

CPSC/ES/TR--98/001

# Assessment of Flammability of Plastic Materials Used As Electrical Appliance Enclosures

---

May 1998



**Hammad A. Malik, P.E.**

Directorate for Engineering Sciences  
Division of Electrical Engineering  
U.S. Consumer Product Safety Commission  
Washington, D.C. 20207

CPSA 6 (b)(1) Cleared

K No Mfr./Priv. lbrs on  
Products Identified

10/13/98  
AB

## Table of Contents

Executive Summary . . . . .	i
Purpose . . . . .	1
Background . . . . .	1
Test Methodology . . . . .	6
Results . . . . .	9
Analysis of Results . . . . .	14
Conclusions . . . . .	15
UL 94HB Test Results . . . . .	Appendix A
UL 94V Test Results . . . . .	Appendix B
UL 746C Flame Test Data . . . . .	Appendix C
UL 746C Flame Application Points . . . . .	Appendix D
Diagram of Test Setup . . . . .	Appendix E

## EXECUTIVE SUMMARY

This report presents the results of a study conducted by the staff of the U.S. Consumer Product Safety Commission (CPSC) of the flammability of plastic materials used as electrical appliance enclosures. The study resulted from a review of national fire data which indicated that electrical product related fires have not followed the same downward trend as all residential structure fires in the United States between 1987 and 1995. Based on this study, recommendations were developed to strengthen the enclosure material flammability requirements contained in the Underwriters Laboratories, Inc. standard UL 746C, "Polymeric Enclosures -- Use in Electrical Equipment Evaluations."

UL 746C is the voluntary standard that deals with the requirements for plastic enclosure materials used in electrical appliances. In some cases, UL 746C permits essentially non-flame retardant plastics to be used as enclosure materials. In 1996, CPSC staff submitted a proposal to UL to eliminate this provision and require the usage of flame retardant plastics as electrical appliance enclosures. This proposal was tabled in favor of further study. Thus, the current study was pursued and appropriate recommendations have been developed.

The testing indicated that the only material that consistently passed the CPSC staff's testing and appeared to provide an acceptable level of safety was plastic that was rated as V-0 in accordance with UL 94, "Test for Flammability of Plastic Materials for Use in Electrical Appliances."

CPSC staff recommends changing UL 746C to require V-0 rated enclosures unless a manufacturer submits the enclosure to more rigorous end-product flame tests, or designs the product such that all internal parts have a V-0 or equivalent rating.

## PURPOSE

The plastics flammability project was initiated by the U.S. Consumer Product Safety Commission (CPSC) staff in 1996 to evaluate the role and performance of plastic enclosures in fires associated with electrical appliances.

## BACKGROUND

Over the last decade, the number of residential fires occurring annually has shown a marked decrease.<sup>1</sup>

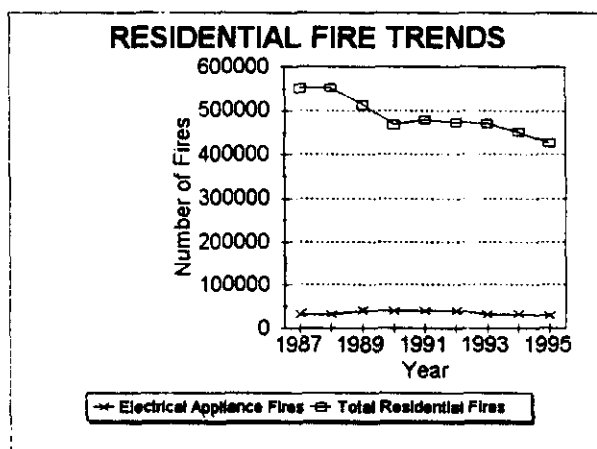


Figure #1

While the residential fire data from 1987 through 1995 shows a definite downward trend in the number of residential fires experienced annually, this same trend is not seen in the number of electrical appliance related fires for the same period. The number of electrical appliance fires remained for the most part at the same level throughout the period. In 1987 there were nearly 31,100 electrical appliance related fires and in 1995 there were around 28,500<sup>2</sup>. See figure #1. In 1987 there were approximately 551,000 residential fires. In 1995 the number of residential fires dropped to near 425,000.

---

<sup>1</sup>Residential Fire Loss Estimates for 1987-1995, U.S. Consumer Product Safety Commission, Directorate for Epidemiology and Health Sciences.

<sup>2</sup> Ibid. Fires for 1987 through 1995 were obtained by adding the fires in portable electric heaters, toaster/toaster ovens, microwaves, coffee makers, deep fat fryers, hot plates, other electrical appliances, and the corresponding portion of the unknowns for each electrical equipment category

Thermoplastics are used extensively by the electrical appliance manufacturing industry. This usage is increasing at a steady rate as shown in Figure #2.<sup>3</sup>

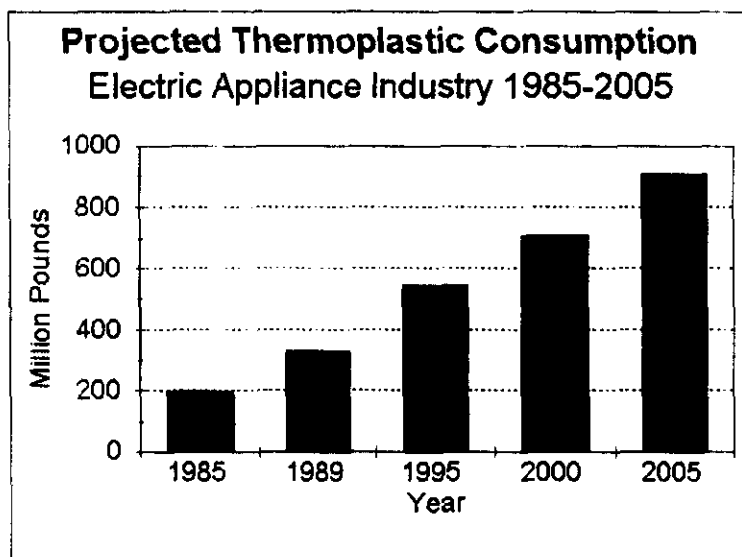


Figure #2

The increasing use of thermoplastics in the electrical appliance industry indicated that a prudent strategy for reducing the number of electrical appliance related fires should involve a careful review of the flammability requirements of thermoplastics used in these appliances.

Whenever an appliance, a lamp, or any electrically powered product receives electricity from a household branch circuit, the amount of energy that can be delivered to this product, especially under the myriad of possible fault conditions, is sufficient to ignite most internal combustible parts. When housed in an enclosure that does not contain the ignition and burning to the confines of the unit or retard the spread of fire, a faulty electrical product can advance from a self-contained mishap to a conflagration involving a room, its contents, and even the building structure itself. The potential for death and injury to the occupants of a building is greatly increased.

Component protective devices within the electrical product can reduce, but not sufficiently eliminate, the risk of fire resulting from electrical failures. For example, a thermal fuse in a motor-operated appliance could offer protection against overloading or stalling the motor, but the fuse would not protect against an overheated switch, connector, lead wire or other electrical part within this product. Even the most basic of electrical components, such as a resistor used for heating, can cause fires when the resistor fails and gets hot enough to ignite the product's flammable housing.

---

<sup>3</sup>Industry Study #765 compiled by the Freedonia Group, Inc., Cleveland, Ohio.

A fundamental approach to addressing fires caused by electrical products is to provide flame retardant housings. While current industry-supported standards require flame retardant housings for several electrical products, such as televisions and computer monitors, these standards are product specific. Major appliance categories, such as heating, cooking, and motor-operated appliances, are not always required to conform to such requirements.

The use of polymeric material, which includes thermoplastics as a subset, in electrically-operated, consumer appliances is evaluated under a voluntary standard published by Underwriters Laboratories, Inc. (UL). The standard is UL 746C, "Polymeric Materials - Use in Electrical Equipment Evaluations." This standard provides guidance on the selection and use of materials in such applications

UL 746C identifies several different flammability ratings of plastic enclosure materials and specifies conditions when the different ratings are required. The flammability ratings are described in another UL standard, UL 94, "Test for Flammability of Plastic Materials for Parts in Devices and Appliances". Flammability ratings of materials give an indication of how the material will behave when exposed to flame. This standard includes tests for plastic materials in two different orientations, vertical (V) and horizontal burn (HB). A passing result for a material tested in the horizontal orientation earns a flammability rating of HB. This rating gives an indication of the burning rate for materials that do not exhibit flame retardant characteristics. Material tested in the vertical configuration can achieve three different levels of flame retardancy. These levels give an indication of the plastic's ability to extinguish flame, thus resisting propagating fire. These levels are V-0, V-1, and V-2, with V-0 indicating the highest level of flame resistance.

UL 746C also contains end-product flame tests. These tests consist of applying a flame to the enclosures of appliances that are in their final production configuration. Flame is applied to areas of the enclosure that are likely to be exposed to flame due to internal electrical failures. These tests are intended to determine if a given appliance is likely to cause flame to propagate beyond the confines of its enclosure. They are considered alternative measures of flammability, in place of flame resistance levels (HB, V-2, V-1, and V-0) assigned in accordance with UL 94 by the manufacturer of the plastic.

Portable cord-connected products with enclosures that contain only electrically insulated parts, and any electrical product designed for attended, intermittent household use are permitted to use enclosures that are not flame retardant per the voluntary standard UL 746C. Once ignited, these non-flame retardant housings typically burn, some with flaming drips, until the housing is completely consumed. Fire can spread to other household materials in the process.

An argument could be made that products that normally involve user attendance during their intermittent operation (such as a can opener, electric shaver, curling iron, etc.) would not need a flame retardant enclosure since the user should be present to respond to an electrical fire situation inside the product, should one develop. However, this logic is not considered valid given the field experience data. A plug-connected product may be left with the plug inserted

into an outlet in a standby mode, but still may experience a mechanical or electrical power switch failure that could energize the unit and overheat some component within its housing while no one is around to interrupt the event before a fire ensues. The numerous potential failure modes within electrical products that could potentially result in a fire indicate that a minimum flame retardancy for product enclosures that receive power from the household electrical supply is needed.

Figure 5.1 is one of the sections in UL 746C that determines the minimum flammability rating requirement for an enclosure of an electrical appliance, based on whether or not the internal electrical parts are insulated. Currently, Figure 5.1 of UL 746C draws a distinction between appliances that have internal electrical parts insulated to a thickness of 0.71mm or more and insulation of a thickness less than 0.71mm. For appliances with internal parts insulated with a thickness of 0.71mm or more, the appliance enclosure material is permitted to be an HB rated plastic. Otherwise, the plastic enclosure material is required to have a V rating as per UL 94.

Since late 1994, CPSC staff has worked with UL providing product failure data to support UL's review of its materials evaluation and end-product standards. In July 1996, CPSC staff proposed a change to UL 746C which would further limit the use of non-flame resistant types of thermoplastics for appliance enclosures. The 1996 CPSC staff proposal was to eliminate criteria involving insulation thickness. This change would require all unattended portable household appliances to have V rated enclosures. The proposed change is shown in Figure #3 which is from Figure 5.1 in UL 746C. The hatched portions represent the CPSC staff's proposed deletion. The proposal was tabled by UL in favor of further study. In response to these tabled recommendations, UL formed an ad-hoc group to address the CPSC staff's concerns with the flammability requirements of thermoplastic enclosures.

In early 1997, the CPSC staff undertook a project to perform further study of the plastics flammability issue. This project reviewed the flammability requirements in UL 746C, measured the performance of plastic specimens taken from actual end-products when tested similar to UL 94, and evaluated how actual end-products performed when subjected to flame consistent with the UL 746C flame tests. Based on the results of the study, CPSC staff formulated recommendations for changes to UL 746C. This report includes the test methodology, test procedure, results, and recommendations.

CPSC/ES/TR--98/001

# Assessment of Flammability of Plastic Materials Used As Electrical Appliance Enclosures

---

May 1998



**Hammad A. Malik, P.E.**

Directorate for Engineering Sciences  
Division of Electrical Engineering  
U.S. Consumer Product Safety Commission  
Washington, D.C. 20207

CPSA 6 (b)(1) Cleared

*K* No Mfr./Privileg on  
Products Identified

10/13/98  
*[Signature]*



## EXECUTIVE SUMMARY

This report presents the results of a study conducted by the staff of the U.S. Consumer Product Safety Commission (CPSC) of the flammability of plastic materials used as electrical appliance enclosures. The study resulted from a review of national fire data which indicated that electrical product related fires have not followed the same downward trend as all residential structure fires in the United States between 1987 and 1995. Based on this study, recommendations were developed to strengthen the enclosure material flammability requirements contained in the Underwriters Laboratories, Inc. standard UL 746C, "Polymeric Enclosures -- Use in Electrical Equipment Evaluations."

UL 746C is the voluntary standard that deals with the requirements for plastic enclosure materials used in electrical appliances. In some cases, UL 746C permits essentially non-flame retardant plastics to be used as enclosure materials. In 1996, CPSC staff submitted a proposal to UL to eliminate this provision and require the usage of flame retardant plastics as electrical appliance enclosures. This proposal was tabled in favor of further study. Thus, the current study was pursued and appropriate recommendations have been developed.

The testing indicated that the only material that consistently passed the CPSC staff's testing and appeared to provide an acceptable level of safety was plastic that was rated as V-0 in accordance with UL 94, "Test for Flammability of Plastic Materials for Use in Electrical Appliances."

CPSC staff recommends changing UL 746C to require V-0 rated enclosures unless a manufacturer submits the enclosure to more rigorous end-product flame tests, or designs the product such that all internal parts have a V-0 or equivalent rating.

CPSC/ES/TR--98/001

# Assessment of Flammability of Plastic Materials Used As Electrical Appliance Enclosures

---

May 1998



**Hammad A. Malik, P.E.**

Directorate for Engineering Sciences  
Division of Electrical Engineering  
U.S. Consumer Product Safety Commission  
Washington, D.C. 20207

CPSA 6 (b)(1) Cleared

No Mfr/Privtlbrs on  
Products Identified

10/13/98  
EB

## Table of Contents

Executive Summary	i
Purpose	1
Background	1
Test Methodology	6
Results	9
Analysis of Results	14
Conclusions	15
UL 94HB Test Results	Appendix A
UL 94V Test Results	Appendix B
UL 746C Flame Test Data	Appendix C
UL 746C Flame Application Points	Appendix D
Diagram of Test Setup	Appendix E

## EXECUTIVE SUMMARY

This report presents the results of a study conducted by the staff of the U.S. Consumer Product Safety Commission (CPSC) of the flammability of plastic materials used as electrical appliance enclosures. The study resulted from a review of national fire data which indicated that electrical product related fires have not followed the same downward trend as all residential structure fires in the United States between 1987 and 1995. Based on this study, recommendations were developed to strengthen the enclosure material flammability requirements contained in the Underwriters Laboratories, Inc. standard UL 746C, "Polymeric Enclosures -- Use in Electrical Equipment Evaluations."

UL 746C is the voluntary standard that deals with the requirements for plastic enclosure materials used in electrical appliances. In some cases, UL 746C permits essentially non-flame retardant plastics to be used as enclosure materials. In 1996, CPSC staff submitted a proposal to UL to eliminate this provision and require the usage of flame retardant plastics as electrical appliance enclosures. This proposal was tabled in favor of further study. Thus, the current study was pursued and appropriate recommendations have been developed.

The testing indicated that the only material that consistently passed the CPSC staff's testing and appeared to provide an acceptable level of safety was plastic that was rated as V-0 in accordance with UL 94, "Test for Flammability of Plastic Materials for Use in Electrical Appliances."

CPSC staff recommends changing UL 746C to require V-0 rated enclosures unless a manufacturer submits the enclosure to more rigorous end-product flame tests, or designs the product such that all internal parts have a V-0 or equivalent rating.

## PURPOSE

The plastics flammability project was initiated by the U.S. Consumer Product Safety Commission (CPSC) staff in 1996 to evaluate the role and performance of plastic enclosures in fires associated with electrical appliances.

## BACKGROUND

Over the last decade, the number of residential fires occurring annually has shown a marked decrease.<sup>1</sup>

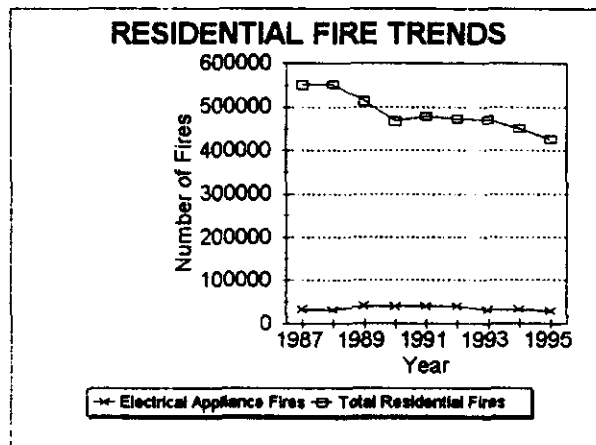


Figure #1

While the residential fire data from 1987 through 1995 shows a definite downward trend in the number of residential fires experienced annually, this same trend is not seen in the number of electrical appliance related fires for the same period. The number of electrical appliance fires remained for the most part at the same level throughout the period. In 1987 there were nearly 31,100 electrical appliance related fires and in 1995 there were around 28,500<sup>2</sup>. See figure #1. In 1987 there were approximately 551,000 residential fires. In 1995 the number of residential fires dropped to near 425,000.

---

<sup>1</sup>Residential Fire Loss Estimates for 1987-1995, U.S. Consumer Product Safety Commission, Directorate for Epidemiology and Health Sciences.

<sup>2</sup> Ibid. Fires for 1987 through 1995 were obtained by adding the fires in portable electric heaters, toaster/toaster ovens, microwaves, coffee makers, deep fat fryers, hot plates, other electrical appliances, and the corresponding portion of the unknowns for each electrical equipment category

Thermoplastics are used extensively by the electrical appliance manufacturing industry. This usage is increasing at a steady rate as shown in Figure #2.<sup>3</sup>

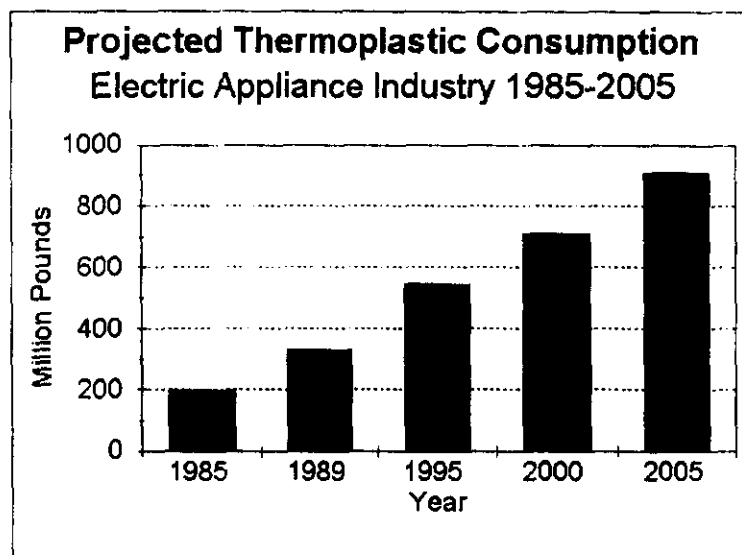


Figure #2

The increasing use of thermoplastics in the electrical appliance industry indicated that a prudent strategy for reducing the number of electrical appliance related fires should involve a careful review of the flammability requirements of thermoplastics used in these appliances.

Whenever an appliance, a lamp, or any electrically powered product receives electricity from a household branch circuit, the amount of energy that can be delivered to this product, especially under the myriad of possible fault conditions, is sufficient to ignite most internal combustible parts. When housed in an enclosure that does not contain the ignition and burning to the confines of the unit or retard the spread of fire, a faulty electrical product can advance from a self-contained mishap to a conflagration involving a room, its contents, and even the building structure itself. The potential for death and injury to the occupants of a building is greatly increased.

Component protective devices within the electrical product can reduce, but not sufficiently eliminate, the risk of fire resulting from electrical failures. For example, a thermal fuse in a motor-operated appliance could offer protection against overloading or stalling the motor, but the fuse would not protect against an overheated switch, connector, lead wire or other electrical part within this product. Even the most basic of electrical components, such as a resistor used for heating, can cause fires when the resistor fails and gets hot enough to ignite the product's flammable housing.

---

<sup>3</sup>Industry Study #765 compiled by the Freedonia Group, Inc., Cleveland, Ohio.

A fundamental approach to addressing fires caused by electrical products is to provide flame retardant housings. While current industry-supported standards require flame retardant housings for several electrical products, such as televisions and computer monitors, these standards are product specific. Major appliance categories, such as heating, cooking, and motor-operated appliances, are not always required to conform to such requirements.

The use of polymeric material, which includes thermoplastics as a subset, in electrically-operated, consumer appliances is evaluated under a voluntary standard published by Underwriters Laboratories, Inc. (UL). The standard is UL 746C, "Polymeric Materials - Use in Electrical Equipment Evaluations." This standard provides guidance on the selection and use of materials in such applications

UL 746C identifies several different flammability ratings of plastic enclosure materials and specifies conditions when the different ratings are required. The flammability ratings are described in another UL standard, UL 94, "Test for Flammability of Plastic Materials for Parts in Devices and Appliances". Flammability ratings of materials give an indication of how the material will behave when exposed to flame. This standard includes tests for plastic materials in two different orientations, vertical (V) and horizontal burn (HB). A passing result for a material tested in the horizontal orientation earns a flammability rating of HB. This rating gives an indication of the burning rate for materials that do not exhibit flame retardant characteristics. Material tested in the vertical configuration can achieve three different levels of flame retardancy. These levels give an indication of the plastic's ability to extinguish flame, thus resisting propagating fire. These levels are V-0, V-1, and V-2, with V-0 indicating the highest level of flame resistance.

UL 746C also contains end-product flame tests. These tests consist of applying a flame to the enclosures of appliances that are in their final production configuration. Flame is applied to areas of the enclosure that are likely to be exposed to flame due to internal electrical failures. These tests are intended to determine if a given appliance is likely to cause flame to propagate beyond the confines of its enclosure. They are considered alternative measures of flammability, in place of flame resistance levels (HB, V-2, V-1, and V-0) assigned in accordance with UL 94 by the manufacturer of the plastic.

Portable cord-connected products with enclosures that contain only electrically insulated parts, and any electrical product designed for attended, intermittent household use are permitted to use enclosures that are not flame retardant per the voluntary standard UL 746C. Once ignited, these non-flame retardant housings typically burn, some with flaming drips, until the housing is completely consumed. Fire can spread to other household materials in the process.

An argument could be made that products that normally involve user attendance during their intermittent operation (such as a can opener, electric shaver, curling iron, etc.) would not need a flame retardant enclosure since the user should be present to respond to an electrical fire situation inside the product, should one develop. However, this logic is not considered valid given the field experience data. A plug-connected product may be left with the plug inserted

into an outlet in a standby mode, but still may experience a mechanical or electrical power switch failure that could energize the unit and overheat some component within its housing while no one is around to interrupt the event before a fire ensues. The numerous potential failure modes within electrical products that could potentially result in a fire indicate that a minimum flame retardancy for product enclosures that receive power from the household electrical supply is needed.

Figure 5.1 is one of the sections in UL 746C that determines the minimum flammability rating requirement for an enclosure of an electrical appliance, based on whether or not the internal electrical parts are insulated. Currently, Figure 5.1 of UL 746C draws a distinction between appliances that have internal electrical parts insulated to a thickness of 0.71mm or more and insulation of a thickness less than 0.71mm. For appliances with internal parts insulated with a thickness of 0.71mm or more, the appliance enclosure material is permitted to be an HB rated plastic. Otherwise, the plastic enclosure material is required to have a V rating as per UL 94.

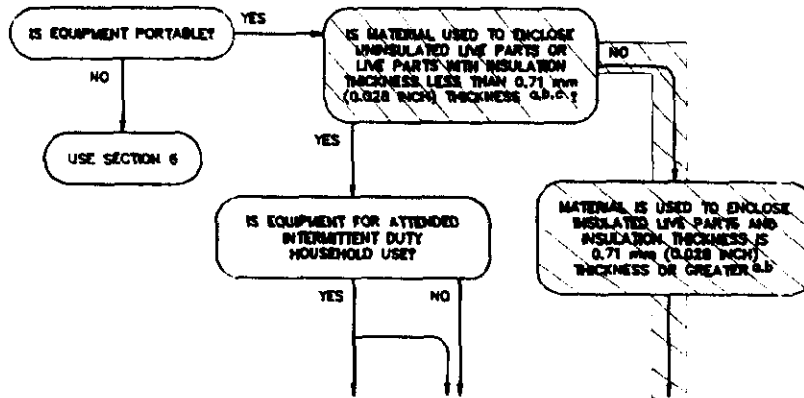
Since late 1994, CPSC staff has worked with UL providing product failure data to support UL's review of its materials evaluation and end-product standards. In July 1996, CPSC staff proposed a change to UL 746C which would further limit the use of non-flame resistant types of thermoplastics for appliance enclosures. The 1996 CPSC staff proposal was to eliminate criteria involving insulation thickness. This change would require all unattended portable household appliances to have V rated enclosures. The proposed change is shown in Figure #3 which is from Figure 5.1 in UL 746C. The hatched portions represent the CPSC staff's proposed deletion. The proposal was tabled by UL in favor of further study. In response to these tabled recommendations, UL formed an ad-hoc group to address the CPSC staff's concerns with the flammability requirements of thermoplastic enclosures.

In early 1997, the CPSC staff undertook a project to perform further study of the plastics flammability issue. This project reviewed the flammability requirements in UL 746C, measured the performance of plastic specimens taken from actual end-products when tested similar to UL 94, and evaluated how actual end-products performed when subjected to flame consistent with the UL 746C flame tests. Based on the results of the study, CPSC staff formulated recommendations for changes to UL 746C. This report includes the test methodology, test procedure, results, and recommendations.



Figure 5.1  
Enclosure requirements for portable appliances

Part 1 - Conditions of use



Part 2 - Applicable requirements

Minimum flammability rating	94HB	94V <sup>0,1</sup>	94HB or 94V <sup>0,1</sup>
Electrical/Mechanical Properties per Table 8.1	Yes	Yes	Yes
Hot-Wire Ignition per Hot-Wire Ignition (HWI) - Abnormal Overload Test, Section 14	Max PLC of 4	Max PLC of 4 <sup>9</sup>	No
Impact Test per Resistance to Impact, Section 24	Yes	Yes	Yes
Abnormal Operation Test per 28.1	Yes	Yes	Yes
Severe Conditions Test per 29.1	Yes	No	No
Mold-Stress Relief Distortion per: A. 32.1 B. 32.2	No Yes	Yes No	Yes No
Input after Mold-Stress Relief Distortion per 31.1	Yes	No	No
Strain Relief Test per 32.1 <sup>d</sup>	Yes	Yes	Yes
Thermal Endurance per Sections 33 - 39	Yes	Yes	Yes
Volume Resistivity per Volume Resistivity, Section 16	Yes	Yes	No

534688

(Continued)

Figure #3

Note: Figure 5.1 from UL 746C has been reproduced with the permission of Underwriters Laboratories. The hatched areas illustrate the CPSC staff proposal from December of 1996.

## TEST METHODOLOGY

This section describes the CPSC test methodology used to support recommendations for UL on the use of plastic enclosures for portable electrical appliances. The sample selection criteria and test approach are presented.

### Sample Selection:

Over 300 field incident investigations involving electrical portable household appliances were reviewed from the CPSC files. From these 300 incidents, six products were selected. The six were selected based on the following criteria: did a failure in the appliance cause a fire, or would the incident have resulted in a fire had the user not been present to take immediate action. The products that met the criteria were two portable oscillating fans, a portable electric heater, a car battery charger, a toaster, and a telephone answering machine. Samples of an identical make and model of the appliances involved in the six selected incidents were procured from the marketplace.

Specimens from each sample were cut, conditioned, and tested to simulate UL 94 testing. Whole samples were conditioned and tested per the UL 746C end-product flame tests. These tests were performed to gain an understanding of the flammability of the enclosure materials relative to the flammability rating assigned to the same materials by the material manufacturer.

### Test Method:

Step 1: Obtained flammability ratings for the enclosure materials of the sample products from UL when available or inferred them based on the requirements of UL 746C and condition samples in accordance with relevant standards.

#### A. Specimen Preparation for UL 94 HB:

For appliances that had HB rated enclosures, 12 specimens were cut from each appliance type from the largest, flattest, and smoothest sections of the thermoplastic enclosure. Specimen numbers were assigned to each piece and the product sample number was recorded. Specimens were cut as close as possible to meet the size and condition requirements as stated in UL 94 given the inherent difficulties with cutting plastic from finished appliances. Six specimens were conditioned in accordance with UL 94. The remaining specimens were labeled with the specimen number and sent to UL for comparison testing.

#### B. Specimen Preparation for UL 94V:

For appliances that had V rated enclosures, 40 specimens were cut from each appliance type from the largest, flattest, and smoothest sections of the thermoplastic enclosure. Specimen

numbers were assigned to each piece and the product sample number was recorded. Specimens were cut as close as possible to meet the size and condition requirements as stated in UL 94, given the inherent difficulties with cutting plastic from finished appliances. Twenty specimens were conditioned in accordance with UL 94. The remaining specimens were labeled with the specimen number and sent to UL for comparison testing.

- Step 2: Six of the specimens from each appliance category with HB rated enclosures were tested in accordance with the UL 94 HB test.
- Step 2A: Twenty of the specimens from each appliance category with V rated enclosures were tested in accordance with the UL 94 V test.
- Step 3: The UL 746C 12mm flame test was performed on all of the product samples.
- Step 3A: The UL 746C 3/4 inch flame test was performed on all of the product samples.

Note: The UL 746C 12mm flame test and the UL 746C 3/4 inch flame test are considered to be equivalent by UL.<sup>4</sup>

Appendix E is a diagram of the CPSC test setup. This setup was similar to that described in UL 94 and UL 746C. The CPSC test setup was composed of a standard laboratory hood with forced exhaust. Two armholes were cut out of a sheet of Plexiglass that was of equal width to the Plexiglass sliding front door of the hood. These armholes had layers of neoprene with "X"s cut into them bolted in place to cover the holes. The piece of Plexiglass was inserted beneath the sliding front door of the hood. Pieces of duct tape were placed along the edges of the plexiglass. This formed an essentially draft-free enclosure. The layers of neoprene prevented drafts from entering the enclosure while allowing a hand to be inserted to perform testing.

---

\* A sufficient number of answering machines were not available to perform this test.

<sup>4</sup> Verbal communication by Don Talka, U.L. Melville, during February 11, 1998 Plastics Flammability Ad-Hoc Committee meeting held at U.L. Research Triangle Park, N.C.

As shown in Appendix E, the gas supply consisted of a gas cylinder with regulator, connected to a shutoff valve, connected to a flowmeter, connected to a manometer, leading to a burner. For both UL 94 and UL 746C 3/4" end-product flame tests, the gas supply was methane and the burner was a Tirrell Burner. For the 12 mm end-product flame test, the gas supply was butane and the burner was a small hypodermic needle.

The points of flame application in the CPSC testing varied from those that UL typically uses. CPSC selected these points based on the location of failures determined by the incident investigations. These included switch failures, wire connection failures, etc. The flame application points selected by CPSC staff were not the same as the UL flame application points.<sup>5</sup>

---

<sup>5</sup> Verbally indicated by Don Talka, U.L. Melville, during February 11, 1998 Plastics Flammability Ad-Hoc Committee meeting held at U.L. Research Triangle Park, N.C.

## RESULTS

Tables 1 through 4 summarize the results of the UL 94 and UL 746C testing conducted by the CPSC staff. A unique sample number, 97-595-9009-XX for example, was assigned to each specific model of a product. The suffix XX is a unique number that separately identified each appliance of the same model. For example, 97-595-9009 referenced a particular model of car battery charger. Six of this particular model were procured. Each one of these had the same basic sample number with unique suffixes of 01 through 06.

Appendices A and B contain the detailed test results for UL 94 testing which are recorded on standard UL 94 data forms. Appendix C contains the detailed test results for UL 746C testing. Any blank spaces on these forms indicate that the information was not relevant or applicable in the context of the CPSC staff tests.

Table 1 summarizes the results of the UL 94 HB tests, performed on specimens taken from portions of the toaster and two fan models, that were either identified by UL as HB or inferred as being HB by the requirements of UL 746C. Six specimens were cut from each sample and tested in accordance with UL 94. A failing result means that the specimen exhibited a burn rate that exceeded 40mm/minute. A passing result means that the specimen exhibited a burn rate of less than 40mm/minute.

TABLE 1 SUMMARY OF UL 94HB TEST RESULTS

Product Type	Sample No.	Specimen No.	Pass/Fail
Toaster	97-595-9006-01	E7-E9	Pass
		E13-E15	Pass
Fan	97-595-9007-01	E1-E3	Pass
Fan	97-595-9007-03	B1-B3	Pass
		B4-B6	Pass
		E1-E3	Pass
Fan	97-595-9007-06	B7-B9	Pass
		B10-B12	Pass
Fan	97-595-9008-01	E7-E9	Fail
		E1-E3	Fail
		E4	Fail

Table 2 summarizes the results of the UL 94 V tests, performed on specimens taken from the portions of a portable electric heater and a car battery charger, that were either identified by UL as V rated or inferred as being V rated by the requirements of UL 746C. Ten specimens were cut from each sample and tested in accordance with UL 94. A V-2, V-1, or V-0 rating is defined as shown in Figure 4:

Criteria Conditions	V-0	V-1	V-2
Afterflame time for each individual specimen ( $t_1$ or $t_2$ )	$\leq 10s$	$\leq 30s$	$\leq 30s$
Total afterflame time for any condition set ( $t_1$ plus $t_2$ for the 5 specimens)	$\leq 50s$	$\leq 250s$	$\leq 250s$
Afterflame plus afterglow time for each individual specimen after the second flame application ( $t_2 + t_3$ )	$\leq 30s$	$\leq 60s$	$\leq 60s$
Afterflame or afterglow of any specimen up to the holding clamp	No	No	No
Cotton indicator ignited by flaming particles or drops	No	No	Yes

Figure 4

A failing result was when a specimen failed to meet any of the criteria. The answering machine was neither tested to UL 94 HB or V. This is because both tests require a 5" by 1/2" specimen. The answering machine enclosure size was not large enough to give the requisite specimen size.

TABLE 2 SUMMARY OF UL 94V TEST RESULTS

Product Type	Sample No.	Specimen No.	Test Result	UI Rating
Portable Heater	97-595-9004-04	F1-F5	Fail	94V-2
		F6-F10	Fail	94V-2
		B11-B15	94V-0	94V-0
		B16-B20	94V-0	94V-0
		B1-B5	94V-0	94V-0
		B6-B10	94V-0	94V-0
	97-595-9004-09	F1-F5	94V-2	94V-2
		F6-F10	94V-2	94V-2
		B11-B15	94V-2	94V-0
		B16-B20	94V-0	94V-0
		B1-B5	94V-2	94V-0
		B6-B10	94V-2	94V-0
Car Battery Charger	97-595-9009-04	E1-E5	Fail	94V-2
		E6-E10	Fail	94V-2
		E11-E15	Fail	94V-2
		E16-E20	Fail	94V-2
	97-595-9009-06	E11-E15	Fail	94V-2
		E16-E20	Fail	94V-2

Table 3 summarizes the results of the UL 746C 12mm end-product flame tests, performed on specimens taken from portions of a portable heater, toaster, car battery charger, telephone answering machine, and fan. The samples were tested in accordance with UL 746C. A failing result means that the specimen sustained ignition for 60 seconds after two 30 second applications of a 12mm butane flame with an interval of one minute between each application. Appendix C contains the complete test results. The 12mm end-product flame test was not performed on one of the fans due to a lack of sufficient samples to perform both the 3/4" and 12mm end-product flame tests. The rating of the enclosure was either provided by UL based on the UL test report for the particular model or was inferred based on the requirements of UL 746C.

TABLE 3 SUMMARY OF UL 746C 12 MM END-PRODUCT FLAME TEST RESULTS

Product Type	Sample No.	Pass/Fail	UL 94 Rating of Enclosure
Portable Heater	97-595-9004-05	Pass	V-0 and V-2
Toaster	97-595-9005-01	Fail	HB
	97-595-9005-02	Fail	HB
Car Battery Charger	97-595-9009-02	Fail	V-2
Telephone Answering Machine	97-595-9003-01	Pass	V-0
	97-595-9003-05	Pass	V-0
	97-595-9003-02	Pass	V-0
Fan	97-595-9008-07	Fail	V-2 and HB
	97-595-9008-09	Fail	V-2 and HB
	97-595-9008-10	Fail	V-2 and HB
	97-595-9008-08	Fail	V-2 and HB



Table 4 summarizes the results of the UL 746C 3/4 inch end-product flame tests, performed on specimens taken from the portions of two fans, a portable heater, toaster, and car battery charger. The samples were tested in accordance with UL 746C. A failing result means that the specimen sustained ignition for 60 seconds after two 30 second applications of a 3/4 inch methane flame with an interval of one minute between each application. Appendix C contains the complete test results. The 3/4 inch flame test was not performed on the answering machine due to an insufficient number of samples being available to perform both the 12mm and 3/4 inch flame test.

TABLE 4 SUMMARY OF UL 746C 3/4 INCH END-PRODUCT FLAME TEST RESULTS

Product Type	Sample No.	Pass/Fail	UL 94 Rating of Enclosure
Fan	97-595-9008-03	Fail	V-2 and HB
	97-595-9008-05	Fail	V-2 and HB
	97-595-9008-04	Fail	V-2 and HB
	97-595-9008-06	Fail	V-2 and HB
Fan	97-595-9007-08	Fail	V-2 and HB
	97-595-9007-09	Fail	V-2 and HB
	97-595-9007-07	Fail	V-2 and HB
Portable Heater	97-595-9004-06	Pass	V-2 and V-0
Toaster	97-595-9005-04	Fail	HB
	97-595-9005-03	Fail	HB
Car Battery Charger	97-595-9009-03	Fail	V-2
	97-595-9009-01	Fail	V-2

## ANALYSIS OF RESULTS

This section reviews the information provided in Tables 1 through 4. The data were analyzed to determine whether the flammability ratings of specimens taken from end-products coincide with those of the same plastic when classified in the form of bar samples by the plastic material manufacturer. An analysis was also made of the test results of the modified UL 746C end-product flame tests as conducted by the CPSC staff.

The specimens obtained from enclosures rated as HB materials passed the UL 94HB tests with a few exceptions. These exceptions involved borderline failures. Due to the inherent roughness of specimens cut from end-product enclosures and variations between the CPSC and UL test setups, the borderline failures are viewed as not significant. These results indicate that plastic material that passes the requirements for an HB rating for the plastic material manufacturer continues to pass these requirements when molded and utilized in an end-product.

The specimens rated V-0 by the plastic material manufacturer performed as V-0 plastics in the CPSC testing, with the exception of a few that performed as V-2 plastics. All of the specimens that had a rating of V-2 by the plastic material manufacturers did not pass the V-2 test by a significant margin when the test was performed by CPSC staff. These failures were not borderline failures. The test data demonstrate that a V-0 rated thermoplastic provides consistency between the performance of the material as classified by the plastic material manufacturer and the same material when used in an end-product configuration.

Samples that had enclosures made of plastics rated as V-0 consistently passed both the 12 mm and 3/4 inch flame tests. Samples with enclosures made of a combination of parts using V-0 and V-2 rated plastics also consistently passed these end-product flame tests. Samples with enclosures that were made of V-2, a combination of parts using HB and V-2, or only HB rated plastics consistently failed the end-product flame tests. Appendix D identifies the specific points of flame application. These results indicated that V-0 materials were the only enclosure materials that passed the UL 746C end-product flame tests as performed by the CPSC staff.

## CONCLUSIONS

The reviewed incident information and test data collected as part of this project demonstrate that the current method of polymeric enclosure material selection for electrical products does not provide the level of fire resistance necessary for containing electrical failures. Specimens cut from appliance enclosures and tested by CPSC staff in accordance with UL 94 test methods performed worse in many cases than the flammability rating assigned by the plastic material manufacturer and UL would indicate. In addition, except for appliances with V-0 rated enclosures, appliances failed the UL 746C end-product flame test when flame was applied proximate to wiring connections and areas where wire fatigue could result in ignition.

Based on the results of the testing and analysis the following conclusions are drawn:

1. Figure 5.1 of UL 746C indicates that the level of flammability of an electrical product enclosure is dependent on whether a product is considered to be attended or unattended. The definitions of these terms are sufficiently vague to allow appliances such as toasters, flatirons, etc. to be considered attended use products. The standard assumes that the user can take action in the event of a fire and, therefore, relatively flammable (HB rated) enclosures are permitted. In reality, based on incident data, users of toasters, flatirons, etc. sometimes leave the appliance unattended during normal operation. This could conceivably occur when the user answers a phone or door bell, etc. The definitions of unattended and attended appliances need to be either eliminated all together or improved so that only appliances where it is highly unlikely they will be left energized in an unattended state are considered as attended use.
2. UL 746C specifies that in the performance of the end-product flame tests, the flame is to be applied to the appliance enclosure areas that are most likely to be exposed to an ignition source due to an internal electrical fault. This requirement needs additional specificity so that it identifies locations where internal faults have been identified in incident data. The CPSC test data indicate that some appliances fail UL 746C end-product flame tests when flame application locations are consistent with information obtained from the CPSC incident files. These locations included plastic surfaces adjacent to wire splice connections and wire flexure points. V-0 rated enclosure material was the only material that consistently did not sustain ignition when subjected to the UL 746C end-product flame tests when applied at these locations. A provision could be included in UL 746C that requires that V-0 rated enclosure material be used unless the enclosure passes a more rigorous UL 746C end-product flame test that recognizes wire connections, switches, and wire fatigue failures as potential sources of ignition, or all internal insulation, plastic, etc. are made of a material that has a V-0 or equivalent rating.
3. Both insulated and uninsulated internal electrical components, except those made of V-0 or equivalent flammability rated materials, should be considered as potential sources of ignition when determining the required minimum flammability rating for enclosure materials.

APPENDIX A  
UL 94 HB TEST RESULTS

FILE NO: \_\_\_\_\_

PROJECT NO: 21660

LAB JOB NO: \_\_\_\_\_

SAMPLE: **97-595-9006-01****UL 94 HORIZONTAL BURNING TEST FOR CLASSIFYING MATERIALS 94HB****METHOD**

Specimens were conditioned for at least 48h at 23±2°C and 50±5% RH and then tested in accordance with UL 94, Fifth Edition Room conditions during testing were maintained at 25±10°C and 60±15% RH

**RESULTS**

SPECIMEN NO.	THICKNESS mm	BURNING BEYOND 25 mm		See Note	BURNING RATE V=60L/t mm/min	PASS/ FAIL
		Time, t s	Damaged Length, L mm			
Material:				Color:		
E7		147	75	( )	30.6122	PASS
E8		151	75	( )	29.8015	PASS
E9		148	75	( )	30.4054	PASS
Material:				Color:		
E10		153	75	( )	29.4118	PASS
E11		150	75	( )	30.0000	PASS
E12		124	75	( )	36.2903	PASS
Material:				Color:		
E13		146	75	( )	30.8219	PASS
E14		153	75	( )	29.4118	PASS
E15		148	75	( )	30.4054	PASS

(1) Ceased to burn before the 100mm reference mark and rate is determined. (may exceed limits)

(2) Ceased to burn before the 25mm reference mark and rate is not determined.

(3) Notes: \_\_\_\_\_

TESTED BY: HAMMAD A. MALIKSIGNATURE: DATE: 12/8/97

94hb(12-1-95)

FILE NO: \_\_\_\_\_

PROJECT NO: 21660

LAB JOB NO: \_\_\_\_\_

SAMPLE: **97-595-9007-01**

**UL 94 HORIZONTAL BURNING TEST FOR CLASSIFYING MATERIALS 94HB**

**METHOD**

Specimens were conditioned for at least 48h at 23±2°C and 50±5% RH and then tested in accordance with UL 94, Fifth Edition Room conditions during testing were maintained at 25±10°C and 60±15% RH

**RESULTS**

SPECIMEN NO.	THICKNESS mm	BURNING BEYOND 25 mm		See Note	BURNING RATE V=60L/t mm/min	PASS/ FAIL
		Time, t s	Damaged Length, L mm			
Material:				Color:		
E1		216	75	( )	20.8335	PASS
E2		195	75	( )	23.0769	PASS
E3		203	75	( )	22.1675	PASS

- (1) Ceased to burn before the 100mm reference mark and rate is determined. (may exceed limits)
- (2) Ceased to burn before the 25mm reference mark and rate is not determined.
- (3) Notes: \_\_\_\_\_

TESTED BY: HAMMAD A. MALIK

SIGNATURE: *H. Malik* DATE: 12/11/97

FILE NO: \_\_\_\_\_

PROJECT NO: 21660

LAB JOB NO: \_\_\_\_\_

SAMPLE: **97-595-9007-03****UL 94 HORIZONTAL BURNING TEST FOR CLASSIFYING MATERIALS 94HB****METHOD**

Specimens were conditioned for at least 48h at 23±2°C and 50±5% RH and then tested in accordance with UL 94, Fifth Edition Room conditions during testing were maintained at 25±10°C and 60±15% RH

**RESULTS**

SPECIMEN NO.	THICKNESS mm	BURNING BEYOND 25 mm		See Note	BURNING RATE V=60L/t mm/min	PASS/ FAIL
		Time, t s	Damaged Length, L mm			
Material:		Color:				
B1		119	75	( )	37.8151	PASS
B2		121	75	( )	37.1901	PASS
B3		132	75	( )	34.0909	PASS
Material:		Color:				
B4		120	75	( )	37.5000	PASS
B5		118	75	( )	38.1356	PASS
B6		117	75	( )	38.4615	PASS

- (1) Ceased to burn before the 100mm reference mark and rate is determined. (may exceed limits)  
 (2) Ceased to burn before the 25mm reference mark and rate is not determined.  
 (3) Notes: \_\_\_\_\_

TESTED BY: HAMMAD A. MALIKSIGNATURE: *H. Malik*DATE: 12/9/97

94hb(12-1-95)

FILE NO: \_\_\_\_\_

PROJECT NO: 21660

LAB JOB NO: \_\_\_\_\_

SAMPLE: **97-595-9007-03****UL 94 HORIZONTAL BURNING TEST FOR CLASSIFYING MATERIALS 94HB****METHOD**

Specimens were conditioned for at least 48h at 23±2°C and 50±5% RH and then tested in accordance with UL 94, Fifth Edition Room conditions during testing were maintained at 25±10°C and 60±15% RH

**RESULTS**

SPECIMEN NO.	THICKNESS mm	BURNING BEYOND 25 mm		See Note	BURNING RATE V=60L/t mm/min	PASS/ FAIL
		Time, t s	Damaged Length, L mm			
Material:		Color:				
E1		164	75	( )	27.4390	PASS
E2		166	75	( )	27.1084	PASS
E3		176	75	( )	25.5682	PASS

- (1) Ceased to burn before the 100mm reference mark and rate is determined. (may exceed limits)  
 (2) Ceased to burn before the 25mm reference mark and rate is not determined.  
 (3) Notes: \_\_\_\_\_

TESTED BY: HAMMAD A. MALIK

SIGNATURE: H. Malik

DATE: 12/11/97

94hb(12-1-95)



FILE NO: \_\_\_\_\_

PROJECT NO: 21660

LAB JOB NO: \_\_\_\_\_

SAMPLE: **97-595-9007-06****UL 94 HORIZONTAL BURNING TEST FOR CLASSIFYING MATERIALS 94HB****METHOD**

Specimens were conditioned for at least 48h at 23±2°C and 50±5% RH and then tested in accordance with UL 94, Fifth Edition Room conditions during testing were maintained at 25±10°C and 60±15% RH

**RESULTS**

SPECIMEN NO.	THICKNESS mm	BURNING BEYOND 25 mm		See Note	BURNING RATE V=60L/t mm/min	PASS/ FAIL
		Time, t s	Damaged Length, L mm			
Material:				Color:		
B7				( 2 )		PASS
B8		120	75	( )	37.5000	PASS
B9		134	75	( )	33.5821	PASS
Material:				Color:		
B10		139	75	( )	32.3741	PASS
B11		97	75	( )	46.3918	FAIL
B12		127	75	( )	35.4331	PASS

- (1) Ceased to burn before the 100mm reference mark and rate is determined. (may exceed limits)  
 (2) Ceased to burn before the 25mm reference mark and rate is not determined.  
 (3) Notes: \_\_\_\_\_

TESTED BY: HAMMAD A. MALIK

SIGNATURE: 

DATE: 12/9/97

94hb(12-1-95)

FILE NO: \_\_\_\_\_

PROJECT NO: 21660

LAB JOB NO: \_\_\_\_\_

SAMPLE: **97-595-9008-01**

**UL 94 HORIZONTAL BURNING TEST FOR CLASSIFYING MATERIALS 94HB**

**METHOD**

Specimens were conditioned for at least 48h at 23±2°C and 50±5% RH and then tested in accordance with UL 94, Fifth Edition Room conditions during testing were maintained at 25±10°C and 60±15% RH

**RESULTS**

SPECIMEN NO.	THICKNESS mm	BURNING BEYOND 25 mm		See Note	BURNING RATE V=60L/t mm/min	PASS/ FAIL
		Time, t s	Damaged Length, L mm			
Material:		Color:				
E7		97	75	( )	46.3918	FAIL
E8		109	75	( )	41.2844	FAIL
E9		86	75	( )	52.3256	FAIL

- (1) Ceased to burn before the 100mm reference mark and rate is determined. (may exceed limits)
- (2) Ceased to burn before the 25mm reference mark and rate is not determined.
- (3) Notes: \_\_\_\_\_

TESTED BY: HAMMAD A. MALIK

SIGNATURE: *H Malik*

DATE: 12/11/97

FILE NO: \_\_\_\_\_

PROJECT NO: 21660

LAB JOB NO: \_\_\_\_\_

SAMPLE: 97-595-9008-02

**UL 94 HORIZONTAL BURNING TEST FOR CLASSIFYING MATERIALS 94HB**

**METHOD**

Specimens were conditioned for at least 48h at 23±2°C and 50±5% RH and then tested in accordance with UL 94, Fifth Edition Room conditions during testing were maintained at 25±10°C and 60±15% RH

**RESULTS**

SPECIMEN NO.	THICKNESS mm	BURNING BEYOND 25 mm		See Note	BURNING RATE V=60L/t mm/min	PASS/ FAIL
		Time, t s	Damaged Length, L mm			
Material:				Color:		
E1		79	75	( )	56.9620	FAIL
E2		104	75	( )	43.2692	FAIL
E3		135	75	( )	33.3333	PASS
Material:				Color:		
E4		75	75	( )	60.0000	FAIL

- (1) Ceased to burn before the 100mm reference mark and rate is determined. (may exceed limits)
- (2) Ceased to burn before the 25mm reference mark and rate is not determined.
- (3) Notes: \_\_\_\_\_

TESTED BY: HAMMAD A. MALIK

SIGNATURE: *H. Malik* DATE: 12/11/97

**APPENDIX B**  
**UL 94V TEST RESULTS**

PROJECT NO 21660  
 SAMPLE NO: 97-595-9009-06

**UL 94 VERTICAL BURNING TEST FOR CLASSIFYING MATERIALS**

Min. 48h Cond. in accordance with UL94 Section 6.1					
Specimens	t1 s		t2 s	t2 + t3 s	
E11	3		41	41	(4)
E12	45	(5)	28	28	(4)
E13	3		4	4	(4)
E14	4	(4)	0	0	
E15	6	(4)	35	35	
Total Flame Time (t1 + t2), s: 169					

FLAME CLASS	
94V-	FAIL

- (1) Specimen burned up to holding clamp
- (2) Specimen did not drip
- (3) Specimen dripped particles which did not ignite cotton
- (4) Specimen dripped particles which ignited cotton
- (5) Fumes from specimen extinguished flame-burner relit during test
- (6) Misc: \_\_\_\_\_

TESTED BY: Hammad Malik

DATE 12/2/97

Min. 48h Cond. in accordance with UL94 Section 6.1					
Specimens	t1 s		t2 s	t2 + t3 s	
E16	5	(4)	75	75	
E17	3	(4)	34	34	
E18	3	(4)	20	20	
E19	3	(4)	65	65	(1)
E20	4	(4)	22	22	(1)
Total Flame Time (t1 + t2), s: 234					

FLAME CLASS	
94V-	FAIL

- (1) Specimen burned up to holding clamp
- (2) Specimen did not drip
- (3) Specimen dripped particles which did not ignite cotton
- (4) Specimen dripped particles which ignited cotton
- (5) Fumes from specimen extinguished flame-burner relit during test
- (6) Misc: \_\_\_\_\_

TESTED BY: Hammad Malik

DATE 12/2/97

PROJECT NO 21660  
 SAMPLE NO: 97-595-9009-04

**UL 94 VERTICAL BURNING TEST FOR CLASSIFYING MATERIALS**

Min. 168 Cond. in accordance with UL94 Section 6.2				
Specimens	t1 s	(4)	t2 s	t2 + t3 s
E11	40	(4)	10	10
E12	5	(4)	24	24
E13	5	(4)	76	76
E14	3	(4)	38	38
E15	2	(4)	22	22
Total Flame Time (t1 + t2), s: 225				

FLAME CLASS	
94V-	FAIL

- (1) Specimen burned up to holding clamp
- (2) Specimen did not drip
- (3) Specimen dripped particles which did not ignite cotton
- (4) Specimen dripped particles which ignited cotton
- (5) Fumes from specimen extinguished flame-burner relit during test
- (6) Misc: \_\_\_\_\_

TESTED BY: Hammad Malik

DATE 11/21/97

Min. 168 Cond. in accordance with UL94 Section 6.2				
Specimens	t1 s	(4)	t2 s	t2 + t3 s
E16	110	(4)	0	0 (1)
E17	86	(4)	2	2
E18	40	(4)	3	3
E19	5	(4)	28	38
E20	98	(1)	0	0 (4)
Total Flame Time (t1 + t2), s: 372				

FLAME CLASS	
94V-	FAIL

- (1) Specimen burned up to holding clamp
- (2) Specimen did not drip
- (3) Specimen dripped particles which did not ignite cotton
- (4) Specimen dripped particles which ignited cotton
- (5) Fumes from specimen extinguished flame-burner relit during test
- (6) Misc: \_\_\_\_\_

TESTED BY: Hammad Malik

DATE 11/21/97

PROJECT NO 21660  
 SAMPLE NO: 97-595-9009-04

**UL 94 VERTICAL BURNING TEST FOR CLASSIFYING MATERIALS**

Min. 168 Cond. in accordance with UL94 Section 6.2				
Specimens	t1		t2	t2 + t3
	s		s	s
E1	4	(4)	8	8
E2	5	(4)	25	25
E3	51	(4)	16	16
E4	45	(4)	5	50
E5	6	(4)	23	23
Total Flame Time (t1 + t2), s: 188				

FLAME CLASS	
94V-	FAIL

- (1) Specimen burned up to holding clamp
- (2) Specimen did not drip
- (3) Specimen dripped particles which did not ignite cotton
- (4) Specimen dripped particles which ignited cotton
- (5) Fumes from specimen extinguished flame-burner relit during test
- (6) Misc: \_\_\_\_\_

TESTED BY: Hammad Malik

DATE 11/21/97

Min. 168 Cond. in accordance with UL94 Section 6.2				
Specimens	t1		t2	t2 + t3
	s		s	s
E6	5	(4)	58	58
E7	3	(4)	55	55
E8	4	(4)	51	51
E9	89	(4)	25	25
E10	8	(4)	64	64
Total Flame Time (t1 + t2), s: 362				

FLAME CLASS	
94V-	FAIL

- (1) Specimen burned up to holding clamp
- (2) Specimen did not drip
- (3) Specimen dripped particles which did not ignite cotton
- (4) Specimen dripped particles which ignited cotton
- (5) Fumes from specimen extinguished flame-burner relit during test
- (6) Misc: \_\_\_\_\_

TESTED BY: Hammad Malik

DATE 11/21/97

PROJECT NO 21660  
 SAMPLE NO: 97-595-9004-09

**UL 94 VERTICAL BURNING TEST FOR CLASSIFYING MATERIALS**

Min. 48h Cond. in accordance with UL94 Section 6.1					
Specimens	t1 s	(2)	t2 s	t2 + t3 s	(2)
B1	0	(2)	0	0	(2)
B2	5	(2)	0	9	(2)
B3	0	(2)	0	48	(2)
B4	6	(2)	1	38	(2)
B5	4	(2)	3	10	(2)
Total Flame Time (t1 + t2), s: 19					

FLAME CLASS
94V- 2

- (1) Specimen burned up to holding clamp
- (2) Specimen did not drip
- (3) Specimen dripped particles which did not ignite cotton
- (4) Specimen dripped particles which ignited cotton
- (5) Fumes from specimen extinguished flame-burner relit during test
- (6) Misc: \_\_\_\_\_

TESTED BY: Hammad Malik

DATE 12/2/97

Min. 48h Cond. in accordance with UL94 Section 6.1					
Specimens	t1 s	(2)	t2 s	t2 + t3 s	(2)
B6	1	(2)	0	14	(2)
B7	2	(2)	0	38	(2)
B8	1	(2)	0	37	(2)
B9	3	(2)	2	2	(2)
B10	0	(2)	0	0	(2)
Total Flame Time (t1 + t2), s: 9					

FLAME CLASS
94V- 2

- (1) Specimen burned up to holding clamp
- (2) Specimen did not drip
- (3) Specimen dripped particles which did not ignite cotton
- (4) Specimen dripped particles which ignited cotton
- (5) Fumes from specimen extinguished flame-burner relit during test
- (6) Misc: \_\_\_\_\_

TESTED BY: Hammad Malik

DATE 12/2/97



PROJECT NO 21660  
 SAMPLE NO: 97-595-9004-09

**UL 94 VERTICAL BURNING TEST FOR CLASSIFYING MATERIALS**

Min. 48h Cond. in accordance with UL94 Section 6.1				
Specimens	t1 s	(4)	t2 s	t2 + t3 s
F1	4	(4)	28	28
F2	3	(4)	12	12
F3	15	(4)	24	24
F4	3	(4)	16	16
F5	4	(4)	9	9
Total Flame Time (t1 + t2), s: 118				

FLAME CLASS
94V- 2

- (1) Specimen burned up to holding clamp
- (2) Specimen did not drip
- (3) Specimen dripped particles which did not ignite cotton
- (4) Specimen dripped particles which ignited cotton
- (5) Fumes from specimen extinguished flame-burner relit during test
- (6) Misc: \_\_\_\_\_

TESTED BY: Hammad Malik

DATE 12/3/97

Min. 48h Cond. in accordance with UL94 Section 6.1				
Specimens	t1 s	(4)	t2 s	t2 + t3 s
F6	3	(4)	9	9
F7	3	(4)	5	5
F8	2	(4)	25	25
F9	3	(4)	14	14
F10	2	(4)	12	12
Total Flame Time (t1 + t2), s: 78				

FLAME CLASS
94V- 2

- (1) Specimen burned up to holding clamp
- (2) Specimen did not drip
- (3) Specimen dripped particles which did not ignite cotton
- (4) Specimen dripped particles which ignited cotton
- (5) Fumes from specimen extinguished flame-burner relit during test
- (6) Misc: \_\_\_\_\_

TESTED BY: Hammad Malik

DATE 12/3/97

PROJECT NO 21660  
 SAMPLE NO: 97-595-9004-04

**UL 94 VERTICAL BURNING TEST FOR CLASSIFYING MATERIALS**

Min. 168 Cond. in accordance with UL94 Section 6.2				
Specimens	t1 s	t2 s	t2 + t3 s	
B1	0	(2) 0	0	0
B2	0	(2) 2	2	2
B3	0	(2) 0	0	0
B4	0	(2) 0	0	0
B5	0	(2) 0	0	0
Total Flame Time (t1 + t2), s: 2				

FLAME CLASS
94V- 0

- (1) Specimen burned up to holding clamp
- (2) Specimen did not drip
- (3) Specimen dripped particles which did not ignite cotton
- (4) Specimen dripped particles which ignited cotton
- (5) Fumes from specimen extinguished flame-burner relit during test
- (6) Misc: \_\_\_\_\_

TESTED BY: Hammad Malik

DATE 11/24/97

Min. 168 Cond. in accordance with UL94 Section 6.2				
Specimens	t1 s	t2 s	t2 + t3 s	
B6	3	(2) 6	22	22
B7	5	(2) 0	0	0
B8	2	(2) 0	15	15
B9	2	(2) 0	8	8
B10	1	(2) 6	30	30
Total Flame Time (t1 + t2), s: 25				

FLAME CLASS
94V- 0

- (1) Specimen burned up to holding clamp
- (2) Specimen did not drip
- (3) Specimen dripped particles which did not ignite cotton
- (4) Specimen dripped particles which ignited cotton
- (5) Fumes from specimen extinguished flame-burner relit during test
- (6) Misc: \_\_\_\_\_

TESTED BY: Hammad Malik

DATE 11/24/97

PROJECT NO 21660  
 SAMPLE NO: 97-595-9004-04

**UL 94 VERTICAL BURNING TEST FOR CLASSIFYING MATERIALS**

Min. 168 Cond. in accordance with UL94 Section 6.2			
Specimens	t1 s	t2 s	t2 + t3 s
B11	1	(2) 3	3
B12	1	(2) 0	14
B13	1	(2) 2	10
B14	0	(2) 0	10
B15	1	(2) 0	15
Total Flame Time (t1 + t2), s: 9			

FLAME CLASS
94V- 0

- (1) Specimen burned up to holding clamp
- (2) Specimen did not drip
- (3) Specimen dripped particles which did not ignite cotton
- (4) Specimen dripped particles which ignited cotton
- (5) Fumes from specimen extinguished flame-burner relit during test
- (6) Misc: \_\_\_\_\_

TESTED BY: Hammad Malik

DATE 11/24/97

Min. 168 Cond. in accordance with UL94 Section 6.2			
Specimens	t1 s	t2 s	t2 + t3 s
B16	2	(2) 0	0
B17	4	(2) 4	22
B18	0	(2) 0	16
B19	0	(2) 0	5
B20	0	(2) 0	3
Total Flame Time (t1 + t2), s: 10			

FLAME CLASS
94V- 0

- (1) Specimen burned up to holding clamp
- (2) Specimen did not drip
- (3) Specimen dripped particles which did not ignite cotton
- (4) Specimen dripped particles which ignited cotton
- (5) Fumes from specimen extinguished flame-burner relit during test
- (6) Misc: \_\_\_\_\_

TESTED BY: Hammad Malik

DATE 11/24/97

PROJECT NO 21660  
 SAMPLE NO 97-595-9004-04

UL 94 VERTICAL BURNING TEST FOR CLASSIFYING MATERIALS

Min. 168 Cond. in accordance with UL94 Section 6.2				
Specimens	t1 s	t2 s	t2 + t3 s	
F1	9	4	10	10
F2	40	4	0	0
F3	46	4	0	0
F4	1	4	30	30
F5	23	4	13	13
Total Flame Time (t1 + t2) s 172				

FLAME CLASS	
94V-	FAIL

- (1) Specimen turned up to holding clamp
- (2) Specimen did not drip
- (3) Specimen dripped particles which did not ignite cotton
- (4) Specimen dripped particles which ignited cotton
- (5) Fumes from specimen extinguished flame-burner relit during test
- (6) Misc \_\_\_\_\_

TESTED BY: Hammad Malik

DATE 11/24/97

Min. 168 Cond. in accordance with UL94 Section 6.2				
Specimens	t1 s	t2 s	t2 + t3 s	
F6	25	4	17	17
F7	120	4	0	0
F8	13	4	50	50
F9	50	4	0	0
F10	60	4	0	0
Total Flame Time (t1 + t2) s 356				

FLAME CLASS	
94V-	FAIL

- (1) Specimen turned up to holding clamp
- (2) Specimen did not drip
- (3) Specimen dripped particles which did not ignite cotton
- (4) Specimen dripped particles which ignited cotton
- (5) Fumes from specimen extinguished flame-burner relit during test
- (6) Misc \_\_\_\_\_

TESTED BY: Hammad Malik

DATE 11/24/97

PROJECT NO 21650  
 SAMPLE NO 97-595-9004-09

**UL 94 VERTICAL BURNING TEST FOR CLASSIFYING MATERIALS**

Min. 48h Cond. in accordance with UL94 Section 6.1				
Specimens	t1 s	t2 s	t2 + t3 s	
B11	4	(2) 3	38	(2)
B12	2	(2) 0	5	(2)
B13	3	(2) 8	38	(2)
B14	0	(2) 0	18	(2)
B15	4	(2) 0	33	(2)
Total Flame Time (t1 + t2), s: 24				

FLAME CLASS	
94V-	2

- (1) Specimen burned up to holding clamp
- (2) Specimen did not drip
- (3) Specimen dripped particles which did not ignite cotton
- (4) Specimen dripped particles which ignited cotton
- (5) Fumes from specimen extinguished flame-burner relit during test
- (6) Misc. \_\_\_\_\_

TESTED BY: Hammad Malik

DATE 12/2/97

Min. 48h Cond. in accordance with UL94 Section 6.1				
Specimens	t1 s	t2 s	t2 + t3 s	
B16	0	(2) 0	9	(2)
B17	3	(2) 3	10	(2)
B18	5	(2) 2	18	(2)
B19	0	(2) 4	30	(2)
B20	1	(2) 0	2	(2)
Total Flame Time (t1 + t2), s: 23				

FLAME CLASS	
94V-	0

- (1) Specimen burned up to holding clamp
- (2) Specimen did not drip
- (3) Specimen dripped particles which did not ignite cotton
- (4) Specimen dripped particles which ignited cotton
- (5) Fumes from specimen extinguished flame-burner relit during test
- (6) Misc. \_\_\_\_\_

TESTED BY: Hammad Malik

DATE 12/2/97

## APPENDIX C

### UL 746C 12MM AND 3/4 inch END- PRODUCT FLAME TEST RESULTS

## UL 746C 3/4" END PRODUCT FLAME TEST

DATE OF TEST	PRODUCT TYPE	SAMPLE NO.	POINT OF APPLICATION	Did Appliance Extinguish Within 60 sec After First Application? (Y/N)	Burn Time After Second Application Seconds	PASS/FAIL
12/30/97	FAN	97-595-9008-03	Under Motor Enclosure	Y	4	PASS
12/30/97	FAN	97-595-9008-05	Proximate to Switch	Y	61	FAIL
12/30/97	FAN	97-595-9008-06	Under Motor Enclosure	N		FAIL
12/30/97	FAN	97-595-9007-08	Under Motor Enclosure	N		FAIL
12/30/97	FAN	97-595-9007-08	Under Motor Enclosure	Y	0	PASS
12/30/97	FAN	97-595-9007-09	Proximate to Switch	Y	61	FAIL
12/30/97	FAN	97-595-9007-07	Under Motor Enclosure	Y	0	PASS
12/30/97	FAN	97-595-9007-07	Proximate to Switch	Y	61	FAIL
1/5/98	FAN	97-595-9008-04	Under Motor Enclosure	Y	0	PASS
12/29/97	HEATER	97-595-9004-06	Top	N		FAIL
12/29/97	HEATER	97-595-9004-06	Back Fin	Y	0	PASS
12/29/97	HEATER	97-595-9004-06	Side Front	Y	9	PASS
12/29/97	HEATER	97-595-9004-06	Front	Y	0	PASS
12/30/97	TOASTER	97-595-9005-04	By Solenoid	Y	0	PASS
12/30/97	TOASTER	97-595-9005-03	Above Slot	Y	61	FAIL
1/8/98	CHARGER	97-595-9009-03	By Solenoid	Y	61	FAIL
1/8/98	CHARGER	97-595-9009-01	Above Transformer	Y	61	FAIL
1/8/98	CHARGER	97-595-9009-01	Above Transformer	Y	61	FAIL

PROJE 21660

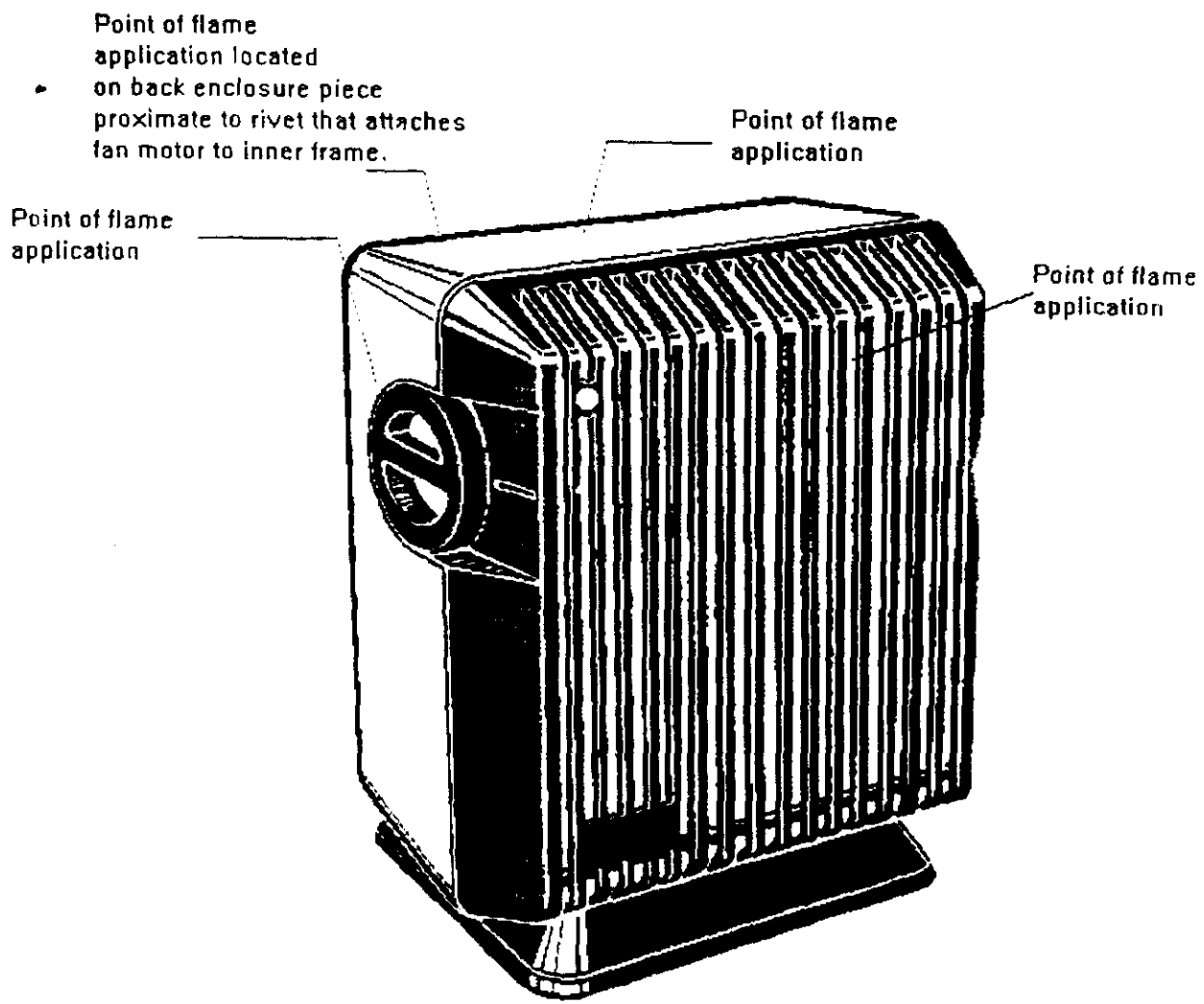
UL 746C 12mm END PRODUCT FLAME TEST

DATE	PRODUCT TYPE	SAMPLE NO	POINT OF APPLICATION	Did Appliance Extinguish Within 60 sec After First Application? (Y/N)	Burn Time After Second Application Seconds	PASS /FAIL
1/15/98	HEATER	97-595-9004-05	Top	Y	0	PASS
1/15/98	TOASTER	97-595-9005-01	Back Fin Solenoid Rim	Y N N	0	PASS FAIL FAIL
1/15/98	TOASTER	97-595-9005-02	Solenoid	N	61	FAIL
1/16/98	CHARGER	97-595-9009-02	Proximate to Switches	Y	0	FAIL
1/16/98	ANSWERING MACHINE	97-595-9003-01	Transformer	Y	0	PASS
1/16/98	ANSWERING MACHINE	97-595-9003-05	Transformer	Y	0	PASS
1/16/98	ANSWERING MACHINE	97-595-9003-02	Transformer	Y	0	PASS
1/16/98	FAN	97-595-9008-07	Under Motor Enclosure	N	0	FAIL
1/16/98	FAN	97-595-9008-09	Proximate to Switch	N	0	FAIL
1/16/98	FAN	97-595-9008-10	Under Motor Enclosure	N	0	FAIL
1/16/98	FAN	97-595-9008-08	Under Motor Enclosure	N	0	FAIL

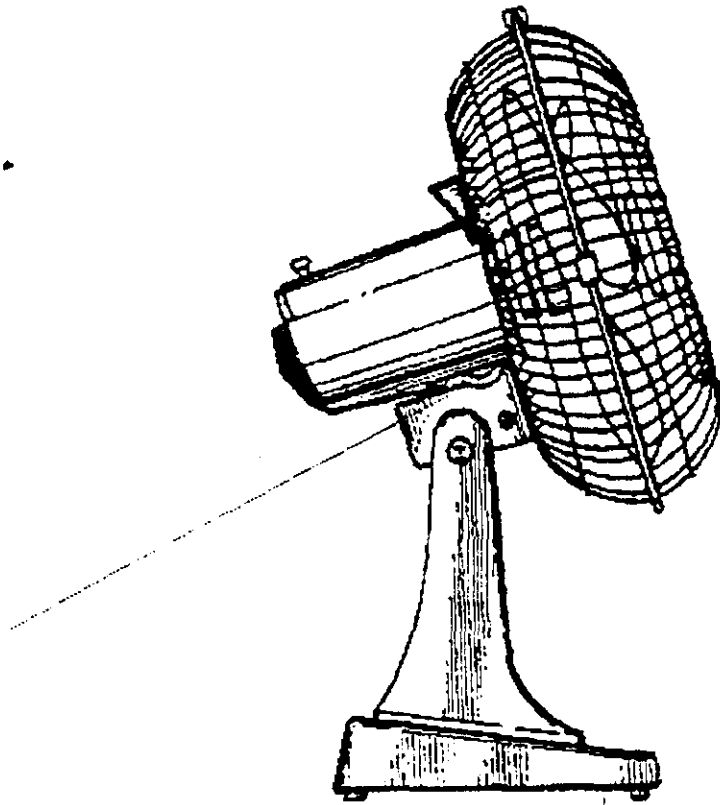


APPENDIX D  
FLAME APPLICATION POINT FOR END-  
PRODUCT FLAME TESTS

Appendix D has diagrams of each of the products tested. These diagrams identify the locations that were "location judged to be likely to become ignited because of its proximity to a source of ignition" per sections 51.2 and 52.2 of UL 746C. These locations were determined based on incident data that described internal failures that ignited the appliance enclosure. Flame was applied on samples identical to those involved in the incident to locations proximate to failed components described by the incident. These included wiring connection, switches, transformers, and wire fatigue fires.

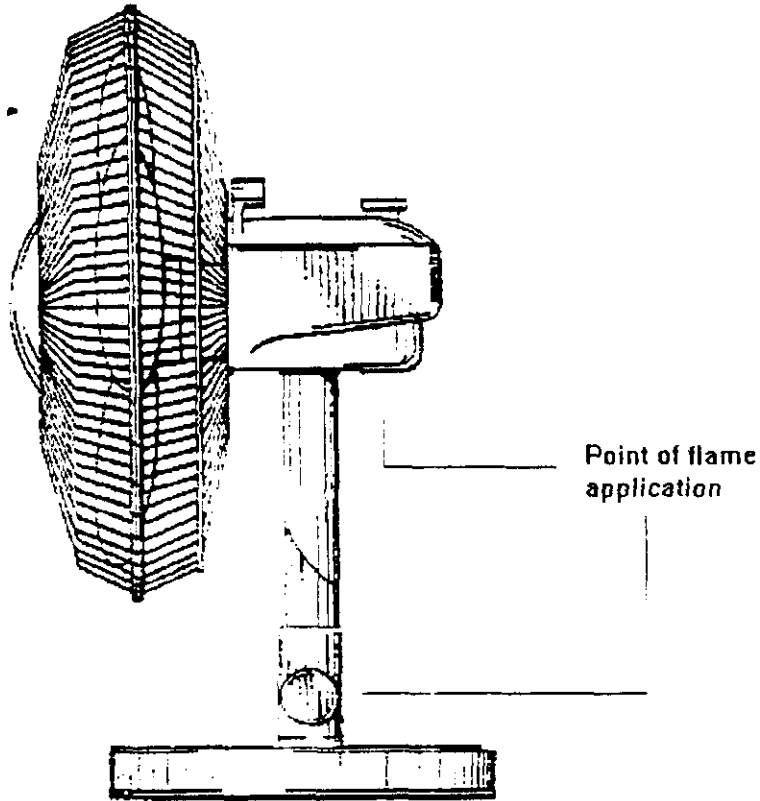


Sample # 97-595-9004-XX  
Portable Heater

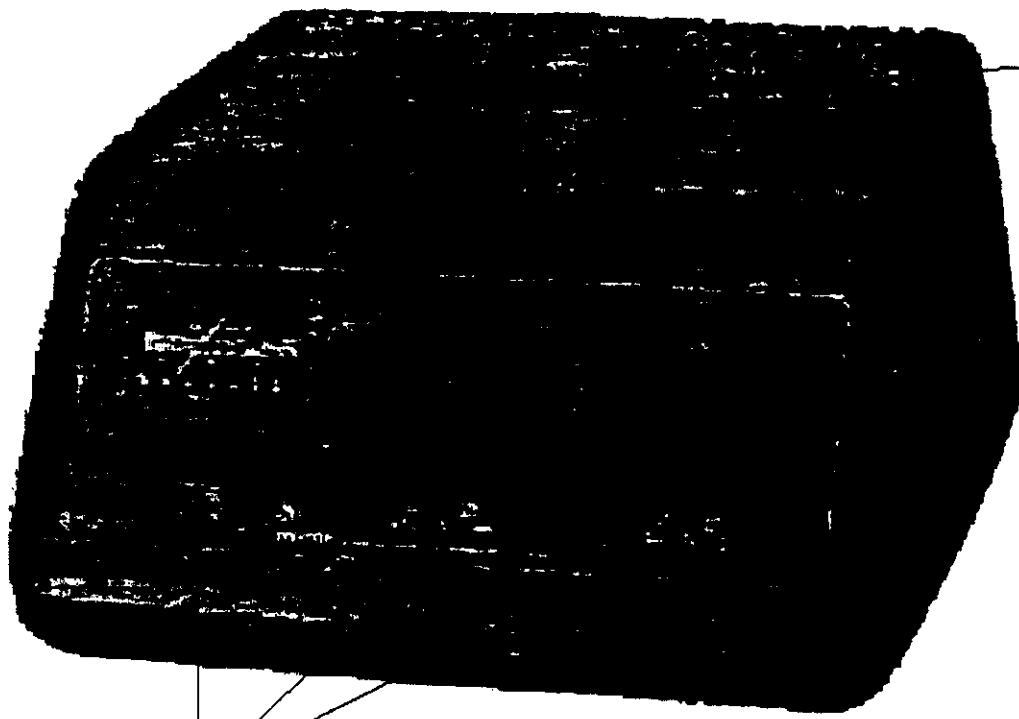


Points of flame  
application

Sample #97-595-9007-XX  
Portable Oscillating Fan



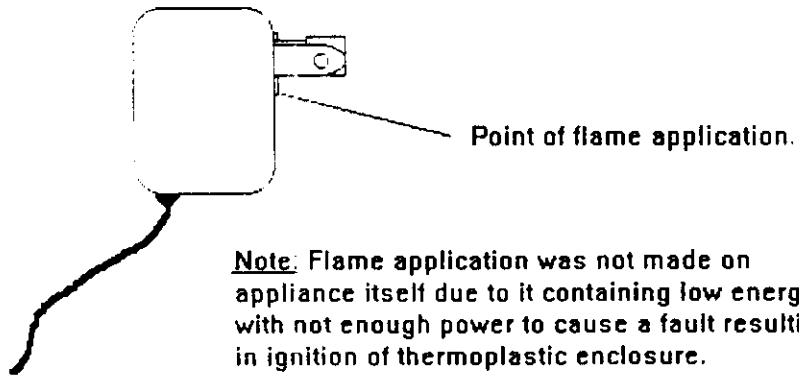
Sample # 97-595-9008-~~X~~  
Portable Oscillating Fan



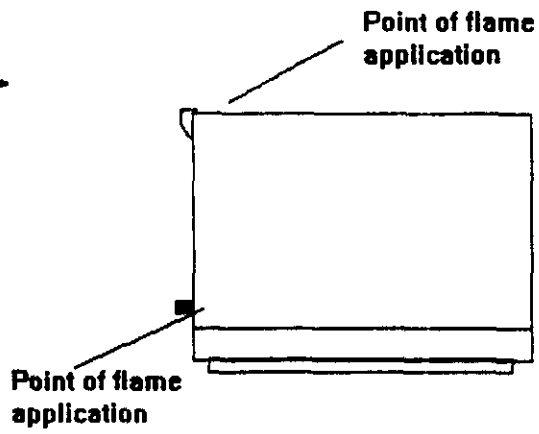
Point of flame application

Points of flame application

Sample # 97-595-9009-XX  
Car Battery Starter/Charger



**SAMPLE # 97-595-9003-XX**  
**Answering Machine Power Supply**



**Sample # 97-595-9005-XX and  
Sample # 97-595-9006-XX**

**Toaster**



APPENDIX E  
CPSC TEST SETUP

