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AIRCRAFT ICE DETECTORS AND ICING RATE MEASURING INSTRUMENTS

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1. SCOPE:

This document provides information regarding ice detector technology, and design and operating requirements. Icing rate information is included where applicable. The primary application is associated with ice forming on the leading edges of airfoils and inlets with significant forward velocities. Information related to detection of ice at static conditions, ice over cold fuel tanks, and icing at low velocity operation is also included. The material is primarily applicable to transport and light aircraft. Special consideration for rotorcraft is appended separately.

1.1 Purpose:

The purpose of this document is to provide information and guidelines related to the method of operation, performance, design, verification, and installation of aircraft ice detectors and icing rate indicators.

2. REFERENCES:

The applicable issue of publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

2.1.1 MIL-STD-210C, "Climatic Information to Determine Design and Test Requirements for Military System and Equipment," 9 Jan. 1987

2.1.2 MIL-STD-704E, "Aircraft Electrical Power Characteristics", 1 May 1991

2.1.3 MIL-STD-5400, "Electronic Equipment, Airborne, General Requirements for", 15 June 1992

2.1.4 MIL-B-5087, Rev. B, "Electrical Bonding and Lightning Protection of Aerospace Systems," December 1984

2.1.5 MIL-D-8181 B (ASG), "General Specification for Aircraft Engines and Airframe Air Intake Duct Ice Detector," March 1965

2.1.6 MIL-S-19500 H, "General Specification for Semiconductor Devices," April 1990

2.1.7 Heinrich, et al., "Aircraft Icing Handbook," Report No. DOT/FAA/CT-88/8-I, March 1991

2.1.8 R. F. Ide, "Comparison of Icing Cloud Instruments for 1982-1983 Icing Season Flight Program," NASA TM 83569, January 1, 1984

2.1.9 NASA TM 78118, "Terrestrial Environment (Climatic) Criteria Guidelines for Use in Aerospace Vehicle Development," Nov. 1977

2.2 FAR Publications:

Available from FAA, 800 Independence Avenue, SW, Washington, DC 20591.

2.2.1 FAR Part 23, "Airworthiness Standards: Normal Category Airplanes," 1986

2.2.2 FAR Part 25, "Airworthiness Standards: Transport Category Airplanes," 1986

2.2.3 FAR Part 27, "Airworthiness Standards: Normal Category Rotorcraft," 1986

2.2.4 FAR Part 29, "Airworthiness Standards: Transport Category Rotorcraft," 1986

2.2.5 FAR Part 33, "Airworthiness Standards: Aircraft Engines," 1986

2.3 Other Publications:

2.3.1 AGARD Advisory Report No. 127, "Aircraft Icing," 1978

2.3.2 AGARD Advisory Report No. 166, "Rotorcraft Icing - Status and Prospects," 1981

2.3.3 AGARD Advisory Report No. 223, "Rotorcraft Icing - Progress and Potential," 1986

2.3.4 J. R. Stallabrass, "Review of Icing Protection for Helicopters," NRC LR-334, 1962

2.3.5 RTCA DO-160C, "Environmental Conditions and Test Procedures for Airborne Equipment," Dec. 1989

2.3.6 B. Magenheim and J. K. Rocks, "A Microwave Ice Accretion Measurement Instrument (MIAMI)," AIAA Paper 82-0385, May 1983

2.3.7 R. J. Hansman Jr. and M. S. Kirby, "Real Time Measurement of Ice Growth During Simulated and Natural Icing Conditions Using Ultrasonic Pulse-Echo Techniques," AIAA Paper 86-0410, January 6-9, 1986

2.3.8 A. Sinnar, "Infrared Icing Monitoring Technique for Aircraft/Helicopter Application," SAE/AHS Icing Technology Workshop, Cleveland, Ohio, September 21-22, 1992

2.4 Definitions:

ACCRETION (OR ICE ACCRETION): The buildup of ice on an exposed surface due to the impingement and subsequent freezing of atmospheric supercooled water droplets.

ANTI-ICING: The prevention of ice buildup on the protected surface, either by evaporating the impinging water or by allowing it to run back and freeze on noncritical areas.

2.4 (Continued):

ASPIRATED: The use of suction to draw a sample of ambient air for ice detection with low forward velocity.

CIRRUS CLOUDS: A high level principal stratiform cloud type composed of detached cirriform elements in the form of white patches or narrow bands. Usually high level 6100 to 9100 m (20 000 to 30 000 ft) altitude; composed mostly of ice crystals usually very thin and appear transparent to the extent that a halo phenomenon may be observed.

CLEAR AIR: Air in which no visible liquid water droplets, snow, ice crystals, etc. are present.

CLEAR ICE: A glossy, clear, or translucent ice formed by relatively slow freezing of large supercooled droplets; expected mostly with temperatures between 0 °C (32 °F) and -10 °C (14 °F).

CUMULIFORM CLOUDS: Like cumulus; the principal characteristics of which is vertical development in the form of rising mounds, domes, or towers.

CUMULUS: A principal cloud type in the form of individual detailed elements which are dense and possess sharp nonfibrous outlines; develops vertically with tops often resembling a cauliflower; altitude 300 to 4600 m (1000 to 15 000 ft).

DEICING: The periodic shedding of small ice buildups by destroying the bond between the ice and the protected surface, either by mechanical, thermal, or freezing point depressant (FPD) fluid means.

GLAZE ICE: See "Clear Ice".

ICE DETECTOR: A device to provide an indication that the aircraft is operating in atmospheric conditions that will or may cause ice to be accreted.

ICING RATE INDICATOR: A device to provide an indication of the rate that ice is accreting on the sensor.

NOTE: Ice accretion rate on any specific aircraft surface may differ from the icing rate indication due to the influence of the local geometry.

ICING SEVERITY SYSTEM: A system that provides information regarding the severity of the icing encounter either in terms of LWC or in terms of light, moderate, and heavy icing.

INDUCTIVE TRANSDUCER: A device to provide an indication of a change in resonance resulting from a change in self-inductance.

INTRUSIVE: The sensor protrudes into the flow stream and disturbs the flow field (see nonintrusive).

2.4 (Continued):

LIGHT ICING: The rate of accumulation that may create a hazard if flight is prolonged in this environment.

LIQUID WATER CONTENT (LWC): The total mass of water contained in all the liquid cloud droplets within a unit volume of cloud. (Units of LWC are usually grams of water per cubic meter of air (g/m^3).)

MAGNETOSTRICTIVE: The property of a ferromagnetic material that causes it to change dimensions and vibrate when subjected to a high frequency magnetic field. In ice detectors, the shift in resonant frequency is used to indicate ice buildup.

MEAN EFFECTIVE DIAMETER (MED): The droplet diameter which divides the total water volume present in the droplet distribution in half, i.e., half the water volume will be in larger drops and half the volume in smaller drops. (The value is calculated based on an assumed droplet distribution.)

MEDIAN VOLUMETRIC DIAMETER (MVD): The droplet diameter which divides the total water volume present in the droplet distribution in half, i.e., half the water volume will be in larger drops and half the volume in smaller drops. (The value is obtained by actual drop size measurements.)

MICROWAVE: A very short wavelength or high frequency (1 to 100 GHz).

NONICING CONDITIONS: Generally, either operating in above-freezing conditions or in clear air; for engine inlets, operating at a temperature above 10 °C (50 °F).

NONINTRUSIVE: The sensor is flush with the aerodynamic surface causing no disturbance to the flow field.

OUTSIDE AIR TEMPERATURE (OAT): The static temperature of the ambient free stream air (outside the aircraft).

PIEZOELECTRIC: The property of a material (usually ceramic) that causes it to change dimensions and vibrate when subjected to a high frequency electric field. In ice detectors, the shift in resonant frequency is used to indicate ice buildup.

RIME ICE: A rough, milky, opaque ice formed by the instantaneous freezing of small, supercooled droplets as they strike the aircraft; usually occurs at temperatures colder than about -10 °C (14 °F), although it has been observed at somewhat warmer temperatures.

ROTORCRAFT: Aircraft powered by a rotor operating approximately in a horizontal plane. They are also known as helicopters or rotary wing aircraft. (The distinguishing features pertinent to ice detection are low forward velocity and rotor down wash.)

SENSITIVITY: The ability to detect slight amounts (or slight differences in amounts) of ice accretion.

2.4 (Continued):

STRATIFORM CLOUDS: Layered clouds of extensive horizontal development.

STRATUS: A low level principal stratiform cloud with a uniform gray base at altitudes usually below 2000 m (6500 ft).

TOTAL AIR TEMPERATURE (TAT): The temperature of an airstream brought to rest isentropically.

TRACE ICING: Ice becomes perceptible; the rate of accumulation is slightly greater than the rate of sublimation. (It is not hazardous, even though deicing/anti-icing equipment is not used, unless encountered for an extended period of time.)

VERY LIGHT ICING: Also called trace icing.

2.5 Abbreviations:

AGARD	Advisory Group for Aerospace Research and Development
AIAA	American Institute of Aeronautics and Astronautics
AIR	Aerospace Information Report (SAE)
AISLIS	Advanced Icing Severity Indicating System
BIT	Built-In-Test
°C	Degrees Celsius
Dec.	December
DOT	Department of Transportation
e.g.	For example
EM	Electromagnetic
et al.	And others
etc.	Et cetera
°F	Degrees Fahrenheit
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FOD	Foreign object damage
FPD	Freezing point depressant
ft	Feet
g	Gram
GHz	Gigahertz
h	Hour(s)
Hz	Hertz
in	Inch(es)
Jr.	Junior
kHz	Kilohertz
km	Kilometers
LWC	Liquid water content
m	Meters
MED	Mean effective diameter
MIAMI	Microwave Ice Accretion Measurement Instrument

2.5 (Continued):

mm	Millimeters
MTBF	Mean time between failure
MVD	Median volumetric diameter
NACA	National Advisory Committee for Aeronautics
NASA	National Aeronautics and Space Administration
No.	Number
Nov.	November
NRC	National Research Council
OAT	Outside air temperature
RTCA	Radio Technical Commission for Aeronautics
TAT	Total air temperature
TM	Technical memorandum
UFR	Undetected failure rate
µm	Micrometer

3. APPLICATIONS:

The ice detector is intended for use on an aircraft to detect icing conditions either inflight or at static conditions and provide crew indication or automatically actuate an anti-icing/deicing system. The icing rate indicator is intended for use with a deicing system to optimize the time-interval between deicing actuations.

3.1 Ice Detector:

The detector is generally designed to provide a signal (for control and/or indication) whenever the aircraft is operating in icing conditions that accrete more than a specified ice thickness. The specified ice thickness varies depending on the aerodynamic sensitivity of the application and the susceptibility of downstream machinery and structure to impact damage. The detector may be mounted remotely from the critical airfoil surface and may be intrusive or nonintrusive.

3.2 Wing Upper Surface Ice Detector:

Ice may form on the upper surface of a wing when an aircraft with a significant amount of fuel in the wing tanks that is cold soaked during a previous flight is parked at an airport with humid atmospheric conditions or light drizzle. If undetected, this ice could add substantially to the aircraft takeoff weight, detract from the wing performance, and could shed into aft mounted engines. The sensitivity required for this type of ice detector is determined by aerodynamic considerations and/or susceptibility of the engine to foreign object damage (FOD).

3.3 Icing Rate Indicator:

The icing rate indicator provides a signal which is proportional to the LWC of the surrounding air. Ice detectors which sense a specific amount of ice can be used as rate indicators by using the cycling rate of the detector. This type of operation is efficient for low accretion rates, however the maximum cycling rate of the detector may limit the maximum rate indication to less than the actual icing rate. True rate sensors are not limited in this way and provide a more accurate and timely indication of icing rate. (True rate sensors are typically used on rotorcraft.)

4. ICE DETECTION METHODS:

A number of methods have been used or are being developed to detect ice formation on aircraft. This section describes concepts that have been certified for use on aircraft or are in various stages of development. The list is not meant to be exhaustive. More detailed information can be found in References 2.1.6, 2.1.7, 2.3.1, 2.3.4, 2.3.6, and 2.3.7.

Only ice detector concepts are described in this section. Icing rate can be determined if an electrical signal proportional to ice thickness can be generated. Detectors and icing rate sensors generally require periodic deicing.

4.1 Visual:

4.1.1 Daytime: The simplest method of detecting icing conditions is for the pilot to note ice accreting on the unprotected portion of the windshield, windshield wiper, or some protruding element in the pilot's field of view (windshield wiper bolt, for example). Icing rate information can be inferred from the visual observations.

4.1.2 Nighttime: For night ice detection, a red light may be aimed vertically at the unprotected location. When ice forms, a small bright red dot becomes visible to the pilot. Alternatively, the pilot may use a flashlight at night.

4.2 Obstruction:

The obstruction type ice detector consists of a scraper rotating on a surface. As ice accretes on the surface, the torque required to rotate the scraper increases. At a preset torque, a signal is generated causing the surface to be deiced electrically. Icing rate can be determined by the slope of the torque versus time curve.

4.3 Differential Pressure:

This concept uses a probe to sense total air pressure through several small orifices (0.4 mm (0.016 in)) on its forward face. This pressure is sensed by one side of a differential pressure sensing device with aircraft total pressure fed to the opposite side. As ice blocks the total pressure orifices, the pressure is bled to static and a differential pressure signal is created. This concept was originally developed by the National Advisory Committee for Aeronautics (NACA) in the early 1950s and has not been used as an icing rate sensor.

4.4 Latent Heat:

Two types of ice detectors use the latent heat of fusion to indicate the presence of ice. Either detector can be used as an icing rate detector by using suitable electronics to interpret the output signal.

The first uses a periodic current pulse through a resistance element to heat a probe. If ice has accreted on the probe, the temperature increase will be temporarily halted at 0 °C (32 °F). Electronic equipment senses and indicates this condition. Figure 1 illustrates one implementation of this concept which is currently used on the B-1B aircraft.

The second concept measures the power required to maintain the probe at a predetermined temperature (typically 90 °C (194 °F)). The instrument must be "zeroed" in nonicing conditions. The increase in power caused by the impingement of water droplets indicates the presence of water or ice; icing conditions may be assumed below a TAT of 10 °C (50 °F).

4.5 Vibration:

Ice on a vibrating surface has three effects:

a. Increased mass decreases the resonant frequency
b. Increased stiffness increases the resonant frequency
c. Increased damping decreases the amplitude of oscillation

Ice detectors have been produced using the first two physical principles and the technology can provide icing rate data.

The most common ice detector in use today uses an axially vibrating probe as a sensor. The probe is oriented as a cylinder perpendicular to the free stream. As ice accretes, the mass increases and the resonant frequency decreases. The device is intrusive by design. A derivative of this design uses a flush diaphragm vibrated at its natural frequency. As ice accretes, the increased stiffness predominates, increasing the resonant frequency. This design has the advantage of being applicable to nonintrusive configurations.

Piezoelectric, magnetostrictive, or inductive transducers are most commonly used to put the sensor in oscillation and read the resonant frequency. The working frequency of such a device is normally between 15 and 100 kHz with a typical frequency change due to ice of 200 Hz (for ice detection devices) to 50 kHz (for ice thickness measurement devices). Ice detectors using these principles can detect and measure the thickness from 0.13 mm (0.005 in) up to 12.7 mm (0.5 in) of ice.

Figure 2 illustrates an application of the magnetostrictive vibratory principle on the B-747 and B-767 commercial transport aircraft. The electronics are integrated into a single unit which uses a magnetostrictive probe to collect and sense ice. The decrease in resonant frequency due to the mass of ice on the sensor is used as an indication of icing.

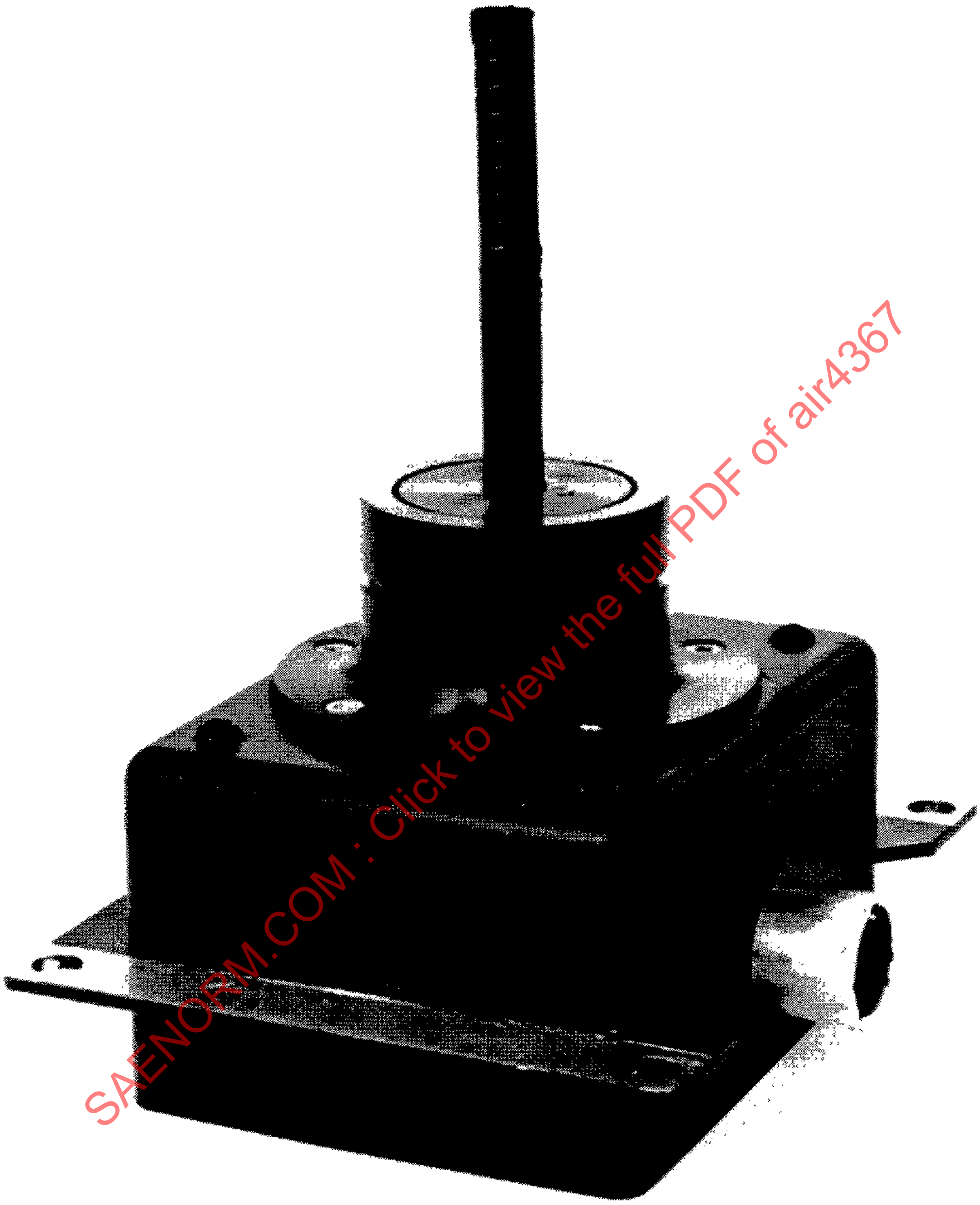


FIGURE 1 - Self-Contained, Engine-Inlet Ice Detector (B-1B Aircraft) Using Latent Heat Principle

FIGURE 2 - Self-Contained B-747/B-767 Ice Detector
Using Magnetostrictive Vibratory Principle

4.5 (Continued):

Figure 3 illustrates an application of the magnetostrictive principle on the MD-11. The sensing elements are located in the wing engine inlets and the electronic processors are remotely located in the wing. As in Figure 2, the effect of ice mass is used to indicate icing.

Figure 4 shows a flush-mounted piezoelectric ice detector on an MD-80 commercial transport aircraft. One sensing unit on each wing is used to detect ice on the wing upper surface as discussed in 6.4.

Figure 5 shows a similar device using the magnetostrictive principle. In both cases, the increase in resonant frequency due to ice stiffness is used to indicate icing.

4.6 Microwave:

One implementation of microwaves to detect ice is a microwave transducer that consists of a resonant surface waveguide embedded nonintrusively into the surface on which the ice accretes. The surface waveguide is constructed from dielectrics such as polyethylene with dielectric properties similar to that of ice. When ice accretes on the dielectric surface, it acts as a part of the waveguide effectively thickening it and changing its phase constant. In this implementation, the waveguide is designed to be resonant in the absence of ice by suitably adjusting the dimensions of its metallic boundaries but allowing its single dielectric surface to be exposed to the surface on which ice accretes. The accretion of ice causes a change in the phase constant lowering its resonant frequency. Instrumentation calculates the ice thickness from the shift in resonant frequency. The device can act as an ice detector, an icing rate meter, and as a liquid water content (LWC) meter.

Ice thickness up to 25 mm (1 in) has been measured in the laboratory. In theory, even larger thicknesses are possible. This implementation has been successfully flight tested behind a tanker aircraft on a Cessna Crusader 303 aircraft under a nonoperating pneumatic boot.

The microwave concept has no moving parts and has a very high resolution making it adaptable for either detection of incipient icing conditions or accurate measure of icing rate. The device can operate with a protective cover and survive extremely harsh environments. The microwave device can be designed to ignore the effects of water and other liquid contaminants or these effects can be measured with suitable instrumentation. For more detailed information, see References 2.1.6 and 2.3.6.

4.7 Electromagnetic (EM) Beam Interruption:

This concept uses an EM source placed on one side of a flattened tube directed at a sensor on the opposite side of the tube. As ice accretes on the tube, the signal is blocked, and an electronic unit senses the interruption in sensor signal.

Various source/sensor combinations can be used such as visible light, infrared, laser, and nuclear beam. This concept has been used to provide icing rate information.

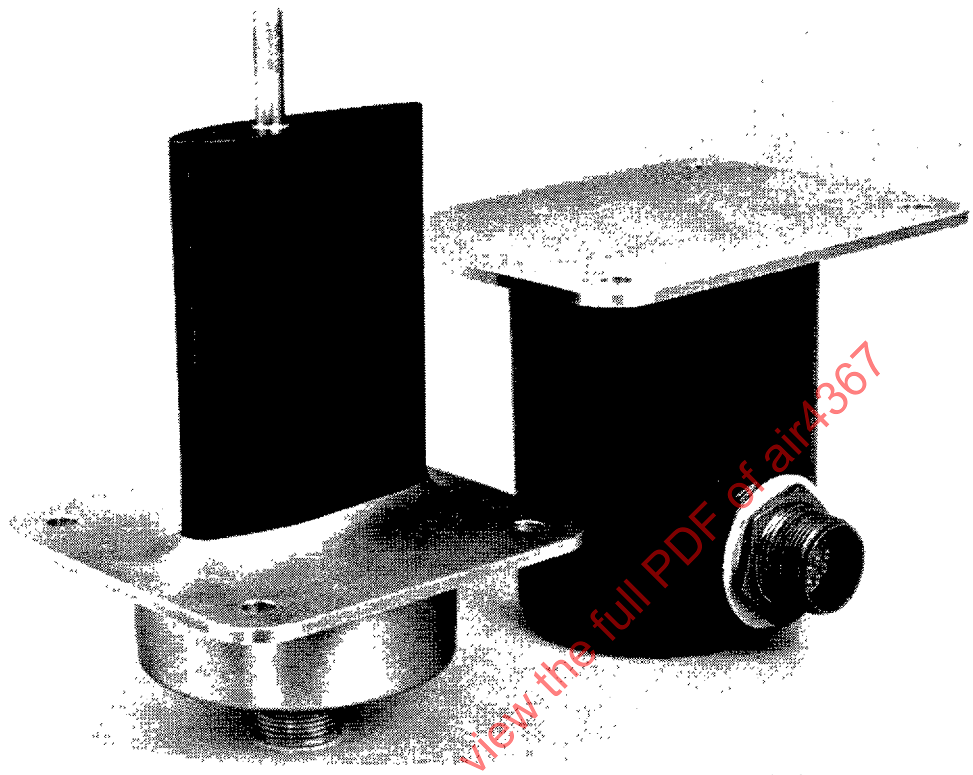
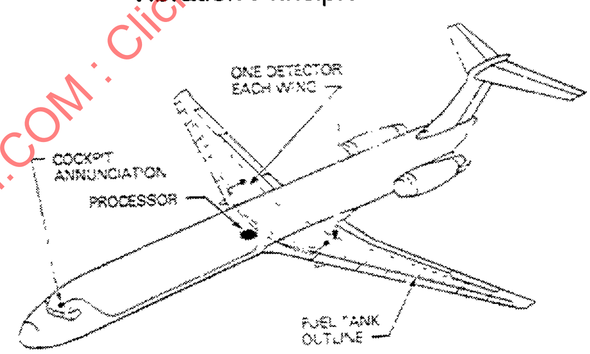


FIGURE 3 - MD-11 Ice Detector Using Magnetostraictive Vibration Principle



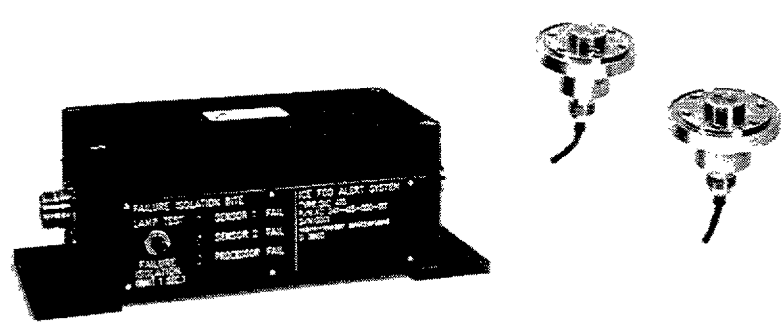


FIGURE 4 - Flush-Mounted MD-80 Wing Upper Surface Ice Detector Using a Piezoelectric Vibrated Diaphragm

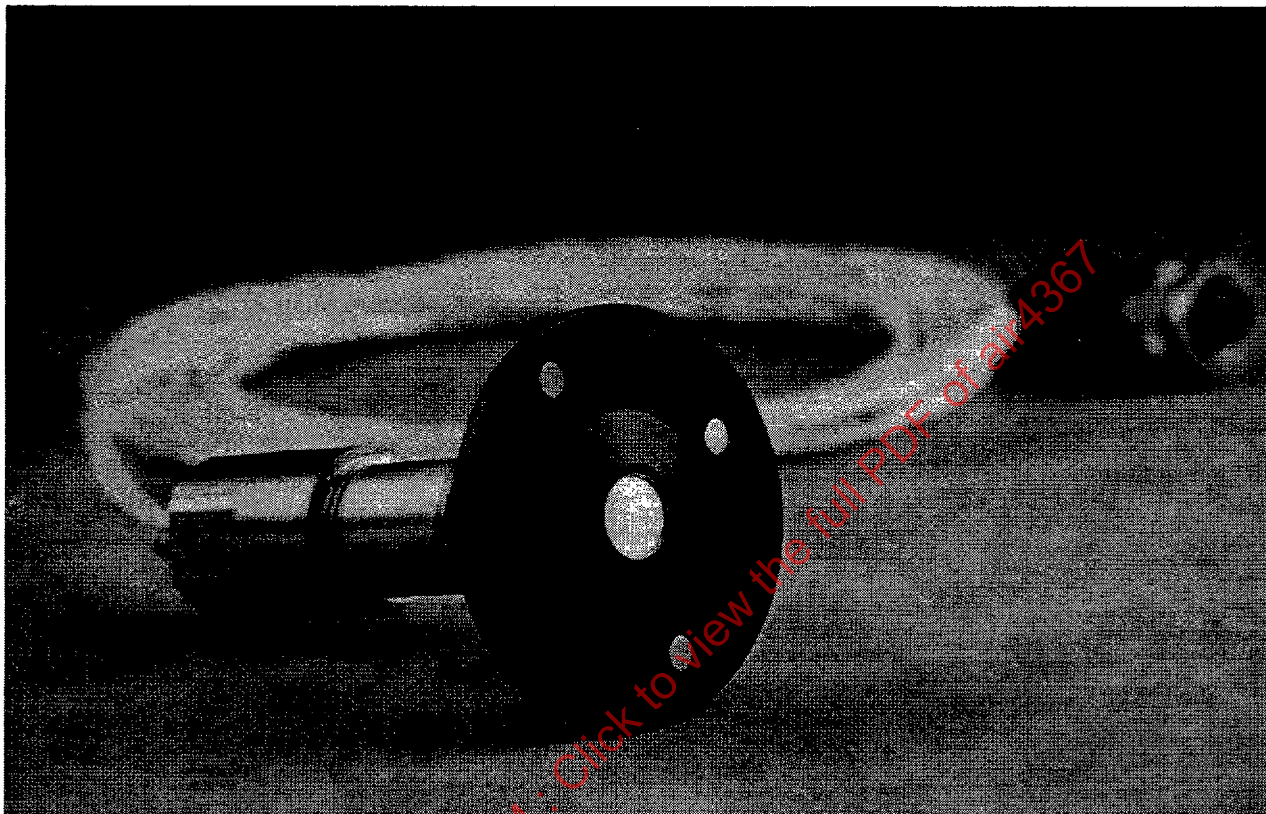


FIGURE 5 - Flush-Mounted Ice Detector Using a Magnetostrictive Vibrated Diaphragm

4.8 Pulse-Echo:

High frequency sound waves are reflected at an ice/air interface. To use this phenomenon to detect ice, a small piezoelectric transducer has been mounted flush with an aircraft surface (e.g., a wing leading edge). The transducer emits ultrasonic waves at the surface. If ice is present, the reflected waves will be received by the transducer and processed electronically. The ice thickness can be determined from the time delay between pulse emission and reception and the speed of sound in ice. Accurate and sensitive indications of ice have been obtained for both rime and glaze ice. By using the proper signal processing, minimum ice thickness and icing rate can be determined. This concept has a distinct advantage of being applicable to nonintrusive ice detectors. For more detailed information, see Reference 2.3.7.

4.9 Aspiration:

Most ice detectors depend on forward velocity to deposit supercooled droplets on the sensor. When operating at low forward velocities (e.g., a hovering operation), a suction device can be used to draw the air and droplets over the sensor. One simple and reliable means of creating the suction is the use of high pressure bleed air as the primary of a jet pump.

4.10 Advanced Concepts:

Five other concepts, under development, are presented.

4.10.1 Capacitance: A surface type ice detector uses an electrical capacitance circuit to indicate the presence and thickness of ice. Two printed circuit capacitance units of different sizes are located within a 76 mm (3 in) diameter area of skin. Logic circuits determine the ice thickness by comparing the transient voltage buildup of the two capacitances.

4.10.2 Vibration: A variation of the detectors described in 4.5 (vibration type) makes use of composite material with piezoelectric properties. This concept detects the change in waveform and frequency output of a segment of the surface being driven at a known frequency and amplitude in clear air.

4.10.3 Infrared: The Infrared Icing Monitoring Technique uses light absorption by the ice/water layer at multiple wavelengths to detect and measure accretion thickness of both ice and water. The selection of wavelengths at which ice absorption coefficients differ substantially from those of water allows detection and measurement of ice/water thickness from a few micrometers to several centimeters. Retroreflectors, flush-mounted at desired detection sites, receive and reflect the attenuated light beam back to a light emitter/receiver unit for signal processing. This nonintrusive and remote sensing technique is suitable for use on an aircraft to detect both static and inflight icing conditions and to automatically actuate a de/anti-icing system at optimum time intervals. For more detailed information, see Reference 2.3.8.

4.10.4 Thermal Flow: The thermal flow concept is implemented into a surface-type ice detector sensor that measures the heat flow change through the surface of a wing occurring when wing surface contaminants, such as frost, deicing fluids, and ice, build up on the surface. The change in condition, detected by the sensor, is brought into the signal processor where it is compared to a calculated heat flow value for a dry wing surface using ambient air and fuel temperature sensor inputs. The difference in the heat flow characteristics of the wing are calibrated to indicate specific conditions, such as ice.

4.10.5 Ultrasonic: Separate transmitting and receiving transducers are used to establish and measure flexural elastic waves in a surface subjected to ice. This implementation yields a measure of the average ice thickness in a particular region (from centimeters to meters in length). Laboratory tests have demonstrated accurate ice measurement up to 10 mm (0.39 in) in a reliable, nonintrusive installation. The concept provides the capability for self-test on the ground and in flight.

5. DESIGN GUIDANCE:

This section is primarily directed toward airfoil ice detectors for aircraft. Special considerations for general aviation, engine inlets (Reference 2.1.5), rotorcraft, and ground icing applications are presented in Section 6.

5.1 Environmental Conditions:

This section supplements the normal environmental considerations of altitude, ambient temperature, humidity, salt spray, sand and dust, shock, vibration, etc. imposed by the aircraft specification and/or such documents as References 2.1.1, 2.1.3, 2.1.8, and 2.3.5. In many cases, the operating ranges exceed the minimum performance requirements for certification but are felt to be desirable for general aircraft operation.

5.1.1 Ambient Temperature: Icing conditions have been reported by aircraft operating in ambient conditions in the range -52 °C (-62 °F) to slightly above freezing. Freezing at ambient temperatures above 0 °C (32 °F) occurs due to freezing rain or the temperature depression that occurs when air drawn into an engine inlet is accelerated through the inlet guide vanes. For general use, an ice detector should be designed to sense ice accretion throughout a range of -54 °C (-65 °F) to +10 °C (+50 °F).

5.1.2 Altitude: Icing conditions have been reported by aircraft operating at altitudes to 11 000 m (35 000 ft). For general use, an ice detector should be designed to sense ice accretion throughout the altitude range from sea level to 15 500 m (51 000 ft).

5.1.3 Liquid Water Content: Whereas most natural icing conditions are associated with clouds having LWCs greater than about 0.1 g/m^3, in some of the higher cirrus clouds, LWCs from about 0.05 to 0.2 g/m^3 can exist over extended distances of 80 to 160 km (50 to 100 miles). Since the bases of these clouds are at high and cold levels, the LWCs are relatively low and in most cases average between 0.05 to 0.1 g/m^3. Although icing conditions may be considered light or very light, ice accumulations of up to 6.4 mm (0.25 in) have been observed on unheated wings after exposures of 30 to 45 min. In contrast, it is not uncommon to encounter LWCs of between 2.5 to 3.0 g/m^3 over short 1.6 km (1 mile) distances in the cumuliform clouds, e.g., thunderstorms. If the ice detector is intended to detect only the onset of icing conditions, an upper limit need not be included and the lower limit of detection may be set to about 0.05 g/m^3.

5.1.4 Drop Size: Although the MVD may well characterize the drop-size distribution of a cloud, the drop-size distributions of clouds having a given MVD can be significantly different. Since for a given airspeed, the collection (or accumulation) of droplets is dependent on their size, it may be more appropriate to specify a minimum drop size instead of the MVD. Also, since icing can occur under freezing rain or drizzle conditions where the drops are of millimeter sizes, it may be more appropriate to specify a lower limit and not the upper limit value for the drop size. An ice detector should be designed to sense supercooled particles having diameters equal to or greater than 5 μm.

5.1.5 Erosion, Hail Impact, and Bird Strike: Ice detectors installed on most aircraft will be subject to impact by rain, ice crystals, sand, dust, hail, or birds. Frequency of occurrence and size distribution are published in documents such as References 2.1.1, 2.1.9, 2.2.2, 2.2.5, and 2.3.5. Consideration should be given to means of preventing unsafe conditions, inasmuch as practical, from the ensuing erosion and impact damage.

5.2 Functional Requirements:

5.2.1 Airspeed: Depending on the application, the ice detector used on a transport aircraft normally is required to operate at air velocities ranging from 93 km/h (50 knots) to 830 km/h (450 knots). The helicopter ice detector may be required to operate in hover and at speeds less than 93 km/h (50 knots).

5.2.2 Sensitivity: The sensitivity of the ice detector should be sufficient to provide a timely indication of ice accretion while having adequate range to accommodate the ice protection system being utilized. The detector should not be overly sensitive to the extent that false warnings cause the pilot to ignore detector indications or unnecessary operation of the ice protection system.

5.2.3 Deicing: The ice detector should have a deicing capability depending on the application.

5.2.4 Switching: The ice detector should be capable of switching an inductive external circuit (such as a relay) with a maximum current of three amperes inductive. Steady state power consumption should be minimized (Reference 2.1.2).

5.2.5 False Signal: The ice detector should not produce an icing signal when operated at any normal flight condition due to the presence of water, deicing fluids, oil, grease, cleaning fluid, or accumulations of atmospheric contaminants.

5.2.6 Self-Test/Built-In-Test (BIT) Features: The ice detection should incorporate self-testing circuitry for preflight checkout as well as continuous BIT failure monitoring. This function can be built into the ice detector or performed by a central computer.

5.2.7 Fail-Safe Design: The ice detection system design should minimize the probability of undetected failure modes in icing conditions.

5.3 Reliability and Creditability:

Reliability requirements vary with the intended purpose of each application. For certification purposes, ice detectors are generally categorized as either primary or advisory. A primary ice detection system can be designed to provide either:

a. Primary means of ice detection with manual activation of the ice protection systems

b. Primary means of ice detection with automatic activation of the ice protection systems