HEAT GENERATION OF DOMESTIC NIGHT LIGHTS... A POTENTIAL FIRE HAZARD

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ABSTRACT: The use of night lights (tea lights) has increased in popularity in recent years and these candles are now often used in many domestic dwellings. Their popularity is in part due to their ease of availability an relative inexpense. The casing of such candles is made of aluminium and as a consequence of use can heat up considerable. This work examined the increase In temperature of the aluminium casing of night lights when burned with a single wick, and double wick both in still air and air flow. In doubled wick cases the temperature rise was often rapid with temperatures of over 200°C easily achieved. This is hot enough to melt through many surfaces such as television casings.

KEY WORDS: Night lights; Double wicking effect; Temperature output.

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INTRODUCTION

Candles are a known ignition source for approximately 1748 fires in England and Wales in 1997 [2] with 87% of these incidents occurring within domestic dwellings. This suggests that candles pose a significant risk to fire in domestic premises. Night lights, or tea-lights (Figure 1), are a common variety of candle for domestic use and are widely available in the United Kingdom and else where in Europe, particularly as they are inexpensive and accessible from many retailers. Such candles consist of circular plugs of paraffin wax (37 mm diameter and 15 mm high) in 0.2 mm thick metal (usually aluminium) casings. In some cases the wax may have additives to impart colour or scent. Candles will burn unaided for approximately 4 hours. These candles are very popular for domestic use and are often left directly on top of television sets, hi-fi equipment, wooden and plastic tables and on the sides of baths. It has long been suspected that such candles have the potential to melt through such materials and provide the initiation for subsequent fires [3], however little published research exists in this area.

Because the metal casing surrounds the candle the heat generated as the wax melts cannot be easily conducted away from the wax bulk and conse-

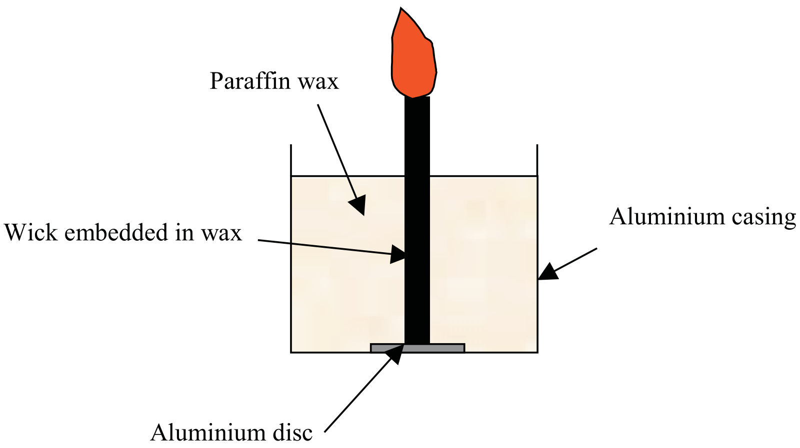

Fig. 1. Components of a typical night light.

quently the wax will melt relatively quickly. Under certain conditions the base of the night light can reach high temperatures and in some cases ignition of the wax can occur. Such conditions include the wick not being properly attached to the base of the container, additives present in the wax, using the candles in aromatherapy pots [1] with insufficient ventilation and the introduction of a double wick effect where a used match has been left in the candle after ignition. It is this double wick effect that is the subject of this study.

EXPERIMENTAL

Two different double wick materials were used, wood and paper matches. The change in temperature with respect to time at the base of the night light was monitored throughout the experiments using a standard thermocouple previously calibrated against both a melting point apparatus and thermometer. Experiments were carried out both in still air and in air flow.

Table 1 indicates the various experiments completed. In each case 25 replicate experiments were undertaken. The data from each of these sets of experiments was evaluated using the χ^2 test. This allowed for the determination of statistical differences between burns across the temperature range measured with respect to time.

Finally the effect of double wicked night lights left on television casings was examined.

TABLE I. EXPERIMENTAL CONDITIONS

Experiment	Conditions
1	Single wick – still air flow
2	Wooden double wick – still air flow
3	Paper double wick – still air flow
4	Single wick – air flow
5	Wooden double wick – air flow
6	Paper double wick – air flow

RESULTS AND DISCUSSION

No significant difference in the data recorded for each experiment was found. The average values for each experimental set of results are used below.

Still air flow – single wick

The temperature at the base of the night light increased steadily throughout the first two thirds of burning. At approximately 110 minutes the temperature levelled off at between 52–63°C. The maximum temperature reached was 67.7°C. In all cases the wax was completely molten by 50°C (87 minutes).

Still air flow – wooden double wick

In this case the temperature increase was much more rapid, with the wax melting within 25 minutes at an average temperature of 59°C. By approximately 57 minutes the fire point of the wax was reached (average temperature of 157°C) and ignition had occurred. The maximum temperature reached under these conditions was 318°C with 63% of tests reaching a final temperature of greater than 200°C. In 6 (24%) cases the double wick fell into the candle and extinguished.

Still air flow – paper double wick

Again, as expected, the temperature increase was much more rapid than for a single wick, with the wax melting within 25 minutes at an average temperature of 60°C. By approximately 62 minutes the fire point of the wax was reached (average temperature of 157°C) and ignition had occurred. The maximum temperature reached under these conditions was 287°C. A much higher number of tests (80%) reached a final temperature of greater than 200°C than occurred previously and only in one test did the double wick fall into the candle and extinguish.

Air flow – single wick

Under air flow the base temperature increased rapidly for the first 40 minutes, levelled off and decreased slowly until burning ceased. Maximum temperature reached was 89°C, significantly higher than in still air conditions. The wax melted within 29 minutes in each case.

Air flow – wooden double wick

In these cases the temperature increase was more even than before over the first 20 minutes, with the wax melting within 14 minutes (average temperature 82°C). By approximately 24 minutes the fire point of the wax was reached (average temperature 182°C) and ignition had occurred. The maximum temperature reached under these conditions was 324°C with 83% of tests reaching a final temperature of greater than 200°C within 1 hour.

Air flow – paper double wick

Again the temperature increase was more even than before over the first 50 minutes, after which time the temperature fell and then rose again. The wax had melted within 14 minutes (average temperature 67°C). The fire point of the wax was reached within 37 minutes (average temperature 126°C) and ignition had occurred. The maximum temperature reached under these conditions was 302°C with only 22% of tests reaching a final temperature of greater than 200°C within 100 minutes.

Comparison of air conditions on base temperature rise

As is evident there are differences between the speed at which high temperatures (> 200°C) are reached depending on air flow. For the single flame candle the temperatures follow more or less the same pattern. Paper double wicked candles behave more erratically in air flow with an overall reduction in temperature compared with their combustion in still air.

Significant differences ($p > 0.01$) are seen in the wooden double wicked candles where in air flow, temperatures of above 300°C can be reached consistently within an hour and in some cases temperatures of > 200°C are reached within 35 minutes of ignition. There are also significant differences ($p > 0.001$) between the behaviour of a paper double wicked candle and a wooden double wicked candle in air flow but not in still air.

These results are illustrated in Figures 2 and 3.

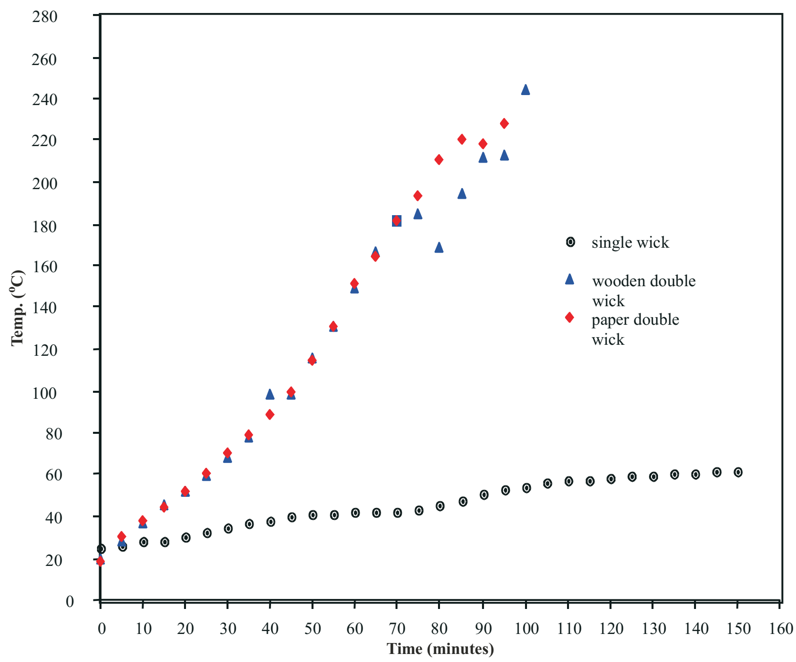

Fig. 2. Still air conditions.

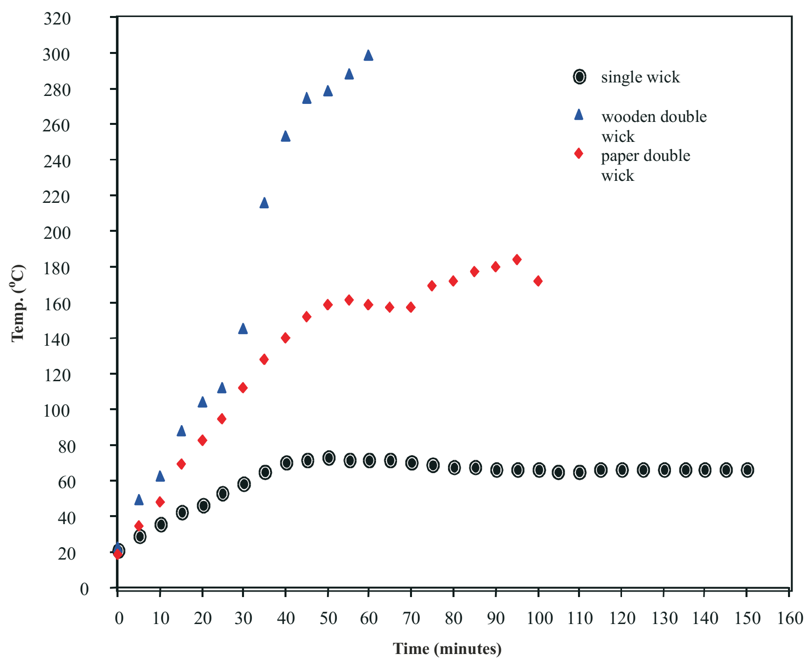

Fig. 3. Air flow.

Effects of night lights on surfaces

Single and double wicked night lights were placed on the casings of various television sets and ignited. The temperature and times for initial melting and for the candle to fall through the casing are shown in Table II. Figures 4 and 5 illustrate these test results.

TABLE II. RESULTS OF TV CONDITIONS

Condition	Melt casing	Temperature	Fall through casing	Temperature
TV 1 – Ferguson				
Single wick	N/A	N/A	N/A	N/A
Paper double wick	43 min	112°C	47 min	155°C
Wooden double wick	35 min	214°C	37min	226°C
TV 2 – Panasonic				
Single wick	N/A	N/A	N/A	N/A
Paper double wick	46 min	153°C	51 min	160°C
Wooden double wick	40 min	248°C	44 min	254°C

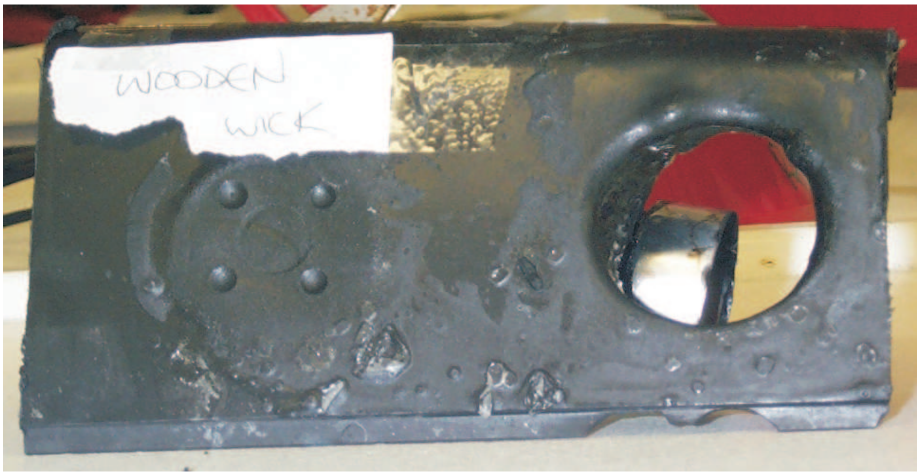

Fig. 4. Ferguson TV casing (after 37 minutes).

Fig. 5. Panasonic TV casing (after 44 minutes).

CONCLUSIONS

The metal containers of candles such as night lights are easily capable of reaching temperatures greater than 60°C when left to burn un-aided and sustaining these temperatures for greater than 30 minutes. If a double wick in introduced to these candles, ignition of the wax can occur in as little as 30 minutes and the candle base can reach temperatures upwards of 300°C in some cases within 1 hour. These temperatures will easily lead to the ignition of materials such as plastics upon which the candles may be placed. Indeed in the case of wooded double wicked candles the casings of modern television sets can be breached in as little as 35 minutes.

These effects are enhanced when the candle is placed in an air flow.

Most (but not all) packages of night lights carry consumer safety warnings with respect to their use but there are no warnings concerning the placement of foreign objects into the candle once it is lit. Such actions represent a significant fire safety risk.

References:

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2. Home Office Statistics, HMSO, 1997.
3. Townsend D., Internal report, London Fire Brigade, Fire Investigation Department, 1999.