NFPA Technical Committee on Gaseous Fire Extinguishing Systems
NFPA 12/2001 ROP Meeting
September 22-24, 2009
Embassy Suites Orlando, FL

Agenda

1. Call to Order 8:30 AM, Tuesday, September 22, 2009

2. Self-introductions

3. Chairman's Remarks

4. Review/Approval of Minutes of ROC Meeting, October 11-12, 2006 – Atlanta, GA.

5. Staff Liaison Report on Document Revision Cycles and miscellaneous NFPA business, R. Bielen

6. Act on NFPA 12 Public Proposals
   a. Presentations by members and guests
   b. Proposal Processing

7. Act on NFPA 2001 Public Proposals
   a. Presentations by members and guests
   b. Proposal Processing

8. Old/New Business

9. Determine Next Meeting Date and Location

10. Tentative Adjournment date and time: Thursday, September 24th, 12:00 noon (assuming work is complete)

2001- Log #CP1 **Final Action: Accept**
(Entire Document)

Submitter: Technical Committee on Gaseous Fire Extinguishing Systems,
Recommendation: Review entire document to: 1) Update any extracted material by preparing separate proposals to do so, and 2) review and update references to other organizations documents, by preparing proposal(s) as required.
Substantiation: To conform to the NFPA Regulations Governing Committee Projects.
Committee Meeting Action: Accept

2001- Log #6 **Final Action:**
(Table 1.4.1.2)

Submitter: Robert G. Richard, Honeywell, Inc.
Recommendation: Add new text as follows:

****Insert Table 1.4.1.2 Here****

Substantiation: Eliminate the comers from within the chemical formulas and put them on the proper lines.

2001- Log #7 **Final Action:**
(Table 1.4.1.2)

Submitter: Robert G. Richard, Honeywell, Inc.
Recommendation: Add new text as follows:
HFO Blend C
Substantiation: Add a new low global warming agent to the standard.

2001- Log #43 **Final Action:**
(Table 1.4.1.2)

Submitter: Paul E. Rivers, 3M Fire Protection
Recommendation: Revise text to read as follows:
Provide the correct chemical formula for FK-5-1-12. ~~CF2CF2C(O)CF(CF3)2~~ CF3CF2C(O)CF(CF3)2
Substantiation: Submitted for correction the last two cycles but hasn't been changed.
This is not original material; its reference/source is as follows:
NFPA 2001-2004 and 2001-2008

Table 1.4.1.2

HFC	Tetrafluoroethane (86%)	CH_2,FCF_3, CHF_2,
Blend B	Pentafluorothane (9%) Carbon dioxide (9%)	CF_3, CO_2

HFC	Tetrafluoroethane (86%)	CH_2FCF_3
Blend B	Pentafluorothane (9%)	CHF_2CF_3
	Carbon dioxide (9%)	CO_2

2001- Log #2 **Final Action:**

(Table 1.4.1.2 “Agents Addressed in NFPA 2001”, A.1.4.1(b) “Physical Properties of inert Gas Agents (SI Units)” and A.1.4.1(d) “Physical Properties of Inert Gas Agents (English Units” and corresponding Tables in the 2008 edition.)

Submitter: William Costello, FirePASS Corp.

Recommendation:

*** Includes 2001_L2_Rec-Sub ***

Substantiation:

*** Includes 2001_L2_Rec-Sub ***

Note: Supporting material is available for review at NFPA Headquarters.

2001- Log #31 **Final Action:**

(1.4.2.5)

Submitter: Philip J. DiNenno, Hughes Associates, Inc.

Recommendation: Add new Section 1.4.2.5:

Clean Agent extinguishing systems shall not be used on energized electrical equipment or circuits, or any Class C hazard.

Substantiation: The design concentration for the use of these agents as energized electrical equipment is unknown. Data indicate that the extinguishing concentrations for energized electrical equipment are higher than the Class A extinguishing concentrations. See, for example, Table A.5.6 (a) in Appendix of this standard and the report from recent NFPRF project (Linteris, G., "Clean Agent Suppression of Energized Electrical Equipment Fires," NFPRF, Quincy, MA, January 2009). A minimum design concentration for energized electrical equipment and circuits is a basic pie requisite for the protection of such hazards.

2001- Log #8 **Final Action:**

(Table 1.5.1.2.1(a))

Submitter: Robert G. Richard, Honeywell, Inc.

Recommendation: Add new text as follows:

<u>HFO Blend C <5% <5%</u>

Substantiation: Add a new low global warming agent to the standard.

1. Please add a new line to Table 1.4.1.2 "Agents Addressed in NFPA 2001" 2004 edition and the corresponding Table in the 2008 edition to read as follows:

Trade Name	**Chemical Name**	**Chemical Symbol**
FirePASS agent	Hypoxic Air	N/A

2. Please add a new column to Tables A.1.4.1(b) and (d) to read as follows:

Table A.1.4.1(b) Physical Properties of Insert Gas Agents (SI Units)

	Units	FirePASS
Molecular Weight	N/A	equivalent as ambient air
Boiling point at 760mm Hg	ºC	N/A
Freezing point	ºC	equivalent to ambient air
Critical temperature	ºC	N/A
Critical pressure	kPa	equivalent to ambient air
Specific heat, vapor at constant Pressure (1 atm) and 25ºC	kj/kgºC	equivalent to ambient air
Heat of vaporization at boiling Point	kj/kg	equivalent to ambient air
Relative dielectric strength at 1 atm at 734mm Hg, 25ºC (N_2 = 1.0)	N/A	equivalent to ambient air
Solubility of water in agent at 25ºC	N/A	N/A

Table A.1.4.1(d) Physical Properties of Inert Gas Agents (English Units)

	Units	FirePASS
Molecular Weight	N/A	equivalent as ambient air
Boiling point at 760mm Hg	ºF	N/A
Freezing point	ºF	equivalent as ambient air
Critical temperature	ºF	N/A
Critical pressure	psia	equivalent as ambient air
Specific heat, vapor at constant Pressure (1 atm) and 77ºF	Btu/lbºF	equivalent as ambient air
Heat of vaporization at boiling Point	Btu/lb	equivalent as ambient air
Relative dielectric strength at 1 atm at 734mm Hg, 77ºF (N_2 = 1.0)	N/A	equivalent as ambient air
Solubility of water in agent at 70ºF	N/A	N/A

Submitters Reason: FirePASS technology has been on the market since 2001. In order to enable FirePASS technology to be accepted for applications in the field, manufacturers, certification agencies, regulatory authorities and other users require some form of acknowledgement of this technology in an NFPA standard. The absence of any recognition of FirePASS technology within NFPA codes and standards is creating a barrier to the technology entering the marketplace. The technology is rapidly developing in Europe – over 300 installations have been reported so far.

In recognition of Section 5.2(d) of the NFPA Regulations Governing Committee Projects (Reg's), this TIA offers the public a benefit that will lessen a recognized hazard (See Technology Overview section below).

In recognition of Section 5.2(e) of the Reg's, this TIA recognizes an advance in the art of safeguarding property and life where an alternative method is not in use. (See Technology Overview section below).

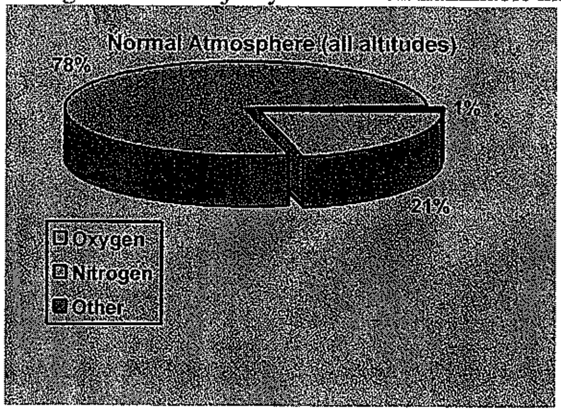
In recognition of Section 5.2(f) of the Reg's, this TIA will correct a situation in which the current edition of NFPA 2001 is having an adverse impact on a product. Currently, AHJ's are seeking reference to FirePASS technology in some NFPA document as means of ensuring due diligence. Without this TIA, AHJ's can find numerous requirements in NFPA 2001 which would not permit FirePASS technology to be installed. This TIA permits FirePASS systems to be installed in those applications fully controlled by the terms of the listing and thus allow Fire Pass technology to enter the marketplace.

TECHNOLOGY OVERVIEW

1. FirePASS Fire Prevention Systems Summary

1.1. How it works

The FirePASS used in preventative mode, FirePASS-P, has the unique ability to create a breathable environment that remarkably prevents flame ignition. FirePASS' fire preventative normobaric hypoxic environment provides a revolutionary solution in fire protection. In preventative mode, the environment in a normally occupied facility is perpetually maintained at 15-16% oxygen, which is healthy for human occupants. (15-16% O_2 at sea level corresponds to an altitude of 2600-2100 meters in terms of O_2 partial pressure.) This preventative environment significantly reduces the possibility of ignition of a majority of common flammable materials.



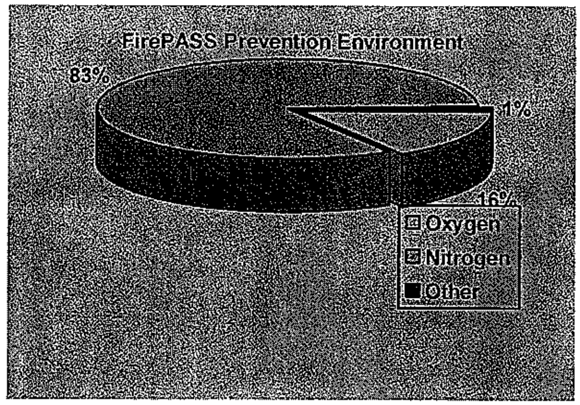


Fig 3.1.1 **Fig 3.1.2**

The occupants of a FirePASS protected facility would regularly work in a normobaric oxygen-controlled atmosphere. Following general ventilation principles, hypoxic generators will ventilate the environment with hypoxic air, thus, maintaining the clean, safe and fire-preventative environment.

An important advantage of preventative FirePASS is that it creates and constantly maintains a slightly positive barometric pressure inside a protected facility, which prevents warfare-aerosolized agents from permeating. At the same time, the intake-air can be decontaminated and filtered from aerosolized biological, chemical and radionuclide agents.

Surprisingly, in most applications, implementation of the FirePASS in a preventative mode does not require costly re-engineering of the protected space to achieve a drastic improvement in the current level of fire safety. Moreover, if needed, the technology allows for combining of various fire suppressive approaches, which can provide a significant synergistic effect.

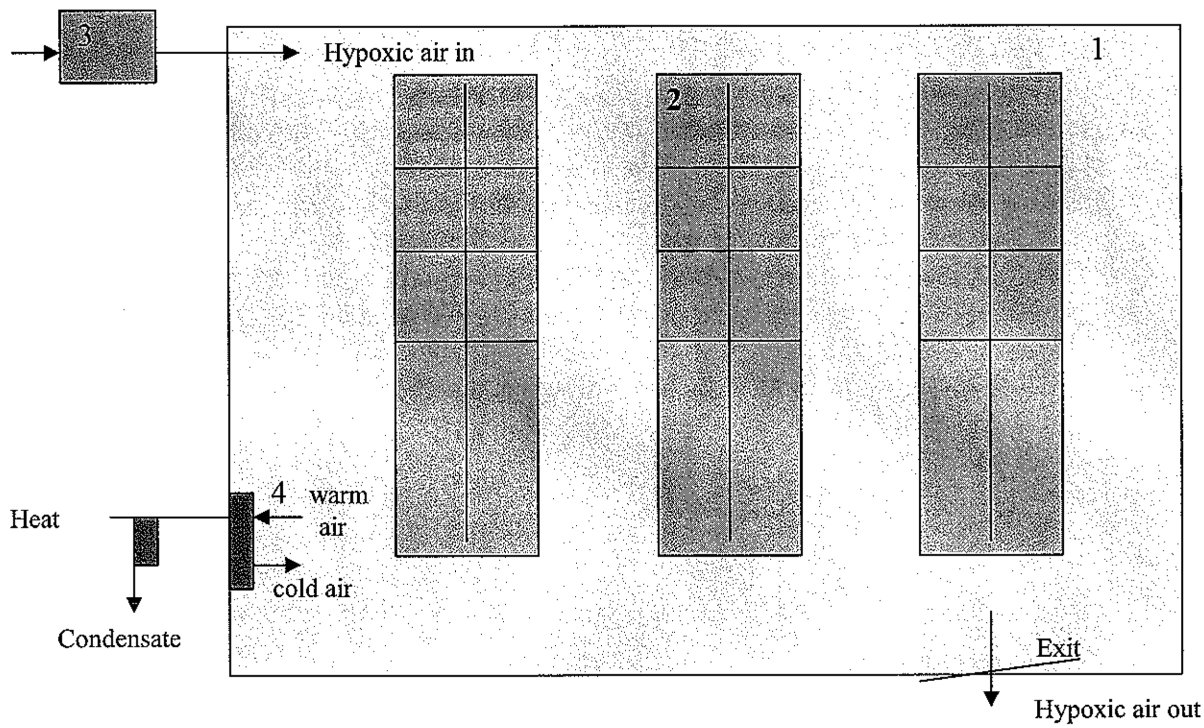


Fig. 3.1: Standard Configuration Schematic for FirePASS Prevention System
1 – Protected Space room, 2-Storage racks, 3-Hypoxic generator, 4-Split a/c unit

The preventative system illustrated above works as follows:

- **a.** Ambient air is drawn into the hypoxic generator where it is purified and made hypoxic.
- **b.** The air ventilates the entire room inhibiting any common ignition sources.
- **c.** Hypoxic air leaks from the room thus completing the flow and ventilating the facility.
- **d.** Heating/ Air-Conditioning units must be split-type closed dedicated systems.

The FirePASS, when executed in an environment such as a data storage facility, would ensure that ignition would simply not occur. In order to install the system in such a data storage facility, the primary concern would be to minimize leakage of ambient air. This can be accomplished through inexpensive measures such as door alterations (i.e. airlock or revolving door).

As long as the protected environment is isolated from any greater ventilation system that supplies the room with non-hypoxic outside air, it will be suitable for preventative FirePASS. In most room applications, this is simply done by closing ventilation outlets and installing an air-conditioning/heating unit dedicated to the protected environment.

Installation of FirePASS in any given facility requires minimal calculations and room alteration to ensure that flow is sufficient to maintain the hypoxic environment at a slightly positive pressure.

1.2. Why it works

Fire prevention and control has long dealt with the familiar fire "triangle" consisting of heat, fuel, and oxygen: all three of which are required to initiate and support combustion. It is also well established that nitrogen, constituting 79% of atmospheric air, can significantly influence combustion. Nitrogen molecules at common flame temperatures (lower than 1100 C) do not return the absorbed thermal radiation. Rather, it is continuously removed from the combustion zone by the convection process. Because of this, an increase of Nitrogen concentration in the air causes a mass – proportional increase in the total loss of emitted thermal energy, which inhibits combustion. Furthermore, increasing the nitrogen content in the gaseous mixture affects its molecular kinetic properties, reducing the availability of oxygen molecules for combustion.

The key discovery is that the processes of ignition and combustion in a normobaric, hypoxic environment are far different from the ignition and combustion process that occurs in a hypobaric natural altitude environment with the same partial pressure of oxygen (i.e. up a mountain). For example, air with a 4.51" (114.5 mm of mercury) partial pressure of oxygen at an altitude of 9,000' (2700 m) can easily support the burning of a candle or the ignition of paper. However, if a corresponding normobaric environment is created with the same partial pressure of oxygen (4.51" or 114.5 mm of mercury), a candle will not burn and paper will not ignite. Even a match will be instantly extinguished after the depletion of the oxygen-carrying chemicals on its tip. Consequently, any fire that is introduced into this breathable normobaric, hypoxic atmosphere is instantly extinguished. Kerosene fuel, gas lighter or propane gas torch will not ignite in this environment either.

This surprising observation leads to an obvious question: "Why do two environments which contain identical partial pressures of oxygen (i.e. the same number of oxygen molecules per specific volume) affect the processes of ignition and combustion so differently?" The answer is simple: "The difference in oxygen concentration in these two environments diminishes the availability of oxygen to support combustion. This happens due to the increased number of nitrogen molecules interfering with the kinetic properties of oxygen molecules". In other words, the increased density of nitrogen molecules in the normobaric environment creates a "buffer zone" that obstructs the availability of oxygen molecules for combustion. When the kinetic properties of both gases are compared, it is revealed that nitrogen molecules are both slower and have a lower penetration rate (by a factor of 2.5) than oxygen molecules.

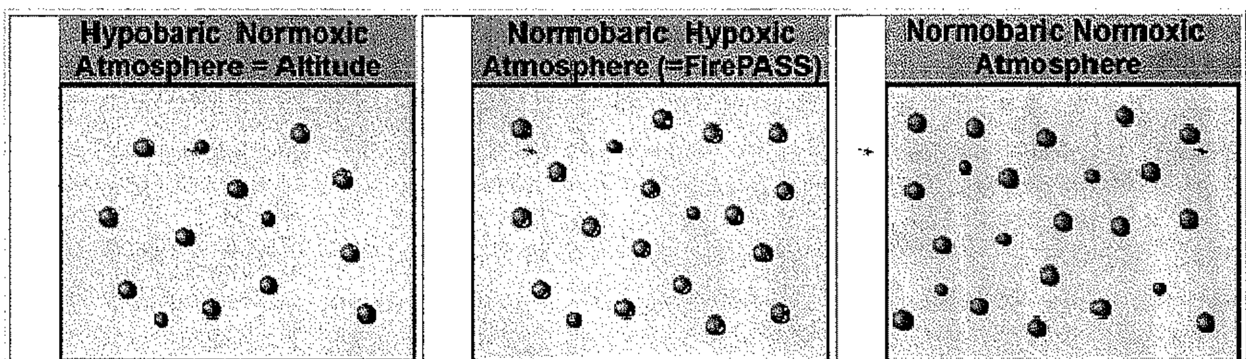


Figure 3.2.1 Figure 3.2.2 Figure 3.3.3

Fig. 3.2.1 presents a schematic view of the density of oxygen and nitrogen molecules in a hypobaric or natural environment at an altitude of 9,000' or 2.7 km. (All other atmospheric gases are disregarded in order to simplify the following explanations). Blue circles represent oxygen molecules, and green circles represent nitrogen molecules.

Fig. 3.2.2 shows the density of molecules in a hypoxic environment with the same partial pressure of oxygen (4.51" or 114.5 mm of mercury), but at a standard atmospheric pressure of 760 mm of mercury. This environment contains approximately 15% of oxygen by volume, which is perfectly suitable for human life, but is not sufficient to support combustion.

As can be seen, both environments contain identical amounts of oxygen molecules per specific volume. However, the relative amount of nitrogen molecules versus oxygen molecules is approximately 6:1 in the second case (*Figure 3.2.2.*) compare to 4:1 in the altitude air (*Figure 3.2.1*). **Fig. 3.2.3** shows ambient air at sea level with the greater partial pressure (159.16 mm of mercury) of oxygen than in the air found at an altitude of 9,000' or 2.7 km (114.5 mm). It should be noted that ambient air in any portion of the Earth's atmosphere (from sea level to the top Mount Everest) has an oxygen concentration of 20.94% by volume. However, the ambient air at sea level is under a substantially higher pressure: As the number of gas molecules per specific volume increases, so the distance between the gas molecules is reduced, and the availability of oxygen to support combustion is unaffected

1.3. Ignition Prevention Properties

As aforementioned, at 15.2% O_2 by volume, *Class A* fires are extinguished, and at 14.3% O_2 by volume, *Class B* fires are extinguished. Interestingly, ignition prevention or inerting occurs at approximately 17% O_2 by volume. Again, this information can be extrapolated from the NFPA inerting values regarding IG-100.[1]

1.4. Environmental Issues

Refer to published IG-100 values. FirePASS' hypoxic generators, used to create a flame- preventative atmosphere, take in ambient air, filter it, then release two streams of gas: the first being hypoxic (oxygen reduced) air, which is used for inerting, and the second slightly oxygen-enriched, which is dispelled back into the atmosphere. The sum of the product and the byproduct is simply purified air.

1.5. Health / Safety

OSHA Respiratory Protection - 63:1152-1300

"OSHA's concern is that employees not be exposed to environments in which the oxygen partial pressure is less than 100 mm Hg; this partial pressure of oxygen is generally regarded as an appropriate IDLH level (Exs. 164, 208)"

FirePASS maintains and environments between 114 - 122 mm of Hg. It is important to reiterate the basic principle upon which FirePASS-S operates. Combustion relies upon a percentage ratio between an inerting agent and O_2. If $<17\%$ O_2 by volume or $>83\% N_2$ by volume are present in any given space, ignition will not occur. While these relative percentage measurements of gasses are essential to determine combustion or suppression, they have nothing to do with human respiration requirements.

Oxygen saturation of hemoglobin relies only upon the absolute values, usually measured in terms of partial pressure (pO_2) of O_2 available for respiration. O_2 partial pressure is measured by multiplying the ambient pressure (760mmHg at sea level) by the percentage of oxygen present (under normal conditions approximately 21% at ALL altitudes). The result is an absolute value that then can be used in health and safety determinations.

One may ask, "How much O_2 is enough?" FirePASS looks to the NFPA definition and the American National Standards institute to determine safety parameters.

- As far as the NFPA is concerned, 12-percent minimum oxygen corresponds to No Observable Adverse Effect Level (NOAEL) and 10-percent minimum oxygen shows Low Observable Adverse Effect Level (LOAEL).1[2]
- ANSI Z.88.2 Notes that at above 95mmHg no significant signs of impairment are present.[3]

Therefore, the FirePASS prevention systems which operates at 15-16%O2 and above 95mmHg O2, is completely safe for human occupants.

2. FirePASS Suppression System Comparison Grid

	CO2	Inergen	Water Sprinklers	Halocarbon (FM200, Halon etc.)	FirePASS Prevention System	Wagner OxyRedux
Prevents Fire	No	No	No	No	Yes	Yes
Environmentally Friendly	No, CO2 is considered a	Yes	Yes	No, Halocarbons deplete the	Yes	Yes

[1] NFPA CODE 2001 CLEAN AGENT STANDARD

[2] NFPA CLEAN AGENT STANDARD 2001

[3] ANSI STANDARD Z-88.2 RESPIRATORY SAFETY

	greenhouse gas			ozone and are subject to EPA Approval		
Safe for Human Occupants	No, CO2 is " inherently lethal"[4]	Partially; Evacuation still required and miscalculations can result in dangerous O2 concentrations or not enough agent dispersal for flame extinguishment	Partially; Steam produced when water meets fire may burn occupants	No; evacuation required prior to agent dispersal. Can be toxic to humans	Yes; FirePASS-P exceeds ANSI respiratory safety standards (Z-88.2)	Yes
Complex Control System	YES	YES	NO	YES	**NO**	YES
Easy Cleanup	NO DATA	NO DATA	NO; water damage to a discharge scenario is often more destructive than the fire itself	No, Halocarbons leave corrosive film over the entire field of discharge	Yes; no fire, no discharge, no cleanup	Yes: no fire, no discharge, no cleanup
Automatic Refill Available	**No**	**No**	No	No	N/A; system never depletes	**NO; Nitrogen Supply Must be refilled**
Extended Discharge to Combat Re-Ignition	**No**	**No**	No	No	N/A; there will be no fire	N/A; there will be no fire

[4] Wickham RT: REVIEW OF THE USE OF CARBON DIOXIDE TOTAL FLOODING FIRE EXTINGUISHING SYSTEMS. www.epa.gov August 8, 2003

ITS Intertek Testing Services
ETL SEMKO

Certificate of Compliance

Item:	Hypoxic Unit
Model Reference Nos:	HYP 100
No. of Samples Tested:	One
EMC Test Report Reference:	EM01005683
Relevant Specification used as Basis of Tests:	EN60601-1-2:1993

This is to certify that, on the basis of the tests undertaken, the sample of the above item is considered to comply with the essential requirements of the above standard.

Signed: ....
D J Taylor
Certifying Officer

Date of Issue:
13th February 2002

Address:
Edge Four Ltd
3rd Floor Northburgh House
10 Northburgh Street
London
EC1V OAT

Serial Number. 80011754

Reference No. EM01005683

ITS Testing & Certification Ltd
ITS House, Cleeve Road, Leatherhead, Surrey KT22 7SB
Tel: +44 (0)1372 370900 Fax: +44 (0)1372 370999
Registered No. 3272281 Registered office: 25 Savile Row, London W1X 1AA

ITS Intertek Testing Services
ETL SEMKO

EMC TEST REPORT

COMPANY: Edge Four Ltd.
PRODUCT: Hypoxic Unit

REPORT NO. EM01005683

WRITTEN BY:	**A Venkatesan**	
APPROVED BY:	**J A Bearpark**	
TEST ENGINEER:	**A Venkatesan**	
ISSUE: 1	**DATE: 18th February 2002**	**TOTAL PAGES: 25**

Opinions and interpretations based on test results are outside our scope of UKAS Accreditation.

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For terms and conditions please see reverse

UKAS No.0029

RETURN TO CERTIFICATION OVERVIEW

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
AIR AND RADIATION

June 23, 2003

Gary Kotliar
FirePASS
50 Lexington Ave., Suite 249
New York, NY 10010
FAX: 212-213-32-47

Re: Determination of SNAP Program on FirePASS-S Extinguishing Agent

Dear Mr. Kotliar:

Thank you for your submission to the U.S. Environmental Protection Agency's Significant New Alternative Policy (SNAP) Program for FirePASS-S extinguishing agent in total flooding applications. Your application states that FirePASS-S is simply ambient air that has been depleted of oxygen so that it consists of 10-12% oxygen and 87-89% nitrogen by volume. Because FirePASS-S extinguishant is essentially the same as other inert gas extinguishing systems (IG-100) already approved under SNAP, we find that it does not require further review and may be marketed. As with all inert gas extinguishing systems, FirePASS-S must comply with the following:

1) Use of the agent, FirePASS-S should be in accordance with the safety guidelines in the latest edition of the NFPA 2001 Standard for Clean Agent Fire Extinguishing Systems.
2) Extinguisher bottles should be clearly labelled with the potential hazards associated with the use of FirePASS-S, as well as handling procedures to reduce risk resulting from these hazards.
3) Should conform with relevant OSHA requirements, including 29 CFR 1910, Subpart L, Sections 1910.160 and 1910.162.
4) Per OSHA requirements, protective gear (SCBA) should be available in the event personnel should reenter the area.
5) EPA has no intention of duplicating or displacing OSHA coverage related to the use of personal protective equipment (e.g., respiratory protection), fire protection, hazard communication, worker training or any other occupational safety and health standard with respect to halon substitutes.

If you have any questions about this determination, please contact me at (202) 564-9749.

Sincerely,

Bella Maranion

Bella Maranion
Alternatives and Emissions Reduction Branch
Global Programs Division

BACK TO CERTIFICATION OVERVIEW

Aircraft Cargo Fire Prevention using Hypoxic Air

Adapted from: AIRCRAFT CARGO FIRE SUPPRESSION USING LOW PRESSURE DUAL FLUID WATER MIST AND HYPOXIC AIR, John Brooks, International Aero Technologies LLC, HOTWC proceedings 2004.

ABSTRACT

Hypoxic air is gaining acceptance and a viable, economical and safe means of fire prevention and suppression in the aerospace industry. In commercial aircraft applications the FAA/CAA have adopted a Minimum Performance Standard (MPS) [1] testing protocol for alternative fire suppression agents based on the level of safety obtained from full scale experiments using HALON 1301. This paper will discuss the full scale testing and experiments used to research design a novel system that exceeds the MPS using low Hypoxic Air.

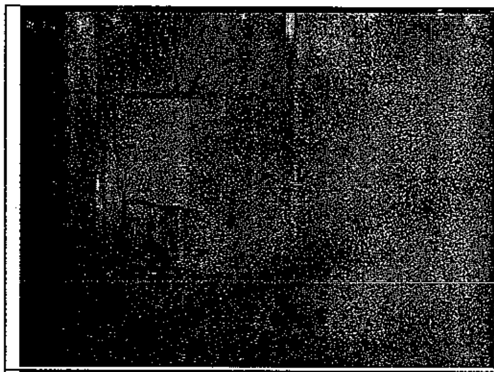
Using available or existing resources on commercial aircraft for fire protection is a novel concept. A new effective fire suppression technology that will not add weight or add new systems to maintain is attractive to operators of an already cash strapped airline industry. Aircraft system designers have always remained within their professional or assigned discipline when working on new designs. Fire suppression, propulsion, environmental control, interior design engineers have always met their individual requirements. Interactions between sub systems has only been interfaced in the overall aircraft requirements of weight, volume and the impact of overall aircraft performance specifications, i.e.: range, fuel consumption and passenger comfort. Integration of these individual systems in the past has only been from a fire and safety standpoint to meet the Federal Aviation Regulations (FAR) requirements.

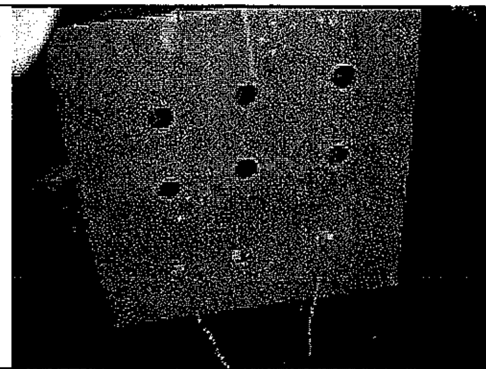
INTRODUCTION

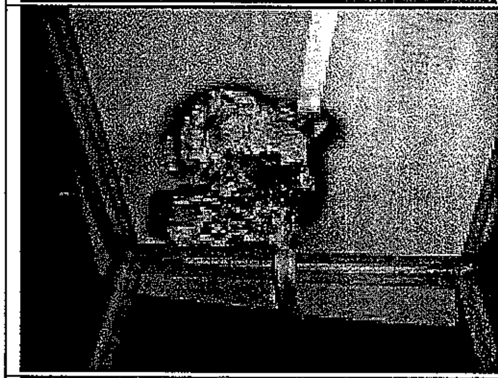
Using available or existing resources, such as air conditioning for a suppression system is a relatively new concept. In the past when a fire safety issue was identified a purpose built suppression system was mandated to mitigate the individual threat. Aircraft lavatory trash containers and detection and suppression systems in cargo compartments have been installed in the last ten years. With the new security and international threats to commercial aircraft, a more cost effective and versatile system is required. Using water as an agent that will meet the FAA/CAA Minimum Performance Standard (MPS) requirements has been a difficult task. Aircraft cargo compartments vary in volume and fuel loads. They can also vary for empty to fully loaded based on individual operator requirements. Projected fire scenarios were developed by the FAA's William J. Hughes Technical Center with the International Aircraft Systems Fire Protection Working Group. Fuel loading, repeatability and suppression difficulty were all considered, along with reflection of fires that had or could be seen in cargo compartments of commercial aircraft in the past. These consist of a Class B surface load, a bulkload deep seated class A and a containerized deep-seated class A fires. In addition, an exploding aerosol can scenario was designed and proved the hardest of the scenarios to mitigate. In 1998 the FAA review the passenger deaths in commercial aircraft and determined that over 80% died from inhalation of toxic post combustion byproducts of the interior components. This led to changing the flammability

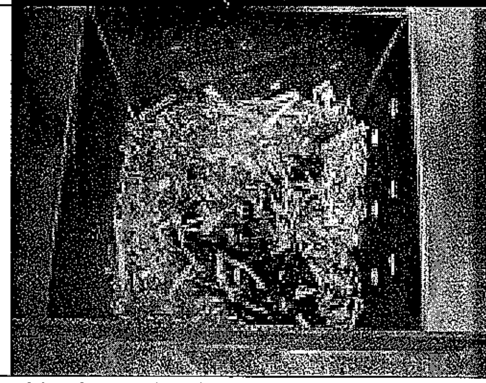
FirePASS Hypoxic air, ***preventive mode***

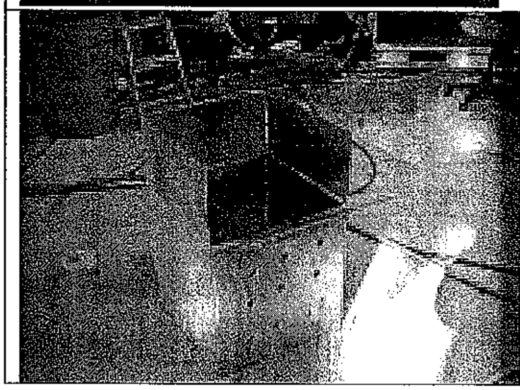
Testing revealed that if the FirePASS hypoxic air is introduced into the MPS device for a short time prior to the ignition source, the fires could be prevented entirely. Starting around 14% local oxygen concentrations the hot wire igniter could be energized with the normal 12.8~13.5 amps of 115Vac for in excess of four hours without flames or excessive damage to the cardboard box containing the ignition source and fuel load. In addition to the deep seated class A bulk load ignition box. Several of these tests were repeated successfully. Starting with 45 minutes, then to 180, then 217 minutes for existing extended over ETOPS and 257 proposed ETOPS +30 min. All of these tests were basically the same. Thermal damage to the shredded paper and card box was limited to areas surrounding the hot wire. The head damage was attributable for the electrical energy dissipated by the ni-chrome.





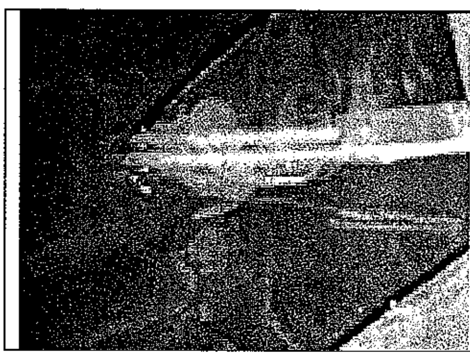


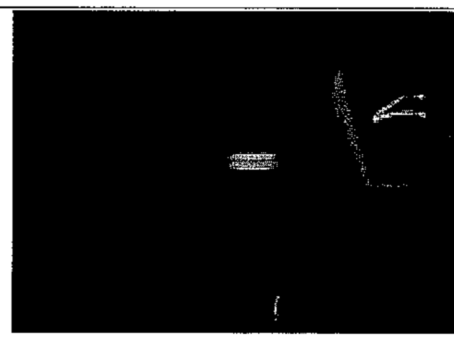


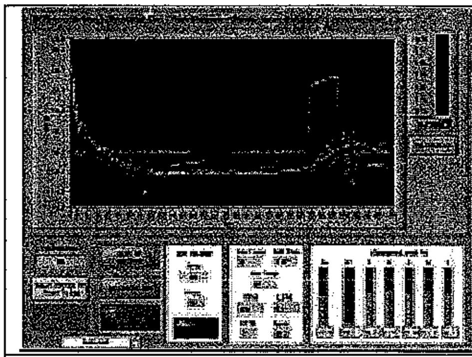
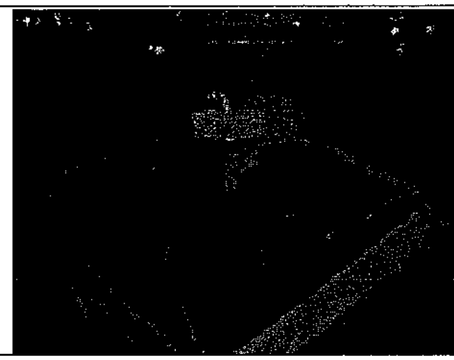


This shows the damage after 180 minutes. It 120 minutes video observations showed occasional sparks falling from the bottom of the box. Later inspection revealed the hot wire had burned through the bottom of the container. Fire brands The FirePASS preventive mode at 15 Percent oxygen concentration was capable of preventing flames. Smoke density was sufficient to alarm on the type of detectors used in commercial aircraft.

The surface pan Class B was tested with N-heptain, isopropyl alcohol, methyl ethyl ketone and a 1800 Deg F electrically heated probe immersed in the fuel without ignition. This preventive mode has shown to not only be a viable alternative to Halon but also provided a superior level of safety over HALON 1301 systems in service today. Note: Explosive vapor buildup inside the container remains after securing the experiment. If the doors are opened too rapidly before the device cools down, with the inrush of fresh air a dangerous atmosphere may exists.





	
	Above shows the hot rod immersed in class B fuel (N-heptain), vapor can be seen rising from the fuel pan. No flames were observed for 25 minutes. Oxygen plot on the lower right shows internal apparatus O2 levels. The spike at 24 - 30 minutes is venting the airside with out the MEDALTM membranes. When it was realized the atmosphere in the apparatus was close to explosive, (due to evaporated n-heptain) the MEDAL were brought back on line for safety.

Further, it is possible that the same Onboard Inert Gas Generating System (OBIGGS) can also be used for the cargo compartment. The FAA will soon mandate using polymeric membranes to provide nitrogen for fuel tank inserting. Since the ullage in the wing tanks is at its smallest level prior to push back from the gate, the volume of NEA needed to inert the tank is not extreme. After the tank ullage has been processed, the airflow can be diverted to the cargo compartment system to achieve the abovementioned benefit. OBIGGS using engine or Auxiliary Power Unit APU can produce large quantities of Hypoxic Air. The output volumes on the ground are more that sufficient to inert the fuel tanks and treat the Cargo compartment without any determent to either aircraft zone.

If sized correctly, OBIGGS can be an integrated design with a "systems approach" for fire protection in commercial aircraft. The system can provide wing tank inerting, fire protection for Cargo Bays, hidden or non-accessible areas. The system can be designed with a minimum of additional cost and weight. A low pressure OBIGGS system does not need stainless or metal plumbing.

Recommendations

The future safety of the flying public from fire is an ever-increasing task. The commercial airline industry is faced with growth along with an escalating threat. Operating cost and fuel prices continues to strain a cash strapped industry. Extra systems to detect and suppress fires are expensive and add additional weight to airliners. Using existing systems and available resources to mitigate the emerging threats only makes sense. The air conditioning systems are available and the OBIGGS will be mandated for fuel tank inerting. If these available resources are used in a systems approach, we can prevent the fires instead of suppressing them. The FirePASS preventive mode will prevent fires under nearly every foreseeable circumstance. FirePASS provides for total protection with no weight gain and no additional maintenance. This is a win-win solution for the airline industry. Hypoxic air answers the MPS for both cargo bays and fuel tanks and with little additional modifications could be installed everywhere for additional protection inside the aircraft cabin.

Conclusions

Data collected using LPDF and Hypoxic air exceed the minimum performance required by the FAA.

References

1. Minimum Performance Standard for Aircraft Cargo Compartment Halon Replacement Fire Suppression Systems. DOT/FAA/AR-TN03/6, April 2003 John W. Reinhardt

2. Limiting Oxygen Concentration Required to Inert Jet Fuel Vapors Existing at Reduced Fuel Tank Pressures DOT/FAA/ARTN-02/79 August 2003 Steven M. Summer

3. A Benefit Analysis for Cabin Water Spray Systems and Enhanced Fuselage Burnthrough Protection CAA Paper 2002/04, ISBN 0 86039 902 8 DOT/FAA/AR-02/49. April 2003 Report prepared by R G W Cherry & Associates Limited
4. A Benefit Analysis for Enhanced Protection from Fires in Hidden Areas on Transport Aircraft CAA Paper 2002/02 04, ISBN 0 86039 875 7, DOT/FAA/AR-02/50 September 2002 Report prepared by R G W Cherry & Associates Limited
5. FirePASS – A NEW TECHNOLOGY FOR TOTAL FLOODING APPLICATION Igor (Gary) K. Kotliar and Jarrod D. Currin HOTWC proceedings 2003
6. FULL-SCALE AIRCRAFT CABIN TWIN FLUID, LOW PRESSURE WATER MIST FIRE SUPPRESSION SYSTEM PROOF-OF-CONCEPT EVALUATION, Naval Air Systems Command, NAWCADLKE-MISC-435100-0011WOLFE, June 2000. JOSEPH WOLFE (Code 435100B)
7. Title of Invention: Liquid Atomizing Nozzle. Inventor: Joseph E. Wolfe. Patent Data: U.S. Patent Application Serial No: 398335.Filing Date: Sept 19, 1984 U.S. Patent No: 5520331 Issue Date: May 28, 1996

BACK TO CERTIFICATION OVERVIEW

2001- Log #29 Final Action:
(1.6)

Submitter: Philip J. DiNenno, Hughes Associates, Inc.
Recommendation: Replace existing text in 1.6 as follows:
1.6 The agent with the least environmental impact, as measured by GWP, that is technically feasible shall be used. Current GWP values for the agents in the standard are given in Table 1-6.

Insert Table 1-6 here
2001_L29_Tb1-6_R

Substantiation: The use of high GWP fire suppression gases is a contributor to climate change. At a minimum, the user, designer and installer should be encouraged to use the lowest possible environmental impact agent consistent with the technical requirements of the installation. The proposal change reflects this important design consideration in an objective and enforceable manner.
In addition, it is essential that all parties be aware of likely environmental restrictions on the use of high GWP agents in the future.

2001- Log #16 Final Action:
(2.3.10)

Submitter: Bob Eugene, Underwriters Laboratories Inc.
Recommendation: Revise text to read as follows:
2.3.10 ULC Publications.
Underwriters~~'~~ Laboratories of Canada, 7 Underwriter's Road, Toronto, Ontario M1R 3B4, Canada.
CAN/ULC S524-~~M91~~ 06, Standard for the Installation of Fire Alarm Systems, ~~1991~~ 2006.
CAN/ULC S529-~~M87~~ 09, Smoke Detectors for Fire Alarm Systems, ~~1987~~ 2009.
Substantiation: Delete the apostrophe after Underwriters so that the ULC Publisher will read "Underwriters Laboratories of Canada". Update standards to most recent revisions.

2001- Log #9 Final Action:
(Table 4.1.2)

Submitter: Robert G. Richard, Honeywell, Inc.
Recommendation: Add new text as follows:
Quality. Agent properties shall meet the standards of quality given in tables 4.1.2(a) through 4.1.2.(~~d~~e)
Substantiation: Add plural where appropriate and add new low global warming agent to the standard.

Table 1-6

Agent	GWP 100 yr
FK-5-1-12	0
HFC-125	2,800
HFC-227ea	2,900
IG-541	0
IG-55	0

2001- Log #21 Final Action:
(Table 4.2.1.1.1(a))

Submitter: Michael Kroneder, Fire Eater
Recommendation: New text to read as follows:
Agent: IG-541 Agent container pressure
at 70F (21C) 4503psig 31,050kPa
at 130F (55C) 5359psig 36,950kPa
Min Design pressure of piping Upstream 4503psig 32,050kPa
Substantiation: To ensure NFPA 2001 is up to date on the technologies and equipment available 300 bar 18-541 must be included.
The technology for 300 bar 18-541 is available and used in many countries, In Europe most new 18-541 installations are 300 bar systems.
This is not original material; its reference/source is as follows:
Infochem UK & ISO 14520-15, 2005

2001- Log #42 Final Action:
(Table 4.2.1.1.1(b))

Submitter: Paul E. Rivers, 3M Fire Protection
Recommendation: Revise text to read as follows:
Remove asterisk from the FK-5-1-12 150 psig pressure reference in the data column Agent Container Charging Pressure at 70°F(21.1°C) (psi).
Substantiation: It was incorrectly inserted into the document in the last cycle. The 150 psig design is predicated on system superpressurization, as originally submitted.
This is not original material; its reference/source is as follows:
NFPA 2001-2008

2001- Log #17 Final Action:
(4.3.1.1)

Submitter: Bob Eugene, Underwriters Laboratories Inc.
Recommendation: Revise text to read as follows:
4.3.1.1 Detection, actuation, alarm, and control systems shall be installed, tested, and maintained in accordance with appropriate NFPA protective signaling systems standards. (See NFPA 70 and NFPA 72. In Canada refer to CAN/ULC S524-~~M91~~ 06 and CAN/ULC S529-~~M87~~ 09.)
Substantiation: Update standards to most recent revisions.

2001- Log #19 **Final Action:**
(4.3.2.1.1 and 4.3.2.1.2 (New))

Submitter: Abhay Nadgir, Kidde-Fenwal, Inc.
Recommendation: Add new sections 4.3.2.1.1 and 4.3.2.1.2 as follows:
4.3.2.1.1 Actuation of clean agent suppression systems from a single air sampling detector shall not be permitted.
4.3.2.1.2 Where air sampling smoke detection is used, the system shall be arranged to activate the release only subsequent to initiating input from a second completely independent air sampling detector or by point type smoke detectors in crossed zone fashion.

Substantiation: One of the benefits of cross-zoned and counting-zoned spot type smoke detection used for automatic actuation of clean agent suppression systems is to ensure confirmation and presence of smoke alarms by two independent smoke detectors, and possibly using two different detection technologies(photoelectric and ionization) before actuation occurs. Failure of one spot type smoke detector will not result in the actuation of the suppression system.
The use of multiple smoke alarm levels from a single air sampling smoke detector doesn't afford protection from single detector point failure and could result in unwanted system actuation.
Air sampling detectors with multiple sampling pipes do not preclude the possibility of suppression system actuation in the event of single detector point failure.
Furthermore, multi-pipe air sampling smoke detectors that use indexed rotational valves are at a higher risk of unwanted discharge in the event of valve failure such as malfunction in the valve gasket seals.

2001- Log #20 **Final Action:**
(4.3.2.4 (New))

Submitter: Patrick Sullivan, Kidde-Fenwal, Inc.
Recommendation: New text to read as follows:
Add new sections 4.3.2.4:
To: 4.3.2.4 At least two detection zones, or at least two devices as initiating inputs, shall be used where the concentration of a clean agent will exceed either the NOAEL for halocarbon agents or 43% for inert gas agents as calculated at the maximum temperature of the protected enclosure.
Substantiation: The proposed requirement is intended to (a) reduce the likelihood of unintended system discharge and the likelihood that personnel would be exposed to clean agent concentrations exceeding NOAEL values or limiting oxygen concentrations due to aberrant alarms from a single initiating device.

2001- Log #3 **Final Action:**
(4.3.3.6)

Submitter: James Everitt, Western Regional Fire Code Development Committee
Recommendation: Revise text to read as follows:
4.3.3.6 The normal manual control(s) for actuation shall be located for easy accessibility at all times~~, including at the time of a fire~~.
4.3.3.6.1 The manual control(s) shall be of distinct appearance and clearly recognizable for the purpose intended.
4.3.3.6.2 Operation of any manual control shall cause the complete system to operate as designed ~~in its normal fashion~~.
Substantiation: Puts the section into the manual of style for one requirement per item. Also removes redundant text in 4.3.3.6. 4.3.3.6.2 clarifies that is pertains to a manual control and changes the language to have the system perform as designed at what is a "normal fashion."

2001- Log #4 **Final Action:**
(4.3.4.1)

Submitter: James L. Kidd, Hiller New England Fire Protection Inc.
Recommendation: New text to read as follows:

Add following wording:

Removal of primary agent container actuating device from the discharge valve and/or selector valve shall result in both audible and distinct visual indication of system impairment.

Substantiation: The main actuating device is supervised for its electrical continuity but not its presence on the container valve. As installers, we can all recall cases of finding solenoids removed from the container upon arrival to a site. This may have been done by the customer or the last person who serviced the system. The release control equipment will not, at this time, recognize this important missing device.

Should the system be required to operate and, does not, there could be serious consequence for all involved.

2001- Log #18 **Final Action:**
(4.3.6)

Submitter: Michael Yakine, Kidde-Fenwal, Inc.
Recommendation: Revise text to read as follows:

4.3.6* Unwanted System Operation:

<u>4.3.6.1</u> To avoid unwanted discharge of a clean agent system, a supervised disconnect switch shall be provided. The disconnect switch shall interrupt the releasing circuit to the suppression system~~.~~ <u>and shall cause a supervisory signal at the releasing control unit.</u>

<u>4.3.6.2 When used, the disconnect switch shall be of the keyed-access type with means to indicate the suppression system operational status.</u>

<u>4.3.6.3 When the disconnect switch is operated and the suppression system is disabled, the access key shall not be removable so that the suppression system can be quickly returned to the operational condition in the event of a fire.</u>

<u>4.3.6.4 Suppression systems disconnect achieved via software programming shall not be acceptable for use in lieu of a physical disconnect switch.</u>

<u>4.3.6.5 The disconnect switch shall be listed for such use.</u>

Substantiation: The additional language will align the key maintenance switch requirements of NFPA 2001 with those of NFPA 72. The keyed-access type will ensure only authorized personnel with proper access can disable the suppression system.

In some applications, the key maintenance switch is not installed adjacent to the control unit. Indication of the system’s operational status at the key maintenance switch location will provide local visual indication of the system’s status, in addition to the control unit.

If a fire occurs when the Key Switch is operated for maintenance or service purposes, the need to quickly restore the system back into operational conditions is critical. A non-removable key will ensure the key is locally present and readily operable.

2001- Log #5 Final Action:
(5.3)

Submitter: James L. Kidd, Hiller New England Fire Protection Inc.
Recommendation: New text to read as follows:
When a clean agent total flooding system is being provided for the protection of a room, a raised or sunken floor beneath the protected room must also be simultaneously protected. This would include the installation of pipe, discharge nozzles and detectors in accordance with their listings.
Substantiation: As an installation company, we have seen, in the recent economy, specifications and installations of room total flood clean agent systems that have ignored the protection of the space below the raised or sunken floor. Even if there is no air flow or cabling in the lower space, the agents are going to eventually leak to the low point and prematurely decay the concentration in the room. If, in fact, there happens to be an incident in the below floor area, the concentration of agent leaking downward will not be enough to reach an extinguishing concentration, and therefore, could possibly cause the heat to produce great amounts of products of decomposition.

2001- Log #32 Final Action:
(5.4.2.2)

Submitter: Philip J. DiNenno, Hughes Associates, Inc.
Recommendation: Replace existing 5.4.2.2 as follows:
The flame extinguishing concentrations for Class A fuels shall be the greater of (a) 91 % of the Class B concentration, (b) the values in Table 5.4.2 or (c) as determined by tests as part of a listing program.

Insert Table 5.4.2 here
2001_L32_Tb5.4.2_R

Substantiation: The current Class A design concentrations are inadequate. They are inadequate based on the following:
1. Compared to historical values for Halon 1301 and CO_2, the Class A concentrations should be 1.5 to 2x the heptane extinguishing concentration value. In the case of clean agents, these concentrations are less than the heptane MEC, let alone 1.5x these values.
2. Full-scale fire test data exist that show these agents cannot extinguish Class A fuels at the current values. See Table 5.6.(a) in the Appendix of NFPA 2001.
3. The extinguishing and design concentrations are substantially lower than European and International standards.
In addition, the NFPA 2001 values for Class A design concentrations are as much as 30% lower than the equivalent design value under ISO 14520. From both an historical perspective and current international practice, the design concentrations for Class A surface fires as described in NFPA 2001 appear too low.
Note: Supporting material is available for review at NFPA Headquarters.

New Table 5.4.2 - Minimum Class A Extinguishing Concentration	
Agent	**Concentration**
FK-5-1-12	4.1%
HFC-125	8.6%
HFC-227ea	6.1%
IG-541	30.7%
IG-55	31.0%

4.

2001- Log #30 **Final Action:**
(5.4.2.4)

Submitter: Philip J. DiNenno, Hughes Associates, Inc.
Recommendation: Change 1.2 to 1.3 in Section 5.4.2.4:
Substantiation: The safety factor for Class A fires should be increased from 1.2 to 1.3 for the following reasons:
1. The current safety factor for Class B hazards is 1.3; there is no practical or theoretical reason for the safety factor to be different for Class A hazards.
2. The historical safety factors for total flooding gases for Class A hazards were in the range of 1.5 to 1.6 for halon 1301 and carbon dioxide. There is no demonstrated reason for the safety factor for Class A fuels to be so much lower with these new alternative agents.
3. Probability of failure calculations performed by I. Schlosser at VdS indicate a decrease in the system failure probability from 17.5% to 10% as the safety factor is increased from 1.2 to 1.3.
Reference:
Schlosser, I, "Reliability and Efficacy of Gas Extinguishing Systems with Consideration of System - Analytical Methods" Proceedings — VdS Congress on Fire Extinguishing Systems, December 1 and 2, 1998, Cologne, Germany.
4. The international consensus view including the USTAG, as reflected in ISO 14520, is that a minimum safety factor of 1.3 is required for Class A hazards.
5. Uncertainty in extinguishing concentration values (see proposals related to (5.4.2.2.) for Class A fuels provides an additional argument for a higher safety factor.

2001- Log #33 **Final Action:**
(5.4.2.5)

Submitter: Philip J. DiNenno, Hughes Associates, Inc.
Recommendation: Section 5.4.2.5 - replace current text with:
The minimum design concentration for Class C Hazards is unknown and, hence, such hazards shall not be protected by clean agent systems.
Substantiation: The design concentration for the use of these agents as energized electrical equipment is unknown. Data indicate that the extinguishing concentrations for energized electrical equipment are higher than the Class A extinguishing concentrations. See for example, Table A.5.6(a) in Appendix of this standard and the report from recent NFPRF project
(Linteris, G., "Clean Agent Suppression of Energized Electrical Equipment Fires," NFPRF, Quincy, MA, January 2009).
In addition, design practice for other similar agents (i.e., CO2 and Halon 1301) indicate a design concentration for Class C hazards 1.8 to 2 times the Class A concentrations.
Previous TG Task Group actions were accepted by a large majority of this committee including industry representatives resulted in a recommendation of dramatically increased concentrations for Class C hazards. This action was overturned as a result by industry led actions at the TCR session during the last cycle. As a result we still have no credible guidance for Class C hazard and the user and designer should be so cautioned.
Clearly the statement in 5.4.2.5 is misleading and provides no useful guidance and requires that this change be made.

2001- Log #28 **Final Action:**
(5.4.2.6)

Submitter: Philip J. DiNenno, Hughes Associates, Inc.
Recommendation: Add new text for 5.4.2.6:
The minimum design concentration for deep seated Class A fuels has not been determined, therefore, clean agent systems shall not be used for deep seated fire hazards.

Substantiation: No testing is required under this standard that addresses deep seated fires in Class A fuels, particularly paper, cardboard, or similar forms of fuel. The lack of test data as an adequate design concentration should preclude the use of these agents on these hazards. Similar hazards involving the use of CO2 and Halon 1301 required concentrations in excess of 1.5x the analogous Class A concentration used for clean agents and often substantially longer hold times.

2001- Log #26 **Final Action:**
(5.5.3.1)

Submitter: Brad T. Stilwell, Fike Corporation
Recommendation: Revise text to read as follows:
5.5.3.1*Tee Design Factor: ~~Other than identified in 5.5.3.1.3~~, Where a single agent supply is used to protect multiple hazards, the agent supply shall be increased by 2.5%. For Example an 8% design concentration would have the initial supply of 8.2% if a single agent supply were protecting more than one hazard. Delete Table 5.5.3.1, 5.5.3.1.1, 5.5.3.1.2 and renumber 5.5.3.1.3 to 5.5.3.1.1
Substantiation: The current standard is confusing and I believe is not used. Requiring designers to increase the agent supply in systems with multiple hazards will help with design flexibility and account for agent splits at tees.

2001- Log #23 **Final Action:**
(5.7.1.2.2)

Submitter: Michael Kroneder, Fire Eater
Recommendation: New text to read as follows:
For inert gas agents, the discharge time required to achieve 95 percent of the minimum design concentration for flame extinguishment based on a 20 percent safety factor shall not exceed 60 seconds for Class B fires or 120 seconds for Class A surface fires, or as otherwise required by the authority having jurisdiction.
Substantiation: As Inert gas do not decompose, a quick discharge is not a requirement for system functionality. Slower discharge will result in less turbulences and less panic and confusion for people located in the room during discharge and add to the overall safety. The required Pressure relief vent area will also be reduced and increase the room integrity.

2001- Log #24 **Final Action:**
(5.7.1.2.2)

Submitter: Thomas J. Wysocki, Guardian Services, Inc.
Recommendation: Revise text to read as follows:

For inert gas agents, the discharge time required to achieve 95 percent of the minimum design concentration for flame extinguishment based on a 20 percent safety factor shall not exceed 60 seconds for Class B fuel hazards, 120 seconds for Class A surface fire hazards or Class C hazards, or as otherwise required by the authority having jurisdiction.

Substantiation: There is long precedent to permit discharge times in excess of 60 seconds for systems using inert gaseous agents. NFPA 12 permits discharge times of 7 minutes for carbon dioxide protection of deep seated hazards which include Class A and Class C fuels. Marine clean agent systems using inert gas are permitted a 120 second discharge time (SOLAS, IMO, USCG regulations). A longer discharge time is desirable so long as risk to life and property is not increased. Advantages of a longer discharge time include smaller pipe and valve sizes are required for the agent delivery system conserving both cost, energy and natural resources; less room venting is required to maintain enclosure integrity during discharge; less turbulence and noise will be generated during discharge reducing potential for secondary damage to contents of the enclosure (less turbulence) and reducing risk to personnel should they be unable to evacuate the protected space before the start of the discharge.

2001- Log #11 **Final Action:**
(Table A.1.4.1(a))

Submitter: Robert G. Richard, Honeywell, Inc.
Recommendation: Add properties of new agent too table.
Substantiation: Add plural where appropriate and add new low global warming agent to the standard.

2001- Log #10 **Final Action:**
(A.1.4.1(c))

Submitter: Robert G. Richard, Honeywell, Inc.
Recommendation: Add properties of new agent too table.
Substantiation: Add plural where appropriate and add new low global warming agent to the standard.

2001- Log #41 **Final Action:**
(A.4.1.4.1(b))

Submitter: Paul E. Rivers, 3M Fire Protection
Recommendation: New and Revise text to read as follows:
1. Add revised graphs for FK-5-1-12 for 360 psig and 25 bar.
2. Add new graphs for FK-5-1-12 for 610 psig and 42 bar.
See graphs below.

Insert Graphs 2001_L41_R.pdf

Note: This was submitted for the last cycle ROP but inadvertently not added into the 2008 edition. Further, the 360 psig and 25 bar charts existing from the 2004 edition that incorrectly wasn't changed was deleted.
Substantiation: 1. Graphs had been updated since the 2004 edition.
2. High-pressure systems are now specified, designed and installed for which the added data are useful.
This is not original material; its reference/source is as follows:
NFPA 2001 F-06, Log #87, 7/5/2005

2001- Log #22 **Final Action:**
(Table A.4.2.3.1(a))

Submitter: Michael Kroneder, Fire Eater
Recommendation: New text to read as follows:
Agent: IG-541 Pressure in Agent Container at 70F (21C) 4508psig 31,050kPa
Minimum Acceptable Fittings:
Class 3,000 lb thrd. forged steel Maximum Pipe Size: 1 in.
Class 6,000 lb thrd./weld F.S. Maximum Pipe Size: All
Class 2,500 flanged joint Maximum Pipe Size: All
Substantiation: To ensure NFPA2001 is up to date on the technologies and equipment available 300bar IG-541 must be included.
The technology for 300bar IG-541 is available and used in many countries, In Europe most new IG-541 installations are 300bar systems.

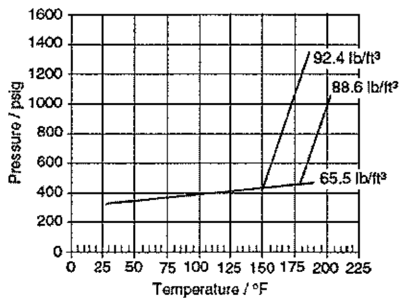
Note: Supporting material is available for review at NFPA Headquarters.
This is not original material; its reference/source is as follows:
Infochem UK & ISO 14520-15, 2005

2001- Log #12 **Final Action:**
(A.5.4.2)

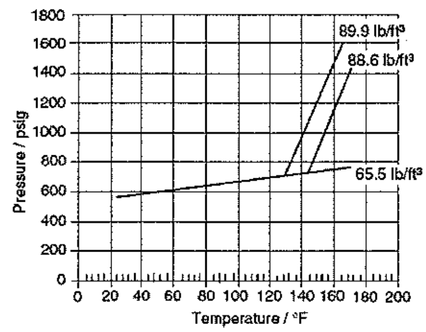
Submitter: Joseph A. Senecal, Kidde-Fenwal, Inc.
Recommendation: Revise the third sentence as follows:
From: "It was reported by Senecal (Senecal 2004) that …"
To: "It was reported (Senecal 2005) that …"
Substantiation: The change is to replace the reference from "Senecal 2004" (a conference presentation) to "Senecal 2004 and 2005" (a peer-reviewed published paper discussing the same material). Add the following reference in E.1.3 Other References: Senecal, Joseph A., "Flame extinguishing in the cup-burner by inert gases," Fire Safety Journal, Volume 40, Issue 6, pp. 579-591, September 2005.

2001-4 Log #87 **Final Action: Accept**
(Figure 1.4.1.4.1(C))

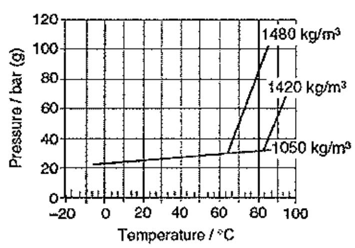
Submitter: Paul E. Rivers, 3M Fire Protection
Recommendation: 1. Revise graphs for 360 psig and 25 bar.
2. Add new graphs for 610 psig and 42 bar.
See graphs on the next page
Substantiation: 1. Graphs have been updated since the last edition.
2. High-pressure systems are now specified, designed and installed for which the added data are useful to the designer.
Committee Meeting Action: Accept



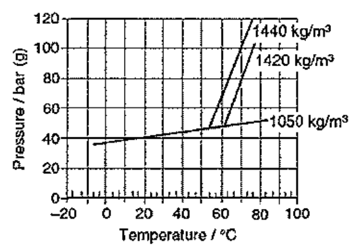
(a) To 360 psig at 70°F



(c) To 610 psig at 70°F



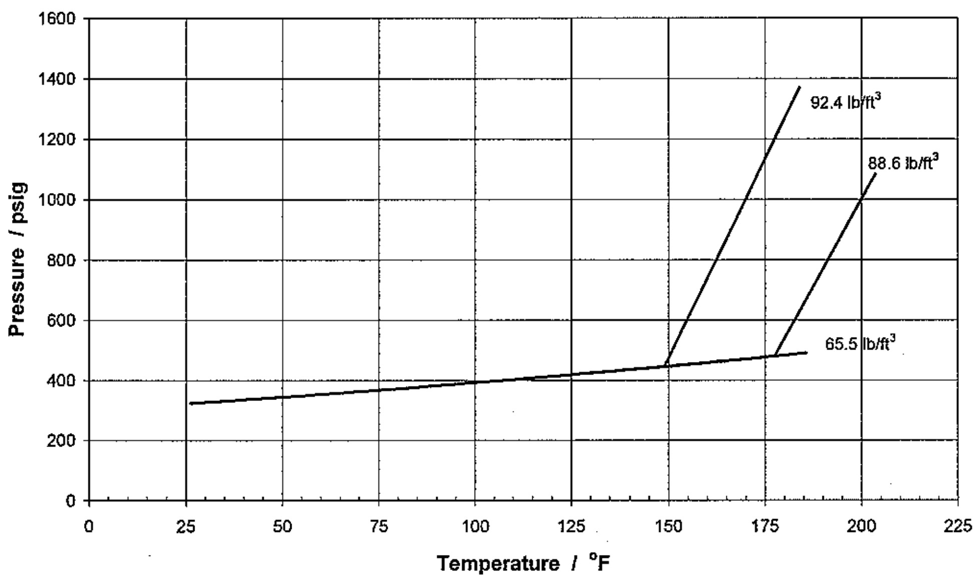
(b) To 25 bar at 20°C



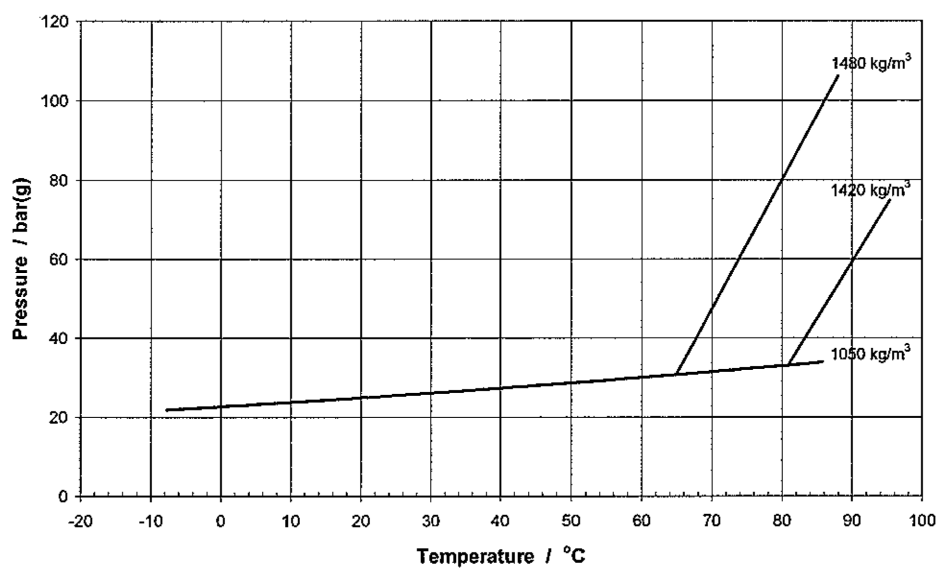
(d) To 42 bar at 20°C

2001 F2010 L41 Graphs
Page 2 of 4

Re: NFPA 2001 A.1.4.1.4.1(c)

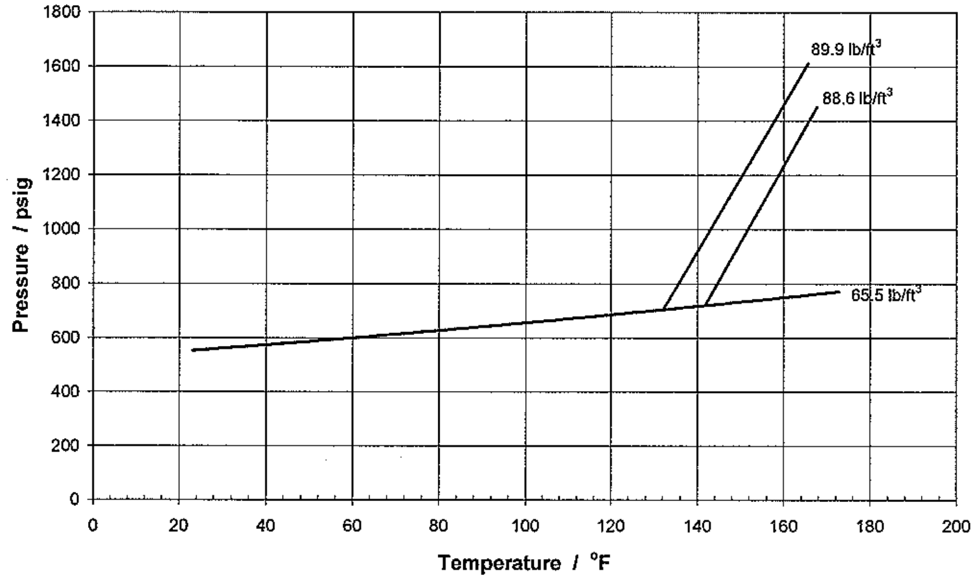


(1) To 360 psig 70F

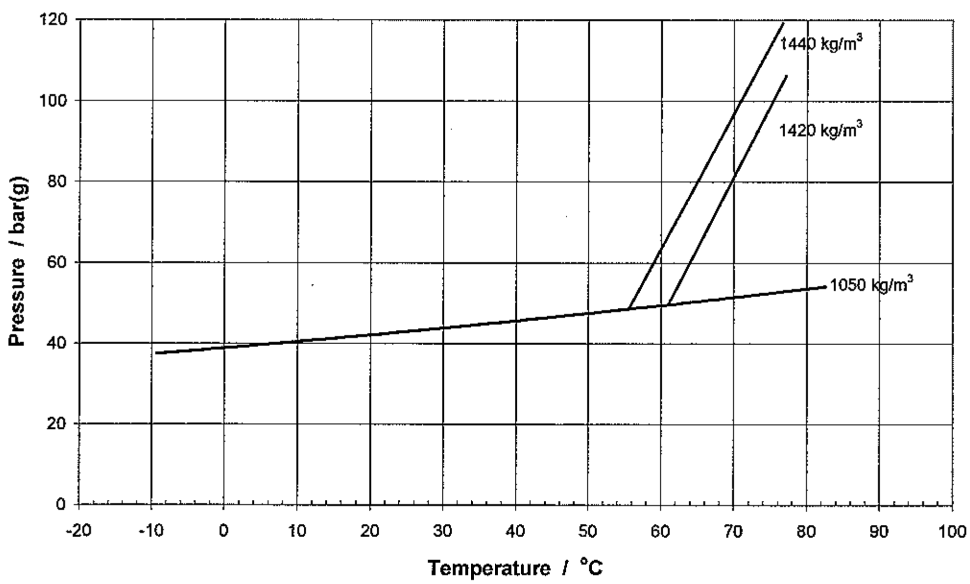


(2) To 25 bar at 20C

Re: NFPA 2001 A.1.4.1.4.1(c)



(3) To 610 psig at 70F



(4) to 42 bar at 20C

2001- Log #25 **Final Action:**
(A.5.4.2.5 (New))

Submitter: Brad T. Stilwell, Fike Corporation
Recommendation:

****Insert Include 2001_L25_R.doc Here****

Substantiation: This proposal gives the users of this standard new information regarding Energized Electrical Testing that was not available during the last standards cycle.

2001- Log #14 **Final Action:**
(Table A.5.4.2(a))

Submitter: Joseph A. Senecal, Kidde-Fenwal, Inc.
Recommendation: Under “By 2008 Method” add the following MEC values:
HFC-227ea 6.62 ± 0.14%
IG-100 32.2 ± 0.7%
Substantiation: The MEC values for HFC-227ea and IG-100 were established by an interlaboratory study described in the following reference: Senecal, Joseph A., "Standardizing the Measurement of Minimum Extinguishing Concentrations of Gaseous Agents," Fire Technology, Vol. 44, No. 3, pp. 207-220, September 2008.

2001- Log #40 **Final Action:**
(Table A.5.5.1(a))

Submitter: Mark L. Robin, DuPont Fluoroproducts
Recommendation: Delete text to read as follows:
Delete all entries in Table A.5.5.1(a) for temperatures below 120 °F.
Substantiation: In the indicated table and formula, “s” is the specific volume of the superheated vapor. A superheated vapor is thermodynamically defined as a vapor at a temperature above it boiling point; therefore, a superheated vapor state of a compound does not exist at temperatures below the compound’s boiling point, and all entries in the table for temperatures below the compound’s boiling point are meaningless (since a superheated vapor does not exist below a compound’s boiling point, there can be no such thing as a specific volume for the superheated vapor when the temperature is below the boiling point). No technical justification exists therefore for the inclusion of these values in the total flooding tables.

A.5.4.2.5 Class C fires have been a topic of great interest by many and it is important to give end users as much information as possible regarding Class C fires. The next few paragraphs will report data gathered by Fike Corporation and DuPont.

Copper Wire

The behavior of copper wire subjected to elevated temperatures was examined by connecting the ends of a ten inch length of 24 AWG bare copper wire to Electronics Measurements, Inc. Model TCR power supplies rated up to 40 volts @ 100 amps. The current was then adjusted to a constant level and the temperature of the wire monitored using unsheathed, bare, thermocouple wires and Fluke thermocouple meters. The results of these tests are shown in Table A.5.4.2.5-1, where it can be seen that for wire temperatures below approximately 950°F, the copper wire remained intact for a time period of at least 10 minutes. Wire temperatures above approximately 1000°F could not be maintained for 10 minutes as the wire would break; higher wire temperatures could be tolerated for shorter time periods before the wire was observed to break.

Table A.5.4.2.5-2 shows the results of the same test, but conducted with jacketed copper wire. In this case the wire was observed to fail at average temperatures in excess of approximately 725°F. Compared to bare wire, less heat is dissipated away from the copper wire when it is surrounded by the insulator, leading to an increased corrosion rate due the higher localized wire temperatures.

Table A.5.4.2.5-1 Overloaded Copper Wire; 24 AWG Bare Copper Wire

Current (A)	Temperature (°F)	Duration (time to wire failure)
21	700	> 10 min
	800-825	> 10 min
23		
25	925-950	> 10 min
26	1000	8 min
27	1050	3:23; 5:13; 6:02

Table A.5.4.2.5-2 Overloaded Copper Wire; 24 AWG Jacketed Copper Wire

Current (A)	Temperature (°F)	Duration (time to wire failure)
20.5	700	> 10 min
21.5	725	24 sec
23.5	850	28 sec
27	1050	10 sec

Additional tests were conducted to examine the temperature limitations of braided copper wire compared to stranded wire, and no significant differences were observed.

A number of important conclusions can be drawn from these tests:

- Bare copper wire can withstand a 10 minute overcurrent only when the wire temperature is limited to 1000°F
- Insulated copper wire can withstand a 10 minute overcurrent only when the wire temperature is limited to 700°F
- Larger gauge wires require more current to attain a given temperature but behave similarly to smaller gauge wires at similar temperatures
- Wire gauge makes little difference in the ability of copper wire to withstand high temperatures: - the maximum temperature which can be tolerated for 10 minutes is approximately 900 to 1000°F
- Stranded cables and single conductor cables behave similarly
- Copper wire heated to 750-1000°F is sustainable for 10 minutes only if these temperatures are not exceeded anywhere along the length of the wire
- When copper wire is heated to above 700°F, corrosion is accelerated and this corrosion is the primary reason for failure at these temperatures

Energized Material Testing

In order to replicate real world materials, the power conductor employed in any Class C standard test should be copper wire or cable, which is employed almost exclusively throughout the industry. PVC dominates as the material of choice for electrical insulation, followed by polyethylene (PE), which is typically employed as an insulation when cables are located outside. Additional insulation materials include Hypalon, cross-linked polyolefin (XLPO), high density polyethylene (HDPE), and Neoprene.

With respect to test conditions, it is critical to keep in mind the limitations of copper wire/cable. As discussed above, copper wire can withstand temperatures of up to only approximately 1000°F for extended periods, and at higher temperatures will quickly fuse, breaking the electrical circuit. Tests carried out at wire temperatures of approximately 1200°F would therefore represent a reasonable worse case scenario, but cannot be performed with copper wire, which will fuse in seconds at such wire temperatures. However, by employing nichrome wire at 1200°F, we can simulate an overcurrent scenario that is very challenging in nature since such a wire temperature is 20% higher than what could be withstood by copper wire.

Ignition of plastic samples as a function of wire temperature was evaluated and it was determined that a wire temperature of 1800°F was sufficient to cause the ignition of a wide range of plastic materials.
Based on the above considerations, the following test protocol was proposed:

- Employ nichrome wire at 1800°F for sample ignition

- At 30 s after ignition, reduce the wire temperature to 1200°F and maintain at 1200°F throughout the remainder of test

- At 60 s after ignition, activate suppression system

- Examine test material for reignition during a 10 minute hold period

Several configurations of plastic sample and ignition/heating wire were examined before deciding on the final configuration. The configuration ultimately adopted is shown in Figures A.5.4.2.5-1 and A.5.4.2.5-2. The test frame is constructed from aluminum and contains two electrical standoffs with ceramic insulators for connection of the test frame to a power supply. The test specimen is shown in Figure 2. It was found that shorter specimens presented a more challenging scenario than taller specimens; when testing PMMA samples, small "finger" flames developed on the top edge of the PMMA sample, which did not develop when taller specimens were employed.

******Insert Artwork Here******

Figure A.5.4.2.5-1. Test Frame Test Frame 18ga NiCr wire loop Insulated Electrical Standoffs (2), 2” tall with wire elevation of 1.4” 3”6”

******Insert Artwork Here******

Figure A.5.4.2.5-2. Baffling System Discharge Baffle (scaled down from UL2166 baffle design) 12” 7.25” 9.25” All baffle material constructed using 5/8” plywood 15” SQ Two pieces required, one frame with feet extending 1.5” from bottom of frame

******Insert Artwork Here******

Figure A.5.4.2.5-3 Polymeric Material Sample Dimensions

Suppression tests were conducted in a 200ft^3 box constructed from plywood and measuring approximately 3.3 feet wide, 7.6 feet deep and 8 feet tall. A walk-in door is on one end of the enclosure, a 12 inch square viewing window and two ventilation ports are used to purge the enclosure between tests. Electronics Measurements, Inc. Model TCR power supplies were used to heat the Ni-Cr wire to the desired temperature. Temperatures are determined using unsheathed, bare, thermocouple wires and Fluke thermocouple meters. Agent was discharged into the test cell using an inverted container to ensure that all contents were discharged into the test cell. A single nozzle was installed centrally in the test cell; the nozzle discharges in a 360º pattern. All tests employed scaled baffling modeled after the UL 2166 polymer fire.

Plastic samples investigated included PVC, HDPE, PMMA, ABS, and PP. PMMA, ABS and PP were investigated due to their inclusion in UL 2166 Class A listing tests.

Tests were conducted with HFC-227ea at its minimum Class A design concentration of 6.25% v/v. A current corresponding to a wire temperature of 1800^{o}F was applied to the nichrome wire to afford ignition of the sample. At 30 seconds after ignition, the current was reduced to a level corresponding to a wire temperature of 1200^{o}F, and maintained at this level throughout the entire test. At 60 seconds from ignition the suppression system was activated. The system was then observed for any re-ignition during a 10 minute soak period.

The test results are shown in Table A.5.4.2.5-3. In all cases, the Class A minimum extinguishing of HFC-227ea (6.25% v/v) was found to be capable of extinguishing the fires and preventing re-ignition over a 10 minute hold period during which the nichrome wire remained energized at a current level corresponding to a wire temperature of 1200^{o}F, well above the upper use limit of copper wire. The tests also demonstrated the "self-extinguishing" nature of PVC. Although small intermittent flames were observed with PVC, a self-sustaining flame could not be generated under the test conditions.

Table A.5.4.2.5-3 Energized Material Sample Tests with HFC-227ea at 6.25%

Plastic	Ignition(s)	Ext Time from EOD (s)	Re-ignition during soak?
ABS	10	10	NO
PP	25	10	NO
PP	30	12	NO
PMMA	5	20	NO
PVC	NA	NA	NO
PVC	NA	NA	NO
PVC	NA	NA	NO
HDPE	30	10	NO
PMMA	20	40	NO
ABS	3	11	NO
PP	4	10	NO
HDPE	30	10	NO
ABS	4	12	NO
PMMA	9	41	NO
HDPE	9	6	NO

Cable Bundle Testing

Another example of a typical, representative Class C hazard is an electrically energized cable bundle. In order to evaluate the performance of the clean agents on cable fires a cable bundle test was devised which employed the test enclosure described above for the plastic slab tests and consisted of a bundle of seven PVC cables through which a central 18 gauge nichrome wire was inserted. The nichrome wire was electrically energized to a wire temperature of 1800°F and maintained at this temperature throughout the entire test. Following ignition, the cable bundle was allowed to burn for 60 seconds (i.e., a 60 s preburn was employed) and the suppression agent was then released, and the test configuration observed for extinguishment and reignition over a soak period. The cable bundle configuration is shown in Figure A.5.4.2.5-4. Tests were conducted at minimum design concentration and as low as minimum design concentration minus 30 percent. In all cases the PVC bundle fire was extinguished by the clean agents. Results of the testing at minimum design concentration are shown in Table A.5.4.2.5-4.

******Insert Artwork Here******

Figure A.5.4.2.5-4 Cable Fire End View

Table A.5.4.2.5-4 Cable Bundle Fire Test Results

Agent	Concentration (%v/v)	Ignition(s)	Ext. Time from EOD (s)
HFC-125	8.0	:10	:08
HFC-125	8.0	:06	-:01
HFC-125	8.0	:10	:05
HFC-227ea	6.3	:09	:05
HFC-227ea	6.3	:08	-:08
HFC-227ea	6.3	:11	-:04
FK-5-1-12	4.2	:09	:03
FK-5-1-12	4.2	:10	:00
FK-5-1-12	4.2	:09	:05
IG-55	34.2	:10	-:50
IG-55	34.2	:11	2:10
IG-55	34.2	:05	:20

If a hazard is going to be protected that contains electrical conductors other than copper and has materials near the copper that have questionable flammability characteristics then further evaluation should be made and tests conducted to determine the proper design concentration.

References

1. Robin, Mark L., Shaw, Bon, and Stilwell, Brad, *Development of a Standard Procedure for the Evaluation of the Performance of Clean Agents in the Suppression of Class C Fires*
2. Robin, Mark L., Shaw, Bon, and Stilwell, Brad, *Summary of Ongoing Class C Fire Research for the Purpose of Identifying and Evaluating Class C Fire Risks and Suppression Needs in Modern Data Centers, Internet Service Providers and Telecommunication Facilities*

Figure A5.4.2.5-1. Test Frame Test Frame 18ga NiCr wire loop Insulated Electrical Standoffs (2), 2" tall with wire elevation of 1.4" 3"6"

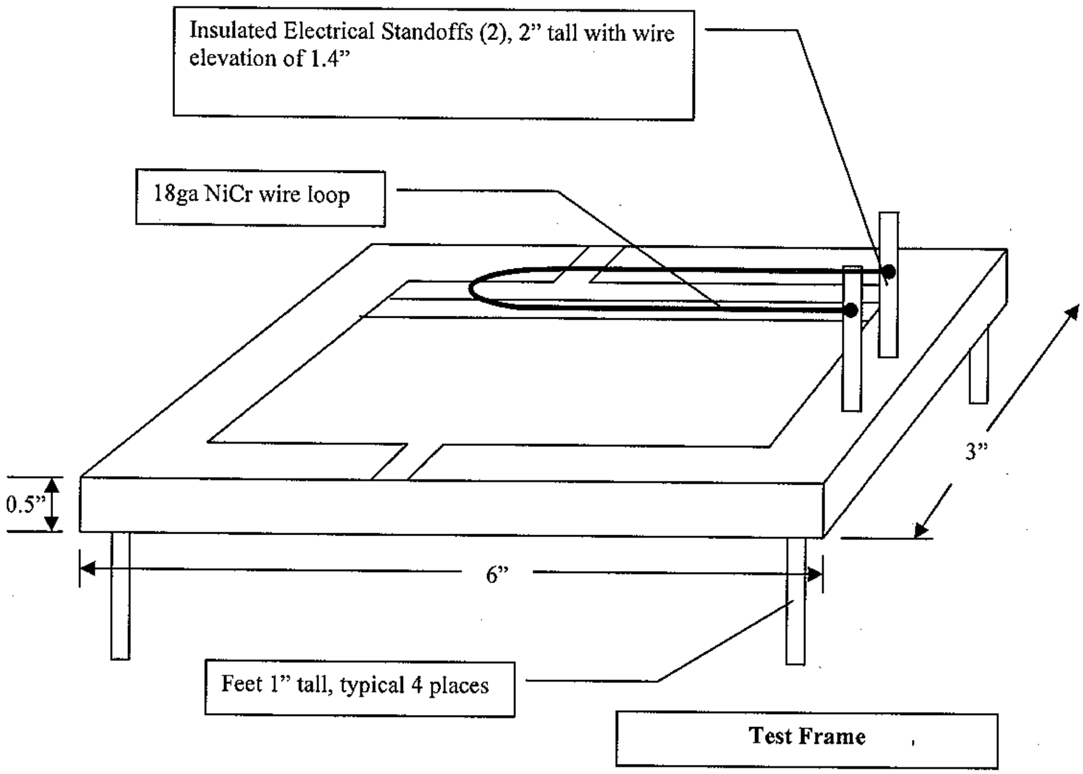


Figure A5.4.2.5-2. Baffling System Discharge Baffle (scaled down from UL2166 baffle design) 12" 7.25" 9.25" All baffle material constructed using 5/8" plywood 15" SQ Two pieces required, one frame with feet extending 1.5" from bottom of frame

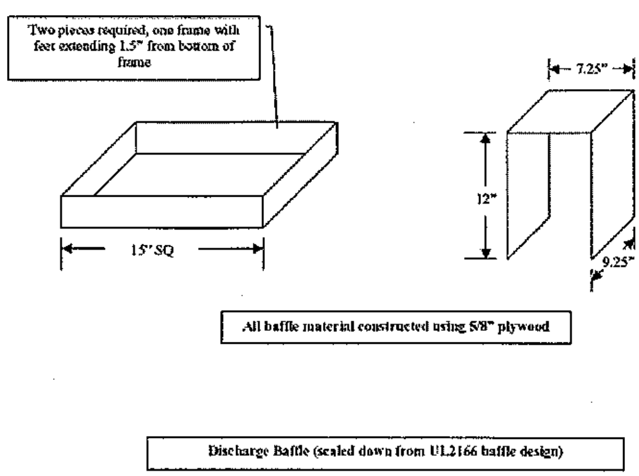


Figure A5.4.2.5-3 Polymeric Material Sample Dimensions

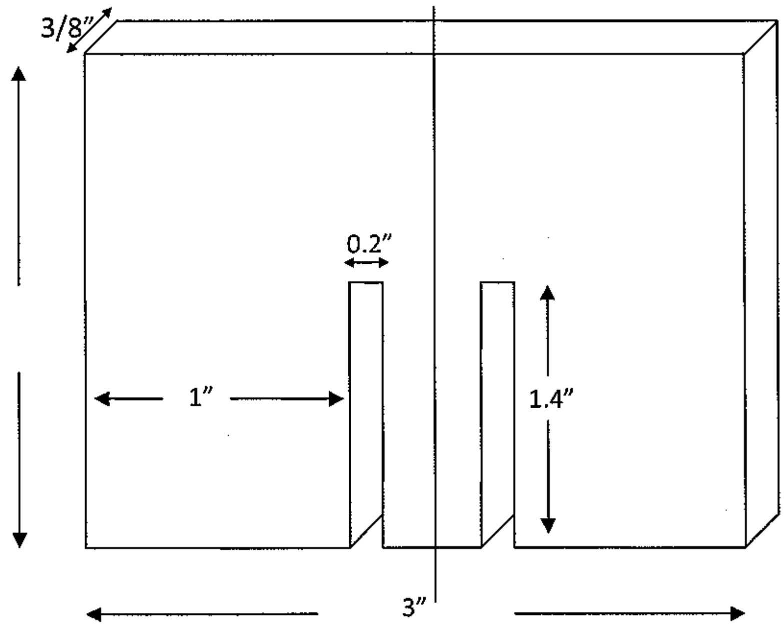
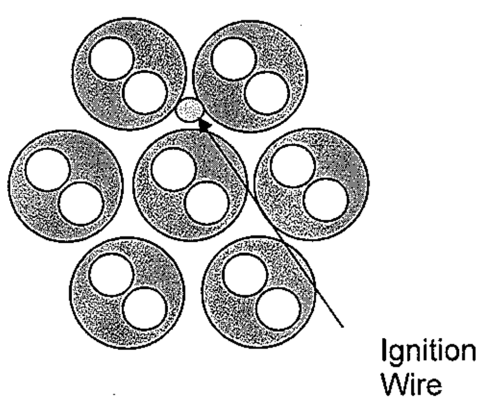


Figure A5.4.2.5-4 Cable Fire End View



2001- Log #44 **Final Action:**
(Table A.5.5.1(b))

Submitter: Mark L. Robin, DuPont Fluoroproducts
Recommendation: Delete text to read as follows:
Delete all entries in Table A.5.5.1(b) for temperatures below 50 °C.
Substantiation: In the indicated table and formula, "s" is the specific volume of the superheated vapor. A superheated vapor is thermodynamically defined as a vapor at a temperature above it boiling point; therefore, a superheated vapor state of a compound does not exist at temperatures below the compound's boiling point and all entries in the table for temperatures below the compound's boiling point are meaningless (since a superheated vapor does not exist below a compound's boiling point, there can be no such thing as a specific volume for the superheated vapor when the temperature is below the boiling point). No technical justification exists therefore for the inclusion of these values in the total flooding tables.

2001- Log #39 **Final Action:**
(Table A.5.5.1(c))

Submitter: Mark L. Robin, DuPont Fluoroproducts
Recommendation: Delete text to read as follows:
Delete all entries in Table A.5.5.1(c) for temperatures below -30 °F.
Substantiation: In the indicated table and formula, "s" is the specific volume of the superheated vapor. A superheated vapor is thermodynamically defined as a vapor at a temperature above it boiling point; therefore, a superheated vapor state of a compound does not exist at temperatures below the compound's boiling point and all entries in the table for temperatures below the compound's boiling point are meaningless (since a superheated vapor does not exist below a compound's boiling point, there can be no such thing as a specific volume for the superheated vapor when the temperature is below the boiling point). No technical justification exists therefore for the inclusion of these values in the total flooding tables.

2001- Log #34 **Final Action:**
(Table A.5.5.1(d))

Submitter: Mark L. Robin, DuPont Fluoroproducts
Recommendation: Delete text to read as follows:
Delete all entries in Table A.5.5.1(d) for temperatures below -35 °C.
Substantiation: In the indicated table and formula, "s" is the specific volume of the superheated vapor. A superheated vapor is thermodynamically defined as a vapor at a temperature above it boiling point; therefore, a superheated vapor state of a compound does not exist at temperatures below the compound's boiling point and all entries in the table for temperatures below the compound's boiling point are meaningless (since a superheated vapor does not exist below a compound's boiling point, there can be no such thing as a specific volume for the superheated vapor when the temperature is below the boiling point). No technical justification exists therefore for the inclusion of these values in the total flooding tables.

2001- Log #35 Final Action:
(Table A.5.5.1(q))

Submitter: Mark L. Robin, DuPont Fluoroproducts
Recommendation: Delete text to read as follows:
Delete all entries in Table A.5.5.1(q) for temperatures below -10 °F.
Substantiation: In the indicated table and formula, “s” is the specific volume of the superheated vapor. A superheated vapor is thermodynamically defined as a vapor at a temperature above it boiling point; therefore, a superheated vapor state of a compound does not exist at temperatures below the compound’s boiling point and all entries in the table for temperatures below the compound’s boiling point are meaningless (since a superheated vapor does not exist below a compound’s boiling point, there can be no such thing as a specific volume for the superheated vapor when the temperature is below the boiling point). No technical justification exists therefore for the inclusion of these values in the total flooding tables.

2001- Log #36 Final Action:
(Table A.5.5.1(r))

Submitter: Mark L. Robin, DuPont Fluoroproducts
Recommendation: Delete text to read as follows:
Delete all entries in Table A.5.5.1(r) for temperatures below -20 °C.
Substantiation: In the indicated table and formula, “s” is the specific volume of the superheated vapor. A superheated vapor is thermodynamically defined as a vapor at a temperature above it boiling point; therefore, a superheated vapor state of a compound does not exist at temperatures below the compound’s boiling point and all entries in the table for temperatures below the compound’s boiling point are meaningless (since a superheated vapor does not exist below a compound’s boiling point, there can be no such thing as a specific volume for the superheated vapor when the temperature is below the boiling point). No technical justification exists therefore for the inclusion of these values in the total flooding tables.

2001- Log #37 Final Action:
(A.5.6)

Submitter: Mark L. Robin, DuPont Fluoroproducts
Recommendation: New text to read as follows:
Insert the following text into Section A.5.6 after the current fifth paragraph (after paragraph beginning " If electrical equipment cannot…):

One of the major shortcomings of previous studies on clean agent suppression of Class C fires was the use of nichrome wire as the electrical conductor [Niemann, et. al., 2001; Driscoll, et. al., 1997; Bayless, et. al., 1998; Bengsaton, et. al., 2005] . Copper is employed as the electrical conductor in almost all electrical applications - nichrome wire is never employed. In order to better understand the characteristics of copper wire, DuPont Fluoroproducts and Fike Corporation carried out a series of simple laboratory scale tests involving electrically energized copper wires [Robin, Stilwell and Shaw, 2008; Robin, Stilwell and Shaw, 2007].

The behavior of copper wire subjected to elevated temperatures was examined by connecting the ends of a ten inch length of 24 AWG bare copper wire to Electronics Measurements, Inc. Model TCR power supplies rated up to 40 volts @ 100 amps. The current was then adjusted to a constant level and the temperature of the wire monitored using unsheathed, bare, thermocouple wires and Fluke thermocouple meters. The results of these tests are shown in Table 1, where it can be seen that for wire temperatures below approximately 950 ºF, the copper wire remained intact for a time period of at least 10 minutes. Wire temperatures above approximately 1000 ºF could not be maintained for 10 minutes as the wire would break; higher wire temperatures could be tolerated for shorter time periods before the wire was observed to break

Table 2 shows the results of the same test, but conducted with jacketed copper wire. In this case the wire was observed to fail at average temperatures in excess of approximately 725 ºF. Compared to bare wire, less heat is dissipated away from the copper wire when it is surrounded by the insulator, leading to an increased corrosion rate due the higher localized wire temperatures.

Insert Table 2001_L37_R_Table1.doc*

Insert Table 2001_L37_R_Table2.doc*

Additional tests were conducted to examine the temperature limitations of braided copper wire compared to stranded wire, and no significant differences were observed.

A number of important conclusions can be drawn from these tests:

- Bare copper wire can withstand a 10 minute overcurrent only when the wire temperature is limited to 1000 ºF
- Insulated copper wire can withstand a 10 minute overcurrent only when the wire temperature is limited to 700 ºF
- Larger gauge wires require more current to attain a given temperature but behave similarly to smaller gauge wires at similar temperatures
- Wire gauge makes little difference in the ability of copper wire to withstand high temperatures: - the maximum temperature which can be tolerated for 10 minutes is approximately 900 to 1000 ºF
- Stranded cables and single conductor cables behave similarly
- Copper wire heated to 750-1000 ºF is sustainable for 10 minutes only if these temperatures are not exceeded anywhere along the length of the wire
- When copper wire is heated to above 700 ºF, corrosion is accelerated and this corrosion is the primary reason for failure at these temperatures

A large number of previous studies [Niemann, et. al., 2001; Driscoll, et. al., 1997; Bayless, et. al., 1998; Bengsaton, et. al., 2005] employed nichrome wire at current levels corresponding to wire temperatures in excess of 1800 ºF. At this temperature, bare copper wire is sustainable for less than 10 seconds, and at 1800 ºF insulated copper wire is sustainable for even lesser periods of time. Hence, these tests involving a nichrome wire would be impossible to conduct if one were to employ, instead of nichrome, the conductor used in essentially all power transmission cables. The conditions employed in these tests are clearly not representative of the real world hazard.

An example of a typical, representative Class C hazard is an electrically energized cable bundle. In order to evaluate

Table 1. Overloaded Copper Wire; 24 AWG Bare Copper Wire

Current (A)	Temperature (^oF)	Duration (time to wire failure)
21	700	> 10 min
23	800-825	> 10 min
25	925-950	> 10 min
26	1000	8 min
27	1050	3:23 ; 5:13 ; 6:02

Table 2. Overloaded Copper Wire; 24 AWG Jacketed Copper Wire

Current (A)	Temperature (^oF)	Duration (time to wire failure)
20.5	700	> 10 min
21.5	725	24 s
23.5	850	28 s
27	1050	10 s

the performance of the clean agents on cable fires a cable bundle test was devised which employed the test enclosure described above for the plastic slab tests and consisted of a bundle of seven PVC cables through which a central 18 gauge nichrome wire was inserted. The nichrome wire was electrically energized to a wire temperature of 1800 °F and maintained at this temperature throughout the entire test. Following ignition, the cable bundle was allowed to burn for 60 seconds (i.e., a 60 s preburn was employed) and the suppression agent was then released, and the test configuration observed for extinguishment and reignition over a soak period. The cable bundle configuration is shown in Figure 1. Test were conducted at minimum design concentration and as low as minimum design concentration minus 30 percent - in all cases the PVC bundle fire was extinguished by the clean agents. Results of the testing at minimum design concentration are shown in Table 3. Figure 2 shows typical results, those for HFC-227ea at minimum design and at minimum design minus 30 percent.

Insert Figure 2001_L37_R_Figure1.doc*

Insert Table 2001_L37_R_Table3.doc*

Insert Figure 2001_L37_R_Figure2.doc*

Several major conclusions may be drawn from a review of the fire suppression literature and the results of the Class C testing by DuPont/Fike:

· The fire history of telecommunications and data processing facilities shows that, while relatively rare, fires in these facilities can lead to substantial damage and revenue loss

· Fires in telecommunications and data processing facilities are characterized by low fuel loads, primarily involving wire insulation, printed circuit boards, electronic components, transformers, insulating materials, and plastic housings

· Fires in telecommunications and data processing facilities typically initiate from an overheat, short or arc condition, are of low energy output, often less than 5 to 10 kW, and produce varying amounts of combustion products, often corrosive and toxic

· Relatively few tests have been reported in which energized electrical or electronic equipment were involved. The vast majority of tests involving electronic equipment employ unpowered equipment and a means of ignition other than electrical

· The vast majority of tests involving powered equipment have been conducted on the recently developed clean agents. Many of these tests employ unusual test configurations which are difficult to relate to real world Class C fire scenarios

· Recent evaluations of the performance of the clean agents on Class C fires indicate that current Class A minimum design concentrations of the clean agents are sufficient to suppress at least some Class C fires, e.g., cable bundle fires

Substantiation: Provides relevant and valuable information of clean agent suppression of Class C fires.

2001- Log #13 **Final Action:**

(Annex B, Figure B.19(a) and B.19(b))

Submitter: Joseph A. Senecal, Kidde-Fenwal, Inc.

Recommendation: Delete Figure B.19(a) and Figure B.19(b). Re-number Figures B.19(c) through B.19(h) to B.19(a) through B.19(f).

Substantiation: The figures currently appearing as B.19(a) and B.19(b) were supposed to have been deleted from the prior edition when new text and figures were introduced at the last revision cycle.

Figure 1. Cable Bundle

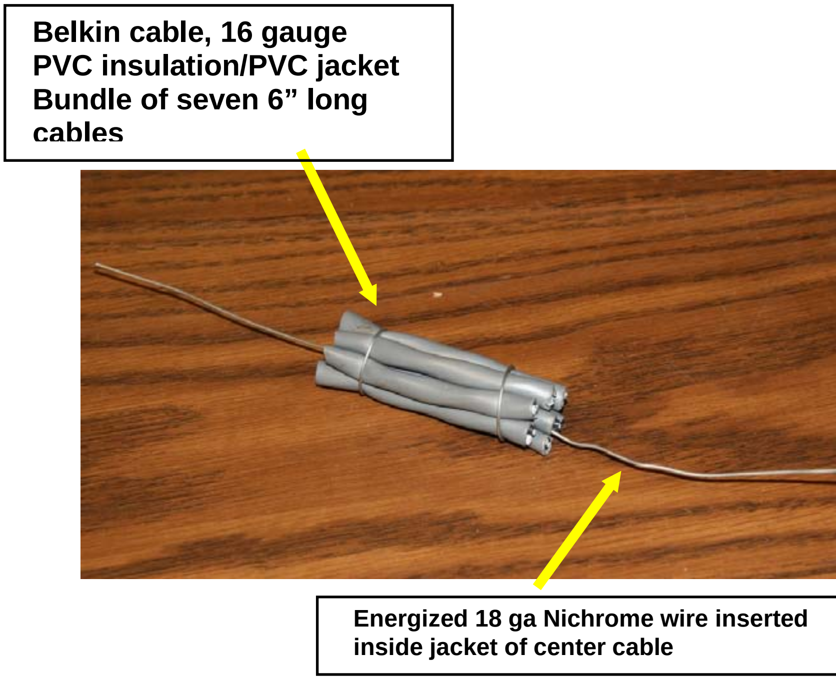
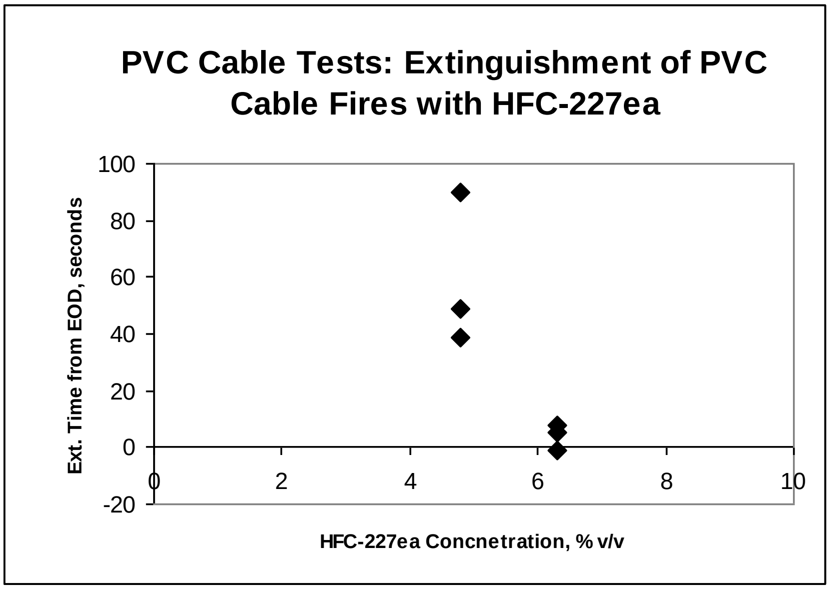


Table 3. PVC Cable Fire Tests: Agent at Design Concentration

Run	Agent	Conc., % v/v	Ignition (s)	Ext time from EOD (s)
A1	HFC-125	8.0	0:10	0:08
A2	HFC-125	8.0	0:06	- 0:01
A3	HFC-125	8.0	0:10	0:05
A4	HFC-227ea	6.3	0:09	0:05
A5	HFC-227ea	6.3	0:08	-0:08
A6	HFC-227ea	6.3	0:11	- 0:04
A7	PFK-5-1-12	4.2	0:09	0:03
A8	PFK-5-1-12	4.2	0:10	0:00
A9	PFK-5-1-12	4.2	0:09	0:05
A10	IG-55	34.2	0:10	- 0:50
A11	IG-55	34.2	0:11	2:10
A12	IG-55	34.2	0:05	0:20

Figure 2. Extinguishment of PVC Cable Bundles with HFC-227ea



2001- Log #38 **Final Action:**
(Annex C)

Submitter: Fred Musser, Fire Safety Technology
Recommendation: Revise text to read as follows:
Delete Paragraphs C.2.6.1.3 through and including C.2.6.1.9 and replace with NFPA 2001/2004 edition paragraphs C.2.6.1.3 through and including C.2.6.1.9 and
Delete Paragraphs C.2.6.3.4 through and including C.2.7.2 and replace with NFPA 2001/2004 edition paragraphs C.2.6.3.5 through and including C.2.7.2
Substantiation: 1. Test procedure adds complexity to test procedure and possible extra equipment with minimal benefit.
2. Calculations as provided are erroneous. Committee has been unable to provide corrected calculations.

2001- Log #27 Final Action:
(C.2.7.1.6.x (New))

Submitter: Todd M. Hetrick, Leawood, KS

Recommendation: New text to read as follows:

Interface Characteristic Thickness: Determine from the Authority Having Jurisdiction the acceptable characteristic thickness, <omega>, of the clean agent being used. This value is generally equal to -0.25 for agents with vapor densities greater than that of atmospheric air. Its value however is a function of the enclosure's dimensions, enclosure contents, agent type, and various other physical parameters.

Equivalent Height, H_e: The equivalent height shall be calculated from the minimum protected height, H, the maximum enclosure height, H_0, the interface's characteristic thickness, <omega>, and the concentration reduction threshold, or fraction of the initial discharge concentration remaining (c_f / c_i), that exists at the protected height at the time of the hold time. First calculate the value,

H_e = H_p / H_0 – <omega> * (c_f / c_i – 1/2).

Then calculate the value of the elevation transition point,

H_tp = abs(<omega> / 2).

For agent types with vapor densities greater than that of atmospheric air and H_e > 1 – H_tp replace the previous value of H_e with,

H_e = 1 – (1 – H / H_0) * [c_i / (2*c_f)].

If H_e < H_tp, replace the previous value of H_e with,

H_e = H_p / H_0 * [2 * (1 – c_f / c_i)]^(-1).

For agent types with vapor densities lesser than that of atmospheric air and H_e < H_tp replace the previous value of H_e with,

H_e = (H_p / H_0) * [c_i / (2 * c_f)].

If H_e > 1 – H_tp, replace the previous value of H_e with,

H_e = 1 – (1 – H_p / H_0) * [2 * (1 – c_f / c_i)]^(-1).

The value of H_e calculated above shall be input to the final hold time equation C.2.7.1.7g or C.2.7.1.7h, whichever may apply.

Substantiation: The sharp interface has been shown to provide overly optimistic (non-conservative) hold time predictions based on 34 full scale hold time tests initiated under the auspices of the NFPA 2001 Gaseous Fire Extinguishing technical subcommittee [Hetrick Thesis – 2009, SUPDET conference proceedings – 2007, 2008, 2009, Fire Technology – Hetrick – 2008-09]. As well, the wide interface theory of ISO 14520.1 is shown to be overly conservative, and drastically so. This proposal recommends that a compromise between the two theories be introduced, hereby referred to as the thick descending interface model. Use of the proposed model (by way of a simple modification to the existing theory) with judiciously chosen input parameters provides for significantly increased modeling accuracy that generally still provides for conservative (less than actual) predictions of the hold time. An in-depth derivation and physical explanation of the introduced hold time theory is attached. Further supporting documentation is too large for email transmittal at present. Please contact the author for the most recent versions of these publications. Available via WPI's ETD database (http://www.wpi.edu/Pubs/ETD/) is this contributor's Master's thesis, which includes extensive supporting theoretical and experimental documentation in support of the subject proposal (technical update of model derivation appendix attached - not yet on ETD).

The proposed model modification alters the interface to represent a thick interface, of defined maximum thickness. This thickness grows initially, is then frozen in form as it descends (or rises) through enclosure elevation, and then collapses out of existence as all available clean agent departs the enclosure.

Note: Supporting material is available for review at NFPA Headquarters.

2001- Log #15 **Final Action:**
(E.1.3)

Submitter: Joseph A. Senecal, Kidde-Fenwal, Inc.
Recommendation: Add the following reference: Senecal, Joseph A., “Flame extinguishing in the cup-burner by inert gases,” Fire Safety Journal, Volume 40, Issue 6, pp. 579-591, September 2005.
Delete the existing reference: Senecal, J.A., “Flame extinguishing in the cup-burner by inert gases: Theoretical & Experimental Analysis,” Central States Section / The Combustion Institute Meeting (March 2004).
Substantiation: The added reference is intended to replace the deleted reference. The added reference, being a peer reviewed publication, is a better reference than the original which is to a conference presentation.