

## L. D. C. L. C. L. Y

### DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

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FIRE OFFICES' COMMITTEE

JOINT FIRE RESEARCH ORGANIZATION

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## THE HAZARD OF ELECTRIC LAMPS OF DECREASED SURFACE AREA

by

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April, 1963.

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### Summary

The number of fires due to electric lamps has nearly doubled since 1956, in which year lamps with smaller bulb sizes were introduced. Reducing the bulb size, either of the standard or the 'mushroom' type, will increase the temperatures of the bulb and its leads. This suggests that part, at least, of the increase in the number of fires is due to the smaller size of the bulbs. Greater care is therefore necessary in the use of these bulbs.

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### 1. Introduction

The size specified for the bulbs of many British Standard tungsten filament electric lamps (1) was reduced in 1956 (Table 1), and it has been suggested that the 1956 standard size of 100 W bulbs should be reduced to the same size as the present 60 W bulb. A new range of lamps is now being manufactured with smaller bulbs of a shape different from the standard bulbs; these are commonly referred to as 'mushroom' lamps and do not conform to the British Standard. Measurements of the surface temperature of electric lamps are presented in this report and their fire hazard is discussed.

Table 1

<u>Dimensions of Electric Lamps</u> (1)

Power-	Overall Length -mm		Bulb Diameter -mm		Neck Diameter -mm		Light Centre 6 Length -mm					
Watts	1956*	1.956	.1961 Amend- ment	1956*	1956	1961 Amend- ment	1956*	1956	1961 Amend- ment	1956*	1956	1961
25 40 60 100 150 200	137•5	100 110 110 125 160 178	105 105 105	75	60 60 60 68 80 90	70 <sup>3£</sup> 80	37	33 33 33 37 39 39		100	70 80 80 90 120 133	75 75 75

- \* Acceptable dimensions while stocks last and until a changeover in manufacture can be effected
- \* Tolerance would allow 68 mm.
- # Suggested dimensions of 100 W. are same as 60 W. in 1961 amendment. of Distance from end of cap (including solder) to centre of filament.
- 2. The number of fires due to electric lamps.

The number of fires (2) caused by electric lamps annually has approximately doubled since 1956 when these new standard sizes were introduced. This increase is much greater than the increase in number of lamps manufactured (3); it is probably greater than the increase in the number of lamps at risk, since the life of a lamp has remained constant at about 1000 hours. It is also greater than the rate of increase of fires due to other electrical apparatus (4), although it still remains a small proportion of the total (Table 2).

Table 2

Fires Caused by Electric Incandescant Lamps - United Kingdom

Year	Number of Fires (2) due to electric lamps	Number of lamps (3) manufactured* millions	Number of fires (4) due to electrical apparatus (not wire and cable)	
1956	124	330	6216	
1957	124	297	6562	
1958	136	312	6876	
1959	172	326	7488	
1960	232	378	8692	

- m Includes torch and car bulbs
- 3. Ways in which electric lamps can cause fires.

The main three hazards from the use of electric lamps are:-

1. Risk of ignition when flammable materials touch the bulb surface.

Most fires (2) concerned with lighting appliances in 1961 arose from careless disposal or siting of installations (25 per cent) accidental movement of the material ignited towards the lamp (35 per cent). Thus 60 per cent of these fires are caused by flammable materials being in close proximity to lamps.

- 2. Ignition of shades.
- 3. Deterioration of the insulation on electrical leads or of the lampholder itself(5). The temperatures attained by lampholders and their associated leads using pre-1956 lamps may be high enough to cause deterioration of rubber insulation\*. The temperatures depend upon a number of factors(5), including the power, design and position of the lamp, the design and materials of the holder, and the design of the shade.

Any reduction in surface area of light bulbs increases their surface temperatures. The reduction in bulb diameter in 1956 of the standard 100 W. lamp from 75 mm to 68 mm has increased the temperature at the bifurcation point by 10 to 15 deg.C(7). In addition, higher wattage lamps are being used: whereas the 60 W. lamp used to be the most common rating, now more 100 W. lamps are made than any other type(8). If a 60 W. lamp is replaced by one of 100 W, then the temperature rise of the lampholder may well be increased by 30 per cent(8).

Morgan et al<sup>(5)</sup> demonstrated several designs of lamps and shades that reduced lead temperatures to low values, but their recommendations have not been adopted. It may be necessary to accept that the leads will reach high temperatures and to use suitable heat resisting insulation materials.

The present I.E.E. regulations (6) state that asbestos-roved flexible cord complying with B.S.1327 should be used where the conductor temperature is likely to exceed 60°C, and should be so installed that the conductors are not liable to attain a temperature exceeding 85°C.

### · 4. Experiments carried out and results.

The lamps used are listed in Table 3; their surface areas were calculated from the projected profile of the lamp in a parallel beam of light. The mushroom type lamps have a smaller surface area than the equivalent standard lamp, but the areas of the necks are practically the same.

Table 3

Lamps used in the experiments

Make	Power - Watts	Туре	Approximate Surface Area -cm <sup>2</sup>
A.	40	Pearl: Standard:	130
A	60	Single Coil	130
Â	100	Ħ	170
B.	150	. <del>19</del> 1:	270
C	40	White: Mushroom: Coiled Coil	120
D	60	19	98
E	100 150	11 • #	140 190
	1,50		120

White lamps are hotter than clear or pearl, and single coil filiment lamps are hotter than identical lamps with 'coiled coil' filaments (8). Thus the following tests compare the 'mushroom' lamps with a hotter type of standard lamp, i.e. the temperature differences are likely to be greater with strictly comparable lamps.

2.1. Surface temperatures of lamps without shades.

Three sets of experiments were carried out: the lamps were:-

- 1. mounted cap down in moulded plastic batten holders (with metal inserts) screwed to a wood batten 3 in wide (Fig.1);
- 2. mounted cap up with the batten inverted and supported on stands;
- 3. suspended cap up in plastic or brass pendant type lampholders hanging on a length of flex from the inverted batten.

The temperature of the surface of the lamps was allowed to reach equilibrium and a chromel-alumel thermocouple (40 S.W.G.) was then moved over the surface of the glass envelope and of the brass cap, and their maximum temperatures determined, (Table 4). In the cap down position, the maximum temperature was found to be near the top of the bulb (X, Fig.1), while in the cap up position, it occurred near the neck (Y, Fig.1).

Table 4

Temperatures of lamps in free air

J	<u> </u>	<u> </u>			
Position	Power - Watts	M	Maximum Temperatures - °C		
POSICION		Type of Lamp	Bulb	Cap	
	40	Standard Mushroom	178 195	38 34	
Cap down	60	Standard Mushroom	195 225	50 50	
	100	Standard Mushroom	220 <b>255</b>	47 50	
,	150	Standard Mushroom	220 267	50 58	
	40	Standard Mushroom	115 108	75 80	
Cap up	60	Standard Mushroom	133 140	110 110	
	100	Standard Mushroom	148 148	130 115	
	150	Standard <b>M</b> ushroom	160 160	1,25 145	
Suspended	100	Standard	150	115	
(Plastic holder)		Mushroom	135	115	
(Brass holder)	60 60	Standard Standard	103 130	91 91	

### 2.2. Ignition of Materials in contact with lamps.

The temperatures attained by lamps of power 60 W. and greater in free air (cap down position) are all high enough to start exothermic reactions in cellulosic materials(9). Furthermore, the presence of such materials, by insulating the bulbs, will raise their temperature still more. There is therefore a possibility of ignition, and a few experiments were performed to test this.

Strips of flannelette (10) which covered only a small part of the bulb surface, were held in contact with both types of 150 W. lamp in the cap down position and left in place for 30 min. The flannelette was not ignited by either lamp although it was severely scorched. Thick smoke

issued from cotton wool on the mushroom lamp after two minutes, whereas that on the standard lamp produced only a slight amount of smoke. After four minutes, the cotton wool on the mushroom lamp was smouldering, but attempts to make it flame by blowing were unseccessful. The cotton wool on the standard lamp was merely scorched. After twenty-four minutes, the cotton wool on both lamps had decomposed completely, although that on the standard lamp did not glow.

### 2.3. Temperatures attained by shades

Two types of shade were tested:

- 1. a cylindrical shade of black cardboard, 12 cm diameter and 20 cm long, completely enclosing the lamp in the cap up position. Thermocouples were attached to the outer surfaces of the top and sides. The results are given in table 5.
- 2. a corrugated plastic lampshade (Fig.2) sold as suitable for lamps up to 60 W.and consisting of two perforated truncated cones held together by a circular plastic band. The 150 W. mushroom lamp just fitted this shade, but the 150W. standard lamp was too large. Thermocouples were attached to the top and between the sections (Fig.2.). The results are given in Table 5.

Table 5
Temperatures of shades

Type of	Power and type	Temperature -°C		
- Shade	of lamp -Watts	Side	Top	
Black card shade	40 Standard 40 Mushroom 60 Standard 60 Mushroom 100 Standard 100 Mushroom 150 Standard	40 45 55 57 1.05 107 115	58 60 80 83 - - 150 170	
Plastic shade	40 Standard 40 Mushroom 60 Standard 60 Mushroom 100 Standard 100 Mushroom 150 Standard	33 33 41 38 60 50 - 70	45 35 57 60 80 75 - 95	

2.4. Temperatures of lamps and lampholder terminals in a totallyenclosed shade.

For a standard lamp in a totally-enclosed wall fitting (fig.3), maximum temperatures attained by the bulb and cap and also the temperature of the neutral lampholder terminal were measured. The results are given in Table 6.

Table 6

Temperatures of standard lamp in enclosed wall fitting

Power -Watts	Maximum Temperatures -°C					
	Bulb	Cap	Terminal			
40 60	128 164	108 136	95 114			

### Discussion

The maximum surface temperatures of the bulbs of various types of lamps are a measure of the likelihood of the lamps: (a) igniting flammable materials touching their surfaces and (b) causing deterioration of the insulation of the leads and holders.

Even when the lamps are in freely circulating air, the temperatures attained sometimes exceed those necessary to initiate exothermic reactions in cellulosic materials. The use of a smaller bulb can lead to glowing in a situation where glowing did not occur on a standard bulb. Covering lamps with a radiation absorbing surface increases their temperatures still further. In the cap up position, the maximum temperatures of the two differently shaped lamps of the same power are the same because of the necks (their hottest portions) have the same areas. The hazards will thus be similar for both standard and mushroom lamps. In the cap down position, however, the temperatures of mushroom lamps were higher than those for comparable standard lamps, and the probable bulb temperature for a given power may be estimated from the surface area of that portion of the envelope above the neck (Fig.4). The hazard will thus be greater for the mushroom lamps than for the standard ones.

Although the surface area of the red and white plastic shade was less than that of the black cardboard one, the temperatures of both side and top were lower for the plastic shade: this may be due to the plastic transmitting much of the radiation. The temperature of the cardboard shade was always higher with a mushroom lamp than with the corresponding standard one, the difference being as much as 45 deg.C in 115°C with the 150 W lamps.

Enclosing the lamp by a shade increased the temperatures of the lamp and its leads, but the temperature attained by the shade was much lower than that of the bare lamp. Thus the possibility of the lamp igniting materials is greatly reduced if it is enclosed in an incombustible shade, provided the lamp and shade are not in direct contact. Careful design can reduce the temperatures reached by the shade and the leads.

Even the 40 W. standard lamp caused the temperature of the lead to the wall light fitting to exceed that recommended for high temperature insulation. There can be little doubt that the rubber insulation on many existing wiring circuits has seriously deteriorated after years of use at high temperatures, and that the wiring continues to function effectively only as long as it remains undisturbed.

### Conclusions

The number of fires due to electric lamps is increasing annually. This may be partly due to the increasing use of electric lamps and the growing use of lamps of higher power. Nevertheless, any reduction in the bulb size of lamps of a given power will result in higher bulb temperatures which:

- 1. Increase the likelihood of igniting materials in contact with the bulb; it has been shown that smaller bulbs can lead to glowing in a situation where glowing did not occur on a standard bulb.
- 2. Increase the risk of deterioration or failure of existing electrical insulation.
- 3. Will lead to the occasional fitting of lamps of a power higher than is suitable for the shade.

It should be possible to eliminate the risk of igniting materials by contact with lamps having high bulb temperatures by fitting suitable incombustible shades.

The hazard of increased lead temperatures could be overcome by using new high temperature insulation; this can be ensured in new buildings and rewired installations. However, as a large proportion of the wiring in this country is old, it is undesirable to subject the insulation to higher temperatures by using hotter lamps, especially as the temperatures reached by pre-1956 lamps are high enough to cause rubber insulation to deteriorate.

Without these precautions smaller bulbs must be expected to lead to more fires.

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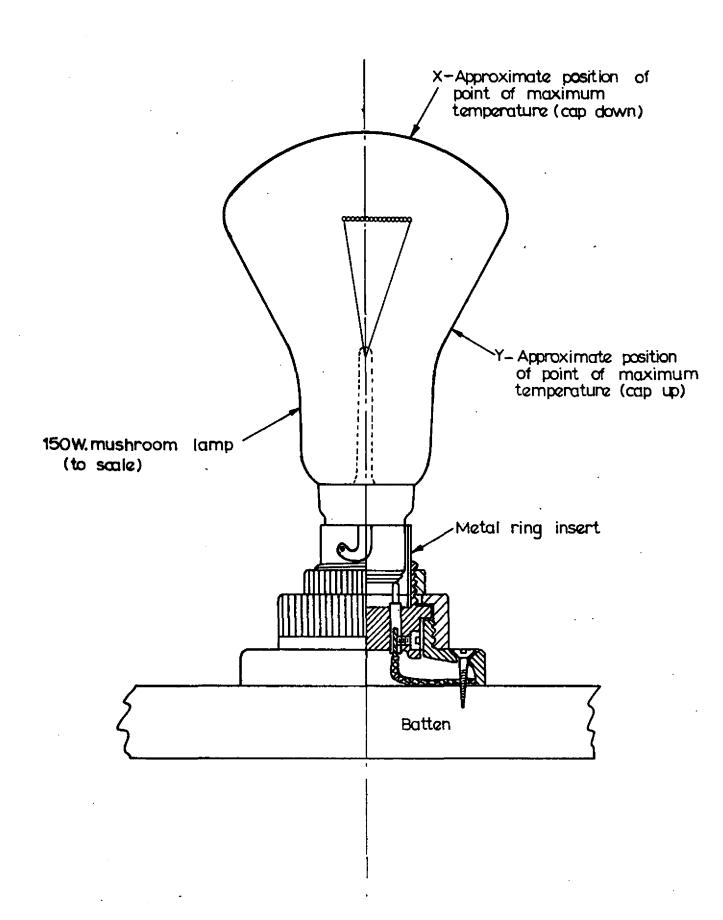


FIG. 1. MUSHROOM LAMP IN BATTEN LAMPHOLDER, CAP POSITION DOWN

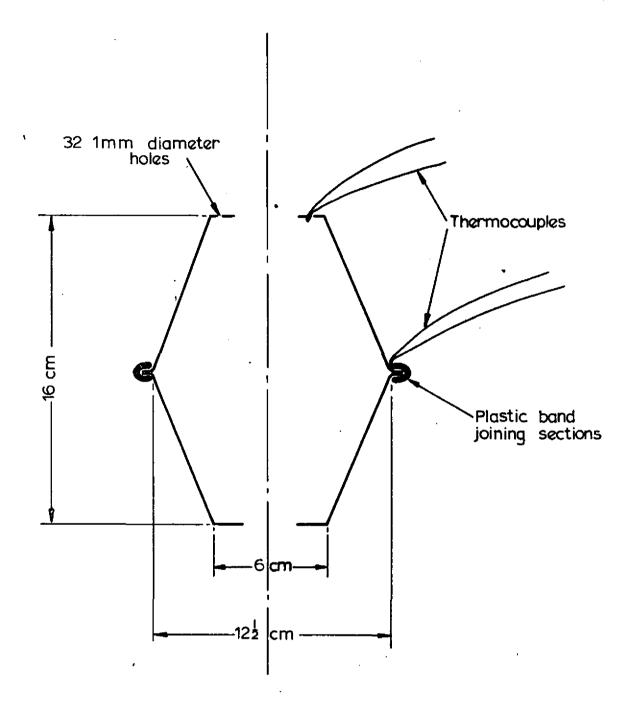


FIG. 2. DIAGRAM OF PLASTIC SHADE

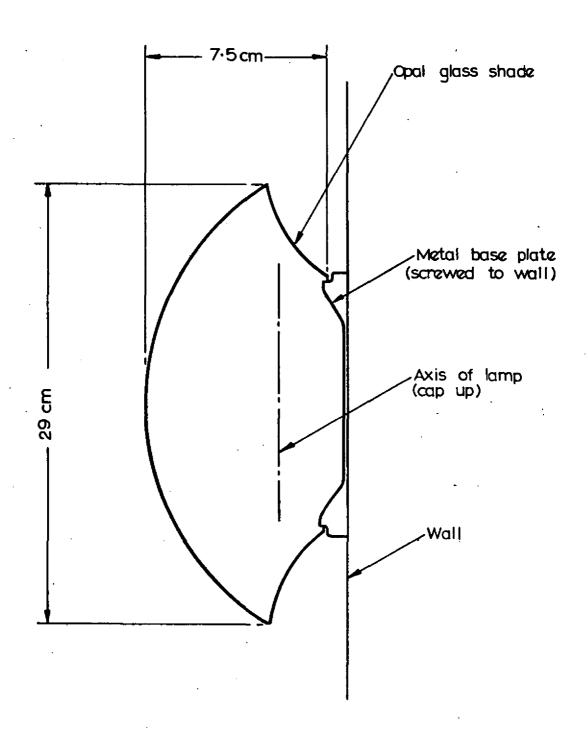


FIG. 3. DIAGRAM OF WALL LIGHT SHADE

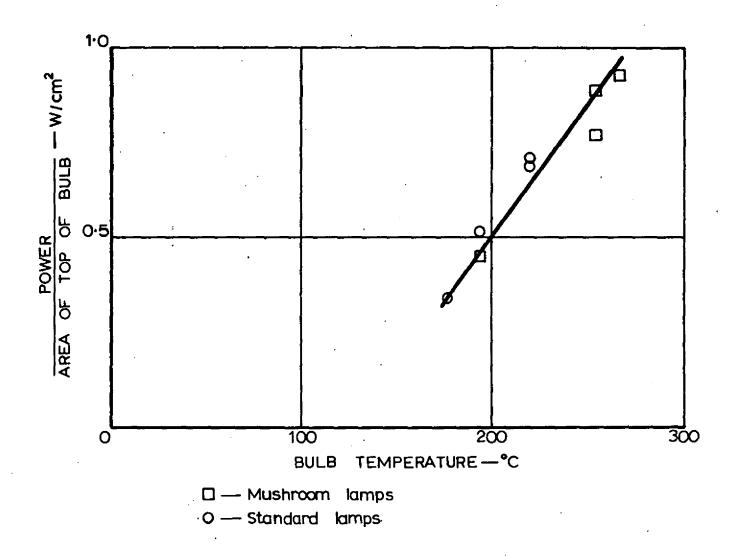


FIG. 4. TEMPERATURES OF BULBS IN CAP DOWN POSITION