Project report on

<u>AIRCRAFT FIRE PROTECTION SYSTEM</u>

Submitted in partial fulfillment of the award of the

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(MECHANICAL)

By

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BONAFIDE CERTIFICATE

This is to certify that project report titled **"AIRCRAFT FIRE PROTECTION SYSTEM**", is a bonafide record of work carried out by **Mr. PAWANSINGH RAJPUT** during the final semester from February 2021 to May 2021 under my guidance, in partial fulfillment of the requirements for the award of **Bachelor of Science in Aeronautics (Mechanical).**

PROJECT GUIDE NAME – HARSHAL.BIRARI.

Prof. Dr. M Suresh Kumar

Principal

DECLARATION

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact
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PAWANSINGH MOTISINGH RAJPUT
(2018-M-025)

ABSTRACT

Fire detection system and fire warning are design features of an aircraft. Fire detection system protects the aircraft and passengers both in case of actual fire during flight. But spurious fire warning during flight creates a panic situation in flight crews and passengers. The conventional fire alarm system of an aircraft is triggered by false signal. ANN based fire detection system provides real observation of deployed zones. An intelligent fire detection system is developed based on artificial neural network using three detection information such as heat (temperature), smoke density and CO gas. This Information helps in determining the probability of three representative of Fire condition which is Fire, smoke and no fire. The simulated MATLAB results Show that the errors in identification are very less. The neural network based fire detection system integrates different types of sensor data and improves the ability of system to correct prediction of fires. It gives early alarm when any kind of fire broke out and helps to decrease in spurious warning

1. INTRODUCTION

Under the rather broad heading of fire protection systems, this module will Examine the main components of alerting, suppression, and containment Features and systems. Consideration of these systems is a natural adjunct To a discussion of hazards and features. The primary components we will examine are fire alarm systems, fire Detection and notification systems, suppression agents and systems, water Distribution systems, , and portable fire extinguishers. This module will cover a lot of Basic material meant to provide the novice inspector a solid foundation on.. As was said in the earlier modules, it is only a beginning In different part of aircraft where a fire protection is required the cargo compartment are-important.

Because cargo's area is dynamic in terms of dimensions and topologies as well as environmental conditions. As we know fire causes and there ingredients are different in nature. Due to that a single physical value may not allow the detection of the broad fire in a correct manner. In recent era many types of automatic fire alarm systems are used in aircraft, which bear with some types of shortcomings. For example detection methods using thermal detectors are affected by transient current. Smoke detectors can be affected by different gases developed in cargo compartment. Due to which we often get spurious (false) fire signal. Thus fire detection systems based on single sensor input are not able to meet the needs of real fire alarm. In view of the above Artificial Neural Network (ANN) based fire alarm system is more compatible than traditional fire alarm system because it can intelligently handles the multi sensor information theory.

2. AIRCRAFT FIRE PROTECTION SYSTEM

A complete fire protection system on modern aircraft, and on many older aircraft, includes a fire detection system and a fire extinguishing system. Fire detection is accomplished in many different ways explained below. Fire extinguishing is accomplished with fixed and portable fire agent dispensing systems also explained in this sub-module.

3. CIRCUIT DIAGRAM

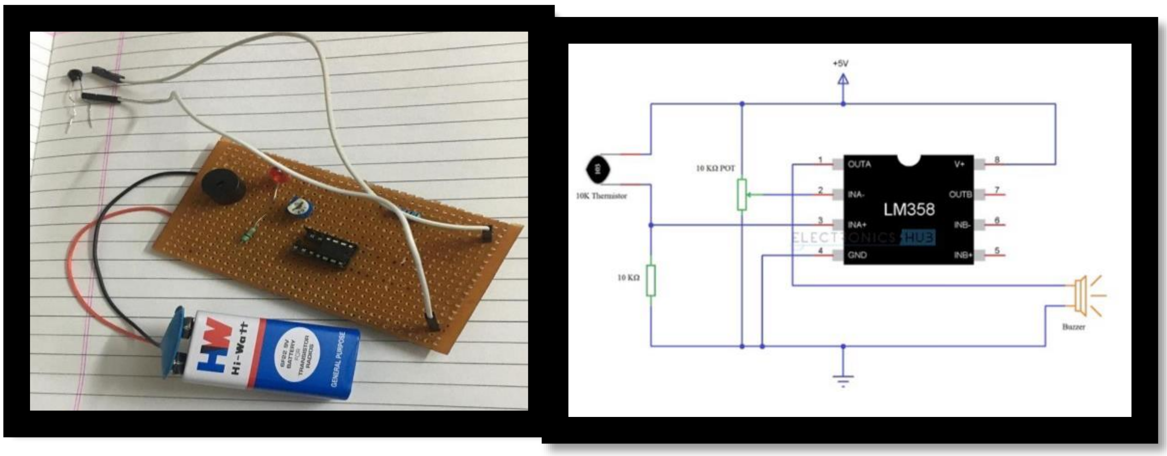

FIG.3.1.CIRCUIT DIAGRAM

Aircraft Fire Protection System Circuit
This is a very simple alarm circuit using Thermistor, LM358 Operational – Amplifier and a Buzzer.
Circuit Diagram:
The circuit diagram of this simple Fire Alarm Project is shown in the following image.
Components Required:
1 x 10 K Thermistor
1 x LM358 Operational Amplifier (Op – Amp)
1 x 4.7 KΩ Resistor (1/4 Watt)
1 x 10 KΩ Potentiometer
1 x Small Buzzer (5V Buzzer) Connecting Wires
Mini Breadboard
5V Power Supply Light-Emitting Diode (LED)

4. AIRCRAFT FIRE ALARM SYSTEMS

Purpose of Fire Alarm Systems A properly designed, installed, operated, and maintained fire alarm system Can reduce the losses associated with an unwanted fire in any building. These losses include property and, more importantly, human life. The Primary motivation for fire alarm system requirements in building and fire Codes is to provide early notification to building occupants so they can exit The building, and to notify the fire service so it can respond to the fire. In Settings such as hospitals the fire alarm system provides notification to Staff so they can respond to the fire emergency (as opposed to evacuating The building). This module will explain the basic features of fire alarm Systems and the inspection of these systems. It should be noted that fire
Alarm systems also are called “protective signaling systems,” especially in NFPA documents and in other codes and standards.

4.1. Types of Fire Alarm Systems

In 1993 the National Fire Protection Association incorporated all of the Existing 72 series standards into one standard that also included NFPA 71. This new standard is titled NFPA 72, National Fire Alarm Code.

Fire alarm systems can be designed and configured to meet the Requirements of local fire codes. In addition to the basic features or Components common to most fire alarm systems, there are several “types” Of fire alarm systems. These are described here (with a reference to the Standard prior to being incorporated into NFPA 72).

Local Protective Signaling System

This type of fire alarm is contained entirely within the building which it Services. The main purpose of this type of system is to provide an Evacuation alarm for occupants of that building. The system need not be Connected by any means to the fire service. Therefore, notification of the Fire service can occur only if someone hearing the evacuation alarm calls And reports the fire alarm. This is the most common type of fire alarm and Was covered previously in NFPA 72A, now part of NFPA 72.

Auxiliary Protective Signaling System

This type of system is connected to a municipal coded fire alarm box Dedicated to that building. Upon activation of the fire alarm within the Building, the municipal box is tripped and sends a signal to the fire Service. It uses the same line as the street fire alarm boxes available to the Public. This type of system, covered previously in NFPA 72B, is now part Of NFPA 72.

Remote Station Protective Signaling System

This type of system uses leased telephone lines to connect the fire alarm System of a given building to a remote receiving station such as the local Fire or police station. This type of system, covered previously in NFPA 72C, is now part of NFPA 72.

Central Station Protective Signaling System

In this type of system the fire alarm system is connected to a privately Owned central station. The central station monitors the fire alarm system And takes the necessary action when an alarm is received, such as to call The local fire department to report an activated fire alarm. This type of System, covered previously in NFPA 71, is now part of NFPA 72.

Proprietary Protective Signaling System

This type of system is similar to the central station system discussed Above, except that the central station is owned by the same concern as the Building being monitored. The building(s) being protected may or may Not be on the same property as the central station. Many large facilities Use this type of system with the security center serving as the central Station. This type of system, covered previously in NFPA 72D, is now Part of NFPA 72.

Voice-Alarm Communication System

Systems can include an emergency voice/alarm communication system. Inclusion of this equipment within the fire alarm system provides for the Transmission of information to occupants of the building. The firedepartment also can use this equipment while operating within the Building. This type of equipment, covered previously in NFPA 72F, is Now part of NFPA 72.

Audible and Visual Alarm Indicators

To make occupants of a building aware of a possible fire emergency, they Must be notified in some manner. Fire alarm systems typically accomplish This through audible and visual indicating devices. So that occupants don't Mistake the signals' purpose, and because the building may be occupied by Handicapped persons, there is a need for both types of signals. For Example, a deaf person will not hear a fire alarm bell and a blind person Cannot see a fire alarm strobe light.
Bells, chimes, horns, buzzers, and Speakers as well as strobe lights, rotating beacons, and flashing lights are Common examples of these devices. Many times the audible devices will Ring in what is referred to as "march time." This means the ringing is not Constant but in an on-off manner. The flashing of lights or strobes acts Better to alert occupants than a steadily illuminated light. It is common Practice, but not always desirable, to locate the audible and visual devices In one unit.

In addition to march-time signals, there are "coded signals." Coded Signals, as the name implies, have a pattern (code) that provides Information regarding the initiation of the alarm. The code may indicate a Location such as a floor or wing where the alarm started. It also could alert The occupants about the required action. The extent and meaning of any Coded fire alarm signal must suit the needs of a particular facility. In Hospitals, for example, where loudspeaker warnings are common, either Coded or direct, such warnings and any fire alarm warnings need Coordination so that the two do not interfere with one another. All Signaling systems should be engineered and tested to ensure they are Capable of alerting all occupants. This requires a knowledge of the Anticipated background noises. For example, a mechanical room thathas.

Equipment operating that produces high noise levels may require special Attention.

4.2. Basic Components of a Fire Alarm System

Fire alarm systems generally have the following components.

- **<u>Alarm Initiating DeviceCircuits</u>**

- These are the circuits which connectinitiating devices such as smoke detectors, heat detectors, manual pull stations, and water flow alarms. Additionally, many system monitor devices important to the overall fire safety of the building also tie in to initiating circuits. These devices indicatean"abnormal"condition,nota fire or "alarm" condition. They'rereferred to as "supervisory devices." One example would be the valve supervisory switch or tamper switch of a valve controlling the automatic sprinkler system. These types of devices also may be connected to supervisory type circuits.

Alarm Indicating Appliance Circuits

Audible and visible alarm indicating appliances tie in to these circuits to Provide warning to the building occupants. Devices which send a signal Off premises also can be connected to these circuits.

The fire alarm control panel contains the electronics that supervise and Monitor the fire alarm system. The initiating and indicating circuits are Connected directly into this panel. Primary Power SupplyThe primary electrical supply powers the entire fire alarm system.
Primary power for fire alarm systems typically I provided by connecting Into the local commercial power service. Secondary Power Supply A separate power supply that will operate automatically when the primary Power fails and is capable of

operating the entire system is considered a secondary power supply.

- **<u>INITIATINGDEVICE</u>**

Initiating devices fall into one of two main categories: either those that Indicate an alarm condition, or those that indicate an abnormal condition Of a monitored device. A brief description of the common types of Devices follows. Fire detection can occur by using any device that responds to conditions Caused by fire. The most common byproducts of fire are heat, smoke, Flames, and fire gases. In addition, people can detect a fire and initiate an alarm by activating a Manual pull station.

Also, when a sprinkler system activates and causes an Alarm, it is a result of the sprinkler system detecting heat produced by the Fire (if the sprinklers have fusible links). We will now look briefly at heatDetectors, smoke detectors, flame detectors, gas sensors, manual fire alarm Boxes, automatic suppression systems, and indicatingappliances.

5. HEAT DETECTOR IN AIRCRAFT

Heat detectors commonly are used to detect fires. They are not as prone to False alarms and are less expensive than smoke detectors. However, the Response of heat detectors may not be adequate in many instances, which Limits their usefulness. Heat detectors are slower to respond to fires than Are smoke detectors because heat detectors cannot respond to smoke. Heat Detectors typically are best suited for detecting fast-growing fires in small Spaces. Heat detectors are also a means of fire detection in locations that Smoke detectors cannot protect due to such environmental effects as mist, Normally occurring smoke, and high humidity

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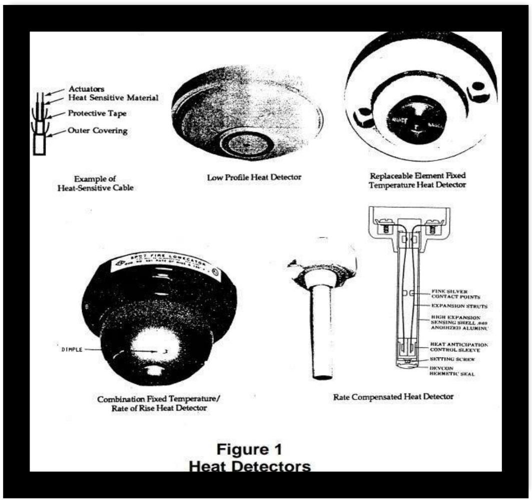

Figure 1
Heat Detectors

FIG 4.2.1.HEAT DETECTOR

6. SMOKE DETECTOR

One cannot overemphasize the benefits of smoke detectors. However, smoke Detectors are not usable in all environments and their effectiveness varies

Depending on the fire scenario and occupant capability. The two basic Operating mechanisms currently used in smoke detectors are photoelectric And ionization. Ionization smoke detectors have a small amount of aradioactive material Located within the detector that “ionizes” the air entering the detection Chamber. Once ionized, the air particles become conductive, allowing a Current to flow through the detector circuitry. Smoke entering the Ionization chamber causes a reduction in the current flowing through the Detector’s circuitry. At a certain reduced level of current flow, the detector Signals an alarm.

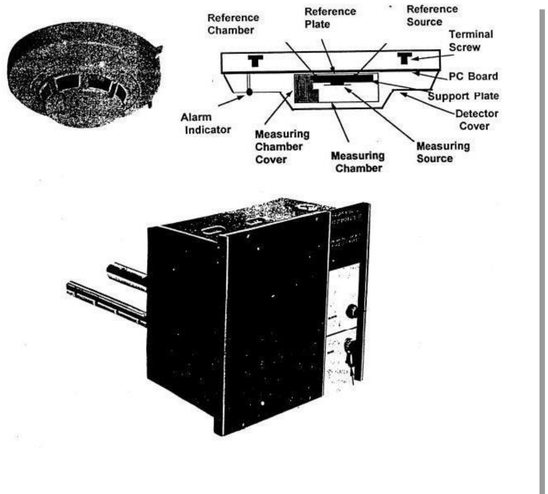

Figure 2
Example of Ionization Smoke Detector with Air Sampling Tubes for Installation in Duct Work for Air Handling System

FIG 4.2.2.SMOKE DETECTOR

7. FLAME DETECTOR

Another method of fire detection is detectors that are sensitive to the light waves emitted by fires. These
typically operate by detecting ultraviolet (UV) or infrared (IR) energy. These detectors are extremely quick to operate and typically are used only in high hazard areas such as industrial process facilities,fuel- loading areas, and areas where explosions may occur. Explosion suppression systems protectthem.
One problem with IR detectors is that they will respond to sunlight, creating an unwanted alarm problem.
Besides, both types of flame detectors must "see" the flame to detect it so they usually have to be pointed toward the locations where fires are likely to originate.

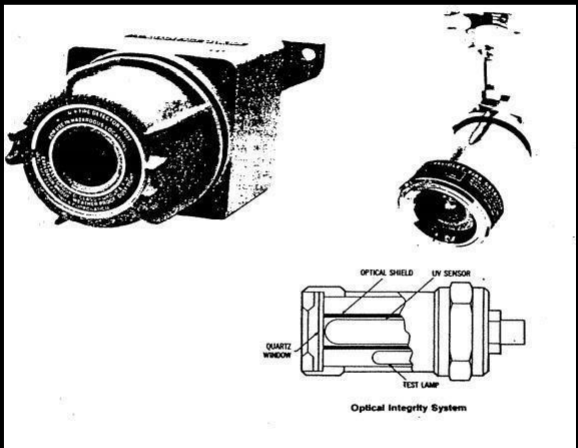

Figure 6
Ultraviolet Flame Detectors

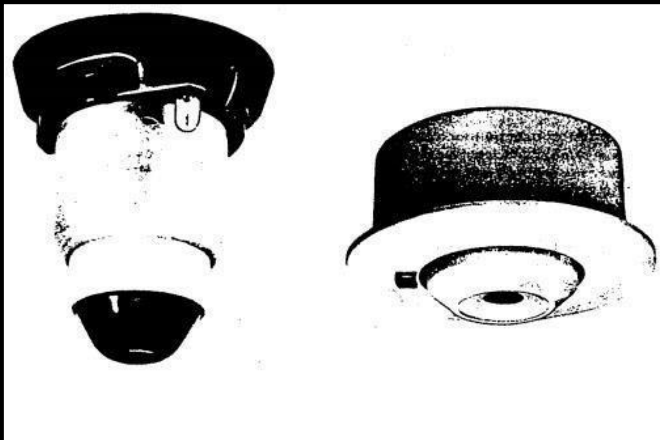

Figure 5
Infrared Flame Detectors

FIG. 4.2.3..ULTRAVIOLET AND INFRARED FLAME DETECTORS.

8. Fire DetectionSystem Maintenance :

Fire detector sensing elements are located in many
high activity areas around aircraft engines. Their location, together with their small size, increases the chance of damage to the sensing elements during maintenance. An inspection and maintenance program for all types of continuous-loop.

- systems should include the following visual checks. Note: These procedures are examples and should not be used to replace the applicable manufacturer's instructions.Sensing elements of a continuous-loop system should be inspected for thefollowing:

- 1. Cracked or broken sections caused by crushing or squeezing between inspection plates, cowl panels, or enginecomponents.

- 2. Abrasion caused by rubbing of the element on cowling, accessories, or structuralmembers.

- 3. Pieces of safety wire, or other metalparticles, that may short the spot-detectorterminals.

- 4. Condition of rubber grommets in mounting clamps that may be softened from exposure tooils or hardened from excessiveheat.

5. Dents and kinks in sensing element sections. Limits on the element diameter, acceptabledents and kinks, and degree of smoothness of tubing contour are specified by manufacturers. No attempt should be made to straighten any acceptable dent or kink, since stresses may be set up that could cause tubing failure

- 7. If shielded flexible leads are used, they should be inspected for fraying of the outer braid. The braided sheath is made up of many fine metal strands woven into a protective covering surrounding the inner insulated wire. Continuous bending of the cable or rough treatment can break these fine wires, especially those near the connectors.

- 8. Sensing element routing and clamping should beinspectedcarefully. Long, unsupported sections may permit excessive vibration that can cause breakage. The distance between clamps on straight runs, usually about 8 to 10 inches, is specified by each manufacturer. At end connectors, the first support clamp usually is located about 4 to 6 inches from the end connector fittings. In most cases, a straight run of one inch is maintained from all connectors before a bend is started, and an optimum bend radius of 3 inches is normally adheredto

- 9. Interference between a cowl brace and a sensing element can cause rubbing.This interference may cause wear and short the sensing element.

- 10. Grommets should be installed on the sensing element so that both ends are centered on its clamp. The split end of the grommet should face the outside of the nearest bend. Clamps and grommets should fit the elementsnugly.

8.1 THE THERMAL SWITCHSYSTEM

A number of detectors or sensing devices are available. Many older model aircraft still operating have some type of thermal switch system or thermocouple system.

- A thermal switch system has one or more lights energized by the aircraft power system and thermal switches that control operation of the light(s).

- These thermal switches are heat-sensitive units that complete electrical circuits at a certaintemperature.

- They are connected in parallel with each other, but in series with the indicatorlights.

- If the temperature rises above a set value in any one section of the circuit, the thermal switch closes, completing the light circuit to indicate a fire or overheatcondition.

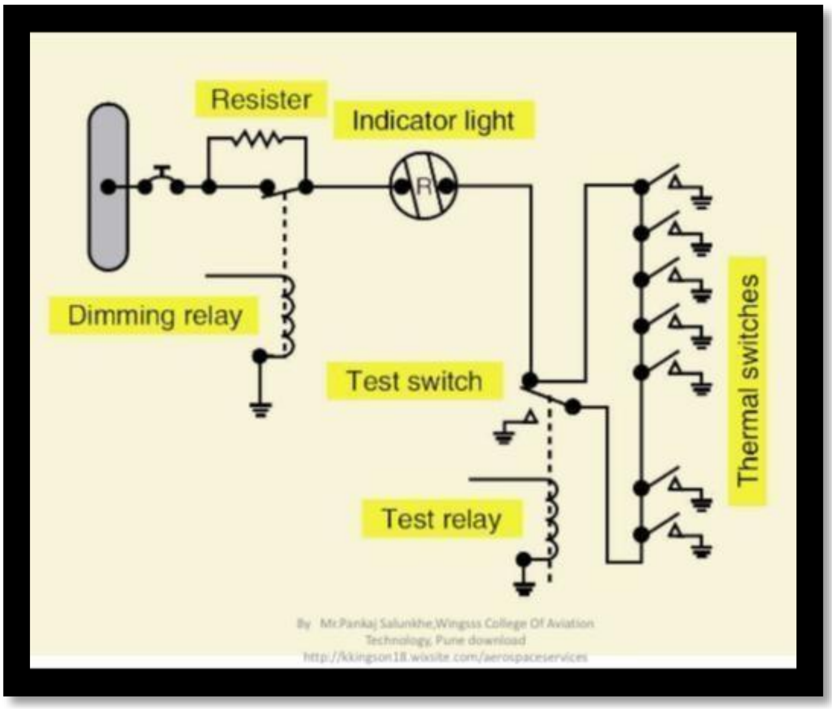

FIG.8.1.1.THE THERMAL SWITCH SYSTEM

8.2.THERMOCOUPLE SYSTEM

• The Thermocouple fire warning system operates on an entirely different principle from the thermal switch system. A thermocouple depends on the rate of temperature rise and does not give a warning when an engine slowly overheats or a short circuit develops. The system consists of a relay box, warning lights, and thermocouples. The wiring system of these units may be divided into the following circuits:

• Detector circuit • Alarmcircuit

• Test circuit

These circuits are shown in Figure . The relay box contains two relays, the sensitive relay and the slave relay, and the thermal test unit. Such a box may contain from one to eight identical circuits, depending on the number of potential fire zones. The relays control the warning lights. In turn, the thermocouples control the operation of the relays. The circuit consists of several thermocouples in series with each other and with the sensitive relay

8.3 .CONTINUOUS - LOOP SYSTEM• Transport aircraft almost exclusively use continuous thermal sensing elements for power plant and wheel well protection. These systems offer superior detection performance and coverage, and they have the proven ruggedness to survive in the harsh environment of modern turbofan engines.

• A continuous-loop detector or sensing system permits more complete coverage of a fire hazard area than any of the spot- type temperature detectors. Two widely used types of continuous-loop systems are the thermistor typedetectors,

1. Fenwal System

2. Kidde System

1. FenwalSystem

• The Fenwal system uses a slender Inconel tube packed with thermally sensitive eutectic salt and a nickel wire center conductor.Lengths of these sensing elements are connected in

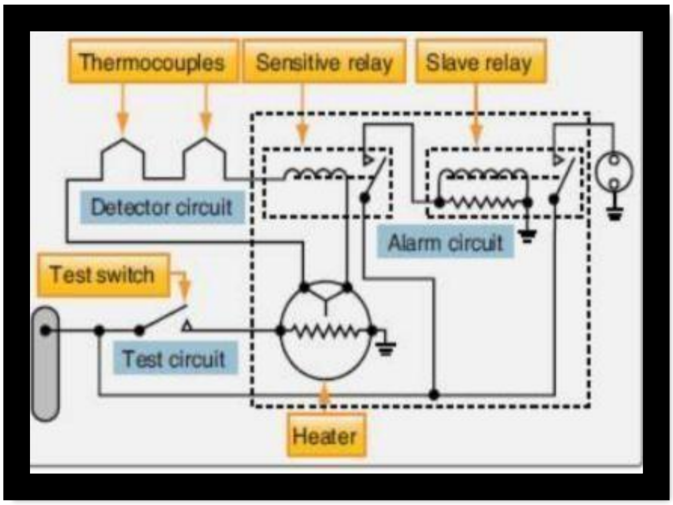

FIG.8.3.1.1.FENWALSYSTEM CIRCUIT DIAGRAM

Series to control a unit. The element may be of equal ofvarying length an of the same or different temperature settings.

•The control unit, operating directly from the power source,

Impress a small voltage on the sensing elements. When an overheat condition occurs at any point along the element length, the resistance of the eutectic salt within the sensing element drops sharply, causing current to flow between the outer sheath and the center conductor.

• This current flow is sensed by the control unit, which produces a signal to actuate the output relay and activate the alarms.

• When the fire has been extinguished or the critical temperature lowered below the set point, the Fenwalsystem automatically returns to standby alert, ready to detect any subsequent fire or overheatcondition.

• The Fenwal system may be wired to employ a loop circuit. In this case, should an open circuit occur, the system still signals fire or overheat. If multiple open circuits occur, only that section between breaks becomes inoperative.

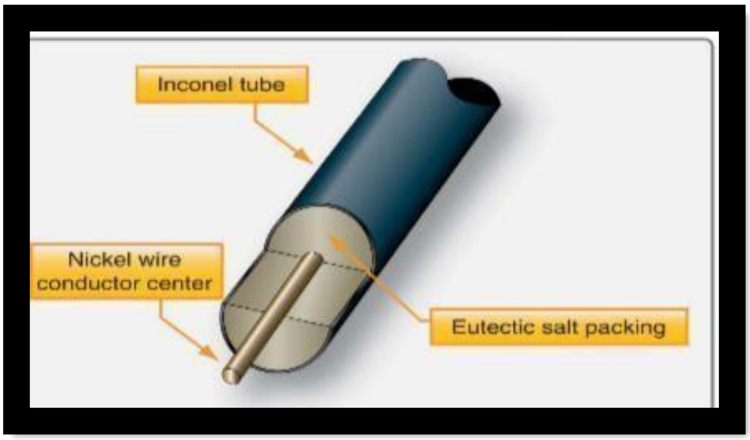

FIG.8.3.1.2.FENWAL SYSTEM.

2. KIDDESYSTEM

- In the Kidde continuous-loop system, two wires are imbedded in an Inconel tube filled with a thermistor core material.

- Two electrical conductors go through the length of the core. One conductor has a ground connection to the tube, and the other conductor connects to the fire detection control unit.

- As the temperature of the core increases, electrical resistance to the ground decreases.

- The fire detection control unit monitors this resistance. If the resistance decreases to the overheat set point, an overheat indication occurs in the flight deck.

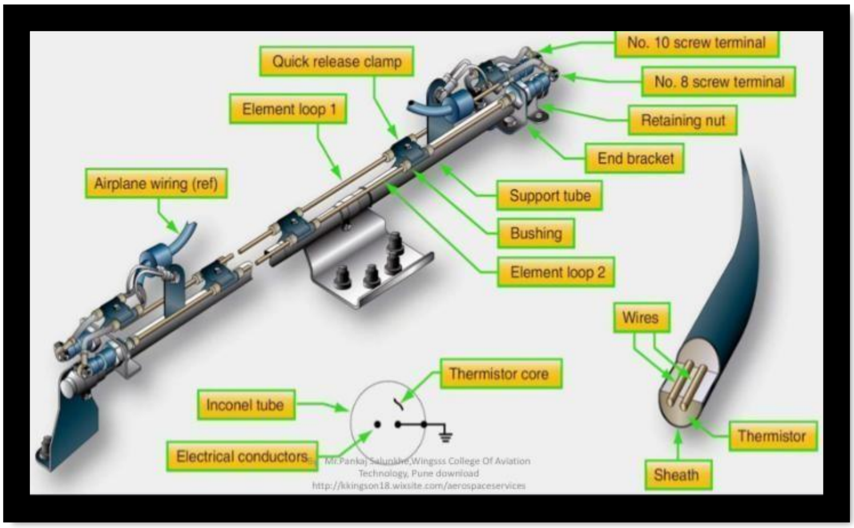

FIG.8.3.2.KIDDIE SYSTEM.

9.Fire Detection SystemTroubleshooting

- The following troubleshooting procedures represent the most common difficulties encountered in engine fire detection systems:

- 1. Intermittent alarms are most often caused by an intermittent short in the detector system wiring. Such shorts may be caused by a loose wire that occasionally touches a nearby terminal, a frayed wire brushing against a structure, or a sensing element rubbing against a structural member long enough to wear through the insulation. Intermittent faults often can be located by moving wires to recreate theshort

2. Fire alarms and warning lights can occur when no engine fire or overheat condition exists. Such false alarms can be most easily located by disconnecting the engine sensing loop connections from the control unit. If the false alarmcease when the engine sensing loop is disconnected, the fault is in the disconnected sensing loop, which should be examined for areas that have been bent into contact with hot parts of the engine. If no bent element can be found, the shorted section can be located by isolating the connecting elements consecutively around the entire loop.

- 3. Kinks and sharp bends in the sensing element can cause an internal wire to short intermittently to the outer tubing. The fault can be located by checking the sensing element with an ohm meter while tapping the element in the suspected areas to produce the short

- 4. Moisture in the detection system seldom causes a false fire alarm. If, however, moisture does cause an alarm, the warning persists until the contamination is removed, or boils away, and the resistance of the loop returns to its normal value.

- 5. Failure to obtain an alarm signal when the test switch is actuated may be caused by a defective test switch or control unit, the lack of electrical power, inoperative indicator light, or an opening in the sensing element or connecting wiring. When the test switch fails to provide an alarm, the continuity of a two-wire sensing loop can be determined by opening the loop and measuring the resistance. In a single-wire, continuous-loop system, the center conductor should be grounded

10. FIRE SUPPRESSION AGENTS AND SYSTEMS BASIC FIRE SUPPRESSION

Fire suppression and extinguishment involve two essential variables: the extinguishing agent and the system or procedure for applying the agent. The primary methods of achieving fire suppression can be explained through the use of the fire tetrahedron which evolved from the familiar fire triangle. The fire triangle is a graphic representation of the three components that must be present for combustion to occur: 1) fuel, 2) heat, and 3) oxygen. If some of these components are removed or sufficiently reduced, combustion ceases. Fire suppression involves the removal or reduction of one or more components of the fire triangle. Or so it was thought until fairly recently.

With the advent of halon and a re-evaluation of the dry chemical extinguishing agents, came a necessity to modify the fire triangle. In addition to the removal of one of the three components just described, fire can be put out by interfering with the complex chemical reactions that are constantly occurring during the combustion process. This “uninhibited chain reaction” now adds a fourth side to the fire triangle, and the fire triangle becomes the fire tetrahedron.

Water

Water is the most common fire extinguishing agent used because it has several features that make it a desirable extinguishing agent. It also has some limitations. Water can extinguish fire by cooling the fuel below the temperature at which the fuel can produce flammable vapors. Water also can extinguish by smothering, dilution, and emulsification.

Water has a very high specific heat; it needs a great deal of heat before it can change from the liquid to the gaseous phase. Therefore, water applied to a fire will absorb a large portion of the heat released by the fire. If there is enough water to absorb the heat, the fire will go out since the fuel cools below the temperature required to liberate additional flammable vapors. Once water is converted to steam, it is still an effective fire extinguishing agent, since the steam can continue to absorb a great deal of heat. It is best to introduce water into the fire area in the form of a spray as opposed to a stream. A spray will allow for the quicker absorption of heat. For this reason, sprinklers discharge water in a spraypattern

When water transforms into steam, its volume increases approximately 1,600 times. This acts to displace the oxygen from the fire area. This will result in the smothering, or oxygen depletion, of the fire. Without adequate oxygen, the fire soon will die. Thus, water transferring to steam acts as a suppression agent in two ways: heat absorption and oxygen displacement.

Extinguishment by dilution means the introduction of water into a burning liquid. The dilution acts to cool the liquid and reduces the vapor production at the fuel surface, since the flammable liquid is diluted.

Emulsification is another method of fire extinguishment using water. Basically, an emulsion is formed when immiscible liquids are mixed and one of the liquids becomes dispersed in the other. The emulsion that forms at the surface will retard the liberation of flammable vapors and the fire will die.
Dilution and emulsification have several limitations and generally are not a good way to extinguish a fire. Spills and boil overs may occur in some tanks, causing the fire to spread and possibly causing injuries.

Perhaps the main benefit of water as a suppression agent is that it is relatively cheap and readily available in most areas, especially if there is a municipal water supply. The major limitations of water are that it is extremely heavy, it conducts electricity, it can damage property, and it can freeze.
However, there are design methods, including the selection of other agents, that can minimize the negative aspects of water as a suppression agent.

Water With Modifiers

Occasionally the water used for fire suppression has modifiers added to change some of its characteristics. Foam is perhaps the most common example. Low- to high-expansion foam concentrates frequently are added to water to form a foam solution for fighting certain types of fire, such as flammable

liquid spills. Additives also include surface tension reducing agents frequently called wetting agents. These increase the ability of water to penetrate combustibles; in turn this allows the water to attack deep-seated fire. Antifreeze is used to reduce the freezing point of water when temperatures at or below freezing threaten the proper use of water- based fire suppression systems. NFPA’s Fire Protection Handbook discusses other water additives used with less frequency.

Carbon Dioxide (CO2)

CO2 is a substance with many commercial uses. Perhaps the most familiar is the carbonation in soda pop and other carbonated beverages. CO2 also

has a number of properties which make it a good fire extinguishing agent. One of the most common uses of CO_2 systems is to protect kitchen cooking equipment. The hood, ducts, and enclosed broilers may be protected with a total flooding application. Deep fryers require local application protection.

At room temperature and pressure, CO_2 can exist as a vapor or a solid. Eventually the solid form (dry ice) will transfer to the gaseous form. For fire extinguishing purposes CO_2 cannot exist at pressures below 75.1 psi absolute (about 60 psi). At this pressure, the liquid, vapor, and solid phases of CO_2 can all exist simultaneously. This point is of importance when designing piping systems to carry liquid CO_2. Pressure in the pipeline must not drop below this point or the attendant formation of dry ice will block the pipe and stop the flow.

In any fire, heat results from the rapid oxidation of the fuel. Some of the heat generated brings the unburned portion of the fuel to its ignition temperature, while a large portion of the heat and combustion escapes by radiation and convection to the surroundings. If the atmosphere that supplies oxygen to the fire is diluted by adding carbon dioxide, the rate of heat generated by oxidation is reduced. When the rate of heat generation is less than the rate of heat loss, the fire will die. Complete extinguishment will occur when all of the fuels involved cool below their ignition temperatures.

When the liquid is discharged to atmospheric pressure, it "flashes" over to vapor and dry ice. The percentage of dry ice and vapor produced depends primarily on the storage condition of the liquid. The superheated CO_2 vapor is about 50 percent more dense than air. The dry ice has a temperature of about -110°F at atmospheric pressure. In spite of the low temperature of the dry ice particles, the heat capacity of the CO_2 is rather low compared to other fire extinguishing agents such as water. Thus the cooling effect, though present, is not as significant on a pound-for-pound basis as the cooling produced by water. Most of the dry ice from a typical total flooding discharge is sublimated by the air in the enclosure.

The evaporation of the dry ice in the fire zone removes heat from surroundings at a rate between 60 and 110 Btus per pound of liquid CO_2 discharged. While this cooling is small compared with the cooling obtained with other agents (water provides ten times the cooling effect per pound), it does contribute to extinguishing effectiveness.

The relative high density of CO_2 vapor makes it useful for blanketing the surface of a fuel. The oxygen in the surrounding air physically separates from the surface of a fuel. This effect is noticeable particularly with local application.

Halon

Halon is a fire extinguishing agent commonly used to protect electronic and electrical equipment, surface burning solids such as some plastics, flammable liquids, and gases. Halon generally is not successful in protecting reactive metals (e.g., magnesium, sodium, etc.) and in extinguishing many fires that can become deep seated. For these fires, high concentrations and a long soak time would be required. Fuels that contain their own oxidizing agent will burn freely in halon, making it ineffective. Halons also are quite expensive, a concern when determining the type of agent and system to use for fire protection.

Halon extinguishes fire by entering into, and disrupting, the chemical combustion chain reaction; the exact mechanism still is not understood completely. This is unique for a fire extinguishing agent in that it affects the chemical chain reaction as opposed to quenching (removal of heat by water) or smothering (by CO_2).

The breaking of the chain reaction allows halon to suppress fires quickly. In addition, halon is considered a "clean" agent, in that it leaves no residue after discharge. It is almost

completely electrically nonconductive; hence its wide use in electronics. Halon is also noncorrosive to many materials.
Since Halon 1301 is a gas when discharged, it has good volume filling capabilities. However, Halon 1211, another fairly common agent, does not vaporize as readily as Halon 1301. The concentrations required typically are low, on the order of five percent by volume. This results in smaller storage containers. Halon is approximately 2-1/2 times more effective than CO_2 on a weight basis. Finally, halon is colorless, which allows people caught in a discharge to see through it.

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Halon systems often protect data processing centers and other areas which contain sensitive electrical equipment. Such systems also exist in electric and telephone switchgear rooms. In addition to the type of hazard protected, another critical criterion for using halon is the need to provide a tight enclosure. Since halon is a gas, it can leak through improperly sealed openings and, as a result, the required design density is not maintained.

Lately, there has been great concern over the effects halon has on the environment, and in particular its depletion effect on the ozone layer. This has resulted in a re-evaluation of the use of halon as a fire suppression agent. In addition, the use of halon in acceptance testing has been subject to study, and options such as using different test gases (e.g., sulfur hexafluoride, SF_6) are now being evaluated. Several new products are now under development to replace the halon agent in existing fire suppression systems.

Dry Chemical

Dry chemical extinguishing agents can extinguish extremely fast if introduced directly into the flaming area. Smothering and cooling result from the application of dry chemical agents, but the primary extinguishing capabilities result from the combustion-chain-reaction-breaking abilities of the dry chemical agent. This is the same principal extinguishing feature of halons.

Dry chemical fire suppression systems use a dry chemical powder mixture as an extinguishing agent. Common dry chemical agents include sodium bicarbonate, potassium bicarbonate, urea-potassium bicarbonate, and mono ammonium phosphate. Additives in the base compound reduce caking, promote water repellence, and increase flow and storage characteristics. Examples of common additives include metallic stearate, tricalcium phosphates, and silicones. Multipurpose dry chemical usually refers to the mono ammonium agent which can be used to suppress fires involving ordinary combustibles, and energized electrical equipment as well as flammable liquids.

Regular dry chemical is not considered a good agent for ordinary combustibles, since water also must be applied to attack any subsurface burning which the regular dry chemical cannot reach. The multipurpose agent does have penetrating

abilities, thus its multipurpose listing. Agents should never be mixed unless specifically listed for mixing, as some agents will generate CO_2. This may cause containers to explode and the agent to cake.

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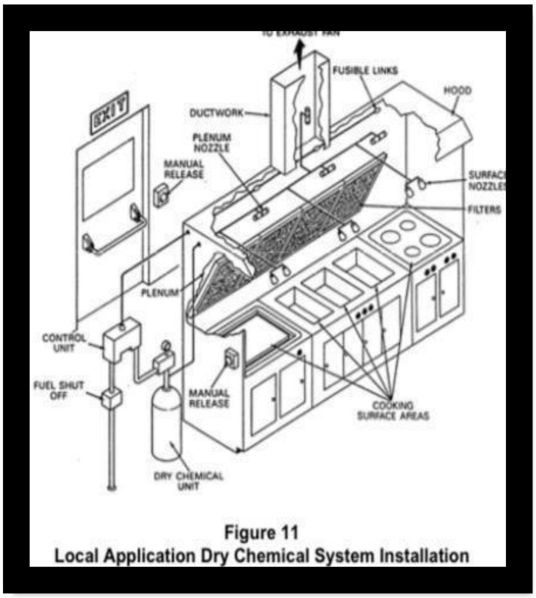


Figure 11
Local Application Dry Chemical System Installation

FIG.10.1. DRY CHEMICAL SYSTEM INSTALLATION

WET CHEMICAL

Wet chemical suppression agents are a relatively new means of suppressing fires involving cooking equipment. Leading manufacturers of wet chemical suppression systems introduced these systems in the early 1980s. Wet chemical suppression systems currently are accepted only for the protection of restaurant, commercial, and institutional hoods, plenums, ducts, and associated cooking appliances. Only pre- engineered systems are used.

Wet chemical extinguishing agents typically are potassium carbonate- based, potassium acetate-based, or a combination

of these, mixed with water. These solutions are alkaline-based and discharge through system piping by an excellent gas. The primary extinguishing capability of the wet agent is its characteristic of mixing with cooking grease to form a foam barrier over the burning fuel. This blanket effect prevents the flammable volatiles from mixing with the oxygen needed for combustion. It also acts to cool the fuel surface; this aids in fire suppression

The wet chemical agents generally are harmless to humans. Any effects that may occur usually disappear once contact with the agent ends. The agents may have corrosive effects on some metals; the manufacturer’s literature should be
consulted for such information. Manufacturers’ warnings to use the right agent in the right system are very important. In part, this is due to the testing of specific systems with specific wet chemical agents. Using non approved agents, or agents from other manufacturers may make a system inoperative.

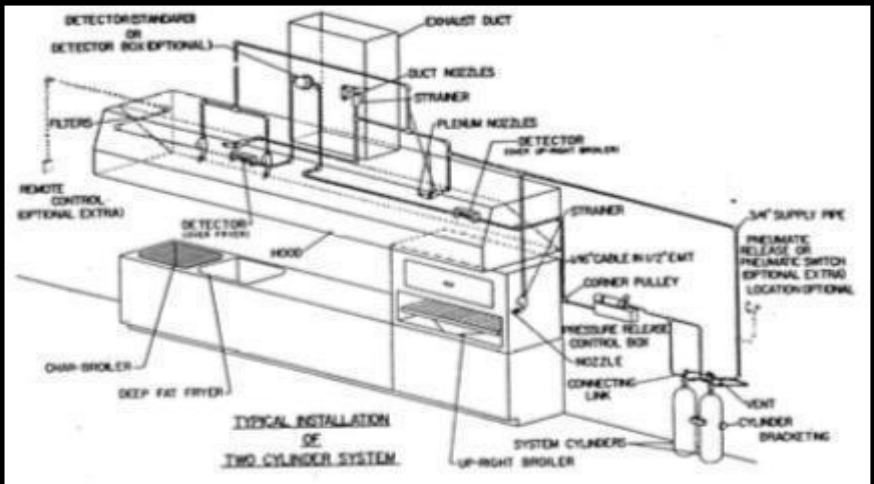


Figure 12
Restaurant Range Hood Wet Chemical System

FIG.10.2.WET CHEMICAL SYSTEM

11. Reason for fire in aircraft

What are the most common areas for airplane fires?

Airplane fires can occur in varying places, and for varying reasons. Airplane fires are typically categorized into three types: engine, cabin, and hidden.

Engine fires– Excess oil spills and igniting are the most common causes of engine fires. Fuel leaks or pressurization within the engines' piping also cause fires. Engines have their own fire suppression and containment systems. The pilot can spool down/switch off fuel to engines on fire. Engine fires are rare and fairly simple to address. The crew can use fire extinguishers on the engine after the fuel supply is shut off.

Cabin fires– There are a few causes of in-flight, or cabin, fires such as wiring failures, electrical component failures, lithium Ion batteries, and faulty circuit protection. There are several types of cabin fires: galley fires, electrical fires, lavatory fires, waste container fires, seat fires, and passenger PED fires.
Many cabin fires are a result of human error (i.e. overheated food items in the galley or improper storage of Lithium batteries in PEDs).

Hidden fires– Hidden fires are fires not easily accessible and challenging to extinguish (i.e. a fire behind sidewall paneling or in overhead areas). Overhead areas contain the aircraft's entertainment system, numerous wiring bundles, control surface cables, portions of the air conditioning system, passenger oxygen system, and other systems. Any of these components malfunctioning can result in a fire in the overhead compartment. In most cases, electrical arcs along wire bundles cause hidden in-flight fires. The electrical arc acts as the initiating event, igniting other surrounding materials.

What can passengers do to prevent in-flight fires?

Notify a crew member immediately if you see fumes, smell smoke, see smoke coming from vents, or interior panels of the aircraft,You may be asked to help combat a fire if you are an able-bodied passenger. Crew members seek out all available resources to extinguish smaller in-flight fires.

As always, prevention is key. For passengers, this means adhering to all rules while onboard (i.e. not smoking or using e-cigarettes) and properly storing personal electronic devices. Finally, TSA has an online “travel checklist” that will help passengers know what to pack and how it pack it.

11.1 Accidents and Incidents Cause By Fire

A sele.ction of incidents from the SKYbrary database related to Post Crash Fire:

B742 / B741, Tenerife Canary Islands Spain, 1977 (On 27 March 1977, a KLM Boeing 747-200 began its low visibility take-off at Tenerife without requesting or receiving take-off clearance and a collision with a Boeing 747-100 backtracking the same runway subsequently occurred. Both aircraft were destroyed by the impact and consequential fire and 583 people died. The Investigation attributed the crash primarily to the actions and inactions of the KLM Captain, who was the Operator's Chief Flying Instructor. Safety Recommendations made emphasised the importance of standard phraseology in all normal radio communications and avoidance of the phrase "take-off" in ATC Departure Clearances.)

B738 / B738, Toronto Canada, 2018 (On 5 January 2018, an out of service Boeing 737-800 was pushed back at night into

collision with an in-service Boeing 737-800 waiting on the taxiway for a marshaller to arrive and direct it onto the adjacent terminal gate. The first aircraft’s tail collided with the second aircraft’s right wing and a fire started. The evacuation of the second aircraft was delayed by non- availability of cabin emergency lighting. The Investigation attributed the collision to failure of the apron controller and pushback crew to follow documented procedures or take reasonable care to ensure that it was safe to begin the pushback.)

B735, vicinity Perm Russian Federation, 2008 (On September 13 2008, at night and in good visual conditions*, a Boeing 737-500 operated by Aeroflot-Nord executed an unstabilised approach to Runway 21 at BolshoyeSavino Airport (Perm) which subsequently resulted in loss of control and terrain impact.)

B462, Stord Norway, 2006 (On 10 October 2006, a BAE Systems 146-200 being operated by Danish airline Atlantic Airways on a passenger flight from Sola to Stord overran the end of runway 33 at destination at a slow speed in normal visibility at dawn (but just prior to the accepted definition of daylight) before plunging down a steep slope sustaining severe damage and catching fire immediately it had come to rest. The rapid spread of the fire and difficulties in evacuation resulted in the death of four of the 16 occupants and serious injury to six others. The aircraft was completely destroyed.)

SW4, en-route, North Vancouver BC Canada, 2015 (On 13 April 2015, a Swearingen SA226 Metro II which had recently departed on a cargo flight was climbing normally when it suddenly entered an unexplained and steep descent a few minutes after takeoff. There were no communications from the pilots. It was later found to have impacted terrain after a rate of descent exceeding 30,000 fpm had created aerodynamic forces which caused structural disintegration to begin before impact. The Investigation could not determine

why but concluded that “alcohol intoxication almost certainly played a role” and noted that indications that the Captain was a chronic alcoholic had not prompted any intervention.)

SW4, vicinity Red Lake ON Canada, 2013 (Synopsis: On 10 November 2013 the left engine of a Fairchild SA227 on final approach suddenly ceased to produce any power at approximately 500 feet whilst continuing to operate. The crew did not identify what had happened in time to avoid losing control of the aircraft which then impacted terrain, caught fire and was destroyed. The Investigation found that premature failure of engine components had caused the engine malfunction and noted that some pilots may believe that the Negative Torque Sensing (NTS) System provided for the engines on this aircraft type will always detect high drag conditions arising from power loss.)

AT75, vicinity Magong Taiwan, 2014 (Synopsis: On 23 July 2014, a TransAsia Airways ATR 72-500 crashed into terrain shortly after commencing a go around from a VOR approach at its destination in day IMC in which the aircraft had been flown significantly below the MDA without visual reference. The aircraft was destroyed and48 of the 58 occupants were killed. The Investigation found that the accident was entirely attributable to the actions of the crew and that it had occurred in a context of a systemic absence of effective risk management at the Operator which had not been adequately addressed by the Safety Regulator.)

SU95, Moscow Sheremetyevo Russia, 2019 (Synopsis: On 5 May 2019, a Sukhoi RRJ-95B making a manually-flown return to Moscow Sheremetyevo after a lightning strike caused a major electrical systems failure soon after departure made a mismanaged landing which featured a sequence of three hard bounces of increasing severity. The third of these occurred with the landing gear already collapsed and structural damage and a consequential fuel-fed fire followed as the aircraft veered off the runway at speed. The subsequent evacuation was only partly successful and 41 of the 73 occupants died and 3 sustained serious injury. An Interim Report has been published.)

DC91 / B722, Detroit MI USA, 1990 (Synopsis: On 3 December 1990 a Douglas DC9-10 flight crew taxiing for departure at Detroit in thick fog got lost and ended up stopped to one side of an active runway where, shortly after reporting their position, their aircraft was hit by a departing Boeing
727-200 and destroyed by the impact and subsequent fire. The Investigation concluded that the DC9 crew had failed to communicate positional uncertainty quickly enough but that their difficulties had been compounded by deficiencies in both the standard of air traffic service and airport surface markings, signage and lighting undetected by safety regulator oversight.)

B733 / SW4, Los Angeles CA USA, 1991 (Synopsis: On 1 February 1991, a Boeing 737-300 had just made a normal visibility night touchdown on Los Angeles runway 24L in accordance with its clearance when its crew saw another aircraft stationary ahead of them on the same runway.
Avoidance was impossible in the time available and a high speed collision and post-impact fire destroyed both aircraft and killed 34 of their 101 occupants and injured 30 others. The other aircraft was subsequently found to have been a Fairchild Metroliner cleared to line up and wait by the same controller who had then cleared the 737 to land.)

Flight crews will treat any in-flight fire or fire/smoke alarm with the utmost attention and urgency. The following effects of fire or smoke could be expected, potentially developing from a relatively benign situation to the worst case scenario within minutes:

Reduced cockpit visibility;

Breathing problems necessitating the donning of oxygen masks and smoke goggles;

Communication difficulties due donning of the oxygen masks; Equipment malfunction or isolation;

Partial or complete flight control loss;

In an effort to mitigate the smoke/fire risk, crews may conduct a:

Emergency descent;

A short or reduced track mile approach High speed approach and landing;

Passenger evacuation on the runway or adjacent taxiways.

Automatic Suppression Systems

Fire suppression systems can connect into a fire alarm panel so that activation of the system causes the panel to signal an alarm. Wet pipe automatic sprinkler systems commonly have water flow detectors. As water starts to flow in the sprinkler piping, it causes a vane to swing into an alarm position; this sends an alarm to the fire alarm panel. Dry pipe sprinkler systems may have pressure sensors for the same reason.

All other fire suppression systems also can be connected to the fire alarm panel. As mentioned above, not all devices signal an alarm condition.

Many devices tie into the fire alarm system so that they will alert for abnormal conditions. Perhaps the most common example is that of a valve supervisory switch or "tamper switch" on a sprinkler system. To assure valves that control a sprinkler system are in the proper position, they can have a tamper switch that will operate if the valve position changes. If the valve moves, a signal will appear at the fire alarm panel indicating the valve should be inspected. This is important since someone could inadvertently, or purposely, close a valve on the sprinkler system, rendering the systeminoperable.

Many other indicating devices can connect into the fire alarm panel for supervision. The following is a partial list.

- water level and temperature in a gravitytank;
- water level and air pressure in storagetank;
- status of firepump;

air pressure on dry pipe system ;and temperature in the sprinkler control valveroom.

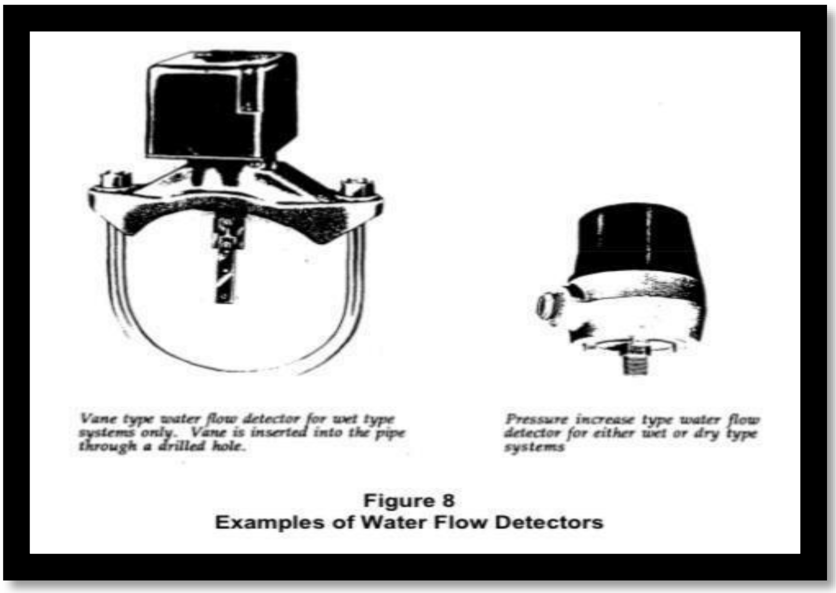


FIG.13.1.WATER FLOW DETECTOR

12. PREVENTION OR PREVENTIVE MEASURES

12.1. TYPES OF WATER DISTRIBUTION SYSTEMS

The two basic types of systems are public systems and private systems.

Public Water Systems

Public water systems usually fall under a unit of local government or an "authority" with legal responsibility. The water utility department and the fire department need to develop and maintain a good working relationship. They should support each other and work together to plan, design, and maintain the system for the benefit of the community. If a public water system and the fire department are both units of the local government, it is easier to work together.

This becomes even more critical when the water authority is separate from local government.

Private Water Systems

Private water systems usually are owned by land development or manufacturing companies. They may supply water utility service to a particular site or in some instances to a community. When serving a single site, the water usually is used for manufacturing, processing, and fire protection.
Generally, the system has its own water storage and, in some cases, its own water processing equipment.

The water distribution system (pipes and valves) is only for use on the site and generally is not connected to a public system. The system may have standard water distribution hardware, or hardware manufactured for the private system owner. If nonstandard hardware is used, sometimes the hydrants and hose connection are not compatible with the local fire department's apparatus. If you have any private systems within your jurisdiction, preplan the site and make arrangements with the private system operators for appropriate hardware so that the fire department's equipment,and the equipment at the site system are compatible or are adaptable for compatibility.

12.2. TYPES OF FIRE EXTINGUISH USED IN AIRCRAFT:

There are different classifications of fires differentiated by the type of material that is burning. In general terms, there are four primary fire types:

Class A - Ordinary combustibles (solid material fires)

- wood, paper, plastic etc,

Class B - Flammable liquids or gases - fuels, alcohol, aerosols,

Class C - Electric fires,

Class D - Combustible metal fires - magnesium, potassium etc.

Fires of all classifications cannot be dealt with in the same way. As a consequence, the airport rescue and fire fighting services (RFFS) must have a variety of fire suppression tools at their disposal. This article identifies the three primary categories of fire extinguishing agentscurrently used by the RFFS in dealing with aircraft fires.

These categories are:

Primary Agents Supplementary Agents Other Agents

For information about the portable fire extinguishers carried on board of the aircraft together with the automated aircraft fire extinguishing systems see the dedicated article on SKYbrary: Aircraft Fire Extinguishing Systems

Primary Agents

Foam is the primary agent used for extinguishing aircraft fires. Foam fire suppressant consist of a combination of bubbles of a lower specific gravity than that of hydrocarbon fuels or water. The foam has strong cohesive qualities and is capable of covering and clinging to vertical and horizontal surfaces. Aqueous foam cools hot surfaces by its high water retention ability and can flow freely over a burning liquid surface to form a tough, air-excluding blanket that seals off explosive and flammable vapours from access to air or oxygen. Good-quality foam should be dense and long lasting, capable of resisting disruption by wind or draft, stable to intense thermal radiation, and capable of re-sealing in event of mechanical rupture of an established blanket.

Supplementary Agents

Supplementary agents are also referred to as secondary agents. Agents that fit into this category are carried on rescue vehicles to handle unique fire fighting requirements most common to airport fire fighting use.

Supplementary agents are employed either singly or in combination with foam to accomplish particular aircraft fire fighting operations such as a three dimensional running fuel fires,

This class of agents include:

DryChemic al

Halotron®I

CarbonDioxide

OtherAgents,

In general there are other special-use fire extinguishing agents available to airport fire fighting services. In particular, those agents used to combat Class D fires (Combustible metals), such as magnesium fires, are referred to as combustible metal agents. Under certain fire situations “wetting agents” also may be appropriate.

These agents can be either in the form of liquid or powder. A wetting agent is defined as a chemical compound that, when added to water in proper quantities, materially reduces its surface tension, increases its penetrating and spreading abilities, and might also provide emulsification and foaming characteristics. These agents should not be mixed in any primary agent tanks.

1) Waterextinguishers:

Water is one of the most commonly used fire extinguishing agent.

Water fire extinguishers work by removing heat from the surface, thereby killing the fire.

In water extinguishers, compressed air pushes water to come out of the tank to be sprayed on fire.

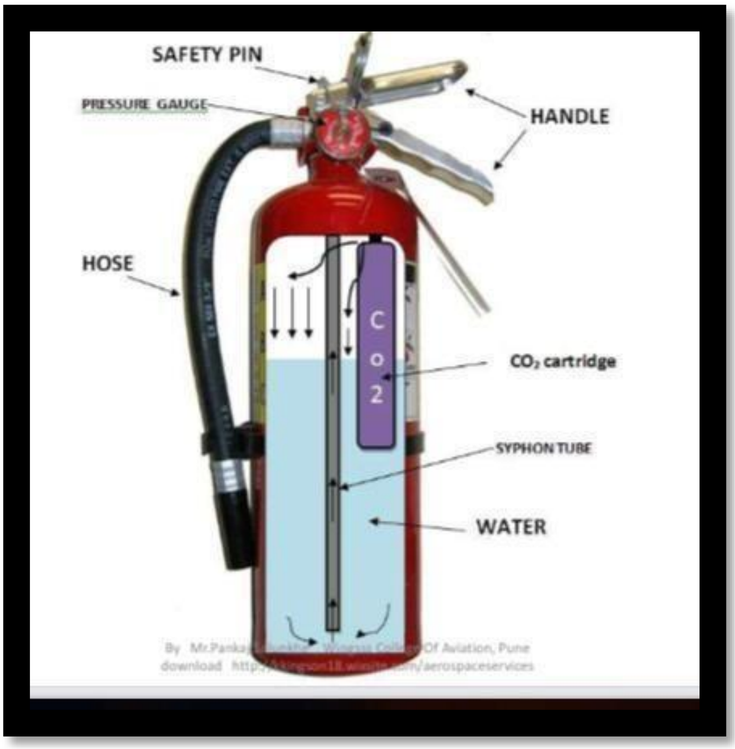


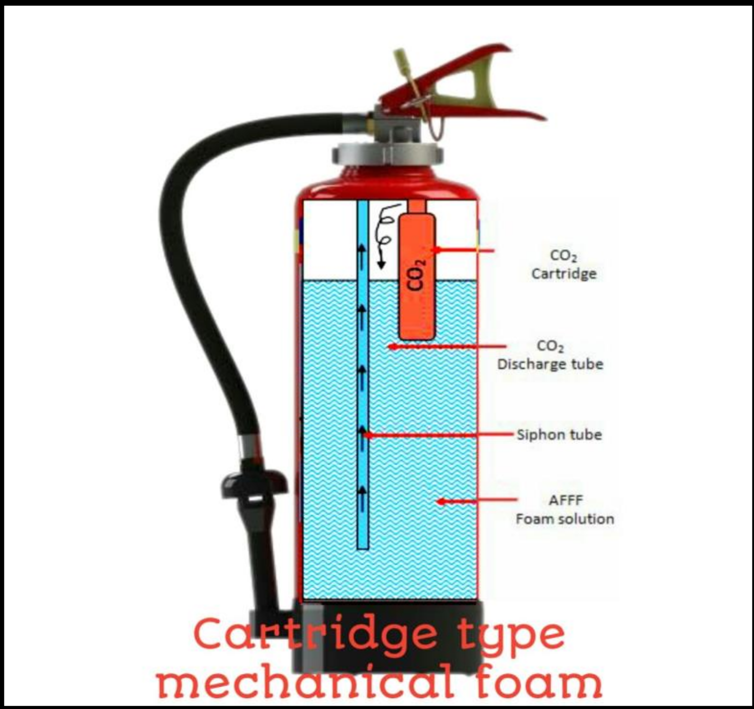
Fig.13.2.1. Water Extinguisher

2) Gasextinguishers:

Carbon dioxide fire extinguishers contain high pressure carbon dioxide in the liquid form.

When this gas is suddenly released on a fire, the gas expands by a huge amount, thereby reducing its temperature. In addition, carbon dioxide is heavier than air, so it settles down.

This means that carbon dioxide fire extinguishers work by removing heat and also oxygen supply to the fire, and thus they are effective in extinguishing fires.



3) <u>Dry chemicalextinguishers</u>

These work by cutting off the fuel supply to the fire.

When dry chemical powder is sprinkled around the fire, the powder tends to form a layer on top of the fuel and thus cuts it off from the fire.

The powder being non-flammable, the fire doesn’t get the fuel to sustain itself and thus extinguishers.

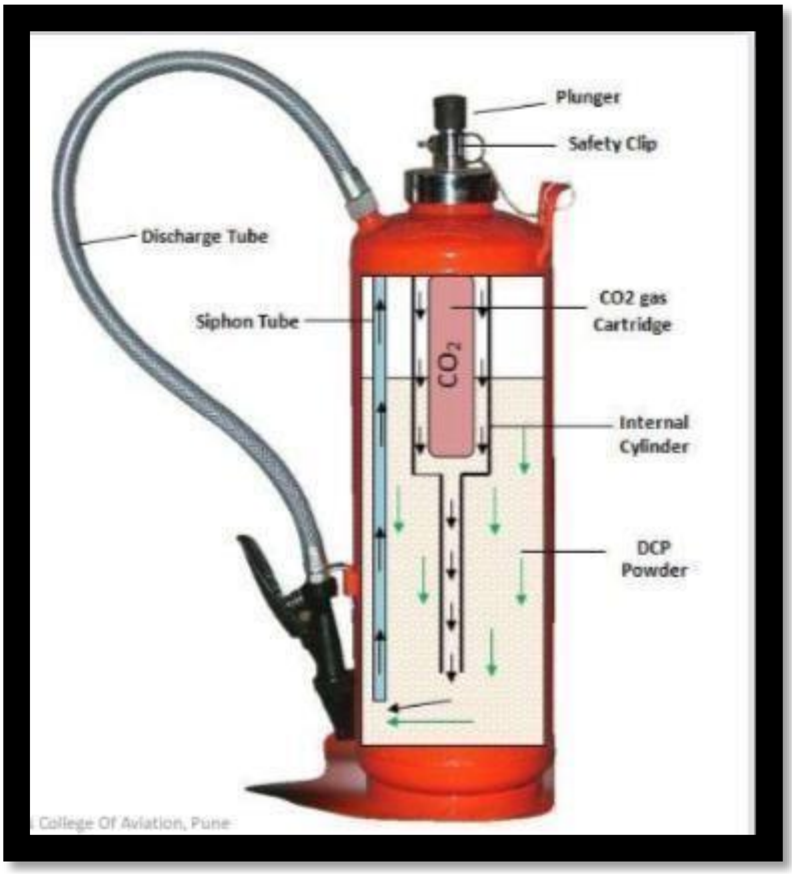


Fig.13.2.3. Dry ChemicalExtinguisher

13. Conclusions

An understanding of the different types of fire protection systems, equipment, and water distribution in your protection area is of the utmost importance. Your fire department depends on these systems for the basic needs of fire protection and fighting fire. Your ability to identify the various components of these systems and to inspect them for operational readiness may mean the difference between life and death should the systems be needed.

In conclusion it is important to have a fire protection system in place as a part of a aircraft safety plan. Without a fire protection system, the lives of those who are inside the building are placed at a high risk in the event an emergency. The systems recommended for use like the fire alarm systems, sprinkler systems, fire pumps, and smoke control systems use some amount of actions to notify of the fire and smoke conditions, help slow the growth of the fire or to help put out the fire altogether. The plan that is recommended follows the guidelines provided by NFPA and if they are put into use the City of Washington

Distribution Warehouse will be a safe place to work and in case of a fire that it will include protections that will result in minimum loss.

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