Safeguarding against

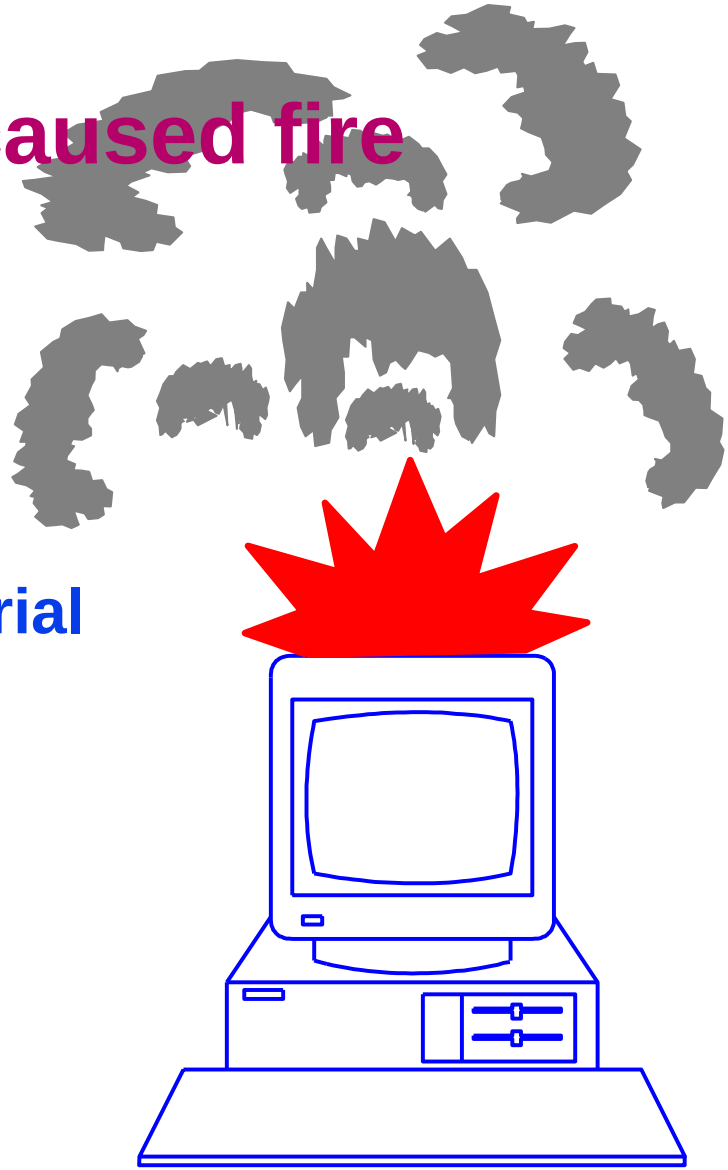
ELECTRICALLY- CAUSED FIRE

Richard Nute
Product Safety Consultant
San Diego

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 SPEARD OF FIRE THROUGH THE ENCLOSURE

Electrically-caused fire



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 watt = 1 joule/second

$$P = I^2 * R$$

$$P = E^2 / R$$

$$P = E * I$$

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

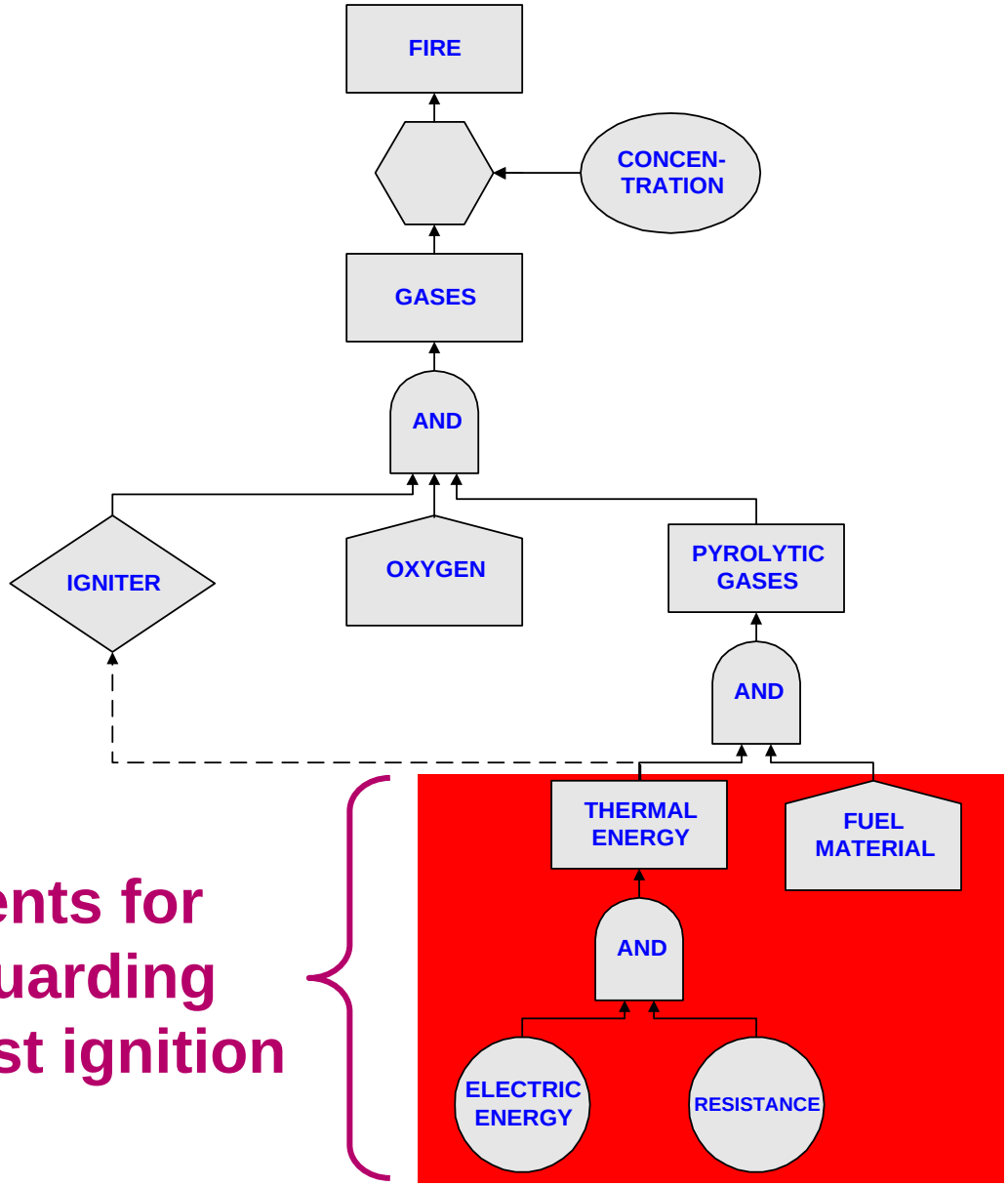
low rate of thermal energy transfer to a fuel material

application of flame-retardant materials

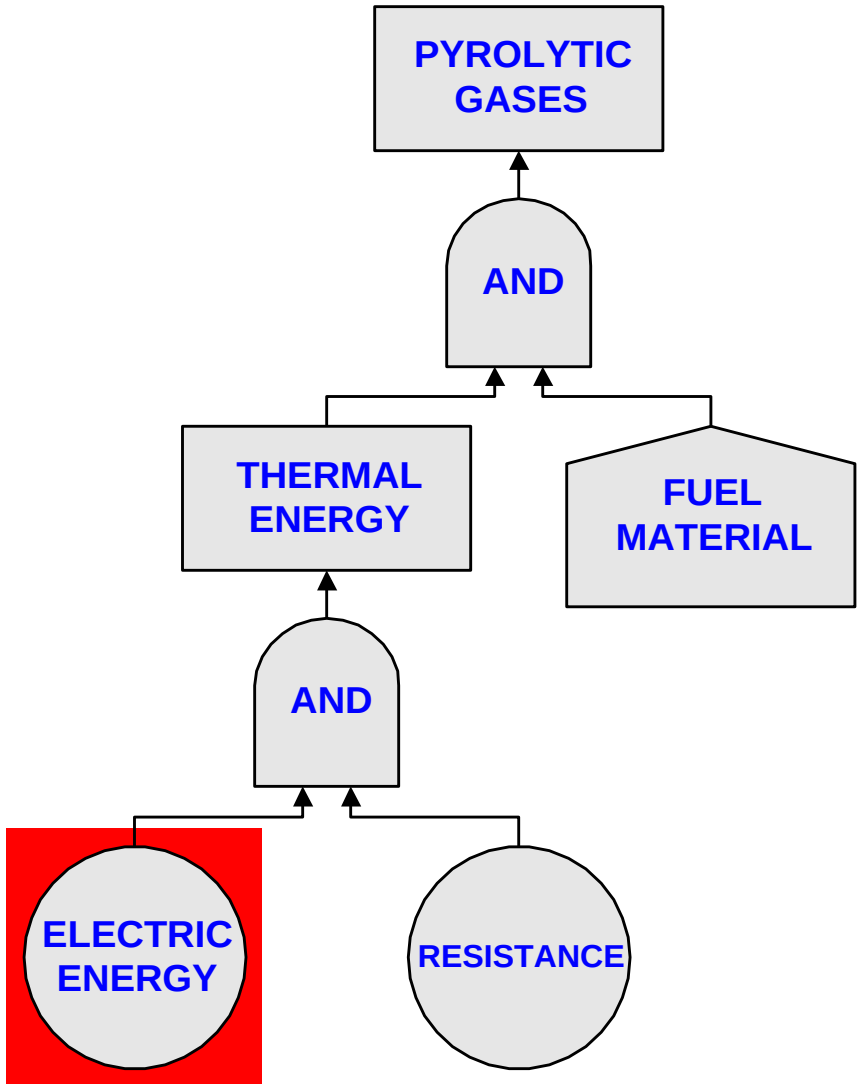
SAFEGUARDS AGAINST SPREAD-OF-FIRE

prevent spread of fire from the point of ignition

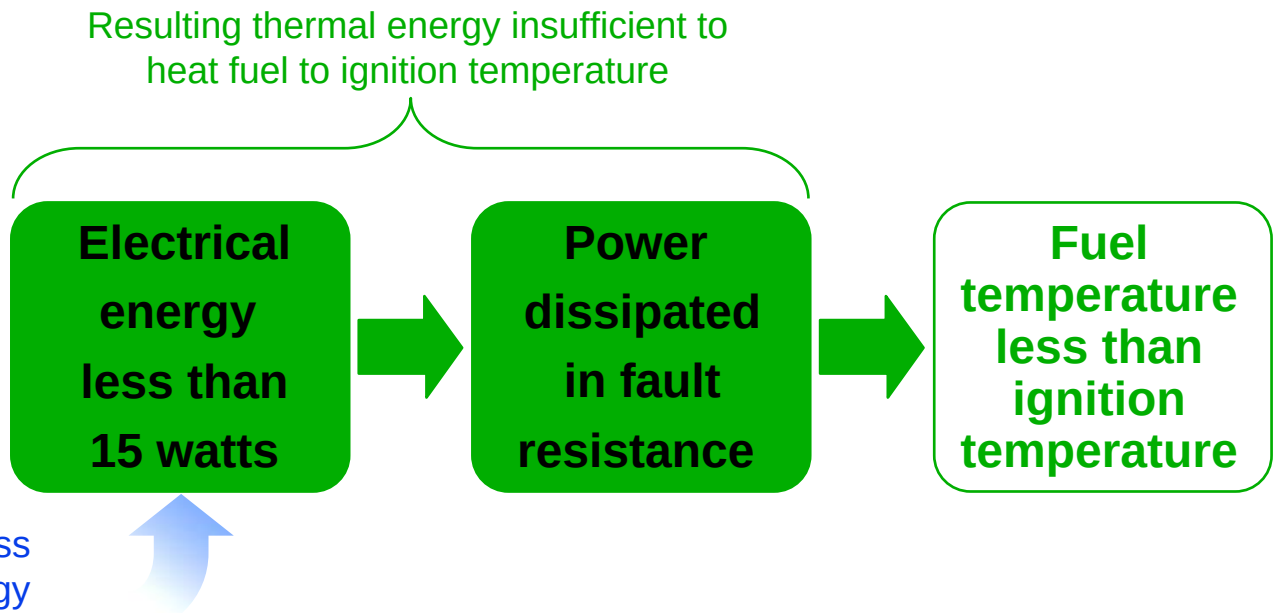
prevent spread of fire through the enclosure



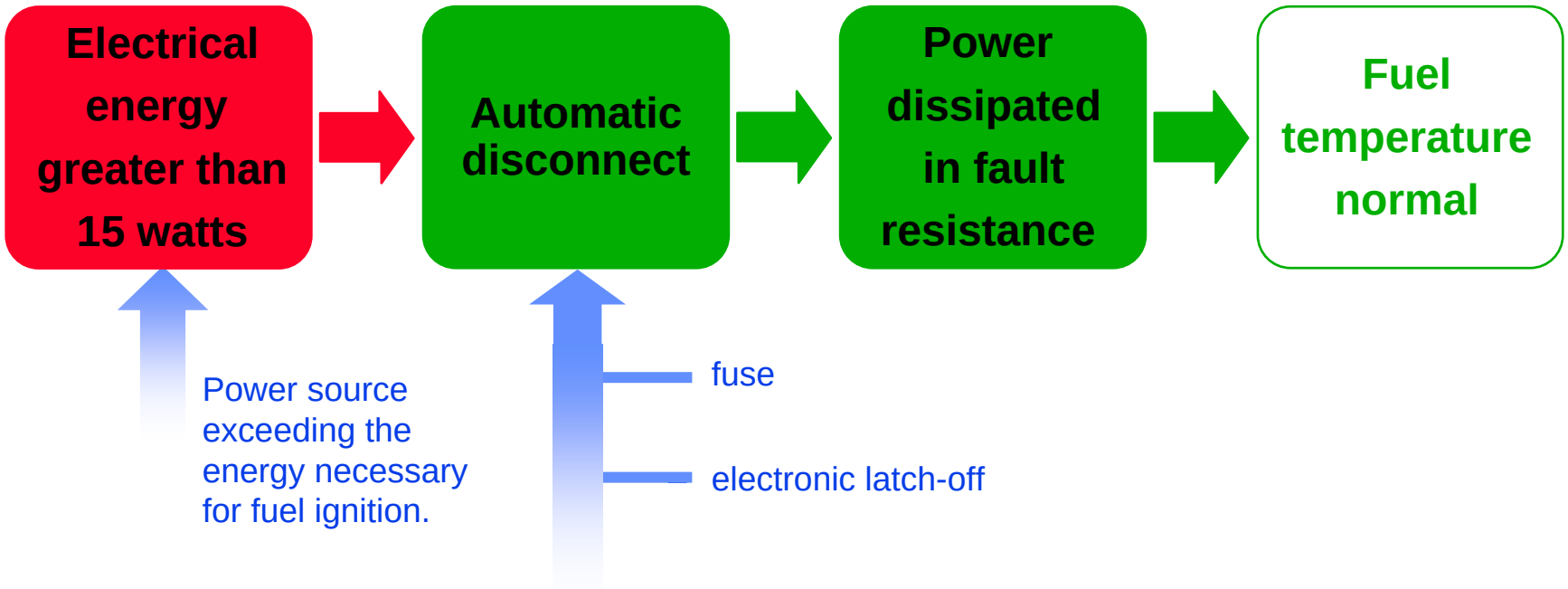
Elements for safeguarding against ignition

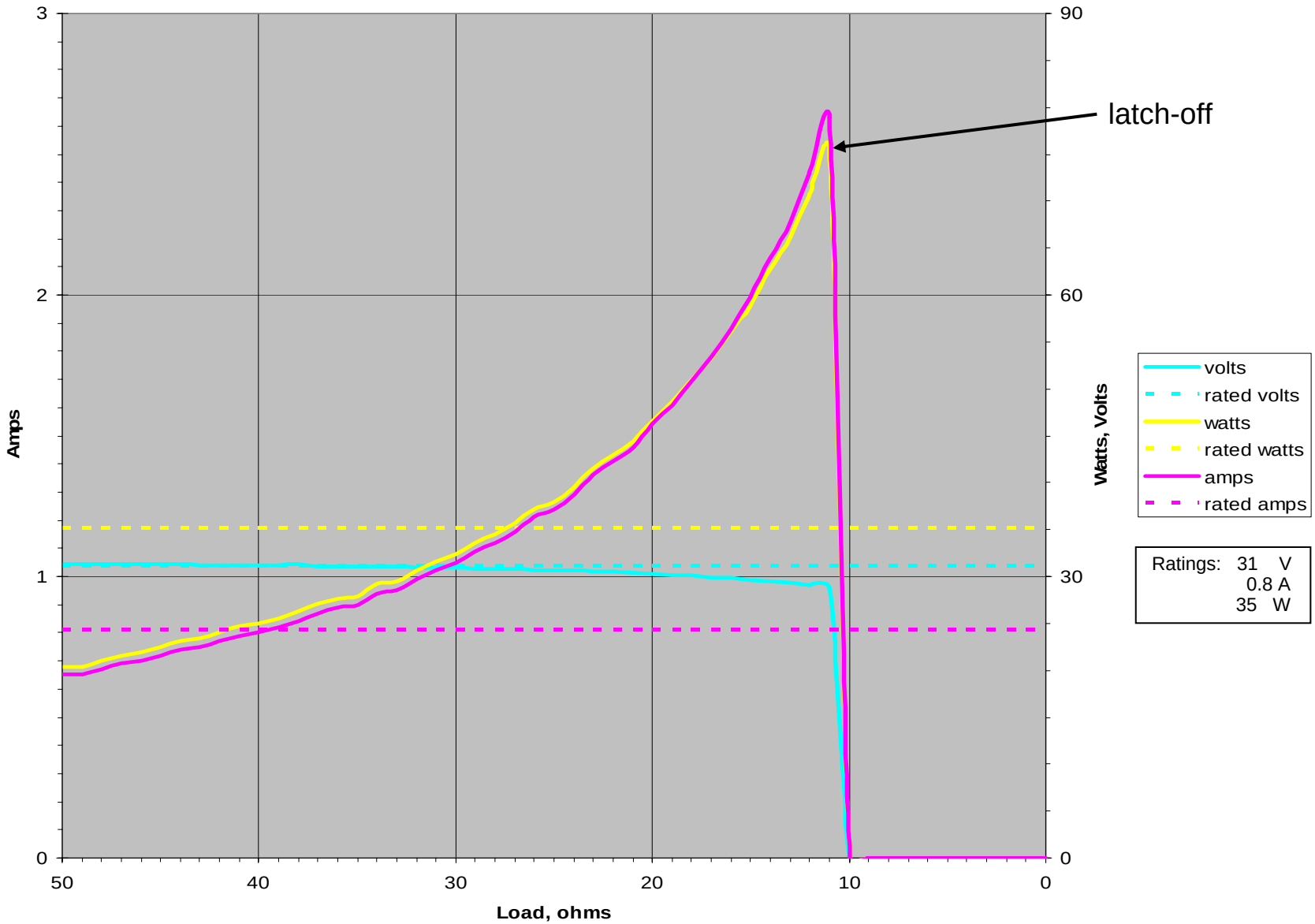


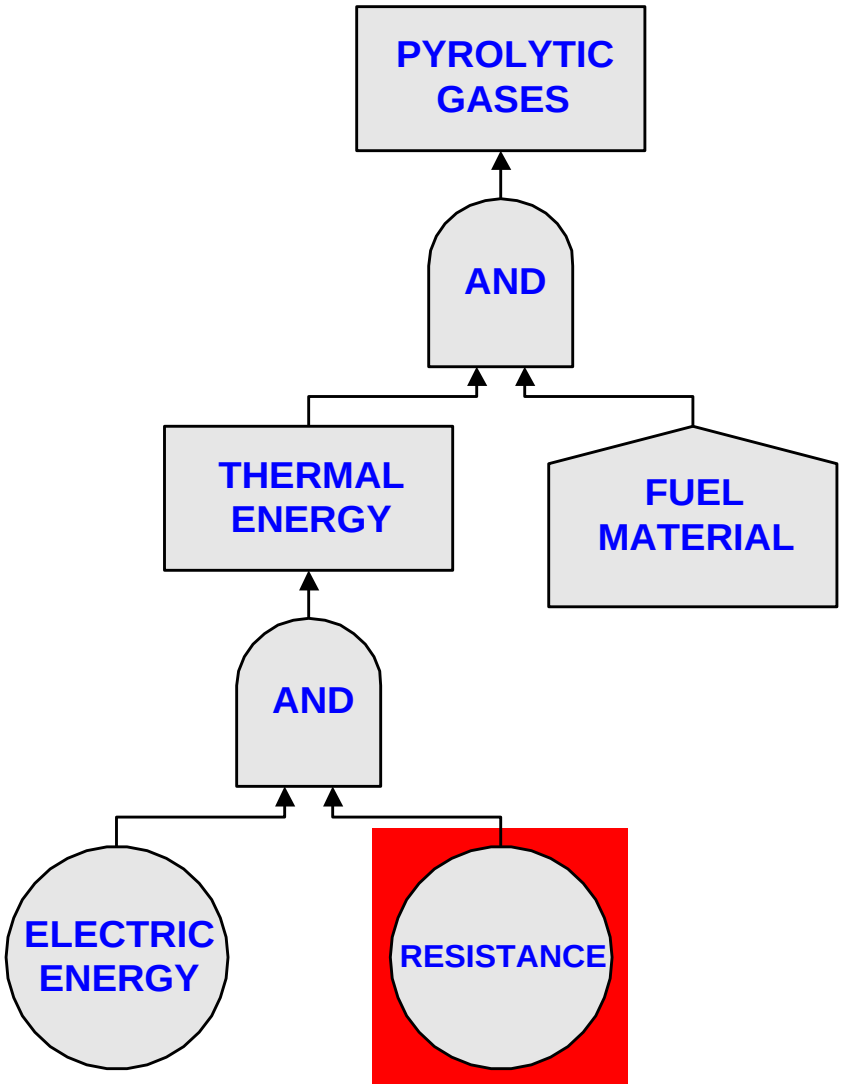
IGNITION SAFEGUARDS



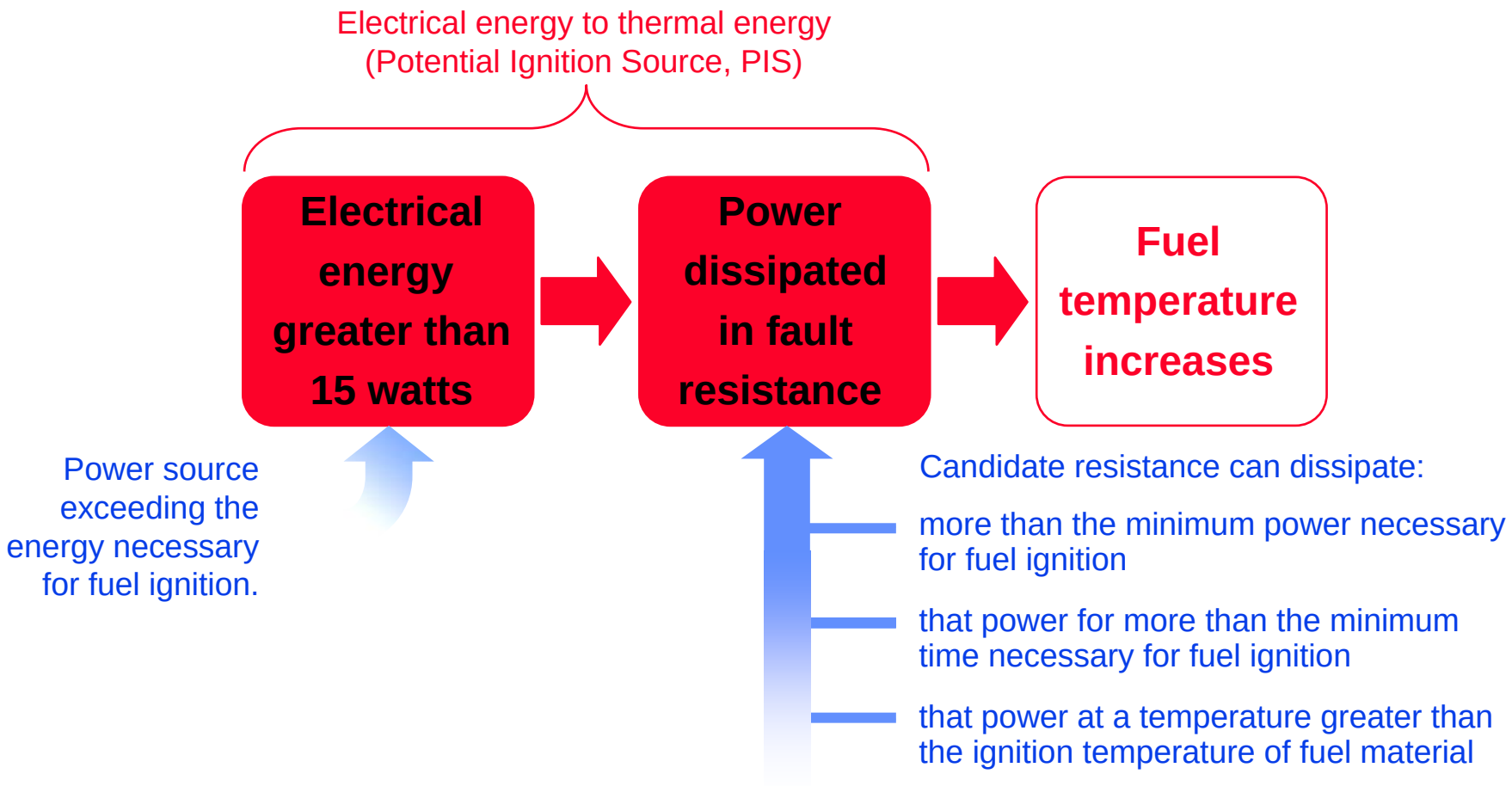
IGNITION SAFEGUARDS







IGNITION SAFEGUARDS



Examples of candidate resistances

Power distribution devices

transformers
rectifiers
series-pass transistors
connectors/connections
conductors

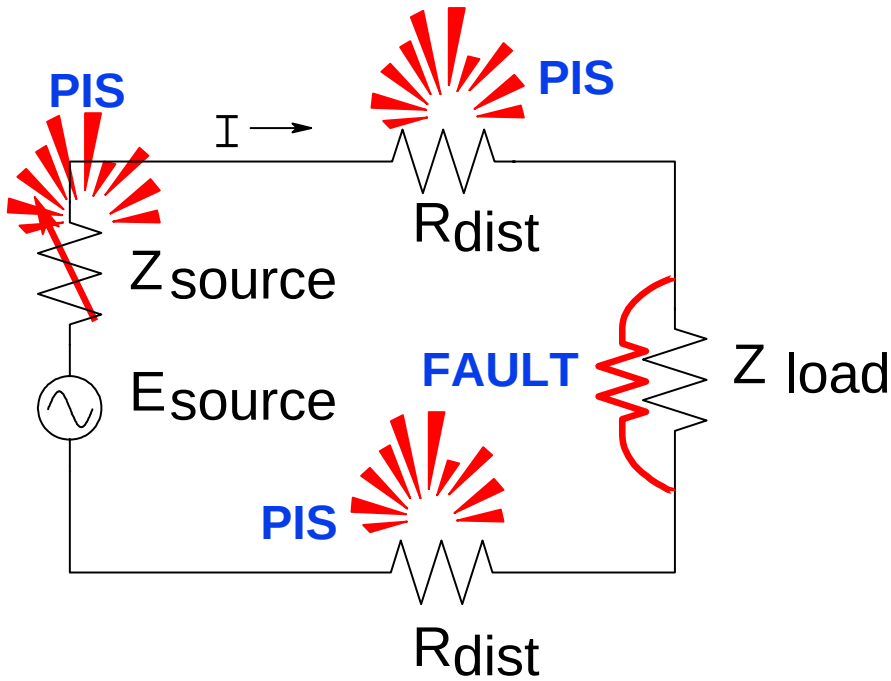
Power consuming devices

resistors
semiconductors (linear)
motors
solenoids

Examples of candidate resistances

Effects of load faults

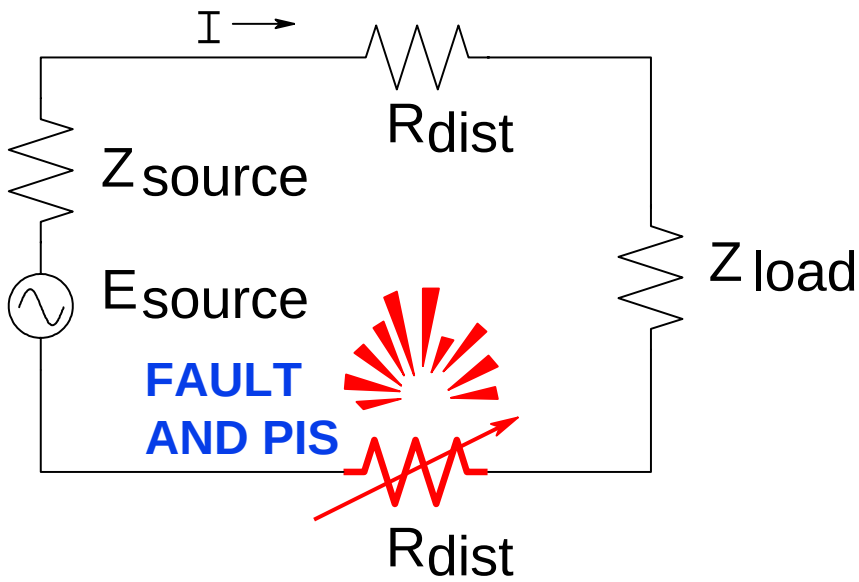
$P = I^2 * R$



Examples of candidate resistances

Effects of distribution faults

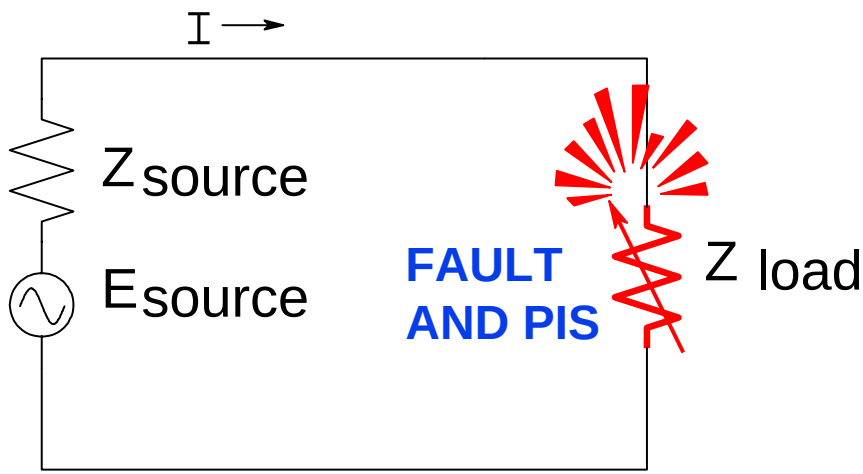
$P = I^2 * R$



Examples of candidate resistances

Effect of component faults.

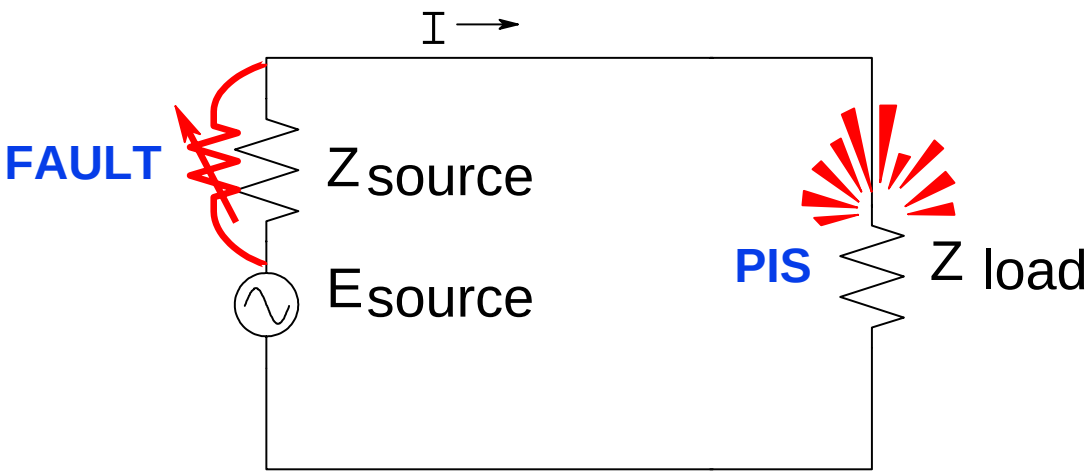
P = E * I

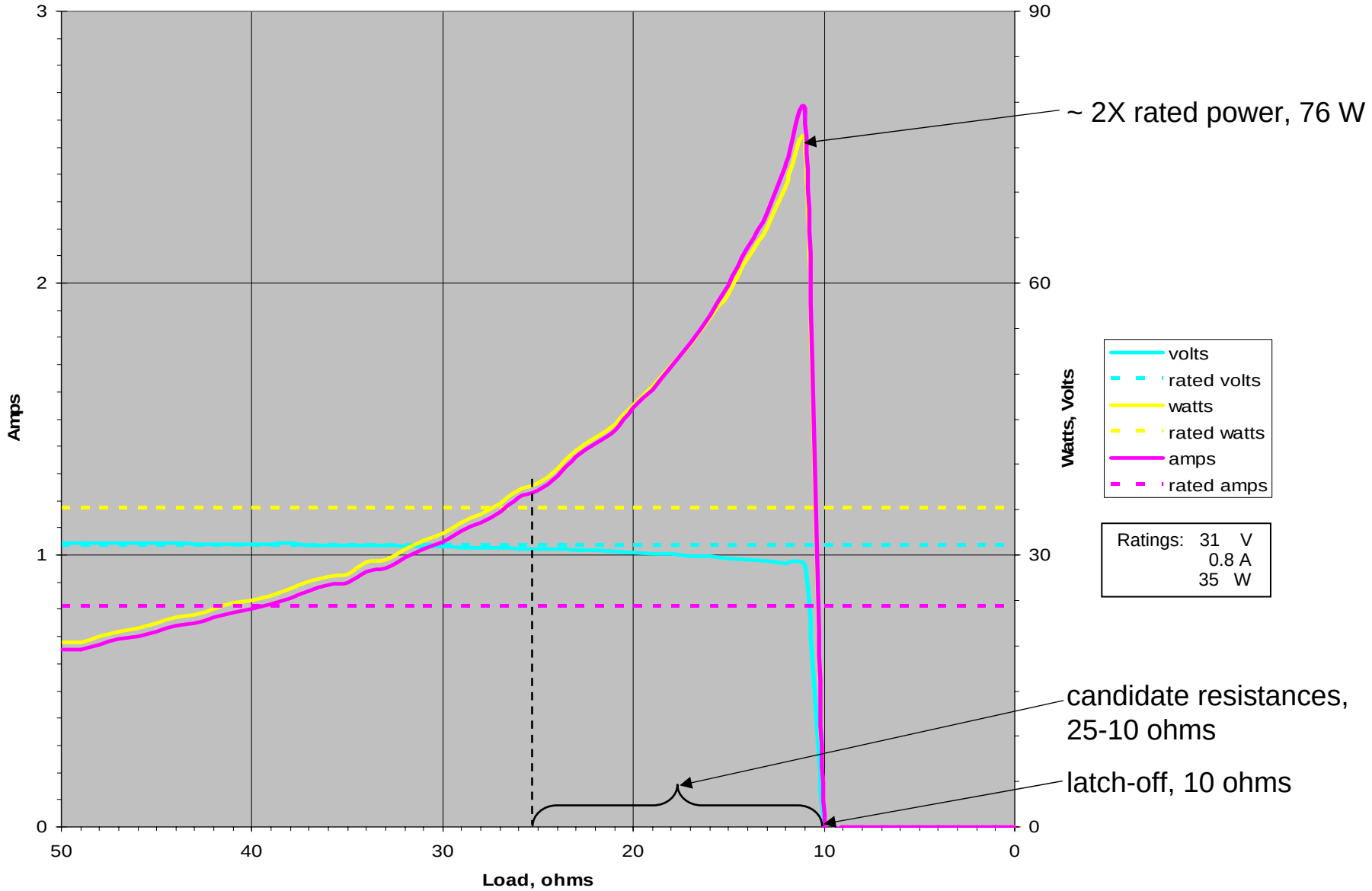


Examples of candidate resistances

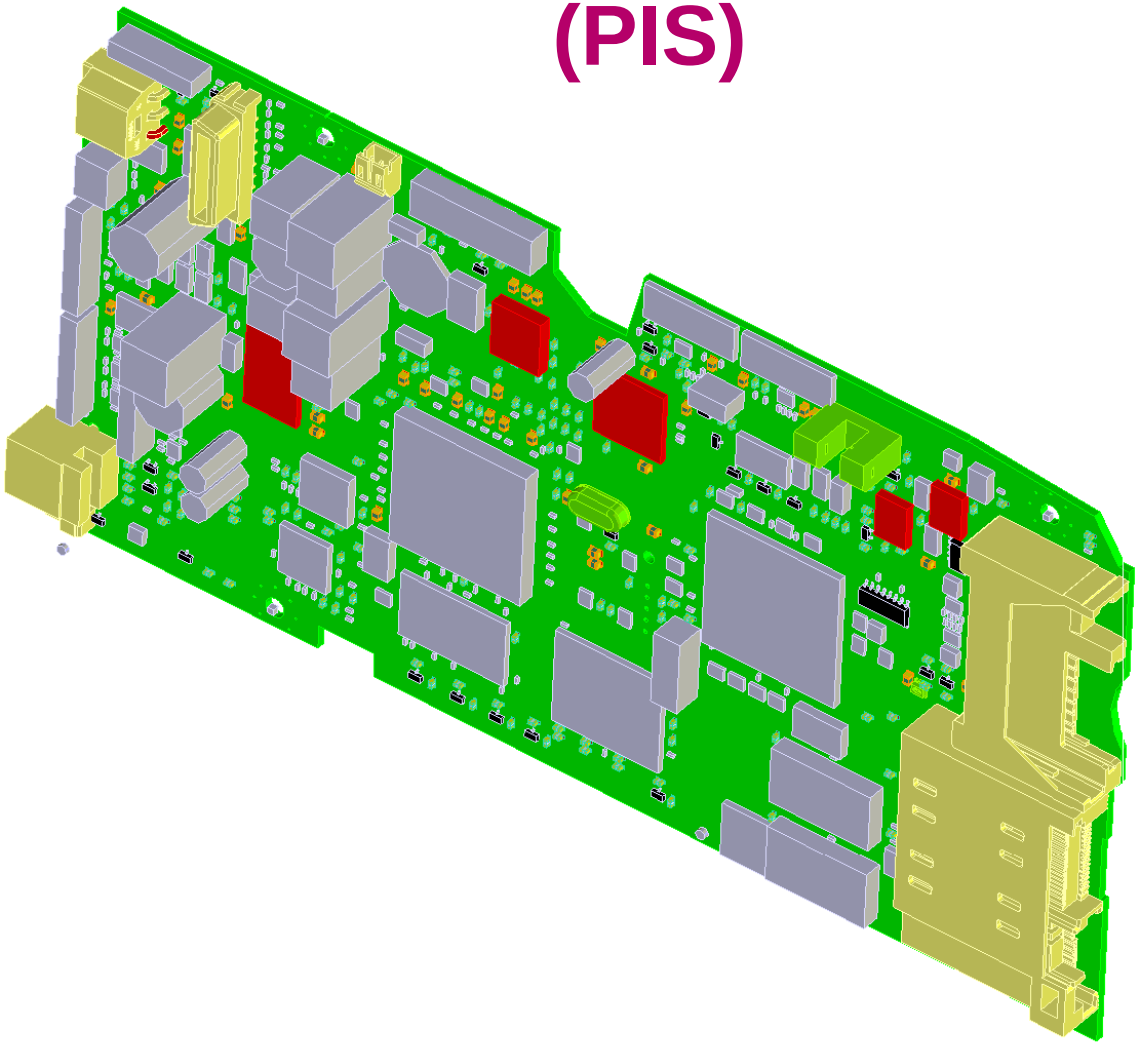
Effects of source faults.

$$P = E^2 / R$$

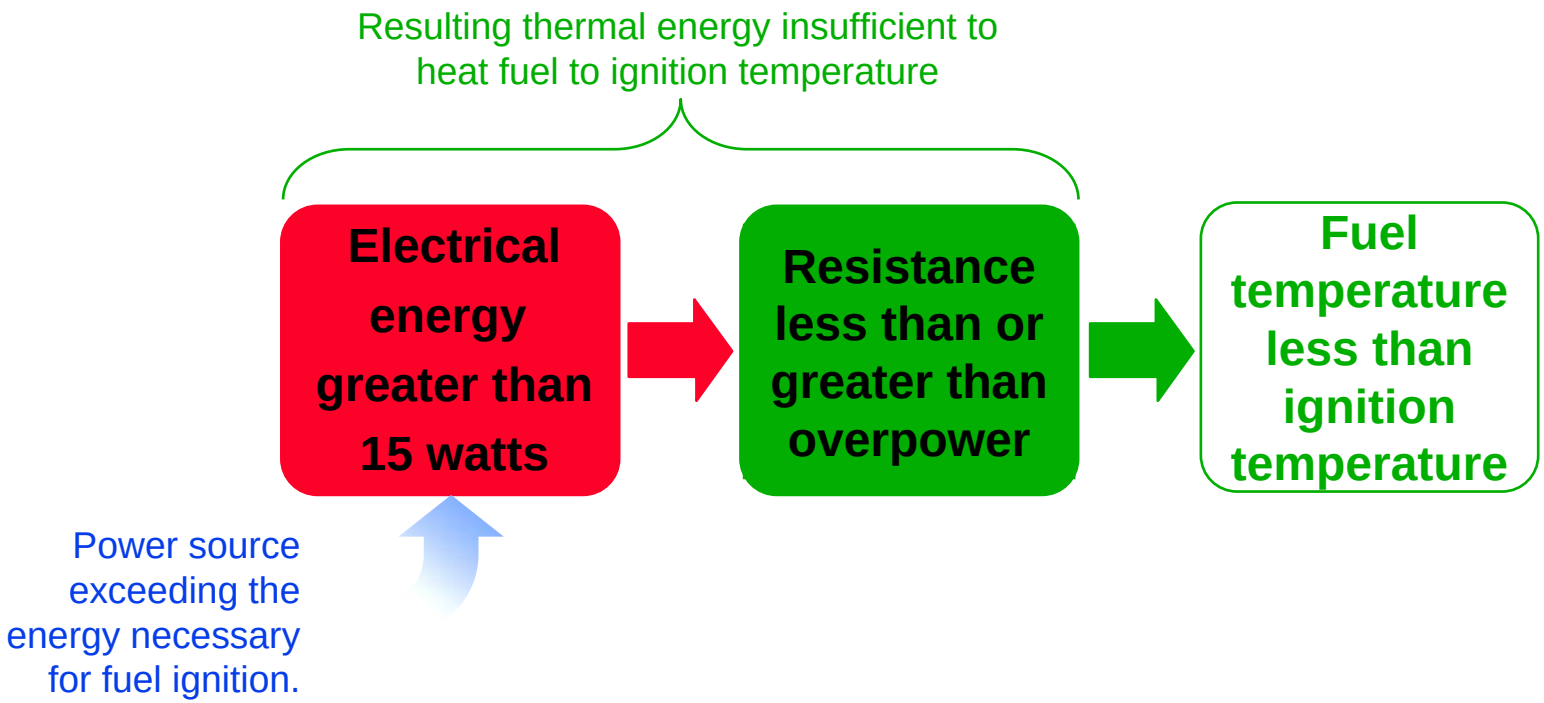


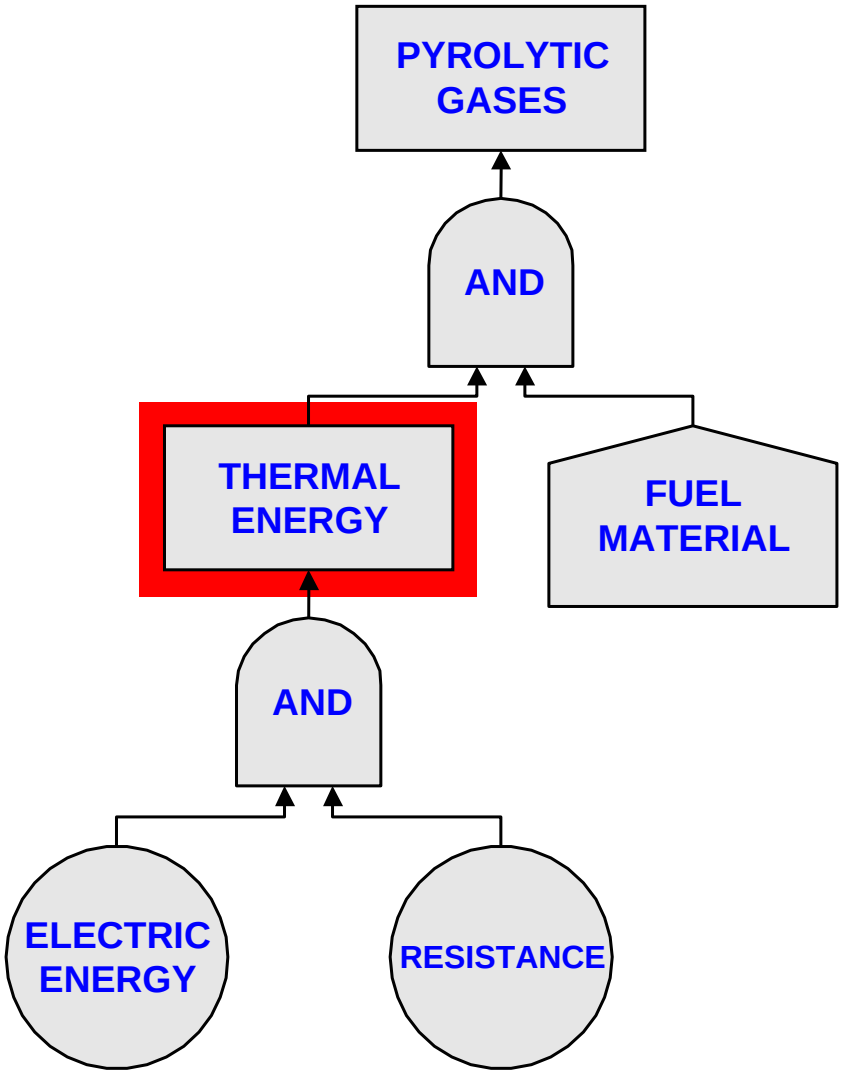


Candidate power-dissipating devices (PIS)



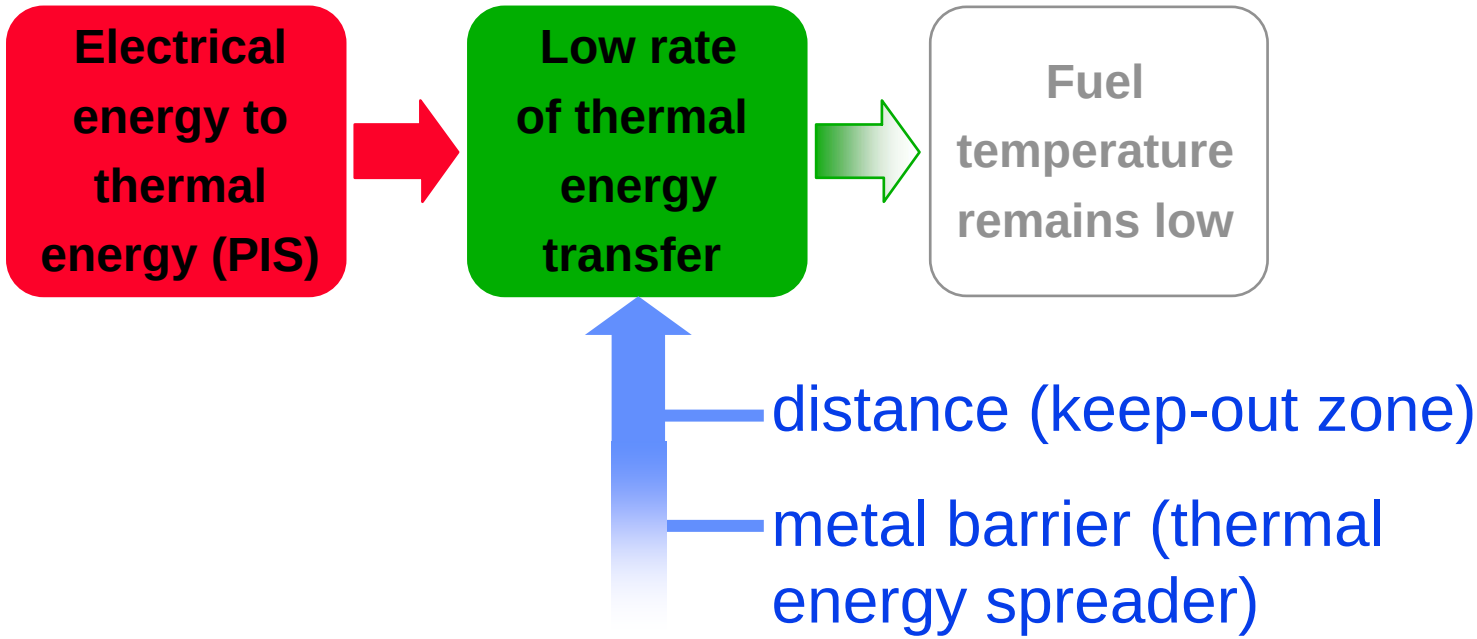
IGNITION SAFEGUARDS





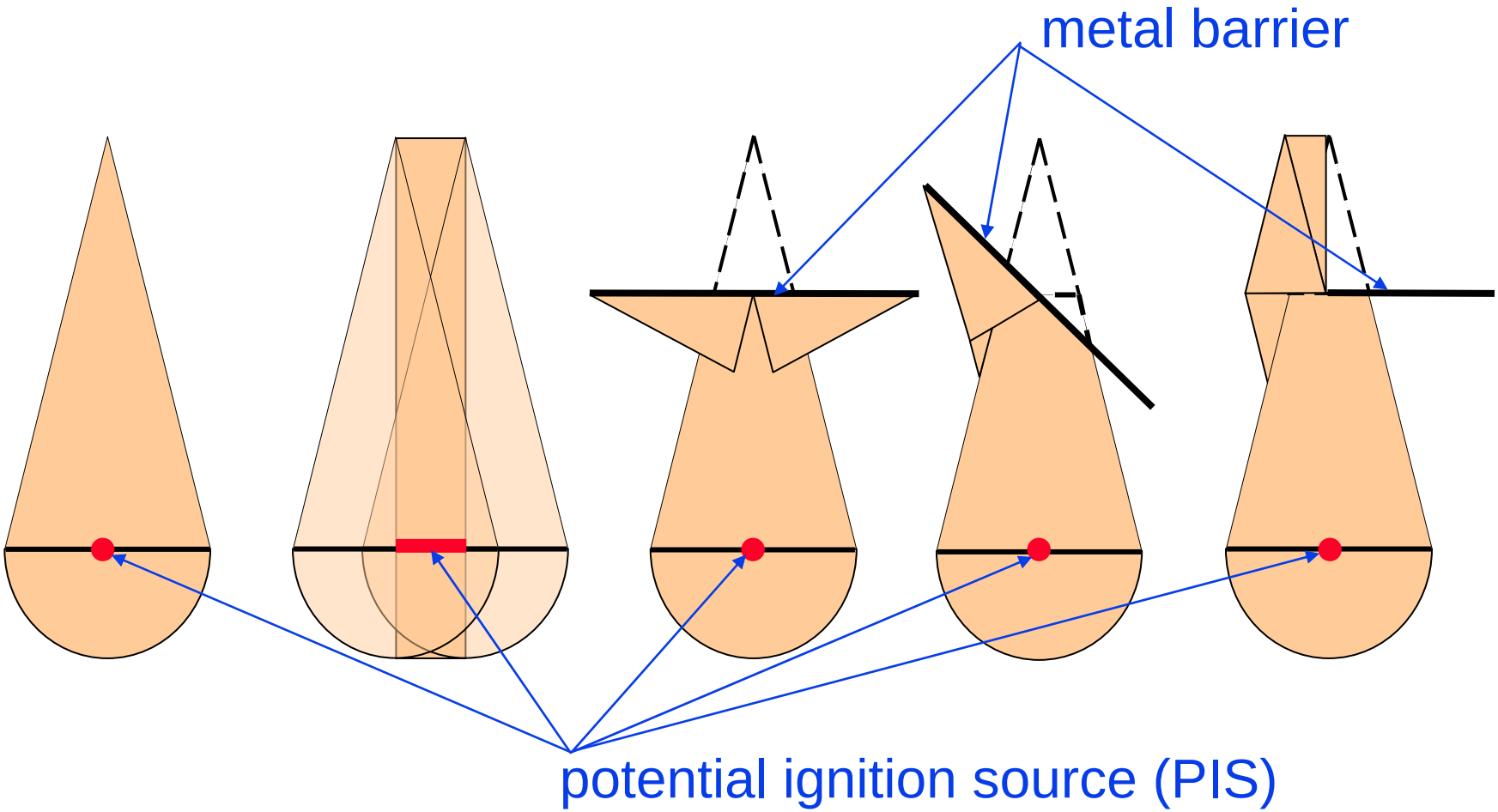
IGNITION SAFEGUARDS

Thermal isolation between thermal source and fuel:

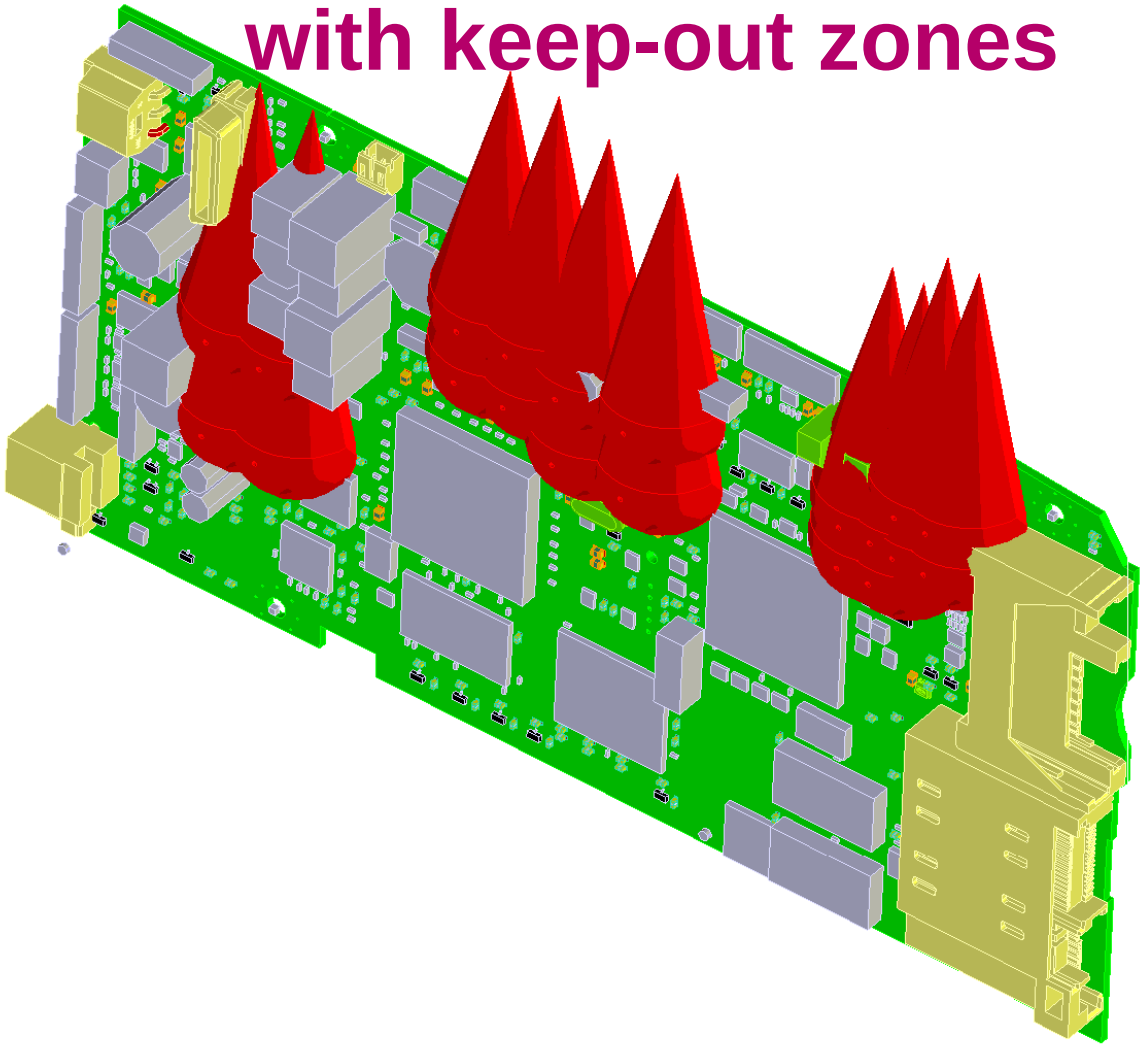


IGNITION SAFEGUARDS

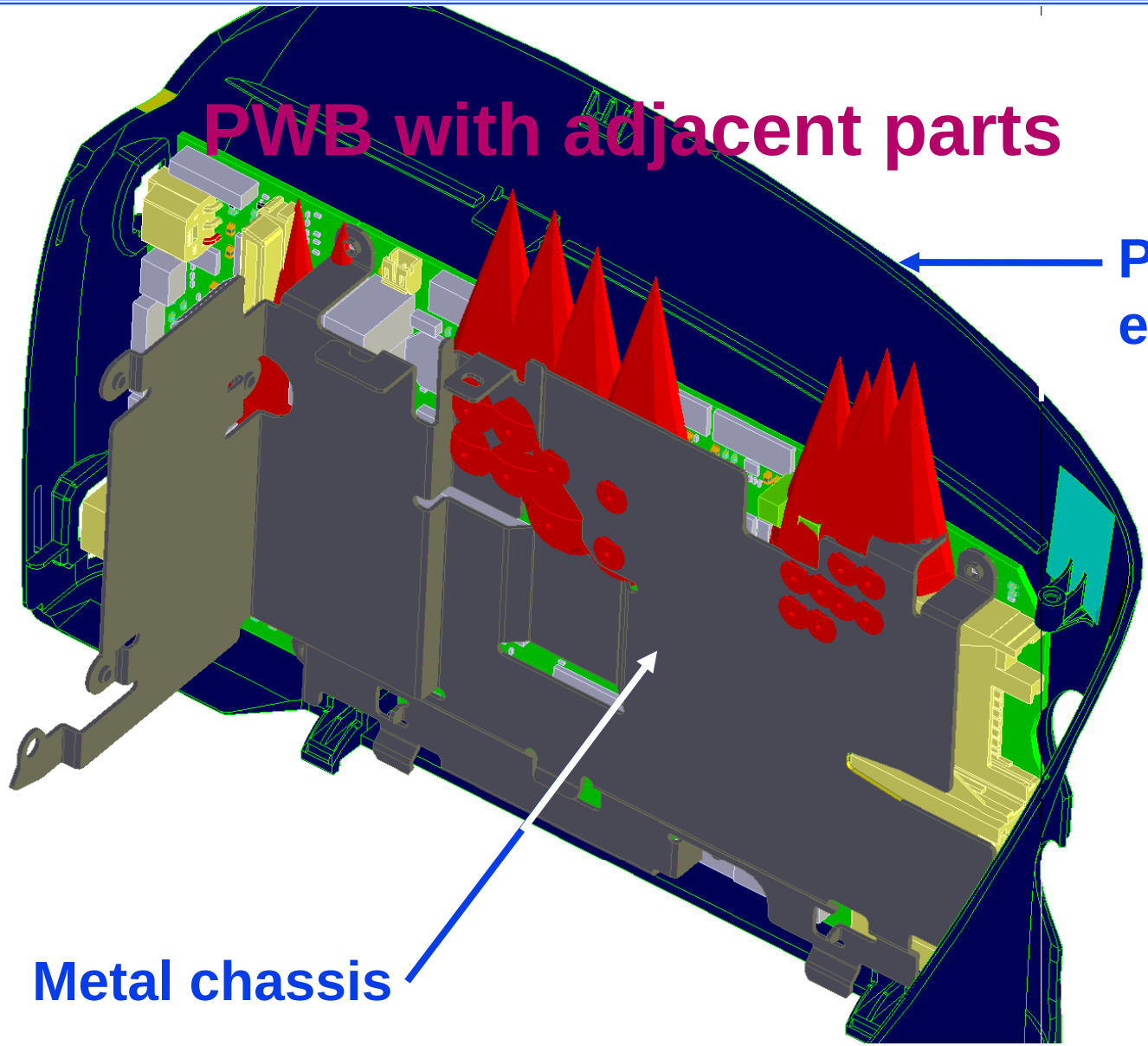
keep-out zone

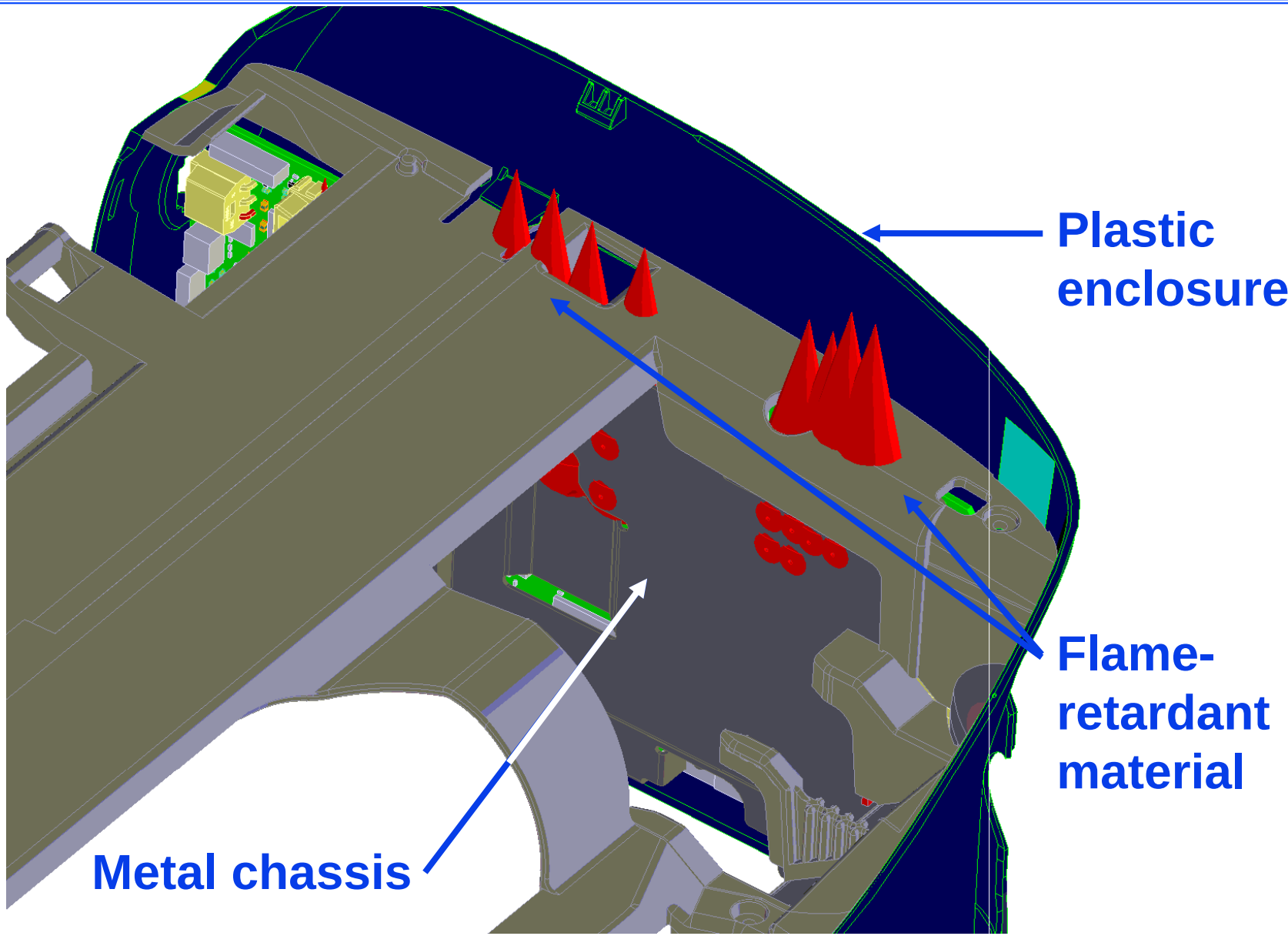


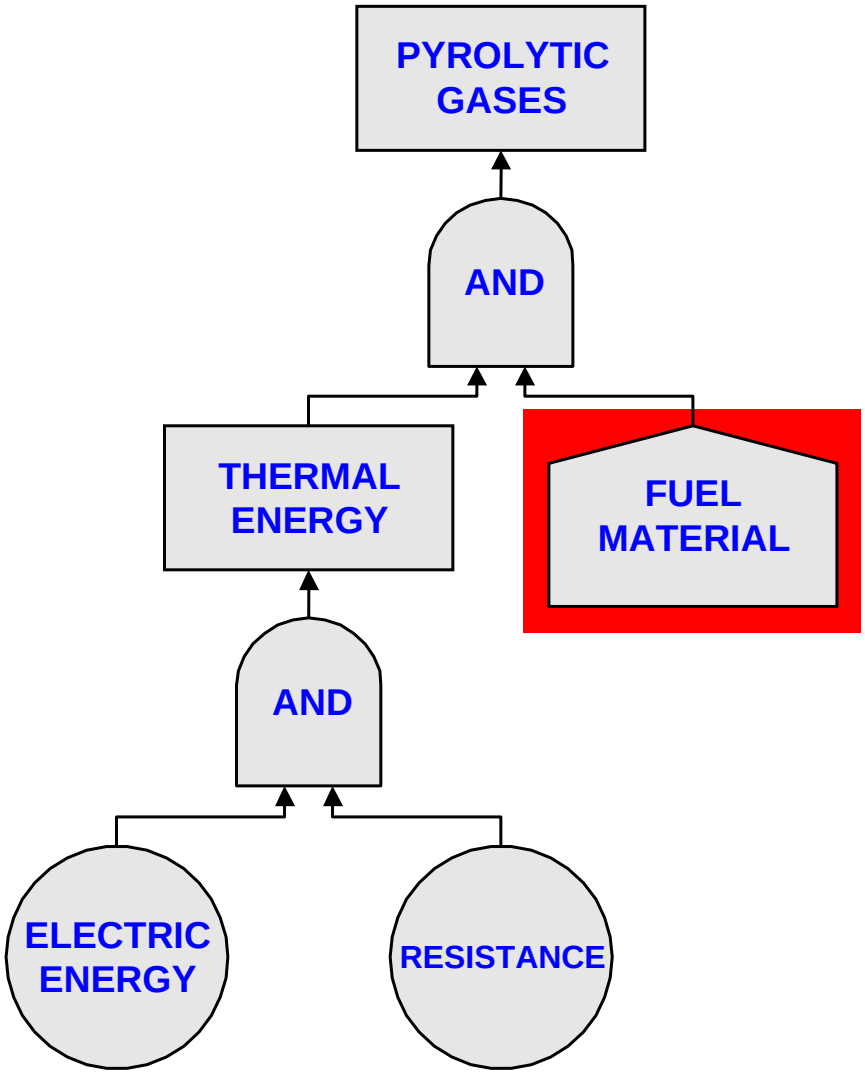
Power dissipating devices with keep-out zones



PWB with adjacent parts

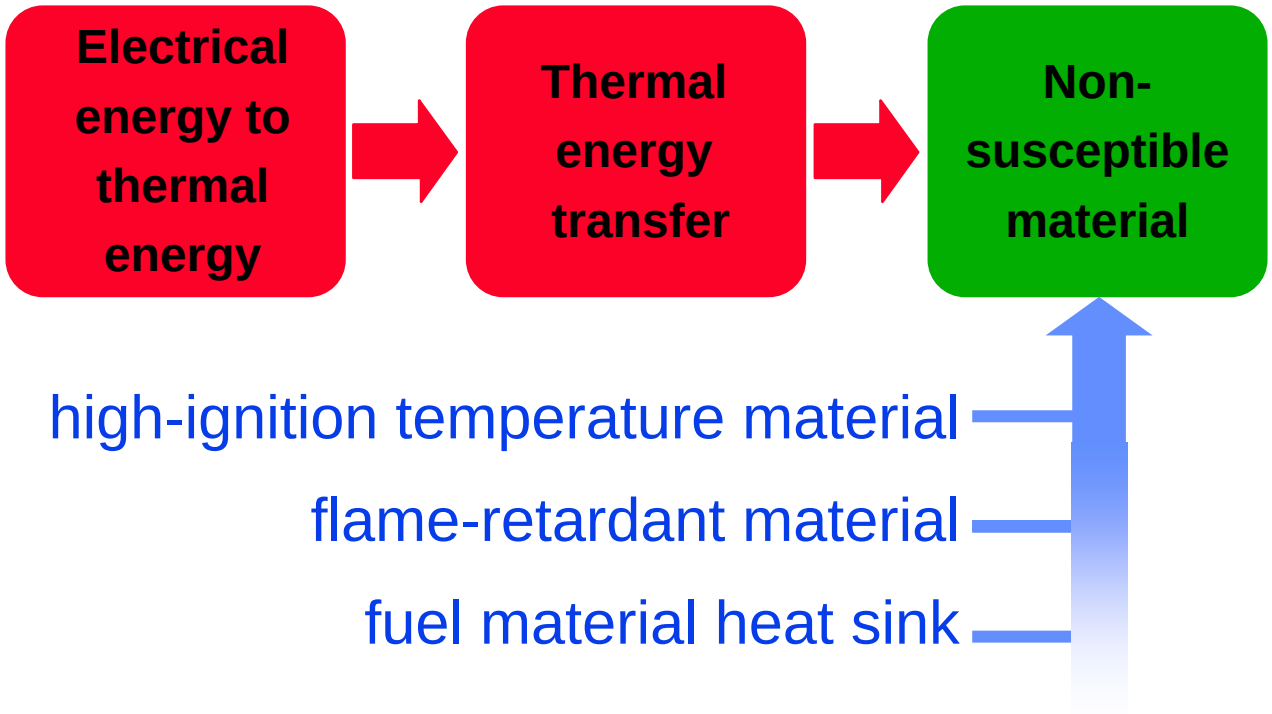




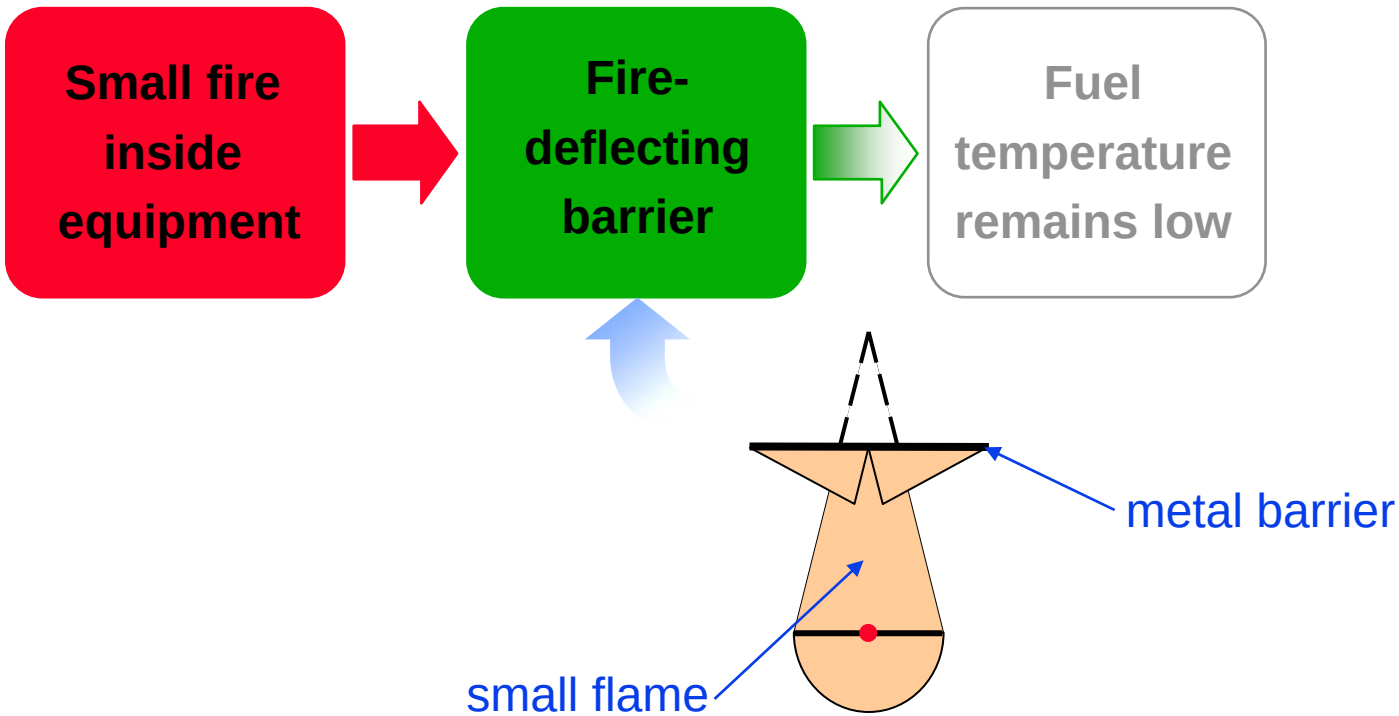


IGNITION SAFEGUARDS

Non-susceptible material:

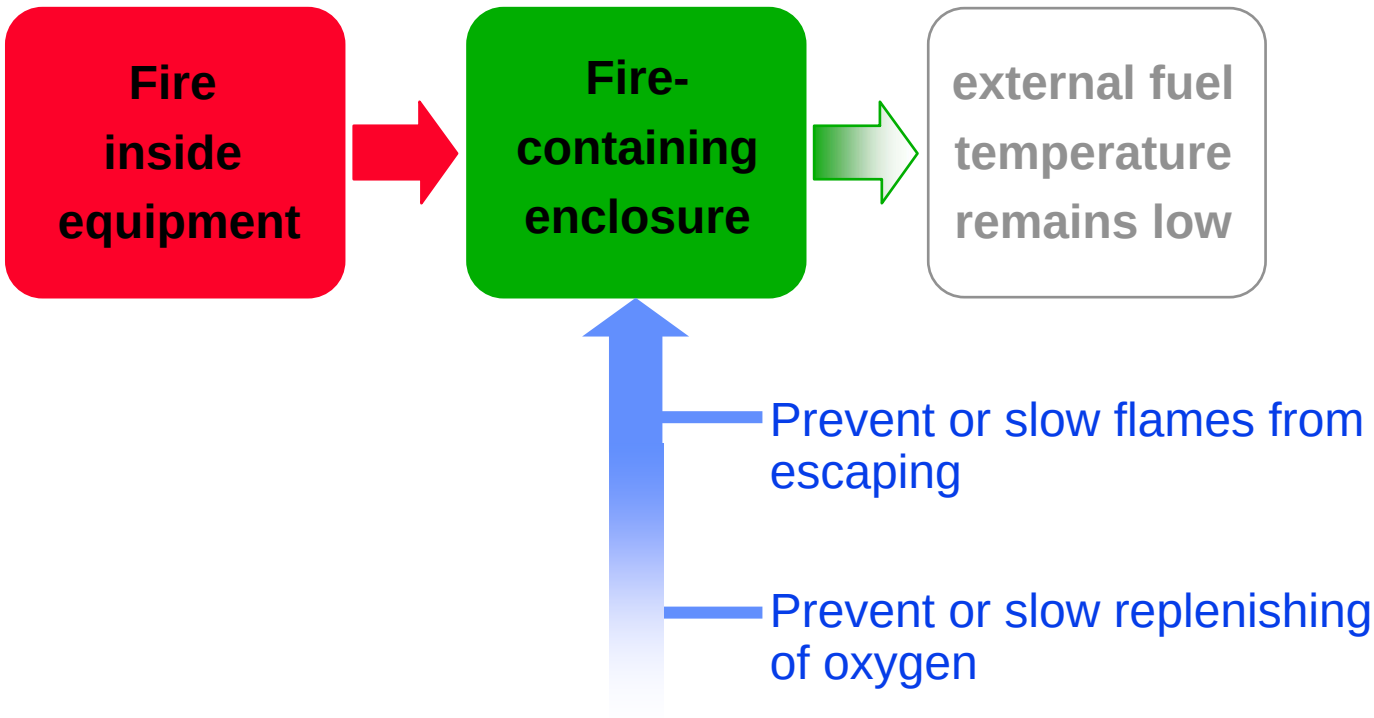


SPREAD-OF-FIRE SAFEGUARDS
from the PIS



SPREAD-OF-FIRE SAFEGUARDS

from within the equipment



The fire-containing enclosure
Video Demonstration

4-mm diameter holes

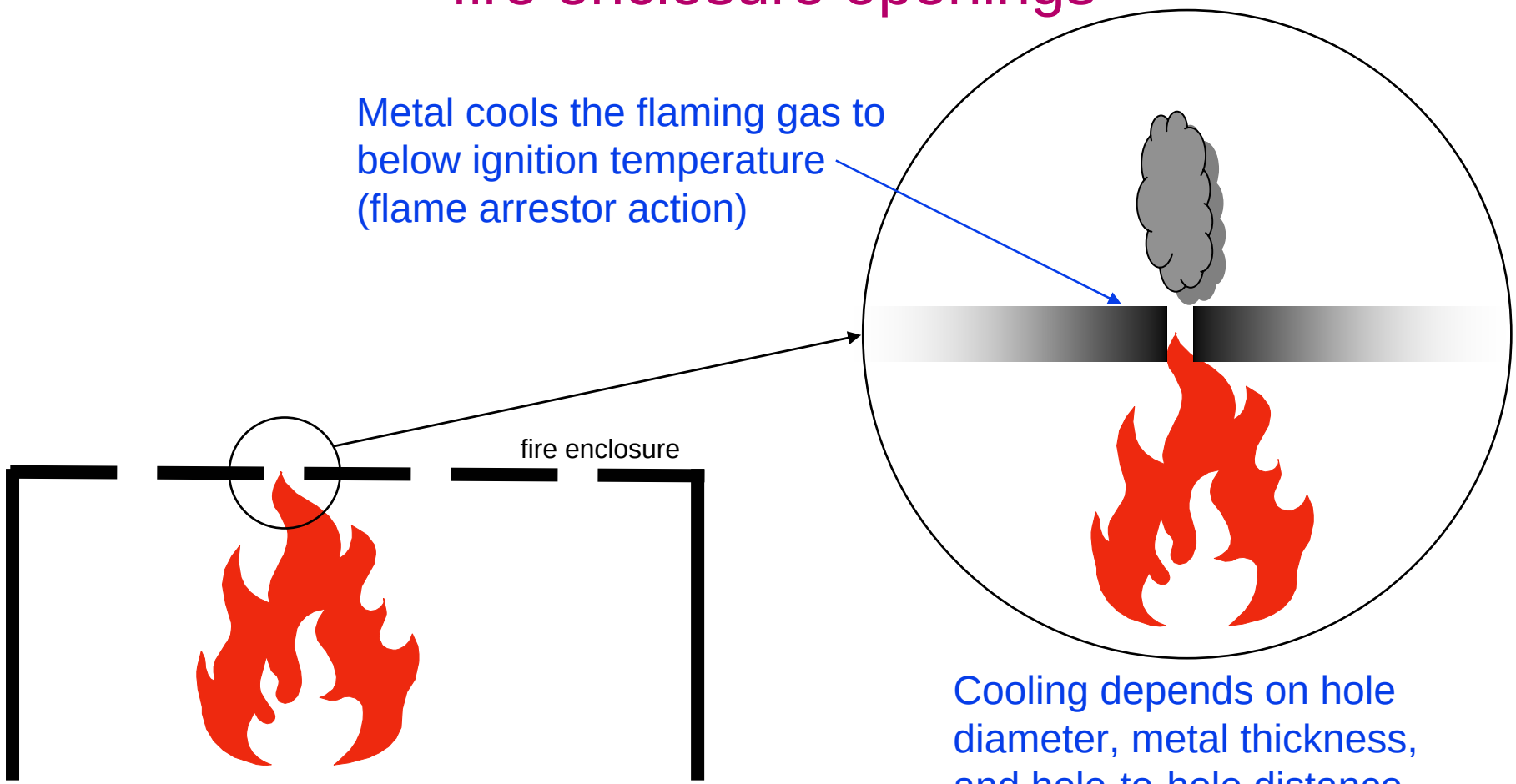
5-mm diameter holes

What is the mechanism that prevents spread of fire through enclosure openings?

6:21 minutes
06:24 – 12:45

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

- **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 SPEARD OF FIRE THROUGH THE ENCLOSURE