Safeguarding against

ELECTRICALLY- CAUSED FIRE

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agenda

• **DEFINITION**
  – ELECTRICALLY-CAUSED FIRE

• **SAFEGUARDS AGAINST ELECTRICAL IGNITION**
  – AUTOMATIC DISCONNECTION OF THE SUPPLY
  – LOW RATE OF THERMAL ENERGY TRANSFER TO A FUEL MATERIAL
  – APPLICATION OF FLAME RETARDANT MATERIALS

• **SAFEGUARDS AGAINST SPREAD OF FIRE**
  – PREVENT SPREAD OF FIRE FROM THE POINT OF IGNITION
  – PREVENT SPREAD OF FIRE THROUGH THE ENCLOSURE
Electrically-caused fire is

• electrical heating of a material to ignition temperature

followed by

• ignition and

• combustion.
Ignition and spread of fire

As with most manually-started fires, electrically-caused fires start with physically small (power-dissipating) heat sources that heat small units of adjacent fuel to ignition.

The small units of fuel ignite larger units of fuel, spreading the fire.
Electrical heating

Electrical heating occurs when ELECTRICAL ENERGY is converted to THERMAL ENERGY.

Electrical energy is converted to thermal energy in a RESISTANCE.

Electrical heating is expressed in WATTS.

\[ 1 \text{ watt} = 1 \text{ joule/second} \]

\[ P = I^2 \times R \]

\[ P = \frac{E^2}{R} \]

\[ P = E \times I \]
Normal operating conditions

ELECTRICALLY-CAUSED FIRES DO NOT OCCUR UNDER NORMAL OPERATING CONDITIONS.

Under normal operating conditions, the principal safeguard against fire is:

• *prevention of fuel material temperatures from exceeding rated material temperatures.*

*A principal safeguard is a safeguard that is effective under normal operating conditions whenever hazardous energy is present.*
Fault conditions

ELECTRICALLY-CAUSED FIRES ONLY OCCUR UNDER FAULT CONDITIONS.

Under fault conditions, the supplementary safeguards against fire are:
- prevention of ignition, and
- prevention of spread of fire, either within the equipment or from the equipment

A supplementary safeguard is a safeguard that is effective in the event of failure of the principal safeguard.
FIRE SAFEGUARDS

SAFEGUARDS AGAINST ELECTRICAL IGNITION

- devices for automatic disconnection of the supply
- low rate of thermal energy transfer to a fuel material
- application of flame-retardant materials

SAFEGUARDS AGAINST SPREAD-OF-FIRE

- prevent spread of fire from the point of ignition
- prevent spread of fire through the enclosure
Elements for safeguarding against ignition
IGNITION SAFEGUARDS

Resulting thermal energy insufficient to heat fuel to ignition temperature

Electrical energy less than 15 watts → Power dissipated in fault resistance → Fuel temperature less than ignition temperature

Power source less than the energy necessary for fuel ignition.
IGNITION SAFEGUARDS

- Electrical energy greater than 15 watts
- Automatic disconnect
- Power dissipated in fault resistance
- Fuel temperature normal

Power source exceeding the energy necessary for fuel ignition.

- Fuse
- Electronic latch-off
PYROLYTIC GASES

AND

THERMAL ENERGY

AND

FUEL MATERIAL

AND

ELECTRIC ENERGY

RESISTANCE
IGNITION SAFEGUARDS

Electrical energy to thermal energy
(Potential Ignition Source, PIS)

Electrical energy greater than 15 watts

Power dissipated in fault resistance

Fuel temperature increases

Candidate resistance can dissipate:
- more than the minimum power necessary for fuel ignition
- that power for more than the minimum time necessary for fuel ignition
- that power at a temperature greater than the ignition temperature of fuel material

Power source exceeding the energy necessary for fuel ignition.
## Examples of candidate resistances

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Examples of candidate resistances

Effects of load faults
\[ P = I^2 \times R \]
Examples of candidate resistances

Effects of distribution faults

\[ P = I^2 * R \]
Examples of candidate resistances

Effect of component faults.
\[ P = E \times I \]
Examples of candidate resistances

Effects of source faults.

\[ P = \frac{E^2}{R} \]

![Diagram showing a circuit with a fault, source resistance, load resistance, and power incident (PIS).]
~ 2X rated power, 76 W

Candidate resistances, 25-10 ohms

Latch-off, 10 ohms

Ratings: 31 V 0.8 A 35 W
Candidate power-dissipating devices (PIS)
IGNITION SAFEGUARDS

Resulting thermal energy insufficient to heat fuel to ignition temperature

- **Electrical energy greater than 15 watts**
- **Resistance less than or greater than overpower**
- **Fuel temperature less than ignition temperature**

Power source exceeding the energy necessary for fuel ignition.
PYROLYTIC GASES

AND

THERMAL ENERGY

AND

FUEL MATERIAL

AND

ELECTRIC ENERGY

RESISTANCE
IGNITION SAFEGUARDS

Thermal isolation between thermal source and fuel:

- **Electrical energy to thermal energy (PIS)**
- **Low rate of thermal energy transfer**
- **Fuel temperature remains low**

- **distance (keep-out zone)**
- **metal barrier (thermal energy spreader)**
IGNITION SAFEGUARDS
keep-out zone

metal barrier

potential ignition source (PIS)
Power dissipating devices with keep-out zones
PWB with adjacent parts

Plastic enclosure

Metal chassis
Metal chassis

Plastic enclosure

Flame-retardant material
PYROLYTIC GASES

AND

THERMAL ENERGY

AND

FUEL MATERIAL

ELECTRIC ENERGY

RESISTANCE
IGNITION SAFEGUARDS

Non-susceptible material:

- Electrical energy to thermal energy
- Thermal energy transfer
- Non-susceptible material

High-ignition temperature material
Flame-retardant material
Fuel material heat sink
SPREAD-OF-FIRE SAFEGUARDS
from the PIS

Small fire inside equipment → Fire-deflecting barrier → Fuel temperature remains low

metal barrier

small flame
SPREAD-OF-FIRE SAFEGUARDS
from within the equipment

- Fire inside equipment
- Prevent or slow flames from escaping
- Fire-containing enclosure
- Prevent or slow replenishing of oxygen
- External fuel temperature remains low
The fire-containing enclosure
Video Demonstration

4-mm diameter holes
5-mm diameter holes

What is the mechanism that prevents spread of fire through enclosure openings?
SPREAD-OF-FIRE SAFEGUARDS
fire enclosure openings

Metal cools the flaming gas to below ignition temperature (flame arrestor action)

Cooling depends on hole diameter, metal thickness, and hole-to-hole distance
end
safeguarding against electrically-caused fire

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