Introduction to

ELECTRICALLY- CAUSED FIRE

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agenda

• DEFINITION
  – ELECTRICALLY-CAUSED FIRE

• VIDEO DEMONSTRATIONS
  – FIRE SAFETY and TV SETS,
  – FIRE CONCEPTS and BEHAVIOR
  – GE COFFEE MAKER FIRE

• PYROLYSIS, IGNITION, FLAMING, FIRE, and COMBUSTION

• ELECTRICAL ENERGY CONVERSION TO THERMAL ENERGY
Electrically-caused fire is

- electrical heating of a material to ignition temperature

followed by

- ignition and
- combustion.
Fire
Video Demonstration

European Flame Retardants Association

“Fire Safety and TV Sets”

17 minutes
Fire Video Demonstration

NFPA
“Fire Concepts and Behavior”
circa 1970

> Note the physical state of the fuel necessary for flame. <

18 minutes
Fire
Video Demonstration

ABC News
“GE Coffeemaker Fire”
Excerpted from *Prime Time*, October 17, 1991

> Note the description of the physical state of the flaming fuel. <

3 minutes
**Pyrolysis**

**Pyrolysis** is the transformation (usually chemical decomposition) of a compound into one or more other substances by heat alone.

**Pyrolysis products** include

- non-combustible gases
- combustible gases
- liquids
- solids, including soot

Conservation of energy

Radiated power output

Convected power output

Conducted power output

Electrical power input
Ignition process

- Flames
- Oxygen
- Gases
- Igniter or more heat
- Fuel
Ignition and ignition types

**Ignition** is the process of initiating self-sustained combustion of gases.

- **Flash/pilot ignition** is ignition of the gases evolved from the fuel by a spark or flame.

- **Auto-ignition/self-ignition** is ignition in the absence of a spark or flame.

- **Spontaneous ignition** is ignition by an internal chemical or biological reaction producing sufficient thermal energy to raise the material temperature to auto-ignition temperature.

Flaming combustion processes
Flame and flame types

*Flame* is the luminous portion of burning gases.

- *Pre-mixed flame* has the oxygen-gas composition fixed prior to combustion, e.g., a Bunsen burner flame, a gas stove.

- *Diffusion flame* has the oxygen diffused into the gas mixture from the surrounding atmosphere, e.g., a candle flame, a cigarette-lighter.

Flame behavior

*Flames* are burning gases.

- The path of the burning gas is the same as the path of a hot gas.
- The flame is always vertically-oriented unless deflected by an object or by air currents.
- The volume of the flame is nearly constant.
**Fire and fire types**

*Fire* is a rapid oxidation process evolving thermal, chemical, and light energy in the form of flames.

- *Fuel-regulated fire* is a fire where the heat release rate and fire growth rate are controlled by the fuel characteristics. The supply of oxygen is relatively unlimited.

- *Oxygen-regulated fire* is a fire where the heat release rate and fire growth rate are controlled by the supply of oxygen. The supply of fuel is relatively unlimited.

Combustion

*Combustion* is a self-sustained high-temperature oxidation reaction.

- *Flaming* is a gas-phase combustion process.
- *Glowing* is a solid-phase combustion process.
- *Smoldering* is an oxygen-regulated solid-phase combustion process.

Glowing combustion process
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*.

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

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

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

\[
P = E \times I
\]
Conversion to thermal energy
Power distribution devices

Effects of load faults
\[ P = I^2 \cdot R \]

Effects of distribution faults
\[ P = I^2 \cdot R \]
Conversion to thermal energy
Power consuming devices

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

Effects of source faults.
\[ P = \frac{E^2}{R} \]
Heating

All heating (temperature rise of an object) is an exponential rise as a function of time.

Start temperature is object’s initial temperature.

End temperature is heat source’s temperature minus coupling and environmental losses.
Thermal Time Constant

Time, minutes

Temperature, degrees C

0 5 10 15 20

0 50 100 150 200 250 300 350 400
Thermal Time Constant

Effect of TC on curve shape

\[ T_t = T_f \left( 1 - e^{-t/TC} \right) \]

- \( T_t \) is temperature at any time
- \( T_f \) is final temperature
- \( t \) is time
- \( TC \) is the thermal time constant

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