AEROSPACE INFORMATION REPORT
Society of Automotive Engineers, Inc.
TWO PENNSYLVANIA PLAZA, NEW YORK, N.Y. 10001

AIR 1276

Issued April 1973
Revised

AIRCRAFT ANTICOLLISION LIGHT SYSTEMS USING FLASHTUBES

1. PURPOSE

This AIR discusses various factors to be considered in the use of flashtubes in anti-collision lighting systems.

2. SCOPE

This document covers red and white aircraft anti-collision lights using flashtubes as the light source.

3. GENERAL

3.1 Background: The 1960's saw increasing use of flashtubes (sometimes called condenser discharge lamps because of the circuitry to operate them and sometimes called strobe lamps because of their use in stroboscopes), as supplementary to the aircraft navigation and anti-collision lighting system. On August 11, 1971, the Federal Aviation Administration revised the Federal Air Regulations 23.1401 and 25.1401 to allow the anti-collision light to be either aviation red or aviation white in color, as defined in FAR 23.1397 and 25.1397. This materially broadened the application of flashtubes for anti-collision lights.

4. LAMP CHARACTERISTICS

4.1 Electrical: The flashtube is essentially an arc chamber or tube made of glass or quartz with an electrode sealed in each end. The size of the arc chamber, which is normally filled with xenon gas is determined by its' operating parameters, voltage, required light output, etc.

4.1.1 A third electrode, usually attached to the external wall of the arc chamber, is needed to "trigger" the flash. This electrode is usually a conductive coating applied to the tube or a fine wire wrapped around the wall of the lamp.

4.1.2 Flashtubes are used in a capacitor discharge circuit, see Fig. 1. The basic components of the circuit and their functions are:

a. DC Power Supply. This is relatively high voltage (normally 300 - 500 volts) and is usually obtained from an alternating current rectifier or from a transistorized DC to DC converter.

b. Charging impedance R. This limits the charge rate of the energy storage capacitor and allows the flashtube to deionize and extinguish after a flash. The charging rate may also be limited by a constant current charging circuit or by a transformer saturation.

c. Capacitor. This stores the energy for the flashtube.

d. High voltage trigger pulse circuit. This is usually a simple step-up transformer pulsed by an SCR. The high voltage pulse applied between the wall and one terminal of the flashtube ionizes the gas, which allows the capacitor to discharge through the flashtube.

e. The flashtube changes the electrical energy into light, with a characteristic blue-white color.

4.2 Illumination: Flashtubes have a characteristic light-time curve with a very high peak intensity and a flash duration on the order of a millisecond. In general, higher voltage operation will provide a shorter flash duration and vice versa for the same energy per flash. Circuitry can also affect the flash duration.

4.2.1 Spectral Energy Characteristics: These lamps have a continuous spectrum spectral energy distribution with some higher energy xenon lines superimposed. In the visible spectrum there is some peaking in the 460 nanometer range, which gives the characteristic blue-white color. The visible radiation is approximately equivalent to 6000° Kelvin. The lamps commonly used in aircraft applications produce about as much energy in the 700 to 1200 nanometer range as in the visible region.

4.2.1.1 Red: Aviation red color can be obtained by using a proper red filter with the flashtube. The resultant transmittance will be in the 13% to 16% range.

4.2.2 Efficacy of Light Output: The efficacy of the lamps will vary somewhat due to energy loading and circuitry. In aircraft applications the efficacy will produce approximately 25 to 35 lumen-seconds per watt-second of input energy to the lamp.

4.3 Physical: Flashtubes are available in many configurations, namely; helical, circular, U-shaped, straight and curved.

5. ANTI-COLLISION UNITS

The flashtube fixtures normally consist of lamps, glass or plastic covers, optical elements, such as lenses or reflectors and the trigger coil which provides the high voltage pulse for flashing the lamp.

5.1 The FAA requirements set forth:

(a) Intensity - Effective intensity in aviation red or aviation white shall equal or exceed the values below:

Angle Above or Below the Horizontal Plane	Minimum Effective Intensity (candelas) Applicable to aircraft whose date of application for type certificate is:	
	Prior to 8/11/71	After 8/11/71
0° to 5°	100	400
5° to 10°	60	240
10° to 20°	20	80
20° to 30°	10	40

The effective intensity, I_e, shall be equal to:

$$\frac{\int_{t_1}^{t_2} I(t)\,dt}{0.2+(t_2-t_1)}$$

I(t) - Instantaneous intensity as a function of time.

t_2-t_1 - Flash time interval in seconds.

Measurements are made on some type of integrating photometer with results in candlepower-seconds, which is the value determined by the integral in the above Blondel and Rey formula. Effective candelas are then obtained by dividing this value by 0.2 since the flash duration of about 1 millisecond can be considered negligible.

5.1 Continued:

(b) Color -

1) Aviation Red
"y" is not greater than 0.335 and "z" is not greater than 0.002.

2) Aviation White
"x" is not less than 0.300 and not greater than 0.540; and "y" is not less than "x-0.040" or "y_o - 0.010", whichever is smaller; and "y" is not greater than "x+0.020" nor "0.636 - 0.400x"; where "y_o" is the "y" coordinate of the Planckian radiator for the value of "x" considered.

(c) Flashrate - the effective flash frequency must be not less than 40 or more than 100 per minute. If there are overlaps in coverage when more than one unit is used, flash frequencies may exceed 100 but not 180 per minute.

5.2 Various types of fixtures using various lamp configurations, with clear covers, lenses or reflectors are used to give adequate coverage per the regulations, either by single units on the fuselage or tail or two or three units located at the wing tips and tail cone if a third is used. On small aircraft it has proven desirable to locate the units at wing tip and tail cone to minimize "back scatter" of light when the atmosphere is hazy, and reflections of white light into the cockpit from aircraft structures.

6. EFFICIENCY

The efficiency of power supplies in use ranges from 20% to 75%. In most simple power supplies where the flashtube capacitor is charged through a limiting resistor from a constant voltage power supply the theoretical maximum efficiency is 50% since the energy dissipated in the charge-limiting resistor is equal to the energy stored in the capacitor. However, most power supplies now use other design approaches to achieve higher electrical efficiencies and less variation in input current.

6.1 Capacitors: For aircraft applications, electrolytic type capacitors are almost always used to take advantage of their size and weight. These capacitors will limit operating temperature capabilities of the power supplies, and care must be taken in the location of the power supply in the aircraft so that temperature capabilities are not exceeded. The electrolytic capacitor has a characteristic of having reduced capacity at very low temperatures, so when the system is turned on at low temperatures, reduced energy is delivered to the lamps. After a few minutes of operation, the temperature of the power supply will be near normal as will the light output.

6.2 Energy to Flashtube: The energy delivered to the lamp per flash is determined by the size of the capacitor and the voltage to which it is charged. The energy in joules, or watt-seconds, is equal to 1/2 CV^2 where C is capacitance in microfarads and V is the voltage in kilovolts. Most aircraft installations operate at about 450 volts and provide from 7 to 60 joules per flash.

6.3 Electromagnetic Interference (EMI): Since the flashtube is an arc lamp, it produces electromagnetic interference over a wide frequency range. High energy flashtubes have been satisfactorily installed on aircraft carrying the most sophisticated electronic communications and navigation equipment. Therefore, EMI considerations which should be taken into account in the design of equipment and installation on aircraft follow:

a) Considering location of power supply and fixtures with reference to antennas including finding antennas. Masking should be used if necessary to preclude direct impingement of radiated energy on the antennas.

b) Flashtube power cables should not be bundled with radio antenna lead-ins and power input leads.