



Property Risk Consulting Guidelines

XL Risk Consulting

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PRC.13.0.0

SELECTING EXTINGUISHING SYSTEMS

INTRODUCTION

While many different extinguishing agents can be used to extinguish a fire, it is essential that the most effective, most reliable, safest and most economical means of extinguishment be used for a given hazard. This section addresses many of the characteristics that must be considered when selecting an extinguishing agent.

POSITION

Consider the following factors in selecting an appropriate extinguishing system:

- Management programs;
- Occupancy characteristics;
- Detection system characteristics;
- Agent characteristics;
- Extinguishing system characteristics.

Management Loss Prevention Programs

Write and implement management programs for loss prevention and control as specified in AXA XL Risk Consulting's *OVERVIEW*. Make sure these programs take into account the selection, operation and maintenance of extinguishing systems. Pay particular attention to the programs for Impairment Handling and Fire Equipment Inspection as well as Employee Training, Hazard Identification and Evaluation, and Hazardous Materials Evaluation.

Occupancy Characteristics and Fire Scenario

Each operation at a facility has the potential for loss. Some involve hazardous chemicals or dangerous processes; whereas others may only have minor combustibles and the only source of ignition may be electrical in nature. Regardless of the occupancy each should be evaluated by the same parameters.

Thoroughly review all aspects of the area to be protected. Consider the following occupancy characteristics:

- Operation hazards;
- Construction features;
- Environmental threat.

Operation Hazards

Analyze each fire compartment and include the following factors in the examination of operations:

- Mission or function of equipment. Consider the ease of access and the potential and vulnerability to loss.
- The presence of trained personnel knowledgeable of their job duties, their workplace hazards and the facility's emergency procedures.
- Energy introduced and used internally. Consider energy exported as result of the operations performed. Energy can be in the form of:
 - Pressurized liquids or gases, either combustible or noncombustible;
 - Electrical, either generated or consumed;
 - Heat released or absorbed, such as heat of compression and friction.
- The value of the facility in monetary terms and societal impact.
- Process bottlenecks and their impact. Even though duplicate operations may exist, this may not necessarily improve fire survivability if operations are in close proximity or within the same enclosure.
- The presence of combustibles. Evaluate normal and transient fuel loading and continuity of combustibles able to sustain combustion. Ambient temperatures, exposed surface areas and materials configuration affect combustibility. Fuels may include:
 - Class A - Cellulosic materials and plastics;
 - Class B - Combustible and flammable liquids and flammable gases;
 - Class C - Live electrical equipment;
 - Class D - Combustible metals such as magnesium and titanium.
- The presence of chemicals which when mixed result in exothermic reactions that could initiate a fire or explosion. Establish process handling and emergency response procedures.
- The presence of chemicals with reactive properties under fire conditions.

Construction Features

Evaluate construction materials, compartmentation, concealed spaces, drainage, heat and smoke ventilation, and utility services.

Construction Materials. Review all construction materials in the fire compartment to determine their composition and probable involvement as fuel in a fire.

Compartmentation. The compartment dimensions (enclosure volume) are determined by the placement and fire resistance of the walls, ceiling and floor. Windows, doors and unsealed penetrations may result in increased fire spread and possible agent loss. Unless floor, ceiling and wall penetrations are protected against fire intrusion, the adjacent compartments should be considered in the analysis. Evaluate personnel access controls and security systems.

Concealed Spaces. Void spaces created by construction design such as ceiling plenums, raised floors, wall cavities and false roofs should be examined for proper fire stopping and sprinkler protection where possible. The lack of appropriate fire stopping may result in increased fire spread unless provisions are made to seal all openings.

Heat and Smoke Ventilation. Evaluate the operation of fire and post-fire ventilation systems. Where gaseous agents are to be employed, delay the operation of these ventilation systems until a suitable soak period has occurred to ensure the agent is not vented before it has a chance to control the situation.

Drainage. Examine the existence of drainage for liquid spills and fire fighting runoff. Improperly installed drainage may cause fire migration.

Utilities. Evaluate each of the following utilities to determine their possible involvement as ignition sources and their impact on the intensity and size of a potential fire:

- Electrical. Electrical circuits and equipment are a major cause of fire ignition. Review the electrical power supplies to determine if they are of proper design and are well maintained.
- Steam, hot water, hot oil systems and roof mounted solar heaters. Review hot fluid systems piping for inadequate clearance or insufficient insulation materials to avoid ignition of nearby combustibles and correct as necessary.
- Heating fuels. Review gas and oil systems and associated piping for appropriate safety controls.
- Air conditioning. Evaluate capacity and type of refrigerant fluids. Air movement system ducts can potentially spread heat and smoke from a hostile fire.

Environmental Threat

Pre Incident. Analyze each fire compartment's environmental arrangement under all operating conditions including air movement, drainage, solid waste removal and temperature variations. Consider the possible environmental contamination of air, water and soil as well as contamination of building, equipment and contents. Consider the fire compartment design for natural disasters such as flood, earthquake, tornadoes, hurricanes, sink holes and land subsidence. Loss of protection may occur during natural disasters.

Post Incident. Evaluate the possible environmental contamination of air, water and soil as well as contamination of building, equipment and contents resulting from either a fire or an unwanted operation of fire protection equipment.

Detection System Characteristics and Selection Factors

The selection of the most appropriate automatic detection system depends on a thorough analysis of the hazard's pre-ignition and burning characteristics. Detection systems provide sensing of thermal changes, smoke evolution, flame spectrum, pressure development or changes in vapor concentrations. Appropriate detection equipment is critical to achieving prompt and reliable response. Detailed information on detection systems can be found in PRC.13.0.1. A detection selection chart can be found in PRC.13.0.1.A.

Agent Characteristics

There are many agent characteristics that must be analyzed before an agent can be selected. Among these are the agent's availability, physical properties, useful life, suppression method, agent uses, limitations, impact on people and the environment including cleanup, agent toxicity and decomposition products. A summary of extinguishing agent selection features can be found in PRC.13.0.0.A.

Availability

Most of the common extinguishing agents have been in existence for some time and have been stockpiled. The agent distributors have elaborate distribution networks that make replenishment within 8 to 12 hrs realistic in even the most remote areas. The determining factor in many cases is finding a supplier who provides 24 hr a day service for emergencies.

Physical Properties

Most extinguishing agents come in one of three forms: gas; liquid; or solid. Some important agent characteristics are molecular weight, density, viscosity and vapor pressure.

Useful Life

A system's useful life depends on its agent characteristics and the quality of its maintenance. Some agents when premixed or diluted with water have reduced shelf lives.

Suppression Method

The combustion process can be terminated by:

- Cessation of fuel supply by consumption, removal or shutoff.
- Reduction of oxidizing agent by air starvation, or by using inert gases to reduce the oxygen present for combustion.
- Reduction of temperature to below the ignition point by shutting off electrical supplies, cooling the fire, or agent reaction.
- Disruption of the combustion cycle removing the hydroxyl radicals OH*. This is sometimes referred to as chain breaking.
- Flame disengagement by pressure waves produced by explosion, sound or released pressure.

Agent Uses

Sprinkler systems are generally provided for area protection. Special extinguishing systems are used to protect specific hazards where:

- Hazard is too severe for sprinkler protection.
- Hazard is too severe for hand extinguishment or human control.
- Configuration is such that sprinkler water cannot reach hazard efficiently.
- Sprinkler protection is undesirable because of damage potential.
- Water supply for a sprinkler system is not available or is insufficient.
- High value contents exist and where a delay associated with normal sprinkler operation is not acceptable.

Various extinguishing agents have different extinguishing abilities for the same fuel. Their use depends on the principle of extinguishment, flow rates or concentrations of agent in air that may be necessary to inhibit, control or extinguish a fire, and the economics of the system.

Water has a specific gravity of 1.0. Many flammable and combustible hydrocarbon based liquids float on the water surface. Large volumes of water application cool many of these materials below their ignition point. Polar solvents are miscible in water and are diluted by its application.

Some agents require a tight enclosure to operate most efficiently. Some other extinguishing agents require means to control agent runoff.

Limitations

Information on the design, installation and maintenance of extinguishing systems is found in the appropriate NFPA documents. Limitations on their use are also addressed. Another source of information on agent restrictions is the manufacturer's design manual.

Impact on People

Personal safety is a very important consideration for an extinguishing agent. All recommended safety procedures and requirements should be followed. Agents may be lethal in their normally expected extinguishing levels. They may be an eye or lung irritant. They may cause burns from high pressure impact and extremely cold temperatures during discharge. They may cause temporary hearing loss due to noise during discharge. They may cause vision obscuration or even blindness if discharged directly into the eye. Choose agents used in normally occupied areas with extra care. Consider the effects of agent toxicity and decomposition products evolved during extinguishment.

Impact on the Environment

Consider the effects of decomposition products evolved during extinguishment will have on materials in the fire area. Thoroughly investigate agent cleanup and contamination of air, soil and water prior to agent selection.

Extinguishing System Characteristics

Extinguishing systems may use one of the following common agents: water; foam; foam-water; carbon dioxide; dry or wet chemical; halon; or other clean agents. There are specific suppression system characteristics that must be analyzed before an appropriate agent can be selected. Among these are hazard area evaluation, fixed vs. portable, automatic vs. manual, connected reserve requirements, and design features including agent discharge time and discharge turbulence and economic factors. A summary of extinguishing system selection features can be found in PRC.13.0.0.B.

Hazard Area Evaluation

Evaluate the ambient temperature, the presence of an appropriate enclosure, and installation space and weight requirements.

All extinguishing agents have a recommended temperature range for storage and use which should be considered in system selection.

Some systems require significant floor space for agent storage. This may require a floor loading calculation to confirm structural adequacy.

Fixed vs. Portable

A system may be fixed, portable, mobile or a hose stream application. Portable equipment is essentially for use on fire in its incipient stage. It is also useful for overhauling after a fire.

Automatic vs. Manual

Automatic operation is preferable. Immediate activation of the system reduces fire size and potential damage and eliminates human decision delays. Only where hazards to operating personnel exist should manual operation be accepted. All systems should have a manual release.

Economic Factors

When purchasing an extinguishing system, many factors other than cost per pound or gallon should be considered. Among these are container size or distribution system, special handling or shipping requirements, and ease of recharging system. Other costs to consider include those for:

- Design;
- Installation;
- Performance of acceptance test including clean up, reclamation and/or disposal;
- Maintenance of the system including weighing, periodic inspection and testing;
- Reclaiming, recycling and disposal of agent at the end of its useful life.

Connected Reserve

Provide a connected reserve to provide protection:

- In case the fire should reflash. Reflash results from:
 - Attempts at extinguishment that have not cooled the fuel sources sufficiently;
 - Excessive loss of agent through leakage;
 - Hazards that exhibit continuous arcing potential.
- To lessen the chance of impairment if primary protection fails to operate. System reliability depends on the system's ability to avoid false operation as well as its ability to operate in an emergency after being idle for most of its existence. The reliability of a system depends on its individual parts. The approval agencies for the most part assure that the individual components of a system such as detection, actuation, distribution, auxiliary functions and the necessary alarms function as intended in accordance with the appropriate NFPA standards and approval agency safety standards. A connected reserve allows for a back up system if the primary system fails to operate properly.

- To restore protection to hazards during recharging. A connected reserve also allows for continued protection after the primary supply has operated. This is especially true when selector valves are involved and more than one hazard is protected by the same set of containers. Where a connected reserve is not used, agent replenishment must take place before operations are resumed.

In single container fixed systems a reserve supply can be provided by timing the discharge and having enough agent for multiple discharges. In multiple container fixed systems a reserve supply can be provided by using a second set of containers with manual switch over by operating the main/reserve switch.

Foam-water systems that protect flammable liquids storage inside buildings are designed so that the main and reserve system operate automatically one after the other to obtain the most benefit from the foam concentrate supply.

Extinguishing System Design Features

There are many factors that should be considered when selecting the method of protection. These include the extent of protection and the specific manner of piping and nozzle selection. A summary of extinguishing agent design features can be found in PRC.13.0.0.C.

Pre-Engineered System

A pre-engineered system is a prepackaged system designed to a rigid set of requirements and limitations. The hazard size, pipe lengths, and number and orientation of fittings and nozzles is strictly controlled. In some instances, small systems can be arranged to operate simultaneously to protect hazards beyond the capability of a single unit.

Engineered System

An engineered system design includes the proper sizing of piping and nozzles based on a specified design concentration. Delivery rate is confirmed by calculations.

Total Flooding

Total flooding, which fills an enclosed volume with an extinguishing atmosphere, may be either a pre-engineered or engineered type. Nozzles are specifically listed for total flooding use. The design should be confirmed by discharge tests where appropriate.

Local Application

Local application protection is used to protect relatively small hazards located in relatively large environments. Local application systems may be of either a pre-engineered or engineered type.

Nozzles are specifically listed for local application use. Each nozzle performs its extinguishing duty on its portion of the hazard. It is essential that engineered systems be designed very accurately and that the installation be thoroughly inspected to ensure that nozzles with the correct orifice size were installed. The design should be confirmed by discharge tests where appropriate. Improper operation of a single nozzle could result in reflash.

Local application systems may be designed on a rate by area or a rate by volume basis.

- A rate by area design provides localized protection for two dimensional, surface type hazards which are not enclosed.
- A rate by volume design provides localized protection for three dimensional hazards which are not enclosed. An enclosure is assumed to exist around the hazard. Two feet in each direction are added to the hazard where an actual solid surface is lacking. The assumed enclosure is used as the volume to be protected.

Agent Discharge Time

System delays prior to agent discharge include response time, evacuation delay or discharge time. Fire growth during these delay periods must be considered.

- Response time - Thermal element delay such as the response time index (RTI), inherent detection delay due to detector placement, and mode of detection need to be considered. Electric-mechanical delays such as those present in resistance heated, electrical operated fusible links, manual operation of systems and response from emergency response teams should also be considered.
- Evacuation delay - Some agents require personnel evacuation for safety purposes. Many gaseous agent systems perform better if the room is properly prepared to accept the agent and doors are not opened during discharge.
- Discharge time - Where agents are stored in containers, the discharge time is measured as the time it takes for the agent to discharge from the nozzles in the quantities required for extinguishment. This is not a factor in most water based systems as there is an unlimited supply. Agent distribution time is restricted by the size of pipes used and the number of nozzles and their orifice sizes. In some extinguishing systems the time it takes to get usable agent to the nozzle must be determined. This is sometimes referred to as transit time.

Discharge Turbulence

For good mixing of gaseous agents, adequate turbulence is required to obtain the design concentration in all hazard areas.

DISCUSSION

To put extinguishing agents in their proper perspective, it is important to first discuss fire and its extinguishment.

The Combustion Process

The combustion reaction is initiated by the presence of fuel, an oxidizing agent such as air, and a source of ignition. This sounds quite simple, but combustion is a very complex process. To simplify the discussion, the process of burning pure methane in pure oxygen will be described. In this process, the cracking of methane releases a variety of combustible fractionated molecules in the space between the flame and the fuel. The cracking of methane (CH_4) releases CH_3^- , CH_2^- , CH^- , C , H^+ and OH^- molecules. As combustion takes place, OH^- radical occurs in almost every reaction. The continuous involvement of the OH^- radical is responsible for continued combustion.

The two major types of burning are surface combustion and glowing combustion. Liquids, gases and most solids burn as a result of surface combustion. Thermal convection and radiant heat from the fire cause more vapor to be released and diffused with air continuing the combustion process. Many plastics are thermoplastics which melt when heated, forming a liquid pool which evaporates driving off volatile combustibles.

Solids such as wood undergo pyrolysis. The process starts with heating and driving off moisture and combustible vapors and ends in deep seated glowing combustion of the charcoal residue. Thermosetting plastics form a char, much like wood, during the combustion process.

The Relationship Between Water and Special Extinguishing Agents

Sprinkler protection is generally used where combustible construction or a combustible occupancy is encountered. Information on the design, installation and maintenance of sprinkler systems is found in NFPA 13. Specific requirements where protection should be provided can be found in occupancy related NFPA documents.

Water extinguishes primarily by cooling, although some smothering and flame disengagement does take place. One pound (454 g) of water has the potential to absorb 1 Btu/°F (4.1 kJ/kg/°C). In order to change a liquid to a gas, a certain amount of energy is required. This is called the latent heat of vaporization and is expressed as 970 Btu/lb (2250 kJ/kg) for water. That is, water will absorb 970 Btu/lb (2250 kJ/kg) when being converted from water (liquid) to vapor (steam). Very little of the discharged water actually converts from water to steam. Water that is not converted to steam absorbs

heat less efficiently. Water's extinguishing efficiency is enhanced by the vast quantities that are usually discharged on a fire.

There is a concept in water extinguishment called water mist, which uses very small airborne water particles. The discharged water can cool the fire more efficiently as a larger portion of the water vaporizes and converts to steam in a hot fire. Better efficiency means less water can be used to control the fire. For more information, see PRC.12.6.1.1.

Information on the design, installation and maintenance of special extinguishing systems are found in the appropriate NFPA documents. The following types of systems are addressed:

- Low-, Medium-, and High-Expansion Foam, NFPA 11 and PRC.12.3.3.1
- Mobile Foam Apparatus, NFPA 1901
- Carbon Dioxide, NFPA 12 and PRC.13.3.1
- Halon 1301, NFPA 12A and PRC.13.4.1.1
- Water Spray Fixed Systems, NFPA 15
- Deluge Foam-Water Sprinkler Systems And Foam-Water Spray Systems, NFPA 16 and PRC.12.3.1.1
- Dry Chemical, NFPA 17 and PRC.13.1.1.1
- Wet Chemical, NFPA 17A and PRC.13.2.1.1
- Wetting Agents, NFPA 18
- Explosion Prevention, NFPA 69
- Water-Mist Systems, NFPA 750 and PRC.12.6.1.1
- Clean Agents, NFPA 2001 and PRC.13.6.1

EXTINGUISHING AGENT SELECTION FEATURES

	Physical State	Conductive	Class	Suppression Method	Clean Agent	Agent Cost	Impact on People	Impact on Environment
SPRINKLERS								
Wet System	Liquid	Yes	A	Cooling	No	V Low	None	None
Dry System	Liquid	Yes	A	Cooling	No	V Low	None	None
Pre-action	Liquid	Yes	A	Cooling	No	V Low	None	None
Deluge	Liquid	Yes	A	Cooling	No	V Low	None	None
FOAM-WATER								
Wet System	Liquid	Yes	AB	Cooling	No	Moderate	Low	Yes
Dry System	Liquid	Yes	AB	Cooling	No	Moderate	Low	Yes
Pre-action	Liquid	Yes	AB	Cooling	No	Moderate	Low	Yes
Deluge	Liquid	Yes	AB	Cooling	No	Moderate	Low	Yes
FOAM SYSTEM								
Low Expansion	Liquid	Yes	AB	Smothering	No	Moderate	Low	Extreme
High Expansion	Liquid	Yes	AB	Smothering	No	Low	Low	Extreme
WATER MIST								
	Liquid	Yes	ABC	Smother/Cool	No	Low	Low	None
CARBON DIOXIDE								
Low Pressure	Liquid/gas	No	ABC	Smothering	Yes	Low	High	None
High Pressure	Liquid/gas	No	ABC	Smothering	Yes	Low	High	None
HALON								
1301	Liquid/gas	No	ABC	Chain breaking	Yes	High	V Low	Extreme
1211	Liquid/gas	No	ABC	Chain breaking	Yes	High	V Low	Extreme
2402	Liquid/gas	No	ABC	Chain breaking	Yes	High	V Low	Extreme
CLEAN AGENTS - Total Flooding								
FK-5-1-2	Liquid	No	ABC	Chain breaking	Yes	High	Moderate	Low
FC-3-1-10	Liquid/gas	No	ABC	Cooling	Yes	High	High	Low
HBFC-22B1	Liquid/gas	No	ABC	Cooling	Yes	High	High	Low
FICFC-124	Liquid/gas	No	ABC	Cooling	Yes	High	High	Low
HFC-125	Liquid/gas	No	ABC	Cooling	Yes	High	High	Low
HFC-227ea	Liquid/gas	No	ABC	Cooling	Yes	High	High	Low
HFC -23	Liquid/gas	No	ABC	Cooling	Yes	High	High	Low
HCFC Blend A	Liquid/gas	No	ABC	Cooling	Yes	High	V High	Moderate
IG-01	Gas	No	ABC	Smothering	Yes	High	Moderate	Low
IG-541	Gas	No	ABC	Smothering	Yes	High	Moderate	Low
IG-55	Gas	No	ABC	Smothering	Yes	High	Moderate	Low
CLEAN AGENTS - Streaming (only)								
HBFC-22BI	Liquid/gas	No	ABC	Cooling	Yes	High	V high	Moderate
HFC-125	Liquid/gas	No	ABC	Cooling	Yes	High	V high	Low
FC-218	Liquid/gas	No	ABC	Cooling	Yes	High	V high	Low
CHEMICALS - Dry Chemical								
Sodium bicarbonate	Solid/gas	No	BC	Chain breaking	No	Moderate	High	Moderate
Potassium bicarbonate	Solid/gas	No	BC	Chain breaking	No	Moderate	High	Moderate
Potassium chloride	Solid/gas	No	BC	Chain breaking	No	Moderate	High	Moderate
Urea/potassium bicarbonate	Solid/gas	No	BC	Chain breaking	No	Moderate	High	Moderate
Potassium carbonate	Solid/gas	No	BC	Chain breaking	No	Moderate	High	Moderate
Monoammonium phosphate	Solid/gas	No	ABC	Chain breaking	No	Moderate	High	Moderate
CHEMICALS - Wet Chemical								
Potassium carbonate	Liquid/solid	No	BC	Chain breaking	No	Moderate	Low	Low
CHEMICALS - Dry Powders								
	Solid (dry)	No	D	Smoothing	No	Moderate	Low	Low

EXTINGUISHING SYSTEM SELECTION FEATURES

	Site Critical	Hand & Hose	Auto/ Manual	System Cost	Connected Reserve (if Applicable)			Design Complexity
					Reflash	Reliable	Restore	
SPRINKLERS								
Wet System	No	Hose	A	V Low	Low	Extreme	Easy	Low
Dry System	No	Hose	A	V Low	Low	High	Moderate	Low
Pre-Action	No	Hose	A&M	V Low	Low	High	Moderate	Low
Deluge	No	Hose	A&M	V Low	Low	High	Easy	Low
FOAM-WATER								
Wet System	No	Hose	A	Low	V Low	Moderate	Involved	Moderate
Dry System	No	Hose	A	Low	V Low	Moderate	Involved	Moderate
Pre-action	No	Hose	A&M	Low	V Low	Moderate	Involved	Moderate
Deluge	No	Hose	A&M	Low	V Low	Moderate	Involved	Moderate
FOAM SYSTEM								
Low Expansion	No	Both	A&M	Moderate	V Low	Moderate	Involved	Involved
High Expansion	No	Both	A&M	Moderate	V Low	Moderate	Involved	Involved
WATER MIST								
	Very	No	A	High	High	Moderate	Involved	V High
CARBON DIOXIDE								
Low Pressure	Yes	Both	A&M	Moderate	Moderate	High	Moderate	Moderate
High Pressure	Yes	Both	A&M	Moderate	Moderate	High	Moderate	Moderate
HALON								
1301	Very	No	A&M	High	Moderate	Moderate	Moderate	Moderate
1211	Very	Hand	A&M	High	Moderate	Moderate	Moderate	Moderate
2402	Very	No	A&M	High	Moderate	Moderate	Moderate	Moderate
CLEAN AGENTS - Total Flooding								
FC-3-1-10	Very	No	A&M	High	Moderate	Moderate	Moderate	Moderate
FK-5-1-2	Very	No	A&M	High	Moderate	Moderate	Moderate	Moderate
HBFC-22BI	Very	No	A&M	High	Moderate	Moderate	Moderate	Moderate
HCFC-124	Very	No	A&M	High	Moderate	Moderate	Moderate	Moderate
HFC-125	Very	No	A&M	High	Moderate	Moderate	Moderate	Moderate
HFC-227ea	Very	No	A&M	High	Moderate	Moderate	Moderate	Moderate
HFC-23	Very	No	A&M	High	Moderate	Moderate	Moderate	Moderate
HCFC Blend A	Very	No	A&M	High	Moderate	Moderate	Moderate	Moderate
IG-01	Very	No	A&M	High	Moderate	Moderate	Moderate	Moderate
IG-541	Very	No	A&M	High	Moderate	Moderate	Moderate	Moderate
IG-55	Very	No	A&M	High	Moderate	Moderate	Moderate	Moderate
CLEAN AGENTS - Streaming (only)								
HBFC-22BI	No	No	M	High	Moderate	Moderate	Moderate	Moderate
WC-125	No	No	M	High	Moderate	Moderate	Moderate	Moderate
FC-218	No	No	M	High	Moderate	Moderate	Moderate	Moderate
CHEMICALS - Dry Chemical								
Sodium bicarbonate	Yes	Yes	A&M	Moderate	Moderate	Moderate	Moderate	Involved
Potassium bicarbonate	Yes	Yes	A&M	Moderate	Moderate	Moderate	Moderate	Involved
Potassium chloride	Yes	No	A&M	Moderate	Moderate	Moderate	Moderate	Involved
Urea/potassium bicarbonate	Yes	No	A&M	Moderate	Moderate	Moderate	Moderate	Involved
Potassium carbonate	Yes	No	A&M	Moderate	Moderate	Moderate	Moderate	Involved
Monoammonim phosphate	Yes	No	A&M	Moderate	Moderate	Moderate	Moderate	Involved
CHEMICALS - Wet Chemical								
Potassium carbonate	Yes	No	A&M	Moderate	Moderate	Moderate	Moderate	Moderate
CHEMICALS - Dry Powders								
	No	No	M	Low	Moderate	Moderate	Easy	V Low

EXTINGUISHING SYSTEM DESIGN FEATURES

	Engineered	Pre-Engineered	Total Flooding	Local Application Volume	Application Area	Pre-discharge Evacuation	System Abort Allowable	Customer Training
SPRINKLERS								
Wet System	N/A	N/A	N/A	N/A	N/A	No	No	Low
Dry System	N/A	N/A	N/A	N/A	N/A	No	No	Low
Pre-action	N/A	N/A	N/A	N/A	N/A	No	No	Low
Deluge	N/A	N/A	N/A	N/A	N/A	No	No	Low
FOAM-WATER								
Wet System	N/A	N/A	N/A	N/A	N/A	No	No	Low
Dry System	N/A	N/A	N/A	N/A	N/A	No	No	Low
Pre-action	N/A	N/A	N/A	N/A	N/A	No	No	Low
Deluge	N/A	N/A	N/A	N/A	N/A	No	No	Low
FOAM SYSTEM								
Low Expansion	N/A	N/A	N/A	N/A	Yes	No	No	Low
High Expansion	N/A	N/A	Yes	N/A	Yes	No	No	Low
WATER MIST								
	No	Yes	Yes	Yes	Yes	No	No	High
CARBON DIOXIDE								
Low Pressure	Yes	No	Yes	Yes	Yes	Critical	No	High
High Pressure	Yes	No	Yes	Yes	Yes	Critical	No	High
HALON								
1301	Yes	Yes	Yes	No	No	Yes	Yes	Moderate
1211	No	Yes	Yes	No	No	Yes	Yes	Moderate
2402	No	No	Yes	No	No	Yes	Yes	Moderate
CLEAN AGENTS - Total Flooding								
FK-5-1-2	Yes	No	Yes	No	No	Yes	Yes	Moderate
FC-3-1-10	No	Yes	Yes	No	No	Yes	Yes	Moderate
HBFC-2281	No	Yes	Yes	No	No	Yes	Yes	Moderate
HCFC-124	No	Yes	Yes	No	No	Yes	Yes	Moderate
HFC-125	No	Yes	Yes	No	No	Yes	Yes	Moderate
HFC-227ea	Yes	Yes	Yes	No	No	Yes	Yes	Moderate
HFC-23	No	Yes	Yes	No	No	Yes	Yes	Moderate
HCFC Blend A	Yes	No	Yes	No	No	Yes	Yes	Moderate
IG-01	Yes	No	Yes	No	No	Yes	Yes	Moderate
IG-541	Yes	No	Yes	No	No	Yes	Yes	
IG-55	Yes	No	Yes	No	No	Yes	Yes	
CLEAN AGENTS - Streaming (only)								
HBFC-22BI	No	No	Yes	No	No	Yes	Yes	High
WC-125	No	No	Yes	No	No	Yes	Yes	High
FC-218	No	No	Yes	No	No	Yes	Yes	High
CHEMICALS - Dry Chemical								
Sodium bicarbonate	Yes	Yes	No	Yes	Yes	Yes	No	Moderate
Potassium bicarbonate	No	Yes	No	Yes	Yes	Yes	No	Moderate
Potassium chloride	No	Yes	No	Yes	Yes	Yes	No	Moderate
Urea/potassium bicarbonate	No	Yes	No	Yes	Yes	Yes	No	Moderate
Potassium carbonate	No	Yes	No	Yes	Yes	Yes	No	Moderate
Monoammonium phosphate	No	Yes	No	Yes	Yes	Yes	No	Moderate
CHEMICALS - Wet Chemical								
Potassium carbonate	No	Yes	No	Yes	Yes	Yes	No	Moderate
CHEMICALS - Dry Powders								
	No	No	No	No	No	No	No	Moderate