NewAvionics CORPORATION

Ice*Meister™ Model 9732-STEEL*

Ice Detecting Sensor for Aircraft

Technical Data Sheet

*<u>Figure 1</u> — Model 9732-STEEL aviation ice detector is a commercial, off-the-shelf , in-flight ice sensor that monitors the optical characteristics of whatever substance is in contact with the probe, either air (NO ICE) or water ice (ICE ALERT). Reports rate-of-ice-accumulation in three stages. Acrylic housing is size and shape of a hockey puck. * Probe is type 316-L marine grade stainless steel for subsonic flight. See fig 2.*

GENERAL DESCRIPTION

Ice*Meister™ Model 9732-STEEL detects ICE on any aircraft. It is demonstrably the smallest, lightest, most sensitive ice sensor aloft today. Model 9732 is entirely optical, has no MHz clock, no moving parts. See figure 2. When ice forms, it forms directly on the probe's optical surfaces. Model 9732 is completely sealed and potted solid with 2-part epoxy; no exposed electronics.

NOTE: Photos subsequent to figure 2 may differ slightly from Model 9732-STEEL.

Because of its slender cross-sectional area, ice forms on probe earlier than on large-area airframe members, such as windshields, wing leading edges, tailplane leading edges, wheels, struts, etc.

The complete unitized system consists of a stainless steel ice sensor probe, a circuit board potted into the housing, and a lightweight blue cable that connects the sensor to the host system. Installation is accomplished by means of two #6-32 stainless steel screws through the body of the sensor, and the probe's 5/16"-24 thread and hex nut. See figure 2 a, b.

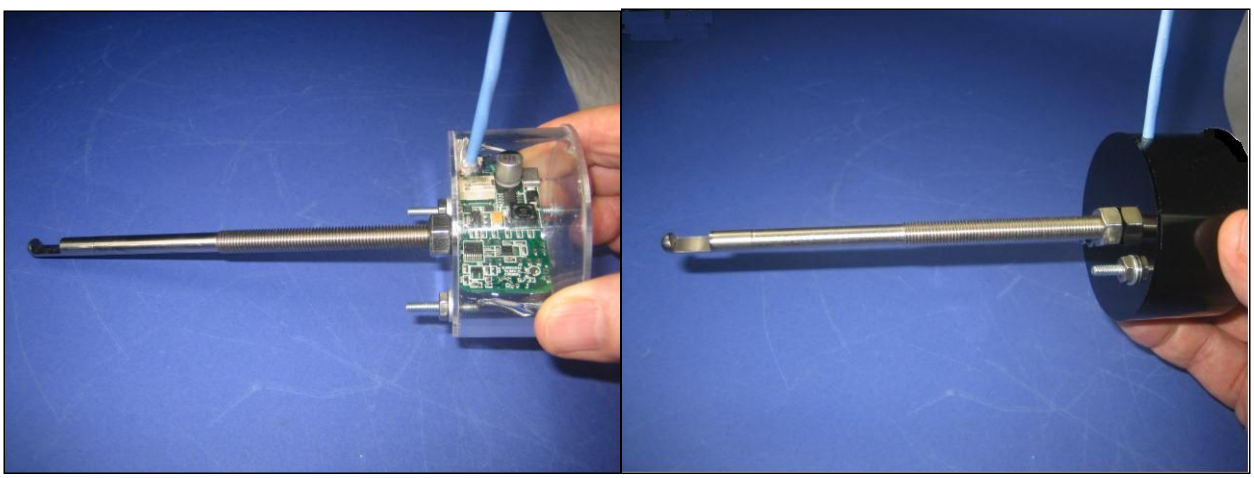


Figure 2 a, b -- Model 9732 ice detector adds lightness to any aircraft. Employs compact, highly-integrated electronic circuits. Integrates optical probe with interface electronics into small, hockey-puck housing. Two-part epoxy-filled assembly is robust, solid as a brick, no moving parts, probe is robust type 316-L marine grade stainless steel.

PRINCIPLE OF OPERATION

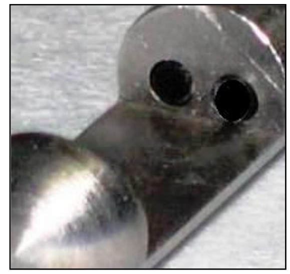


Figure 3 – detail of air gap

9732's OPTICAL ICE-SENSING SYSTEM consists of two light-manipulating windows, an air gap facing the oncoming air stream, and a reflecting wall.

In-flight ice sensing occurs when molecules of ice appear on the surfaces of either optical window and/or on the reflecting wall of the air gap at the end of the probe. Accumulating molecules of ice kill reflectivity of the airgap wall, attenuate the signal, and trigger ICE ALERT.

The sensor monitors ambient air for the empirical presence of an icing domain, which by definition forms ice on an exposed surface.

The observed fact of physical ice formation and detection has been documented at NASA Glenn Icing Research Tunnel according to a matrix of temperature, humidity, altitude, air speed, liquid water content, drizzle drop diameter, and air pressure. Test tunnel matrix and report available upon request.

THE PROBE DOES NOT SENSE ICE. The probe is simply a structural member that fixes the optical ice sensing elements in alignment with each other, and provides a means of attachment to the aircraft.

Ice formations on an exposed surface in an icing domain can be either clear ice or rime ice, depending upon atmospheric variables. Ice*Meister™ detects clear ice by its optical index-of-refraction, and rime ice by its optical opacity, both simultaneously. If it is necessary for the pilot to differentiate between clear and rime ice formations on the airframe, 9732 reports that difference per "test technique II".

IN NON-ICING CONDITIONS, the aircraft's ambient wind stream removes liquid H2O from the probe. Air is in contact with the probe. The probe senses air, and reports NO-ICE.

IN ICING CONDITIONS, H2O molecules bind together and accumulate on the optical surfaces as a solid, resisting removal by the ambient windstream. ICE is in contact with the probe. The probe senses ICE, and 9732 reports one or more of three icing conditions: ICE ALERT, MORE ICE, SATURATION.

See the red panel in the upper right corner of figure 4, below:

Figure 4 a, b, c -- Test program conducted at NASA Glenn's Icing Research Tunnel demonstrates Model 9732 conforms to defacto standard Minimum Operational Performance for In-flight Icing Detection Systems SAE AS 5498 ¶ 5.2.1.1.1.   See also SAE AIR 4367 ¶ 4.11.   Note Pitot tube in left foreground.

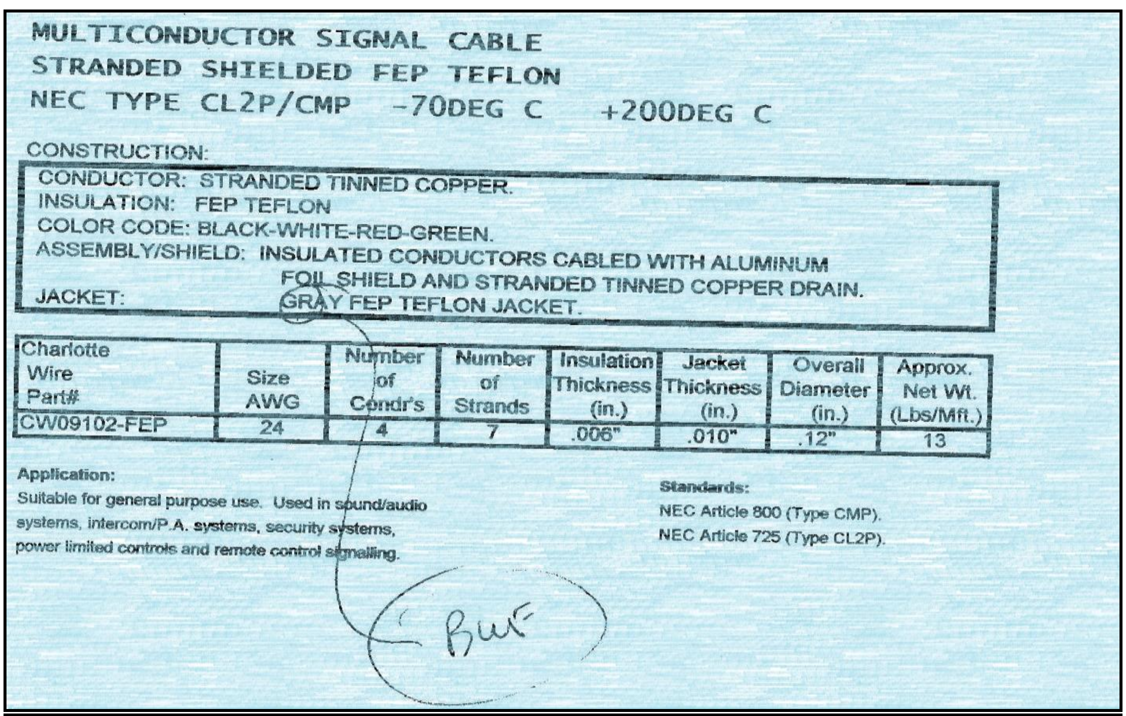
INSTALLATION

Model 9732 provides a 3-point installation system, with (1) 5/16-24 thread on the probe itself, and (2) #6-32 screws. Alignment is offset to damp mechanical resonance.

The sensor mounts inside and underneath the wing, with the air gap facing forward. This maximizes sensitivity, helps protect the probe from unwanted UV and IR radiation, and shelters the probe from precipitating dirt and other debris while the aircraft is parked on the tarmac.

Figure 5 -- 9732 installs with (2) #6-32 screws through wing and directly through the epoxy-filled body of the unit. The steel probe's 5/16-24 thread provides the third attachment screw.

LIGHTWEIGHT BLUE CABLE.



MULTICONDUCTOR SIGNAL CABLE
STRANDED SHIELDED FEP TEFLON
NEC TYPE CL2P/CMP -70DEG C +200DEG C

CONSTRUCTION:

CONDUCTOR: STRANDED TINNED COPPER.
INSULATION: FEP TEFLON
COLOR CODE: BLACK-WHITE-RED-GREEN.
ASSEMBLY/SHIELD: INSULATED CONDUCTORS CABLED WITH ALUMINUM FOIL SHIELD AND STRANDED TINNED COPPER DRAIN.
JACKET: GRAY FEP TEFLON JACKET.

Charlotte Wire Part#	Size AWG	Number of Condr's	Number of Strands	Insulation Thickness (in.)	Jacket Thickness (in.)	Overall Diameter (in.)	Approx. Net Wt. (Lbs/Mft.)
CW09102-FEP	24	4	7	.006"	.010"	.12"	13

Application:
Suitable for general purpose use. Used in sound/audio systems, intercom/P.A. systems, security systems, power limited controls and remote control signalling.

Standards:
NEC Article 800 (Type CMP).
NEC Article 725 (Type CL2P).

Figure 6 -- Lightweight blue cable specifications.

CONNECTION TO INSTRUMENT PANEL

Model 9732 provides a rate-of-accumulation feature. Three discrete logic (TRUE/FALSE) outputs cumulatively indicate ICE ALERT, MORE ICE and SATURATION ICE. The aircraft's pilot monitors the rate of icing accumulation for advisory as to when to disengage autopilot, activate anti-icing systems, activate engine anti-ice, climb, descend, turn around, etc. See figure 7 below.

Logic table 1

ICING STATE	ice alert wht	more ice grn	sat ice blk
no ice 000	**0**	**0**	**0**
ice alert 100	**1**	**0**	**0**
more ice 110	**1**	**1**	**0**
sat ice 111	**1**	**1**	**1**

Logic table 1 **0<0.5 volts 1>3.0 volts**

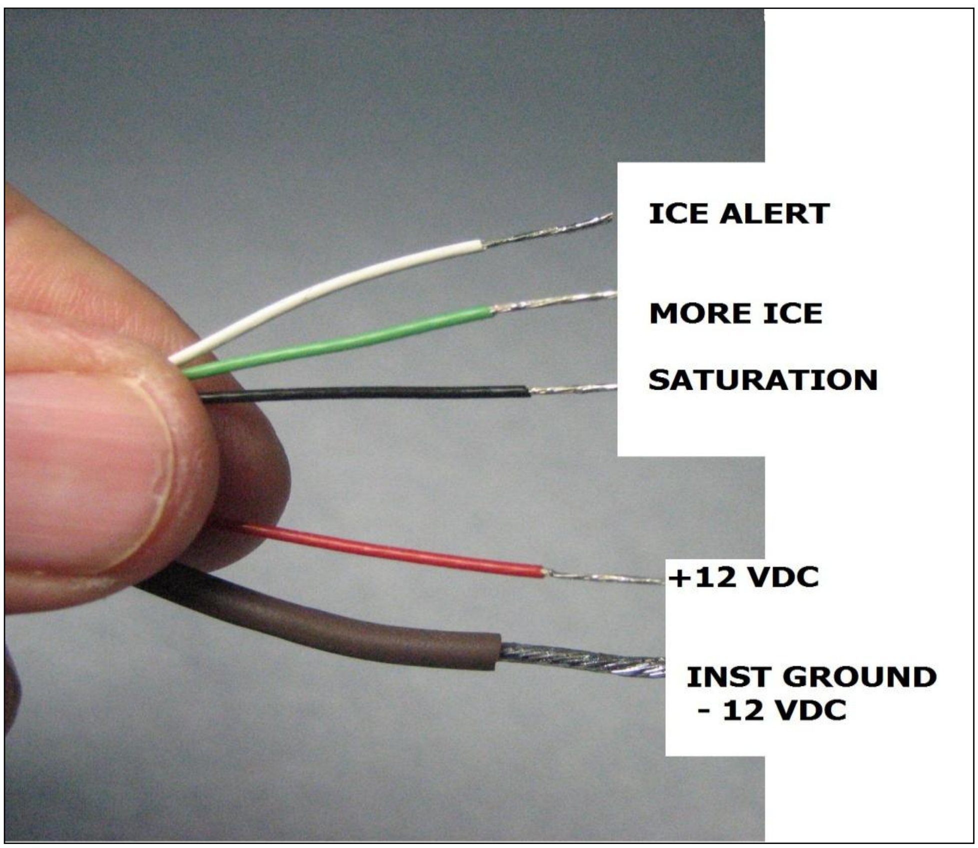


Figure 7
Lightweight blue cable provides three cumulative outputs that report the icing rate-of-accumulation .

TESTING

STANDARD TEST CONDITIONS for testing in a laboratory		
ambient temperature	energize unit, soak at ambient temp ½ hour	25 deg C (normal office temp)
ambient lighting	fluorescent illumination (from ceiling)	500 lux (normal office lighting)
	white LED illumination	no limit
	sunlight	0.0
	incandescent lamp	0.0
mechanical	sensor air-gap orientation	as shown in fig 8.
	probe body orientation	as shown in fig 8.
	proximity of foreign objects other than supporting table.	nothing within 6 inches
technique I	primary test for rime ice with tetrafluoroethane sprayed into air gap (fig 8) for 5-10 seconds	may take up to 30 sec to respond.
technique II	primary test for clear ice with clear tumbler filled with clean tap water (fig 10)	differentiates clear ice from rime ice
technique III	secondary test for rime ice with provided 2370 acrylic test chip (fig 11)	tests sensor fuzziness
technique IV	casual test for rime ice with any soft, dry, resilient, opaque, non-reflective substance	convenient, available, low cost

TESTING I: Test for rime ice with cold spray.

The primary test for Model 9732-STEEL is to test for rime ice sensitivity with a sprayed blast of Radio Shack tetrafluoroethane component cooler p/n 64-4321. See figure 9. It leaves no residue. Cold spray freezes moisture out of the ambient air, creates detectable surface frost in the air gap.

As frost forms, observe output logic states as they progress from NO ICE >> ICE ALERT >> MORE ICE >> SATURATION. Then as frost ablates, observe reverse sequence from SATURATION >> MORE ICE >> ICE ALERT >> NO ICE. In the absence of an ambient airstream to remove residual moisture on the optics, use a soft clean paper towel to blot it away. This concludes the test.

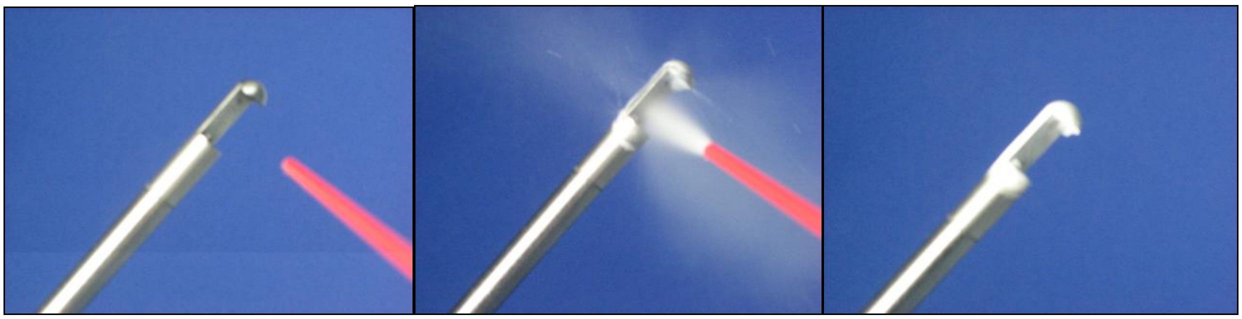


Figure 8 a,b,c – Primary test mode simulates rime ice by using cold spray.

Figure 9 a,b -- Radio Shack component cooler. Be certain to use ONLY tetrafluoroethane component cooler to avoid damage to the acrylic optical components in the air gap.

TESTING II: Test for clear ice with clean tap water.

To differentiate the formation of clear ice from rime ice, clear ice forces 9732 to set all three states TRUE *simultaneously*, not *sequentially*. ICE ALERT = MORE ICE = SATURATION ICE = TRUE.

Submerge probe tip in clean tap water and observe all three states come TRUE simultaneously . Remove probe from water, dry with a soft clean paper towel, and observe all three states return to FALSE.

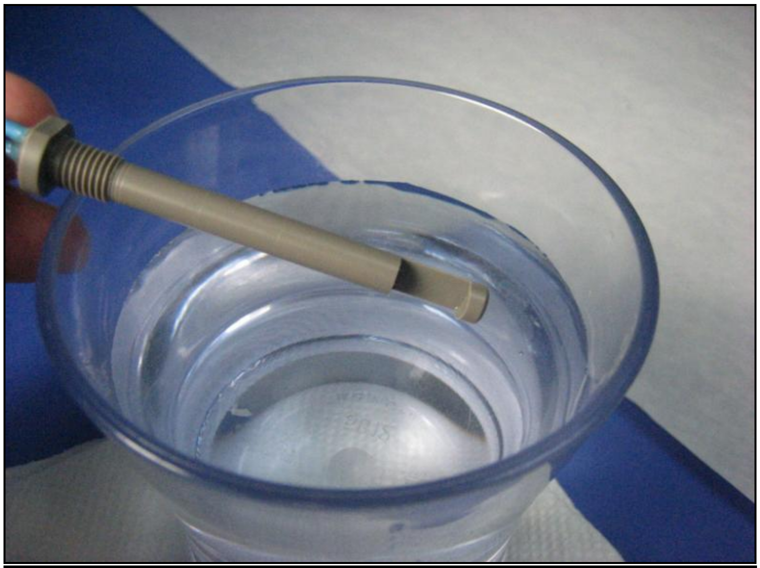


Figure 10 – Ordinary clean tap water simulates clear ice .

TESTING III: Alternative test for rime ice with 2370 acrylic test chip.

To provide a more cost-effective test for rime ice, Model 9732 allows for tetrafluoroethane substitution with provided 2370 acrylic chip. Hold chip firmly against the saddle at 135 degrees, and observe ICE ALERT state become TRUE.

This test should indicate ICE ALERT. Due to the "fuzzy" nature of ice formation and detection, test may or may not indicate MORE ICE, but should not indicate SATURATION. See CAVEATS.

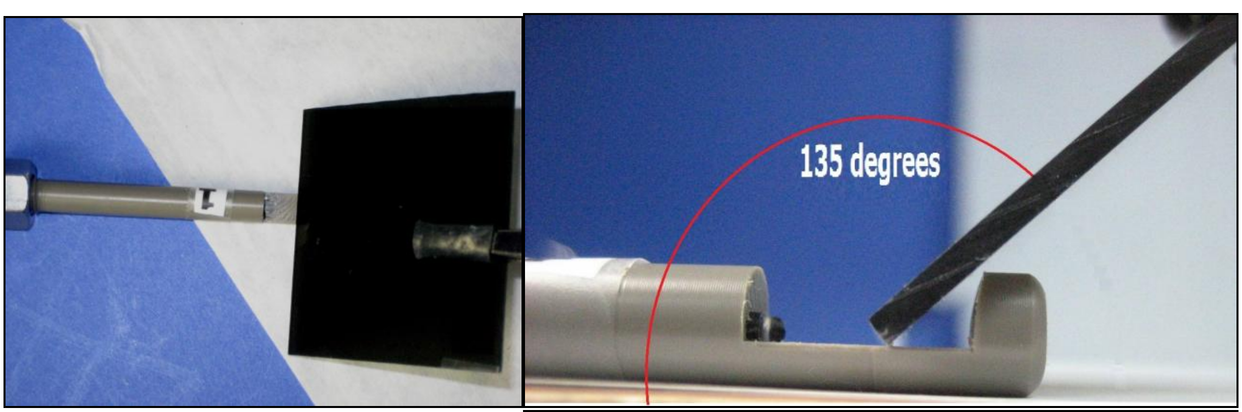


Figure 11 a, b cost-effective rime ice test using 2370 acrylic plastic chip.

TESTING IV

In case neither tetrafluoroethane component cooler nor a 2370 acrylic chip is readily available for testing, it is permissible to use a soft, dry, resilient, opaque, non-reflective substance to fill the air gap, such as a piece of conductive ESD-protecting soft black dunnage commonly found with packaged semiconductors and other electronic parts. It prevents the sensor's excitation signal from transiting the air gap and reflecting off the wall and back into the receiver channel. It should produce the same results as the clear ice test (II), but with the three icing states turning *progressively* TRUE instead of *simultaneously* TRUE.

Figure 12 -- ice formation on sensor probe is by nature rough, imprecise, "fuzzy".

CAVEATS

● The in-flight velocity of airborne super-cooled drizzle drops impinging on 9732 sensor probe's air gap necessarily creates a rough, imprecise "fuzzy" surface and thickness of ice that is not easily quantifiable.

Even though the resultant ice thickness may be difficult to measure, 9732's optical rate-of-ice-formation sensing accounts for surface irregularities. It detects and reports ice's indistinct and imprecise "fuzzy" nature.

For this reason, Model 9732 functions as a digital go/no-go ice sensor only. It has no specific calibration, and is in no way to be used an analog measuring instrument of any kind.

● 9732 is not a recommended replacement for BFG Model 871 pneumatic boot controller. It is a supplementary early-warning ice sensor that reports airframe ice well before ordinary BFG 871 boot controllers can activate an airplane's pneumatic boots.

With 9732 installed as an early-warning ice sensor, pilots benefit from enhanced situational awareness. Where BFG 871 requires 0.020 inch of ice to activate, NAC 9732 requires only a thin film of non-reflective ice to set ICE ALERT. See figure 4b.

PROBE TIP NOMENCLATURE

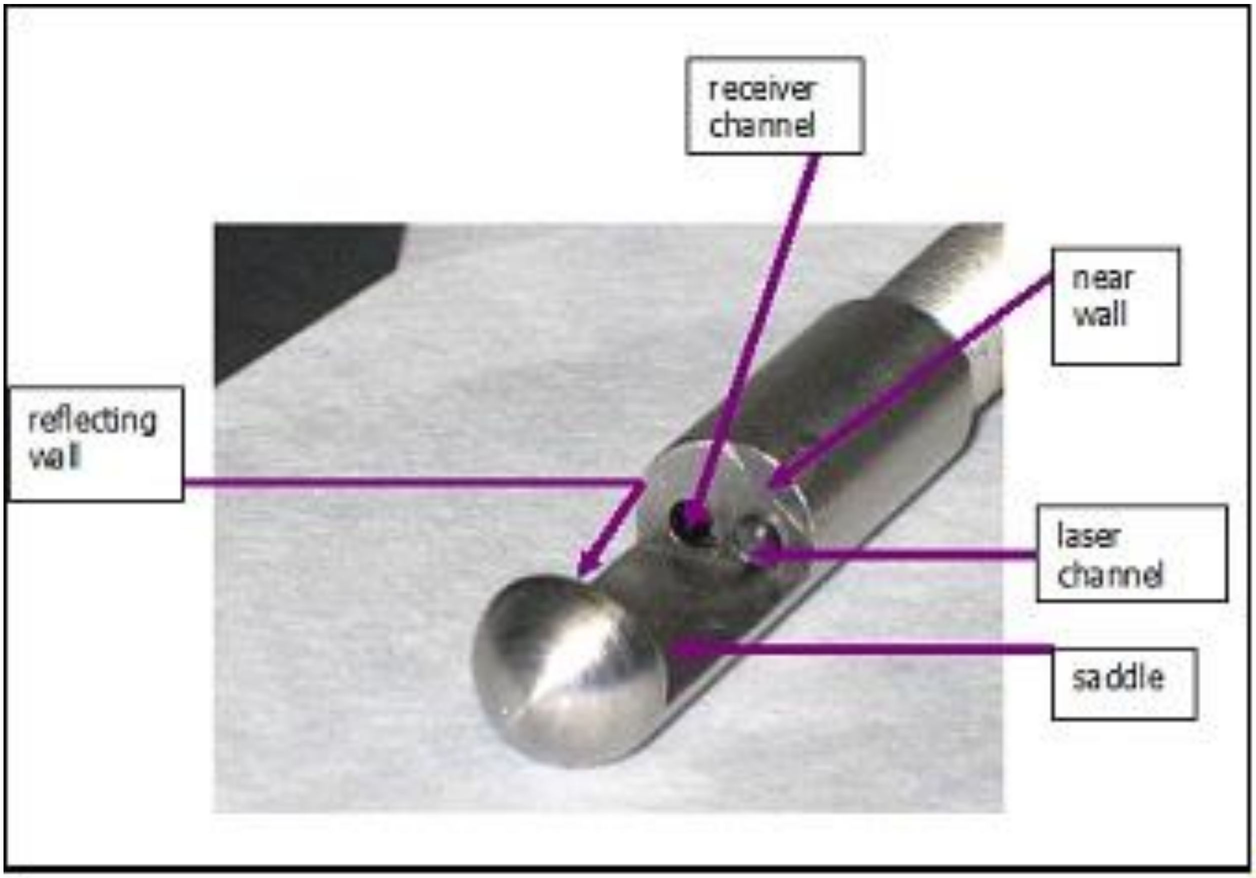


Figure 13 probe tip nomenclature. Test by blocking the optical air gap with a soft, dry, resilient, opaque, non-reflective substance.

SPECIFICATIONS

SENSITIVITY TO ICE:
- Better than 0.010" of ice
- Conforms to SAE AS 5498 ¶ 5.2.1.1.1

OPERATING / STORAGE TEMPERATURE:
- -40 deg C to + 50 deg C.
- Not warranted to detect ice above 0 deg C nor in non-icing conditions.

ELECTRICAL INPUT:
- ±24 VDC **or** ±12 VDC
- 200 mA max
- red wire = + volts DC
- shield drain wire = instrumentation ground, - 0 volts DC

ELECTRICAL OUTPUT
- ICE ALERT = white wire
- MORE ICE = green wire
- SATURATION = black wire
  - FALSE <0.5 volt / TRUE >3.0 volts

CONNECTING CABLE
- 0.1 inch diameter lightweight four-conductor ground-shielded cable, stripped, tinned, and ready for customer's connector.
- LENGTH: 10 feet
  - Red, shield wires: ± VDC in
  - White, green, black wires: data out
- WEIGHT: 6 ounces, exclusive of cable and connector.

DIMENSIONS:

Housing diameter:	2.5 inches
Housing height:	1.4 inches
Probe diameter:	0.26 inch
Probe extension:	5.9 inches

MOUNTING HARDWARE:
- (2) #6-32 screws and hex nuts
- (1) 5/16-24 screw and hex nut

PROBE MATERIAL:
- 316-L marine grade stainless steel

DIMENSIONS   MODEL 9732-STEEL

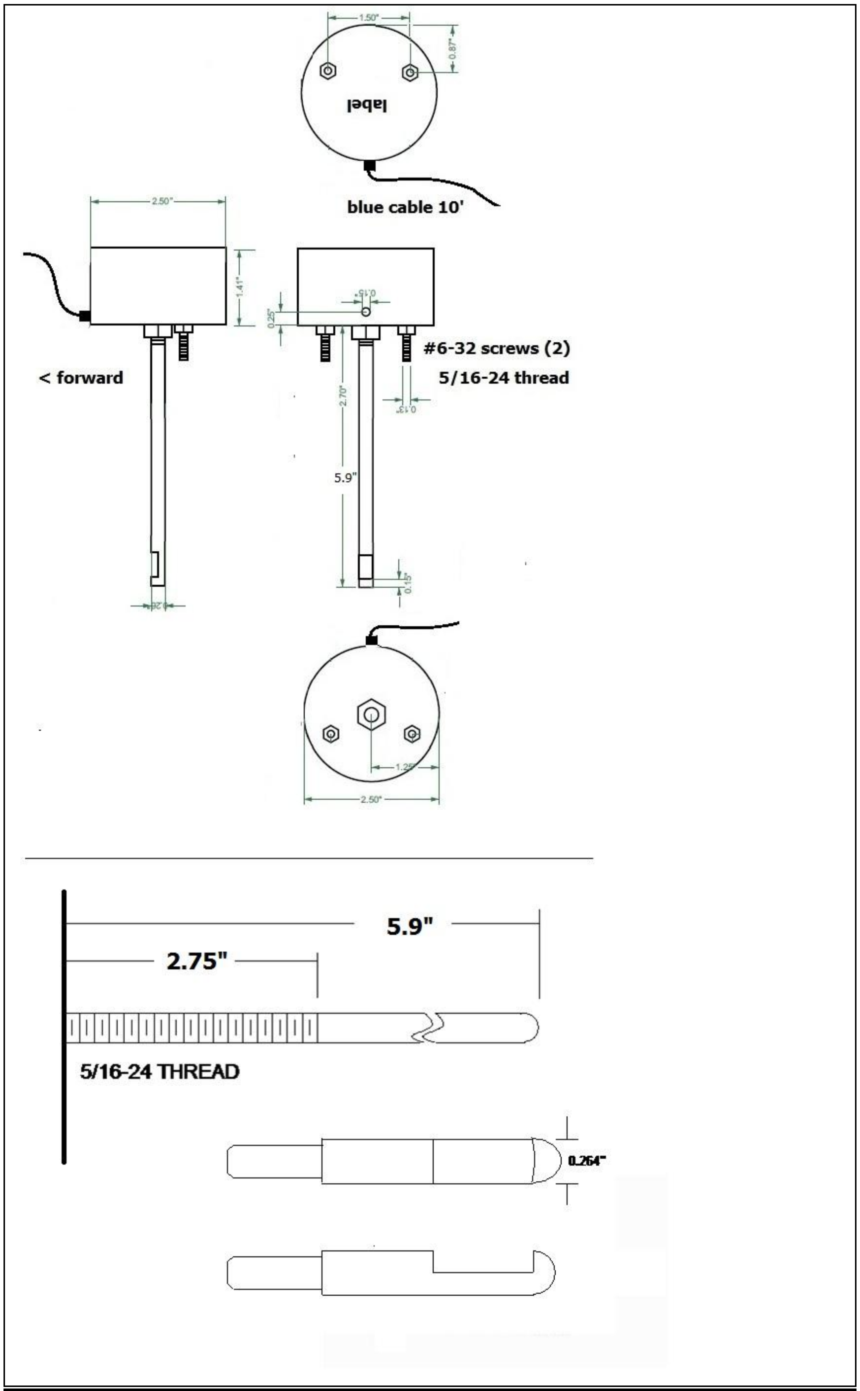


Figure 14 -- dimensions

DISCLAIMERS

1. Specifications and other contents are subject to change at any time without notice.

2. This document is not contractual. Nothing in it constitutes or implies a warranty or guaranty of any kind, explicit or implicit. Warranty information is given only in separate "warranty" statement.

3. Probe optical elements are acrylic plastic. Optics should be protected from mechanical abuse, abrasion and harsh chemicals. Damage to the probe optics voids the warranty. Flying in volcano ash or pumice voids the warranty.

4. No warranty is given as to the suitability of this product for any particular application.

5. Initial thermal shocking of the sensor may cause condensation to form on the optics and register as "ice". For best results, allow unit to soak under power and at ambient temperature before evaluating.

6. This unit is not an analog measuring instrument. It provides no specific calibration.

7. For best results, test under airborne icing conditions -- subdued light, no incandescent lamps, soak under power and ambient temperature. See STANDARD TEST CONDITIONS page 6.

8. Customer acknowledges there is no FAA TSO issued for in-flight ice detectors. This product does not conform to any FAA TSO, and is not certified for installation in any FAA certified aircraft.

9. This device functions as a digital go/no-go ice sensor only. It has no specific calibration, and is in no way an analog measuring instrument of any kind. See CAVEAT page 9.

10. 9732 is a supplementary early-warning ice sensor for subsonic aircraft. It is not a recommended replacement for BFG Model 871 pneumatic boot controller.

NOTES

1. Ice*Meister™ is a trademark of New Avionics Corporation.
2. Ice*Meister™ is protected under one or both US Patents oooooo & ooooooo.

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