ES-2

UNITED STATES GOVERNMENT

MEMORANDUM

U.S. CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, D.C. 20207

MAY 3 1990

TO : The Commission

Through: Sadye E. Dunn, Secretary
Through: Susan Birenbaum, Acting General Counsel
Through: Thomas W. Murr, Jr., Acting Executive Director
Through: Douglas L. Noble, Director, Office of Program Management and Budget
Through: Carl W. Blechschmidt, Program Manager, Office of Program Management and Budget

FROM : Linda L. Glatz, Project Manager, Office of Program Management and Budget

SUBJECT: Transmittal of Staff Reports from the Cords/Plugs Project

The Electrical Hazards Team began a project in Fiscal Year 1988 to address fires involving appliance cords. The Directorate for Epidemiology estimates that 9,600 residential structural fires involving appliance cords have occurred annually over the period 1985-1987 and that these fires resulted in an estimated 160 deaths, 460 injuries and $92.4 million in property loss annually. The death rate per fire ranks the second highest of all electrical product groups.

Due to resource limitations, additional project work was terminated in Fiscal Year 1989. The staff completed the analysis of incident data but was unable to begin the testing and analysis of new appliance cords intended to contribute to the development of improved voluntary standards.

A major effort of this project involved the identification of incidents for investigation and subsequent analysis by the Divisions of Hazard Analysis and Human Factors, Directorate for Epidemiology (EP), and the staff of the Directorate for Engineering Sciences (ES). To identify incidents, the staff conducted a media campaign to encourage reporting of cord-related incidents where a small amount of damage had occurred. Due in large part to the efforts of the staff in the Directorate for Field Operations, we received more than two hundred samples and 281 follow-up investigations of incidents to evaluate.

The cord and plug failures represented in these samples were verified and analyzed by the ES Laboratory. This work is recorded in a series of reports now located in the ES Electrical Engineering Division files. The ES report cited below was based upon the laboratory reports and they were also used to verify the relevance of samples for inclusion in the hazard analysis.

NOTE: This document has not been reviewed or accepted by the Commission.
Initial MH Date 5/3/90

CPSA 6 (b)(1) Cleared
X No Mfrs/PrvtLblrs or Products Identified
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___ Firms Notified,
Comments Processed

This memorandum transmits three reports related to the data collected. Although the staff does not presently have a project on cords/plugs, we will share the attached reports and continue to encourage review of voluntary standards with interested industry groups such as Underwriters Laboratories, Inc., the Association of Home Appliance Manufacturers, and the National Electrical Manufacturers Association.

The reports are summarized below:

o Tab A **Technical Analysis of Failing Cords and Plugs 1988-1989, dated September 1989, by Dennis McCoskrie, Directorate for Engineering Sciences**

This report identified a number of failure modes of appliance cords such as 1) bad crimps within molded plug or connector, 2) bad mating contact with wall receptacle, extension cord current tap, or male contacts of appliance, 3) flexure failure of cord usually at sharp bend points or at entry to appliance or appliance strain relief, 4) tension failure at plug, 5) plug blades pitted from arcing caused by bad contact or withdrawal of plug while full appliance current is flowing, and 6) flexure or abrasion failure of cord insulation leading to arcing between conductors or to grounded metal objects that the ungrounded conductor contacts. This report discusses the types of failure modes observed with various appliances such as space heaters, lamps, air conditioners, irons, hair dryers, coffeemakers, and fryers.

o Tab B **Electrical Hazards Involving Appliance Cords, dated February 1990, by Linda Smith, Directorate for Epidemiology**

The major findings of this report were as follows:

- Based on national fire data from the U.S. Fire Administration and the National Fire Protection Association, it is estimated that fire service attended residential structural fires involving all cords and plugs, including extension cords, decreased by about 25 percent from 1980 to 1987. Deaths from these fires, however, decreased by only 7 percent; injuries showed no decrease.

-Using supplementary data to adjust national fire data, it was estimated that 9,600 residential structural fires involving appliance cords (other than extension cords) occurred annually over the period 1985-1987. These fires resulted in an estimated 160 deaths, 460 injuries and $92.4 million in property loss annually. These losses reflect casualty rates of 17 deaths per 1,000 fires, a per-fire death rate second only to portable heaters among products involved in electrical fires.

-Failure points identified among the investigated incidents indicated that about 39 percent of the failures occurred at the attachment plug end of the cord, 38 percent occurred at the appliance end, and 22 percent occurred along the cord length. However, among those that caused a fire, almost one-half occurred along the cord length.

-Investigated cord failures that occurred along the cord length, as opposed to the end connections, most often involved products that were left plugged in for extended periods of time such as large appliances, consumer electronics items, lamps, and fans. These incidents contributed the greatest number of reported fires that involved damage over $1,000.

-Investigated cord failures that occurred at a strain relief mostly involved heat producing small appliances such as hair dryers, irons, and curling irons where this construction is most common. Few such failures proceeded to high damage fires.

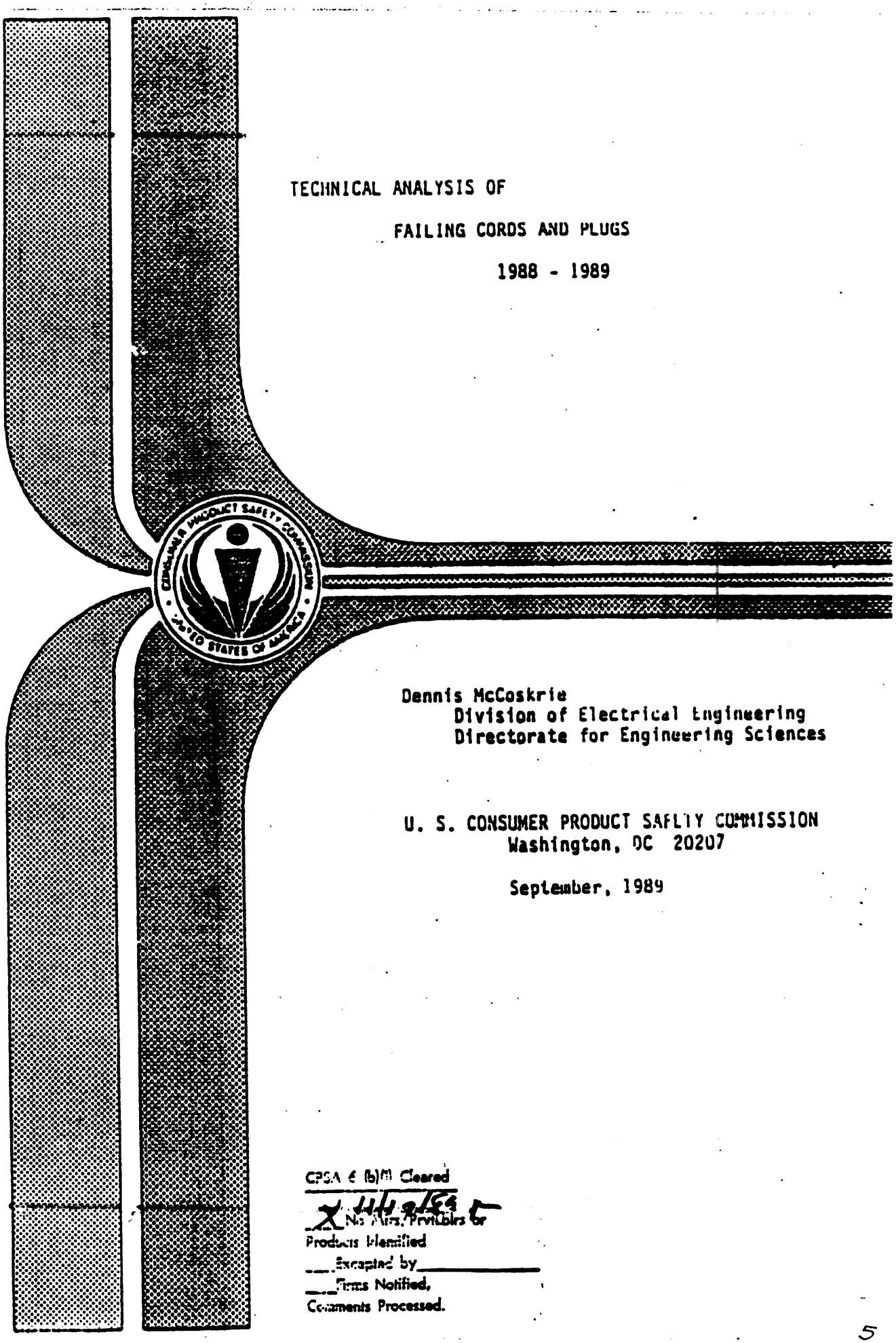
-Investigated cord failures that occurred at the attachment plug end of the cord predominantly involved cooking or other heat producing appliances, having features that generally involved both high electrical loads and physical stress from handling.

o Tab C **Assessment of Consumer Behavior Around Electricity, dated February 1990, by Marie Bellegarde, Directorate for Epidemiology**

The major findings of this analysis reveal that consumers sometimes failed to observe warning signs exhibited by failing appliance cords posing a fire or electrical shock hazard. A review of the literature on people's perceptions of electrical safety helps to explain the behavior exhibited by consumers in the investigated cases. People perceive electricity as being safe since it works well and seldom fails. Consequently, electricity is taken for granted and common electrical appliances are considered nonhazardous. Familiarity with the electrical appliances involved also increase the perceived safety of these appliances. The findings of this analysis support the need to increase people's awareness of electrical safety as well as the need to consider the intended and foreseeable use of these appliances in the home.

Pursuant to Section 5 of the Commission General Policies of March 18, 1987, the Acting Executive Director indicates that he is reasonably unaware of any relevant and significant minority or dissenting views on this issue except for those contained in this package.

A



TECHNICAL ANALYSIS OF

FAILING CORDS AND PLUGS

1988 - 1989

Dennis McCoskrie
Division of Electrical Engineering
Directorate for Engineering Sciences

U. S. CONSUMER PRODUCT SAFETY COMMISSION
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ACKNOWLEDGMENT

Joe Young, Sample Custodian, received and kept track of almost three hundred official samples sent in by our field representatives. He did not need more samples, in addition to the normal traffic, to reach a substantial overload. Those of us who were lucky enough to work personally with him enjoyed and marveled at his patience and good humor.

SUMMARY:

A major segment of the two-year project "Cords and Plugs" was a campaign combining the contributions of the Consumer Product Safety Commission's epidemiological staff, field staff, engineering laboratory, administrative office, and electrical engineering division. The intent was to overcome an inherent problem in the analysis of residential fires attributed to electrical appliance cords -- as a result of involvement in the fire, the cord usually is extensively damaged and cannot provide reliable information about the mechanism of damage leading to ignition.

The campaign was intended to collect sample appliance cords, and in some cases appliances and electrical outlets, exhibiting overheating, arcing, smoking and other symptoms believed to be manifestations of impending ignition. More than two hundred samples were collected by the field staff, received and coordinated by the Sample Custodian and technically analyzed for the cause of failure by the engineering laboratory. A reduced group, those samples that were determined by the laboratory actually to be involved in appliance-cord ignited fires, was statistically analyzed by the hazard analysis group of the epidemiological staff and is the subject of this Engineering report.

BACKGROUND:

Recent estimates* by CPSC epidemiologists attribute about one fifth of electrical fires associated with household distribution systems, 10,600 annually, to ignition by extension cords and appliance cords. Other, related, estimates indicate that these fires are divided about equally between extension cords and appliance cords. The Cords and Plugs project is intended to study the mechanisms that cause appliance cords to ignite residential fires; the goal is to recommend improvements in the voluntary safety standards for these components. Extension cords were studied in a FY87 project, and recent changes in the UL standard for extension cords ("cord sets" in UL'S terminology) are expected to reduce current overloading as a source of ignition.

Current and past fire statistics attribute large numbers of destructive fires to ignition from defective or damaged appliance cords. However, it is rare that a fire report records the specific role of the appliance cord in starting the fire. In order to identify the particular cord characteristics that cause fires, a special field campaign was conducted during FY88 to collect appliance cords that consumers considered to be dangerous -- that demonstrated overheating, sparking, bare conductors, etc. At the beginning of this campaign, we anticipated that as many as one hundred samples might be collected. The total number of samples collected was well over two hundred, although some submitted appliance samples turned out not to have cord/plug defects. Almost all of the collected samples have been examined and analyzed for safety defects by the Engineering Laboratory (ESEL).

* "Residential Electrical Distribution Fires", Smith, L. and McCoskrie, D., U. S. CPSC, December, 1987, p.4.

DISCUSSION:

A. Appliance Cord Failure Modes.

Failure modes of appliance cords observed in the many kinds of appliances represented in the campaign tend to fall in these categories:

1. bad crimp within molded male plug or female connector.

2. bad mating contact with wall receptacle, extension cord current tap, or male contacts of appliance.

3. flexure failure of cord, usually at sharp bend points such as entry to plug or plug strain relief or at entry to appliance or appliance strain relief.

4. tension failure at plug, cord insulation separated from molded plug.

5. plug blades pitted, arcing, bad contact or withdrawal of plug while full appliance current is flowing.

6. flexure or abrasion failure of cord insulation leading to arcing between conductors or to grounded metal objects that the ungrounded conductor contacts.

B. Descriptions of Appliance-Cord Failure Modes.

A "bad crimp" is a wire connection to a plug blade or some other terminal that is contaminated or improperly assembled so as to cause a high resistance connection between the terminal and the wire. Particularly in appliances such as portable heaters and hair dryers that require currents close to the maximum rating of the residential branch circuit, the high resistance crimps may become hot enough to melt the plug insulation, or even ignite the plug and wire insulation.

"Bad mating contact" often results from mechanical wear of contacts or the loss of contact pressure as the spring temper of metal parts is reduced by age and overheating. Firm metal-to-metal contact is lost, and a high temperature arcing or "glowing" type of conduction takes place. This phenomenon can cause severe overheating of the plug and receptacle. Similar reactions in extension-cord to appliance-cord connections cause severe overheating without a clear indication as to which cord was defective. Kitchen appliances such as roasters, broilers, frying pans, and kettles may exhibit contact overheating at the junction between the female connector of the cord and the male input pins of the appliance. Wear can be a factor in this problem, as well as films of food-related materials deposited on the appliance pins.

Flexure failure of either wire insulation or the metal conductor itself is common in appliances that receive lots of hand manipulation in normal use. Products such as irons, hair curlers, and hair dryers suffer failures at any point where a sharp bend of the cord will occur. In older appliances that did not incorporate bend-relief reinforcement at the plug and the entry to the body of the appliance, failures signalled by sparking, arcing, and smoking will occur just where the cord exits from the plug or body. Revisions to the voluntary standard for cords have introduced reinforced sections (bend reliefs) at these locations so that newer appliances suffer cord failures at the end of the reinforced section.

Tension failure at a plug can cause exposure of the wire conductors because the molded plug was not bonded adequately to the cord insulation. Failure of this bond permits tension on the cord to be directly transmitted to the wire/blade connections. In turn this can lead to arcing and a resultant fire hazard.

One occasional type of failure is indicated by severe discoloring and/or pitting of plug blades, usually caused by loose or intermittent contact with the receptacle outlet. In some cases it can be established that initial damage to the blades and contacts was caused by using the plug to interrupt a high current load, or an inductive load such as an air conditioner or refrigerator. In extreme cases, the blades are eroded by arcing. This type of failure tends to occur in window air conditioner installations connected to a 115-volt outlet rather than a 230-volt service that would operate at half the current or less.

Most often seen in flat cords with parallel conductors, flexure, crushing or abrasion failure of cord insulation will often result in arcing or conduction through damaged insulation between the conductors or between the ungrounded wire of the cord and some grounded metal surface in contact with the cord. Overheating and fire can result.

C. Failures Observed in Unattended* Appliances.

1. Air Conditioners, Window (5 reports)
   (3) severe overheating, arcing;
   (1) overheating of cord;
   (1) overheating of plug, failure of crimp.

* "Unattended" is an arbitrary term to designate an electrical appliance that is usually or frequently left in operation without an operator or observer. An air conditioner normally is unattended; a curling iron would be "attended".

2. Blankets (2 reports)
   (2) flexural failure of blanket supply cord close to blanket connecting plug.

3. Clothes Dryers (3 reports)
   (2) one gas fired, arced at plug;
   (1) overheated plug, loose connection in receptacle.

4. Fans (3 reports)
   (2) flexural failure at plug;
   (1) cord shorted at entry, no strain relief present.

5. Space Heaters (22 reports)

   (11) overheated plugs; probably defective crimp.
   (6) plug and receptacle overheating.
   (1) plug overheated by aluminum wire connections to receptacle;
   (1) plug overheated by faulty twist-on connector.
   (2) plug blades pitted, sparked, overheated.
   (1) flexural failure at plug.

6. Lamps (8 reports)

   (2) cord shorted at entry to base.
   (1) short circuit inside base ignited cord.
   (1) cracked insulation caused short circuit through base.
   (1) flexural failure at lamp-socket base.
   (1) cord arced, melted.
   (1) cord pinched in crack in plastic mat arced, smoked.
   (1) plug blades arced, melted.

7. Other unattended appliances such as humidifiers and waterbed heaters were represented by only one or two reports.

D. Failures Observed in Attended Appliances.

1. Broilers, Rotisseries, and Combinations (9 reports)

   (5) line plugs overheated, melted; blades burned.
   (4) female plug that connects to appliance overheated, poor-contact, arcing, or flexural failure.

2. Coffeemakers, Percolators (17 reports)

   (11) flexural failure at line plug.
   (3) bad contact at female connector.
   (2) failure of plug crimp connection.

3. Curlers, Curling Irons (9 reports)

(9) flexural failure at entry to appliance, some failed at cord entrance to plug also.

4. Fryers, Skillets (9 reports)

(6) bad contact at female plug to pan
(2) overheated plug; defective crimp
(1) plug overheated in bad receptacle.

5. Hairdryers (22 reports)

(9) flexural failure at plug
(11) flexural failure at body or at strain relief
(1) wire insulation separated from plug insulation
(1) plug overheated from internal arc.

6. Irons (29 reports)

(13) flexural failure at cord entry to iron
(8) flexural failure at plug
(5) flexural failure at strain relief
(2) flexural failure at female plug
(1) plug overheated in bad receptacle.

7. Kettles, Teapots, etc. (7 reports)

(3) flexural failure, female plug
(2) flexural failure at plug
(1) plug overheated from bad crimp.

8. Mixers (3 reports)

(1) flexural failure at female plug
(1) crimp defect in female plug
(1) cord insulation cracked, sparked.

9. Radios (6 reports)

(1) flexural failure at male plug
(1) flexural failure at female plug
(1) male plug overheats
(1) cord arced and destroyed radio
(1) cord arced to flexible gas connector.

10. Toasters and Toaster-Ovens (8 reports)

(5) flexural failure at male plug
(1) arcing in plug
(1) flexural failure at entry to appliance
(1) plug overheated in defective receptacle

11. Vacuum Cleaners (8 reports)

(2) flexural failure at entry to cleaner;
(1) flexural failure of cord about 29" from cleaner
(1) cord jacket pulled out of plug body
(1) crimp failure in plug
(1) plug overheated in worn outlet
(1) broken blade in plug
(1) contact failed in cord/wand connection.

12. Other attended appliances, such as cook pots, waffle irons, hair clippers, etc. were represented by only one or two reports each.

OBSERVATIONS:

The tabulated data in the previous section does not suggest any strong patterns in relationships between cords and plugs and residential fires. Figure 1 presents the same data graphically and suggests some general comments.

It would have been useful if the relative numbers of cord-and-plug failures reported for different appliances in this study could have been compared with the estimated numbers of fires attributed to the cord-and-plug components of the same kinds of electrical appliance. Unfortunately the latter data comparison is not available; the data that are available relate to fires and appliances and it is suspected that these figures may be inaccurate to the extent that some fires that should have been classified as cord-and-plug fires may be included in the appliance-fire data.

A comparison is shown in Figure 1. between relative numbers of sample reports and the estimated numbers of several varieties of electrical appliance now in use. There does not seem to be any obvious correlation between these statistics.

Examination of the patterns of hazard causes for the various appliances does not identify strong similarities among them. This being the case, it may be useful to examine the evidence about each kind of appliance identified in the field and sample reports.

A. Space Heaters

It is generally accepted that cord and plug failures are relatively common in portable space heaters and, because these heaters are often unattended (sometimes operated in rooms with sleeping occupants), these failures are more likely to ignite a fire than, for instance, the failure of an iron cord.

The heater cord failures reported during our "Cords and Plugs" campaign were similar to those reported before and which are being studied by UL and the associated Industry Advisory Committee. Predominantly they are characterized by overheating of the plug, often accompanied by overheating of the outlet. Often it is apparent that the overheating originated in at least one of the crimped terminations between a wire and some other terminal of the heater.

Because many heaters are in circulation that have older cords and plugs installed, it can be expected that the incidence of cord-related heater fires will continue to be high. A major cause of overheating of heater plugs has been identified and a "temporary" correction has been added to UL 1025, Electric Air Heaters. Effective August 6, 1986, crimped wire connections for 1000-watt-or-more heater cords must either be soldered, brazed, or welded, or derated so as to require a larger size wire and crimp terminal. In time, this provision, or another "permanent" measure with the same intent, should reduce overheating failures of heater cords and, accordingly, heater fires.

B. Lamps

Electric power used by residential portable lamps rarely approaches full branch-circuit capacity. It can be expected, then, that overheating will be less of a contributor to failures in service. Among the samples collected in this campaign, crimp overheating is not a major fire cause, but various mechanical stresses are reported to have damaged the electrical insulation so as to cause conduction between the cord conductors, or from a conductor to the metal base of the lamp. It was not uncommon for arcing to occur, a phenomenon that produces a very high temperature ignition source.

We are not aware of any specific effort to improve the resistance of lamp cords to mechanical hazards. An evaluation of the current provisions and recent history of UL 153, Portable Electric Lamps, could reveal some appropriate changes that should be recommended. One possibility might be to limit the wide variety of cord types and sizes now listed as acceptable in UL 153.

C. Air Conditioners, Window

Severe overheating of the cord and plug was the most common failure symptom found in this appliance. Many of the units in use are rated to operate with relatively high a-c current levels close to the permitted branch-circuit loading so that overheating of the crimped connections occurs in these appliance cords too. Air conditioners are subject to temporary current overloads on startup which also contribute to overheating and deterioration of the connections. A trend that may, in time, reduce the incidence of these failures is the introduction of increasingly efficient air-conditioners that utilize less current.

Current marketing practices tend to influence the user toward providing adequate branch-circuit current capacity and the correct heavy-duty receptacle to supply power to a portable air-conditioner. Continued information and education efforts may also help to reduce overloading of air-conditioner cords. A review of UL 484, Room Air Conditioners, might reveal some room for improvement.

D. Unattended Appliances in General

Analysis of fire reports and statistics is needed to determine whether or not most serious appliance-related fires are caused by electrical appliances that are not attended at the time of the ignition. It seems logical that this should be so and that improvements should be considered for the standards for the unattended appliances most frequently involved in cord-related fires.

E. Irons

Not surprisingly, portable irons were the most frequently reported attended appliances experiencing cord failures. Twenty-eight out of twenty-nine cord failures were attributed to flexural failure of the cord, usually at some point where the cord tended to bend over the edge of a plug or the entry to the iron. On the basis of past reports from industry and consumer complaints, these iron-cord failures do not often result in destructive fires. The failures usually become evident while the iron is in use, and a prudent user will stop using the iron. Depending upon the circumstances, sparks or particles of molten conductor have struck the user so as to cause minor burns. A serious injury might result if this material should strike the user's eye.

F. Hairdryers

This appliance also exhibits flexural failures at the location on the cord where it tends to be bent around the junction with the plug, with the entry to the hairdryer, or, in later models, with a bend-relief at either end of the cord. These failures are evidenced as exposed metal, overheating, and,or arcing and smoking. Typically little or no sustained ignition occurs, and the user discontinues use of the hairdryer. Some representatives of the appliance-cord manufacturing industry express strong convictions that round cords would withstand the steady flexure of this application much better than the parallel-conductor flat cords now typically supplied. This opinion seems to be technically acceptable, but no test data has been submitted, that we are aware of, that demonstrates the superiority of round cords.

G. Coffeemakers, Percolators
Kettles, Teapots

Combining of these two categories accounts for twenty-four failure reports, seventeen coffeemakers, and seven kettles. The most prevalent type of failure, in both groups, was flexural failures at line plugs, at appliance connecting plugs, and at entry to the appliance, if a connecting plug was not supplied. While these appliances do not usually draw currents as great as those of electric space heaters, a few failures of crimp connections between terminals and conductors were observed in this group. Again, these attended appliances did not seem to pose a significant fire hazard because the fault usually was observed by the user and use of the appliance was stopped.

H. Fryers, Skillets
Broilers, Rotisseries

These appliance groups combined to contribute eighteen of the reported cord-and-plug failures, nine from each. A different mode of failure was observed in these appliances, which almost always have a detachable cord with a female connector that mates with male pins attached to the appliance. Because these connectors are in areas where food spills occur, or where food vapors can condense in the region of the connector, insulating layers tend to build up on the connecting surfaces and interfere with conduction. This results in overheating of the connector and subsequent baking of the food materials into a very tenacious layer on the connecting surfaces. Also, because of the buildup of more conductive food products on insulating surfaces, arc-tracking phenomena may also contribute to overheating. These appliances, too, exhibited overheating of the crimped connections in the a-c plug. Often users of these appliances tended to continue to use them, even though they were aware of overheating of connectors. Even so, overheating or ignition was not reported as occurring external to the appliance and its cord.

RECOMMENDATIONS:

A. Unattended Appliances

Continue to monitor UL's current effort to revise their requirements for heater cords and encourage settlement of the IAC dispute over the need for a separate standard for cord/blade subassemblies.

Review the standards that govern other high-current appliances to identify those standards that should be revised "in step" with the heater cord standard.

Review the UL Standards that govern construction and materials for portable-lamp cords with the objective of recommending requirements to improve durability and resistance to cutting and crushing.

B. Attended Appliances

Encourage manufacturers, UL, and trade groups to devise test protocols for cords and plugs that more realistically simulate the stresses that they meet in actual use. While flexural failures of cords do not seem to be a major contributor to residential fires, insulation failures do present some possibility of fire, spark/burn and shock hazard. The same organizations should be encouraged to determine whether or not round cords would substantially reduce flexural failures in irons, as compared to flat, parallel conductor cords.

C. Cords and Plugs in General

Through NEMA and other channels, encourage continued development of comparative test protocols for electrical cords to develop data that supports specification of cord materials and construction in voluntary safety standards for electrical appliances.

Develop and disseminate educational materials to warn against continued use of damaged cords and plugs, to instruct users in the detection of damage that can lead to hazards, and to suggest prompt, professional replacement of damaged and worn appliance cords.

B

ELECTRICAL HAZARDS INVOLVING APPLIANCE CORDS

FEBRUARY 1990

Linda Smith

U.S. CONSUMER PRODUCT SAFETY COMMISSION
Directorate for Epidemiology/EPHA
Washington, D.C. 20207

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EXECUTIVE SUMMARY

In 1987, the Consumer Product Safety Commission (CPSC) Electrical Hazards Team began a project to reduce residential fires that involved electrical equipment cords. As part of that effort, this report presents fire data estimating national residential fire losses involving electrical cords and an analysis of failure causes based on CPSC field investigations.

To identify relevant incidents for investigation, CPSC field staff conducted a media campaign to solicit reporting to CPSC of low-damage incidents that demonstrated electrical cord failure.1/ This means of data collection provided failure information that was frequently unavailable once a fire had occurred and destroyed the point of origin. The data collection effort resulted in a total of 281 follow-up investigations of electrical cord incidents. About one-half resulted from this solictation process and one-half from unsolicited reports such as consumer complaints and newspaper clippings.

The major findings were as follows:

- Based on national fire data from the U.S. Fire Administration and the National Fire Protection Association, we estimate that fire service attended residential structural fires involving all cords and plugs, including extension cords, decreased by about 25 percent from 1980 to 1987. Deaths from these fires, however, decreased by 7 percent; injuries showed no decrease.

- Using supplementary data to adjust national fire data, we estimate that 9,600 residential structural fires involving appliance cords (other than extension cords) occurred annually over the period 1985-1987. These fires resulted in an estimated 160 deaths, 460 injuries and $92.4 million in property loss annually. These losses reflect casualty rates of 17 deaths per 1,000 fires, a per-fire death rate second only to portable heaters among products involved in electrical fires.

- Failure points identified among the investigated incidents indicated that about 39 percent of the failures (102 of 263) occurred at the attachment plug end of the cord, 38 percent (100 of 263) occurred at the appliance end, and 22 percent (57 of 263) occurred along the cord length. However, among those that caused a fire, almost one-half (37 of 81) occurred along the cord length.

1/ In-scope incidents involved fire, smoke, overheating or physical deformation, arcing or electric shock.

- Investigated cord failures that occurred along the cord length, as opposed to the end connections, most often involved products that were left plugged in for extended periods of time such as large appliances, consumer electronics items (including televisions and radios), lamps, and fans. These incidents contributed the greatest number of reported fires that involved damage over $1,000.

- Investigated cord failures that occurred at a strain relief (a reinforced section of the cord near the appliance end) mostly involved heat producing small appliances such as hairdryers, irons, and curling irons where this construction is most common. Few such failures proceeded to high damage fires.

- Investigated cord failures that occurred at the attachment plug end of the cord predominantly involved cooking or other heat producing appliances, having features that generally involved both high electrical loads and physical stress from handling.

Although this report does not provide estimates of cord fires by product, the nature of the cord industry is such that a given cord construction is often common to several appliances or to whole groups of appliances. It is hoped that this report will assist CPSC staff, the cord industry, appliance manufacturers, and voluntary standards organizations to identify areas in need of remedial action.

A. Background

Local newspapers throughout the U.S. commonly report fires caused by "failure of an electrical cord". A Hazard Analysis of "Fires Associated with Portable Electric Heaters" (Directorate for Epidemiology - Division of Hazard Analysis April 1986), stated that in 1984, death rates in cord and plug fires, as a function of the number of fires, ranked second only to portable heaters among products involved in residential electrical fires. That rate was 16 deaths per 1,000 cord/plug fires. It was estimated that in 1984 electrical cords and plugs of all kinds (including extension cords) were involved in about 9,200 residential structural fires that resulted in 140 deaths, 510 injuries, and $86.9 million property loss. 1/

As a first step to reducing this hazard, CPSC initiated a project in FY 1987 to evaluate extension cords, a major segment of this cord/plug group. Data analysis indicated that in 1985 extension cords were involved in about one-half of all the cord and plug fires; cords for a wide variety of electrical appliances and equipment were involved in the remaining one-half. The results also indicated that electrical overloading and mechanical stress failures at the attachment plug/cord connection were factors in extension cord failures.

During this period, both the National Electrical Code (in 1984) and Underwriters Laboratories (effective March 1987) made changes to their voluntary standards to address problems of extension cord overloading. The NEC and UL changes required overcurrent protection sized to the current-carrying capacity of the cord conductors for cords with size 17 and 18 AWG conductors. This has had the effect of drastically reducing the availability of smaller capacity extension cords and is expected to reduce the number of extension cord fires in future years as households replace older, smaller capacity cords with newer, large capacity cords.

As a second step to reduce cord and plug fires, the Directorate for Epidemiology - Division of Hazard Analysis (EPHA) initiated data collection in FY 1987 to study incidents involving the broad range of electrical appliance/equipment cords. This report presents the results of that effort.

1/ These estimates were based on data from the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association.

B. Data Collection Methodology

One of the difficult features of evaluating fire hazards is that once a fire has occurred, the amount of damage frequently prevents effective failure analysis. This is particularly true when you need to know, for example, that the fire originated not only in the cord but where in the cord. To overcome this problem, CPSC conducted a data collection effort that solicited consumer reporting of electrical failures 2/ in appliance cords and offered reimbursement to the consumer for the product. The solicitation took a number of forms -- newspaper advertisements, newspaper articles that described the project, television and radio segments and posters. (See copy of poster/ad in Attachment A.) These incidents were then investigated by CPSC field staff. CPSC staff also conducted field investigations of incidents that were reported to CPSC through other sources (including unsolicited consumer complaints, newspaper clippings and fire departments).

Solicitation of low-damage incidents also allowed collection of a large number of product samples -- a key element in failure analysis. Through physical examination of product samples, CPSC's Engineering Laboratory evaluated cord failure for 160 of the 281 incidents used in this report. The CPSC Directorate for Engineering report "Technical Analysis of Failing Cords and Plugs, 1988-1989", September 1989, discusses their results.

Appendix A describes in greater detail the sources and types of incidents that were reported.

Although we hoped to achieve reporting of electrical cord incidents from all kinds of consumer electrical appliances and equipment, this may not have occurred uniformly.

2/ In-scope incidents involved fire, (defined as presence of flame) smoke, overheating (defined as too hot to touch) or physical deformation, arcing or electric shock.

a) The data included relatively few incidents of cords for large appliances. This could indicate that fewer failures occurred with such cords as a result of their being handled and moved less frequently than other cords. However, some modes of solicitation, such as television or radio segments, may not have made clear our interest in cords to large, as well as small, appliances.

b) Subsequent communication with project staff indicated that our intent to include lamps was not clear to everyone. Few lamp cord-related incidents were reported through the solicited reports, whereas lamp cord fires were reported relatively more often through investigations of newspaper clippings. Also, follow-up of national fire data included a substantial number of fires involving lamp cords relative to other appliances involved in cord failure.

c) Most of the fan cord incidents were reported through newspaper clippings and were investigated as part of a simultaneously-running CPSC project on fan fires. This is likely to have resulted in a larger number of fan cord fires than otherwise would have been included. It illustrates, however, that many appliance fires, e.g., "fan malfunction" actually involve cord malfunction. This type of occurrence is a crucial barrier in identifying incidents and estimating the number of cord failures, both as a group and for individual appliances. This issue will be discussed in greater detail in the following section.

Taken together, these sources of possible bias preclude the use of these data to estimate reliably the product distribution of cord failures. Nevertheless, the U.S. map shown in Figure 1 indicates that the investigated incidents are a reasonably good mix of incidents from most climates. This factor is of particular concern in evaluating the frequency of incidents that involve either heating or cooling appliances.

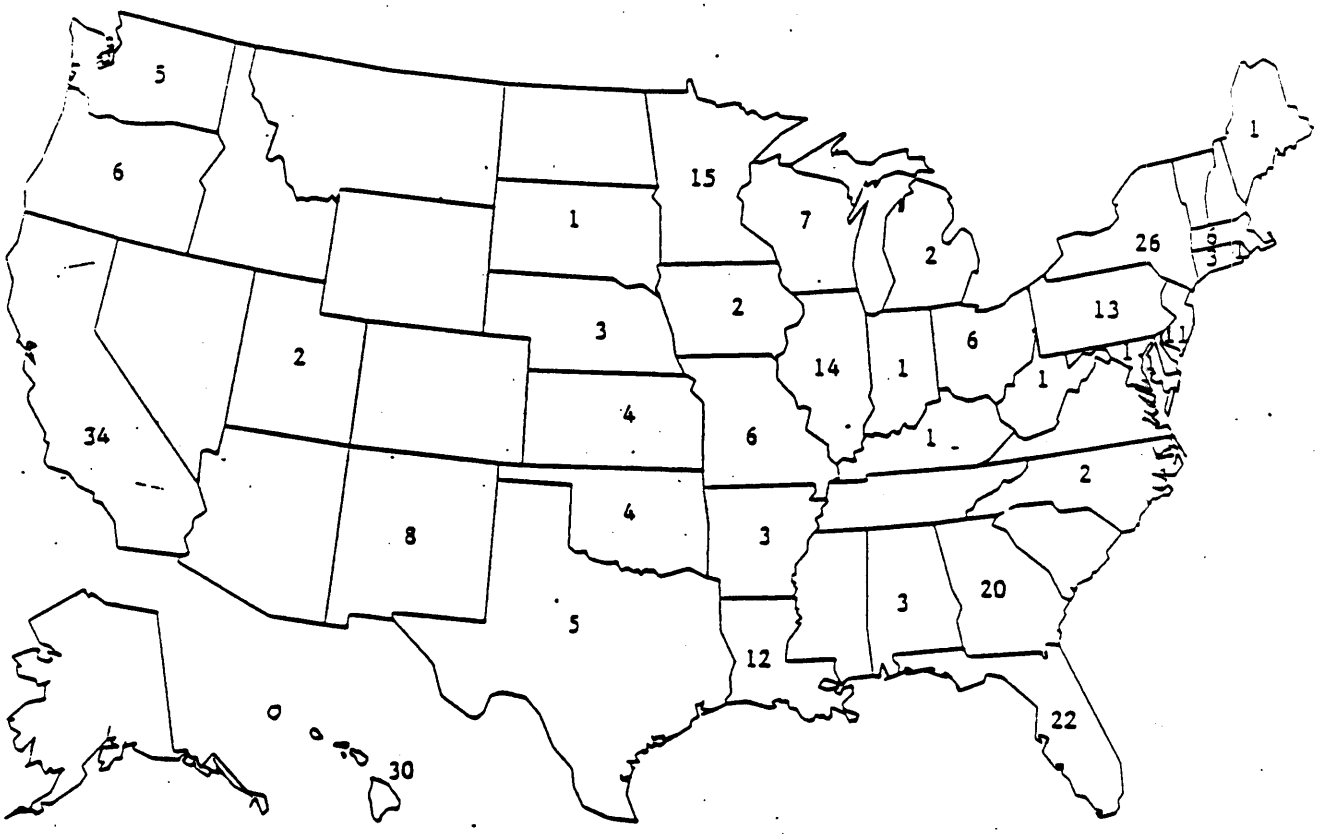
C. Results

1. National Estimates of Cord Fires

Fire incident data obtained from the U.S. Fire Administration (USFA) identifies only the general group of "cord, plug" fires. As shown in Table 1, national estimates of residential structural fires involving the general

FIGURE 1

GEOGRAPHIC DISTRIBUTION OF
281 INVESTIGATED INCIDENTS OF
ELECTRICAL APPLIANCE CORD FAILURE



SOURCE:
EPIDEMIOLOGIC INVESTIGATION REPORTS
U.S.CONSUMER PRODUCT SAFETY COMMISSION
DIRECTORATE FOR EPIDEMIOLOGY, EPHA

Table 1
Estimated Residential Structural Fire Losses Involving
Electric Cords and Plugs, 1980-1987

	Year							
	1980	1981	1982	1983	1984	1985	1986	1987
Fires								
Total Residential	757,500	733,000	676,500	641,500	623,000	622,000	581,500	551,500
Cords, Plugs	12,200	11,200	10,700	10,200	9,200	9,900	9,600	9,200
Extension Cords	--	--	--	--	--	5,000	4,800	4,600
Appl. Cords	--	--	--	--	--	5,000	4,800	4,600
Deaths								
Total Residential	5,500	5,600	5,000	4,840	4,240	5,025	4,770	4,660
Cords, Plugs	140	130	140	110	140	130	200	130
Extension Cords	--	--	--	--	--	70	100	70
Appl. Cords	--	--	--	--	--	70	100	70
Injuries								
Total Residential	21,100	20,375	21,100	21,450	19,275	19,825	19,025	20,440
Cords, Plugs	450	390	610	430	510	420	500	450
Extension Cords	--	--	--	--	--	210	250	230
Appl. Cords	--	--	--	--	--	210	250	230
Property Damage (in $ millions)								
Total Residential	3,042	3,259	3,253	3,306	3,440	3,774	3,556	3,699
Cords, Plugs	77.0	108.9	88.5	92.0	86.9	99.0	93.9	84.0
Extension Cords	--	--	--	--	--	49.5	47.0	42.0
Appl. Cords	--	--	--	--	--	49.5	47.0	42.0

Note: Separate estimates for extension cords and appliance cords are not available for years prior to 1985.
Column detail may not add due to rounding. Fire estimates have been rounded to the nearest hundred, deaths and injuries to the nearest ten.

Source: Based on data from the U.S. Fire Administration (NFIRS), the National Fire Protection Association, and a 1985 CPSC special study that provided a distribution of extension cords and appliance cords.
CPSC/EPHA

category of "cords, plugs" have decreased steadily since 1980, following a similar decrease in residential structural fires overall. Cord and plug fires have decreased by 24 percent since 1980, while residential fires of all kinds have decreased by 27 percent. Casualties resulting from all kinds of cord fires have changed relatively little, however. "Cord, plug" related deaths occurring in residential fires decreased by 7 percent, while "cord, plug" injuries essentially were unchanged. For all kinds of residential structural fires, deaths decreased by 15 percent and injuries decreased by 3 percent.

The cord-related fire estimates cited above were based on distributions of fire service-attended fires reported in the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS), extrapolated to national estimates of aggregate fire losses developed by the National Fire Protection Association (NFPA).[3/] Fires involving appliance cords were included within the NFIRS "cord, plug" equipment code that also included extension cords (not part of this report).

A 1985 CPSC special study provided data to allow separation of extension cords from the more general category. It indicated that cord and plug fires were about evenly divided between those involving extension cords and those involving appliance cords. (Appendix B provides a more detailed discussion of the data bases and estimation procedure used.)

Based on these sources and considering only fires coded in NFIRS as "cord, plug" fires, we estimate that about 4,800 residential structural fires occurred annually over the period 1985-1987 involving electrical cords other than extension cords. These fires resulted in an estimated 80 deaths, 230 injuries, and $46.2 million in property loss annually (See Table 2).

In addition, the results of the current project indicated that many fires that actually started in an appliance cord were reported by fire departments as starting in the appliance itself. Follow-up investigations of cord failures conducted for this project included 30 fires attended by the fire service that reported an NFIRS equipment

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3/ John R. Hall, Jr. and Beatrice Harwood, "The National Estimates Approach to U.S. Fire Statistics", Fire Technology, Vol. 25, No.2, May 1989.

Table 2
Estimated Annual Residential Fire Losses
Involving Appliance Cords, 1985-1987

	Appliance Cord Losses[a] in NFIRS "Cord, Plug" Equipment Codes	Appliance Cord Losses[b] Adjusted to Include Cord Fires in Other NFIRS Equipment Codes
Fires	4,800	9,600
Deaths	80	160
Injuries	230	460
Property Damage($million)	$46.2	$92.4

a/ Estimate is based only on incidents reported in the U.S. Fire Administrations NFIRS "cord, plug" equipment code.

b/ This estimate has been adjusted to include appliance cord/plug fires that were not coded as "cord, plug" fires in NFIRS. This adjustment was based on the distribution of NFIRS equipment codes cited among the CPSC investigated cord fires.

Source: Based on data from the U.S. Fire Administration, the National Fire Protection Association and a 1985 CPSC special study CPSC/EPHA.

code. Only 14 of the 30 had been coded by the fire service as a "cord, plug" fire, indicating that an estimate based solely on the "cord, plug" fires may severely underestimate the number of cord fires occurring and that a complete estimate may be as much as twice the number cited earlier -- 9,600 fires, 160 deaths and 460 injuries annually as shown in Table 2. These losses reflect casualty rates of 17 deaths and 48 injuries per 1,000 appliance cord fires occurring.

Given the nature of the data, it is not appropriate to estimate a distribution of fires or failures among the appliances involved. Nevertheless, both the investigations conducted for this cord project and the 1985 CPSC special study on electrical fires provide frequency distributions of some appliance cords involved. Table 3 presents appliance distributions included in these data bases ranked by the appliances with the highest total number of incidents (both fire and nonfire) in the current cord project. It is important to note that some appliances, e.g., irons and hairdryers, with a relatively large number of total incidents investigated nevertheless were reported in relatively few fires serious enough to require fire service attendance. For example, there were 38 investigated incidents of iron cord failure in this cord project. Although 14 proceeded to a fire, only one fire was serious enough to require fire service attendance. Similarly, there were 5 fires among the 22 cord failures involving hairdryers, but none were attended by the fire service. In the 1985 CPSC study of fire service-attended fires, iron cords and hairdryer cords were rarely identified.

Since many cord fires attended by the fire service are believed to be reported as appliance fires, Table 3 also presents national residential fire estimates of selected appliance fires. The extent to which these appliance fires reflect cord failures probably varies by product. For "lamps, lighting equipment" the proportion of cord failures is likely to be relatively high. The 1985 CPSC special study data indicated that about 40 percent of this code involved light bulbs. It is considered likely that the remainder (about 60 percent of 1,900 fires, 1,100) predominantly involved the lamp cord. For heat producing appliances such as electric heaters, however, the proportion of cord fires was probably much lower since failures internal to the heater are believed to be a major factor in heater fires. As indicated earlier, these data are not specific enough to allow estimates of cord involved fires by product but provide an additional reference point for evaluating their likely involvement.

Table 3
Comparative Fire Data for Selected Products Involved in Cord Failures, Ranked by Number of Incidents Reported in CPSC Cord Study

Appliance	Incidents Reported in '87-88 CPSC Cord Study		Fire Dept. Attended Cord-Related Fires Reported in '85 CPSC Special Study[a]	National Estimates of Fire Department Attended Appliance Fires, 1987[b]
	Total Incidents	Fires	Incidents	
Total	235	78	101	
Irons	38	14	1	500
Heaters Electric	28	6	15	2,800
Hair Dryers	26	5	1	400
Lamps/Lighting (not Fixtures)	22	12	57	1,900
Vacuum Cleaners	20	2	--	100
Coffeemakers	20	7	--	600
Fans	15	12	13	3,000
Ovens/Broilers	14	--	--	800
Phono's, TV's, Radios	14	8	8	3,400
Curling Irons	12	4	--	300
Toasters	10	3	--	2,000
Frying Pans	9	--	--	N.A.
Air Conditioners	7	5	6	700

[a] This study was designed to identify products involved in electrical fires independent of fire department equipment codes. Incidents refer to hard copy fire incident reports that identified involvement of an appliance cord.

[b] These estimates are based on data from the U.S. Fire Administration, the National Fire Protection Association and a 1985 CPSC special study on electrical fires. These estimates denote appliance fires rather than cord fires.

Source: Consumer Product Safety Commission/Division of Hazard Analysis

2. General Characteristics of Investigated Incidents

The remainder of this report presents information about the characteristics of cord fires generally, based solely on the 281 investigated incidents of cord failure collected for this cord project. Although we cannot conclude relative incidence of cord failure by appliance, we selected some appliances for further attention. This selection was based on the frequency of occurrence among the investigated incidents in conjunction with an assessed likelihood that failures might result in serious fires. The appliances selected were cord-connected heaters, fans, lamps and lighting equipment, and consumer electronics (televisions, radios and phonographs). Characteristics of the cords involved are discussed separately for each group following the discussion of general investigation findings. It must be noted that the selection of these appliances was based on available hazard information and does not preclude the possibility that other appliances may warrant similar consideration.

a. Incident Type

The 281 investigated incidents of electrical cord failures involved a variety of appliances and a variety of failure types.

As shown in Table 4, the distribution of incident failure types was as follows:

- 94 fires -- evidenced by actual flame
- 88 overheating -- predominantly evidenced by physical deformation or smoke.
- 80 arcing -- arcing incidents that did not proceed to a fire.
- 9 mechanical damage -- such as crushing by furniture without subsequent electrical damage.
- 10 electric shock or exposed wires -- includes only incidents that did not involve other scenarios such as arcing or fire.

Both fire and nonfire incidents were reported for most kinds of appliances. From a hazard assessment point of view, the nonfire incidents provided information on precise failure points while the occurrence of fire demonstrated the consequences that could result from such failures.

Table 4
Type of Incident by Product Involved for
281 Investigated Incidents of Electrical
Appliance Cord Failure

Appliance	Total	Type of Incident				
		Fire	Overheat	Arcing*	Mech. Damage	Electrical Shock/ Exposed Conductor
Total	281	94	88	80	9	10
Large Appliances	12	8	1	2	-	1
Clothes Dryers	4	3	1	—	—	—
Refrigerators/Freezers	3	3	—	—	—	—
Ranges	2	1	—	1	—	—
Other	3	1	—	1	—	1
Small Kitchen Appliances	67	10	30	25	1	1
Coffeemakers	20	7	3	9	—	1
Ovens/Broilers	14	—	9	5	—	—
Toasters	10	3	3	4	—	—
Frying Pans	9	—	7	1	1	—
Other	14	—	8	6	—	—
Other Appliances; Producing Heat	112	32	38	37	2	3
Irons	38	14	9	13	2	—
Heaters	28	6	19	3	—	—
Hair Dryers	26	5	5	14	—	2
Curling Irons	12	4	3	5	—	—
Electric Blankets	5	2	1	1	—	1
Other	3	1	1	1	—	—
Other Appliances; Not Producing Heat	90	44	19	16	6	5
Vacuum Cleaners	20	2	7	5	5	1
Fans	15	12	1	1	—	1
TV, Radio, Phono.	14	8	3	2	—	1
Table/Floor Lamps	14	9	1	4	—	—
Other Lighting	7	3	1	2	—	1
Air Conditioners	7	5	2	—	—	—
Other	13	5	4	4	1	1

* Included 5 incidents that involved both shock and arcing.

Source: Epidemiologic Investigation Reports
Consumer Product Safety Commission/Division of Hazard Analysis.

b. **Casualties**

Overall, 19 deaths and 34 injuries resulted from these 281 investigated incidents (Table 5). Sixteen deaths resulted from fires. Three deaths resulted from electric shocks. Among the 34 injuries, 19 occurred from fires, 15 from nonfires such as arcing. The injuries involved were mostly electric shock, and electric or thermal burn. Fire injuries were all burns or anoxia. Nonfire injuries were either electric shock or electric burns caused by arcing.

c. **Property Damage**

In about three-quarters of these cord-related incidents (212/277), damage was confined to the products in use or to an estimated damage of $50 or less (Table 6). This distribution was a direct consequence of the incident solicitation process and a feature that was critical to the identification of failure point. Nevertheless, 46 cords were involved in incidents that resulted in property damage of more than $1,000. It should be noted that most of the deaths and more than half the injuries resulted from these same incidents, involving appliances such as table or floor lamps, fans, and electronic equipment such as televisions and radios. Other appliances such as irons, hairdryers and curling irons, vacuum cleaners, and small kitchen appliances were infrequently involved in incidents of high damage even though some involved flames.

Descriptions of these incidents indicated that intervention by the consumer was frequently a critical factor that affected the severity of incidents and was more common among some products than others (Table 7). Incidents involving coffeemakers, irons, and hairdryers appeared to be interrupted more frequently relative to their total incidents than were other appliances and probably accounted for the findings of generally low property damage involving these appliances. When consumers interrupted the incident they were successful in restricting damage either to the appliance and its cord or to $50 or less in almost three-quarters of the incidents even when a fire occurred, 29 of 42 fires (Table 8a). Among those where consumers did not

Table 5
Casualties and Losses by Product Involved for
281 Investigated Incidents of Electrical
Appliance Cord Failure

Appliance	Incidents	Deaths	Injuries	Property Damage>$1,000
Total	281	19*	34	46
Large Appliances	12	2	2	4
Clothes Dryers	4	--	--	2
Refrigerators/Freezers	3	2	--	2
Ranges	2	--	--	--
Other	3	--	2	--
Small Kitchen Appliances	67	--	3	3
Coffeemakers	20	--	3	2
Ovens/Broilers	14	--	--	--
Toasters	10	--	--	1
Frying Pans	9	--	--	--
Other	14	--	--	--
Other Appliances; Producing Heat	112	1	14	6
Irons	38	--	4	--
Heaters	28	1	2	6
Hair Dryers	26	--	6	--
Curling Irons	12	--	1	--
Electric Blankets	5	--	1	--
Other	3	--	--	--
Other Appliances; Not Producing Heat	90	16	15	33
Vacuum Cleaners	20	--	--	--
Fans	15	5	6	12
TV, Radio, Phono.	14	6	2	7
Table/Floor Lamps	14	5	2	8
Other Lighting	7	--	2	1
Air Conditioners	7	--	1	2
Other	13	--	2	3

* 16 of 19 deaths occurred from fires, 3 from electric shock.

Source: Epidemiologic Investigation Reports
Consumer Product Safety Commission/Division of Hazard Analysis

Table 6
Property Damage and Product Involved for
Investigated Incidents of Electrical
Appliance Cord Failure

Appliance	Total	Property Damage					
		No Visible Damage	Appliance, App. Cord	Appliance/ App. Cord/ Ext. Cord/ Receptacle	≤$50	>$50 ≤$1,000	>$1,000
Total Known	277	21	167	13	11	19	46
Large Appliances	12	--	4	--	--	4	4
Clothes Dryers	4	--	1	--	--	1	2
Refrigerators/Freezers	3	--	--	--	--	1	2
Ranges	2	--	1	--	--	1	--
Other	3	--	2	--	--	1	--
Small Kitchen Appliances	65	9	47	5	--	1	3
Coffeemakers	20	1	16	--	--	1	2
Ovens/Broilers	13	3	8	2	--	--	--
Toasters	10	2	7	--	--	--	1
Frying Pans	9	2	5	2	--	--	--
Other	13	1	11	1	--	--	--
Other Appliances; Producing Heat	111	7	83	4	7	4	6
Irons	38	2	31	--	5	--	--
Heaters	27	3	15	3	--	--	6
Hair Dryers	26	--	25	1	--	--	--
Curling Irons	12	1	8	--	2	1	--
Electric Blankets	5	1	2	--	--	2	--
Other	3	--	2	--	--	1	--
Other Appliances; Not Producing Heat	89	5	33	4	4	10	33
Vacuum Cleaners	19	1	14	2	1	1	--
Fans	15	1	1	--	1	--	12
TV, Radio, Phono.	14	--	6	--	--	1	7
Table/Floor Lamps	14	1	4	--	--	1	8
Other Lighting	7	--	2	--	1	3	1
Air Conditioners	7	1	--	2	--	2	2
Other	13	1	6	--	1	2	3

Source: Epidemiologic Investigation Reports
Consumer Product Safety Commission/Division of Hazard of Analysis

Table 7
Consumer Intervention to Interrupt Incident
by Product Involved,
Investigated Incidents of Electrical
Appliance Cord Failure

Appliance	Total	Consumer Intervention	
		Interrupted Operation	Did Not Interrupt Operation
Total Known	266	171	95
Large Appliances	9	3	6
Clothes Dryers	3	—	3
Refrigerators/Freezers	2	—	2
Ranges	2	1	1
Other	2	2	—
Small Kitchen Appliances	64	45	19
Coffeemakers	19	16	3
Ovens/Broilers	12	7	5
Toasters	10	7	3
Frying Pans	9	5	4
Other	14	10	4
Other Appliances; Producing Heat	110	83	27
Irons	38	30	8
Heaters	27	16	11
Hair Dryers	25	21	4
Curling Irons	12	9	3
Electric Blankets	5	5	—
Other	3	2	1
Other Appliances; Not Producing Heat	83	40	43
Vacuum Cleaners	19	13	6
Fans	12	2	10
TV, Radio, Phono.	13	4	9
Table/Floor Lamps	13	5	8
Other Lighting	6	4	2
Air Conditioners	7	3	4
Other	13	9	4

Source: Epidemiologic Investigation Reports
Consumer Product Safety Commission/Division of Hazard Analysis

Table 8
Property Damage and Incident Type
by Whether or Not Consumer Interrupted
the Incident, Investigated
Incidents of Electrical Appliance Cord Failure

a/ Consumer Interrupted Incident

Property Damage	Type of Incident		
	Total	Fire	Nonfire
Total Known	167	42	125
No visible damage	8	—	8
Appliance, appliance cord	127	21	106
Appliance, appliance cord, extension cord, or receptacle	9	1	8
$50 or less	10	7	3
$51 - $1,000	11	11	—
More than $1,000	2	2	—

b/ Consumer Did Not Interrupt Incident

Property Damage	Type of Incident		
	Total	Fire	Nonfire
Total Known	95	43	52
No visible damage	12	—	12
Appliance, appliance cord	34	—	34
Appliance, appliance cord, extension cord, or receptacle	4	—	4
$50 or less	1	—	1
$51-$1,000	6	5	1
More than $1,000	38	38	—

Source: Epidemiologic Investigation Reports
Consumer Product Safety Commission/Division of Hazard Analysis

intervene (Table 8b), fire damage was higher, all 43 fires involved damage over $50 and most were over $1,000. It should be noted, however, that some failures did not proceed to fire even without consumer intervention. Overall, about one-half of the fires and about 70 percent of the nonfire incidents were interrupted by consumer intervention. A total of 61 fires were attended by the fire service.

d. **Failure Point**

Identification of the exact failure point along the cord is essential to a determination of possible remedial actions. Among incidents where failure point was identified, failures at the attachment plug end of the cord accounted for 39 percent of the failures, failure at the appliance end accounted for 38 percent, and failures along the cord conductors accounted for 22 percent (Table 9); the distributions were different for fire incidents than for nonfire incidents. Failures along the cord conductors were involved in almost one-half of the fire incidents but only about 10 percent of the nonfire incidents investigated. The failure point on the cord could not be identified for some cord fires that destroyed major portions of the cord.

Failure Along Cord

Failures at some point along the cord conductors (cord length) resulted in 37 fires and 20 nonfires and were associated most heavily with products that are not physically handled during normal use. (See Tables 10a and 10b). The products involved in cord length failures frequently were those that were left in operation, in place, such as large appliances, televisions, and lamps. Some of these failures reportedly resulted from external damage caused by foot traffic or the appliance itself resting on the cord.

Failure at Appliance End

Failure at the appliance end of the cord predominantly involved a variety of heat-producing appliances and resulted in 26 fires and 74 nonfires. These failures mostly involved products that were handled a lot such as irons, hairdryers, and curling irons. They occurred predominantly at the strain relief, a reinforced section of the cord where it enters

Table 9
Failure Point by Incident Type Among
Investigated Incidents of Electrical
Appliance Cord Failure

Failure Point	Total		Type of Incident			
			Fire		Nonfire	
	No.	%	No.	%	No.	%
Total Known	263	100	81	100	182	100
Appliance End	100	38	26	32	74	41
Cord Connection to Appliance	31		9		22	
Strain relief on appliance connection	45		16		29	
Female receptacle	17				17	
Cord connection to female receptacle	7		1		6	
Along Cord Conductors	57	22	37	46	20	11
Attachment Plug End	102	39	17	21	85	47
Cord connection to plug	53		8		45	
Attachment plug	26		4		22	
Plug/Wall Receptacle Interface	17		2		15	
Plug/Extension Cord Receptacle Interface	6		3		3	
Male/female connection integral* to appliance cord	4	1	1	1	3	2

Note: Column details may not add due to rounding.
* Refers to a construction where the cord is in two separable sections.

Source: Epidemiologic Investigation Reports
Consumer Product Safety Commission/Division of Hazard Analysis

Table 10a
Cord Failure Point in Fires, by Product
Investigated Incidents of Electrical
Appliance Cord Failure

Appliances	Total	Failure Point: Appl. End	Along Cord	Attachment Plug End	Male/ Female Conn. Integral to Cord
Total	81	26	37	17	1
Large Appliances	7	1	6	--	--
Clothes Dryers	3	1	2	--	--
Refrigerators/Freezers	3	--	3	--	--
Ranges	--	--	--	--	--
Other	1	--	1	--	--
Small Kitchen Appliances	10	3	2	5	--
Coffemakers	7	3	1	3	--
Ovens/Broilers	--	--	--	--	--
Toasters	3	--	1	2	--
Frying Pans	--	--	--	--	--
Other	--	--	--	--	--
Other App., Producing Heat	29	20	5	4	--
Irons	13	11	2	--	--
Heaters	5	1	1	3	--
Hair Dryers	5	4	--	1	--
Curling Irons	4	3	1	--	--
Electric Blankets	2	1	1	--	--
Other	--	--	--	--	--
Other App., Not Producing Heat	35	2	24	8	1
Vacuum cleaners	2	--	--	1	1
Fans	8	1	7	--	--
TV, Radio, Phono.	7	--	6	1	--
Table/Floor Lamps	7	1	6	--	--
Other Lighting	3	--	1	2	--
Air Conditioners	4	--	1	3	--
Other	4	--	3	1	--

Source: Epidemiologic Investigation Reports
Consumer Product Safety Commission/Division of Hazard Analysis

the appliance. Since the early 1980's manufacturers have incorporated a strain relief on these appliance cords to accommodate the stress caused by handling. Strain relief of this type is less common on other kinds of appliances.

Other failures that occurred at the appliance end of the cord involved failure of a detachable female connector, the end fitting of the cord that allows the cord set to be detached from the appliance. This type of construction is most common on cooking appliances and 23 of 24 failures of detachable female receptacles or the cord connection to the female receptacle involved cooking appliances. Only one progressed to a fire.

Failure at Attachment Plug End

Failures occurring at the attachment plug end that plugs into a wall receptacle outlet contributed 17 fires and 85 nonfires. Incident reports mostly specified damage to the attachment plug body or to the cord where it entered the attachment plug. It is likely, however, that some incidents classified as failure at the cord connection to the plug (8 fires, 45 nonfires) could have resulted from initial failure of the cord connection internal to the plug. Some failures likely resulted from manipulation -- plugging and unplugging. Various kinds of cooking and other heat producing appliances were involved most often in such failures.

A total of 17 incidents (2 fires, 15 nonfires) involved fire/overheating at the interface of the attachment plug and wall receptacle outlet. The appliances involved in these incidents also were predominantly those that produce heat -- cord connected heaters, frying pans, and other cooking appliances.

Male/Female Connection Integral to the Cord Set

Four incidents, 1 fire and 3 nonfires involved failure at a male/female connection that was integral to the appliance cord (where the cord could be separated into 2 sections). Two such incidents involved connections to vacuum cleaner power wands. Two incidents involved counter-top broilers/rotisseries. Tables C-1a and C-1b within Appendix C present cross-tabulations by product and failure point in greater detail.

Table 10b
Cord Failure Point in Nonfires, by Product
Investigated Incidents of Electrical
Appliance Cord Failure

Appliances	Total	Failure Point: Appl. End	Along Cord	Attachment Plug End	Male/ Female Conn. Integral to Cord
Total	**182**	**74**	**20**	**85**	**3**
Large Appliances	**4**	**1**	**1**	**2**	--
Clothes Dryers	1	--	--	1	--
Refrigerators/Freezers	--	--	--	--	--
Ranges	1	--	1	--	--
Other	2	1	--	1	--
Small Kitchen Appliances	**55**	**24**	**2**	**27**	**2**
Coffemakers	13	3	1	9	--
Ovens/Broilers	12	6	--	5	1
Toasters	7	1	1	5	--
Frying Pans	9	6	--	3	--
Other	14	8	--	5	1
Other App., Producing Heat	**79**	**34**	**3**	**42**	--
Irons	24	12	2	10	--
Heaters	21	--	1	20	--
Hair Dryers	21	11	--	10	--
Curling Irons	8	7	--	1	--
Electric Blankets	3	2	--	1	--
Other	2	2	--	--	--
Other App., Not Producing Heat	**44**	**15**	**14**	**14**	**1**
Vacuum cleaners	16	4	4	7	1
Fans	3	1	1	1	--
TV, Radio, Phono.	6	1	3	2	--
Table/Floor Lamps	5	2	2	1	--
Other Lighting	4	4	--	--	--
Air Conditioners	2	--	--	2	--
Other	8	3	4	1	--

Source: Epidemiologic Investigation Reports
Consumer Product Safety Commission/Division of Hazard Analysis

Age of Appliance Cord

Evaluation of product age * indicated that about two-thirds of the products (155/234), were 5 years old or less (Table 11). Over 40 percent were 2 years old or less. It appears that failures occurring at the appliance end of the cord involved somewhat newer appliances than did failures occurring at other locations. The mean age of the appliance cords failing at the appliance end was 4.9 years, compared to 5.8 years among failures at the attachment plug end and 6.4 years among failures along the cord. While 18 percent of all incidents involved products less than one year old, 39 percent of failures occurring at the cord/appliance termination (hard wired only) and 28 percent of attachment plug failures involved products less than one year old.

(Table C-2 in Appendix C presents these data in greater detail.) About one-half of these failures of new products at the cord/appliance termination involved lamps or night lights. Most of the failures of new products at the attachment plug involved portable heaters.

Electrical Ratings:

The ability of an appliance cord to safely carry the electrical load of an appliance is dependent upon the cord's construction features such as the wire size of the conductors and the method of assembly. Appliances of higher wattage ratings place a greater load upon a cord than do those of lower wattage ratings. As a result, appliances of higher wattages generally are of most concern when evaluating the adequacy of the cord.

Among products of 1500 or more wattage ratings, failures occurred most often at the attachment plug end of the cord, accounting for 34 of 46 failures (Table 12). Failures at the attachment plug or cord entry to the plug accounted for 20 incidents, failures at the interface of the attachment plug with the duplex receptacle outlet or extension cord accounted for 14

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* Appliance age was used as a surrogate for cord age because when both ages were known they were identical in all but 2 instances. Appliance age was reported more often.

Table 11
Age of Product by Failure Point for 234
Investigated Incidents of Electrical
Appliance Cord Failure

Age(Years)	Total		Failure Point: Appl. End		Along Cord		Attachment Plug End		Other	
	No.	%	No.	%	No.	%	No.	%	No.	%
Total	234	100	91	100	40	100	99	100	4	100
Less than 1	42	18	20	22	9	22	13	13	--	--
1-2	56	24	25	27	8	20	22	22	1	25
3-5	57	24	19	21	7	18	31	31	--	--
6-10	47	20	17	19	9	22	19	19	2	50
11-15	13	6	4	4	1	3	7	7	1	25
Over 15	19	8	6	7	6	15	7	7	--	--
Mean Age	5.6		4.9		6.4		5.8		8.0	

Note: Column detail may not add due to rounding.

Source: Epidemiologic Investigation Reports
Consumer Product Safety Commission/Division of Hazard Analysis

Table 12
Failure Point by Appliance Electrical Rating,
Investigated Incidents of Electrical
Appliance Cord Failure

Failure Point	Total	Watts			
		Under 500	500-999	1000-1499	1500 and over
Total Reported	191	41	15	89	46[a]
(Percent)	(100)	(22)	(8)	(46)	(24)
Appliance End	85	25	5	48	7
Connection to Appliance	19	10	1	6	2
Detach. Female Connector/Cord Entry to Connector	23	5	2	14	2
Strain Relief	43	10	2	28	3
Along Conductors	16[b]	9	1	3	3
Attachment Plug End	87	7	9	37	34
Attachment Plug/Cord Entry to Plug	67	5	9	33	20
Plug/Wall Receptacle or Extension Cord Interface	20	2	--	4	14
Other	3	--	--	1	2

[a] Four incidents were rated at over 1650 watts. Two products, a water heater and a clothes dryer, were reportedly 240 volt. The remainder were 120 volt.

[b] An additional 41 failures along conductors did not specify electrical rating, often due to fire damage.

Source: Epidemiologic Investigation Reports
Consumer Product Safety Commission/Division of Hazard Analysis

incidents. Overall, high wattage appliances were involved in 14 of 20 incidents that occurred at the plug/outlet interface. National Electrical Code guidelines for flexible cords indicate that cord sets with size 18 AWG conductors are suitable to carry electrical loads up to 10 amperes, 1250 watts. Four cords in this study, however, used size 18 AWG conductors for larger loads, 2 were used to carry 1400 watts, 2 carried 1500 watts. The products involved were a broiler oven, a portable heater, a tea pot and a tea kettle.

It is noteworthy that 41 additional incidents where failures occurred along the conductors were not included in Table 12 because the electrical rating was not specified. Of these 41, about one-half involved low wattage equipment -- 8 involved televisions, radios or phonograph equipment, 8 involved lighting equipment, and 5 involved fans. When this information is considered in conjunction with the failure point information in Table 12, (where 13 of 16 incidents that happened along the length of the cord involved wattages below 1500), then reported failures along the cord conductors did not appear to be related to high electrical loads.

Overall, only 7 incidents in this study involved 220 volt appliances. Additional cross-tabulations of power cord wire gauge (AWG) and power cord insulation type by incident type and failure point are included for reference in Appendix C, Tables C-3 through C-6.

Of the 205 incidents for which UL listing status was specified, 192 (94 percent) were UL listed, the remainder were not.

3. Comments on Selected Products

As indicated earlier, based on the frequency and severity of incidents reported, we have selected four products or product groups for examination in greater detail.

a) Cord-connected Heaters (Table 13)

This group included 27 portable electric heaters and one wall-installed 220 volt heating/cooling unit. In the latter incident a fire occurred and the failure point was identified only as an unspecified location on the cord. Overall, there were six fires, 19 overheating incidents and 3 arcing incidents.

Table 13
Characteristics of 28 Incidents
Involving Electric Heater Cords

a)Appliance:	No.
Portable Electric Heaters	27
Heating/Cooling Unit	1

c)Appliance:Age (years):	
Total Known	26
Less than 1	6
1-2	6
3-5	9
6-10	5

e)Electrical Rating (watts)	
Total Known	26
Less than 1500	4
1500	19
1650	2
3300 (220 volts)	1

g)Wire Gauge (AWG)	
Total Known	18
#16	17
#18	1

b)Power Cord Insulation	
Total Known	18
HPN	15
SPT-2	3

d)Power Cord Shape	
Total Known	23
Flat	21
Round	2

f)Power Cord Polarization	
Total Known	24
Polarized	6
Not Polarized	18

h)Failure Point by Incident Type

Failure Point	Incident Type		
	Total	Fire	Nonfire
Total Known	26	5	21
Cord connection to heater	1	1	--
Along conductor length	2	1	1
Attachment plug	11	1	10
Cord connection to attachment plug	2	--	2
Attachment plug/wall receptacle interface	8	1	7
Attachment plug/extension cord interface	2	1	1

Source: Epidemiologic Investigation Reports
Consumer Product Safety Commission/Division of Hazard Analysis

Most of the investigated cord-connected heater failures occurred at the attachment plug end of the cord (23 of 26 known). Failure of the attachment plug itself occurred most frequently (11 incidents). Eight incidents occurred at the attachment plug/receptacle interface but little information was available on the receptacles involved. Most heaters involved were high wattage products. Nineteen were rated 1500 watts, two were rated 1650 watts.

Of the 22 incidents where UL listing status was reported, all but one were UL listed.

Beginning in FY 1985, CPSC's Electrical Hazards Team conducted a project to evaluate and reduce the fire hazards associated with portable electric heaters. Ensuing staff recommendations included the following:

- Develop and implement revised or supplemental performance requirements for the attachment plug used on portable electric air heater power cords.

- Reduce the maximum permissible input power rating of portable heaters to 900 watts. Require non-standard attachment plugs and additional instructions for higher input-power rated portable heaters.

CPSC staff transmitted these recommendations to UL and the heater industry for suggested modification of the UL voluntary safety standard. Changes intended to strengthen the internal connections of the attachment plug are in process but no UL changes to reduce power ratings are contemplated at this time. Nevertheless, the data from this cord study lend further support to these previously identified issues.

b) **Lighting Equipment (Table 14)**

Floor or table lamps were involved in 14 of 21 lighting equipment incidents. Cord-connected night lights were involved in three incidents. Other incidents involved a make-up mirror, an interior cabinet light, and a Christmas decoration. Overall, there were 12 fires, 2 overheating incidents, 6 arcing incidents and 1 electric shock.

Failure in lighting equipment occurred most frequently along the length of the conductor. There were 9 incidents -- 7 fires, 1 arcing, and 1 electric shock. All but one of these 9 incidents involved a table or floor lamp. The remaining incident involved a cord-connected fixture. While not subject to the effects of high electrical ratings,

Table 14
Characteristics of 21 Incidents Involving Lighting Equipment Cords

a)Appliance:

Floor/table lamps	14
Nightlight	3
Cord-connected fixture	1
Christmas decoration	1
Cabinet lamp	1
Make-up mirror	1

b)Power Cord Polarization

Total Known	10
Polarized	3
Not Polarized	7

d)UL Listing

Total Known	8
UL Listed	6
Not UL Listed	2

c)Appliance Age (years):

Total Known	15
Less than 1	6
1-2	2
3-5	4
6-10	2
11-15	--
Over 15	1

e)Failure Point by Incident Type

		Incident Type	
Failure Point	Total	Fire	Nonfire
Total Known	19	10	9
Cord Connection to Lamp	7	1	6
Along Conductor Length	9	7	2
Cord Conn. To Attachment Plug	2	2	--
Attachment Plug	1	--	1

f)Failure Point by Product

		Product			
Failure Point	Total	Table/Floor Lamp	Fixture	Cord-connected Night light/ Make-up Mirror	Cabinet Light/ Decoration
Total Known	19	12	1	4	2
Cord Conn. to Product	7	3	--	4	--
Along Cord Length	9	8	1	--	--
Cord Connection to Attachment Plug	2	--	--	--	2
Attachment Plug	1	1	--	--	--

Source: Epidemiologic Investigation Reports
Consumer Product Safety Commission/Division of Hazard Analysis

several incidents cited physical damage, from heavy furniture and foot traffic. One cord had been spliced, for reasons that were not reported. The electric shock resulted in the electrocution of an infant when he rolled onto an old frayed cord with conductors exposed.

The second most common failure point in lighting equipment involved failure at the cord connection to the product. Seven such failures occurred -- 3 that involved table/floor lamps, 3 that involved cord-connected night lights which are in most cases a type of table lamp, and a make-up mirror.

The characteristics of the cords involved, particularly cord insulation type, wire gauge, and cord shape were not well reported. However, in the past, lamp cords have been almost exclusively 18 gauge, SPT-1 covered and flat. (Incident data bear this out). Eleven reported wire gauge (all 18 AWG), 12 reported cord shape (all flat), and 7 reported cord insulation (6 SPT-1, 1 SPT-2). In common parlance, the term "lamp cord" is often used to describe a cord of minimal specifications.

UL listing status was identified in only 8 incidents -- 6 UL listed, 2 not UL listed. Although we lacked information on the percentage of products on the market that were UL listed, it was considered likely that the percentage may have been lower for lighting equipment than for other electrical products that are more complicated to produce. For example, the Christmas decoration involved was a home - assembled product with a "smaller than normal" gauge cord that was not UL listed.

c) **Fans (Table 15)**

As discussed earlier, it was likely that CPSC's project on fans, based primarily on fires, contributed to the larger number of fan fires than nonfires (12 and 3 respectively) in this cord study. However, these incidents demonstrated both the severe consequences of fan cord failures and the occurrence of cord failures among fires reported as product rather than cord fires. Five deaths and six injuries involved fans.

Because of the number of destructive fires, few incidents reported cord characteristics. Three incidents cited conductor size -- two #18 AWG and one #16 AWG. Three incidents cited cord shape, all flat; and only one cited insulation type - SPT-1. Nevertheless it is known that fans generally are low-wattage appliances with cords appropriate for such use.

Table 15
Characteristics of 15 Incidents Involving
Electric Fan Cords

a) Appliance Age (years):

Total Known	11
Less than 1	1
1-2	1
3-5	2
6-10	3
11-15	1
Over 15	3

b) Failure Point by Incident Type

Failure Point	Incident Type		
	Total	Fire	Nonfire
Total Known	11	8	3
Cord Connection to Fan	2	1	1
Along Cord Conductors	8	7	1
Cord Connection to Attachment Plug	1	—	1

Source: Epidemiologic Investigation Reports
Consumer Product Safety Commission/Division of Hazard Analysis

We note that the most commonly reported failure point among these incidents (8 of 11 known) was along the cord length. Several incidents indicated that the cord had suffered physical damage. Three reportedly had been spliced and one was the cause of a fatal electric shock.

Compared to other products, the fans included here were somewhat older; 7 of 11 were over 5 years old, 3 were over 15 years old. Only 2 incidents cited a UL marking. UL listing status of the remainder was unknown.

d) **Consumer Electronics - Televisions, Radios, and Phonographs (Table 16)**

The 14 appliances involved in this group included 9 radios, 4 televisions and 1 phonograph. Failures included 8 fires, 3 overheating incidents, 2 arcing and one electric shock. Similar to lighting equipment and fans, these products normally have low wattage ratings and place relatively small electrical loads upon the cord. However, individual characteristics were not reported for the majority of incidents. Electrical ratings were reported for only 4 incidents, all were under 200 watts. Cord insulation type and cord shape were reported for 3 incidents, all were flat and SPT-1. Only two cited conductor size, both #18 AWG.

Most failures among this group occurred along the cord conductors, 9 of 13 where failure point was known. Again, similar to lighting equipment and fans, seven incidents cited damage to the cord by furniture or other external sources as the cause of failure. One of these resulted in the fatal electric shock to an infant who contacted exposed conductors. Overall, there were six deaths (one electrocution and 5 deaths in one fire) and two injuries related to this product group.

Discussion

The NFIRS data on which cord estimates were based were not designed to facilitate product-by-product cord estimates. The NFIRS coding system calls for all cord fires to be included within one equipment code "cords, plugs", which includes extension cords. An earlier study conducted in 1985 allowed us to estimate the proportion of extension cords versus other cords within this group. About 50 percent were extension cords and 50 percent were other kinds of electric cords. However, based on failures investigated for this cord study, it appeared that estimates based solely on data coded as "cords, plugs" greatly underestimated appliance/equipment

Table 16
Characteristics of 14 Incidents Involving
Television, Radio and Phonograph Cords

a) Appliance:

Radios	9
Televisions	4
Phonographs	1

b) Appliance Age (years):

Total Known	7
Less than 1	3
1-2	1
3-5	-
6-10	3

c) Failure Point by Incident Type

		Incident Type	
Failure Point	Total	Fire	Nonfire
Total Known	13	7	6
Cord Connection to Product	3	1	2
Cord Connection to Detachable Female Receptacle	1	-	1
Along Cord Conductors	9	6	3

Source: Epidemiologic Investigation Reports
Consumer Product Safety Commission/Division of Hazard Analysis

cord fires. About one-half of the appliance cord fires for which fire service coding was known were coded by the fire service as appliance rather than cord fires, indicating that there may be twice as many appliance/equipment cord fires occurring as that estimated from the "cord, plug" code alone -- a total of 9,200 fires that resulted in 160 deaths, 460 injuries and $92.4 million in property loss annually.

Early in the cord project planning, we recognized that the destructive nature of the fires associated with these products was a major obstacle to failure analysis. The data collection methodology designed to address this problem, solicitation of low-damage failures, was successful in providing much information that was previously not available. However, it was not a controlled sample that could support product-specific estimates of the cords involved.

The 281 resulting investigations that involved electrical cord failure indicated that a variety of product cords were involved in these failures. Many of the tables in the preceding section presented comparisons of fire and nonfire incidents, by product, cord characteristics, failure point, etc. Such comparisons illustrated that both fires and nonfire incidents resulted from the same kinds of failures, e.g., that failure at the strain relief of an iron cord could result in either arcing alone when interrupted by a consumer or actual flames with the potential for more widespread damage if not interrupted.

It appeared that consumer intervention was a critical factor in affecting outcome once a failure occurred. For example, while failures of iron cords were reported more often than any other cords, none progressed to the point that fire service attendance was required; and iron fires as a product group appeared relatively infrequently in national fire data. The nature of iron use, that requires the active attention of a consumer, probably explains the apparent effectiveness of consumer intervention in such failures. However, a feature of equal importance in understanding outcome is whether or not the product is normally left plugged in and unobserved while not actually in use.

Directing our concern to failures that led to attended fires, we selected four product groups for individual evaluation -- heaters, lighting equipment, fans, and consumer electronics equipment such as television, radios, and phonographs. The primary failure point was along the cord length for all groups except heaters. In each of these three groups, several incidents cited physical damage to the cord that appeared to be related to its placement and use. Cords

were not only placed in areas that subjected the cord to damage but by common usage the cords were left plugged in between periods of active use. In addition, the nature of consumer use for these products was probably different than for products such as irons, since consumers were probably less likely to be in the same room and able to intervene quickly.

Heater cord failures occurred most often at the attachment plug end of the cord -- the attachment plug and the interface between the attachment plug and the duplex receptacle outlet. These failures appeared to be related not to external factors but to the electrical loads placed on the components by high-wattage equipment.

Although these four product groups were selected for special evaluation, their selection does not imply that other products may not warrant similar attention. The failure and incident characteristics exhibited by lighting equipment, fans, and consumer electronic equipment may also occur in a variety of other equipment. Attachment plug failures identified among portable electric heater cords occurred among a variety of other high-wattage appliances as well.

In planning any future efforts, it should be noted that the nature of the cord industry is such that while there are many different cord constructions, cords supplied for several types of products may be identical. It is considered likely that even if a change is directed at only one or two products, that change will likely find its way into cords for a number of other products as well.

In closing, we caution again that the nature of this data collection effort was such that the frequencies reported among the investigated incidents cannot be used to assess relative risk among products. Nevertheless, the common failures involved should provide direction for efforts to reduce cord failures.

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The author and other members of the Electrical Hazards Team gratefully acknowledge the extensive efforts of the CPSC field investigators who worked diligently to solicit consumer reporting of cord failures and to collect product samples. Without those efforts, identification of cord failure points and other incident characteristics vital to the analysis would not have been possible.

APPENDIX A
SOURCES AND TYPES OF INCIDENTS

Table A-1 presents the results of the data collection effort, by source and type of incident. Overall, 281 incidents, 94 fires and 187 nonfires, met the study criteria. As expected, the data sources differed in the types of incidents they reported most often. Unsolicited incidents, such as newspaper clippings, produced over 80 percent of the fires and about 25 percent of the nonfire incidents. Solicited incidents produced about 15 percent of the fires and about three-quarters of the nonfire incidents.

The amount of property damage also differed among the various data sources since damage generally was related to the occurrence or the nonoccurrence of fire. Of 42 newspaper clippings, 90 percent cited property damage that extended beyond the product, its cord, and the extension cord or receptacle into which it was plugged. Among incidents reported by fire departments, about two-thirds involved damage of that amount. In contrast, less than 20 percent of unsolicited consumer complaints and only about 5 percent of all project-solicited incidents involved damage of that extent (Table A-2). Of the 19 deaths and 34 injuries included in this study, all of the deaths and 26 of the injuries occurred in incidents from unsolicited sources -- predominantly newspaper clippings.

Table A-3 presents a distribution of the appliances reported by the source of the incident. Newspaper clippings and fire department reports, that generally report the more serious fires, predominantly reported non-heat producing appliances.