CLEAN AGENTS & CLASS C FIRE HAZARDS

NEW DEVELOPMENTS

Presented by:
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For:
Fire Safety Annual Conference
Greater Atlanta Chapter
Society of Fire Protection Engineers
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DEFINITIONS

- **NFPA 2001**
  - Standard on Clean Agent Fire Extinguishing Systems
  - 2004 Edition (current)
  - Annual 2007 Revision Cycle

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DEFINITIONS

- **CLEAN AGENT**
  - Electrically nonconducting, volatile, or gaseous fire extinguishant that does not leave a residue upon evaporation.

    NFPA 2001 (2004 Ed.): Sec. 3.3.6

    - *Does not conduct electricity*
    - *Gaseous*
    - *Does not leave a residue behind*
    - *Is not carbon dioxide*

Table 1.4.1.2 Agents Addressed in NFPA 2001

Halocarbon

FC-3-1-10	Perfluorobutane	C_4F_{10}
FK-5-1-12	Dodecafluoro-2-methylpentan-3-one	$CF_3CF_2C(O)CF(CF_3)_2$
HCFC Blend A	Dichlorotrifluoroethane HCFC-123 (4.75%)	$CHCl_2CF_3$
	Chlorodifluoromethane HCFC-22 (82%)	$CHClF_2$
	Chlorotetrafluoroethane HCFC-124 (9.5%)	$CHClFCF_3$
	Isopropenyl-1-methylcyclohexene (3.75%)	
HCFC-124	Chlorotetrafluoroethane	$CHClFCF_3$
HFC-125	Pentafluoroethane	CHF_2CF_3
HFC-227ea	Heptafluoropropane	CF_3CHFCF_3
HFC-23	Trifluoromethane	CHF_3
HFC-236fa	Hexafluoropropane	$CF_3CH_2CF_3$
FIC-13I1	Trifluoroiodide	CF_3I

Inert

IG-01	Argon	Ar
IG-100	Nitrogen	N_2
IG-541	Nitrogen (52%)	N_2
	Argon (40%)	Ar
	Carbon dioxide (8%)	CO_2
IG-55	Nitrogen (50%)	N_2
	Argon (50%)	Ar

DEFINITIONS

- **CLEAN AGENTS – MOST IN USE**
  - FK-5-1-12
    - Tradename: **Novec 1230®**
    - Manufacturer: 3M
    - Class: Halocarbon

DEFINITIONS

- **CLEAN AGENTS – MOST IN USE**
  – HFC-125
    - Tradename: **FE-25®**
      – Manufacturer: DuPont
    - Class: Halocarbon

DEFINITIONS

- **CLEAN AGENTS – MOST IN USE**
  - HFC 227ea
    - Tradename: **FM-200®**
      - Manufacturer: Chemtura
    - Tradename: **FE-227®**
      - Manufacturer: DuPont
    - Class: Halocarbon

DEFINITIONS

- **CLEAN AGENTS – MOST IN USE**
  - HFC-23
    - Tradename: **FE-13®**
      - Manufacturer: DuPont
    - Class: Halocarbon

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DEFINITIONS

- **CLEAN AGENTS – MOST IN USE**
  - IG-541
    - Tradename: **Inergen®**
      - Manufacturer: Tyco:Ansul
    - Class: Inert

DEFINITIONS

- **CLEAN AGENTS – MOST IN USE**
  - IG-55
    - Tradename: **Argonite®**
      - Manufacturer: Ginge-Kerr *(owns Trademark)*
    - Class: Inert

DEFINITIONS

- **CLASS C FIRES**
  - Fires that involve energized electrical equipment where the electrical nonconductivity of the extinguishing media is of importance

    NFPA 2001 (2004 Ed.): Sec. 3.3.5

DEFINITIONS

- **FLAME EXTINGUISHING CONCENTRATION**
  - The clean agent concentration that is proven to extinguish flame by methods defined in NFPA 2001

    See NFPA 2001 (2004 Ed.): Sec. 5.4.2.1 and 2

DEFINITIONS

- **MINIMUM DESIGN CONCENTRATION**
  - MDC - The flame extinguishing concentration times the specified safety factor *NFPA 2001 (2004 Ed.): Sec. 5.4.2.3*

DEFINITIONS

- **CLASS C FIRE HAZARDS – MINIMUM DESIGN CONCENTRATION**
  - Minimum design concentration for Class C hazards shall be at least that for Class A surface fires

    NFPA 2001 (2004 Ed.): Sec. 5.4.2.5

DEFINITIONS

- **CLASS A SURFACE FIRE HAZARD – MINIMUM DESIGN CONCENTRATION**
  - The minimum design concentration for a Class A surface fire hazard shall be the extinguishing concentration, as determined in 5.4.2.2, **times a safety factor of 1.2**

    NFPA 2001 (2004 Ed.): Sec. 5.4.2.4

DEFINITIONS

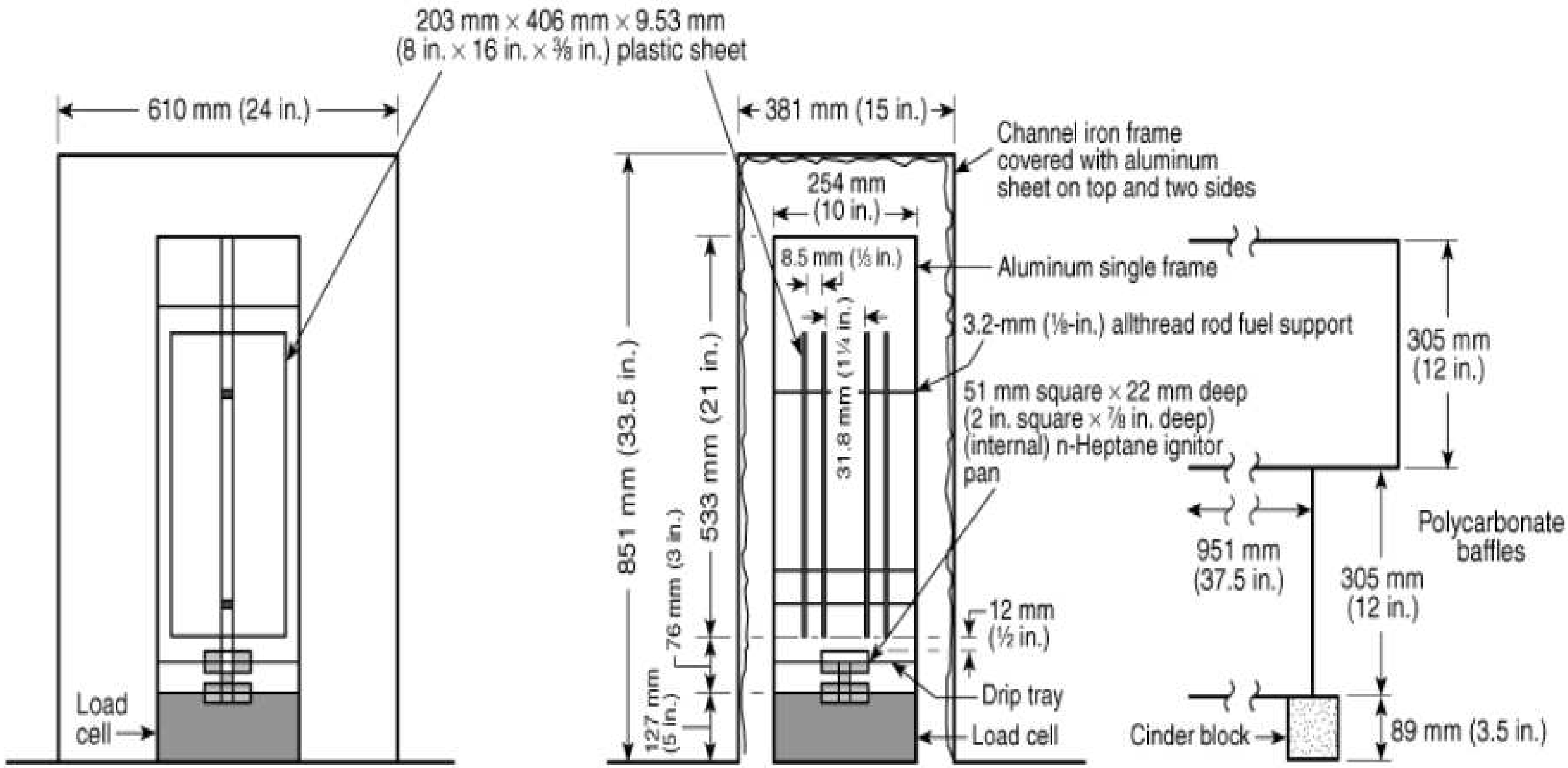
- **CLASS A SURFACE FIRE HAZARD – MINIMUM DESIGN CONCENTRATION**
  - *Recognized Class A test methods*
    - *UL 2127 (Inert clean agents)*
    - *UL 2166 (Halocarbon clean agents)*
  - *Class A test*
    - *Wood crib – 6 minute preburn, 10 minute hold*
    - *Non-cellulosic polymer sheets (next slides)*

DEFINITIONS

- **CLASS A SURFACE FIRE HAZARD – MINIMUM DESIGN CONCENTRATION**

Fire Extinguishment Test (Noncellulosic) Class A Surface Fires. The purpose of the tests outlined in this procedure is to develop the minimum extinguishing concentration (MEC) for a gaseous fire suppression agent for a range of noncellulosic, solid polymeric combustibles. It is intended that the MEC will be increased by appropriate safety factors and flooding factors as provided for in the standard.

CLASS A SURFACE FIRE TEST
NON-CELLULOSIC



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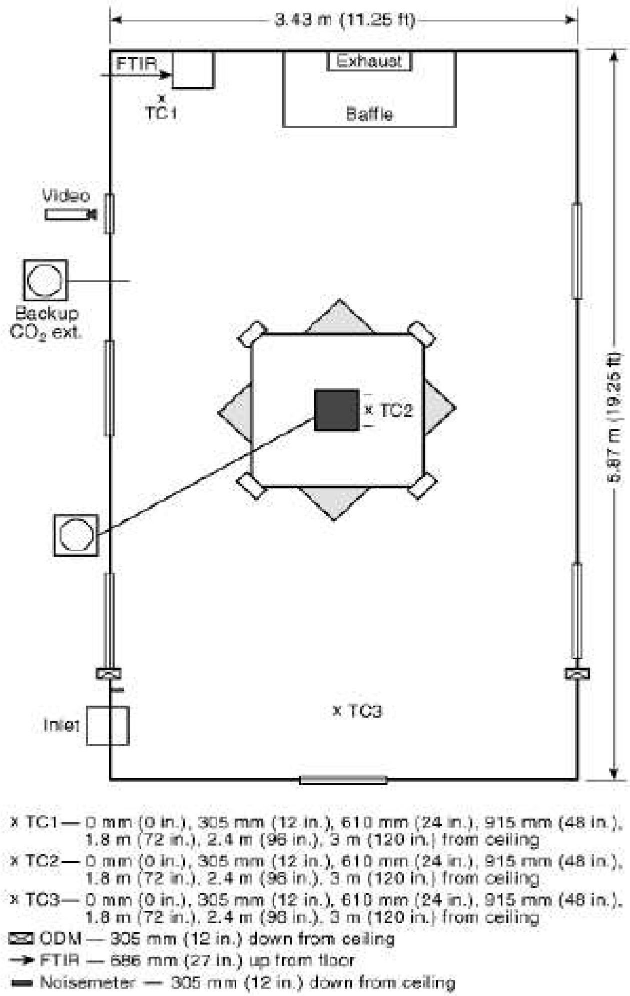
CLASS A SURFACE FIRE TEST NON-CELLULOSIC

N-Heptane burn: 0 - 90 s

Agent discharge: 210 s

Hold time: 600 s



Class C Fire Hazards

- **Duration of Protection**
  - It is important that the agent design concentration not only shall be achieved, but also shall be maintained for the specified period of time to allow effective emergency action by trained personnel. This is equally important in all classes of fires since a persistent ignition source (e.g., an arc, heat source, oxyacetylene torch, or "deep-seated" fire) can lead to resurgence of the initial event once the clean agent has dissipated.

    NFPA 2001 (2004 Ed.) – Sec. 5.6

History of Class C Fire Tests

- Telecommunications industry has been concerned about this energized electrical fires for many years….why?...
- They don't want to interrupt power in the event of a small fire – for very good reasons…

History of Class C Fire Tests

- **At least ten papers produced by manufacturers**
- **At least five papers presented in conjunction with or by government entity**
  - NIST
  - Japan Fire Institute
- **One from consultant**
- **General conclusions: Design concentrations tend to be higher**

History of Class C Fire Tests

1. Niemann, R., Bayless, H., and Craft C., "Evaluation of Selected NFPA 2001 Agents for Suppressing Class C Energized Fires," Halon Options Technical Working Conference Proceedings, Albuquerque, NM, May 7-9, 1996, pp. 399-412.

2. Driscoll M., and Rivers P.E., "Clean Extinguishing Agents and Continuously Energized Circuits," Annual Conference on Fire Suppression Research: Abstracts, NISTIR 5904, K. Beall, Ed., Gaithersburg, MD, October 28-31, 1996.

3. Driscoll M., and Rivers P.E., "Clean Extinguishing Agents and Continuously Energized Circuits: Recent Findings," Halon Options Technical Working Conference Proceedings, Albuquerque, NM, May 6-8, 1997, pp. 129-140.

4. Braun, E., Womeldorf C., Grosshandler W. L., "Determination of Suppression Concentration for Clean Agents Exposed to a Continuously Energized Heated Metal Surface," Halon Options Technical Working Conference Proceedings, Albuquerque, NM, May 6-8, 1997, pp. 149-161.

5. Kelly, A., Rivers P.E., Grosshandler W.L., Braun, E., "Clean Agents Concentration Requirements for Continuously Energized Fires," Annual Conference on Fire Suppression Research: Abstracts, August 1997.

History of Class C Fire Tests

6. Smith D.M., Kelly, A., Rivers P.E., Grosshandler W.L., Braun, E., "Energized Fire Performance of Clean Agents: Recent Developments," International Conference on Ozone Protection Technologies, Baltimore, MD, November 11-13, 1997.

7. McKenna, L. A. Jr., Gottuk D.T., DiNenno P.J., Mehta S., "Extinguishment Tests of Continuously Energized Class C Fires Using HFC-227ea (FM-200™)," Submitted to NFPA 2001 Technical Committee on Halon Alternative Protection Options, March 1998.

8. Niemann, R., Bayless, H., "Update on the Evaluation of Selected NFPA 2001 Agents for Suppressing Class C Energized Fires," Halon Options Technical Working Conference Proceedings, Albuquerque, NM, May 12-14, 1998, pp. 293-295.

9. Steckler K., Grosshandler W. L., Smith D.M., Rivers P.E., "Clean Agent Performance on Fires Exposed to an External Energy Source," Annual Conference on Fire Suppression Research: Abstracts, NISTIR 6242, K. Beall, Ed., Gaithersburg, MD, November 2-5, 1998.

10. Smith D.M., Rivers P.E., Grosshandler W. L., Steckler K., "Effectiveness of Clean Agents on Burning Polymeric Materials Subjected to an External Energy Source," Halon Options Technical Working Conference Proceedings, Albuquerque, NM, April 27-29, 1999.

History of Class C Fire Tests

11. Smith, D.M., Niemann, R.; Bengtson, G.; “Examination and Comparison of Existing Halon Alternatives and New Sustainable Clean Agent Technology in Suppressing Continuously Energized Fires. Smith, D. M.; Halon Options Technical Working Conference Proceedings, Albuquerque, NM, April 24-26, 2001.

12. Bengtson, G.; Flamm, J. G.; Niemann, R.; “Update on the Evaluation of Selected NFPA 2001, Agents for Suppressing Class "C" Energized Fires Featuring C6 F-Ketone,” Halon Options Technical Working Conference Proceedings, Albuquerque, NM, 2002.

13. Bengtson, G.; Flamm, J. G.; Niemann, R., “Update on the Examination and Comparison of Existing Halon Alternatives and New Sustainable Clean Agent Technology in Suppressing Continuously Energized Fires,” Halon Options Technical Working Conference Proceedings, Albuquerque, NM, 2002.

Energized Fire Tests

#1

1996

EVALUATION OF SELECTED NFPA 2001 AGENTS
FOR SUPPRESSING CLASS "C" ENERGIZED FIRES

Richard Niemann, Harvey Bayless, and Craig Craft
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INTRODUCTION.

A review of total flooding fire extinguishing tests conducted on new clean agents by government agencies, universities and testing laboratories indicates that practically all of the tests have been conducted on Class " A and "B" fires. Limited guidance is available for conducting tests on Class "C" energized fires either in National Fire Protection Association (NFPA) Standard 2001 or testing laboratory standards. The Class "C" energized fire tests conducted by one testing laboratory employed a high energy electric arc as the ignition source. They acknowledged that this high energy level was a worst case heat scenario used to generate decomposition products and should not be considered as representative of low energy levels found in typical electronic systems.

In response to a number of electronics customers who had expressed a requirement to maintain power to essential electronic circuits in the event of a fire, Modular Protection Corporation decided to perform an in-house evaluation of selected NFPA 2001 agents for suppressing Class "C" energized fires.

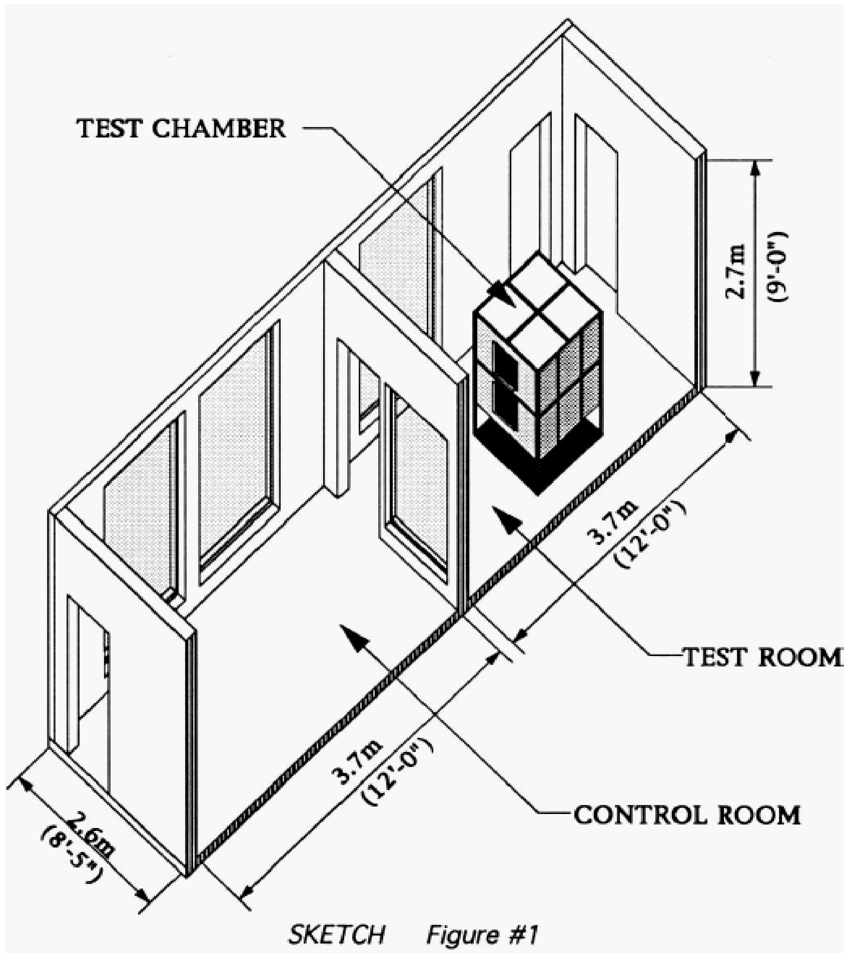
OBJECTIVE:

The objective of the tests was to investigate the effectiveness of new clean agents to extinguish Class "C" energized fires of polymeric materials ignited by nickel-chromium resistance wire energized by a Direct Current (DC) power source. Specific tests were conducted to determine: (1) minimum agent concenuation required to extinguish Class "C" energized fires, (2) minimum agent concentration required for inerting to prevent reignition and reflash.

AGENT SELECTION CRITERIA:

The criteria considered for selecting the new clean agents to be tested were that they must (1) have zero Ozone Depletion Potential (ODP), (2) be approved as a total flooding agent for use in occupied areas by EPA/SNAP and NFPA 2001.

Energized Fire Tests



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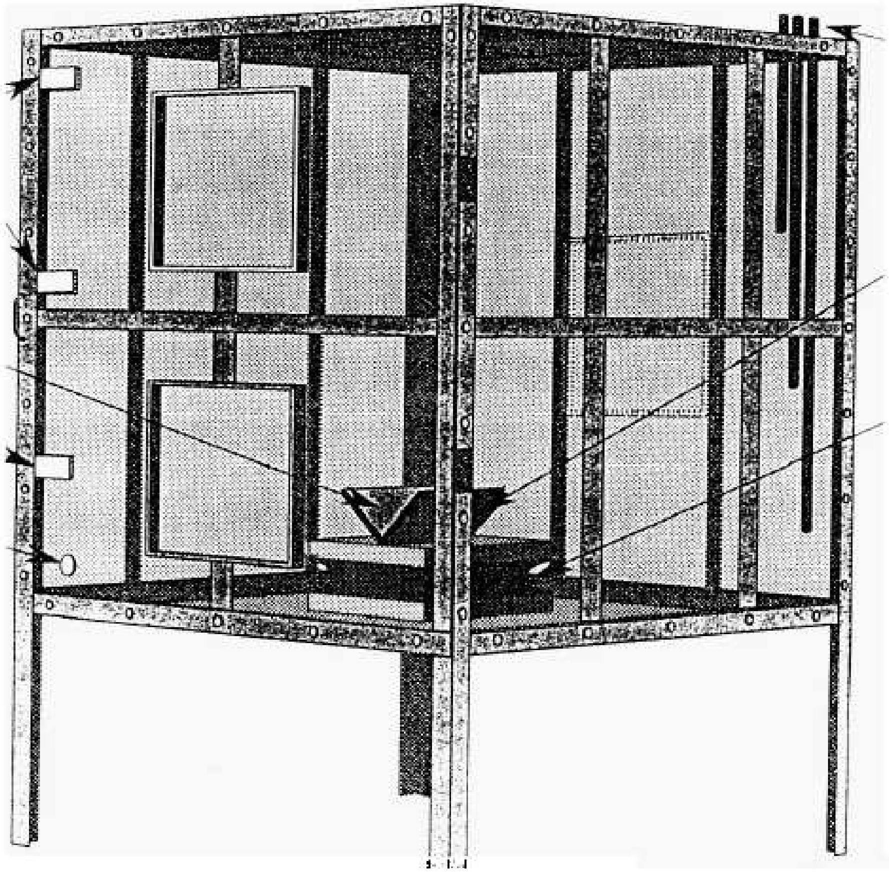
Energized Fire Tests



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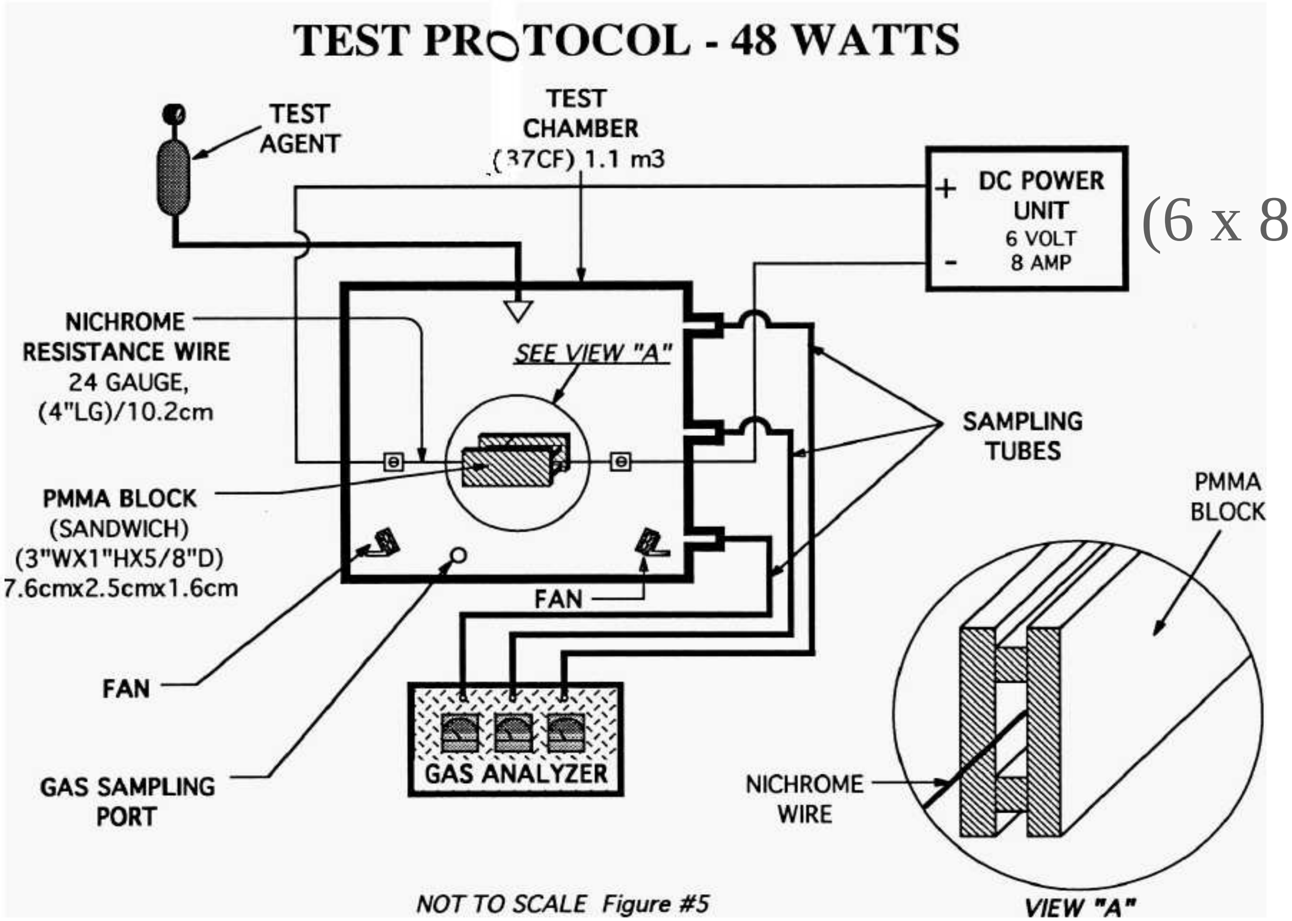
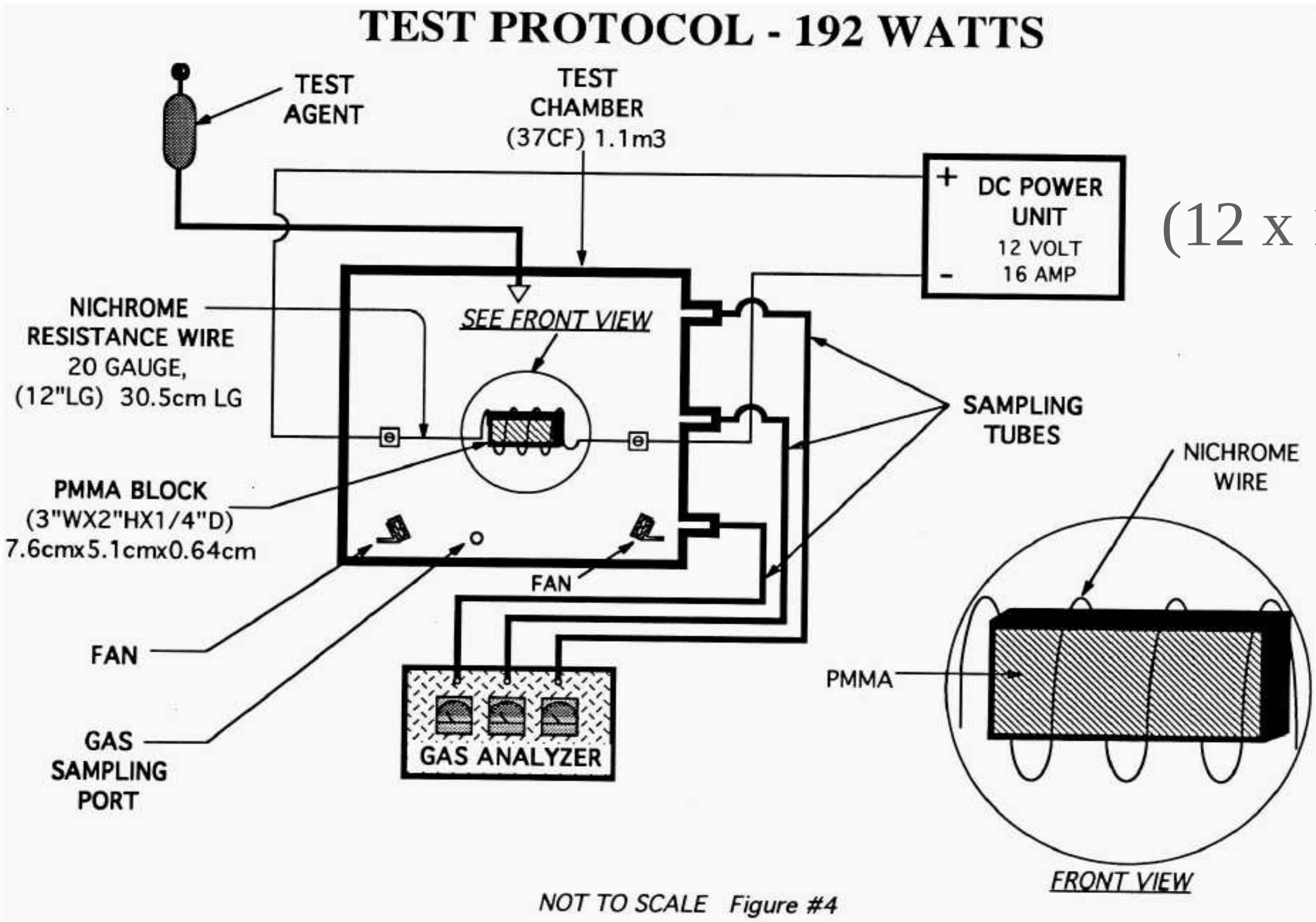


(6 x 8 = 48)

Energized Fire Tests



(12 x 16 = 192)

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Energized Fire Tests

CONCLUSIONS:

The following conclusions were reached:

- Clean agent extinguishing and inerting concentration values for Class "C" energized fires should be based on the energy levels to be protected. Higher energy circuits require higher agent concentration values for adequate fire protection.

- To prevent reflash or reignition of Class "C" energized fires, clean agent concentration values should be designed for the test inerting value plus a minimum 10% safety factor.

- The greater levels of HF generated using clean agent inerting concentrations to prevent reignition or reflash may make it necessary to limit the time that electronic circuits can be energized to prevent corrosion damage to sensitive electronic equipment.

Energized Fire Tests

#3

1997

Clean Extinguishing Agents and Continuously Energized Circuits: Recent Findings

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St. Paul, MN 55144-1000, USA
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Abstract

Recent testing by Niemann, et al[1] indicates that even low energy, 48 W and 192 W Class C energized fire scenarios require elevated clean agent concentrations for proper mitigation of the hazard (flame extinguishment and inertion). Agents included for that study are recognized by the NFPA 2001 standard as follows: FC-3-1-10 (CEA-410), HFC-227ea (FM-200), HFC-23 (FE-13) and IG-541 (Inergen).

This study, of which this paper reports in part, involves several phases. Phase I of the study[2] encompasses a modification of the cup burner apparatus included in NFPA 2001 "Standard on Clean Agent Fire Extinguishing Systems - 1996 ed.". Two terminals from a 1.2 kW DC power supply were fixed to the top of the burner and a length of nichrome resistance wire between them was employed to complete the circuit. The purpose of this experiment was to demonstrate the effect of a continuously energized circuit on extinguishing concentration for a steady fuel/energy scenario.

Phase II of that study extended the investigation to increased energy levels for the halocarbon agents. It is suspected that a point of diminished performance will be reached at which time the agent concentration may become excessive(above cardiotoxic limits). The magnitude of thermal decomposition was documented to illustrate whether adverse effects to sensitive equipment located within the protected enclosure should be expected. The purpose of Phase II testing was to demonstrate the performance capabilities of various clean agents on continuously energized fuel/energy sample on an intermediate scale scenario. Energy levels to 1500 W are expected to be tested in this test series.

Phase III testing (an extension of previous tests) involves analysis of similar continuously energized fuel samples and an initial quantification of the production of thermal decomposition products measured via advanced data analysis techniques. A number of items were discovered. A minimum agent concentration exists below which extinguishment or prevention of reignition does not occur for a given fuel/energy scenario. In fact, insufficient agent concentration resulted in continuous or intermittent flaming of the sample causing continuous agent breakdown at a decomposition rate as high as 8-10 ppmv/sec. The HF to COF_2 ratio of total thermal decomposition products levels reported was found to be in the range of 1.5-5:1 depending upon agent concentration with HFC-23 having the lowest ratio(most COF_2 in the mix) and FC-2-1-8 having the highest ratio. Degradation of agent concentration in the volume does not occur in quantities sufficient to cause reignition of the test sample after initial extinguishment. In other words, the sample is reigniting for reasons other than a reduction in agent concentration or agent loss. Increases in agent concentration seemed to show an improvement in performance in terms of extinguishment, prevention of reignition and reduction of TDP. Performance leveled off, particularly with regard to thermal decomposition at the higher concentrations for this fuel energy scenario.

Results indicate a need for elevated design concentrations to effect faster extinguishment, minimize thermal decomposition and to assure sufficient time to respond to a real energized fire event. This is in agreement with previous studies of energized systems, electrical or otherwise. Finally, the limited data quantifying the characteristics of this type of fire illustrates the lack of guidance to the fire professional in designing active fire suppression for energized electrical hazards and the need for quantitative performance-based design criteria.

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[1] R. Neimann, H. Bayless, and C. Craft, Modular Protection Group, "Evaluation of Selected NFPA 2001 Agents for Suppressing Class 'C' Energized Fires", Halon Options Technical Working Conference Proceedings, May 7-9, 1996, pp. 399-412.

[2] M. Driscoll, P. Rivers, "Clean Extinguishing Agents and Continuously Energized Circuits", presented at the NIST Annual Conference of Fire Research, Gaithersburg, MD, October 28-31, 1996.

Energized Fire Tests

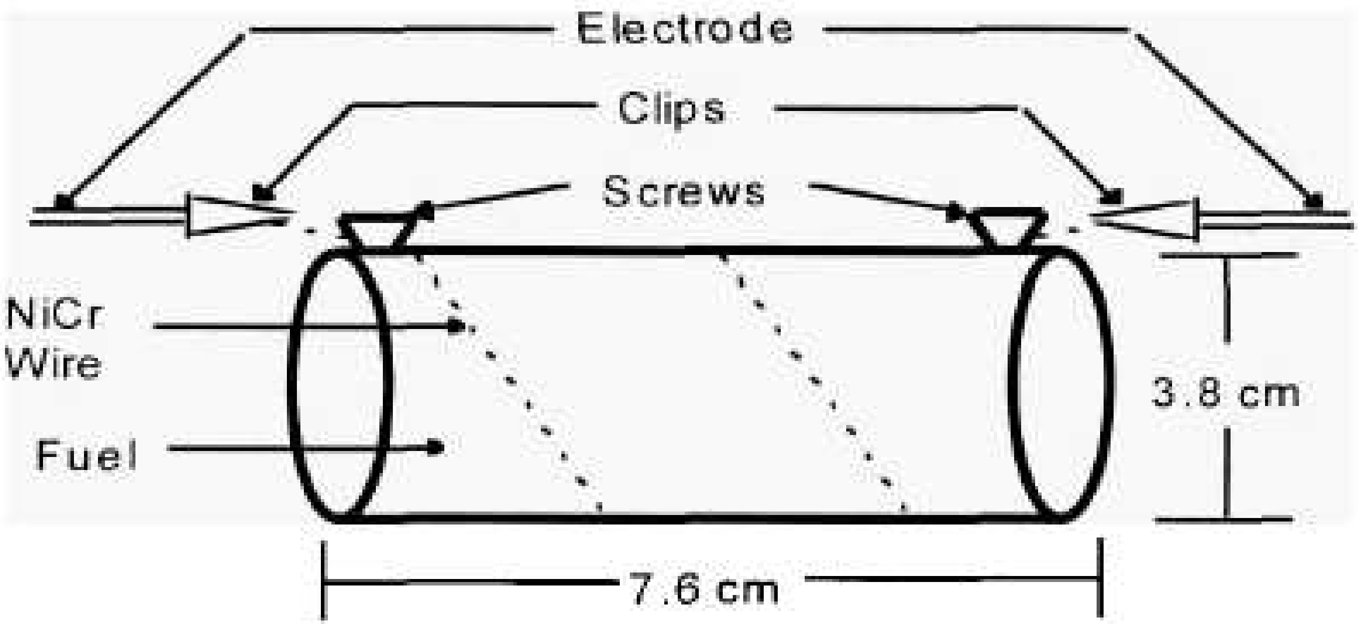

Figure 1: Configuration No. 3 - Fuel/energy scheme

Energized Fire Tests

Conclusions

This research resulted in the following conclusions:

1. For a given fuel/energy configuration there will exist a minimum agent concentration below which flame suppression will not be complete (e.g. no flame extinguishment or re-ignition following initial flame extinction).
2. Agent concentration traces verified that sample re-ignition, following initial sample flame extinguishment, was not the result of agent breakdown or loss from the test enclosure but more likely due to the presence of a continuous ignition source.
3. Levels of HF were approximately 1.5 to 5 times higher than corresponding levels of COF, depending on the agent.
4. Inadequate enclosure agent concentrations (no flame extinguishment or reignition following initial flame extinguishment) resulted in continuous agent breakdown, via intermittent sample flaming, and TDP generation rates as high as 8 - 10 ppmv/second.
5. Increases in agent concentration resulted in performance improvements (decreased flame extinguishment times, no sample re-ignition, and lower enclosure TDP levels). Due to the absence of an appropriate definition for flame extinguishment, as applied to Class C testing, there existed no consistent relationship between sample extinguishment time and TDP levels.
6. Future work needs to be directed at higher energy levels added to the system increasing from the 225 watt system used here up to 1.5 kW in energized power added. This may show heat release rates from the test samples up to 5 kW, the size of a typical circuit board in a switch bay, as an example. It may also indicate a practical circuit capacity limit for the use of clean agents in energized Class C fire scenarios above which they would they would be inappropriate for use.
7. In addition to the test configuration included in this to date, an arcing configuration would be interesting to examine as a test series to quantify agent performance on that type of fire.

Energized Fire Tests

#7

1998

DRAFT

EXTINGUISHMENT TESTS OF
CONTINUOUSLY ENERGIZED CLASS C FIRES
USING HFC-227EA
(FM-200™)

PREPARED FOR:

GREAT LAKES CHEMICAL COMPANY

WEST LAFAYETTE, IN 47906

PREPARED BY:

L. A. MCKENNA JR.
D. T. GOTTUK
P. J. DINENNO
S. MEHTA

HUGHES ASSOCIATES, INC.
3610 COMMERCE DRIVE, SUITE 817
BALTIMORE, MD 21227-1652
(410) 737-8688

23 FEBRUARY 1998

Energized Fire Tests

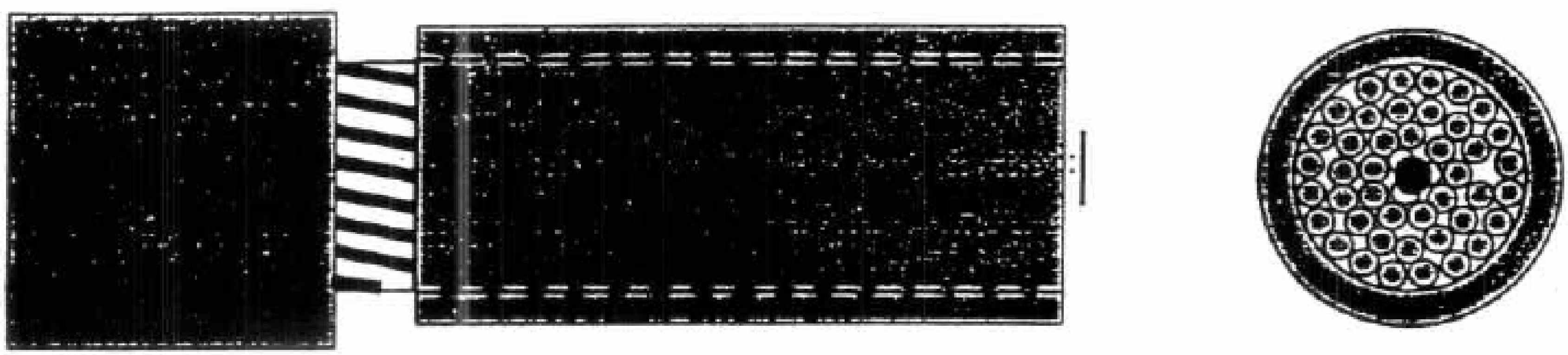

Figure 1. Overheated Connection Test - Details of Cable Attachment

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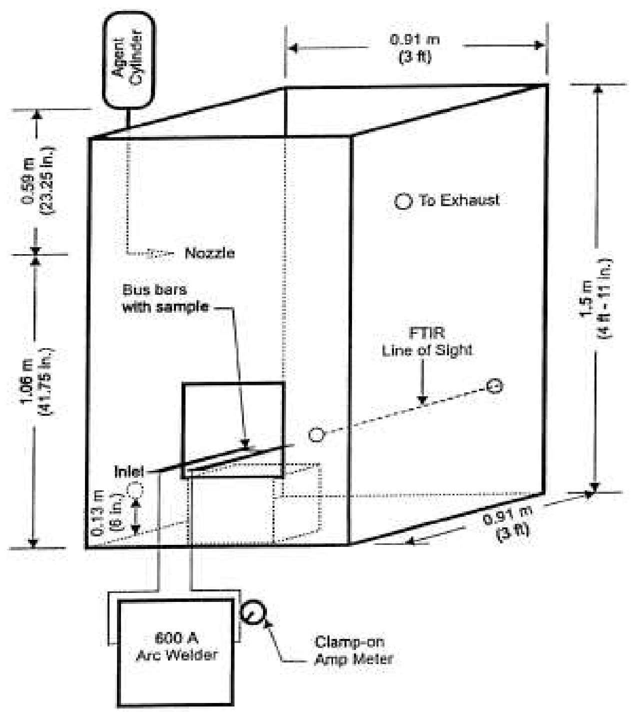
Energized Fire Tests



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Energized Fire Tests

The results presented in Section III-D for the ohmic heating tests demonstrate that HFC-227ea was effective at extinguishing energized electrical cable fires at the minimum design concentration of 7.0 % by volume used for Class A and Class B fuels. For all material types tested, fire extinguishment was achieved at concentrations of 6.8% or less. For XLPE, SJTW-A and Neoprene over rubber electrical cables, fire extinguishment was achieved at concentrations of 5.8 % (the minimum reported cup burner concentration [DiNenno]) to as low as 5.0 % by volume.

Energized Fire Tests

In conclusion, although a fairly realistic test scenario was developed, there are a number of factors that point out the difficulty of developing an energized electrical cable fire as a result of ohmic heating. First, most wires tended to either smolder, melt, or char or the wires would fuse due to the thermal stress of the current overload. It was difficult to find a wire type (also manufacturer dependant) that would actually auto-ignite due to ohmic heating instead of smoldering/fusing. Secondly, establishing an energized electrical fire required a pilot flame for the reasons stated above. Thirdly, unless wires are bundled, it is difficult to establish a fire of any considerable size or duration.

Energized Fire Tests

The results presented here for the conductive heating tests demonstrate that HFC-227ea was effective at extinguishing cable fires at the minimum design concentration of 7.0 % by volume used for Class A and Class B fuels. For all material types tested, fire extinguishment was achieved at concentrations of 6.0% or less.

Energized Fire Tests

#10

1999

EFFECTIVENESS OF CLEAN AGENTS ON BURNING POLYMERIC MATERIALS SUBJECTED TO AN EXTERNAL ENERGY SOURCE

David M. Smith and Paul E. Rivers
3M Chemicals
St. Paul, MN 55144-1000, USA

INTRODUCTION

Testing over the past few years has shown that liquid and solid fuel fires burning in the presence of an uninterrupted electrical energy source can be more difficult to extinguish than those fires burning without such a source [1,2,3]. This situation can pose problems to a system designer during selection of a proper extinguishing design concentration. Critical applications exist where electrical energy passing through the equipment cannot be immediately and automatically powered down or turned off. In a Class C fire event, an uninterrupted power supply can continue to reignite the Class A or B fuels within close proximity. If sufficient electrical energy remains on during and after a system discharge, tests have also shown that, with inadequate agent concentration, surrounding materials may readily reignite.

The NFPA 2001 Standard on Clean Agent Fire Extinguishing Systems [4] provides guidance for selection of design concentrations for clean extinguishing agents. The design concentration is found by adding a safety factor to the minimum extinguishing concentration for a given fuel, determined by the cup-burner method [5] or by full-scale testing. Section A-1-4.2.3 of NFPA 2001 suggests that clean agents are suitable for use around electrical equipment. This same section continues to describe that the electrical equipment could be the source of ignition and should be powered down prior to or during the agent discharge. Section A-3-7 provides the following additional guidance:

> Energized electrical equipment that might provide a prolonged ignition source should be de-energized prior to and during agent discharge. If electrical equipment cannot be de-energized, consideration should be given to the use of extended discharge, the use of higher initial concentration, and the possibility of the formation of combustion and decomposition products [4].

No criteria for identifying the appropriate agent concentration in the event that electrical equipment cannot be immediately and automatically de-energized are provided. Therefore, for facilities where immediate power-down is not desirable or not an option. information needs to be provided outlining appropriate extended discharge times or appropriate higher level of initial concentrations. This research continues the ongoing effort to quantify those criteria.

PURPOSE AND OBJECTIVES

During the past two years, testing at the National Institute of Standards and Technology (NIST) has shown that current minimum design concentrations may be inadequate to extinguish fires of polymeric materials when subjected to an electrical energy source [6]. Additionally, as levels of radiant energy are increased, there is a need for higher extinguishing concentrations to achieve flame extinction and maintain fire control.

Energized Fire Tests

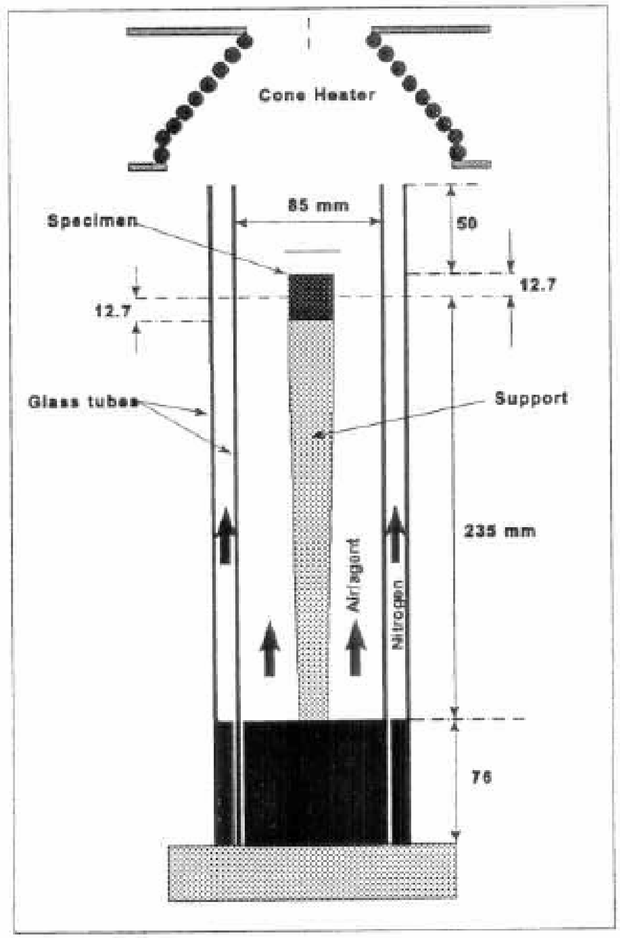

Figure 2: Second-Generation Modified Cup Burner

SFPE

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Energized Fire Tests

CONCLUSIONS

These tests have confirmed that more research is necessary to understand the effect of continuously energized equipment on extinguishing concentrations for halon alternatives. The need for higher concentrations for fuels subjected to continuously energized electrical sources was again proven through tests conducted in a separate facility using the same materials and an apparatus similar to that used previously at NIST [6]. These results are consistent with trends observed with different fuels and geometry by Braun [1], Driscoll and Rivers [2], and Niemann [3]. Initial indications that extinguishing concentrations as high as 3.2 times published cup-burner values are needed may need to be re-examined, although recent tests indicate values would remain near 2.5 times the cup-burner values published by NIST. This decrease should not affect the efforts being put forth, yet increase the need to determine a proper method of evaluation.

The results of these tests are preliminary and are being used to determine an appropriate method for evaluation. A direct correlation linking these test results to conditions in the field during an electrically energized fire does not yet exist. The REED does have advantages over previous work using hot metal surfaces, for the device closely resembles the cup-burner apparatus, an internationally recognized test method. In addition. the REED can provide comparison data with respect to the extinguishing concentration at a given energy level versus the No Observable Adverse Effect Levels (NOAEL) also listed in NFPA 2001. Using these criteria, design concentrations for N_2, IG-541, and HFC-227ea at energy levels above 20 kW/m^2 would then be above their respective NOAEL thresholds.

Energized Fire Tests

#11

2001

EXAMINATION AND COMPARISON OF EXISTING HALON ALTERNATIVES
AND NEW SUSTAINABLE CLEAN AGENT TECHNOLOGY IN
SUPPRESSING CONTINUOUSLY ENERGIZED FIRES

David M. Smith
Western Fire Center

Richard Niemann and Gordon Bengtson
Modular Protection Group, Inc.

ABSTRACT

This paper describes the results from testing the effectiveness of halon alternatives in extinguishing a tire scenario representing continuously energized electrical equipment. Three likely modes of failure in telecommunications facilities have been identified and three fire tests to examine these scenarios have been developed.' Objectives of this study were to replicate and verify that extinguishment could be accomplished using HFC-227ea design concentrations at and slightly lower than the minimum cup-burner level and to assess the ability of 3M Company's experimental product L-15566 in suppressing tires using the Conductive Heating Test protocol from their report. An additional goal was to evaluate the effect of a constant electrical arc or ignition source above the sample using these same extinguishing agents and design levels.

INTRODUCTION

The National Fire Protection Association (NFPA) Standard 2001, *Standard for Clean* Agents, provides guidelines for the design and installation of clean agent total-flooding systems as determined by the consensus standards writing process. It is this standard that provides necessary information to system designers as to the properties of the agents and system installation guidelines including appropriate design concentrations. Minimum design concentrations specified in NFPA 2001 are determined for either Class A or Class B fuel fires. Currently, no standard test method exists, which are agreed upon by industry leaders, to provide a fair representation of a Class C, energized electrical fire event. As a result, guidance for designing a system to protect electrical equipment areas where de-energizing the equipment is not an immediate option has been limited to the following suggestion found in the 1996 Edition, Appendix, NFPA 2001,

> A-3-7: Energized electrical equipment that might provide a prolonged ignition source should be de-energized prior to or during agent discharge. If electrical equipment cannot be de-energized, consideration should be given to the use of extended discharge, the use of higher initial concentration, and the possibility of the formulation of combustion and decomposition products [1].

Test methods have been developed during the past several years in efforts to quantify this phenomenon and include energized wires surrounding polymethylmethacrylate (PMMA) [2, 3], energized wires across the top of the cup-burner apparatus [4], hot metal surfaces [5], and radiant conical heaters [6]. However, the most recent tests conducted utilized various electrical cables placed inside a circular electric heater to replicate an overheated connection achieved by passing high current through small cable bundles placed between copper bus bars [7].

New test data from the two most recent test methods mentioned above has been included in Appendix A-3-6 of NFPA 2001, 2000 Edition [7]. This information indicates that design concentrations as low as 5.2% and 5.0% [V/V] of HFC-227ea are capable of extinguishing and preventing re-ignition of energized cable fires using the Conductive Heating Test and Ohmic Heating Test protocols, respectively.

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harrington group
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Energized Fire Tests

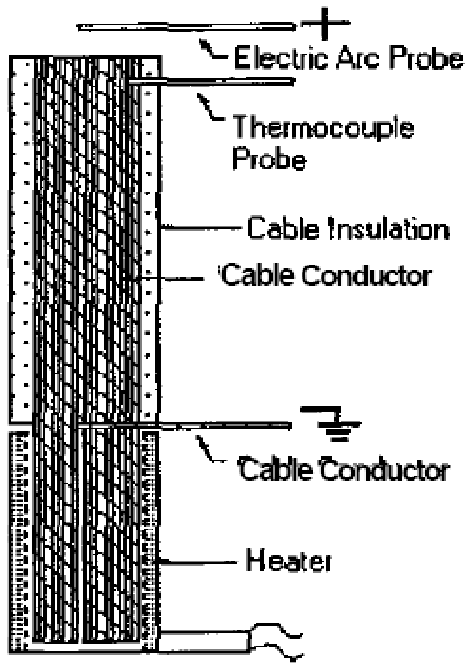

Figure 2. Test setup for modified conductive heating test.

Energized Fire Tests

TABLE 6. DETAILS OF SELECTED MODIFIED CONDUCTIVE HEATING TESTS.

Test	Agent Tested	Cable Type	Design Concentration [%]	Ignition [s]	Discharge Time [s]	Time of Initial Ext. [s]	Reignition [Yes/No]
CONDO24			5.6	534	606	DNE	DNE
CONDO53			5.6	615	675	DNE	DNE
CONDO25			7.0	537	608	848	Yes
CONDO51	HFC-227ea	KS-5482L28FR	8.0	603	663	DNE	DNE
CONDO52			8.0	690	750	766	No
CONDO50			11.0	555	615	639	Yes
CONDO23			11.0	510	580	702	Yes
CONDO26			5.3	498	578	DNE	DNE
CONDO15			5.6	486	530	DNE	DNE
CONDO21			7.0	509	582	DNE	DNE
CONDO20	HFC-227ea	KS-20921L2	8.0	483	543	661	Yes
CONDO47			8.0	536	596	615	No
CONDO48			8.0	587	647	DNE	DNE
COND017			11.0	460	532	832	No
CONDO49			11.0	495	555	584	No

Proposed Changes

- **Existing Sec. 5.4.2.5**
  - Minimum design concentration for Class C hazards <u>shall be at least that for Class A surface fires</u>

Proposed Changes

- **Proposed Sec. 5.4.2.5**
  - Where Class C fire hazards are de-energized, the minimum design concentration shall be in accordance with either 5.4.2.3 or 5.4.2.4 depending on whether it becomes a Class A or Class B fire hazard

Proposed Changes

- **Proposed Sec. 5.4.2.5.1**
  - Where electrical equipment cannot be de-energized, the design concentrations provided in 5.4.2.3 *(Class B)* and 5.4.2.4 *(Class A)* shall be considered inadequate

Proposed Changes

- **Proposed Sec. 5.4.2.5.2***
  - A minimum design concentration shall be determined by multiplying the flame extinguishing concentration as determined in 5.4.2.2 ***(Class A fuels)*** times a safety factor of 1.6 where the power dissipation from an electric circuit failure is not likely to exceed 1500 W continuous.

**Plus new annex guidance*

Proposed Changes

- **Proposed Sec. 5.4.2.5.3**
  - Where the power dissipation exceeds this value, <u>higher concentrations shall be specified</u>.

Proposed Changes

- **Proposed Sec. 5.4.2.5.4**
  - A written emergency response plan based on the response time of emergency personnel shall be implemented.

Example

- Hazard: Telecommunications room – 48 volt DC continuously engergized equipment – cannot de-energize – maximum expected continuous energy dissipation is 1500 W.

Example

- **Clean Agent Candidates:**
  - FK-5-1-12
  - HFC-125
  - HFC-227ea
  - HFC-23
  - IG-541

Example

- Minimum design concentration (MDC) equals the minimum extinguishing concentration for Class A surface fire (MEC^A) times a safety factor of 1.6
- $MDC = MEC^A \times 1.6$

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Example

	MEC CLASS A	CLASS C SAFETY FACTOR	MDC CLASS C
FK-5-1-12	3.50%	1.6	5.60%
HFC-125	6.70%	1.6	10.70%
HFC-227ea (Listing A)	5.80%	1.6	9.28%
HFC-227ea (Listing B)	5.25%	1.6	8.40%
HFC-23	15.00%	1.6	24.00%
IG-541	28.50%	1.6	45.60%

Example

	MEC (Class A)	Class C Safety Factor	MDC (Class C)	5-min exposure time - Max %
FK-5-1-12	3.50%	1.6	5.60%	10.00%
HFC-125	6.70%	1.6	10.70%	11.50%
HFC-227ea (Listing A)	5.80%	1.6	9.28%	10.50%
HFC-227ea (Listing B)	5.25%	1.6	8.40%	10.50%
HFC-23	15.00%	1.6	24.00%	30.00%
IG-541	28.50%	1.6	45.60%	43.00%

Example

	MEC (Class A)	Class A Safety Factor	MDC (Class A)	MDC (Class C)	ADDITIONAL CLASS C
FK-5-1-12	3.50%	1.2	4.20%	5.60%	1.33
HFC-125	6.70%	1.2	8.00%	10.70%	1.33
HFC-227ea (Listing A)	5.80%	1.2	7.00%	9.28%	1.33
HFC-227ea (Listing B)	5.25%	1.2	6.25%	8.40%	1.33
HFC-23	15.00%	1.2	18.00%	24.00%	1.33
IG-541	28.50%	1.2	37.50%	45.60%	1.33

WHAT NEXT?

- **Just guessing but…**
  - Interested groups are changing their mind
  - Not happy with the mandatory 1.6 safety factor – put in annex as advisory only
  - Want to develop standardized test method
  - This issue likely will be debated on the floor at NFPA June meeting in Boston

WHAT NEXT?

- **In the mean time consider…**
  - Many tests have shown that Class C fire hazards sometimes require higher concentrations of clean agent to achieve fire extinguishment and prevent re-flash during the hold time
  - Concentrations greater than Class A times 1.2 may be required.
  - Class A times 1.6 may be a good rule of thumb until an industry-accepted test standard is developed

Q & A

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