CLEAN AGENT SYSTEMS

INTRODUCTION

National Fire Protection Association (NFPA) documents describe a level of fire protection agreed on by persons representing a variety of interests. The guidance in these documents does not reflect unique conditions or special considerations, such as system performance under adverse conditions. Nor does NFPA guidance reflect the increased systems reliability that AXA XL Risk Consulting recommends for high valued properties.

This PRC Guideline takes a position on the provisions of NFPA 2001 that AXA XL Risk Consulting believes require clarification or changes. To understand the position, this PRC Guideline must be read with a copy of NFPA 2001. The provisions of the NFPA document are not repeated.

POSITION

General

This standard covers total flooding and local application clean agent systems. Equipment must be listed by a nationally recognized testing laboratory such as Underwriters Laboratories Inc. (UL). Current agents used in occupied areas are found in Table 1. PRC.13.6.0 states AXA XL Risk Consulting's position on clean agent halon replacements.

TABLE 1
Agents Recognized in NFPA 2001

Halocarbon			Inert Gas		
Agent	**Trade Name**	**Manufacturer**	**Agent**	**Trade Name**	**Manufacturer**
HFC-23	(FE-13™)	Dupont	IG-01	Argotec	Minimax
HFC-227ea	(FM-200®), (FE-227™)	Dupont	IG-541	Inergen	Ansul
HCFC Blend A	(NAF S-III)	NAFG	IG-55	Argonite	Ginge-Kerr
HCFC Blend B	(Halotron®)	American Pacific Corporation	IG-100	NN100	Koatsu
FK-5-1-12	(Novec™ 1230)	3M™			
HFC-236fa *	(FE-36™)	Dupont			
HCFC-124 *	(FE-241)	Dupont			
HFC-125	(FE-25™)	Dupont			
FIC-1311*	Triodide	Pacific Scientific			

* also used as streaming agents used in portable extinguishers

Although many prospective halon substitutes have surfaced, no simple drop-in agent has been found. Several of the current agents have come close, but have not been able to meet the safety requirements for both occupied areas and the environment:

- FIC-1311 is a very active cardiac sensitizer at extremely low concentrations. However, all of its other qualities are outstanding, especially from an extinguishing and environmental standpoint.
- Care must be taken with using HCFC Blend A in occupied areas. The Class B cup burner test results is 9.9%. When used in large-scale tests, extinguishment takes place well below cup burner test results. Adding 20% to the cup burner values exceeds the NOAEL.
- HFC-125 has been marketed as a near drop-in replacement for Halon 1301. In most cases, the piping can be reused, and only new storage containers and nozzles are needed.

Although used in total flooding applications for unoccupied areas, fine powdered aerosols are not clean agents. Aerosol systems are covered by NFPA 2010.

System designers must be knowledgeable and competent. One way to demonstrate competency is by certification. In the U.S. the National Institute for Certification of Engineering Technologies (NICET) provides such a service for extinguishing system designers.

Use pre-engineered systems only in applications meeting listed room size and piping limitations. Otherwise use engineered systems which are designed for the specific hazard being protected.

Submit proposed systems to AXA XL Risk Consulting’s Plan Review Office for review and acceptance. Requirements for data to be reviewed are found in PRC.13.0.2. Make sure the equipment used is listed, or the manufacturer is actively pursuing a listing. In the latter case, as part of the contract the installer must agree to update the installed equipment to conform to the future listing requirements. Although clean agents are effective on Class A surface fires, there are no current listing requirements for deep seated or burrowing fires. Deep seated fires generally require higher concentrations and longer soak periods.

Applications

Clean agent systems may be used in the following occupancies, alone or in combination with sprinkler protection.

- Flight simulators;
- Archival storage of media and documents;
- Tape vaults;
- Enclosed electronic equipment with an extended discharge;
- Computer rooms without combustible accumulations;
- Cable rooms or tunnels;
- Aircraft under construction or undergoing maintenance;
- Motor homes under construction;
- Yacht cabins under construction;
- Dust collection systems;
- As an extinguishing agent in explosion suppression systems;
- Interior of wet benches in semiconductor fabrication, if decomposition products can be confined;
- Inerting systems to protect against potentially explosive gas vapors;
- Marine applications (machinery spaces, pump rooms, flammable liquids rooms, etc.).

Unsuitable Applications

In addition to those stated NFPA 2001, halocarbon-based clean agents are not suitable in the following applications:

- Hot surfaces, such as ovens and furnaces operating above 700°F (371°C).
- High-energy electrical equipment such as transformers and switchgear equipment which cannot be de-energized, where continuing arcing generates harmful quantities of decomposition products.
- Internal combustion engines.

Agent Decomposition

The amount of decomposition products depends on fire size, intensity, speed of detection, speed of system operation, length of discharge, and the presence of electrical arcing. If the concentration of agent is insufficient to extinguish the fire or if the extinguishment time is prolonged, potentially harmful amounts of corrosive and toxic by-products may be released. Formation of hydrofluoric acid (HF) in some tests has been high enough to etch glass.

Hazards To Personnel

In occupied areas, use only extinguishing agents that ensure extinguishment at safe exposure levels. AXA XL Risk Consulting does not specify design concentrations, but does require that the stipulations of this standard be followed. If a system design concentration above the NOAEL is proposed by the system designer, the purchaser of the protection system must understand the safety implications of exceeding the NOAEL and be willing to proceed with the installation.

Halocarbon Exposure

Needless exposure to any extinguishing agent is discouraged. People should evacuate before the system operates during a fire condition. If an accidental operation of the system occurs, evacuation of all nonessential personnel should take place immediately. Those that remain in the room should use breathing apparatus. Some halocarbon clean agent systems are designed near concentrations that cause abnormal reactions in most people and can induce cardiac sensitization in some people.

Although halon suppresses fire by chemical chain breaking, most of the halocarbon clean agents rely on thermodynamic cooling to extinguish combustion. Like halon, the halocarbon clean agent extinguishing process releases corrosive decomposition products. Human exposure limits to HF are found in the Annex of NFPA 2001. After discharge, prohibit smoking until the room has been purged of halocarbon clean agents. Decomposition products of halocarbon clean agents produced by burning smoking materials create strong acids that can be ingested.

Inert Gas Clean Agents

The inert gases extinguish fires by lowering the oxygen levels below that needed to support combustion while leaving enough oxygen for minimal breathing. Under some conditions inert gas clean agents can displace sufficient oxygen to become lethal. People with breathing problems would be the first ones affected.

Inert gases do not create toxic decomposition products. Toxic combustion products are still produced by the fire. When designing protection with inert gas agents, the higher the agent design concentration the lower the enclosure's residual oxygen content.

A discussion of O_2 and CO_2 levels is found in the Chapter on Toxicology in the SFPE *Handbook of Fire Protection Engineering*.

Primary Agent Supply

Adjacent clean agent protected spaces may be considered as separate hazards if doors or dampers protecting connecting openings are quickly and automatically closed when the first detector activates. Design protection for each space as an independent system.

In adjacent areas where a fire may spread, design agent quantities for each area, but operate all protection areas simultaneously.

Design systems to maintain the discharge concentration long enough to extinguish the fire and allow fire fighting personnel time to arrive at the scene; ten minutes is usually long enough and is generally an industry accepted hold time. Deep-seated hazards may require higher design concentrations and longer soak periods.

Reserve Agent Supply

Design systems with a connected reserve supply arranged to put the second quantity of agent in the automatic mode by operation of a main/reserve switch. Locate the main/reserve switch where it will be accessible during an emergency.

Do not operate important production equipment without the fire protection in service. A third set of containers can be kept on premises if the containers cannot be serviced within 24 hrs. Although they need not be connected to the protection system, they must be inspected, tested and maintained.

Containers of halocarbon-based clean agent must be conditioned for a period of time before being filled to their final weight and pressure, rendering on-site filling ineffective.

Storage Containers

Locate storage containers as close as possible to the protected area without exposing the containers to a possible fire or explosion. If locating the containers within the protected area is absolutely necessary, make sure the wiring from the control panel to the containers is rated above 212°F (100°C). Install the wiring as one of the following:

- A mineral-insulated, metal-sheathed cable, Type MI.
- A power-limited **or** a nonpower-limited fire protective signaling cable designed in accordance with the control unit listing. Install cabling in an intermediate or rigid metal conduit.

Pipe Joints

Do not use plain end fittings because of the extreme dynamic forces generated during discharge.

Detection, Actuation, Alarm, And Control Systems

Use listed detectors appropriate for the hazard, and designed, installed, maintained and tested in accordance with NFPA 72 and PRC.11.1.1.0. Connect the detectors to control units listed by a nationally recognized testing laboratory that are suitable for “releasing device service.” Where possible, locate the control panel directly outside the area being protected so the panel is accessible in an emergency. Install this equipment in accordance with PRC.13.0.1.

In computer and electronic occupancies, the system should normally shut off the computer electric power when the clean agent discharges. However, power shutdown procedures should be reviewed with the supervisor of computer operations before an emergency occurs to prevent difficulties with “real-time” computing applications. If power must be left on or if the operator must shut down the system manually, provide proper breathing apparatus and training in its use for the operator. Consideration should be given to installing an Emergency Power Off (EPO) switch outside of the protected space to allow for remote shutdown of all electrical power.

Arrange the clean agent system to automatically transmit a fire alarm signal to a constantly attended location for appropriate action in accordance with NFPA 72.

To reduce the possibility of false trips, arrange sensitive detection systems so a second detector confirms the alarm condition before the clean agent system actuates. Detectors requiring protection against false trips include ionization and photoelectric smoke detectors, and infrared and ultraviolet flame detectors. Air sampling smoke detectors can alarm at several levels. In a facility using a rate-of-rise detection system or any system of fixed temperature devices, do not provide second detector confirmation. Instead, use a single detector to actuate the system as soon as the time delay to evacuate and secure the room has expired. See PRC.13.0.1.

Manual Operation

AXA XL Risk Consulting does not recommend manual-only systems. Arrange clean agent systems for automatic operation.

Normal Manual Release

Locate at least one manual release immediately outside the protected enclosure. Manual releases may be electric or pneumatic and must bypass all abort switches. Train employees to properly operate all features of the system.

Emergency manual releases are not addressed in this standard. Mechanical emergency manual releases (MEMRs) provide a way to actuate a system independently from the normal means of operation, even if the automatic and the normal manual releases fail. Install MEMRs in accordance with PRC.13.0.3. Provide them for both the main and reserve containers, and arrange them to operate all devices and delays that control discharge. Properly identify the area they protect.

MEMRs must be accessible during a fire in the protected space. When MEMRs are located on the containers, locate containers so they are accessible.

Some listed equipment cannot readily be adapted to a strictly mechanical type of emergency release. When releases are operated electrically, or when mechanical emergency release devices are located in inaccessible areas, such as above suspended ceilings or in locked closets, install all wiring needed for actuation using one of the following cables rated at or above 212°F (100°C):

- A mineral-insulated, metal-sheathed cable, Type MI;
- A power-limited or a nonpower-limited fire protective signaling cable in accordance with the control unit listing. Install cabling in an intermediate or rigid metal conduit.

Provide a standby power source in accordance with NFPA 72.

Replace explosive actuating devices at the time interval (shelf life) the manufacturer specifies.

Control Equipment

Supervise all electric and pneumatic devices and connections to the detection system, the actuation system, alarms and power supplies on all new or modified systems. Include both audible and visual trouble signal indication. Refer to the supervision requirements in PRC.13.0.1.

Electric Control Equipment

AXA XL Risk Consulting strongly supports a fully integrated design that uses all system components listed by the same manufacturer. This establishes accountability when component service, replacement or repair is needed. It is particularly important when existing Halon 1301 installations are being replaced with clean agent systems and the same detection system is to remain in service. An additional requirement to provide visual and audible notification of removal of the electric actuator from the discharge valve has been added in the 2012 edition of the standard. This provision has an effective date of January 1, 2016 to allow the equipment manufacturers time to develop equipment that can meet this provision and time for this new equipment to be listed.

Pneumatic Control Equipment

AXA XL Risk Consulting strongly supports supervising pneumatically actuated systems. Using supervisory pressure in sealed actuation tubing or piping is an acceptable way to detect failure. Mechanical protection of pneumatic actuation lines between containers is essential. Adjacent containers in equipment manufacturer's racks that operate on backpressure though the manifold usually require no additional protection. All other pneumatic actuation lines should be supervised, placed in concentric piping or provided with protective barriers.

Abort Switches

AXA XL Risk Consulting strongly discourages installing abort switches. Abort switches allow a delay in actuating the system even though the detection circuits may have been activated. The need for aborting the system has been greatly reduced by greater detector reliability, power surge control and detection confirmation to initiate discharge.

In addition to the requirements stipulated in this section, an abort switch may be accepted if it:

- Can only be operated before second detector confirmation has occurred.
- Is located inside the protected area so the operator can observe conditions. An accessible telephone may be helpful for summoning assistance when only one person is present.
- Does not recycle any time delays.

Time Delays

Time delays should not exceed 20 s after the confirming second detector or a single rate-of-rise detector operates, otherwise, the fire may be too large for effective extinguishment. A longer time delay, to ensure evacuation, is acceptable if documentation shows that occupants cannot be evacuated in a nominal 20 s. Time delays should not recycle or reset. During the time delay period, people must evacuate the enclosure, the dampers and doors must close, and the fan must coast down before the agent is released. Evacuating during discharge or during the agent soak time could jeopardize system extinguishing effectiveness.

Agent leakage must be controlled to keep the agent concentration at proper levels. Even when the system is manually operated, all controllable sources of leakage must be sealed before the agent leaves the container. This means that the discharge should be delayed during these operations.

Unwanted System Operation

Equipment "lockout" or "service disconnects" help prevent false discharges when the system is periodically tested or serviced. In addition, releasing refrigerant aerosols, soldering, or turning electric plenum heaters on for the first time after a long period of idleness may cause the detection system to operate and may subsequently trip the system.

Make sure equipment service disconnects located outside a locked control panel are of the "keyed-access" type. Operating the service disconnect should annunciate an audible and visual indication at the protected hazard and at a constantly attended location when the device is "out of service."

Set up written procedures for removing the protection system from service. Only the facility's loss control or maintenance personnel should have access to the service disconnect. Use impairment procedures outlined in PRC.1.1.0 and AXA XL Risk Consulting's *OVERVIEW* program.

System Flow Calculations

The computerized calculation method used for design by the various manufacturers is listed as part of the equipment being listed. The pressure recession method presently being used by many halocarbon clean agent manufacturer's varies greatly from the method described in NFPA 12 and NFPA 12A. There is presently insufficient design information in the standard to manually check pressure recession in new clean agent systems.

Enclosures

Equip interconnected rooms, plenums or underfloor areas with automatic closing doors or dampers. Consider each space as an independent hazard.

Ensure that windows in outside walls are self-closing or permanently secured against unauthorized opening. Open windows will jeopardize effectiveness of the protection system. Doors may require rubber sealing strips at the bottoms and sides to prevent agent from leaking.

Secure the piping so that it is properly supported during system operation. Secure the lay-in type ceiling tiles around the discharge nozzles to prevent them from moving during agent discharge.

Enclosure Ventilation

Shut down external air conditioning equipment and close the dampers as soon as the first detector activates. Ventilation systems, if not shut down, will remove vital agent from the protected enclosure.

Avoid using extended discharge systems to compensate for ventilation losses because they require more complex designs and much more agent.

Shut down freestanding self-contained unit air conditioners preferably when the first detector operates, unless the underfloor space is used as an air plenum for the computer equipment. In that case, unit air conditioners may continue to run. In rooms with extremely high ceilings, fans may be allowed to run to achieve a more homogeneous agent/air mixture. But in either case, the smoke detection system will be less effective because detection is difficult when air is flowing at a high velocity. Air sampling detection may be more appropriate here because of it sensitivity.

If dampers can be remotely reset, power the resetting devices by the primary source, the drain on the emergency reserve battery power may be too great. Rapidly closing the dampers on large ducts can collapse the ducts unless a pressure equalizing automatic damper is provided for the exhaust system. In such a case, arrange dampers for slow shutdown.

In computer facilities, provide ventilation systems to exhaust the residual agent, its decomposition products and combustion products. Design the exhaust system for 3 cfm/ft^2 (0.15 m^3/min/m^2) of floor area in computer rooms, or 4 cfm/ft^2 (0.20 m^3/min/m^2) in underfloor areas and magnetic tape vaults. Interlock the exhaust system so it cannot operate during the discharge and soak periods. Provide makeup air from a clean source.

Design Concentration Requirements

Unlike Halon 1301, clean agents have a wide range of design concentrations based on the materials that are expected to be involved in the fire.

When calculating protection volume, include all duct volumes that are cut off by dampers and are within the protected space. Usually the protected enclosure is considered empty. However, deduct large, permanent solid objects if the hazard is contained inside a relatively small enclosure. Failure to make this deduction may result in an excessive concentration. Consider tape storage rooms as empty.

Class A Extinguishment

Keep halocarbon clean agent discharge times of as short as possible to minimize formation of decomposition products. Maintain design concentration for at least a 10 min soak period.

For Class A materials with deep seated characteristics, higher concentrations and longer soak periods will be needed. Prove extinguishment of the specific fuel and arrangement in a large-scale test for the specific agent and add 20% to the extinguishing concentration. Hold concentration for a long enough period to ensure extinguishment. Generally, deep-seated fires require concentrations that may exceed the limits for occupied areas. Therefore, provide adequate warning alarms to evacuate personnel. Extinguishing agents, such as water, can handle deep-seated fires more economically without excessive decomposition material generation.

Class B Extinguishment

The minimum agent concentration for extinguishment for Class B fires is determined by the cup burner test. Previous cup burner data was inconsistent due to variation in cup burner apparatus and test methods. A standard cup burner method with a defined test apparatus has been added to Annex B of the standard for the 2008 edition. Values for minimum flame extinguishing concentrations based on the previous editions of the standard have been retained, however it is anticipated that new values will be developed based on the new cup burner standard and will be included in future versions of the standard.

There is more HF generation with Class B fires due to the ease of agent by-products removing loosely bonded H atoms from the fuel.

Maintain the concentration long enough to allow heated surfaces to cool to prevent re-ignition.

Inerting

Inerting concentrations are generally much higher than those needed for extinguishment. See the table in the Annex for test results; add 10% for design concentration. Inerting prevents ignition from occurring.

Design Factors

Design systems as simply as possible. Agent mixing and distribution in systems involving complex piping arrangements or selector valves can only be confirmed with a discharge test. Complex piping systems have unbalanced piping layouts as well as many asymmetrical flow splits, layouts discharging into multiple enclosures, or enclosures having obstructions to agent dispersal.

Design Factor For Enclosure Pressure

After determining the quantity of agent required for the specific hazard using the minimum design concentration at the ambient enclosure temperature, adjust for ambient enclosure pressure. The ambient enclosure pressure is affected by elevation and enclosure pressurization.

Local Application Systems

Currently there are no listed and approved local application systems, however several manufacturers are developing local application systems. This chapter was added by the committee to provide basic guidance for future systems. Local application systems should be installed in accordance with the listing and the manufacturer's design manual.

Container Test

Hydrostatic testing of halocarbon containers is not routinely conducted to avoid moisture in the container. If the container shows signs of damage during routine examination, either replace the unit or perform a hydrostatic test and dry the container thoroughly before refilling.

Although not addressed in the standard, conduct a hydrostatic test every 12 years on inert gas containers that have not been refilled.

Pipe Pressure Test

Pressure testing cannot be done hydrostatically on halocarbon based agents because residual moisture may be left in the system piping. Use extreme caution during pneumatic testing, because it presents a severe safety hazard. Hydrostatic testing of inert gas piping is preferred.

Puff Test

In addition to performing AXA XL Risk Consulting's visual check, the installing contractor should physically inspect all system piping to ensure that all pipe joints and supports are tight enough to prevent leakage or hazardous movement during discharge.

NFPA offers little guidance on how to conduct a "puff test." This test may be performed by discharging a sufficient flow of nitrogen through the system. The flow rate should be capable of blowing off covers placed on the open nozzles. This test does not confirm the anticipated dynamic discharge forces and only proves the piping is not completely obstructed. To confirm the dynamic discharge forces, the test would have to simulate the system mass flow rates, which is essentially a discharge test. When a discharge test is performed, this test can be omitted.