural atmospheric dispersion.
Locations Requiring Consideration of Fire Resistant Measures

The application of fire resistant materials is commonly afforded to locations where large hydrocarbon spillages or high pressure high volume gas releases may occur with a high probability (i.e. fire hazardous zones). These locations commonly are associated with rotating equipment and locations where high erosion/corrosion effects could occur. Alternatively fireproofing materials are used to provide a fire barrier where adequate spacing distances are unavailable (i.e., offshore installations, escape measures, etc.). API Publication 2218 provides further guidance in the application and materials used in the industry.

- **Onshore**
  - Vessel, tank and piping supports in fire hazardous zones.
  - Critical services (ESD valves, control and instrumentation).
  - Pumps and high volume or pressure gas compressors.

- **Offshore**
  - Hydrocarbon processing compartments.
  - Floors, walls, roofs for accommodations.
  - Structural support located in fire hazardous zones.
  - Room doors and windows.
  - Pump and high volume or pressure gas compressors

- **Common Petroleum Industry Fireproofing Material Applications**

  **Vessel and Pipe Supports:**
  - Onshore: 2 inches of Concrete; UL 1709, 2 hour rating
  - Offshore: Ablative or intumensent materials, UL 1709, 2 hour rating

  **Cable Trays:** Stainless steel cabinets or fire rated mats, UL 1709, 20 minute rating

  **ESD Control Panels:** Stainless steel cabinets or fire rated mats, UL 1709, 20 min. rating

  **EIVs:** (If directly exposed) - Stainless steel cabinets or fire rated mats UL 1709, 60 min.

  **EIV actuators:** Stainless steel cabinets or fire rated mats UL 1709, 20 minute rating

  **Firewalls:**
  - Onshore: Concrete or masonry construction, UL 1709, 2 hour rating
  - Offshore: Ablative, composite or intumensent, UL 1709, 2 hour rating

Flame Resistance

**Interior Surfaces**

Most building fire codes set fire resistive standards for interior wall and ceiling finishes and overall requirements for building construction fire resistance features. Based on fire statistics, the lack of proper control over an interior finish is second only to the vertical spread of fire through openings in floors as the cause of loss of life in buildings. The dangers of unregulated interior finish materials are mainly: (1) The rapid spread of fire presents a threat to the occupants of the building by either limiting or delaying their use of exitways within and out of a building. The production of dense black smoke also obscures the exit path and exit signs. (2) The contribution of additional fuel to a fire. Unregulated finish materials have the potential for adding fuel to the fire, thereby increasing its intensity and shortening the time available for occupants to escape. The intent of most building fire codes is to regulate only the interior finish of materials on walls and ceilings and not to regulate floor coverings since experience tells that traditional type of interior finish materials such as wood, vinyl tile, linoleum, and other resilient floor covering materials do not contribute to the early spread of fire.
Electrical Cables

Electrical conductors are normally insulated for protection and avoidance of electrical shorting. Typical insulating materials are plastics that can readily burn with toxic vapors. The NEC specifies certain fire resistant rating to electrical cables to lessen the possibility of cable insulation ignitability and fire spread.

Optical fiber cables

The increasing use of fiber optics for electronic communications poses critical communications risks. The fire resistant requirements of fiber optical cables are currently similar to the requirements of fire resistant ratings applied to electrical cables within the specifications of the NEC.

Fire Dampers

Fire dampers are an assembly of louvers that are arranged to close to prevent the passage of flame and heat. Dampers are installed in ventilation openings or shafts to provide a fire rated barrier equal to the surrounding barrier. They are activated by spring release by the melting of a fusible link or by remote control signals.

Acceptance testing of fusible link fire dampers should always include a random sample actual fusible link (melting) test of the installed assembly that causes the damper to close. Many times an improperly installed damper will not close correctly and the shutter louvers become hung up or twisted. An alternative sometimes available is a link assembly that can be temporary installed that is easily cut by a pair of clippers. The fusible link melting temperature can then be tested separately at a convenient location without subjecting the installation heat or flames for testing purposes.

Smoke Dampers

Smoke dampers are used to prevent the spread of products of combustion within ventilation systems. They are usually activated by the fire alarm and detection system. Smoke dampers are specified on the leakage class, maximum pressure, maximum velocity, installation mode (horizontal or vertical) and degradation test temperature of the fire.

Flame and Spark Arrestors

Flame arrestors stop the flame propagation from entering through the opening. The device contains an assembly of perforated plates, slots, screens, etc., enclosed in a case or frame that absorb the heat of flame entering and thereby extinguish it before can pass. When burning occurs within a pipe, some of the heat of combustion is absorbed by the pipe wall. As the pipe diameter decreases, an increasing percentage of the total heat is absorbed by the pipe wall and the flame speed in the pipe decreases. By using very small diameter (one or two millimeters), it is possible to completely prevent the passage of flame, regardless of flame speed. A typical flame arrestor is a bundle of small tubes, which achieves the required venting capacity but prevents the passage of flame. The "Davy" miners lamp was the first use of flame arrestor in which a fine mesh screen of high heat absorption properties was placed in front of the flame of the miner lamp to prevent ignition of methane gas in coal mines.
Research has shown that pressure-vacuum vents are just as effective as flame arrestors for storage tanks against internal ignitions.

Spark arrestors are provided on the exhaust of source or fire where a hot particulate might be released (i.e., internal combustion engines, chimneys, incinerator stacks, etc.). The spark arrestor consists of a fine metal screen to prevent the particulate matter from being released from the exhaust mechanism.

**Piping Detonation Arrestors**

Pipe detonation arrestors are provided where there is a possibility of highly accelerating flame fronts within piping systems due to poor piping designs to prevent such occurrences.
Bibliography


14. Industrial Risk Insurers (IRI), *IM.2.5.1, Fireproofing for Oil and Chemical Properties*, IRI, Hartford, CT.

15. Industrial Risk Insurers (IRI), *IM.2.2.1, Firewalls*, IRI, Hartford, CT.


Also see Appendix B.1