Issued August 21, 2017

Ice*Meister™ Model 9732-STEEL
Ice Detecting Sensor for Aircraft
Technical Data Sheet

Figure 1 — Model 9732-STEEL aviation ice sensor is a commercial off-the-shelf, in-flight ice sensor. It monitors the optical characteristics of whatever substance is in contact with the optical surfaces of the sensor probe, either air (NO ICE) or water ice (ICE ALERT). Ambient wind stream blows liquid water away, but ICE molecules form and adhere to the optical surfaces for detection. Probe is tested by NASA, made of stainless steel, and is physically robust for use at subsonic airspeeds. Probe is set at 45 degrees to the airstream to protect the optics against airborne dust and particulates.

GENERAL DESCRIPTION

Ice*Meister™ Model 9732 detects ICE on any aircraft in flight.

Tested by NASA, it is demonstrably the smallest, lightest, most-sensitive ice detector aloft today.

The sensor consists of a unitized probe, circuit board, housing, and cable. The probe itself does not detect ice, but rather functions as a cantilever that holds two optical windows and a reflecting wall out into the airstream.

Ice forms and is sensed on any of the three optical surfaces.

The probe's inboard end mates with a small interface board, the size of your thumb. The board is submerged in rock-solid epoxy inside the housing.

A lightweight 4-conductor shielded blue cable exits from the aft bulkhead and connects the unit to its host system. The cable is jacketed in tough FEP Teflon specially formulated for harsh environments. Standard length is 6 feet, but it can be supplied in virtually any length on special order.

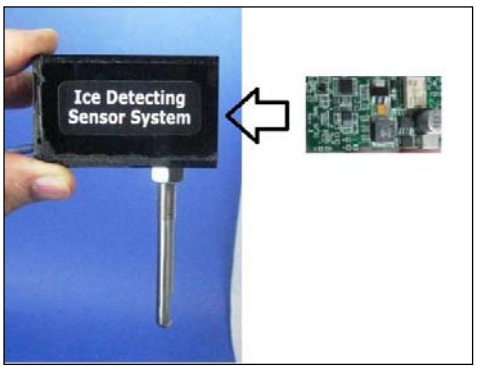


Figure 2 — 9732 is completely self-contained

9732 has no MHz clock, no moving parts. It is robust, internally potted in 2-part epoxy with no exposed electronics, is totally submersible in water, solid as a brick. The probe of is stainless steel, and robust against the rigors of subsonic wind airspeeds.

9732 typically installs either down from under the wing or horizontally from the fuselage immediately under the wing, and so protected from precipitating debris and the sun's deleterious UV and IR rays. The airgap faces forward, set at 45 degrees to the air stream against airborne dust and particulates

9732 is installed with its 5/16-24 threads and a stainless steel nut. Threads are tightened finger tight and fixed in place with LOCTITE® 425™ Cyanoacrylate. Attachment nut can be removed with an open-end wrench, and re-attached fingertight and fixed in place again with LOCTITE® 425™.

PRINCIPLE OF OPERATION

Ice molecules forming on the optical windows or reflecting wall attenuate 9732's infrared sensor excitation signal. The excitation signal is created and received by the interface board. The board interprets the signal and outputs variations as logical ice alert (001), more ice (011), and saturation ice (111).

9732's probe is pencil thin, and creates minimum ram-air heating of airborne H2O molecules. Ambient wind removes liquid water from the sensor optics, but ICE sticks to it and accumulates for detection.

Figure 3 — ICE forms directly on the optical surfaces

9732 is sensitive to H2O phase-change between liquid water and solid ice. The probe itself does not detect ice. It is a passive cantilever-holder for the optical ice sensing elements in the air gap. When ice forms, it forms directly on the optical surfaces, thus its sensitivity.

PRINCIPLE OF OPERATION, cont

Because of ram-air heating effects, ICE forms *last* on those airframe members with the largest cross-sectional area (windshields, leading edges, struts) but *earliest* on thin members (antennas, OAT gauges, ice sensor probes). For this reason, 9732 is the smallest, lightest, most-sensitive ice detector aloft.

In-flight ice sensing occurs when a sufficient number of ice molecules attach and accumulate on the surfaces of the exposed optical surfaces.

9732's ice formation and detection has been tested and 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.

Ice formations on an exposed surface in an icing domain can be either clear ice or rime ice, depending upon atmospheric variables. 9732 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 its presence by annunciating SATURATION ICE directly, skipping over intermediate ICE ALERT and MORE ICE states.

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 in solid form, and resist 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 below:

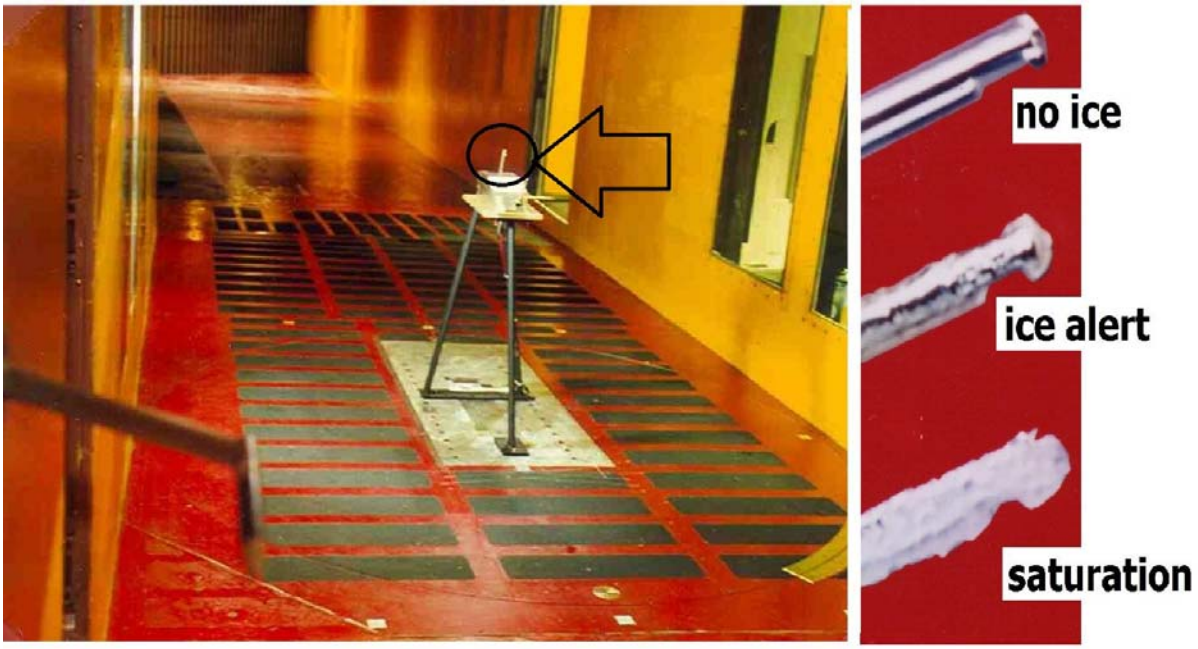


Figure 4 a, b -- Test program conducted at NASA Glenn's Icing Research Tunnel demonstrates Model 9732 conforms to defacto standard Minimum Operational Performance for In-flight Icing Detection Systems SAE AS 5498 ¶ 5.2.1.1.1. See also SAE AIR 4367 ¶ 4.11. Note test probe at top of test fixture, Pitot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

A WORD ABOUT DUST

9732's key optical element faces downwind, 45 degrees to the aircraft's port side. Its optically-sensitive face is positioned in the lee of its own optical fiber. Given that dust particles are vastly more massive than H2O molecules, inertia carries airborne dust particles downstream away from the optical face, while supercooled H2O molecules are caught up in the eddy currents in the lee of the optical element. They deposit themselves on its optically sensitive face for detection there.

INSTALLATION

9732 normally installs vertically down from the wing's undersurface, housing parallel to the aircraft centerline, cable exiting aft, air gap forward, 45 degrees to the wind. This maximizes sensitivity and helps protect the unit from unwanted UV and IR radiation, shelters the optics from precipitating dirt, dust, and other debris whether the aircraft is aloft or parked on the tarmac.

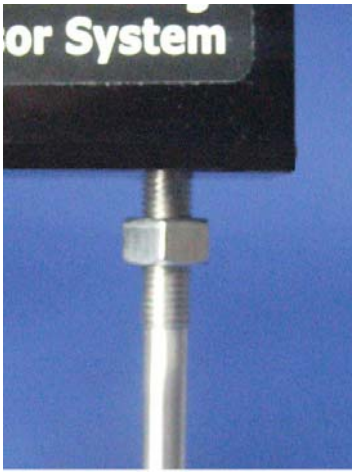


Figure 5 -- 9732 installs with the same 5/16-24 thread as an ordinary OAT gauge

The probe shaft is secured in place with a stainless steel nut on its 5/16-24 thread at the base of the probe, tightened 2-3 pound-foot (*2.7 - 4.1 N-m*) of torque, and fixed in place against vibration with four drops of LOCTITE® 425™ adhesive -- a fast curing, low strength adhesive for locking metal and plastic fasteners.

LOCTITE® 425™ cures quickly on metal and plastic fasteners; fixturing is achieved in less than 2 minutes, and full strength within 24 hours. Once cured, minimum torque to breakaway nut is 9.7 lb-in (*1.1 N-m*).

LOCTITE® 425™	CHARACTERISTICS:
Technology	Cyanoacrylate
Chemical	Type Ethyl cyanoacrylate / Aliphatic ester
Appearance	Dark blue liquid LMS
Components	One part - requires no mixing
Viscosity	Low
Cure	Humidity
Application	Low strength thread locking / retaining
Key Substrates	Metals and Plastics
Minimum torque to remove	> 9.7 lb-in (*1.1 N-m*)
Storage temp	Ship ambient / store refrigerated

Figure 6

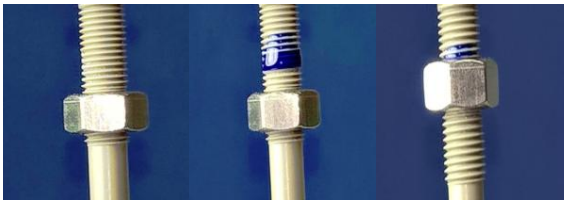


Figure 7 -- Installation nut is fixed with LOCTITE® 425™

A supply of LOCTITE® 425™ is provided with each shipment, is available from Ellsworth distributors http://www.ellsworth.com/ info@ellsworth.com and also available from New Avionics Corp. Data sheet is given at ...

https://www.ellsworth.com/search/?q=loctite%20425&p=products

MAINTENANCE.

9732 air gap optics and reflecting wall should be cleaned prior to each flight with a soft cotton swab soaked with ordinary isopropyl alcohol.

LIGHTWEIGHT BLUE CABLE

RoHS Compliant

PLENUM CABLE

DESCRIPTION

4 Conductors AWG 24/7x32 TC
Overall Foil Shield FEP / FEP **Blue** CL2P CMP

PHYSICAL PROPERTIES

Conductors / Insulation

# Conductors	AWG	Material	Material	Wall	Finished OD
4	24/7x32	Tinned Copper	FEP	.006"	.036"

Outer Shield Material / Drain Wire

Layer 1 Type	Material	Coverage	Fold Technique	AWG	Material
Overall Foil Shield	Alum / Mylar	100%		24/7x32	Tinned Copper

Outer Jacket Material / Cabling

Jacket Material	Color	Wall	Overall O.D.	Lay
FEP	Blue	.010"	.111" Nom.	2" Lay on Cable with Clear Mylar

MECHANICAL PROPERTIES

Operating Temp	Total Weight	Bend Radius
Rated -80C to 200C	13.2 lbs / m	10 X OD

ELECTRICAL PROPERTIES

Max. Operating Voltage
UL Rated 300V Power Ltd.

INDUSTRY APPROVALS AND COMPLIANCE

Standards & Environmental Programs

Reach / RoHS Compliant	YES
Suitability	Indoor, Direct Burial, Wet Location
Resistance	Oil, Gas, Sunlight, Abrasian, Acid
Applications	Communications, Audio, Control, Instrumentation Remote, Signaling, Power-limited systems
Flame Test	NFPA 262 / FT6
NEC / (UL) Specification	CL2P / CMP
CEC / C (UL) Specification	CMP

MISCELLANEOUS

Markings: TYPE CL2P - TYPE CMP 24 AWG (UL), C(UL) FEP/FEP E130356 ROHS

Color Code: Black / Red / White / Green /

Figure 8 -- Lightweight blue cable specifications.

LOGICAL CONNECTION TO HOST AIRCRAFT

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 as a advisory as to when to disengage autopilot, activate anti-icing systems, activate engine anti-ice, climb, descend, turn around, etc.

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**
output voltage		**0 <0.5 volt**	**1 >3.0 volts**	

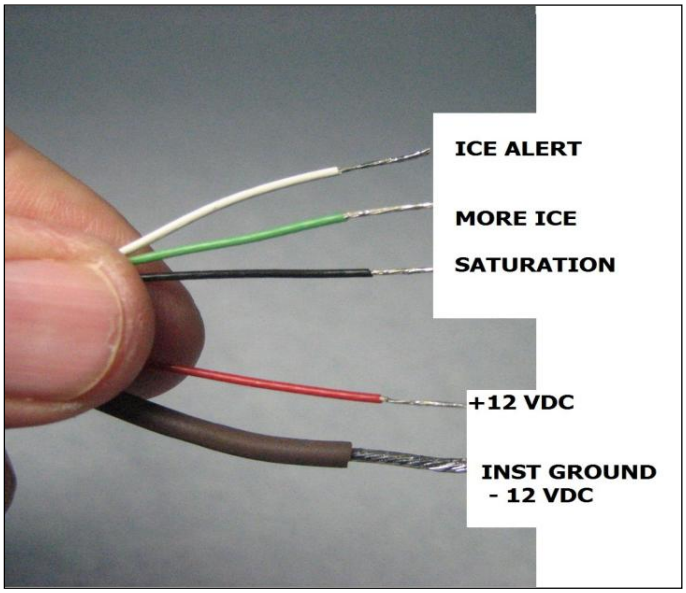


Figure 9 -- Lightweight blue cable provides three discrete outputs that report the icing rate-of-accumulation.

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 9.
	probe body orientation	as shown in fig 9.
	proximity of foreign objects other than supporting table.	nothing within 6 inches.
technique I	primary test with tetrafluoroethane spray into air gap for 5-10 seconds	may take up to 30 sec to respond.
technique II	field test with charcoal packing foam or other soft, dry, resilient, opaque, non-reflective substance press carbon foam into air gap, simulate accumulation of ice molecules, attenuate sensor excitation signal, trip thresholds ice alert, more ice, saturation in sequence	convenient field test.

* Tests can be accomplished using a simple 9-volt battery to power the unit.

TECHNIQUE I: PRIMARY TEST FOR ICE WITH TETRAFLUOROETHANE COLD SPRAY.

The primary test for Model 9732 is to test for ice sensitivity with a sprayed blast of an environmentally-benign, generic **tetrafluoroethane** component cooler. See figure 10 for example. Cold spray freezes moisture out of the ambient air, creates detectable surface frost in the air gap, leaves no residue.

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.

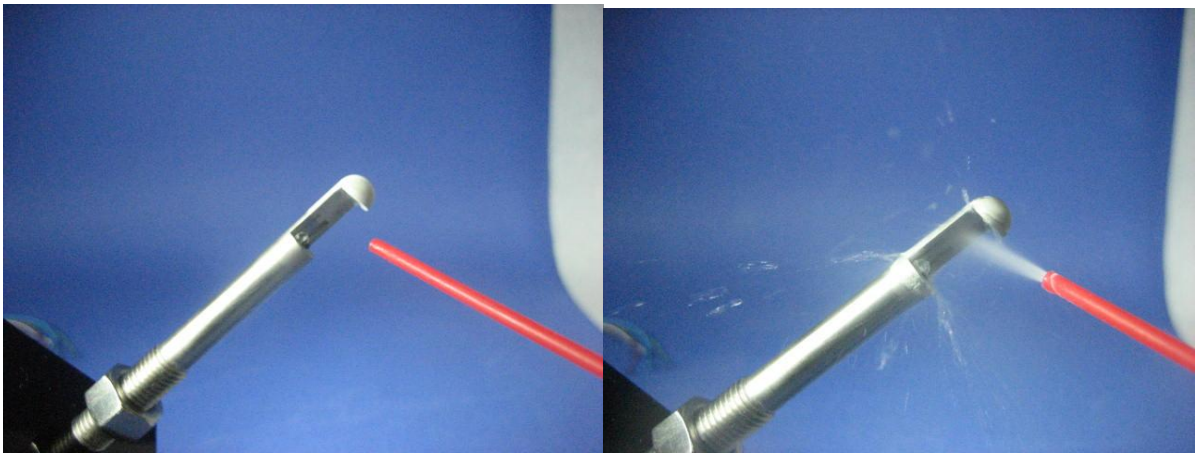


Figure 10 a,b – Primary test technique simulates rime ice by using cold spray.

Figure 11 a,b -- Example of generic tetrafluoroethane component cooler. Be certain to use ONLY tetrafluoroethane component cooler to avoid damage to the acrylic optical components in the air gap.

TESTING II: CASUAL FIELD TEST FOR ICE WITH CHARCOAL PACKING FOAM.

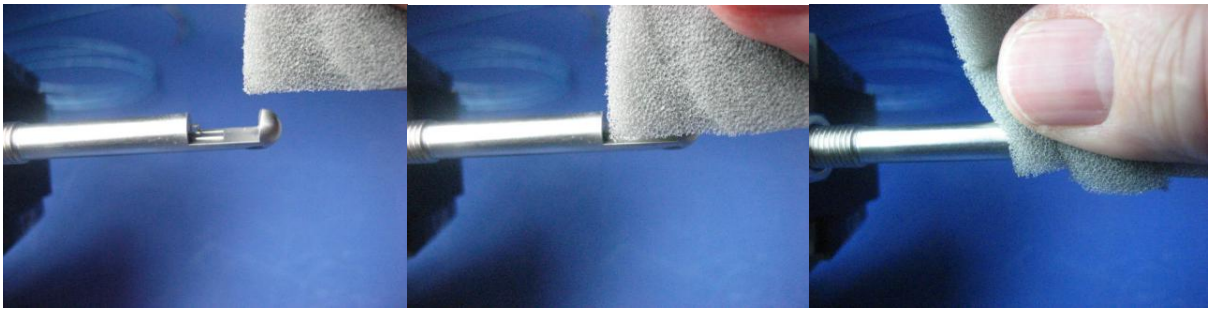
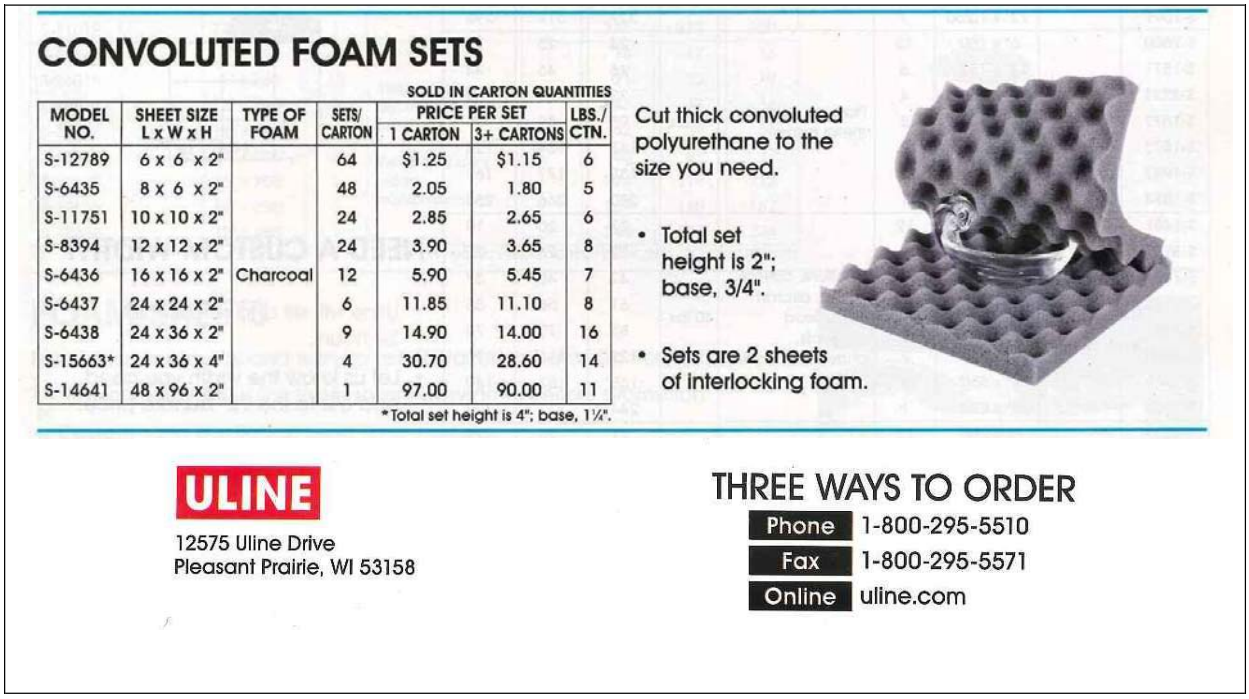


Figure 12 a, b, c -- Field test for accumulating ice by gradually blocking the optical air gap with a piece of readily available charcoal packing foam -- soft, dry, resilient, opaque, non-reflective, supplied with each shipment.



CONVOLUTED FOAM SETS

MODEL NO.	SHEET SIZE L x W x H	TYPE OF FOAM	SETS/ CARTON	SOLD IN CARTON QUANTITIES PRICE PER SET 1 CARTON	3+ CARTONS	LBS./ CTN.
S-12789	6 x 6 x 2"		64	$1.25	$1.15	6
S-6435	8 x 6 x 2"		48	2.05	1.80	5
S-11751	10 x 10 x 2"		24	2.85	2.65	6
S-8394	12 x 12 x 2"		24	3.90	3.65	8
S-6436	16 x 16 x 2"	Charcoal	12	5.90	5.45	7
S-6437	24 x 24 x 2"		6	11.85	11.10	8
S-6438	24 x 36 x 2"		9	14.90	14.00	16
S-15663*	24 x 36 x 4"		4	30.70	28.60	14
S-14641	48 x 96 x 2"		1	97.00	90.00	11

*Total set height is 4"; base, 1¼".

Cut thick convoluted polyurethane to the size you need.

- Total set height is 2"; base, 3/4".
- Sets are 2 sheets of interlocking foam.

ULINE

12575 Uline Drive
Pleasant Prairie, WI 53158

THREE WAYS TO ORDER

Phone 1-800-295-5510
Fax 1-800-295-5571
Online uline.com

Figure 13 -- Opaque charcoal test foam is readily available. A useful sample is supplied with each 9732 shipment..

NOMENCLATURE

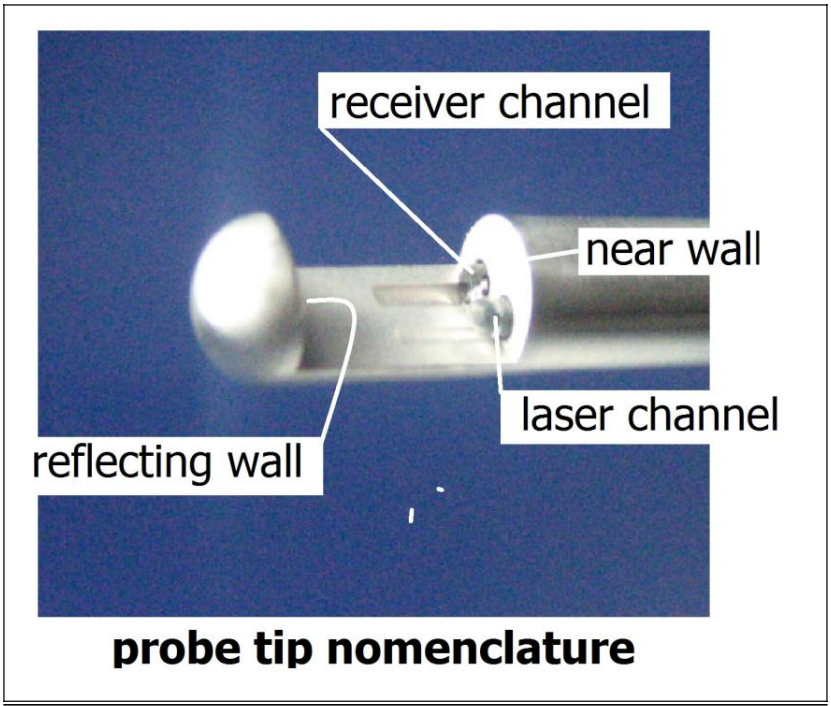


Figure 14 -- Probe tip nomenclature.

Figure 15 -- Serial number is located next to lightweight blue cable exit from aft bulkhead.

CAVEATS

Figure 16 -- ice formation on sensor probe is by nature rough, imprecise, "fuzzy".

NOT A PNEUMATIC BOOT CONTROLLER

9732 is an absolute ICE sensor-indicator. It indicates the real time presence of ICE on host airframe and its relative rate of accumulation.

9732 is not a replacement for BFGoodrich 871 resettable pneumatic boot controllers, which are specifically designed for that purpose.

NOT A MEASURING INSTRUMENT

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

Even though 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.

SPECIFICATIONS

SENSITIVITY TO ICE:
Better than 0.010 inch *(0.254 mm)* of ice
Conforms to SAE AS 5498 ¶ 5.2.1.1.1
Listed in SAE AIR 4367 ¶ 4.11

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:
Minimum 6 VDC
Maximum 24 VDC
Standard 24 VDC • 100 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 cable with ground-shield
stripped, tinned, and ready for customer's connector.
LENGTH: 6 feet *(1.8 m)*
Red, shield wires: ± VDC in
White, green, black wires: data out

WEIGHT: 6 ounces, exclusive of cable.

DIMENSIONS:

Housing height:	1.6 inches	*(40.6 mm)*
Housing width:	1.3 inches	*(33.0 mm)*
Housing length:	2.61 inches	*(66.3 mm)*
Probe diameter:	0.26 inch	*(6.65 mm)*
Probe extension:	2.8 inches	*(71.1 mm)*

MOUNTING HARDWARE:
5/16-24 thread on probe shaft, with stainless steel hex nut
(similar to aftermarket Outside Air Temperature gauge per TSO C43c)

MAINTENANCE:
Air gap optics and reflecting wall should be cleaned before each flight with a soft cotton Q-tip swab soaked with isopropyl alcohol.

DIMENSIONS

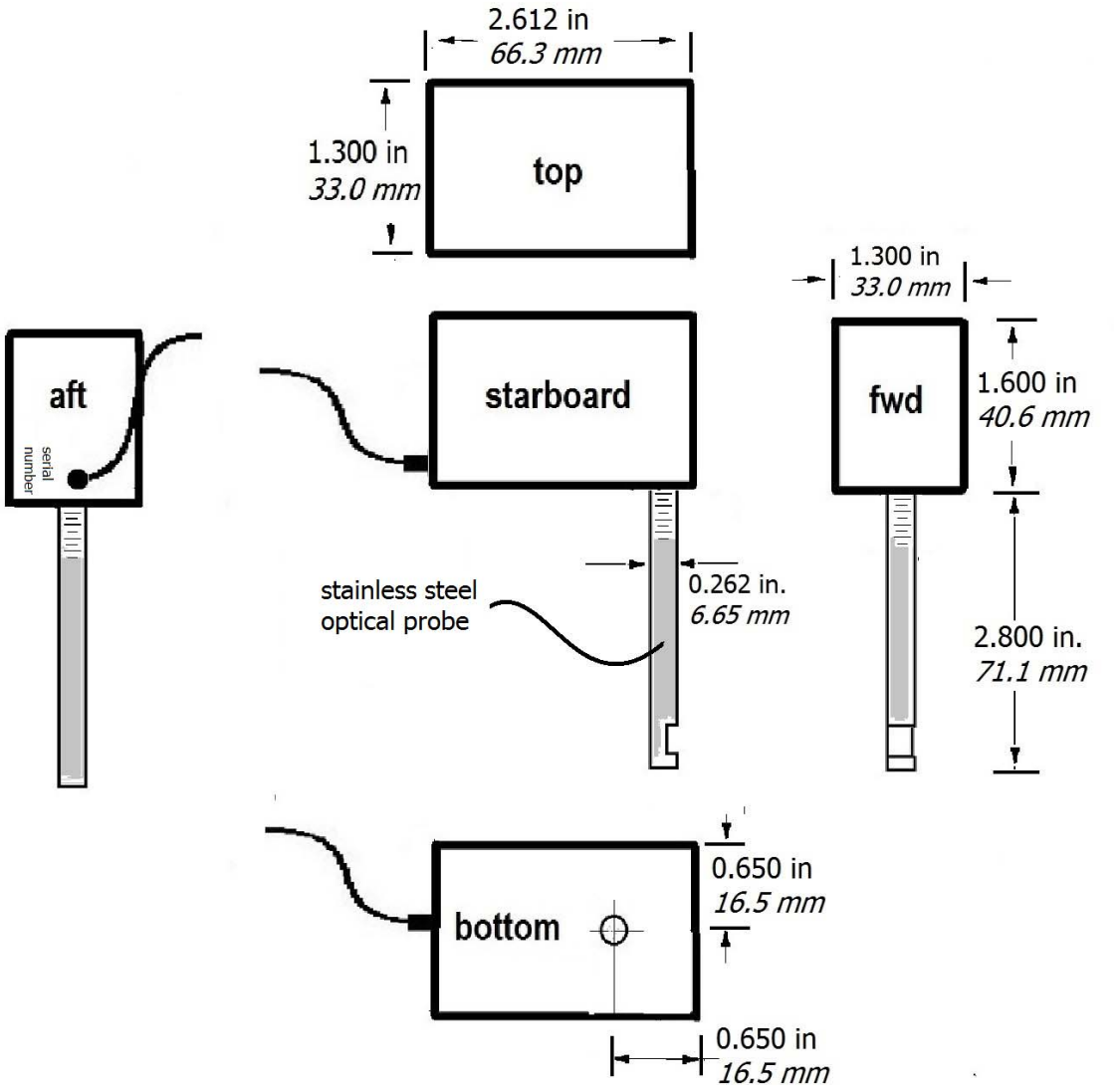


Figure 17 -- dimensions

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. Optical elements in the probe air gap are made of acrylic, the same material as aircraft windshields. Optical elements 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.

8. Customer acknowledges there is no FAA TSO published 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 CAVEATS.

10. This device is not a replacement for BFGoodrich Model 871 pneumatic boot controller. See CAVEATS.

NOTES

1. Ice*Meister™ is a trademark of New Avionics Corporation.
2. Ice*Meister™ is protected under one or both US Patents 6010095 & 7772993.

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Ice Detecting Sensor for Aircraft
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