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PROPELLER ICE PROTECTION

PROPELLER ICE PROTECTION SYSTEMS

Ice formation on propeller blades, in effect, produces altered blade airfoil sections that cause:

- loss in propeller efficiency.

Generally, ice collects, to some measure:

- asymmetrically on a propeller blade
- produces propeller unbalance
- harmful vibration
- increases the weight of the blades

To minimize the risk of danger associated with propeller icing, systems may be incorporated to either :

- prevent the formation of ice

or

- remove ice that has accumulated on the propeller.

The two basic ice protection approaches are:

1) anti-icing systems
2) de-icing systems

ANTI-ICING SYSTEMS

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anti-icing systems are activated:

- before the formation of ice on the propeller

Once ice builds on the propeller, this system is:

- largely ineffective in removing ice. (not useful in the presence of ice)

Accordingly, the anti-icing system must be in operation whenever:

- the aircraft is flying in conditions when ice formation is possible

Depending on ambient conditions and conditions likely to be encountered at altitude during flight;

- the anti-ice fluid tank may require replenishment before each flight to provide maximum protection against ice formation.

Meaning : if the weather conditions and altitude will produce ice abnormally the tank should be refilled before flight

The basic operation of this system is that :

- anti-ice fluid is dispersed to the shank of the propeller blade to mix with moisture in that area

The resultant mixture of the anti-ice fluid and moisture does not:

- readily freeze and prevents the formation and accumulation of ice

A typical fluid system includes:

- a tank to hold a supply of anti-icing fluid.

This fluid is delivered: By a

- to each propeller through the use of a pump

The control system permits:

- variation in the pumping rate so that the quantity of fluid delivered to a propeller can be varied, depending on the severity of icing.

A quantity indicator is useful in determining:

- the level of anti-ice fluid and calculating the time remaining in terms of system operation.

Fluid is transferred from a:

- stationary nozzle on the engine nose case into a circular U-shaped channel (slinger ring) mounted on the rear of the propeller assembly.

Using centrifugal force:

- the fluid is transferred through the discharge nozzles to each blade shank.

Because airflow around a blade shank tends to disperse anti-icing fluids to areas where ice does not collect in large quantities:

- feed shoes, or boots (overshoes), are installed on the blade leading edge to direct the flow of the fluid.

These feed shoes are:

- narrow strips of rubber extending from the blade shank to a predetermined blade station

The feed shoes are:

- molded with several parallel open channels in which fluid flows from the blade shank toward the blade tip by centrifugal force.

The fluid flows laterally from the:

- channels over the leading edge of the blade.

The anti-icing fluid used with this system must readily blend with :

- moisture and produce a solution with an extremely low freezing point to prevent ice build up

Types of fluids that can be used:

1, Isopropyl alcohol:

- is used in some anti-icing systems because of its availability and low cost

2, Phosphate compounds are:

- comparable to isopropyl alcohol in anti-icing performance and have the advantage of reduced flammability.

However, phosphate compounds are:

- comparatively expensive and, consequently, are not widely used

To determine proper system operation:

- technician should follow maintenance and testing procedures published in the appropriate maintenance manual

It may be necessary to inspect or replace:

- filters and other system components.

Aside from determining general operation:

- a flow test may be used to determine whether the delivery to the propeller complies with specifications

The smell of isopropyl alcohol provides :

- ample evidence of the existence of system leaks on units serviced with that fluid.

The propeller anti-icing system has disadvantages:

1, several components that add weight to the aircraft, especially the anti-ice fluid contained in the tank.

2, the duration of anti-ice operation available is confined to the amount of fluid on board and the rate of fluid discharge.

Meaning of point 2: The performance of the system depend on the amount of fluid in tank

This system is not used on many aircraft:

- because of these limitations

Instead:

- electric de-icing systems have been developed that provide ice protection for the entire duration of the flight, if necessary

DE-ICING SYSTEMS

An electric propeller icing control system consists of an:
- electrical energy source
- a resistance heating element
- necessary wiring

The heating elements are:
- mounted internal ly or externally on the propeller spinner and blades

Electrical power from the aircraft system :
- is transferred to the propeller hub through electrical leads that terminate in slip rings and brushes

Flexible connectors are used to:
- transfer power from the hub to the blade elements

de-ice system have a:
- one or more on-off switches

The pilot controls the operation of the de-ice system by :
- turning on one or more switches

All de-ice systems have a :
- master switch

and may have another :
- toggle switch for each propeller.

Some systems may also have a:
- selector switch to adjust for light or heavy icing conditions or automatic switching for icing conditions

The timer or sequencer unit determines:
- the sequence of which blades (or portion thereof) are currently being de-iced, and for what length of time

The sequencer timer :
- applies power to each de-ice boot, or boot segment, in a sequence or all on order

A brush block, which is normally mounted on the engine just behind the propeller, is used to:

- transfer electricity to the slip ring

The slip ring:

- rotates with the propeller and provides a current path to the blade de-ice boots

slip ring wire harness is used on :

- some hub installations to electrically connect the slip ring to the terminal strip connection screw

A de-ice wiring harness is used to :

- electrically connect the de-ice boot to the slip ring assembly

de-ice boot contains:

- internal heating elements or dual elements.

The boot is securely attached to the:

- leading edge of each blade with an adhesive

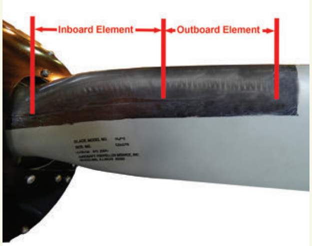

Figure 5-8. De-icing boots or overshoes.

Icing control is accomplished by:

- converting electrical energy to heat energy in the heating element

Balanced ice removal from all blades must be:

- obtained as nearly as possible if excessive vibration is to be avoided

To obtain balanced ice removal:

- variation of heating current in the blade elements is controlled so that similar heating effects are obtained in opposite blades

Electric de-icing systems are usually designed for:

- intermittent application of power to the heating elements to remove ice after formation but before excessive accumulation.
- التطبيق المتقطع للطاقة على عناصر التسخين لإزالة الجليد بعد التكوين ولكن قبل التراكم المفرط.

Proper control of heating intervals:

- aids in preventing runback
- since heat is applied just long enough to melt the ice accumulation in contact with the blade.

If heat supplied to an icing surface is more than that required for melting just the inner ice accumulation, but insufficient to evaporate all the water formed:

- water will run back over the unheated surface and freeze.

Runback of this nature:

- causes ice formation on uncontrolled icing areas of the blade or surface

If heat is not enough: the water or cold parts a bigger block of ice will form at the tip so the heat must be enough to

As ice is melted or softened:

- centrifugal force slings (throw) the ice from the propeller blades

This often results in the ice:

- striking the side of the

1, fuselage
Or
2, other parts of the aircraft.

To prevent or minimize this scenario:

- some pilots prefer to activate the de-icing system before the accumulation of ice

They activate the de-icing system when:

- conditions are favorable for ice formation.

Under such operations, the system is being used as an anti-icing system.

Sequencing timers are used to :

- energize the heating element circuits
- for periods of 15 to 30 seconds,
- with a complete cycle time of two minutes.

A sequencing timer is an :

- electric motor driven contactor that controls power contactors in separate sections of the circuit.

Controls for propeller electrical de-icing systems include:

- on off switches,
- ammeters or loadmeters to indicate: current in the circuits,
- protective devices such as : current limiters or circuit breakers

The ammeters or loadmeters permit:

- monitoring of individual circuit currents and reflect operation of the timer
-

The ammeter should indicate a:

- green arc level of current draw

Figure 5-9. Propeller de-icer ammeter. Heating elements should draw green arc current.

As the system changes from one heating element to the next:

- the ammeter will show a quick deflection in the needle toward zero and back to showing the current draw on the subsequent element receiving power

The normal sequence of heat application begins with the:

- outboard segment of the heating element

After that:

- inboard segment is heated

The sequence of removing ice from the outboard section before heating the inboard element:

- allows the ice on the slower rotating inboard section to sling off the propeller
- without interference from the ice that would otherwise be accumulated on the outboard section of the de-icing boot.

To prevent element overheating the propeller de-icing system is used only when :

- the propellers are rotating
- for short test periods of time during the takeoff check list or system inspection.

When the blades are not rotating:

- there is a lack of cooling air flow passing over the heating elements

Follow testing procedures provided by:

- the manufacturer to determine proper operation.

INSPECTION, MAINTENANCE, AND TESTING for the :

- ANTI-ICING SYSTEM

Inspection of the system begins with the:

- reservoir

Check for proper anchoring of the :

- tank and adequate sealing by the filling cap
- تحقق من التثبيت المناسب: للخزان والختم الكافي بواسطة غطاء التعبئة

A strong Smell will be present if:

- the tank or plumbing possess a leak and the system contains isopropyl alcohol

It may be necessary to:

- drain and flush the tank on a periodic basis.

If draining the system:

- verify that the quantity indicator reads empty when the tank is depleted
- تحقق من أن مؤشر الكمية يقرأ فارغا عند استنزاف الخز

When refilling the tank:

- check the quantity indication by filling the tank to the 1/2 level and reading the gauge and rechecking the gauge when the tank is full
- تحقق من إشارة الكمية عن طريق ملء الخزان إلى مستوى 1/2 وقراءة المقياس وإعادة التحقق من المقياس عندما يكون الخزان ممتلئًا

Check or replace filters as :

- prescribed in the maintenance instructions.

Inspect the pump and any associated check valves for:

- leaks
- security of installation
- other defects.

Check the plumbing to the:

- slinger rings and discharge nozzles

Inspect the overshoes for

- its condition and proper bonding to the propeller blades

For systems with variable delivery rates:

- a check of the rheostat is performed during the flow check

Airplanes with an anti-icing system may also use the:

- anti-icing fluid for windshield anti-icing operations

Applying anti-icing fluid on the windscreen may have an:

- impact on the available duration of the fluid in the tank

In some systems, when the windshield anti-ice system is activated:

- the pump runs at the maximum delivery rate, regardless of the position of the rheostat,
- and anti-icing fluid may be diverted from a propeller during windshield anti-icing operation

Refer to the appropriate technical data for the aircraft being tested

To verify fluid consumption perform the flow test, or similar check:

- as dictated in the maintenance instructions.

Example

In this example a twin-engine aircraft has a :
- three U.S. gallon anti-icing fluid tank (384 fluid ounces or 11.4 liters).

Figure 5-11. Rheostat control on anti-ice with variable flow.

The rheostat provides a means whereby the pilot may :
- vary the flow through the system based on possible icing conditions.

The minimum flow rate for the system provides :
- the maximum duration interval of 3.5 hours of operation.

The maximum flow, or minimum duration, is
- one hour.

With the mark on the rheostat knob lined up with the NORM position indicator:
- two hours of operation are provided by the system.

To check the operation of the system:
- three flow rates are measured.

Before testing the system ensure that an
- adequate quantity of fluid is contained in the tank.

Take precautions to prevent
- fires

and have on
- hand fire fighting equipment if a fire break out.

Beware that alcohol fires may :
- be difficult to visually detect.

Disconnect the delivery lines going to the :
- slinger rings of each engine.

Divert the outputs from the delivery lines to :
- separate containers.

Activate the system and capture the output from each system.

When turning on the anti-ice system, it is often recommended to
- initially run the pump at the maximum flow rate for a brief period to establish steady flow before setting the desired rate of delivery.

Rather than running the systems until the tank is depleted:
- conduct the test for a limited measure of time and calculate flow in units of hours or any other suitable timeframe.

In this test, flows will be gathered over
- six-minute intervals

the flow rate determined by :
- multiplication.

At maximum flow rate:
- each engine should receive 19.2 U.S. fluid ounces (0.57 liters). Using mathematics, 19.2 ounces per engine provides a total delivery of 38.4 ounces over a six-minute period.

Multiplying 38.4 ounces by 10 to :
- determine flow rate per hour yields a flow of 384 fluid ounces or three U.S. gallons (3.4 liters) of flow.

At the NORM position, each engine should receive
- 6 U.S. fluid ounces (0.28 liters) over a six minute test.

At this flow rate:
- the total flow over a six minute run equals 19.2 fluid ounces.
- Multiply by 10 to determine the flow rate per hour.
- This equals 192 fluid ounces. Dividing 192 into the tank capacity of 384 U.S. fluid
- ounces indicates that the tank will be depleted in two hours.

The test to determine the
- correct flow at the minimum delivery rate should produce 5.45 fluid ounces per engine over a six minute test or a total of 10.9 fluid ounces for both engines (0.32 liters).

Multiplying that figure by 10 provides a :
- 109 fluid ounces delivered over the course of an hour. Dividing 109 ounces per hour into the tank capacity of 384 ounces results in approximately 3.5-hour duration.

INSPECTION, MAINTENANCE, AND TESTING THE :

- ELECTRIC DE-ICING SYSTEM

Testing the de-icing system is normally accomplished by:

- activating the switch and observing the ammeter

Figure 5-9. Propeller de-icer ammeter. Heating elements should draw green arc current.

The current draw on the ammeter should be in the:

- green arc

If the current draw is too high:

- the system could be heating too many elements

or

- have an element with low ohmic value or a wiring fault

If the current draw is too low:

- the problem may be associated with a defective heating element,
- a problem at the brush block and slip ring assembly,
- or a wiring problem

An ammeter reading of zero is likely due to an:

- open circuit

or

- defective sequencer timer

After 30 seconds of operation:

- the sequencing timer should switch to the next heating element.

This is verified by a :

- momentary fluctuation in the ammeter reading

At the propeller, very carefully touch the heating elements to:

- ensure that the outboard sections of the overshoes on each propeller blades heats up
- followed by the heating of the inboard sections

Most sequencing timers :

- do not reset each time they are energized.

The operation of the system begins where:

- the previous operation stopped

Consequently, it may be necessary to run through the cycle more than once to:

- verify correct sequencing

Check the:

- manufacturer's instructions regarding any time limitations placed on running the test.

BRUSH BLOCK ASSEMBLY

Routine maintenance of the brush block is :
- minimal

During inspections :
- examine the brush block for cleanliness.

If deposits of carbon, grease, oil, etc. are found on the brush block assembly:
- clean the assembly

or
- replace parts, as necessary

If brushes are worn beyond their service limits or have other defects, such as
- uneven wear or chips, (replaced them)

Ensure that the brushes have:
- proper alignment and 100% contact with the slip rings.

The brushes wear away as the system
- accrues hours of operation.

Often brushes have limit pins:
- attached so that when they wear beyond their service limits ;
- the pins no longer protrude beyond the housing or no longer protrude a prescribed distance beyond the housing

Other units may include holes in the brush block casing:
- that are used to verify whether the brushes have worn beyond their service limits in terms of depth

Measuring the depth that a pin or piece of wire may be inserted into the wear limit holes is used to
- determine serviceable length of the brushes.

The brushes should be replaced when they are :

- worn beyond their service limits.

Be certain to use the:

- correct part number brushes in the proper location as the brushes may have different part numbers

As the slip ring assembly normally has :

- three concentric copper segments,

the outboard slip ring has :

- more total surface length and travels at a greater speed than the inboard segments.

When replacing the brushes it is common practice to:

- replace the associated springs

Bear in mind that because the spring-loaded brushes remain in:

- constant contact with the slip ring assembly

anytime the engine is rotating :

- the brushes encounter erosive friction.

The brushes may also chatter if:

- the brush block is not critically aligned with the slip rings

The brush block is normally set at a slight angle to the:

- slip rings (e.g., 2°) to minimize brush chattering

This angle may be established by :

- properly inserting a wedge with the correct angle between the brush block and slip ring

or

- by using the appropriate thickness gauges during installation (e.g., 0.07 inches on the right side of the housing and 0.10 inches on the left side of the housing as seen from the front of the engine looking down)

Chattering accelerates:

- the wear on brushes

Check the manufacturer's instructions on :

- brush block alignment

When reinstalling the brush block assembly, ensure that the :

- brushes make complete contact with their associated slip rings.

If the contact between the brushes and slip rings is less than 100%:

- implement the requisite corrective measures (install or remove alignment shims) to establish complete contact

Refer to the manufacturer's instruction for additional detail concerning brush alignment.

Ensure that all attaching hardware is:

- securely installed and safetied

SEQUENCING TIMER ASSEMBLY: Heating period

The sequencing timer has proven to be a: reliable component

One simple operational test is to:

- activate the system and feel the overshoes to determine whether the boots are heating in the proper sequence of operation

Along with this test:

- monitor the ammeter to verify current draw and duration of each heating operation.

more complex examination of the sequencer timer is to :

- refer to the wiring schematic ;
- to determine which pins are used for the input voltage and ground and which connectors are outputs to the overshoes

By applying system voltage and ground to activate the input circuit:

- a voltmeter may be used to ascertain sequence of output

The technician must move the:

- voltmeter probe to the proper output pin in the proper order to verify sequence

RESISTANCE CHECKS

As current draw by the system will largely depend on:
- ohmic resistance,
- the manufacturer may specify a series of measurements

Each heating element in the overshoe will have a :
- fairly low resistance
- (e.g., 1 ± 0.5 ohms on a 12-volt system).

As the heating elements from each propeller blade are connected in parallel:
- the ohmic value for multiple overshoes will be less,
- approximately 1⁄2 for a two bladed propeller and 1⁄3 for a three bladed propeller
- when the resistance is measured at the slip rings.

The resistance will normally be higher when measured at the:
- outlet of the sequencing timer as the resistance of the brushes and slip rings will add to the total ohmic value.

Check the appropriate technical documents for specifics regarding resistance checks

In most cases it will be necessary to:
- disconnect plugs and wires, as needed, to obtain accurate readings

Be certain to properly :
- reconnect the wires as crossing the wires at the connections will generate problems in terms of system operation.

Recheck the operation of the system at the :
- conclusion of the maintenance procedure

Deviations from the specified ohmic values indicate a :
- fault.

Deviations from the specified ohmic values indicate a :

- fault.

Technicians need to locate the fault and correct the problem :

- bad brushes and dirty slip rings
- defective heating element in overshoe
- open wire from sequencing timer to brush block

REPLACING OVERSHOES

overshoe:
- experiences wear

Damage and wear to the overshoes occur as
- the boots accrue time in service

Some damage may be:
- repaired
- according to the manufacturer's information

When the damage is beyond the repairable limit or the heating element embedded in the overshoe:
- the overshoe becomes defective
- the boot may be replaced

The overshoes are commonly replaced during:
- overhaul of the propeller (2000 flight hour)

It is important to change the overshoe with the:
- correct replacement part

The following instructions are provided to illustrate the procedures used to replace overshoes of a propeller with metal blades that are still assembled and mounted on the engine.

Removal :

Before using solvents to soften the adhesive of the defective boot:

- mask off the area to protect against chemical damage in unwanted locations (It will damage propeller if not softened)

position the propeller blade so that:

- chemical drips will do no harm to other components cowling

As in every procedure involving harsh solvents:

- use protective gear and garments to avoid physical injuries (use ppE)

Also, ensure the work area has:

- adequate ventilation

Take necessary precautions to prevent :

- fires when handling flammable chemicals

Before beginning the process:

- take note of how the wires are routed all wire clamping hardware and measure the distance between the inboard edge of the boot and blade shank.

Digital photographs or hand drawn sketches of the installation :

- may prove useful during the installation and reassembly process

The replacement boot must be :

- properly installed in terms of position and wiring

To initiate the removal of the defective overshoe:

- apply toluene or methyl-ethyl keytone (MEK) to a corner of the overshoe to debond the edge

Lifting the corner of the boot as the solvent:

- dissolves the adhesive,

continue applying the solvent while:

- working to free the overshoe

If using a scraper for this process:

- use only a nonmetallic scraper
- as scratches to the propeller blade in this area may result in blade failure.

When a sufficient amount of the overshoe is free of the propeller blade:

- grasp the loosened corner of the overshoe with pliers or vise-grips
- and exert a pulling force to the boot while applying the solvent.

It may be advantageous to include a:

- soaking period for the solvent to soften the adhesive

Continue pulling the boot away from the propeller blade while:

- applying solvent until the entire boot is free of the propeller blade.

Remove any:

- residual adhesive from the propeller blade using the solvent

Installation

Preparing the propeller surface for installation of the replacement boot may vary from:

- one manufacturer to another.

Mask around the area where the overshoe is to be:

- installed (So no dames from the adhesive by masking)

If paint was removed from the propeller surface while removing the overshoe:

- refinish the surface as specified by the manufacturer (e.g., coat surface with polane paint)

Defects in the finish underneath the overshoe may result in:

- poor adhesion
- and blade corrosion

The bonding surface must be:

- very clean

Do not use solvents or brushes that contain:

- contaminants

do not touch the surface with:

- bare hands or fingers.
- Due to : the natural oil in the finger or dirt

Before attaching the boot:

- place a temporary alignment mark on the shank of the blade
- that corresponds with the centerline of the leading edge.

This reference mark will be used to :

- center the overshoe on the propeller blade.

The centerline on the overshoe is

- lined up with the centerline of the blade leading edge

Another temporary mark is placed on the blade shank to:

- reveal the edge location of the overshoe

Temporarily place the new overshoe:

- in position and wrap it around the leading edge of the propeller blade.

Place a temporary mark around the perimeter of the boot approximately:

- 1⁄2 inch (13 mm) beyond the edges of the overshoe.

After removing the overshoe:

- apply masking material to define outer perimeter of the overshoe.

If the area beneath the overshoe has been repainted:

- it may be necessary to lightly sand the surface to enhance adhesion

Carefully wipe the:

- bonding surfaces of the boot and propeller blade with toluene or MEK with a lint free rag and allow the surfaces to completely dry.

Using the specified bonding agent (e.g., 3M 1300L) apply:

- an even layer of adhesive to the masked off area of the propeller blade and to the interior surface of the overshoe

Allow the adhesive to dry as:

- directed (one hour).

Apply a second coat of adhesive to:

- both surfaces and allow the adhesive to dry, as required (until faintly sticky).

Do not apply the adhesive unless :

- the ambient temperature and humidity requirements are met.

Position the de-icing boot:

- over the mark indicating the starting position on the blade shank and centering the boot with the centerline.

Carefully apply the:

- overshoe along the centerline of the leading edge of the blade
- working from the shank-end toward the propeller tip

Do not wrap the overshoe around the propeller blade until :

- the centerline is established

If necessary:

- pull the overshoe away from the blade and realign with the centerline of the leading edge.

Once in position:

- use a rubber roller to attach only the leading edge contact area at this time.

Do not use a :

- metal roller as damage to the heating element may occur

firm rolling motion is used to ensure:

- secure bond

Gradually attach the remainder of the boot by:

- working from the leading edge along the blade.
- Using a slight tipping angle on the roller away from the leading edge,
- begin attaching the boot to the back and face of the propeller blade.

Avoid trapping:

- air between the overshoe and the blade surface

Allow the adhesive to :

- dry the requisite period (eight hours) before running engine.

After the drying interval:

- check the bonding of the boot along the perimeter

If improper bonding is found:

- reapply the adhesive in the loose area and re-roll the overshoe.

Allow the adhesive to;

- fully cure and recheck for proper bonding.

To finalize the bonding operation:

- mask off an area 1⁄2 inch (13 mm) beyond the perimeter of the overshoe and 1⁄4 inch (6.5 mm) inside the perimeter of the boot

This provides:

- 3⁄4 inch (19 mm) area for the application of a perimeter sealant

The sealant protects:

- the bond line around the edge of the overshoe
- Apply the sealant recommended by the manufacturer

Reconnect :

1, the wires

2, anchoring devices

- that protect the wires from the centrifugal force encountered during operation.

Check system operation using :

- procedures prescribed in the appropriate manual

check of the :

- dynamic balance of the propeller may also be appropriate following the replacement of one or more de-icing boots