U.S. CONSUMER PRODUCT SAFETY COMMISSION
DIRECTORATE FOR ENGINEERING SCIENCES

EVALUATION OF ELECTRIC LIGHTING PRODUCTS

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I. INTRODUCTION

For the time period 1999-2003, there was an annual average estimated 6,080 residential structure fires associated with all lighting products. These fires resulted in an average estimated 28 deaths, 178 injuries, and $102 million in property loss annually[1]. For the same time period, there was an annual average ten electrocutions associated with lighting products[2]. The U.S. Consumer Product Safety Commission (CPSC) staff initiated an evaluation of electric lighting product incidents to identify potential hazard scenarios and product features that may contribute to fire or potential fire incidents, as well as electric shock incidents. This report presents the results of the staff's evaluation. Information from this evaluation will be used to develop recommendations to the relevant voluntary standards, as appropriate.

II. PROJECT OUTLINE

The staff evaluation was divided into two major tasks. First, data was collected for the period October 1, 2002 to September 30, 2004. Once an incident was identified, it was assigned to a CPSC field investigator for follow-up by conducting an investigation and documenting it in an In-Depth Investigation (IDI) report. IDI reports may contain interviews with victims, witnesses, and the emergency personnel responding to an incident.

The data collection effort covered all types of lighting products (except seasonal lights and displays) that were involved in incidents relating to fire or shock. Incident data were categorized by several characteristics, including product type, type of injury involved, and consumer use environment[3] (see Appendix A). CPSC investigators also attempted to collect incident samples while conducting in-depth investigations. This was expected to be challenging because incident samples are often destroyed by fire or discarded by consumers before investigators are able to contact them. CPSC investigators also attempted to collect exemplars that were of the same or similar make and model to incident samples. If the field investigators were able to collect incident and/or exemplar samples during their investigations, the samples were sent to CPSC engineering staff for analysis.

Second, CPSC engineering staff examined the samples collected to determine possible product-related causes for the incident and whether the incident was related to a specific component failure or design feature. When possible, staff also determined whether the product was listed to or appeared to comply with the applicable industry voluntary safety standard.

III. VOLUNTARY STANDARDS

There are several voluntary standards that apply to electric lighting products. Underwriters Laboratories Inc. (UL) voluntary standard 1598, *Luminaires,* applies to most

[1] Chowdhury, R. et al.; *1999-2003 Residential Fire Loss Estimates,* October 2006, Directorate for Epidemiology, Division of Hazard Analysis, U.S. Consumer Product Safety Commission.
[2] *Electrocutions Associated with Consumer Products, 1999, 2000, 2001, 2002,* and *2003,* Directorate for Epidemiology, Division of Hazard Analysis, U.S. Consumer Product Safety Commission.
[3] Memorandum from R. Chowdhury to A. Luo, Hazards Related to Electric Lighting Products, March 8, 2005, U.S. Consumer Product Safety Commission.

installed (fixed) lighting products; and UL 153, *Portable Electric Luminaires*, applies to most portable (non-fixed) lighting products typically found in homes. Some special lighting products such as fluorescent self-ballasted lamps, rope lights, nightlights, and emergency lights use separate standards: UL 1993, *Self-Ballasted Lamps and Lamp Adapters*, UL 2388, *Flexible Lighting Products*, UL 1786, *Nightlights*, and UL 924, *Emergency Lighting and Power Equipment*, UL 496, *Lampholders*, respectively.

The voluntary standard, UL 153, *Portable Electric Luminaires*, is issued jointly by the American National Standards Institute (ANSI) and UL. The standard does not apply to lighting products covered by other standards such as, but not limited to, Christmas tree and decorative lighting outfits, or electric candles and candelabras without lamp shades, direct plug-in nightlights, sun and heat lamps, aquarium lamps, portable electric hand lamps, and photographic lamps.

The voluntary standard, UL 1598, *Luminaires*, is issued jointly by the Association of Standardization and Certification (ANCE), the Canadian Standards Association (CSA), and UL. The standard is published as an equivalent standard for CSA and UL and a proposed equivalent standard for ANCE. An equivalent standard is a standard that is substantially the same in technical content. Technical differences are allowed for national differences resulting from conflicts in codes and governmental regulations. The standard does not apply to lighting products covered by other standards such as, but not limited to, aquarium lights, cabinet lights, decorative lighting strings, electric signs, swimming pool lighting, portable luminaires, and flexible lighting products.

The relatively new UL voluntary standard for rope lights (first published in July 2002), UL 2388, *Flexible Lighting Products*, covers portable flexible lighting products with a maximum input voltage rating of 120 volts to be used in accordance with the National Electrical Code (NEC), ANSI/NFPA 70. These products are provided with a power supply cord and are intended for decorative lighting use.

IV. TERMINOLOGY

Some of the terms used throughout this report for components of a lamp or lighting fixture may differ from technical terminology commonly used by the lighting industry as follows:

Lamp. A lamp is a device that produces light and is intended to be inserted into a lampholder. This is commonly referred to as a "light bulb" or "bulb." In this report, the terms "light bulb" and "bulb" are used.

Luminaire. A luminaire is a complete lighting unit designed to accommodate a bulb and to connect the bulb to a power source. This is commonly referred to as a "fixture." In this report, the terms "light," "fixture," "lighting product" and "luminaire" are used interchangeably.

Lampholder. A lampholder, which is commonly referred to as a socket, is used as a wiring device for making the connection to the electrical circuits of a bulb and, in some cases,

providing support. The lampholder may contain a switch, as typically found on portable lighting products. In this report, the term socket refers to the portion of the lampholder that supports the bulb and electrical connections to the bulb.

For this report, *portable lighting products* are lighting products that are not directly wired to the branch circuit and can be readily relocated. *Installed lighting products* are generally those that are wired into the branch circuit and do not contain an exposed power cord or attachment plug. For this report, nightlights are classified as portable lighting. Hanging lights, with or without attachment plugs, are classified as installed lighting.

V. PRODUCT CHARACTERISTICS

Most of the lighting products installed in homes are within the scope of the voluntary standard UL 1598, *Luminaires*. These lighting products are typically intended for direct installation on branch circuits of 600 V nominal or less between conductors in accordance with the NEC, ANSI/NFPA 70.

Most of the portable lighting products found in homes are within the scope of the voluntary standard UL 153, *Portable Electric Luminaires*. Portable lighting products are typically provided with a flexible cord and an attachment plug for connection to a nominal 120-volt, 15- or 20-ampere branch circuit. The products may also be dedicated portable luminaires that employ a connector other than an attachment plug that is intended to connect to a compatible connector assembly for connection to a nominal 120-volt, 15- or 20-ampere branch circuit.

Nightlight products are a specialized form of portable Luminaires, typically directly inserted in a common parallel-slot receptacle rated 15 or 20 amperes, 120 volts and do not contain a power supply cord. A nightlight may have a switch or a sensor to turn the light on and off. A nightlight may use a low wattage (4 to 7 watt) incandescent bulb, fluorescent bulb, or electroluminescent panel.

Electroluminescent nightlights are very low wattage devices that include a special low-conductivity material that glows when exposed to an electric potential (100-140 volts AC). Electroluminescent nightlights are not bright but can last several years, which is an advantage over incandescent lamps.

Flexible lighting products, commonly referred to as rope lights, are portable flexible lighting products with a maximum input voltage rating of 120 volts. These products are provided with a power supply cord and are generally intended as decorative lighting. The products use non-replaceable series and series/parallel connected bulbs enclosed within a flexible polymeric tube or extrusion. Flexible lighting may be used to create light sculptures.

Halogen torchiere lamps, which are also referred to as tungsten-halogen lamps, quartz-halogen lamps, or quartz-iodine lamps, first began to appear in the consumer market in the early 1990s. The halogen bulb consists of a tungsten filament, which is sealed into a small envelope filled with a halogen gas such as iodine or bromine. The gas pressure (7-8 atmospheres) and temperature (250° C to 600° C) of a halogen bulb are much higher than those for a non-halogen

lamp. To withstand the high operating pressures and temperatures, a halogen bulb must be made of hard glass or fused quartz. In addition, to reduce the fire and burn hazard associated with halogen bulbs, the voluntary standard, UL 153, *Portable Luminaires*, requires a halogen lamp to have a guard to prevent contact with the bulb and bulb glass cover.

Compact fluorescent bulbs or lamps (CFL) are an energy efficient and long-life alternative to incandescent and halogen bulbs. CFLs operate at relatively low surface temperatures which are less likely than other lamps to cause burns or fires. CFLs use substantially less energy than standard halogen or other incandescent lamps while producing similar light output. A compact fluorescent bulb consists of a circular or spiral twisted glass tube with a filament at each end and an electronic ballast in the plastic bulb base. The bulb operates by igniting an arc within a glass tube filled with phosphorescent gas. When the bulb is energized, the filament at each end of the tube heats up to start this process. Once the arc is ignited, the filament heating circuit is de-energized. Compact fluorescent bulbs are within the scope of the voluntary standard UL 1993, S*elf-Ballasted Lamps and Lamp Adapters.*

VI. TASK 1 – Review of Incident Data (See Appendix A)

CPSC staff reviewed 402 lighting product-related reports for In-Depth Investigations (IDIs) conducted from October 1, 2002, through September 30, 2004[4]. The period of data/sample collection includes some incidents that occurred prior to October 1, 2002.

The scope of the collection effort included all types of portable and installed lighting products, except seasonal lights or displays. Of the 402 IDIs analyzed, 374 IDIs were within the scope of the project. For simplicity, these 374 IDIs were classified into three groups:

- 150 incidents involved portable lighting products such as table/desk lamps, floor lamps, clip-on lamps, nightlights, etc.
- 145 incidents involved installed lighting products such as ceiling/wall surface-mounted fixtures, recessed fixtures, ceiling hanging fixtures, surface-mounted fixtures on furniture or under-counter/shelf/closet, etc.
- 79 incidents involved lighting products in which external factors may have contributed to the incident (e.g., lamp knocked over onto combustible material, lamp shade contacted a light bulb, power cord pinched by furniture, excessive wattage, or light bulb shattered).

A. Portable Lighting Incidents

There were 150 incident reports related to portable lighting products. The lighting product types were categorized as follows: table/desk lamps (55), floor lamps (41), nightlights (33), work lights (6), decorative rope lights (4), clip-on lights (4), specialty lamps such as lava or novelty lights (3), and unknown types of lamps (4). Figure 1 shows the distribution of portable lighting incidents collected between October 1, 2002, and September 30, 2004.

[4] The number of incidents reported or collected does not reflect or represent any statistical national average. The numbers presented also have not been normalized for the population of the specific type of lighting product.

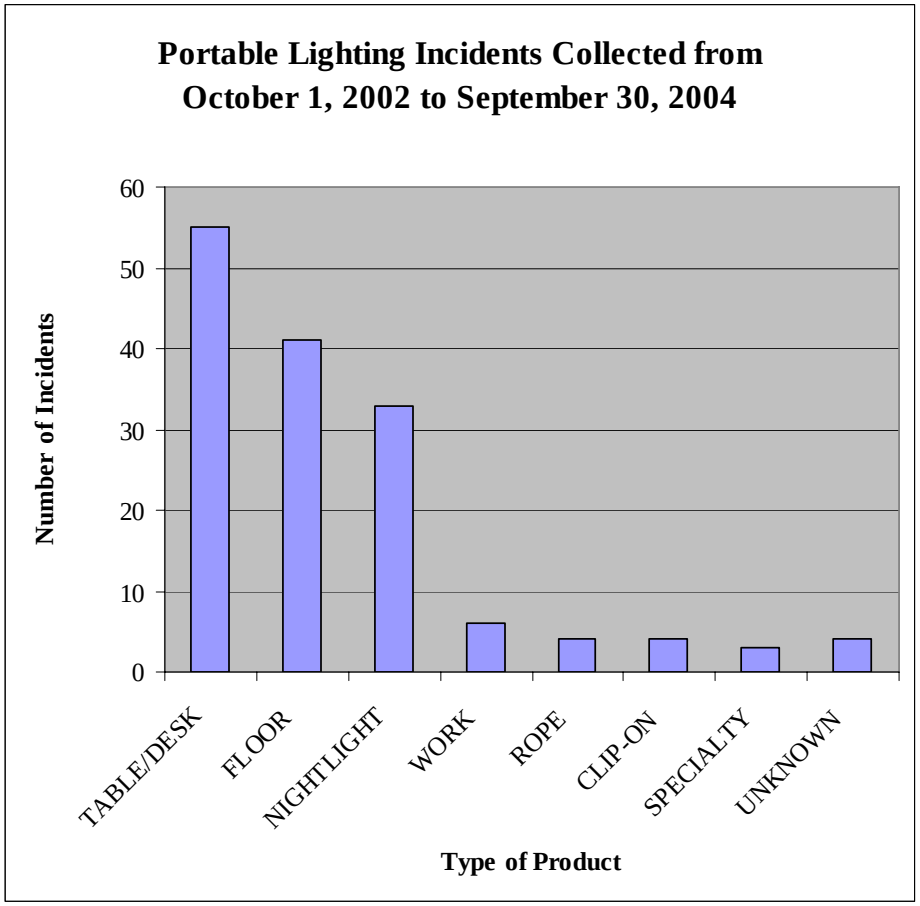

Figure 1. Incidents Involving Portable Lighting Products

The hazards described in the 150 IDIs were identified as: fire (60), potential fire[5] (78), explosion (7), electrocution (3), and electrical shock (2). Product or component failures identified in the IDIs included bulb (31), power cord (29), fixture (28), combination of components (9), other such as switch, shade, socket, etc. (22), and unknown (31).

B. Installed Lighting Incidents

There were 145 incidents related to installed lighting products. The lighting product types were categorized as: ceiling surface-mounted fixtures (60), wall surface-mounted fixtures (33), recessed fixtures (19), ceiling hanging fixtures (13), surface-mounted fixtures on furniture, under-counter, shelf, closet, etc. (8), fixtures on ceiling, no further detail available (5), other specialty lighting such as swimming pool and emergency exit lighting (2), and unknown (5). Figure 2 shows the distribution of installed lighting incidents collected between October 1, 2002, and September 30, 2004.

[5] Flames (did not propagate to the structure), sparks, smoke, overheating, or burning odor

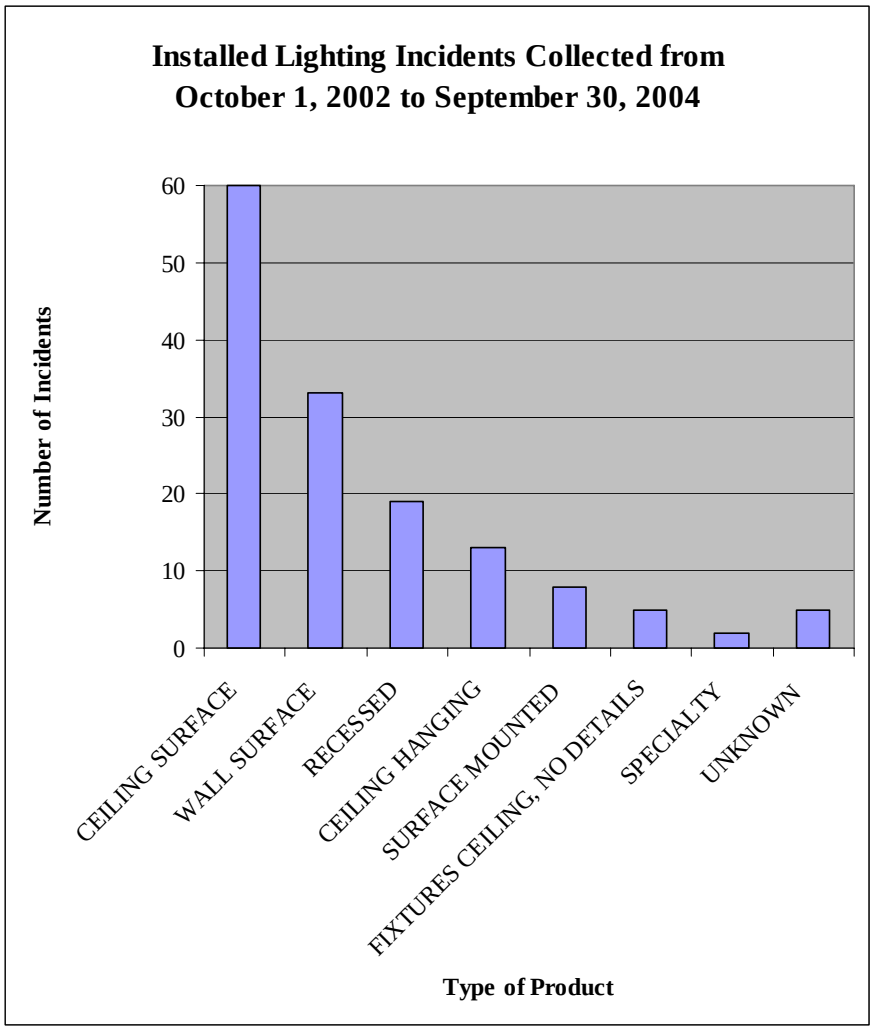

Figure 2. Incidents Involving Installed Lighting Products

The hazards identified in the 145 IDIs were: fire (74), potential fire (57), explosion (11), electrical shock (2), and electrocution (1). Product or component failures identified in the IDIs included: bulb (44), wiring (24), fixture (25), other such as ballast, connection, switch, housing, etc. (22), combination of components (5), and unknown (25).

C. Incidents Associated with Other Factors

There were 79 incidents in which external factors may have contributed to the incident (e.g., lamp knocked over onto combustible material, lamp shade contacted a light bulb, power cord pinched by furniture, excessive wattage, or light bulb shattered). Among the 79 incidents, there were 40 incidents related to the heat from the bulb igniting nearby combustibles such as curtains, clothes, bedding materials.

VII. TASK 2 - Inspection of Collected Samples

For the 374 in-scope IDIs conducted, there were 121 incident samples and exemplars collected. The samples were separated into two groups, portable (67) and installed (54) lighting products. CPSC engineering staff examined all the samples; a summary of the results of the staff examination is presented below.

A. Portable Lighting Samples

CPSC engineering staff examined 67 samples that were identified as follows: clip-on lamps (2), floor lamps (17), lava/novelty lamps (2), nightlights (19), rechargeable light (1), rope lights (4), table lamps (20), and work lights (2).

1. *Clip-on lamps* (2 samples): Clip-on lamps consist of a bulb and a shade with a large clip for mounting to objects such as a bed headboard or shelving. Clip-on lamps typically have a maximum bulb rating of 60 watts (W).

    - An incident occurred when the lamp fell onto the consumer's comforter, the bulb came in contact with the comforter and caused it to smolder. The staff analysis revealed the sample showed no sign of abnormality.

    - An incident occurred when a consumer touched the metal lamp shade and was burned. The staff analysis revealed that the temperatures on the lamp shade were within the UL 153 requirements for maximum allowable temperatures.

2. *Floor lamps* (17 samples): Among 17 floor lamp samples, there were three halogen floor lamps, a candelabra-base floor lamp, and 13 Edison-base (medium-base) floor lamps.

    - Three incidents involved halogen floor lamps. All three halogen lamps did not have a guard as required by the UL standard. In one case the lamp was tipped over onto a bed and ignited the bedding materials. In another case, a blanket or a stuffed toy animal contacted the bulb of an energized halogen floor lamp and was ignited. The burning material then fell onto a nearby upholstered chair and ignited the chair. In the third case, the switch of the lamp had a poor connection which resulted in localized overheating.

    - One incident sample involved a nine-month old, UL listed, candelabra-base lampholder floor lamp. The lamp had five lamp heads on separate flexible arms to allow the consumer to illuminate different areas as needed. The analysis showed there was a short circuit in one of the lampholders which resulted in localized arcing and smoking.

    - There were 13 Edison-base lampholder floor lamp incidents. These lamps used a medium Edison screw or MES (E26) lamp base.

- Two incident samples involved a compact fluorescent bulb failing; however, there appeared to be no damage to the lamp or lampholders.

- Five incident samples appeared to involve a short circuit in the lampholders. The incident samples ranged from almost new to three years old. Of the five samples, three had 60W bulbs installed, one had a 3-way bulb (50-100-150W) installed, and the other had a 23W compact fluorescent bulb installed. For all five samples, the sockets and the bases of the bulbs showed evidence of arcing or carbonization. In three samples, the hot or center contacts of the socket were burned away. All the samples had a UL listing label.

- An incident sample involved an insulation-piercing, in-line cord switch failure. The sample was one year old. The switch had a poor connection which resulted in localized arcing and overheating. It was unknown whether the lamp was UL listed.

- An incident sample, which consisted of three lampholders and metal shades at different heights on a metal pole, was knocked down during a party and ignited nearby combustible material. The type and wattage of the bulbs at the time of the incident were unknown. The lamp was about five years old and had a UL listing label.

- A goose-neck type floor lamp exemplar with a 27W fluorescent bulb showed no electrical abnormalities that would result in a fire. The incident sample was destroyed in the fire. It was also reported that candles were lit during the night of the incident.

- Three incidents involved a power cord failure. All the lamps ranged from almost new to 16 months old. One incident sample was badly damaged in a fire and showed evidence of beading on the wire. In the second sample, bare strands of wire were exposed at the location where the cord entered the top of the metal pole and led to the on/off switch. In the third incident, the IDI reported that the cord of the incident lamp began to smoke and burn from the receptacle to the lamp (the incident sample was not available, but an exemplar was collected). All the samples had a UL listing label.

3. *Lava/novelty lamps* (2 samples): In one incident a consumer discovered overheating, melting, and discoloration to the plastic housing of a two-week old electric lava lamp. This resulted from the heat of a 40W medium-base bulb. The lamp was rated for a maximum of 40W. The lamp had an Intertek (ETL) listing label. In a second incident, the power cord of a five-month old novelty lamp was severely damaged. Both plug blades were missing and the receptacle showed severe arcing. The cord insulation was bubbled, charred, and bare wires were exposed. The lamp had a UL listing label.

4. *Nightlights* (19 samples): Among 19 nightlight samples, there were three mini fluorescent, six electroluminescent, and ten standard incandescent (candelabra base) nightlights.

- Three incident mini fluorescent nightlights ranged from one month to one year old. The nightlights had an on/off switch and a small non-replaceable fluorescent bulb with an electronic ballast. The staff analysis showed that there was arcing and carbonization at the electronic ballast. All samples had a UL listing label.

- Of six electroluminescent nightlights, five were under a year old and one was about five years old. In all the incidents, the illuminating plate showed signs of overheating. All samples had a UL listing label.

- Ten incident samples were standard incandescent nightlights. Ten of the nightlights were about a year old. All the incident samples had a UL listing label.

  - Two incident samples used 4W bulbs. In one incident, the nightlight was covered by a comforter which resulted in localized charring of the comforter. In the second incident, the nightlight was covered by a stuffed animal. In both cases the nightlights were still functional, but the plastic shields had melted.

  - One incident sample had a discolored plastic housing. A 7W bulb was used at the time of the incident.

  - There were two samples (an incident sample and an exemplar) that each used a 4W bulb and a sensor to turn the light on and off automatically. Analysis of the incident sample showed degradation of internal electrical connections that resulted in an arcing failure on the circuit board. In the other incident, the IDI reported that the nightlight was blown away from the receptacle, and the plug blades were still stuck in the receptacle. An exemplar was collected, but the incident sample was not available.

  - One incident sample nightlight was overlamped, using a 15W light bulb while the lamp's label indicated a maximum 7.5W. The overlamping caused localized overheating.

  - One incident involved 4W and 7W light bulbs installed in two nightlights. One bulb shattered, and the other bulb separated from its base. There were no signs of overheating of the sockets.

  - Two incidents involved 5W nightlights. In one incident, a two-week old nightlight set off the smoke alarm. The consumer unplugged it and found it was hot to the touch. In the other incident, a one-month old nightlight

was on for a few minutes when it started to smoke; the consumer unplugged it.

- One incident resulted when a gel filled plastic shade that covered the top of nightlight's bulb melted. The nightlight had a 4W light bulb installed at the time of the incident. The light bulb and nightlight were still functional.

5. *Rechargeable light* (1 sample): A one-week old light was plugged into a receptacle for charging. Within 24 hours, the consumer heard a pop and discovered the light had fallen from the wall, and the NiCad battery had burst apart. The light had a UL listing label.

6. *Rope lights* (4 samples): The incident sample rope lights ranged in age from almost brand new to three months old. All had evidence of overheating in multiple locations. All the incident samples had UL listing labels.

7. *Table lamps* (20 samples): Among 20 table lamp incident samples, ten samples involved compact fluorescent bulbs, four samples involved electrical shorts in the medium Edison-base lampholders, two samples involved power supply cord failures, one sample involved a switch failure, one sample had a wiring connection failure, one sample involved a shock hazard, and one sample involved an overheated neon lamp.

   - Ten incidents involved failures of compact fluorescent bulbs. The compact fluorescent bulbs ranged from three months to three years old. In all the incident samples, either the ballasts of the bulbs failed or the filaments in the fluorescent glass tubes overheated resulting in melting or discoloration of the plastic bulb housing, or breaking of the glass tube. All the samples had UL listing labels.

     Compact fluorescent bulbs have several end-of-life failures that produce additional heat and smoke. In most cases, when the filament burns out or the electronic ballast fails, it emits smoke, chars or melts the plastic housing, or possibly breaks the glass tube; then the bulb no longer functions. UL 1993, *Self-Ballasted Lamps and Lamp Adapters*, requires the plastic housing of the bulb to meet UL 746C, *Polymeric Materials – Use in Electrical Equipment Evaluations*, for flammability rating.

   - Four incident samples appeared to involve a short circuit in the Edison-base lampholders. The lamps ranged from three months to three years old. Two samples used 60W bulbs, one sample used a 3-way bulb (50-100-150W), and one used a 23W compact fluorescent bulb. The lamp sockets and the bases of the bulbs installed at the time of the incidents showed evidence of arcing or carbonization. The hot contacts of the socket were burned away in three of the incident samples. All the lamps had UL listing labels.

- Two incident samples involved cord failures. In one incident, the consumer reported that the cord of a teddy bear lamp was pinched by a dresser drawer and ignited. The burning cord then contacted the carpeted floor, and the fire quickly spread to the house. The incident sample was about seven years old, and it could not be determined if it had a UL listing label because it was badly damaged during the fire. The incident sample had evidence of beading in the wires, which would tend to confirm that the cord may have been damaged.

  In the other incident, it was reported that a fire started behind a headboard and ignited the bed. The three-year old lamp was plugged into a wall receptacle behind the headboard. The lamp had a UL listing label. The lamp was undamaged except for the power cord insulation, which had melted and burned away. For unknown reasons, the attachment plug was not included in the collected sample. The cord showed beading at the ends of the conductors.

- One incident sample involved a switch failure of a 20-year old lamp. The switch had localized overheating.

- One incident occurred with a five-year old lamp that contained a ceramic housing, a 7W bulb, and a power cord with an in-line cord switch. A screw used for the in-line cord switch was screwed into the electrical hot conductor, which presented a shock hazard.

- A one-month old incident sample exhibited a connection failure of the lampholder. It appeared that the neutral conductor had a high resistance connection or short, which resulted in a fire. The sample had a UL listing label.

- One incident involved a small motorcycle-shaped neon light that overheated while energized. The incident occurred in a store; the incident sample was not available for analysis.

8. *Work lights* (2 samples): One incident involved a 13-month old fluorescent work light. The wires in the ballast area of the light overheated. Another incident involved a new dual halogen work light. The power cord smoked and arced at the junction where the cord splits for each light. The analysis showed a poor crimp connection most likely caused the overheating. Both samples had a UL listing label.

B. Installed Lighting Samples

CPSC engineering staff examined 54 samples that were identified as follows: ceiling-hanging lights (5), ceiling-surface-mounted lighting fixtures (33), wall-mounted lighting fixtures (13), and furniture/cabinet-mounted lighting fixtures (3).

1. *Ceiling-hanging lights* (5 samples): Two incident samples involved ceiling lights with UL-listed compact fluorescent bulbs installed. The compact fluorescent bulbs overheated, resulting in smoke. Two incidents involved the explosion of a 60W bulb. The other incident involved a switch failure of a UL-listed light ; the switch had a poor connection which resulted in localized overheating.

2. *Ceiling-surface-mounted lighting fixtures* (33 samples): Among the 33 ceiling-surface-mounted lighting fixture samples, 21 incidents involved installed compact fluorescent bulbs, one incident involved a metal halide lamp, five incident samples used candelabra-base lampholders, 3 incident samples used an Edison-base lampholder, one low voltage light, one halogen track light, and one incident involved a light cover for the ceiling lighting fixture.

    - Twenty-one incidents involved a compact fluorescent bulb failing in the lighting fixture. In these samples, either the ballast of the bulb failed or the filaments in the fluorescent glass tube failed resulting in smoke. The analysis indicated that there was little or no damage to the lampholders.

      In most cases, when the filament burns out or the electronic ballast fails, it emits momentary smoke, chars or melts the plastic housing, or possibly breaks the glass tube, before becoming permanently disabled. UL 1993, *Self-Ballasted Lamps and Lamp Adapters*, requires the plastic housing of the bulb to meet UL 746C, *Polymeric Materials – Use in Electrical Equipment Evaluations*, for flammability rating.

    - One incident involved a 400W metal halide light. It exploded in a manufacturing facility and caused a fire to nearby combustible materials.

    - Five incidents involved a short circuit in candelabra-base lampholders. The lighting fixtures ranged from four to eight years old. Each fixture had three or four candelabra-base lampholders that were connected in parallel to the power supply cord. The sockets and the bases of the bulbs showed evidence of overheating and arcing. Portions of the internal electrical wiring were burned and melted. The lampholders also contained cracks. All the lighting fixtures had UL listing labels.

    - Three incident samples involved ceramic Edison-base lampholders. Two incidents appeared to involve a short circuit in the fixtures' lampholders. These samples had UL listing labels. In one of the incidents, the fixture was 10 years old and had three ceramic Edison-base lampholders. The lampholders showed signs of corrosion and deterioration. The wires leading to the lampholders were overheated and discolored. In the other incident, the fixture was about seven years old and had two ceramic Edison-base lampholders. The wire insulation was brittle and was missing in some places resulting in bare conductors. These lampholders had signs of corrosion and deterioration.

The third incident involved a lighting fixture with a single ceramic Edison-base lampholder with a 60W incandescent bulb installed. The portion of branch wiring connected to the sample showed signs of overheating; however there was no damage to the lampholder or the bulb. The lighting fixture socket had a CSA imprint.

- A seven-week old incident sample involved a low-voltage lighting fixture. The light had a UL listing label. The staff analysis revealed that the sliding fuse tray of the light was not fully inserted into the fuse contact box, which resulted in a high resistance connection and localized overheating of the metal spring contacts.

- One incident sample involved an 115V halogen track light. The housing showed signs of discoloration. The analysis revealed that the cause of the discoloration was most likely from the radiant heat from the light bulb. The remainder of the lighting fixture showed no signs of damage.

- One incident sample involved the glass globe cover for a lighting fixture; the cover separated from the fixture, shattering when it hit the floor. The fixture was about 16 months old and had a UL listing label. The staff analysis did not reveal any fire or shock hazards.

3. *Wall-mounted lighting fixtures* (13 samples): Among the 13 wall-mounted lighting fixture samples examined, 7 samples involved installed compact fluorescent bulbs, one incident involved melting of the fixture's plastic housing, two incidents involved overheating of internal components in emergency lighting fixtures, two incidents involved melting of plastic components of outdoor lighting fixtures, and one incident, which caused electrical shock, involved an outdoor flood light.

   - Seven incident samples involved wall-mounted lighting fixtures with compact fluorescent bulbs installed. Six of the compact fluorescent bulbs used electronic ballasts, and one used a magnetic ballast. The samples were between eight weeks to two years old. Five samples had UL listing labels, one sample had an ETL listing label, and one sample had a CSA listing label. For all the samples, either the ballast of the bulb failed or the filaments in the fluorescent glass tube overheated resulting in smoke and/or smoke odor. The analysis showed that the lampholders had little or no damage.

   - A fairly new incident sample involved a wall lighting fixture which used candelabra-base bulbs. At the time of the incident, 40W bulbs were installed. The incident involved melting of the plastic housing. The lighting fixture had a UL listing label. The analysis revealed that the lighting fixture was improperly installed when the consumer over-tightened the mounting screws, causing the plastic housing to lean toward the light bulb.

- Two incidents involved emergency lights. Both samples had UL listing labels. The samples, which were manufactured by the same company, were approximately two years old and five years old. The analysis revealed that an internal electrical component overheated in the samples resulting in localized overheating.

- Two incidents involved outdoor lights with Edison-base lampholders. Both samples had a UL listing label. The analysis of one incident sample showed that the plastic that holds the ceramic light socket melted. The light was installed for approximately 10 months. The other incident sample had a melted plastic housing for the motion sensor. The light was installed for approximately seven months. The analysis showed that there was no indication that the sample would have ignited.

- One incident sample involved an outdoor floodlight where the consumer was shocked during installation. The analysis showed that most likely a screw had contacted the internal wiring during production and assembly of the light. The sample was new and had a UL listing label.

4. *Furniture/cabinet-mounted lighting fixtures* (3 samples): One incident involved an under-cabinet light in a kitchen in which the electronic ballast of a 15W fluorescent light overheated. The light was 13 months old and had a UL listing label. One incident involved a compact fluorescent bulb overheating in a lighting fixture mounted under a desk. The light was15 months old and had a UL listing label. The third incident involved a halogen light mounted under a kitchen cabinet. The plastic that supports the fixture's glass cover melted, which resulted in the glass cover dropping to the counter below. The light was two months old and had a UL listing label.

VIII. DISCUSSION

CPSC staff elected to conduct a more detailed analysis of two of the failure modes that were identified: A) Failures associated with installed ceiling-surface-mounted fixtures, and B) Damage to power supply cords for portable lighting products. These topics were selected because they appeared to be addressable failures. Both of these are discussed below.

A. Ceiling-Surface-Mounted Fixtures

A ceiling-surface-mounted fixture typically consists of a metal housing/plate with three or four lampholders (candelabra-base or Edison-base) attached to it. The lampholders are connected to the input power via wiring, which ultimately is connected directly to the home's branch circuit wiring. In the samples examined by CPSC engineering staff, the lampholders were connected to the input power by sandwiching the wiring between two socket halves that included insulation-piercing electrical terminals directly onto the cord, as illustrated in Figure 3; the socket halves were then riveted together to mechanically hold the connection.

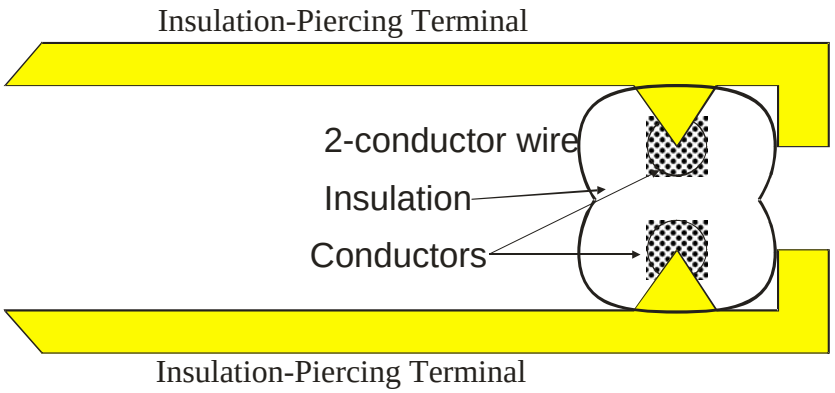

Figure 3. Insulation-Piercing Terminals for Lampholders

Depending on the depth of the housing (proximity of the bulbs to the ceiling), the fixture may include thermal insulation over the lampholders, which would help protect the ceiling from damage due to bulb heat, as illustrated in Figure 4.

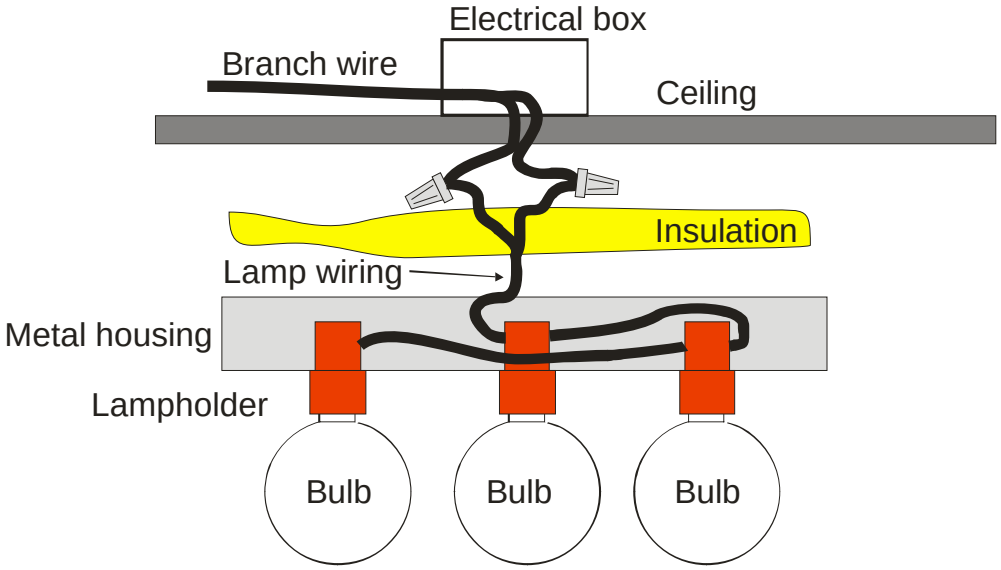

Figure 4. Typical Configuration for Ceiling-Surface-Mounted Lighting fixture

The following are analyses of descriptions of incidents collected by CPSC field investigators and samples examined by CPSC engineering staff.

- *Analysis of Incident Sample from IDI 060426CCC3467 (This incident occurred after the collection period of October 1, 2002, to September 30, 2004, so it was not included in the total number of incidents.)*

CPSC Field Investigator's Report

In December 2005 and January 2006, an electrical contractor installed about 100 ceiling lighting fixtures in all the corridors of the buildings of a brand new ski resort village. The village consists of a five-story condominium complex with 60 residential one- to three-bedroom condominiums and four commercial businesses on the ground floor, a four-story condominium complex, and a single-story condominium complex. The ceiling lighting fixtures contained four 60W candelabra-base bulbs, which were on 24 hours a day.

In February 2006, fire department personnel at the ski resort responded to a smoke alarm on the third floor corridor of the five-story condominium complex. The building maintenance supervisor reported that he had checked the corridor and found smoke in the hallway and a strong electrical smell. Fire personnel checked the corridor and noted the strongest electrical smell was coming from a ceiling lighting fixture next to the smoke alarm. The building maintenance supervisor contacted an electrician who removed the lighting fixture and found the internal wires charred and one wire in direct contact with the metal housing.

In April 2006, fire department personnel responded to a smoke alarm on the second floor corridor of the same condominium complex. They found light smoke in the corridor and a strong electrical smell. They took apart the ceiling lighting fixture next to the smoke alarm and found charring and a burnt wire. The fire department reported that they responded to at least four similar incidents involving the lighting fixtures at the ski resort.

An incident sample was collected by the CPSC field investigator and sent to CPSC staff for analysis.

CPSC Engineering Staff Analysis

The ceiling-mounted lighting fixture did not have any label or information regarding its model and manufacturer. However, the contractor who did the original installation provided model and manufacturer information to the fire chief. The product description from the manufacturer's Web site included the following: 15"W x 7 ½"H, four 60-watt candelabra bulbs, 11 lbs natural iron finish with screened opal glass, and UL-listed.

The incident sample had one burned-out 25W bulb and two severely damaged 60W bulbs. The only remnants of the two 60W bulbs were two brass-colored screw shells that still remained in the two light sockets. The lighting fixture was rated for four 60W bulbs; the four lampholders were UL Recognized Components rated at 75W. The glass lens/cover and manufacturer's labels were missing. Figure 5 shows a view of the fixture base that encloses the wiring. Soot deposits were found on all surfaces inside the fixture base.

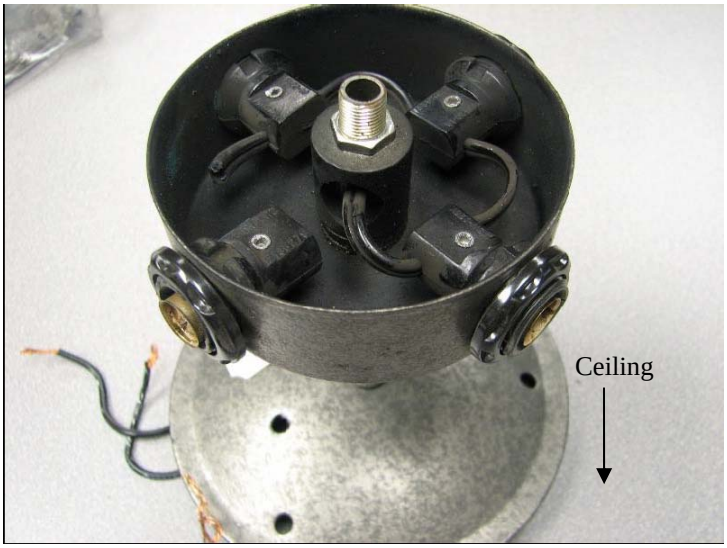

Figure 5. Lampholders in Incident Sample

The fourth socket was damaged from overheating; it appeared that a portion of the wiring to that socket was consumed in a local fire, as shown in Figure 6.

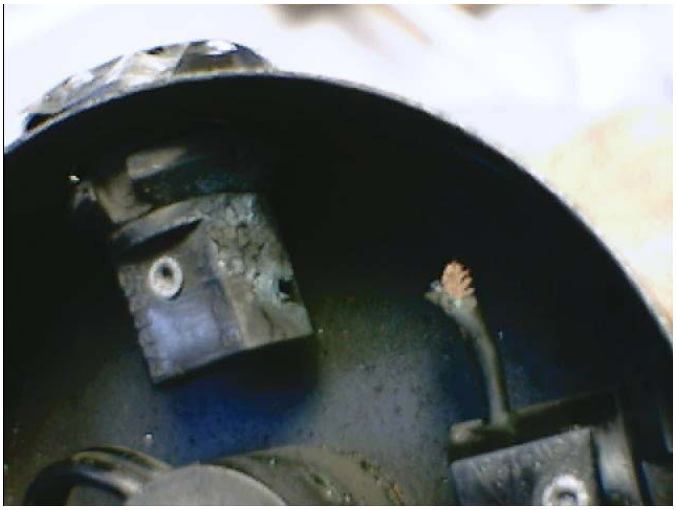

Figure 6. Damaged Fourth Socket of Incident Sample

A close-up view of the wiring leading to the fourth socket showed a ball of re-solidified copper on the “hot” conductor (a small amount of insulation was trimmed away for examination), as shown in Figure 7. In addition, the condition of the exposed wiring inside the fixture base showed signs of thermal damage. The wiring to the damaged fourth socket was brittle; the exposed wiring that connected the other three sockets was quite stiff and not pliable. However, the rest of the wiring, including the portion that was inside a rod leading to the ceiling disk, retained its pliability and did not show any signs of thermal damage.

Figure 7. Close-up of Wiring to the Fourth Socket

Figure 8 shows the interior conditions of sockets No. 2 and No. 4. As shown, both insulation-piercing terminals of socket No. 2 were still intact and undamaged. Socket No. 4 had only part of its vertical insulation-piercing terminal (neutral contact); the lower portion that had a sharp triangular tip for piercing the insulation was missing and perhaps consumed by the localized overheating. The horizontal insulation-piercing terminal (hot contact) was completely consumed and only a greenish mark was left where the electrical wire entered the socket. The remains of this socket were charred and brittle.

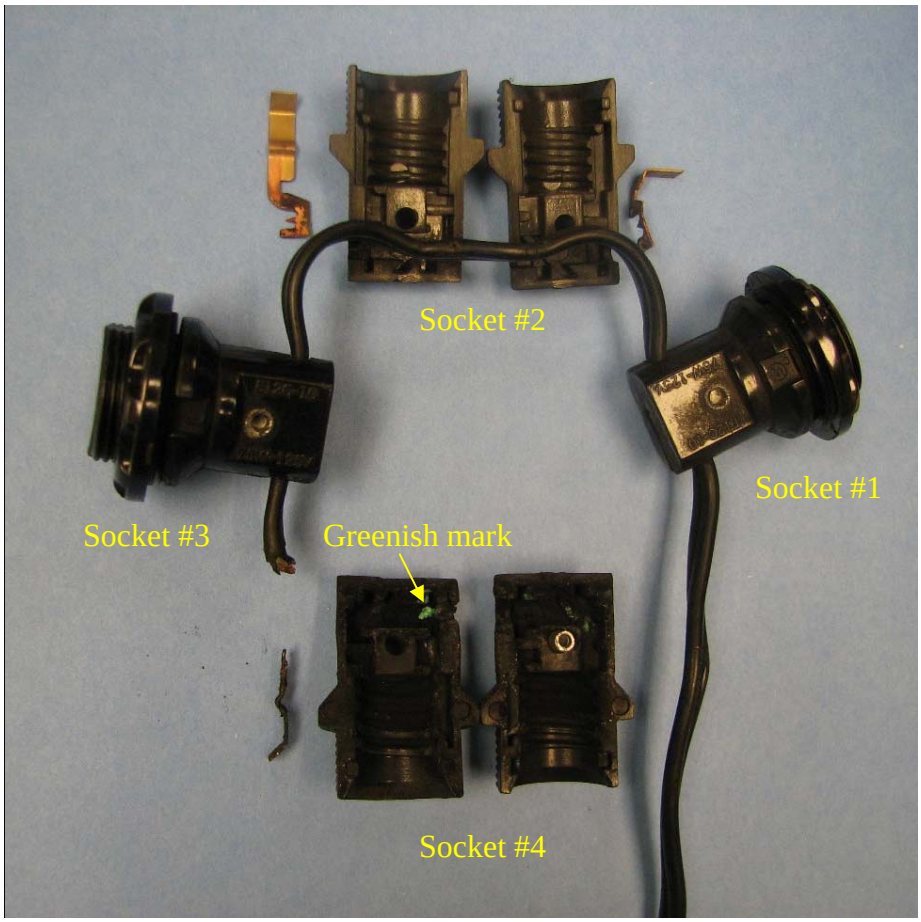

Figure 8. Four Sockets Removed from Fixture with Socket Nos. 2 and 4 Disassembled

Examination of the incident lighting fixture showed thermal damage from overheated electrical connections within the lighting fixture base. There was evidence of a localized flame in one lampholder or socket (No. 4). The likely causes of the incident may have been from insufficient cooling from the radiant heat generated by the four light bulbs (total 240W), a poor wire-piercing connection, a short within the lampholder, or a combination of these.

- *Analysis of Incident Sample from IDI 050712CCN0745 (This incident occurred in 2005 after the collection period of October 1, 2002, to September 30, 2004, so it was not included in the total number of incidents.)*

CPSC Field Investigator's Report

In 1996, a consumer built a two-story wood frame house with a finished basement. The house has attached garages at both the first floor and basement levels. The consumer installed three ceiling-mounted lighting fixtures in the hallway and stairway leading to the basement. The lighting fixtures had a polished brass base with a beveled glass cover. Each fixture contained three light bulbs. The base was mounted at

the ceiling, and there was fiberglass insulation covering the wiring, between the fixture and the ceiling.

The consumer used these lighting fixtures without noting any problems for over seven years; however, he did notice that the bulbs often burned out. This happened again in 2003, when the consumer noted that two of the bulbs in one of the fixtures were out. When he went to change the bulbs, he noticed that the sockets were severely melted around the burned out bulbs. He purchased a new lighting fixture of the same model to replace the damaged one; he threw the old fixture away. During this process, he noted that the new lighting fixture was slightly different from the old one. The "old style" lighting fixture had the bulbs installed directly in the base of the fixture; the "new style" had the bulbs installed onto a center pole. After replacing the damaged lighting fixture, he continued to use the three lighting fixtures in the basement hallway/stairway for the next two years without any additional problems.

In May 2005, the consumer experienced an incident with a second "old style" model lighting fixture, which was installed in the basement hallway. During this incident, he observed a popping and banging sound. When he investigated further, he saw a flash of light – a torch-like flame – coming from the lighting fixture. He quickly turned off the light, but the flames continued. He used a fire extinguisher to put out the fire.

The incident and exemplar samples of the old and new style fixtures were collected by the CPSC field investigator and sent to CPSC for analysis.

CPSC Engineering Staff Analysis

There were three samples for analysis: one incident unit (old design) and two exemplars (one new and one old design). The samples were ceiling-mounted fixtures with each fixture consisting primarily of a metal housing/plate with three candelabra-base lampholders and mini globes or round bulbs. The three lampholders were connected in parallel to the input power and located 120 degrees apart from each other. The fixture had an octagonal-shaped glass cover with decorative brass edging. The fixture also had a foil-backed fiberglass insulation pad which, when installed, was sandwiched between the base and the ceiling. Each socket was rated "75 watts, 125V." The sockets did not have a UL Recognized Component marking. Each fixture had a warning label "…RISK OF FIRE 25 watt lamp max…"

Figure 9 shows the thermal damage on the incident "old design" sample. Soot deposits were seen on the fiberglass insulation. The parallel-conductor power supply cord, which had a temperature rating of 125°C, was separated from the last socket. Copper balls were observed on each conductor at the last socket terminal; the socket was brittle. The thermal damage appeared to be the result of localized arcing.

Figure 9. Incident Sample “Old Design”

It appears that overlamping of the incident sample may have contributed to the failure. The bulbs installed in the lampholders were 25W, 40W, and 60W; the bulbs should have been 25W maximum. The markings on the lampholders were not consistent with the markings on the socket or the fixture, which could be misinterpreted by a user.

The new design fixture had three sockets mounted horizontally into an extension at the center of the fixture, as shown in Figure 10. The wiring in this fixture had a temperature rating of 150°C. This fixture contained two burned-out 60W bulbs (broken filaments and/or detached glass bulb) and one operational 25W bulb. The sockets of the fixture appeared normal, but the white insulation of the wiring was discolored.

Figure 10. The Exemplar “New Design”

Staff conducted operational tests of the exemplar units to determine the temperature between the fiberglass insulation and metal housing when different light bulb wattage combinations were installed in the units. A digital thermometer with type-K thermocouples was used to record the temperatures. The results of the staff tests are shown in Table 1. These were approximate readings after about two hours of continuous operation. The temperatures fluctuated by a couple of degrees during testing and represent testing in a controlled environment. Environmental factors that could affect actual temperatures in a home installation, such as from an insulated attic space, were not accounted for in the staff testing. Test results showed that the temperatures were not much different between the old design and the new design.

Table 1. Maximum Temperatures Using Various Wattage Bulbs

Maximum recorded temperatures of various bulb combinations	**Sub 1 – Old design**		**Sub 2 – New design**	
	T1—at the black and white insulators	T2—inside the steel plate	T3—at the black and white insulators at the center core	T4—inside the steel plate
3 bulbs @ 25W 118.4V, 0.60A, 70W	71.2°C	80.2°C	74.5°C	80.6°C
2 bulbs @ 25W 1 bulb @ 60W 119.3V, 0.73A, 86W	75.9°C	88.0°C	96.8°C	108.3°C
2 bulbs @ 60W 1 bulb @ 25W 118.3V, 1.0A, 117W	84.3°C	106.2°C	107.1°C	115.1°C
3 bulbs @ 60W 118.5V, 1.27A, 149W	95.8°C	115.8°C	110.2°C	119.2°C

In the staff tests, overlamping resulted in significant increases in temperatures inside the fixtures' metal housings. The increase was dependent on the number (one, two, or three) of incorrect bulbs. Excess energy in the form of heat can shorten the useful life of the wiring insulation and other components in a lighting fixture, which could lead to a potential fire hazard.

- *Analysis of Incident Sample from IDI 040206HNE1315*

CPSC Field Investigator's Report

The incident occurred on January 7, 2004, in a 2,200 square-foot, center-hall, two-story colonial home built in 2000. The consumer's five-year old daughter entered the upstairs hallway from her room and heard a loud "pop" sound. Almost immediately after hearing the loud sound, the girl observed smoke coming from a lighting fixture and screamed. The consumer's 16-year old son entered the upstairs hallway to investigate; he

reported that he observed flames coming from the lighting fixture. The consumer's son yelled to his father that the light was "on fire," and he immediately turned the light off at the wall switch. The father had his wife dial "911" and ran to the location of the lighting fixture. By the time he arrived, it appeared that the flames had self-extinguished as he did not observe any flames, but smoke continued to "pour from the fixture." There were no injuries as a result of the incident.

The homeowner reported that there were three lighting fixtures in the home that were provided by the builder, and the incident lighting fixture was one of them. The ceiling-mounted, hard-wired, three-bulb lighting fixture was installed by the builder in the upstairs hallway at the top of the home's main staircase. Three 25-watt, incandescent bulbs were installed in the fixture at the time of the incident. The consumer described the bulbs as clear-colored, round in shape, with a smaller-than-normal base. The lighting fixture had an inverted bowl-shaped shade that the consumer believes was made out of glass. The shade was discarded immediately after the incident. The lighting fixture was used on a daily basis.

The incident sample was collected by the CPSC field investigator for analysis.

CPSC Engineering Staff Analysis

The incident sample was a lighting fixture consisting of a steel housing/plate with three candelabra-base lampholders; each lampholder was rated for a maximum 25W bulb. A rod threaded on both ends passed through the center of the plate; one end was used to attach the fixture to the electrical outlet in the ceiling, and the downward end of the rod was used to hold the glass cover. The three lampholders were connected in parallel to the input power via wiring. The wiring was sandwiched between two socket halves with insulation-piercing terminals, and the socket halves were riveted together. The fixture included foil-backed fiberglass insulation, which covered the lampholders.

Figures 11 and 12 show the lighting fixture as received. The glass cover was not included in the sample. One socket contained the base of a bulb. The housing/plate was slightly rusty in two areas but was otherwise intact. On the exposed surface of the plate, there was a warning label to use only 25-watt bulbs or lower; the label was faded and nearly illegible. The bare ground conductor was firmly attached to the plate on the top (ceiling side) of the fixture.

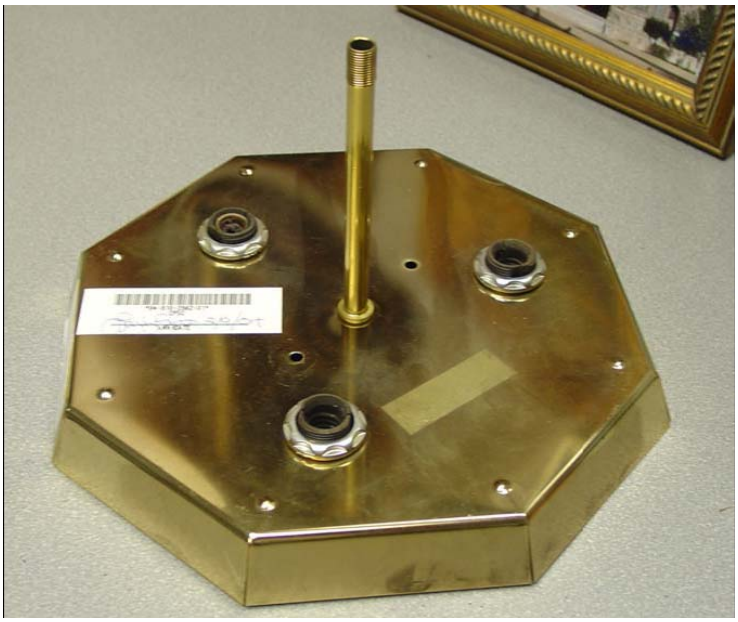

Figure 11. Lighting fixture Exposed Surface

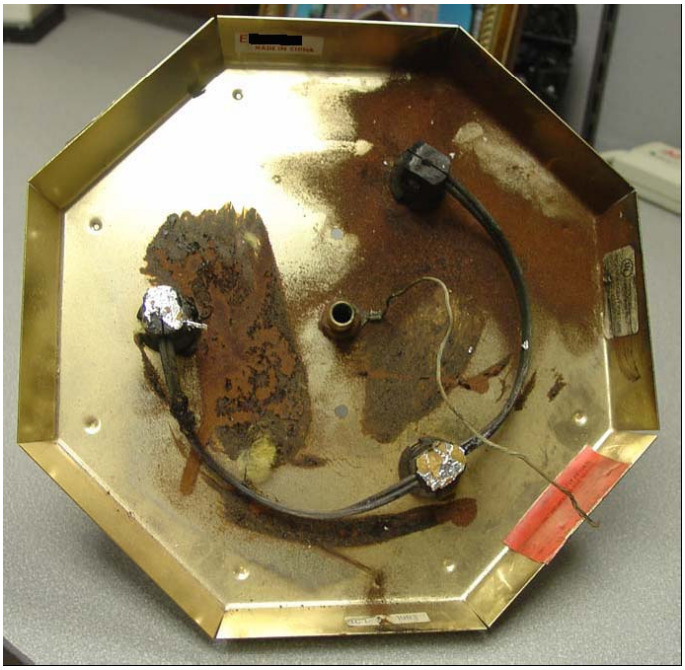

Figure 12. Lighting fixture Top (Ceiling-Side) Surface

The plastic sockets were overheated and cracked. The interior of one socket (physically, the first one attached to the electrical wiring as it entered the fixture from the house wiring) was blackened and sooty inside. When this socket was split open, it was found that one of the insulation-piercing terminals had burned away. The other terminal was burned and corroded.

The foil insulation (the side that is positioned against the plate) was covered with soot in the area next to the socket. Inside the burnt socket, the input power wiring was burned and melted and had green/blue corrosion on the copper wire strands. Figure 13 shows a close-up picture of the socket. Figure 14 shows a picture of the wiring after its removal from the socket. The wires showed no sign of arcing or beading.

Figure 13. Overheated Socket

Figure 14. Electrical Wiring in Socket

Most likely, the initial assembly of the socket/insulation piercing terminals to the wiring resulted in a poor electrical connection. Over a period of use, the poor connection resulted in overheating of the connection and socket. The three bulbs likely exacerbated the problem by providing additional heat, which would be trapped between the metal disk

and the fiberglass. The wiring insulation degraded, and the copper conductors became corroded and embrittled.

The incidents described in the IDIs and the samples analyzed by CPSC staff suggest that when a high-resistance connection occurs between an insulation-piercing terminal and the copper strands of a conductor, it causes excessive heat at the socket. The result is degradation of the socket and the wire insulation over a period of time, which has the potential to lead to fire. The condition may be exacerbated by heat from the fixture's bulbs that is trapped between the metal housing/plate and the thermal insulation.

B. Power Supply Cords for Portable Lighting Products

The analysis of incidents in the IDI reports suggests that lamp power cords can be damaged in various scenarios, such as being pinched or crushed by furniture. In most cases, the incidents resulted in fire that spread beyond the product and, ultimately, destroyed the product. In these cases, the CPSC engineer relied heavily on the IDI reports for eyewitness accounts during the early stages of an incident to determine possible causes for the incident. The following are staff analyses of incident data collected by CPSC field investigators.

- *CPSC Field Investigator's Report IDI 031125HCC2141*

In October 2003, a consumer came home and observed smoke coming out the front windows of his house. He heard crashing sounds and witnessed the glass break in his bedroom. The fire department was dispatched to the structure fire that occurred at approximately 5:50 p.m., and they quickly extinguished the fire.

After the fire was extinguished, the consumer was questioned as to what had been in the area where the fire originated. He stated that there was a night stand/end table with an alarm clock and a table lamp without a lampshade on it. He stated that he was certain that the lamp was off before he left. The fire investigator found that the electrical cord of the lamp was burned off about one-and-a-half inches from the base of the lamp. The area where the electrical cord insulation was burned off showed beading. The lamp and alarm clock had both been plugged into an undamaged outlet about two feet away. The consumer stated that there were clothes and magazines piled in the area where the fire originated. The incident lamp was not available for collection.

- *CPSC Field Investigator's Report IDI 040504HCC1655*

In January 2004, all three floors of a twin home apartment were occupied by tenants when a fire occurred. The owner of the adjoining twin house was also at home. The Fire Marshal stated that a 53-year-old male victim had a table lamp that was connected to a wall receptacle. The lamp was sitting on top of a wooden bookcase. The electrical cord of the lamp was pushed against the wall by the bookcase. The Fire Marshal stated that the bookcase actually sat on the cord, resulting in the cord being pinched and shorted, igniting the bookcase and the other combustibles in the living room.

The fire spread rapidly because of the paneling in the victim's apartment and paneling located throughout the entire building. The occupants of the apartment house and the adjoining home were alerted to the fire by their smoke alarms. Everyone was able to escape the fire safely except for the victim. The Fire Marshal stated that it appeared that, as the victim attempted to exit his apartment, he was overcome by smoke. The victim's body was found lying between his kitchen and the doorway to the rear exit of the house. The incident lamp was not available for collection.

- *CPSC Field Investigator's Report IDI 030414HEP9002*

An eight-year old female received an electrical burn to her right thumb when she touched a cord that had been chewed by a puppy. She was taken by her family to the emergency room where she was treated and released. It was reported that there was no flame or smoke involved in the incident. The incident sample was not available for collection.

IX. CONCLUSIONS

CPSC staff reviewed 402 lighting product-related In-Depth Investigation reports for investigations conducted from October 1, 2002, through September 30, 2004. The scope of the collection effort included all types of portable and installed lighting products, except seasonal lights or displays. Of the 402 IDIs analyzed, 374 IDIs were within the scope of the project. These included 150 incidents involving portable lighting products, 145 incidents involving installed lighting products, and 79 incidents involving lighting products in which external factors may have contributed to the incident. For the 374 in-scope IDIs conducted, there were 121 incident samples and exemplars collected. CPSC engineering staff examined all the samples.

CPSC staff examination of a particular style of ceiling-surface-mounted fixtures that were collected from seven incidents (five occurred during the collection period of October 1, 2002 to September 30, 2004 and the other two occurred after the collection period) revealed that the lighting fixture sockets showed evidence of overheating and arcing. Portions of the internal electrical wiring were burned and melted. The incidents described in the IDIs and the samples analyzed by CPSC staff suggest that when a high-resistance connection occurs between an insulation-piercing terminal and the copper strands of a conductor, it causes excessive heat at the socket. The result is degradation of the socket and the wire insulation over a period of time, which has the potential to lead to fire. The condition may be exacerbated by heat from the fixture's bulbs that is trapped between the metal housing/plate and the thermal insulation, especially in the case of overlamping. Among the seven incidents, one involved overlamping.

Among 150 follow-up IDIs, there were 29 incidents involving power cord failures due to damage caused by various scenarios (e.g., pinched by a bookcase, crushed by a bed headboard, chewed by pets, etc.). In most cases the incidents resulted in large fires, and in some cases the incidents posed a shock hazard to the users. Analysis of actual incident samples proved difficult since incident samples were often destroyed in the fires or the collected samples were badly damaged, obscuring evidence of how the fire started. Examination of the incident samples that were not badly damaged and review of information from the IDI reports indicated that the damaged cord arced or shorted, causing the insulation to melt and possibly ignite nearby combustibles.

APPENDIX A

Hazards Related to Electric Lighting Products

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: March 8, 2005

TO : Anna Luo
Project Manager, Electric Lighting Products Project
Directorate for Engineering Sciences

THROUGH: Russell Roegner, Ph.D. RR
Director, Division of Hazard Analysis
and Acting Associate Executive Director
Directorate for Epidemiology

FROM : Risana T. Chowdhury RC
Division of Hazard Analysis

SUBJECT : Hazards Related to Electric Lighting Products *

An estimated 8,780 residential structure fires (excluding incendiary and suspicious fires) associated with all electric lighting products, were attended by fire departments annually from 1995 through 1999. These fires resulted in an estimated 310 civilian injuries, 40 civilian deaths, and $119.2 million in property loss, annually (Table 1). According to the latest report available, an estimated 6% of all consumer product-related electrocutions in 2001 were attributable to electric lighting products. [1]

In order to obtain information about hazards related to lighting products, CPSC staff identified and reviewed 402 follow-up investigations of incidents [2] occurring between October 1, 2002 and September 30, 2004. Of interest were portable products such as floor/table/desk/clip-on lamps, and work/rope/night lights, as well as permanent products such as all mounted/hanging/recessed lighting fixtures. The focus of this data review was on structure fires, potential fires[3], electrocutions, electric shocks, or electrical hazards. After screening the investigation reports to retain only the in-scope cases, 374 incidents were classified into three distinct groups. One group involved the malfunction of portable products (150 incidents), while another group involved malfunction of installed products (145 incidents). A third group

*The views expressed here are those of the CPSC staff. They have not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

[1] Chowdhury, Risana T.; 2001 Electrocutions Associated With Consumer Products, June 2004, Directorate for Epidemiology, Division of Hazard Analysis, U.S. Consumer Product Safety Commission.

[2] While they are not a statistical sample of all incidents that may have occurred between October 2002 and September 2004, they provide useful information on the incident scenarios.

[3] Flames, sparks, smoke, overheating, or burning odor.

consisted of 79 incidents where factors other than product failures created the hazard. A discussion of this last group is considered beneficial since many of the scenarios illustrate common, preventable human errors which created the hazardous conditions that led to the subsequent chain of events. Analysis of each of these groups is presented separately below.

Table 1
Estimated Residential Structure Fires, Deaths, Injuries, and Property Loss Associated with All Electrical Lighting Products
1995-1999

Year	Fire Estimates[4]	Death Estimates[5]	Injury Estimates[6]	Property Loss Estimates(millions)[7]
1995	8,800	50	310	$120.3
1996	9,000	60	330	$103.2
1997	9,600	30	340	$142.8
1998	8,000	60	250	$102.5
1999†	8,500	20	310	$127.0
Total	43,900	220	1,540	$595.8
Annual Average	**8,780**	**40**	**310**	**$119.2**

Sources: Smith, L., and Mah J., Revised Residential Fire Loss Estimates 1980-1998, Division of Hazard Analysis, Directorate for Epidemiology, U.S. Consumer Product Safety Commission.
Miller, D., Smith, L., and Greene, M., 1999 Residential Fire Loss Estimates, Division of Hazard Analysis, Directorate for Epidemiology, U.S. Consumer Product Safety Commission.
† Due to change in data structure, use of 1999 data with earlier data for trend comparison is not recommended.

I: Failure of Portable Products

Product Description

A portable lighting product is an appliance (usually cord-connected) capable of being easily moved by hand from place to place. This category includes table lamps (including touch or clap on-clap off types), desk lamps, reading lamps, floor lamps (including torchiere or pole types), night lights (usually cordless, plug-in style), work/trouble lights, decorative rope lights, and specialty lamps like lava lamps, among others. Information concerning the product type, failure mode, product age, manufacturer and safety listing is presented below.

[4] Rounded to nearest 100.
[5] Rounded to nearest 10 .
[6] Rounded to nearest 10.
[7] Rounded to nearest tenth of a million.

Product Type

Based on a review of 150 portable lighting product-related incidents, 5 hazards were identified as follows: potential fire (78 incidents), fire (60 incidents), explosions (7 incidents), electrocutions (3 incidents), and electrical shocks (2 incidents). Among the 78 potential fires, the eruption of a small flame in the product was reported in 20 incidents and smoke was reported to be emanating from the product in 19 others. In 17 other cases, the product was discovered by the consumer to have sustained some sort of fire/heat damage, although the consumer was not aware of it at the time of the incident. The remaining cases involved sparks, overheating, and burning odor in the product. Table/desk lamps, floor lamps, and night lights accounted for 86% of the total incidents. The distribution of portable lighting products classified by hazards is presented in Table 2.

Table 2
Distribution of Portable Lighting Products Classified by Hazards
October 1, 2002 – September 30, 2004

Lighting Product Type	Total	Hazard
Table/Desk lamps	**55**	Fire (30), Potential Fire (20), Explosion (4), Electrocution (1)
Floor lamps	**41**	Potential Fire (20), Fire (19), Explosion (1), Electrical Shock (1)
Night lights	**33**	Potential Fire (28), Fire (2), Explosion (2), Electrical Shock (1)
Work lights	**6**	Fire (2), Potential Fire (2), Electrocution (2)
Decorative rope lights	**4**	Potential Fire (4)
Clip-on lights	**4**	Fire (3), Potential Fire (1)
Specialty lamps	**3**	Fire (2), Potential Fire (1)
Unspecified lamps	**4**	Fire (2), Potential Fire (2)
Total	**150**	**Potential Fire (78), Fire (60), Explosion (7), Electrocution (3), Electrical Shock (2)**

Source: U.S. Consumer Product Safety Commission (CPSC), In-Depth Investigation Reports File, Directorate for Epidemiology, Hazard Analysis Division.

Sources of Failure

Based on a review of 150 portable lighting product-related incidents, the known failure sources associated with these products were mainly bulbs (21%) and power cords (19%). When more specific information was unavailable, “fixtures” were generally identified in another 19% of the incidents. Occasionally more than one component was cited as the source of failure. For instance, bulb/ballast, bulb/cord, bulb/socket, bulb/wiring, or cord/plug combinations made up another 6% of the failure sources. For a large proportion (21%) of the incidents, the extent of the damage made it impossible to identify the source of failure. The remaining incidents (15%) involved a variety of failure sources such as malfunction of the switch, screen/shade, socket, plug, housing, and sensor, among others. Table 3 below illustrates the distribution of failure mode by hazards.

Failed bulbs occurred most frequently in table lamps (13 incidents) and floor lamps (7 incidents); failed power cords occurred most often in table lamps (16 incidents) and floor lamps (10 incidents). General fixture failures were cited most often in night lights (15 incidents). Beside the fact that most (65%) of the involved products were switched on at the time of the incident, very little additional detail was available on the exact nature of failure.

For the 38 incidents where bulbs were found to be the source of failure (either alone or in combination with some other product component), the most common bulb types identified were fluorescent (15 cases) and incandescent, including black incandescent (14 cases). The ratings of the bulbs varied greatly from 0.03 watts (in electro-luminescent bulbs) to 1000 watts (in halogen bulbs). Very sketchy information was available on the ratings of the power cords or extension cords. No power cord information was available for 90 of the 150 incidents, while it was reported that no power cord was being used in another 30 incidents. In the latter cases, the products were plugged directly into the outlet. For the remaining 30 cases, the ratings of the power cords varied between 16-18 AWG and 110-300 volts. An extension cord was known to be present in only 5 incidents, but scarcely any information was available on the rating or length. For the rest of the incidents, either no extension cord was being used or no information was available.

Table 3
Distribution of Sources of Failure Classified by Hazards
Among Portable Lighting Products
October 1, 2002 – September 30, 2004

	Hazard					
Source of Failure	Potential Fire	Fire	Explosion	Electrocution	Electrical Shock	**Total (Percent)**
Bulb	19	8	4	0	0	**31 (21%)**
Power cord	3	24	0	1	1	**29 (19%)**
Fixture, no further detail available	24	2	1	1	0	**28 (19%)**
Combination of components	6	3	0	0	0	**9 (6%)**
Other (switch, shade, socket, etc.)	13	6	2	0	1	**22 (15%)**
Unknown	13	17	0	1	0	**31 (21%)**
Total	**78**	**60**	**7**	**3**	**2**	**150 (100%)**

Source: U.S. Consumer Product Safety Commission (CPSC), In-Depth Investigation Reports File, Directorate for Epidemiology, Hazard Analysis Division.

Product Age and History

A review of the 150 portable lighting product related-incidents showed that over 71% of the products were purchased new. For 22% of the cases, this information was unavailable and for the remaining 7%, it was reported that the product was bought "used". Fifty-four of the 150

failed product-components were under one year old. Forty were between 1 and 5 years old, and 10 were over 5 years old. In a few (7) cases the product was described very generally as being "a few years/ fairly/ very" old. No information was available on the age of the remaining 39 failed product-components.

For a majority (64%) of the cases, the consumers reported no prior problem with the product. For another 25%, no information was available. In 11% of the incidents the consumer reported experiencing some sort of problem with the product, or with another similar product. Repair or modification of the product was rare. Only 2 consumers reported repairing the product prior to the incident. For the vast majority (70%), no product repair had taken place, while for 29% of the cases, no such information was available.

Manufacturer and Safety Listing

Loss of information on the characteristics of the lighting products occurred most often when the products were completely destroyed in a fire or discarded by the fire departments or the owners. The manufacturer or the brand of the failed lighting product (or the relevant component) could be identified in 60% of the incidents. No information was available for the rest. Information concerning safety standards on the lighting products and the components was also limited. About 54% of the products were identified as UL/CSA listed, while no information could be obtained for 42% of them. For the remaining 4%, no safety label was visible.

Of the 150 products, 57 were identified as being equipped with a 2-prong polarized plug, 39 were equipped with a 2-prong plug (polarization was unknown for a good proportion of these), and 8 were with a 3-prong grounded plug. No information was available for the remaining 46 products.

II: Failure of Installed Products

Product Description

A permanently installed lighting product is a stationary fixture that cannot be easily moved from place to place. Installed lighting products can be mounted on or hanging from surfaces such as ceilings, walls, furniture, or under-the-counter, among other locations. The mounted fixtures may be either surface-mounted or recessed.

Product Type

A review of 145 installed lighting products shows fires (74 incidents), potential fires (57 incidents), explosions (11 incidents), electrical shocks (2 incidents) and electrocution (1 incident) to be the hazards involved. Surface mounted fixtures on ceilings and walls were responsible for

64% of the incidents. The distribution of permanently installed lighting products classified by hazards is presented in Table 4.

Table 4
Distribution of Installed Lighting Products Classified by Hazards
October 1, 2002 – September 30, 2004

Lighting Product Type	Total	Hazard
Surface mounted, ceiling fixtures	**60**	Potential Fire (32), Fire (22), Explosion (5), Electrical Shock (1)
Surface mounted, wall fixtures	**33**	Fire (18), Potential Fire (11), Explosion (4)
Recessed, ceiling fixtures	**19**	Fire (14), Potential Fire (5)
Hanging, ceiling fixtures	**13**	Potential Fire (6), Fire (5), Explosion (2)
Surface mounted fixtures on furniture, under-counter, shelf, closet, etc.	**8**	Fire (4), Potential Fire (3), Electrical Shock (1)
Fixtures on ceiling, no further detail available	**5**	Fire (5)
Other (swimming pool and emergency exit lighting)	**2**	Fire (1), Electrocution (1)
Unknown installed lighting	**5**	Fire (5)
Total	**145**	**Fire (74), Potential Fire (57), Explosion (11), Electrical Shock (2), Electrocution (1)**

Source: U.S. Consumer Product Safety Commission (CPSC), In-Depth Investigation Reports File, Directorate for Epidemiology, Hazard Analysis Division.

Sources of Failure

A review of the 145 installed lighting product-related incidents revealed that the known failure sources associated with these products were mainly bulbs (30%) and wiring (17%). As seen for portable products, often (in 17% of the incidents) the "fixture" was generally cited as the source of failure when more precise information was unavailable. For a large proportion (17%) of the incidents, no source of failure could be determined. Failures in the ballast, connections, switch, housing, cord, circuit board, or sensor made up another 15% of the incidents. For the remaining 3%, a combination of components such as bulb/ballast, bulb/wiring, or connections/wiring was cited as the source of failure. Table 5 below illustrates the distribution of failure mode by hazards.

All of the major problems such as failed bulbs, wiring, or fixtures, occurred disproportionately more often in surface mounted ceiling fixtures (20 incidents involved bulbs, 12 involved fixtures, and 9 involved wiring). Surface mounted wall fixtures ranked second both in bulb failures (9 incidents) and wiring failures (6 incidents). Recessed ceiling products ranked second in fixture failures (8 incidents). In cases of fixture failure, the specific component of the fixture was not identifiable. Other than the fact that the product was turned on in most cases (61%), very little detail was available on exactly how each failure occurred.

There were 47 incidents where either the bulb alone or some combination of components including the bulb malfunctioned. In 33 of the 47 incidents, the bulb type was fluorescent. Seven cases involved incandescent bulbs, 4 involved halogen bulbs, and 1 involved a multi-vapor metal bulb. No bulb information was available for the remaining 2 incidents.

Table 5
Distribution of Sources of Failure Classified by Hazards
Among Installed Lighting Products
October 1, 2002 – September 30, 2004

		Hazard				
Source of Failure	Fire	Potential Fire	Explosion	Shock	Electrocution	**Total (Percent)**
Bulb	4	30	10	0	0	**44 (30%)**
Wiring	19	4	0	1	0	**24 (17%)**
Fixture, no further detail available	11	13	1	0	0	**25 (17%)**
Other (ballast, connection, switch, housing, etc.)	16	5	0	1	0	**22 (15%)**
Combination of components	5	0	0	0	0	**5 (3%)**
Unknown	19	5	0	0	1	**25 (17%)**
Total	**74**	**57**	**11**	**2**	**1**	**145 (100%)**

Source: U.S. Consumer Product Safety Commission (CPSC), In-Depth Investigation Reports File, Directorate for Epidemiology, Hazard Analysis Division.

Of the 145 products, 96 were reported to have "on-off" switches (among them, 4 had pull chains, 1 was rocker-type, and 1 was touch-type). Only 4 cases reported the presence of a "dimmer" switch, and 5 cases reported no switches. For the "no-switch" scenario, a key or motion-detector activated the lights. For the remaining 40 incidents, no information on switch was reported. The time that the product was in use, immediately prior to the incident, varied from "not in use" to "continuously".

While the bulbs ranged anywhere from 2 to 400 watts, very scant information was available on wiring or switch specifics such as wire gauge, voltage, wattage, etc.

Product Age and History

A review of 145 installed lighting product related-incidents showed that around 59% of the products were purchased new. No information was available for another 39%, while only 2% reported the product to have been bought "used". Twenty-eight of the 145 malfunctioning products (or components) were under one year old, 35 were between 1 and 5 years old, and 22 were over 5 years old. In 20 cases the product was described in very general terms as being "old" or "very old". In 2 cases, where a combination of components was cited as the source of failure, the age of the one component was under 18 months while the other component was more

than 5 years old. In contrast to portable lighting products, a sizeable fraction (29%) of the permanent products was over 5 years old. No information was available on the age of the remaining 38 failed product components.

For a majority (85) of the cases, the consumers reported no prior problem with the product. For another 37 cases, no information was available. In 23 of the incidents the consumer reported experiencing some sort of problem with the product, or with another similar product. Repair or modification of the product was again rare. Only 7 consumers reported repairing the product prior to the incident. For the vast majority (99 cases), no product repair had taken place, while for 39 cases, no information was available on repair history.

Manufacturer and Safety Listing

As was the case for portable lighting products, the manufacturer or the brand of the failed lighting product (or the relevant component) could be identified only part of the time (58% of the incidents); no such information was available for 42% of the cases. Information concerning safety standards on the lighting products and the components was also limited. For 62 of the 145 cases, the products were identified as being UL listed (with one product reported as being HVI certified) and 5 products had no safety labels whatsoever. No information was reported for the remaining 77 cases.

III: Incidents Caused by Factors Other Than Product Malfunction

There were 79 cases where factors other than product malfunction played the key role in triggering the incident. The most common scenario (40 cases) was when the heat from the bulb ignited nearby combustibles. For a majority of these instances, a bare bulb (with no shade or guard) was placed very close to or in contact with curtains, clothes in a closet, or stacks of paper. In other instances, clothing articles or the lampshade ignited because the consumer either had placed clothes on top of the shade or had pushed the shade to one side. In several other instances, children, pets, or adults knocked over lamps onto combustible material (usually a mattress, blanket, rug, or newspapers) which in turn ignited. In a handful of cases, faulty installation such as insufficient clearance between the light fixture and insulation caused the problem. Another common scenario was the location of the power cord such that it got pinched by large furniture pieces. In a few cases, there was the presence of gasoline/solvent fumes, or even gas leaks in the surrounding environment; the subsequent accidental shattering of a light bulb or a spark from a light-switch ignited a flash fire and explosion. A few cases were the result of overheating due to excessive wattage, or melting due to using rope lights before uncoiling. In the remaining cases, the cause was either not a component of a lighting product (such as a faulty transformer used for outdoor lighting, a consumer contacting live wiring while working on a lighting product, or a faulty switch which was part of a separate cord kit) or could not be determined with certainty to be related to a lighting product.

Presence of Safety Devices

Whether the fire incident was a direct result of a lighting product malfunction or not, the presence and effectiveness of a safety device such as a smoke alarm, heat detector, or sprinkler system, is of interest because of the degree to which it can affect the severity of the outcome. Table 6 below presents the distribution of safety device status by disposition of the victim(s) in all 374 incidents. Except for one case with a heat detector and one with a sprinkler system, in the vast majority of the incidents, the safety device refers to a smoke alarm.

Table 6
Distribution of Safety Device Status by Victim Disposition
October 1, 2002 – September 30, 2004

Safety Device	No Injury	Treated and Released	Dead on Arrival	Transferred to Another Hospital	Unknown	Total
No safety devices or safety devices not operating	45	3	7	1	0	56
Operating safety device	55	14	5	3	0	77
Unknown if safety device present or worked	53	11	16	4	1	85
Not applicable[8]	133	19	4	0	0	156
Total	**286**	**47**	**32**	**8**	**1**	**374**

Source: U.S. Consumer Product Safety Commission (CPSC), In-Depth Investigation Reports File, Directorate for Epidemiology, Hazard Analysis Division.

A circuit breaker or a fuse can be a different type of safety device. They detect the presence of excessive current flow in the branch circuit and automatically shut it off before an electrical fire can start. For the most part (205 of the 374 incidents) no information was available on any breakers or fuses; in 118 incidents, no circuit breaker tripped; in 40 cases, the breaker was reported to have tripped, and in 3 cases, a fuse blew. In 2 additional cases, the circuit breaker was intentionally shut off by the consumer or reset after it had tripped. There was no electrical incident in the remaining 6 cases; hence, the tripping of a circuit breaker was not applicable.

Conclusion

An estimated annual average of 8,780 residential structure fires attended by fire departments from 1995 through 1999 were associated with electrical lighting products. These fires resulted in an estimated annual average of 310 civilian injuries, 40 civilian deaths, and over $119 million in property loss.

Based on 150 follow-up investigations of portable lighting product-related incidents occurring between October, 2002 and September, 2004, fire and potential fire (small flames,

[8] Safety system is considered not applicable in cases of potential fire, electrocution, or electrical shock.

sparks, smoke, overheating, or burning odor) were the major hazards and accounted for over 92% of the total incidents. Table/desk lamps, floor lamps, and night lights were the most frequently involved product types with power cord and bulb malfunctions, the most common identifiable failure sources. Most of these incidents occurred while the product was switched on for varying lengths of time (anywhere from "moments" to "continuously"). Most of the products were bought new, less than 5 years of age at the time, with no problem or repair history.

Based on 145 follow-up investigations of installed lighting product-related incidents occurring between October, 2002 and September, 2004, fire and potential fire were the major hazards once again, accounting for over 90% of the total incidents. Surface mounted fixtures, on ceilings and walls, were the most frequently involved product types, with most failures occurring in the bulb or wiring components. Similar to portable products, most of the installed products were also purchased new, less than 5 years of age, with no prior problem or repair reported.

The 79 incidents with no lighting product malfunction demonstrate a lack of consumer awareness of preventive measures that may have mitigated the hazardous conditions that triggered the incidents.