CPL Theory
Aircraft Systems (CSYA)

CSYA 10 – Fire Protection Systems

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3. Disclaimer

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CONDITIONS NECESSARY FOR FIRE

Conditions Necessary for Fire

- Fire is arguably the most dangerous threat to an aircraft

- Because of this, all large aircraft and some light aircraft have:

  1. A fixed fire protection system (usually to protect the engines)

  2. A portable fire protection system (hand-held extinguishers)

- 3 things are required for a fire:

  1. Fuel

  2. Oxygen

  3. Heat

Conditions Necessary for Fire

- If one of these three elements is removed, then the fire will extinguish

- **Fixed and portable fire protection systems on aircraft aim to remove one of these elements**

CLASSES OF FIRE

Classes of Fire

- Before we examine the protection systems themselves, we need to understand the different types of fires that may occur

Class A Fire

- Fires in ordinary combustible materials e.g. wood, cloth, paper etc.

Class B Fire

- Fires in flammable liquids/ petroleum products e.g. grease, paints etc.

Class C Fire

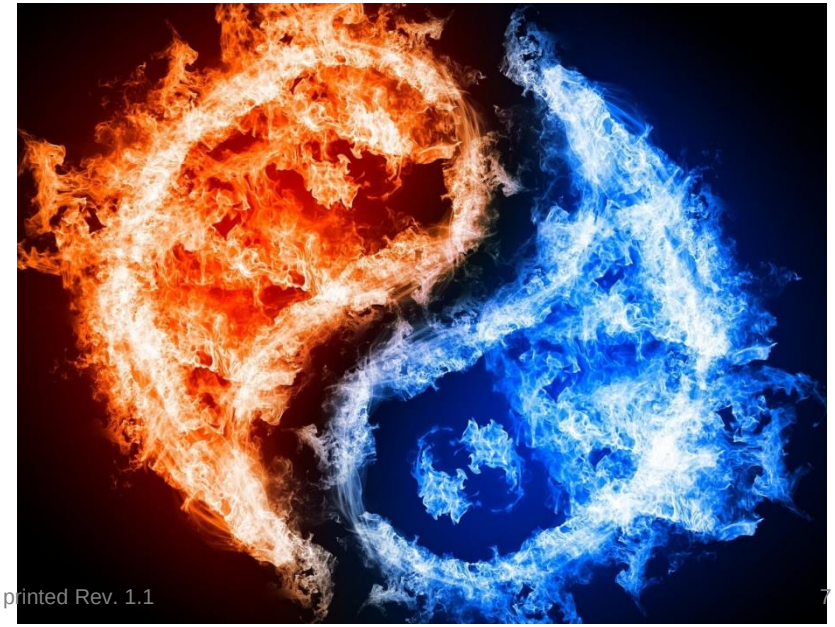
- Fires involving flammable gases e.g. methane

Class D Fire

- Fires involving flammable metals e.g. magnesium

Class E Fire

- Electrical fires



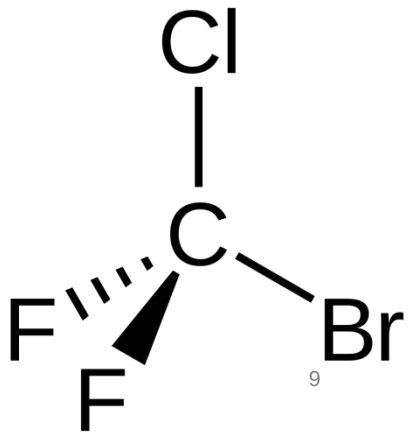
TYPES OF EXTINGUISHING AGENTS

Fire Extinguishing Agents

- A fire can be most effectively extinguished if the right extinguishing agent is used for that class of fire

- Common extinguishing agents include:

1. **Water**
2. **Non-Combustible Gas (CO2)**
3. **Dry Powder**
4. **Halogenated Hydrocarbon Agents**



Water

- Water cools burning fuel below its combustion temperature – it removes **heat**
- It will best extinguish a **Class A Fire**
- Not suitable for fires that involve flammable liquids (Class B) or electrical equipment (Class E), the most common sources of aircraft fires
- Aviation fuels such as AVGAS and AVTUR are also lighter than water – they will float above water and therefore retain access to oxygen and continue to burn
- Aviation Fire Fighting equipment may add a “foaming” agent to water to enable the extinguishing agent to sit atop fuel
- Portable fire extinguishers containing water will have a **red strip**

Non-Combustible Gas (CO2)

- Carbon Dioxide and nitrogen are both inert gases used for fire extinguishers
- They are compressed into liquid form and work to smother the fire – removing **oxygen**. They also have a cooling effect, helping to remove **heat**
- Can be used on **Class A, B, C, E Fires**
- Portable extinguishers inside aircraft cabins/cockpits commonly contain CO2
- The downside of this is that CO2 displaces oxygen – thus the cabin must be well ventilated after use!
- Portable fire extinguishers containing CO2 will have a **black strip**

Dry Powder

- A chemical compound that exists as a fine white powder
- When it is heated it releases CO2 – once again removing **oxygen** and reducing **heat**
- Can be used on **Class B and D Fires**
- Not suitable for engine fires because they leave a corrosive residue which is difficult to clean
- Also not suitable for use in the cockpit/cabin area as it can damage sensitive equipment, irritate the eyes and reduce visibility when discharged
- Portable fire extinguishers containing Dry Powder will have a **white strip**

Halogenated Hydrocarbon Agents

- These include gases such as BCF, Halon and Freon
- These gases are compressed in liquid form and when they are released, they expand to displace **oxygen** and reduce **heat**
- These are the most effective extinguishers as they also work on a molecular level to disrupt the chemistry between oxygen and fuel
- Can be used on **all classes of fires (commonly A, B, C, E)**
- Used in High Rate Discharge (HRD) systems for engine fires and leave no residue
- Most suitable for use in cockpit/cabin areas but may cause irritation in eyes and nose
- Portable fire extinguishers containing this agent may have a **green strip**

FIRE PROTECTION DETECTORS

Fire Protection Detectors

- Before we can extinguish the fire, we need to know that it is there!

- Aircraft may have both:

1. Fire Detectors

2. Smoke Detectors

Fire Detectors

- Fire Detectors use an electrical circuit known as a “Fire Wire Loop”
- When there is no fire, the loop is open – meaning no alarms or warning
- When fire is detected, the detector closes the loop – sending current to the alarms and warning indicators

Thermal Switch

- Also known as “overheat detectors”
- When a pre-selected temperature is exceeded, the switch closes

Thermocouple

- Also known as a “rate-of-temperature-rise detector”
- When a rapid temperature rise occurs, two dissimilar metals expand and join together, closing the loop

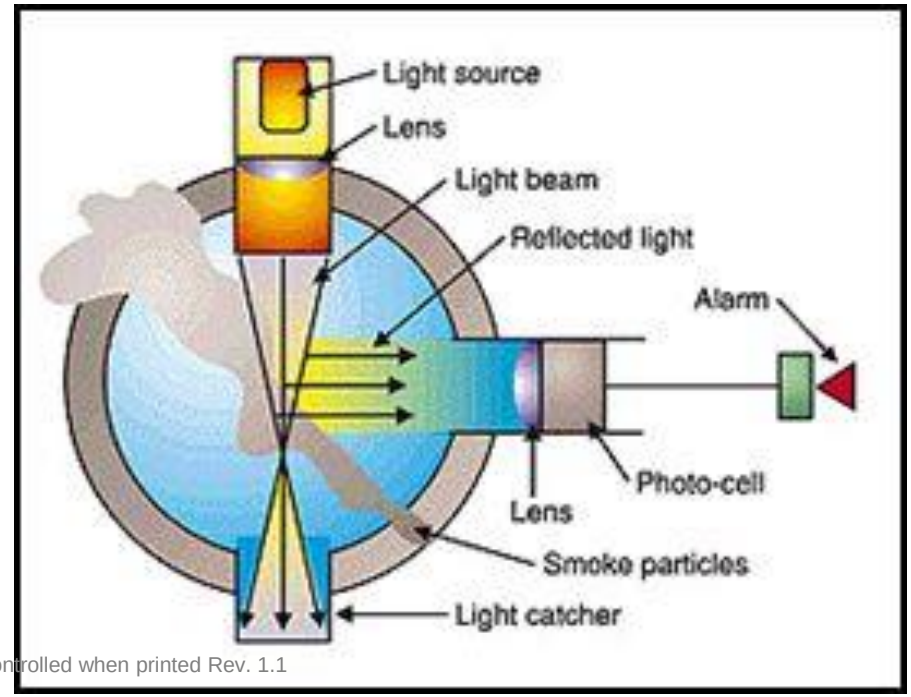
Pneumatic Detector (Systron Donner)

- Uses a diaphragm filled with an inert gas (usually helium)
- As the temperature rises, the gas expands inside the diaphragm which will eventually contact the circuit and close the loop

Smoke Detectors

Optical Detector

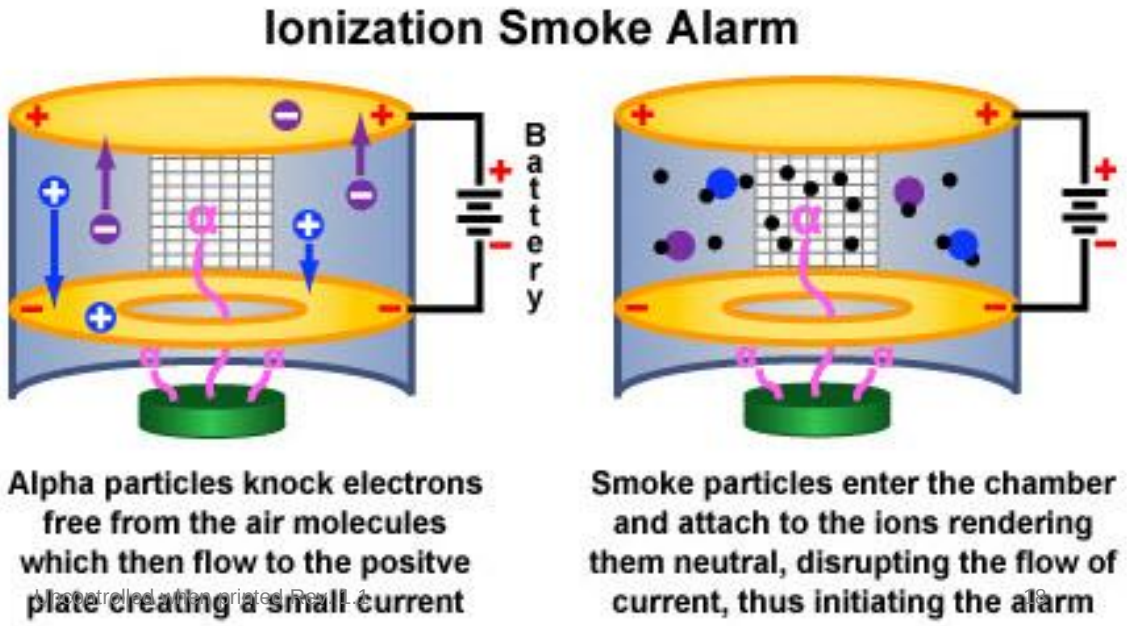
- Also known as Photoelectric Cell Detectors
- Smoke particles will affect the intensity of an optical beam inside the detector
- A 10% concentration of smoke (or reduction in the transparency of the atmosphere) will trigger the detector
- Usually in large spaces



Smoke Detectors

Ionization Detector

- Can detect smoke particles too small for the eye to see
- These detectors contain a radioactive material which produces alpha particles
- When air interacts with the alpha particles, an electric current is generated
- Smoke particles will react differently, changing the flow of current and triggering the alarm
- More prone to false alarms
- Usually in small spaces



FIRE PROTECTION WARNING DEVICES

Fire Protection Warning Devices

- Aircraft fitted with fire protection systems will have multiple warning devices:

  1. Visual (red light) Indications

  2. Aural (bell) Warnings or Alarms

- Once the pilot has been alerted, they must follow the POH

- A typical sequence might be:

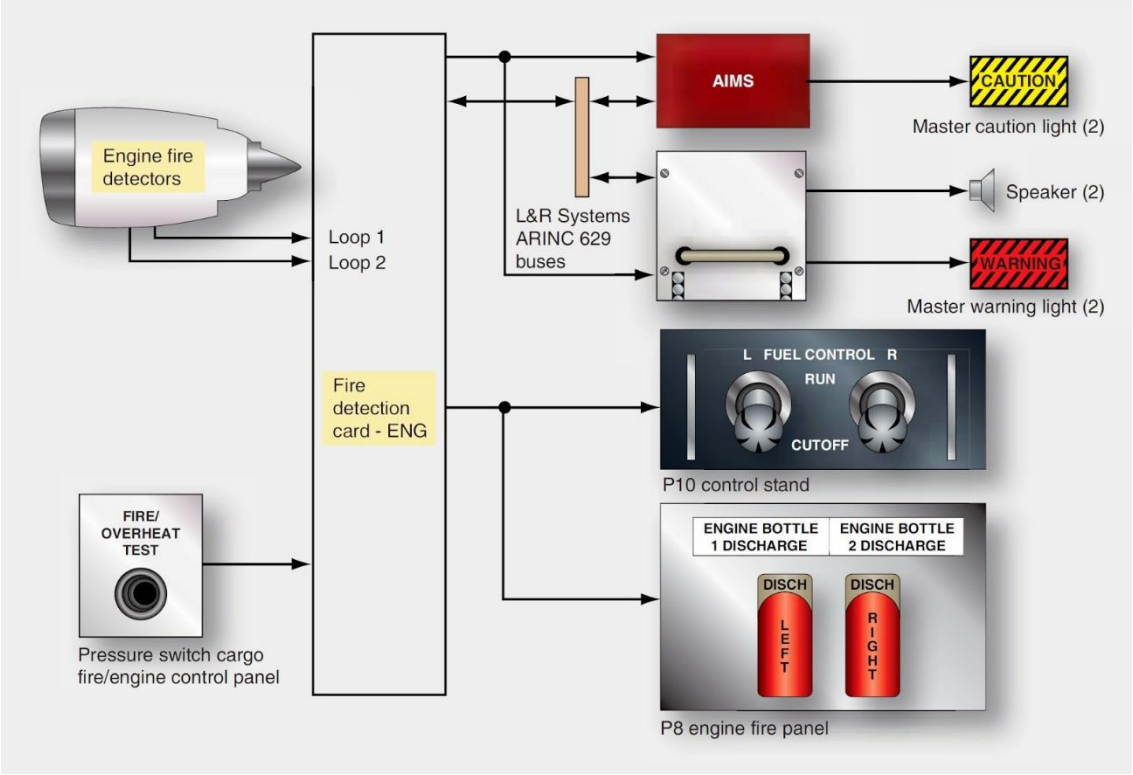
1. Cancel master warning
   (in case of another fire)

2. Pull engine shutdown switch
   (cut off supply of fuel to give extinguishing agent best chance)

3. Arm & deploy fire bottle
   (extinguishing agent)

Fire Protection Warning Devices

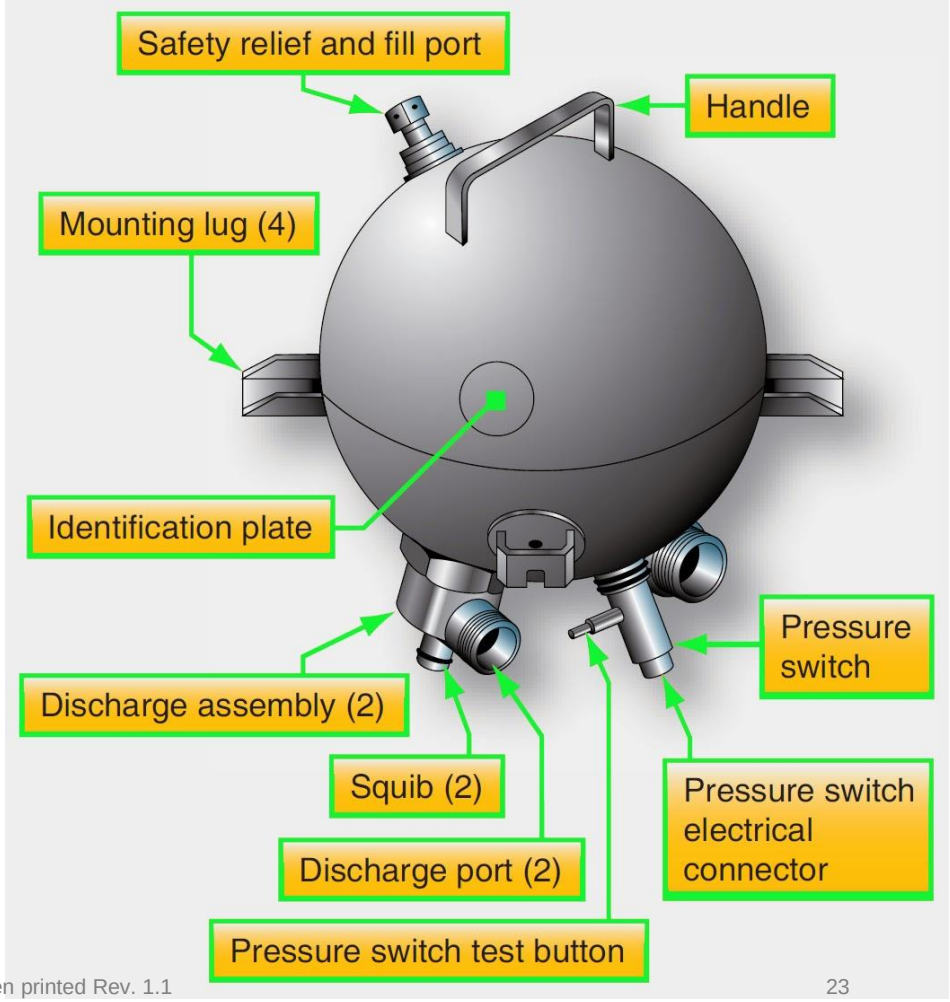
- The pilot in the previous image was pressing the “test” feature of the fire system
- Pressing the test button will test the integrity of the fire wire loop, ensuring that the lights and aural alarms are working properly
- Note that the test feature in most light aircraft will not test the integrity of the individual detectors themselves, only the warning lights and alarms



FIRE PROTECTION EXTINGUISHERS (FIXED)

Fire Protection Extinguishers (Fixed)

- Most large aircraft will have a fixed fire protection system in the form of High Rate Discharge (HRD) Systems
- The most common system involves a High Rate Delivery Spherical Gas Bottle
- A gaseous extinguishing agent e.g. BCF is compressed within the bottle
- When the pilot activates the fire extinguisher, a cartridge in the squib ruptures a breakable disk which seals the agent in the bottle
- The release agent now flows through a discharge line and into the engine nacelle where it is strategically positioned to cover all key engine parts



Fire Protection Extinguishers (Fixed)

- Bottles will be located in each engine nacelle or even in the fuselage or wing, with discharge lines running to the engines

- Depending on the size and sophistication of the aircraft, arrangements include:

1. A single bottle that can be directed to either engine – “single shot”

2. Two bottles, one for each engine – “single shot”

3. Two bottles, each can be directed into either engine – “double shot”

- It is important to shut off fuel to the engine first as you only have 1 or 2 shots to put the fire out!

Fire Protection Extinguishers (Fixed)

- HRD Systems may also have fitted to them:

  1. Inertia Switches

  2. Crash Switches

Inertia Switches

- Similar to ELT activation

- Sudden deceleration (like that in a crash) will automatically activate the bottle

Crash Switches

- Located in the bottle of the aircraft fuselage

- Any crushing or deformation of the airframe (like that in a crash) will automatically activate the bottle