

S A E
AEROSPACE INFORMATION

REPORT

No. 3

SURVEY OF OPERATING PRACTICES
WITH
PROPELLER ICE ELIMINATION EQUIPMENT



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I PURPOSE

It is the purpose of this report to present a tabulation and summary of the answers received in reply to the questionnaire on Propeller Ice Elimination Equipment (Appendix D), circulated February 7, 1942 to the manufacturers and operators of transport and military aircraft, listed in Appendix E.

II CONCLUSIONS

The tabulation of replies is given in Appendix A. Additional detailed comments which were received are given in Appendix B and Appendix C.

A. The following conclusions are made on the basis of this summary.

1. Most operators are using denatured Ethyl alcohol for propeller deicing rather than a mixture of alcohol and glycerine.
2. Most operators use the following alcohol flow rates for three bladed propellers fitted with feed shoes:

Max 8 to 10 qts./hr./three bladed propeller
Norm 4 qts./hr./propeller
Min 2 qts./hr./propeller
3. The provision of a sight gage or equivalent indicator of available fluid in the supply tank is essential.
4. The use of a manual adjustment for the rate of fluid flow to the propellers is essential, however the use of an individual manual adjustment for each propeller is desirable, but not an essential feature.
5. The provision for shutting off fluid flow to each propeller independently of the others is a desirable feature.
6. The use of an indicator of the rate of fluid flow within an accuracy of $\pm 10\%$ is desirable.
7. The deicing system of applying fluid directly to the blade shanks without auxiliary guiding on the blades is unsatisfactory. The use of feed shoes is becoming general practice.
8. The problem of maintaining the propeller free from harmful ice accumulation warrants immediate attention from the whole aircraft industry.

(II Cont'd)

B. Supplementary Observations By Committee A-10

Since the accumulation of the data reported herewith, practices in the use of propeller ice elimination equipment have undergone certain changes. The replies to the questionnaires as set forth in this report cover the use of such equipment as was practiced up to February 1942. The comments below will serve to bring attention to more recent trends and developments and to bring the practice in the use of this equipment to date as of January 1943.

1. The amount of anti-icing fluid carried in commercial and military transports was marginal, however tankage has been increasing to compensate for:
 - a. More frequent operation in icing conditions
 - b. Longer range of operations
 - c. Less experience of personnel with specific installations
 - d. Lack of adequate rate of fluid flow control
 - e. Use of more volatile anti-icing fluids
2. The trend towards anti-icing fluids of plain alcohol is desirable since it permits use of a single supply of fluid for protecting propellers, windshields, and carburetors. Corrosion and gumming of tanks, pumps and lines is materially reduced when glycerine is omitted.
3. Alcohols of higher molecular weights, such as butyl or isopropyl, giving better performance than denatured Ethyl alcohol by virtue of their better wetting characteristics and slower evaporation, are desirable and warrant further consideration, especially where operation at high temperatures previously dictated the use of glycerine-alcohol mixtures.
4. The increasing use of externally fitted anti-icing shoes, whether of the fluid spreading or electric-heating types, suggests the desirability of modifying the propeller blade leading edge to reduce aerodynamic penalties. New propeller designs should incorporate adequate means for the anti-icing of the propeller assembly.
5. The flammable character of the suitable alcohols render them hazardous for use in combat, and warrants further emphasis on the development of propeller anti-icing systems not requiring alcohol as, for example, electrical heating. (Similar efforts are being directed toward the elimination of alcohol for the anti-icing of other aircraft components)
6. The preservation of propeller thrust during flight through ice is secondary in importance only to the preservation of engine power.

III SUMMARY

The questions in the original questionnaire (Appendix D) are quoted herein, followed by a brief summary of the replies received.

Question 1.

The answers to this questionnaire apply to Model _____ airplanes.

Engine Description

Propeller Description

Manufacturer _____

Manufacturer _____

Model # _____

Model # _____ hub

Normal Rating _____ HP at _____ RPM

_____ blades

Gear Ratio _____

Airplane Performance - Indicated Air Speed

For cruising is _____ MPH at _____ RPM normally and _____ MPH at _____ RPM in ice.

For single engine operation is _____ MPH at _____ RPM normally and _____ MPH at _____ RPM in ice.

The majority of replies pertained to operation of the Douglas DC-3 type airplane. The answers indicate that no specific operating practice has been definitely established for operation in ice. While some reported increasing the engine speed during operation in ice, the majority reported no change from the normal cruising operation.

Question 2.

The fluid used as a deicing agent consists of a mixture of _____% alcohol and _____% glycerine. If some other fluid used, please describe _____.

The choice of alcohol or a mixture of 85% alcohol and 15% glycerine seems dependent upon conditions other than the propeller. When fluid is required for other deicing equipment such as windshield or carburetor, alcohol is generally used for the propeller as well.

Question 3.

The fluid is supplied to EACH propeller at the rate of _____ qts/hr Maximum
_____ qts/hr Minimum
_____ qts/hr Normal

It was hoped by the committee that the replies to this question would permit the formulation of definite recommended operating practices for rates of fluid flow, however the scattering of answers does not warrant definite recommendations. Nevertheless, it should be noted that those operators who based their replies on their own experience in ice reported a normal rate of 3 to 6 quarts per hour.

Question 4.

The rates described in Question (3) are based on:

- Our experience in flight in ice. _____ Yes _____ No.
- Recommendations of other operators. _____ Yes _____ No.

The majority of answers were based on the actual experience of the airline operator. In reviewing this questionnaire, the replies have been tempered by consideration of whether or not they were based on "Experience in flight in ice."

Question 5.

It is considered essential for the fluid supply system to provide for the following range of rate of fluid flow to EACH propeller
_____ qts/hr Maximum
_____ qts/hr Minimum

The scattering of answers on the "Essential" maximum and minimum rate of flow does not warrant definite recommendations. It is noted, however, that they fall in the range of 8 - 10 qts/hr maximum per 3 bladed propeller, 4 normal and 2 minimum for cases using alcohol and feed shoes. It is noted, further, that the ratio between maximum and minimum varies from 4:1 to $2\frac{1}{2}$:1. This may present problems to the pump manufacturer.

Question 6.

The permanent supply tank of the airplane has a capacity of _____ gallons.
Of this, _____ gallons is assigned to the propeller.
Of this, _____ gallons is assigned to the windshield.
Of this, _____ gallons is assigned to the carburetor.

The capacity of the permanent supply tank as well as the proportioning of the fluid supply to the different components appear to vary with the operators.

Question 7.

On what basis was the capacity of the main supply tank chosen?

- a. Number of hours of expected flight in ice?
Yes _____ No. How many hours? _____
- b. Percent duration of flight _____ Yes. What % _____ No.
- c. Ratio of deicing fluid to gasoline capacity? _____ Yes.
Ratio was _____ No.
- d. Other basis. Please describe. _____

While an effort is apparently made to provide for deicing on a definite basis, the most used practice is that of specifying the number of hours of expected flight in ice rather than correlation with other factors. Further study of this point is warranted so as to provide a better criterion for comparing new equipment.

Question 8.

Do you believe a ratio such as Question 7b or 7c could be established for a given type of airplane? Yes. _____ No.

The approximately 50-50 split in "YES" and "NO" answers to this question can indicate a need for establishing such a ratio, but it also can indicate, as some commented, that many factors regarding the class of service expected needs to be considered in such a ratio.

Question 9.

Is provision made for re'filling the supply tank during flight from auxiliary containers? Yes No.

The majority of replies indicated that no provision was made for refilling the supply tank during flight.

Question 10.

The auxiliary supply is usually gallons.

A few operators reported the use of an auxiliary supply in two or five gallon containers.

Question 11.

Is the provision for a sight gage or equivalent on the supply tank considered essential? Yes No. (Desirable .)

The almost unanimous affirmative reply to this question indicates that the provision of a sight gage or equivalent on the supply tank is an essential requirement.

Question 12.

Is the use of a manual adjustment for the rate of flow of fluid to the propellers considered essential? Yes No. (Desirable .)

The majority of operators considered the use of a manual adjustment for the rate of flow of fluid to the propellers essential.

Question 13.

Is the use of an individual manual adjustment of flow to EACH propeller considered essential? Yes No. (Desirable .)

The majority of opinion did not consider an individual manual adjustment to each propeller essential. It was indicated as desirable but not a requisite.

Question 14.

Is the provision for shutting off fluid flow to each propeller independently of the others considered essential? Yes No. (Desirable .)

The slight majority of affirmative answers to this question indicated that the provision for shutting off the flow to each propeller independently of the other, was at least a desirable feature, and to be recommended.

Question 15.

Is the use of an indicator of the rate of flow of fluid considered essential? Yes No. If so, what accuracy is essential? %.

(III Cont'd)

The almost fifty-fifty split in reply to this question indicated that this feature is recommended although not considered essential. An accuracy of $\pm 10\%$ seemed essential.

Question 16.

Are feed shoes used on the blades? ☐ Yes ☐ No.

According to these replies, the minority of operators use feed shoes. It is believed, however, that the use of feed shoes is becoming general practice.

Question 17.

Are cuffs used on the blades? ☐ Yes ☐ No.

Practically no experience with blade cuffs was reported.

Question 18.

Does the conventional arrangement of applying deicing fluid directly to the blade shanks without auxiliary fluid guiding on the blades give satisfactory deicing? ☐ Yes ☐ No.

The majority of replies indicated that the essential arrangement of applying deicing fluid directly to the blade shanks without auxiliary fluid guiding on the blade does not give satisfactory deicing. This, together with the specific comments which were received in reply to this question, indicate that the problem of maintaining the propeller free from harmful ice accumulation warrants immediate attention from the whole aircraft industry.

APPENDIX A
QUESTIONNAIRE ON PROPELLER ICE ELIMINATION EQUIPMENT

SOURCE	GENERAL COMMENT	1 AIRPLANE, ENGINE, PROPELLER	2	3 Max/ Min/ Normal	4		5 Max/ Min	6				7								8	9	10	11	12	13	14	15		16	17	18
					A	B		Total	Prop.	Wind- shield	Carb.	A		B		C		D	Yes/ No								%				
												Yes	No	Yes	No	Yes	No														
American Airlines		Douglas DST, DC-3 WAC G102 (3:2) HSP 23EEO-6153A-1B	100% Al.	6/3/5	Y		*	6-1/2	*	*	*							*	Y	N		Y	Y	N	Y	Y	±2	N	N	N	
Bureau of Aero- nautics	*	Patrol & Scout-Bomber Torpedo Transport	*				8/2					N		*				N	Y	Y		Y	Y	N	Y	N		N	*	N	
Catalina Air Transport	*																														
Chicago & Southern		Douglas DC-3 WAC G202A (3:2) HSP 23EEO-6153A-1B	Solox D-1	5/1/2-3	Y		6/1	9	*	*	*		Y	75				Y	N		Y	Y	Y	N	Y	±6	N	N	N		
Delta Air		Douglas DC-3 WAC G202A (3:2) HSP 23EEO-6153A-1B	Solox	10/4/6	N	N	10/4	4	4	0	0	*		1			1/150	Y	N		D	D	D	D	*	86	N	N	Y		
Mid-Continent		Lockheed 1807 PWA S1E3G R1890 (3:2) HSP 23EEO-6153A-12	Solox D-1	4 Max	Y	Y	4/*	8	7	1	0	Y	3-1/2		N		N	N	N	0	D	D	D	*	N	*	N	N	N		
National Airlines	*	Lockheed 18-50 WAC G202A or C96-C (3:2) HSP 23EEO-6153A-12																N			D			N		N	N				
Naval Aircraft Factory		PBN-1 PWA R1850-92 (16:9) HSP 23EEO-6153A-12	85% Al. 15% Gl.	8/3/4	N	Y	8/3	8	3	0	0	Y	3 1/2		N		N	N	Y	*	Y	N/D	N	N	N		N	N	Y		
Northwest Airlines		Douglas DC-3A PWA R1850-SG3-G (16:9) HSP 23EEO-6153A-1B	100% Al.	5/2/4	Y		8/2	7	7	0	0						N	Y	Y	2	Y	Y	N	Y	Y		Y		N		
Pan American Eastern Division	*																														
Pan American Western Division	*	Douglas DC-3A PWA R1850-S1C3-G (16:9) HSP 23EEO-6153A-1B																													
Pan American Atlantic Division		Boeing B-314 & A WAC C14A (16:9) HSP 23EEO-6243A-3	100% Al.	12/3/*	Y		*	40	0	10							*	Y	Y	0	N/D	Y	N	N	N	*	N	N	Y	*	
Pan American Alaska Division		Lockheed 18-08 PWA S1C3G (2:2) HSP 23EEO-6139A-12	Solox	7/2.8/3.5		*	*/3	4 1/2	4 1/2	0	0	N	N		N		N	*	N	N	0	Y	Y	Y	Y		90	Y	N	N	
Pan American Grace	*																														
Penn-Central		Douglas DC-3 WAC G102A (3:2) HSP 23EEO-6153A-1B	100% Al.	16/2/4-8	Y	N	12/6	4	4	0	0	Y	1		N		N	N		Y	Y	N	D	Y	10	N	N	Y	*		
TWA		Douglas DC-2 WAC F-3A (16:11) CFC C632-D-P22/89203-18		10 Max.	Y	N	10 Min.	11	4 1/2	1 1/2	5	N			N		N	*	N	N		Y	N	N	Y	Y	*	Y	N	N	
United Air Lines		Douglas DC-3A & DST PWA S1C3-G (16:9) HSP 23EEO-6139	85% Al. 15% Gl.	8/2/3-3 1/2	Y	N	8/1-2	6	6	0	0	Y	4		N		1/100	N	Y	N	0	Y	Y	D	Y	Y	±10	Y	N	N	
Western Air		Douglas DC-3A PWA S1C3-G (16:9) HSP 23EEO-6153A-1B	85% Al 15% Gl.	8/0/4	Y		8/0	6	5	0	0	Y	3	Y	100		8/3	N	N	N		Y	Y	Y	Y	Y	10	N	N	Y	
Prop. Lab., Materiel Div. Air Corps			*100% Al. or 85% Al. & 15% Gl.	*	Y	Y	8/3	*	*	*	*				N		N	*	Y	*	*	*	*	N	N	N	*	*	*	Y	*
Douglas Aircraft		C-55 PWA R-1850-92 (16:9) HSP 23EEO-6153A-1B	85% Al. 15% Gl.					4	4	0	0						*	N	N	*	N	Y	N/D	N/D	N		N	N			
Lockheed Aircraft	*																														
Vought-Sikorsky		V8-44A PWA 1850-C51G (16:9) HSP 33DEO-6257A-6	80% Al. 40% Gl.	*	N		8/1-3/4	20	20	0	0		4-5	20		200/1		N	N	0	*	Y	D	N	N		N	N			

* - See Report for Special Comment