

US Army UH-60M Main Rotor Ice Protection System

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Sikorsky

A United Technologies Company



Sikorsky Aircraft designed a new main rotor blade for a new version of the BLACK HAWK helicopter
the UH-60M...

The composite main rotor blades incorporate new airfoils, larger blade chord, and blade tip enhancements

Blades incorporate heater mats compatible with the control system from the legacy rotor ice protection system

UH-60M ice protection systems are similar to those of the UH-60A/L

The attributes of the ice protection system were analyzed and calculated performance was acceptable

UH-60M was tested in icing conditions with acceptable results





The need for helicopter ice protection

Description of the UH-60M helicopter

Description of the UH-60M ice protection systems

Analyses used to confirm acceptable icing, deicing, and performance

UH-60M program had the benefit of the results of icing flight tests of a similar blade on the Sikorsky S-92A®

UH-60M icing flight test program results

Qualification of the UH-60M for flight in icing conditions



Military has a need to fly in icing conditions



- The US Army finds icing conditions around the world. US Army helicopters need to be able to fly in all-weather conditions and, therefore, ice protection is needed to enable flight in these conditions
- The US Army established an icing envelope to meet majority of conditions found in military operations
- The previously-tested UH-60A is qualified for that envelope, reports from the field are favorable, and that system functions as intended



The UH-60M



The “M” still looks like a BLACK HAWK, but with upgrades...



- Two T700-GE-701D engines, rated at 2000 SHP (1491 kW)
- New main rotor blades - composite, more chord, new tip
- New glass cockpit
- Active vibration control



UH-60M Anti-iced Components



Engine - front frame is anti-iced

Engine Inlet - inlet lip, interior walls of the inlet, and nose gearbox fairing are anti-iced

Air Data System - Pitot-static probe heads and supports are anti-iced and outside air temperature sensors are shielded from ice accretion

Main Cockpit Windshields - windshield panels each contain heating zones to maintain an ice-free area for visibility

Ice Rate Meter - probe head and supports are anti-iced (active element in probe is deiced as it functions to provide LWC)

Drop Stops - once RIPS is activated, droop stop pins are anti-iced to maintain droop stop function upon landing and rotor shutdown



UH-60M Deiced Components

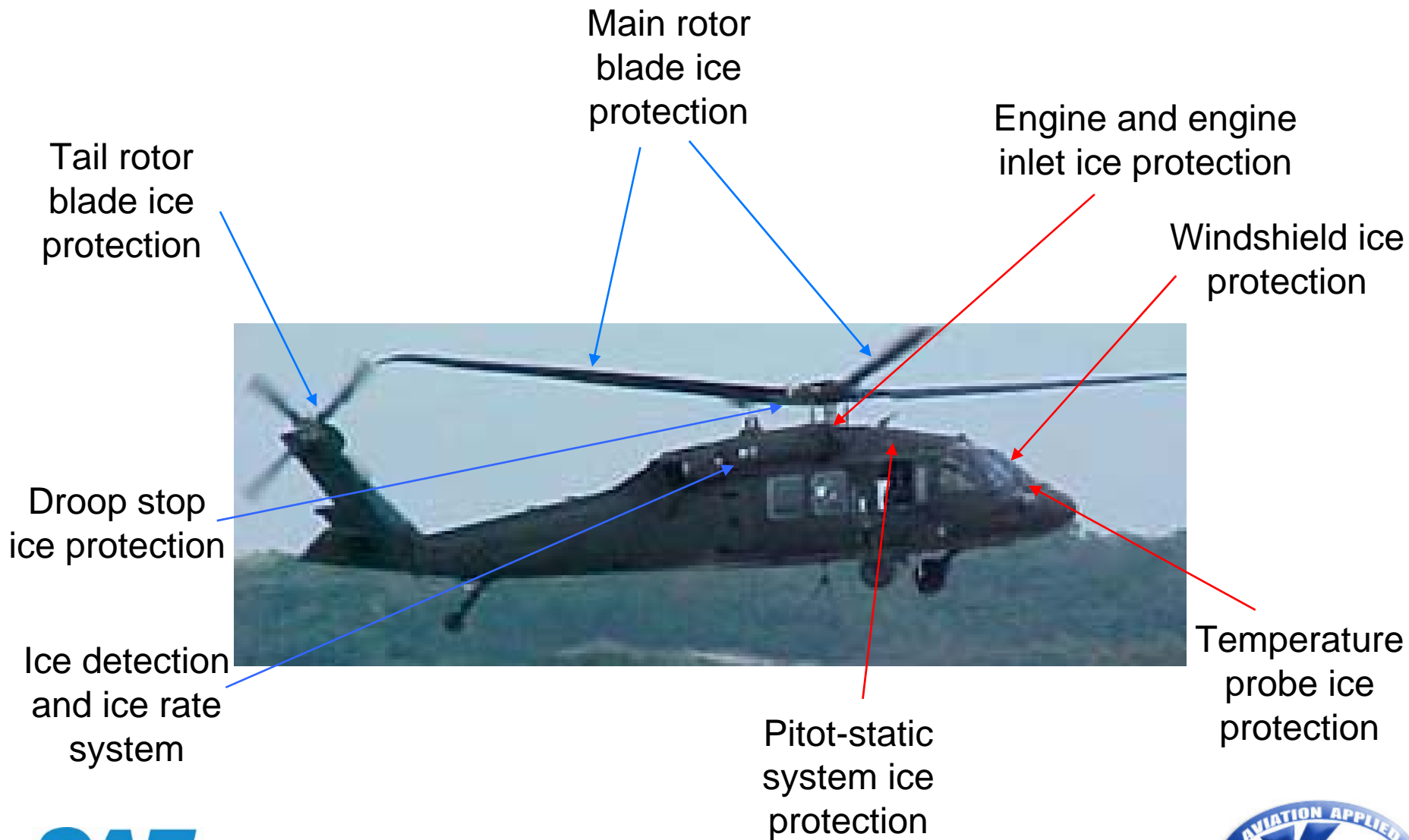


Main Rotor Blades - a spanwise four-zone heater mat is installed in the UH-60M main rotor blade leading edge sheath, controlled by an electro-mechanical control system

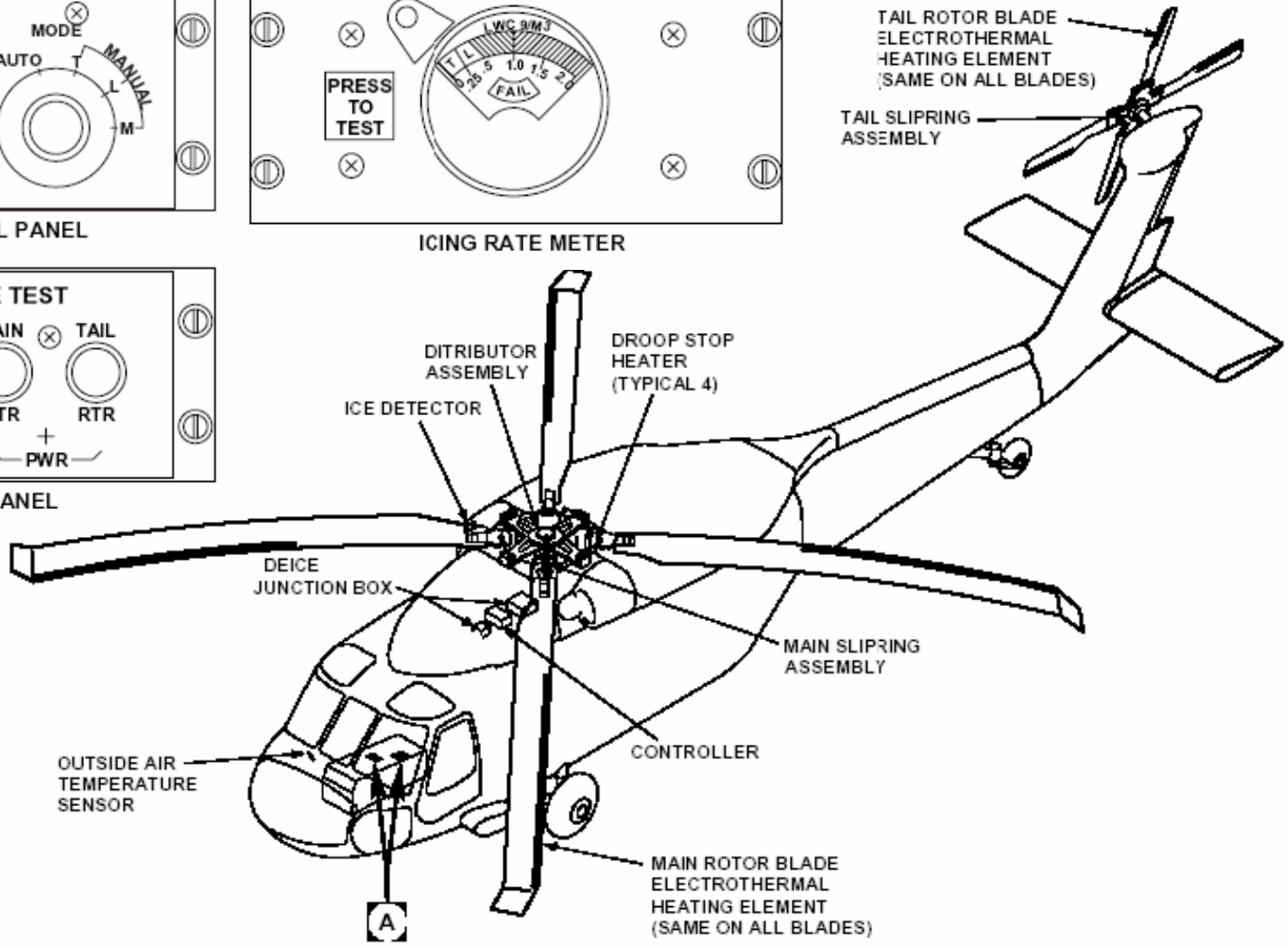
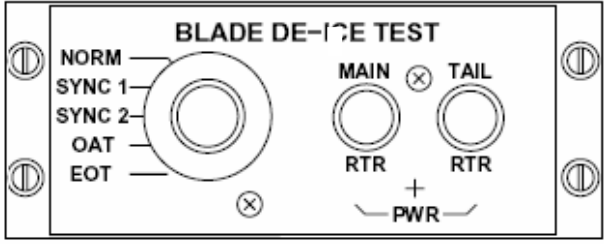
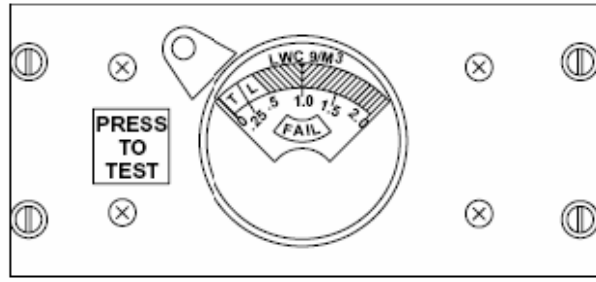
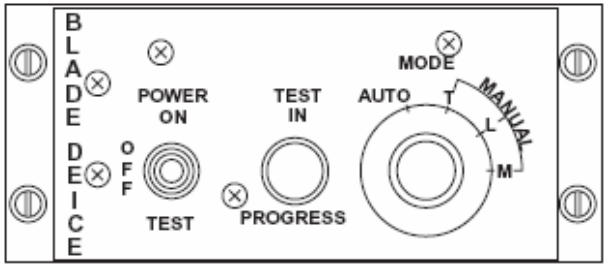
Tail Rotor Blades - a single heater mat is installed in each tail rotor blade



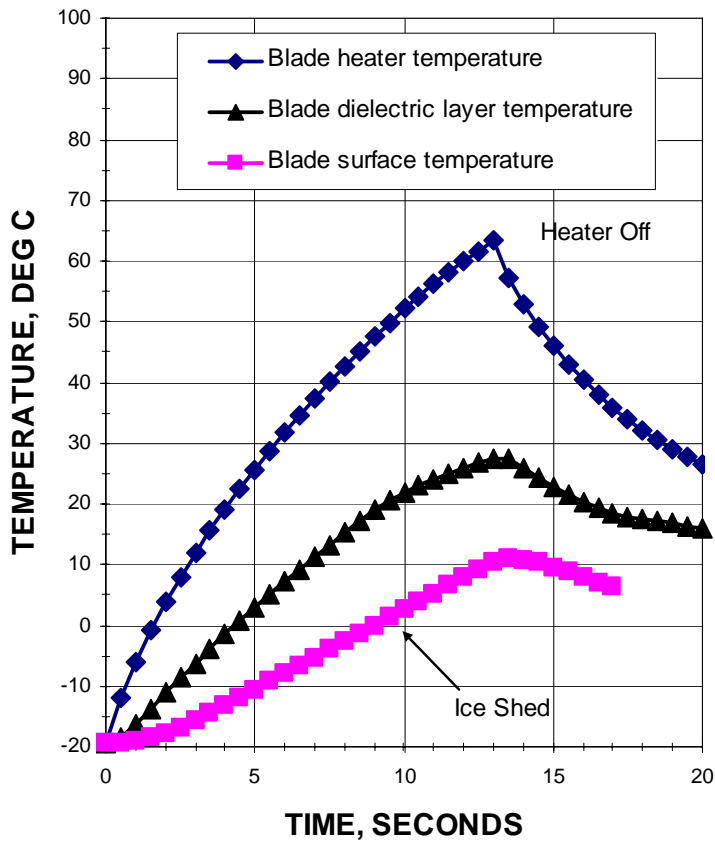
UH-60M Ice Protection System



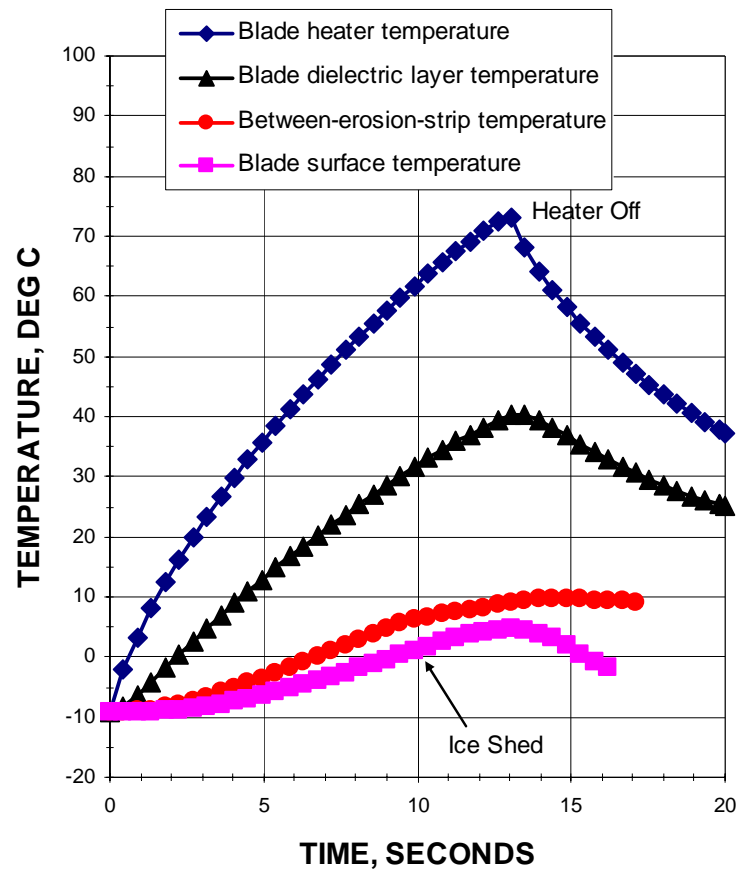
UH-60M Retains UH-60A/L RIPS Controls



UH-60M Main Rotor Blade Temperatures



Inboard Blade Station

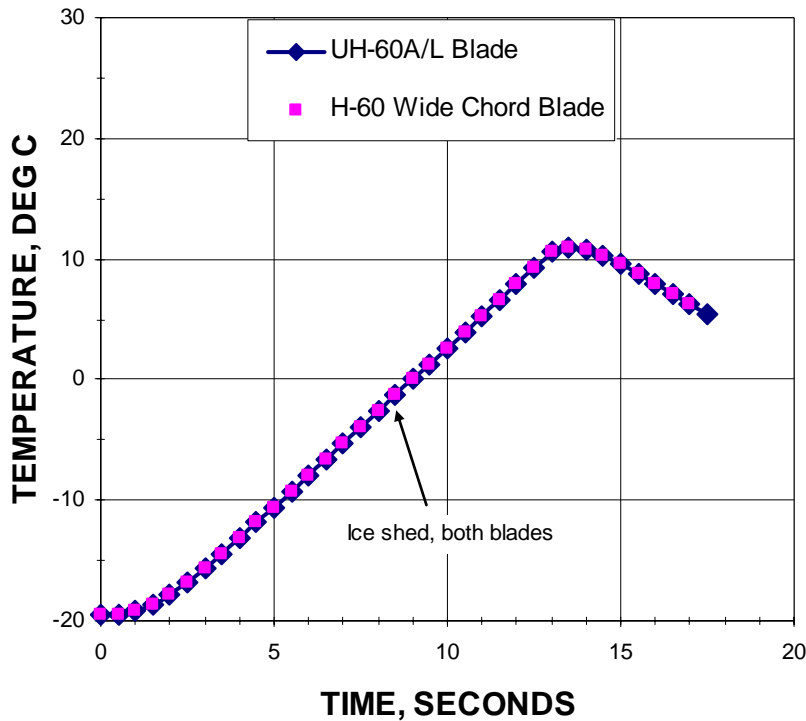


Outboard Blade Station

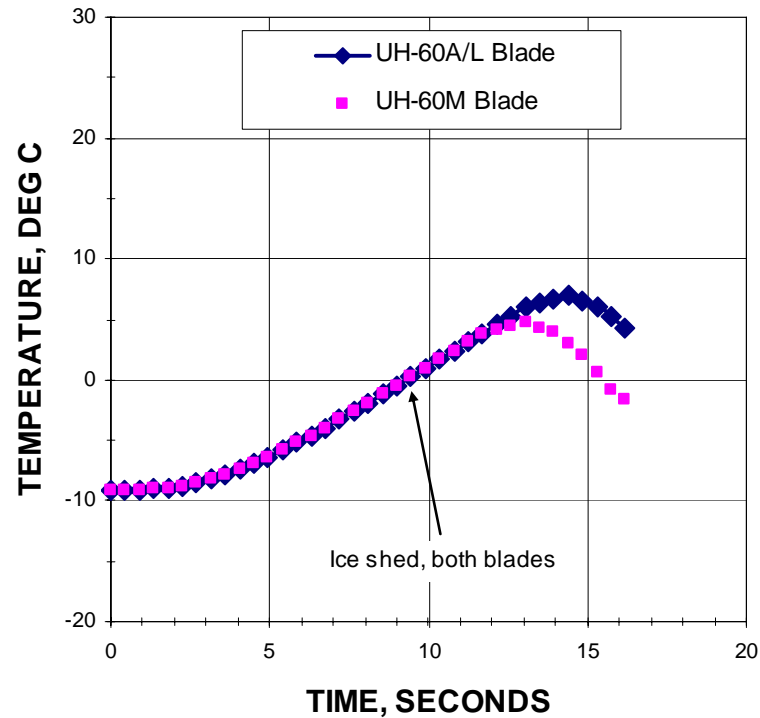
Note - the predicted ice shapes were similar



Comparison of "A" and "M" Blade Temperatures



Inboard Blade Station



Outboard Blade Station

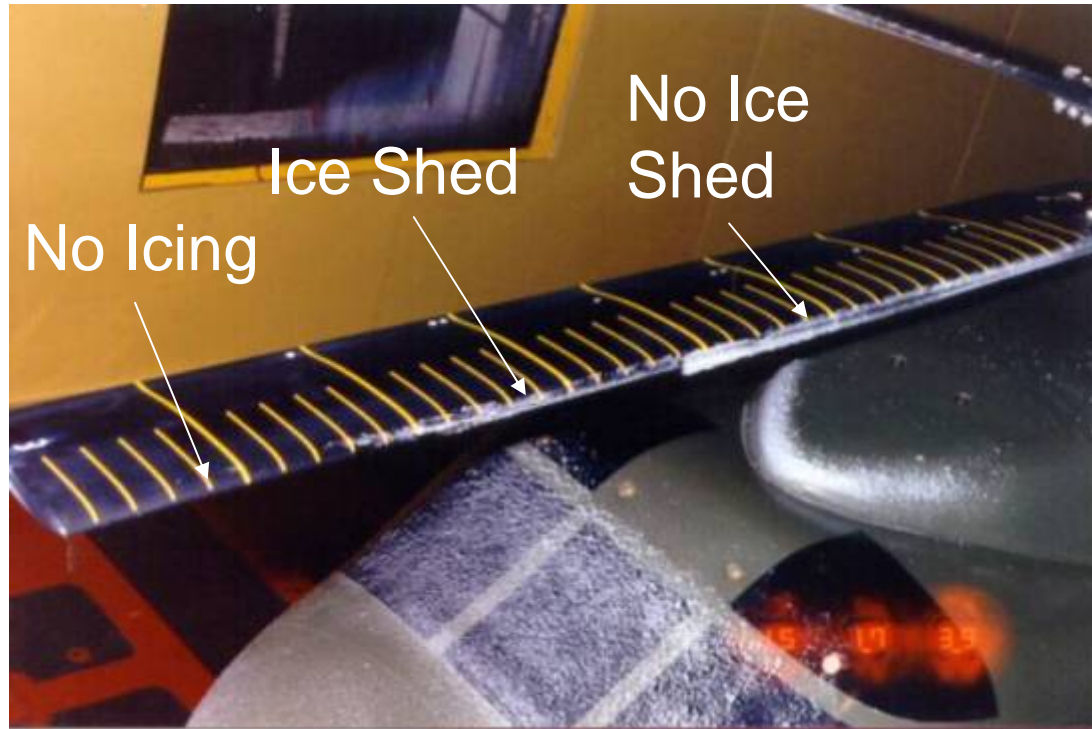


Model Rotor Blade After Artificial Icing Encounter



1993 TEST IN THE NASA ICING RESEARCH TUNNEL

Region of ice accretion inboard, region with regrowth ice after a shed midspan, and region of no icing toward the blade tip



This test became the foundation for the Sikorsky power and shedding prediction methodology, methods used for the UH-60M



The S-92A main rotor ice protection system (RIPS)

S-92A has same blade design and heaters as the UH-60M helicopter

S-92A has dual RIPS controllers, two ice rate meters, and dual channels in junction box, main rotor slip ring and main rotor distributor

Icing tests of the S-92A main rotor blades **preceded** the icing flights of the UH-60M main rotor blades

S-92A simulated ice tests - for ice roughness effects

S-92A artificial icing tests - Climatic Lab & HISS tanker

S-92A dry air system flight tests

S-92A natural icing tests



S-92A Simulated Ice Roughness on MR Blades



40 grit roughness
bonded to blade
leading edge



S-92A Artificial Icing at the McKinley Climatic Lab



S-92A Helicopter



US Army HISS Tanker



S-92A AND CH-47D HISS
TAKEN FROM C-12G IN
THE SKIES ABOVE
MARQUETTE, MICHIGAN

Many members of the Army team that supported the S-92A artificial icing flight program and initial natural icing flights were also involved in the icing qualification of the UH-60M



S-92A after a flight in natural icing conditions



The S-92A Type Certificate was modified by the FAA on October 14, 2005, to allow flight in icing conditions, prior to the start of UH-60M icing flight tests

S-92A Icing Tests



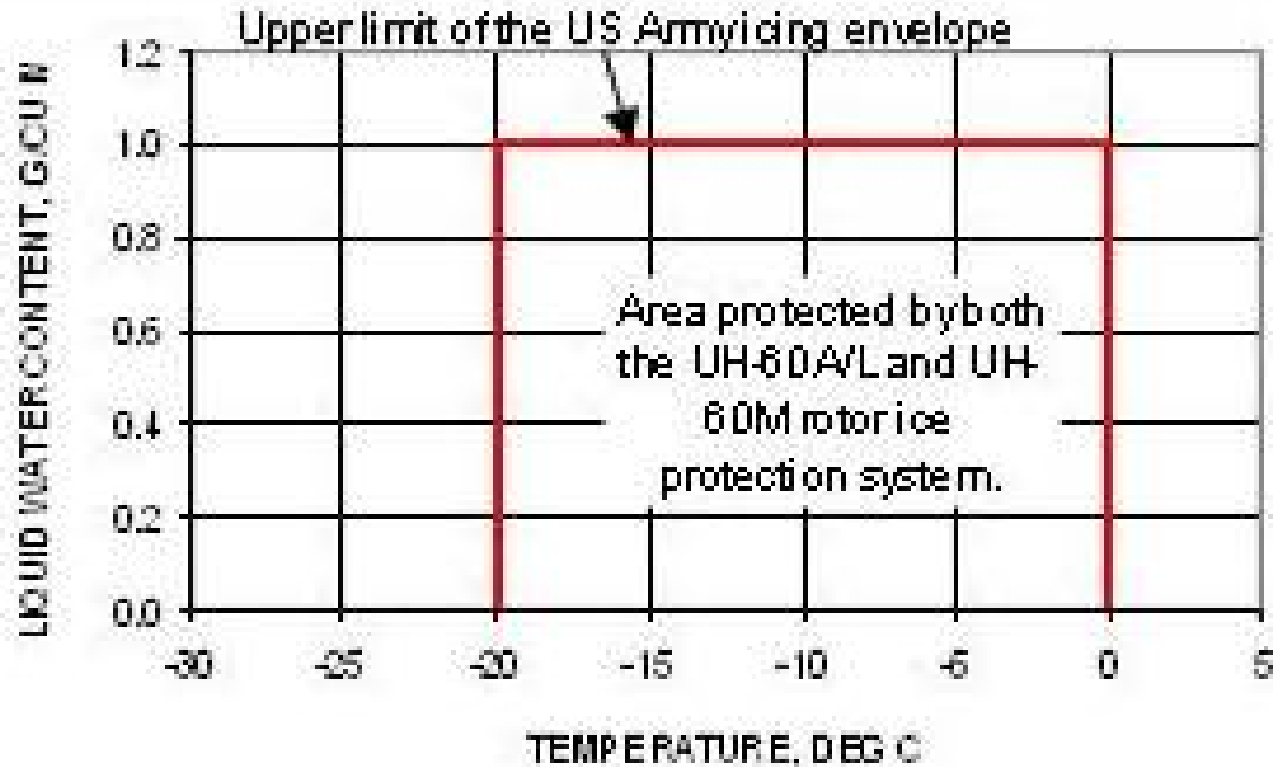


With UH-60M analyses completed and with considerable icing flight experience with the new main blade on the Sikorsky S-92A, the US Army could define a short flight test program to validate the combination of the new main rotor blades and legacy controls.

The objectives of the UH-60M icing flight test were to evaluate the ice accretion and shedding characteristics of the UH-60M BLACK HAWK helicopter and assess the effects of icing on handling qualities and performance **to substantiate issuance of an airworthiness release (AWR) for flight into icing conditions.**



UH-60M Icing Envelope



The Tests Were Supported by a Scout Aircraft



INSTRUMENTED US ARMY JRC-12G KING AIR



UH-60M Natural Icing Flight Test Conditions



Flight No.	TAS	OAT	LWC	MVD	Time in Cloud	Ice Thickness
	km/hr	deg C	g/cu m	μm	minutes	cm
2	237	-9.0	0.20	16	27	2.5
3	231	-3.5	0.35	25	29	---
4	231	-3.0	0.60	38	33	6.4
5	237	-13.0	0.20	17	50	3.8
6	222	-16.0	0.20	15	65	4.4
7	220	-20.0	0.25	20	52	10.2
8	224	-19.5	0.15	23	53	3.8
9	220	-15.0	0.20	14	61	6.4
10	224	-14.0	0.35	17	40	7.6

Total icing flight test time was 6.8 hours



UH-60M After Flight in Natural Icing Conditions



Icing Flight 5

Icing Flight 10

Photograph from Flight 6
was shown earlier in this
presentation



UH-60M After Flight in Natural Icing Conditions



UH-60M After Flight in Natural Icing Conditions



UH-60M Icing Flight Test Conclusions



- Changes in thermal characteristics between the UH-60A/L and UH-60M main rotor blades are small and/or insignificant.
- The larger chord airfoils of the UH-60M result in lower icing power rises, especially at higher gross weight conditions.
- The rotor blade deice system operational characteristics are unchanged from previous testing and are satisfactory.
- The operational characteristics of the UH-60M anti-ice systems are unchanged from previous testing and are satisfactory.



UH-60M Icing Flight Test Conclusions (Continued)



- Changes in vibration level and frequency are not apparent while operating in icing conditions with normal active vibration control system operation. The vibration characteristics of the UH-60M during deice cycles are satisfactory.
- Proper operation of the RIPS can be verified by observing torque changes resulting from ice accretion and shedding.
- UH-60M can safely operate in icing conditions up to a moderate intensity at outside air temperatures greater than -20°C .
- The UH-60M meets the icing requirements of the UH-60M system specification.



May I answer any questions?

