Fire Protection for Electronic Equipment

Mark L. Robin, Ph.D.
DuPont Fluoroproducts

Presented at:
2010 SFPE-SAC Conference
Al-Khobar, Saudi Arabia
October 19, 2010
Electronics/Electronic Computers

- Rapid development in recent decades
  - Electronics, hardware, application programs
- New industries
  - Internet & Telecommunications Industries
1946: ENIAC: World’s First Electronic Computer
  - Electronic Numerical Integrator And Computer

- 30 tons
- 1,500 ft²
- 19,000 vacuum tubes
- 5,000 additions/sec

Nuclear Physics Problem:
ENIAC  2 hours
Man    100 engineers, one year
Electronic Computers

- 1951: UNIVAC
  - (Universal Automatic Computer)

- 29 tons
- 112 ft²
- 5,600 vacuum tubes
- 18,000 crystal diodes
- 300 relays
- 8,000 additions/sec
Electronic Computers

1971: Intel 4004 CPU
- Single chip microprocessor
- 2,300 transistors
- 92,000 IPS

2010: Intel Core i7 (32 nm)
- 42 x 45 mm
- 560,000,000 transistors
- 150,000,000,000 IPS
Electronic Equipment

- Plays essential role in business operation
- Computer and other electronic equipment are particularly susceptible to fire damage
  - Heat, steam, combustion products
- Financial impact of service interruptions due to electronic equipment failure can be severe
  - Particularly in energy, telecommunication industries
19 hour loss
Cost: $4.8 billion

22 hour outage
Cost: $200,000 per hour

2 outages - 1 hour each
Cost: $1.5 billion
Information Technology (IT) Facilities

- Vast array of electronic devices connected together and configured to analyze, collect, distribute, manage and store information
  - Computers
  - Blades & blade servers
  - Local Area Networks (LAN)
  - Magnetic tape libraries
  - Converters
  - Servers
  - Routers
  - Switches
  - Storage area networks (SAN)
  - Direct access storage devices (DASD)
IT Facilities

- **Support Equipment**
  - Computer rated air-conditioning units (CRACs)
  - Power distribution units (PDUs)
  - Uninterruptable power supplies (UPSs)

- **Specialized Electronics**
  - Control and Automation Electronics
    - *Petroleum, steel, paper production*
    - *Semiconductor fabrication*
    - *Telecommunications*
    - *Automation systems: Assembly lines, robotics*
IT Facilities: Fire History

- Fire History
  - Typically involve small fires
  - Potentially large impact
    - Sensitive, expensive equipment
    - Cost of downtime
  - Leading cause: electrical distribution equipment
    - Wires, cables, cord, plugs, outlets

- Fire Hazard
  - Fuel load primarily electronic equipment and power cables: plastics
  - Can be electrically energized
IT Facilities: Fire Protection

- NFPA 75 Standard for the Protection of Information Technology Equipment
- Standards specify construction requirements of
  - Electronic equipment itself
  - Building housing the electronic equipment
  - Material and equipment permitted in IT facilities

Reduce the Potential for Fire
IT Facilities: Fire Protection

- NFPA 75
  - Only computer and IT equipment and support equipment are permitted in the computer room
  - Office furniture within the computer room must be of metal construction
  - The amount of records within the computer room must be kept to the absolute minimum required for essential and efficient operation
  - Rooms used for the storage of records are to be separated from the computer area by fire-resistive construction
Telecommunications

- Originally single service industry: telephone service
- In a short time, progressed to include:
  - Telephone service
  - ATMs
  - Teleconferencing services
  - Video conferencing services
  - Electronic funds transfer
  - Cable TV
  - Internet access
# Hazard Areas in Telecommunications Facilities

<table>
<thead>
<tr>
<th>Area</th>
<th>Contents</th>
<th>Fire Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telecommunications</td>
<td>Electronic equipment in racks or cabinets or under a raised floor</td>
<td>Slow developing, smoky fires with heat release rates of typically 5 to 15 kW, which do not exceed 150 kW for fully involved cabinet or rack</td>
</tr>
<tr>
<td>equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable entrance facility</td>
<td>Cables with no fire resistance rating entering building from outside and spliced to rated cables</td>
<td>High or low heat release rate fires</td>
</tr>
<tr>
<td>Power areas</td>
<td>Batteries on racks Switchgear, Rectifiers Bus bars, cables</td>
<td>Low heat release rate fires</td>
</tr>
</tbody>
</table>
### Hazard Areas in Telecommunications Facilities

<table>
<thead>
<tr>
<th>Area</th>
<th>Contents</th>
<th>Fire Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main distribution frame</td>
<td>Large quantities of low voltage communications wire</td>
<td>Low to medium heat release rate smoky fires</td>
</tr>
<tr>
<td>Standby engine area</td>
<td>Generator powered by internal combustion engine; Fuel day tank Starting batteries</td>
<td>Electrical or fuel fires</td>
</tr>
<tr>
<td>Tech support areas</td>
<td>Metal desks, cabinets, tools, equipment</td>
<td>Same as for telecommunications equipment since combustibles load is small</td>
</tr>
</tbody>
</table>
Telecommunication Facilities

- **Fire History**
  - Typically involve small fires (5 to 10 kW)
  - Potentially large impact
    - Sensitive, expensive equipment
    - High downtime cost
    - In a disruption, all information in transit lost
  - Leading cause: electrical distribution equipment
    - Wires, PC boards, transformers, plastic housings

- **Fire Hazard**
  - Fuel load primarily electronic equipment and power cables: plastics
  - Can be electrically energized
Telecommunication Facilities: Fire Protection

- NFPA 76 Standard for the Fire Protection of Telecommunication Facilities
- Construction requirements similar to NFPA 75
Electronic Equipment: Fire Damage

- Thermal Damage
  - Due to fire itself (heat)

- Non-thermal Damage: Combustion Products
  - Smoke, soot, water, acids

- Non-thermal Damage: Suppression Agent
  - e.g., water, foam, dry chemical

Electronic equipment is very susceptible to damage from fire
## Electronics: Thermal Damage

<table>
<thead>
<tr>
<th>Component</th>
<th>Onset of Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage media (magnetic tape, floppies, etc.)</td>
<td>125 °F (52 °C)</td>
</tr>
<tr>
<td>Hard drives</td>
<td>150 °F (66 °C)</td>
</tr>
<tr>
<td>Electronic components</td>
<td>174 °F (79 °C)</td>
</tr>
<tr>
<td>Paper</td>
<td>350 °F (177 °C)</td>
</tr>
<tr>
<td>Polystyrene cases, reels</td>
<td>650 °F (310 °C)</td>
</tr>
<tr>
<td>Microfilm</td>
<td>225 °F (107 °C)</td>
</tr>
</tbody>
</table>
Electronics: Non-Thermal Damage from Combustion Products

- Steam, Smoke, Soot, Various Combustion Products
- Hydrogen Chloride
  - From combustion of PVC
  - Reacts with galvanized zinc components forming ZnCl₂
  - ZnCl₂ layer formed, reacts with humidity to produce a corrosive ZnCl₂ solution
- Corrosive Combustion Gases
  - HF, HBr, SO₂, CH₃COOH, NO₂, HCN
Electronics: Non-Thermal Damage from Combustion Products

- **Smoke**
  - Hard drive damage by particulates as small as 0.5 micron

- **Non-conductive Soots**
  - Formed from smoldering, slow growth fires
  - Deposit out on horizontal surfaces, forming insulating layer which can interrupt electrical contacts

- **Conductive Soots**
  - Formed from rapidly growing fires
  - Deposit on horizontal and vertical surfaces leading to electrical shorting
Electronics: Non-Thermal Damage from Suppression Agent
Suppression Systems for Electronic Equipment Fires

- **Clean Agent Systems**
  - *Traditional protection for expensive, sensitive equipment*
  - *Rapid detection, rapid extinguishment*
  - *No residues, no cleanup, no downtime*
  - *Three-dimensional: can extinguish hidden, obstructed fires*

- **Original clean agent: Halon 1301**
  - Restricted use due to Montreal Protocol
  - As of 2010 no production for fire suppression purposes

- **Current Clean Agents/Halon 1301 Replacements**
  - Halocarbon-Based: FM-200® (CF₃CHFCF₃)
  - Inert Gases: Inergen™ (N₂ / Ar / CO₂)
Suppression Systems for Electronic Equipment Fires

- **Sprinklers?**
  - Large fire sizes at activation
    - increased damage vs clean agents
  - Design objective is control
  - Electronics sensitive to water
  - Extensive cleanup and downtime
    - Water and smoke damage
  - Water not three dimensional
    - Inability to extinguish hidden, obstructed fire

*For protection of the STRUCTURE, not its contents*
Suppression Systems for Electronic Equipment Fires

- *Water Mist?*
  - Poor performance on small fires
  - Water mist is not three dimensional
    - Poor performance on hidden fires
  - Electronics sensitive to water
  - Cleanup and downtime
Clean Agents: Class A Fires

- **NFPA 2001**
  
  Class A minimum extinguishing concentration (MEC) determined as part of system listing

  UL 2166: Wood crib & plastic sheet tests (PMMA/PP/ABS)

  Minimum design concentration (MDC)

  \[
  \text{MDC} = 1.2 \times \text{MEC}
  \]

  Typical IT/Telco Facility

  7 % FM-200®

  34.2 % Inergen™
Class C Fires

- NFPA 10 (2010 edition), Section 5.2.3
  - Class C fires are fires that involve energized electrical equipment.

- Very few studies – with any suppression agents
  - Electronic equipment testing reported – no current flow
  - Tests with current flow, but test conditions/materials not representative of real hazards
  - Tests with current flow, representative materials/conditions
    - Hughes Associates, Inc. (McKenna, et. al.): FM-200®
    - Fike Corporation/DuPont (Robin, et. al.): Halocarbons/Inert Gases
Class C Hazards

- Typical Class C Hazards
  - IT and Telecommunications facilities
    - Cables, electronic equipment

- Power Conduction
  - Almost always copper
  - Small percentage aluminum

- Power Cable Insulation
  - Majority PVC, FR-PVC, PE, HDPE
  - Some Hypalon, XLPO
Hughes Associates

- Investigated three Class C fire scenarios
- Representative materials and conditions
  - Simulated overheated cables
  - Simulated overheated wire
  - Simulated PC board arcing failure
- Electrically energized through preburn, ignition, suppression and soak time
- Tests with FM-200®

Conclusion: Class A design concentration of FM-200® is sufficient for the suppression of Class C fires typical of IT/telecommunication facilities

McKenna, et. al., 1998 HOTWC
Plastic Slab Tests

- Plastic samples ignited by electrically energized Nichrome (Ni-Cr) wire heated to 1800 °C
  (Note: copper wire rapidly fuses at 1000 °C)
- Current flow maintained throughout ignition, preburn, suppression, and 10 minute soak period
- PMMA, ABS, PVC, HDPE, PP
- Halocarbon & Inert Gas Clean Agents

Class A design concentration of clean agents is sufficient for the extinguishment of Class C fires involving materials encountered in IT/Telco facilities

Robin, et. al., 2007 SUPDET Conference;
Electrically Energized Cables

- PVC cable bundle
- Employ NiCr wire as ignition source and as heat source during preburn and soak periods
- Copper only able to withstand temperatures up to 1000 °F for extended periods
- Ignition, preburn and soak: NiCr @ 1800 °F

Challenging conditions – wire temperature 800 °F higher (almost twice) upper use limit of copper wire

Robin, et. al., 2008 SUPDET Conference
Belkin cable, 16 gauge PVC insulation/PVC jacket Bundle of seven 6” long cables

Energized 18 ga Nichrome wire inserted inside jacket of center cable
Electrically Energized PVC Cable
Fire Tests: Summary

- Fires extinguished at the Class A design concentration of clean agents

- Fires extinguished at as low as 30% below the Class A design concentration of clean agents

For clean agents, the Class A design concentration is sufficient for Class C hazards typical of IT/Telco facilities
Fire Protection for Electronic Equipment: Conclusions

- The fire history of IT/Telco facilities shows fires in these can lead to substantial damage and revenue loss.

- Fires in IT and telco facilities are characterized by low fuel loads, primarily involving wire insulation, PC boards, electronic components, transformers, insulating materials and plastic housings.

- Fires in IT/Telco facilities typically initiate from an overheat, short or arc condition, are of low energy output, often 5-10 kW and produce various amounts of toxic and corrosive combustion products.
Conclusions

- Clean agent systems offer the best protection option for sensitive and expensive electronics
  - Gaseous nature allows extinguishment of hidden or obstructed fire occurring anywhere within the protected area
  - Rapid detection/extinguishment minimizes damage
  - Lack of cleanup = minimal downtime
  - Suitable for Class A hazard protection
  - Suitable for Class C hazard protection
    - Only class of fire suppression agents extensively tested on Class C fires
    - Field Experience of 20 years