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Effects of Ambient Temperatures on Typical Models of Exterior Aircraft Lights

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NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Effects of High Ambient Temperatures on Typical Models of Exterior Aircraft Lights

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1. SCOPE OF REPORT

This report gives the results of tests made to determine the maximum ambient temperature at which typical current models of aircraft exterior lights may be operated without damage to the lighting unit.

2. LIGHTS TESTED

All the lighting units tested were furnished by the Grimes Manufacturing Co. of Urbana, Ohio. Each unit was marked with the manufacturer's type number and the Defense Department's catalog number. Table I lists the units tested, identifying them by both of the above numbers, and giving a description of the unit in each case.

3. PROCEDURE OF TESTS

3.1 Preliminary Tests

Before beginning the measurements to be reported, a series of nine preliminary tests was made in order to be certain that the test procedures were giving dependable results. The unit used for these tests was an extra red unit of the Grimes Company type No. B6345. From these tests the range of temperatures which could be used was determined and the differences in temperature to be expected between different parts were measured. A check was made to make certain that the measurements being obtained would not be significantly influenced by heat conducted along the thermocouple leads to or from the junctions. A simple colorimeter was constructed to test the changes of color with temperature and this device was tested to make certain that reproducible results could be obtained. A procedure was also worked out for measuring the relative intensity of the light emitted by the unit at different temperatures.

3.2 Definitive Measurements

The position light units were measured one at a time. Each unit was placed in the test chamber on a sheet of transite resting on a shelf. The units, excepting the taillights, were right side up as in use. A baffle was used in the chamber to prevent measurements from being influenced by radiation received directly from the nearest wall of the test chamber. Each unit was operated at normal current until it reached approximately its maximum operating temperature and the temperature of the chamber was then gradually increased until the maximum obtainable was reached or the unit failed. Throughout the test the temperature at the center of the chamber,

"the chamber ambient" was recorded by an automatic pressure type thermometer. At intervals during the heating, the thermocouple voltages were recorded, the chromaticity of the light was determined by comparison with a series of filters, and the light output was measured with a photoelectric cell.

3.3 Landing Light Test

The landing light was measured by a somewhat different procedure since these lights are not operated continuously in service. The temperature of the chamber was raised by steps and at each step the temperature was held constant for a time to give the unit an opportunity to reach an equilibrium temperature. The unit was then opened and the lamp turned on. The lamp was operated for about two minutes and then the unit was returned to its case. After several such cycles the chamber temperature was raised to a higher point and then the whole process repeated until the mechanism refused to operate.

4. RESULTS

4.1 Temperature Measurements

The results of the heat tests on the position lights are summarized in Table II. The original temperature readings are given in °C and the equivalent °F values are stated in parallel columns. All these values have been rounded to multiples of five degrees since closer values would not be significant. A comparison of the various values show, in fact, considerable variations for which no explanations are evident. Presumable large accidental effects are present and the general average values are more significant than the individual ones.

One particular irregularity deserves special notice; namely, the large difference between the ambient temperature of the cabinet with the AN-3158 white unit and the corresponding yellow unit. The low value recorded for the white unit was caused by the fact that the cabinet heater was not used in this case. On examining the yellow unit it was found that the lamp solder had become fused and the white unit was examined before heating the cabinet. As the solder in this case was also fused, the unit was not exposed to further heating. Quite probably the solder on the lamp of the yellow unit had softened before the chamber was heated but its fusion was not discovered at that stage. The question naturally arises as to how it is possible to use this unit in service. It seems probable that the answer is to be found in the thermal conductivity of the structural parts in which the unit is customarily mounted. Presumably these relatively heavy metal parts carry away so much heat that the temperature does not rise to the point of fusing the solder.

4.2 Examination After Test

The results discovered on examining the units after the heat tests will be considered part by part. In no case did the glass parts of the units

show any permanent damage. During the time of high temperature there is a very considerable loss in light transmittance and although the green is not as bad as the red in this respect the lowering of the green transmittance is considerably greater than had been anticipated. The change in color of the red units is in the direction of safety, and there was no significant change in the color of the green lights. The blacking of the glasses in certain cases is not due to any characteristic of the glasses themselves but is an indication that other parts are unsatisfactory. The structural metal parts of the fixtures were all satisfactory in every case.

The weakest element in all the units is the solder which has been used. This applies both to the solder used on the lamps and to the solder used in the assembly of the fixture parts. In every case there was evidence of melting on the center contact of the lamps and, in all but one type of unit, the solder used in the fixture shows signs of having softened during the test.

The lamps also proved unsatisfactory in the AN-3158 and AN-3177 units in that there was considerable corrosion of the upper portion of their bases. This was presumably caused by an interaction between the brass of the base and the base cement. Some material associated with the gaskets might have caused it but, in that case, other parts of the AN-3158 units would probably have been corroded also, as this unit is largely brass.

Four types of gaskets were used in the five types of units tested. The rubber gaskets in the AN-3032 and AN-3033 units showed no definite evidence of damage although the cement with which they were installed had been softened by the heat. The silicone rubber gaskets of the AN-3122 units withstood the heating well. They are more resilient after heating than the rubber but they may have been so before heating. The gasket cement in these units had softened somewhat. The asbestos gaskets used in the AN-3158 units appeared in good condition on examination but the blackening of the glass indicates the heating of the gaskets or lamp bases must have given off undesirable gasses. The cork gaskets used in AN-3177 were badly charred and are quite evidently unsuited for high temperature units.

The finish on those parts of the units which are intended to be exposed in service withstood the heating in every case. The finish on the parts which are intended to be enclosed in service generally showed some effects but most of these were not very serious. Units AN-3158, for example, merely showed some darkening of the brass which does not indicate any deterioration of the unit. On units AN-3177 the finish of the underneath parts of the clear unit cracked but that on the white diffusing unit showed no evident deterioration. The other three types of units, AN-3032, AN-3033 and AN-3122 all developed considerable roughening of the metal and this could mean that their protective coatings are deteriorating and this may shorten the life of a unit or interfere with maintenance operations.

4.3 Landing Lights

The following is a log of the landing light test:

Time	Chamber Ambient °C	Chamber Ambient °F	Report
10:00	30	86	Control reset for 70°C.
11:00	70	158	Lamp, motor, switches, and relay work satisfactorily.
13:00	70	158	" " " " " " "
13:15	105	221	" " " " " " "
14:15	105	221	" " " " " " "
15:00	130	266	" " " " " " "
16:00	143	289	Lamp, relay, and switches worked satisfactorily. Motor sluggish both out and in. RF filter leaking.
16:30	148	298	Lamp and relay work satisfactorily. Stop switches work. Indicator light switch remains on. Motor operates very slowly and does not completely retract lamp.
16:35	148	298	Motor failed on second cycle.

Examination after the completion of the above test showed that some of the winding connections on the armature had come loose from the commutator on account of the solder fusing. The examination showed no other damage to any part of the unit.

5. RECOMMENDATIONS

5.1 It is recommended that this report be considered by engineers of the Wright Air Development Center who are familiar with the use of the several types of lights and that such conclusions as may be indicated regarding the application of these units be formulated. This Bureau will be very glad to assist in such an analysis but we do not have the background to do it without guidance.

5.2 It is recommended that tests be made with units similar to those tested in this series with the exception that all soldering on both lamps and fixtures be done with high melting-point solders or be replaced by other forms

of construction designed to resist the higher temperatures; that the units be equipped with lamps having base cements of the best heat-resisting qualities presently obtainable; that the gaskets and gasket cements be improved and that no cements be used in connection with the new units that may give off fumes that can blacken the cover glasses or injure metal parts.

5.3 Recommended action with reference to the landing light will be deferred until there has been an opportunity to discuss the improvement of the motor with the manufacturer of the unit.

Table I

Identification of Lights Tested

Dept. of Defense No.	Manufacturer's No.	Description			Lamps			Gaskets
		Location	Color	Type	No.	Volts	Watts	
AN 3032-5	A 1815-G-24	Wing-tip	green	recessed	A7512-24	28	26	Rubber
AN 3032-5	A 1815-R-24	" "	red	"	"	"	"	"
AN 3033-10	A 2138-G-24	Wing-tip	green	external	1524	28	21	Rubber
AN 3033-10	A 2138-R-24	" "	red	"	"	"	"	"
AN 3122-15-24	B 6345-2-24	Wing Light	green	reflector	A4174	28	40	Sil. Rub.
AN 3122-15-24	B 6345-1-24	" "	red	"	"	"	"	" "
AN 3158-4	A 5715-1-1683	Tail	white		1683	28	32.2	Asbestos
AN 3158-5	A 5715-2-1683	"	yellow		"	"	"	"
AN 3177-9	B 3525-23-24	Fuselage	clear		311 303	28 "	43.4 8.4	Cork
AN 3177-9	B 3525-22-24	"	frost		311 303	" "	43.4 8.4	"
MIL-L-8210	G 5400-3	Under wing	clear		4559 Par-64	28	600	

Lamps		Fixtures		
Base	Solder	Solder	Finish	
OK	Fused	Fused	Roughened	*Automatic #See text.
OK	Fused	Fused	OK	#See text.
OK	Fused	Fused*	Roughened	*Parts rej
OK	Fused	Fused*	Roughened	*Parts rej
OK	Fused	Fused	Roughened	*Cement lo
OK	Fused	Fused	Roughened	*Cement lo
Corroded	Fused	OK	Sl.Dark'd	*Tested on
Corroded	Fused	OK	Sl.Dark'd	*Tested on
Corroded	Fused	Fused	OK	*Tested ba
Corroded	Fused	Fused	Cracked	*Tested ba

Table II

Summary of Results of Heat Tests on Position Lights

Description of Unit				Maximum Temperatures Reached (1)						Color (y") (R-U-C-3)		Relative Intensity	Effects of Heat						Notes
													Cover Glasses	Gaskets		Lamps		Fixtures	
Number	Designed Mounting	Color	Lamp Watts	Cabinet Ambient °C *	Outside Cover °C	Inside Cover °C	Cabinet Ambient °F	Outside Cover °F	Inside Cover °F	Cold	Hot	Hot / Cold	Blackening	Cement	Material	Base	Solder	Solder	Finish	
AN-3032	Recessed	Green	26.	150	200	285	300	390	545	Negligible		0.73	Slight	Melted	OK #	OK	Fused	Fused	Roughened	*Automatic record from bulb at center. #See text.
AN-3032	"	Red	26.	110	175	230	230	345	445	-0.39	-0.45	0.55	Slight	Melted	OK #	OK	Fused	Fused	OK	#See text.
AN-3033	Wing Tip	Green	21.	155	180	285	310	355	545	Negligible		0.66	None	?	OK #	OK	Fused	Fused*	Roughened	*Parts rejoined on cooling. #See text.
AN-3033	" "	Red	21.	155	155	260	310	315	500	-0.33	-0.44	0.55	None	Melted	OK #	OK	Fused	Fused*	Roughened	*Parts rejoined on cooling. #See text.
AN-3122	Wing Tip	Green	40.	140	310	---	285	595	---	Negligible		0.83	None	Softened*	OK #	OK	Fused	Fused	Roughened	*Cement loosened.
AN-3122	" "	Red	40.	155	250	---	310	480	---	-0.33	-0.44	0.49	None	Softened*	OK #	OK	Fused	Fused	Roughened	*Cement loosened.
AN-3158	Tail *	White	32.	30	220	330	86	430	625	---		--	Much	?	OK	Corroded	Fused	OK	Sl.Dark'd	*Tested on side.
AN-3158	" *	Yellow	32.	135	220	365	275	430	690	---		--	Much	?	OK	Corroded	Fused	OK	Sl.Dark'd	*Tested on side.
AN-3177	Fuselage*	White Diff.	52.#	185	---	265	365	---	510	---		Reduced by stain	Slight	Charred	Charred	Corroded	Fused	Fused	OK	*Tested bases up. #Total for two lamps.
AN-3177	" *	Clear	52.#	180	240	290	355	465	555	---		Reduced by stain	Much	Charred	Charred	Corroded	Fused	Fused	Cracked	*Tested bases down. #Total for two lamps.

(1) Original readings in °C and equivalent °F values expressed in 5° intervals.