Fire and Smoke Detection System

There is a requirement for duplication of automatic smoke and fire detection systems. Each detector is able to operate independently but they are normally operated in parallel to prevent spurious warnings.

Both detectors have to register the smoke or fire before the warning is given.

Each pair of smoke detectors share a common air supply.

Two firewires or capillary tubes run side by side to form two loops for each fire detector.

Class A Compartments: Places which are permanently staffed (flight decks, passenger cabins) and do not require smoke or fire detecting units. People are excellent smoke detectors!

Class B Compartments: Unmanned compartments that the crew can access during flight e.g. avionics bays.

Class C Compartments: Compartments that are not accessible have smoke detection and remotely operated fire extinguishers i.e. Cargo bays and Holds.

Class D Compartments: Cargo bays with increased fireproofing. Fire will not affect the structure of the aircraft, so is left to burn.

Class E Compartments: On aeroplanes used only for the carriage of cargo.

Compartments Requiring Smoke Detection:
- Galleys
- Toilets
- Class B, C and D Compartments.

Jet Engine Zones:
Jet engine bays, nacelles or pods are divided into three zones.

Zone 1:
Area surrounding the hydraulic pumps, accessory gearbox, oil reservoir, fuel control unit etc.
It is the most likely place for a fire to start.
It is the only zone that has fire detection and remotely operated fire extinguishers.
To reduce the chance of fire spreading, the zone is kept at a lower pressure than the other bays by a ventilation system.

Zone 2:
Area where compressor blades could touch the engine case and create a metal fire.
Indicated via the engine vibration monitoring system.
It is hotter than Zone 1.

**Zone 3:**
Area surrounding the engine and jet pipe aft of the combustion chamber
It is the hottest Zone.
Zone 3 is separated from Zone 1 by a stainless steel fire bulkhead.

**APU Zone:**
APUs can be divided into zones in the same way as the main engines.
In most cases the whole bay in which the APU is located is classed as Zone 1.

**Wheel bays:**
They have overheat detection systems only and no extinguishing system.
The gear needs to be lowered to blow the fire out.
Overheated brakes on the ground are prone to exploding if normal water or foam extinguishant is applied to them.
Therefore they should never be approached from the side.
Sand or dry powder extinguishers used to be used on brake fires, nowadays a special water mist is applied

**Smoke Detection**

**Ion Detection Systems:**
Radioactive material bombards the oxygen atoms in the air with alpha particles.
This create ions (charged gas molecules) in a small chamber.
Ions allow current flow through the air from one side of the chamber to the other.
Smoke particles absorb alpha particles without ionising.
Current falls which is sensed and coupled with a warning light or alarm.

**Optical System:**
The labyrinth smoke detector works on the principle that smoke particles scatter light.
The unit is located in an air extraction duct where a fan draws a constant flow of air through it.
A beacon lamp is located upstream of the labyrinth.
A photoelectric cell is located at the other end of the labyrinth.
Without smoke labyrinth prevents light from the beacon lamp to reach the photoelectric cell.
With smoke the light reflects and refracts and makes its way through the labyrinth to the photoelectric cell.

This creates a current.

Current detection sends a fire warning signal.

Test switch powers a test lamp located behind the photoelectric cell. Both lamps are wired in series so the complete circuit is tested.

**Fire Detection**

Aircraft fire detection and suppression systems are DC powered.

There are four different designs for fire detection units.

These are designed to react to:

General heating - Temperatures between 175-800°F (80-425°C) over a wide area.

Hot spot heating - Temperatures between 800-1200°F (425-650°C) over a small area.

The systems are:

- Resistive continuous fire wire system - Kidde and Fenwal
- Capacitive continuous fire wire system - Kidde and Fenwal
- Gas pressure system - Systron Donner
- Thermocouple system

**Resistive Fire Detection:**

There are two independent loops of firewire supported by a central structure, either a piece of thicker wire or a more rigid tube.

Both loops have to be activated for a fire to be reported.

A resistive fire has a central electrode surrounded by filler material inside a capillary tube.

The capillary tube is earthed to the aircraft's structure.

The two ends of the wire are brought together at a junction which is linked to an arrangement of diodes called a diode bridge or a "wheatstone bridge".

When the system is switched on a 28 volt DC electrical potential will be present in the central core but no current will flow.

Increase in temperature due to fire decreases the resistance of the filler material.

There is a leakage of current to ground via capillary tube.

This flow of electricity unbalances the wheatstone bridge.

A signal is sent to the logic circuit.

If the wire is crushed a false warning can be generated if central electrode is earthed.

In the test mode, detection loop is earthed out warning signal is generated.
**Capacitance Fire Detection:**

The central electrode of the fire wire is connected to a charging and measuring unit.

The charging unit charges the central electrode for a set length of time then discharges it into the measuring unit.

Measuring unit measures the central electrode's capacitance and compares it with a reference value.

With an increase in temperature due to fire the capacitance increases.

Measuring unit senses this and sends a signal to the logic circuit.

If the fire wire is crushed, there will be a loss of capacitance, therefore no (false) fire warning.

Test mode alters the capacitance and thus a warning is generated.

**Systron Donner Fire Detection System:**

It is a gas pressure activated system.

It consists of:

- A responder with two pressure switches.
- A capillary tube with a central core of titanium hydride.

7psi of helium gas (averaging gas) acts on one of the pressure switches and keeps it closed.

Drop in pressure opens the switch, giving a failed signal.

Titanium hydride gives off hydrogen gas in a fire situation.

Gas pressure is raised to 40 psi which closes the alarm switch.

If the capillary tube is crushed, the system will operate provided that there is a gas path to the responder unit.

Test mode checks the responder unit's electrical circuit and the sensor by heating it electrically from the test circuit.

**Thermocouples:**

Loops of wire made of two different metals are joined end to end.

One joint is placed where the temperature is high, the hot junction.

And one joint where the temperature is low (in the cockpit), the cold junction.

Temperature difference causes a current to flow through the wire loop.

In a fire the current flow will increase for thermocouples which have their hot junction in the fire.

The difference in current between these and a reference thermocouple activates the warning system.

The system will fail if fire burns the interconnecting cable.

Testing is carried out by heating one of the thermocouples.
Overheat Sensors:

Used in ducts carrying hot bleed air.

Work on the principle of differential expansion as heat is applied.

A high expansion rate tube expands with heat.

The tube has a pair of low expansion rate spring strips (bi-metallic strips) each with a contact.

With expansion it stretches and pulls the springs together to close the contacts and make the warning circuit.

To be used for fire detection, a delay circuit is used to avoid false alarms due to vibration.

Classification of Fires:

According to ISO 3941:

Class A: Fires involving ordinary combustible materials which are best attacked with water to douse the flames and lower the temperature.

Class B: Electrical fires and those involving flammable liquids (fuel, paint) that need to be smothered.

Class C: Gas fires.

Class D: Burning metal.

BCF:

BCF (bromo chloro difluoro methane) is the preferred fire-extinguishing agent.

Also known as Halon 1211 or Freon.

It acts as a flame inhibitor by absorbing the oxygen in the air.