

HAZARD ANALYSIS



ALUMINUM WIRING

APRIL 1975



U.S. CONSUMER PRODUCT SAFETY COMMISSION
Bureau of Epidemiology
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HAZARD ANALYSIS
OF
ALUMINUM WIRING

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U.S. CONSUMER PRODUCT SAFETY COMMISSION

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ABSTRACT

Reports of electrical failures in homes wired with aluminum have become a concern nationwide. According to rough estimates by the Aluminum Association, the total number of homes wired with aluminum in 15 and 20 amp circuits reached 2 million by 1972. The U.S. Consumer Product Safety Commission has collected almost 500 reports of aluminum wire incidents involving electrical malfunctions in single family dwellings, mobile homes, and multifamily dwellings between 1967 and 1975. In these reports, damage ranged from failure of an electrical component to fires with extensive structural damage. Twelve deaths were reported. Summaries of 198 incidents are included in the Appendix.

I. INTRODUCTION

For decades copper was the principal metal used as an electrical conductor, but today almost half of all the electrical cable used in the United States is made of aluminum.¹ The demand for aluminum increased as the cost of copper rose during periods of short supply; in time copper lost its economic advantage.^{2,3} Prior to 1960, most aluminum had been used industrially for high tension utility wires and for heavy conductors in large buildings. Since the midsixties, aluminum has been used in significant amounts for branch circuit wiring in single family homes. By 1972, aluminum was utilized in almost 100 percent of the transmission conductors leaving the generating plants, 80 percent of the service entrance cable, and 15 percent of the branch circuit wire in single family dwellings (Table 1).

A survey of members of the Aluminum Association⁴ provided yearly production figures on aluminum cable by weight. The Association converted these weights to feet of cable, as shown in Table 2. The amount produced in 1971 was three times that produced in 1967, but production has been decreasing since 1971.

Both the National Bureau of Standards (NBS) and the Aluminum Association made rough estimates of the national total of homes wired with aluminum in 15 and 20 ampere branch circuits by using this data plus some broad assumptions.⁵ Their estimates for 1972 ranged between 1.5 and 2 million homes. Since these referred to houses completely wired with aluminum, the estimates would have been higher if homes partially wired with aluminum had been included.

Building codes for electrical wiring vary according to local regulations throughout the United States. Many local jurisdictions follow the National Electric Code, a voluntary model code that is kept current by a panel of electrical experts who update it on a three-year cycle. Some jurisdictions have additional requirements and some may have no codes at all. Many areas require Underwriters' Laboratories, Inc. (UL) approval of electrical components. For that reason, it is interesting to note the changes in the UL positions between 1966 and 1974 with regard to the branch circuit terminal devices, the aluminum conductor, and methods of connecting the two.

Between 1966 and 1974, at least 5 different recommendations were made regarding terminal devices. At first, general use wiring devices (except those using screwless push-in terminals) were acceptable for use with aluminum wiring.⁶ Then UL listed devices acceptable for aluminum were labeled "AL-CU" but later approval of the devices was withdrawn. In 1972, UL listed a wiring device labeled "CO/ALR."

TABLE 1

PROPORTION OF ALUMINUM CABLE USED IN 1972

TYPES OF CABLE	PERCENT
Transmission conductors	Almost 100%
Distribution conductors	95%
Service entrance cable	80%
Feeder cable	20%
Branch circuits	15%

Source: Aluminum Association, Aluminum Wiring Hearings, CPSC, March 27, 1974, pg. 201.

TABLE 2

ESTIMATE OF PRODUCTION OF ALUMINUM WIRE 1960 - 1973

YEAR	MILLIONS OF FEET*
1960-1965	84
1966	136
1967	175
1968	227
1969	390
1970	430
1971	586
1972	357
1973	327

* Yearly production quantities by weight converted to length by a single conversion factor for an assortment of wire sizes (# 10 and # 12 AWG).

Source: Aluminum Association, Aluminum Wiring Hearings, CPSC, March 27, 1974, pg. 206.

Effective January 1974, devices not marked "CO/ALR" were required to indicate they were not suitable for aluminum wiring. A summary of these recommendations is given in Appendix E.

During this period devices with plated steel screws (usually zinc plated) instead of brass screws were produced; these were later determined to be incompatible with aluminum wire (see Appendix F). Additional bulletins on wiring devices were sent out by Leviton, a major manufacturer of devices and by the National Electrical Manufacturing Association.

By 1968, UL had received field reports of problems associated with aluminum electrical wiring. They attempted to make a survey of the problem in 1969. The response rate was poor for a statistical evaluation of risk, but they did receive reports of difficulties that they proceeded to attempt to solve in their laboratories.⁵

From 1970 to 1974, cognizance of the existence of a problem is evidenced by the actions of both testing laboratories and manufacturers with regard to aluminum wire. UL revised its specifications for aluminum wiring repeatedly (Appendix G). Manufacturers developed new aluminum alloys as well as nickel plated and copper-clad aluminum wire.

An Ad Hoc Committee on the Use of Aluminum Conductors with Wiring Devices in Electrical Wiring Systems was organized by UL in August 1972, "in order to allow for the exchange of information about actions that have been or should be taken to ensure proper and safe use of aluminum conductors and wiring devices."⁵ Members of the committee came from all areas of technical interest in aluminum conductors and wiring devices. In March 1973, final recommendations of the Ad Hoc Committee were released (Appendix I).

In spite of all these efforts there are still problems with aluminum wiring. With each revision of specifications, some homes were left with potentially unsafe wiring.

Basically, the nature of the concern referred to as "the aluminum wiring problem" has been reported as heat generation at the connection of aluminum conductors to terminal devices. Devices such as wall receptacles, wall switches, twist-on wire connectors, outlet boxes, junction boxes, panel boxes (fuse or circuit breaker boxes), etc., may become overheated and result in fire if combustible materials are close by. Overheating of the terminal connection has been related to a number of factors including:^{7,9}

. Oxidation

Aluminum reacts with oxygen in air to form aluminum oxide, a poor conductor of electricity. A buildup of aluminum oxide on the wire at the connection interface creates a high resistance between it and the connecting metal. This high resistance to current flow can result in heat buildup at the interface. Sufficient torque on a binding screw connection is necessary to break the oxide film and obtain good metal to metal contact at a connection.⁸

. Creep

When subjected to compressive stress, some types of aluminum wire tend to cold flow or creep away from a stressed area more than wires made of copper or of certain aluminum alloys. This tendency increases with temperature.

. Higher coefficient of thermal expansion

Aluminum expands more than copper, brass, and steel when heated. This could adversely affect the integrity of connections involving dissimilar metals if sufficient heating and cooling take place. Under these conditions, loose terminations may result.

. Susceptibility to corrosion

Electrolytic action may cause serious corrosion problems when dissimilar metals such as aluminum and copper are in the presence of an electrolyte such as moist air. It can result in erosion of a connection.

On September 1, 1971, UL withdrew listing of all receptacle and switch outlet devices then available for use with aluminum wire. This amounted to a prohibition of aluminum wiring in some areas since building codes in many jurisdictions require that all electrical components used be listed by UL. At that time some communities took action to ban aluminum wiring in new construction.⁵ Appendix H gives the type of restriction and effective date for various areas throughout the United States. Although UL later listed devices labeled CO/ALR, many jurisdictions did not withdraw their restrictions.

II. METHODOLOGY

Hazard analyses by the U.S. Consumer Product Safety Commission (CPSC) are generally based on injury data from the National Electronic Injury Surveillance System (NEISS), operated by CPSC's Bureau of Epidemiology. Designed to develop valid, nationally representative product-related injury data, the NEISS is a computer-based network of 119 statistically selected hospital emergency rooms located throughout the country. Since most reported aluminum wire electrical failures resulted in damage to the electrical component or the structure rather than injury, this system did not provide data for the analysis of the possible risk associated with aluminum wire. NEISS reported injuries involving electric wire or electrical components were usually precipitated by children putting metal objects in wall receptacles.

Although NEISS was not productive in collecting incidents involving the electrical malfunction of aluminum wire, the Commission actively pursued other sources to locate fire incidents involving aluminum wire failures. Follow up of these leads supplied the Commission with numerous in-depth investigations by field personnel of the Bureau of Epidemiology. These reports provided detailed descriptions of the electrical systems on the homes involved, as well as photographs and brand names of aluminum conductors and terminating devices.

Reports of electrical failures involving aluminum wiring have come to the attention of the Commission from various concerned individuals and groups: individual consumers who have become aware of this hazard in their own homes; associations of homeowners or tenants who have become aware of this hazard in their community; fire marshals and chief electrical inspectors who have become aware of this hazard from repeated incidents in their jurisdictions; and the National Fire Protection Association which has become aware of this hazard because of the number of incidents occurring nationwide. Summaries of 198 cases are included in Appendices A - D.

Table 3 shows the source of the reports which have been used to evaluate the conditions associated with the failure of electrical systems using aluminum wire as the conductor. Following is a summary of background information about each source of data:

TABLE 3
SOURCES FOR REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE

	(ID)**	TOTAL	TYPE OF DWELLING		
			SINGLE FAMILY	MOBILE HOME	MULTI-FAMILY
1. Statements Submitted for Public Hearings Held by CPSC on Aluminum Wire					
. Washington, D. C.					
Prince George's, Maryland*	(PGM)	18	14		4
(Chief Electrical Inspector)	(CF)	5	4		1
7/71-8/73					
Other Testimony at Wash. Hearings	(AHW)	1	1		
. Los Angeles, California					
Fountain Valley, California*	(FVC)	21	21		
(Fire Marshals)	(FRC)	10	8	2	
11/70 - 12/73					
Huntington Beach, California*	(HBC)	25	21	3	1
(Fire Marshal)					
11/70 - 12/73					
Other Testimony at Calif. Hearings	(AHC)	4	3	1	
2. National Fire Protection Association	(NFP)	30	2	24	4
(Fire Reports)					
9/72 - 10/73					
3. CPSC - In-Depth Investigations					
Hampton Bays, Long Island, New York	(CC)	1	1		
Suffolk County, New York	(CC)	6	6		
Others	***	26	18	6	2
4. Consumer Complaint Letters	(CC)				
. Associations of Tenants or Homeowners					
Tammy Brook Tenant Association	(CC)	12			12
Weymouth, Massachusetts					
Twelve Pines Civic Association*	(CC)	5	5		
Medford, Long Island, New York					
Montgomery Village Civic Association*	(CC)	3	3		
Concerned Individuals	(CC)	19	10	7	2
	(P)	1		1	
	(CF)	11	11		
TOTAL		198	128	44	26

*Testified at Aluminum Wiring Hearings, CPSC

**These abbreviations identify the source in the summaries of electrical incidents (Appendix A-D)

***In-Depth Investigations are identified by a 6 to 13 digit code.

SOURCE: U.S. CONSUMER PRODUCT SAFETY COMMISSION/Bureau of Epidemiology

PUBLIC HEARINGS HELD BY CPSC

Congressional interest in fire hazards associated with electrical wiring systems using aluminum conductors prompted the Commission to plan public hearings on the subject. A notice was published in the Federal Register on February 28, 1974, of two public hearings, one in Washington, D. C. (March 27 and 28, 1974), and a second in Los Angeles, California (April 17 and 18, 1974).

Representatives from the General Council's Office, the Bureau of Engineering, the Office of Standards Coordination and Appraisal, and the Commissioners of the Consumer Product Safety Commission heard testimony from individual consumers, representatives of industry, testing laboratories, the scientific community, etc. Persons who were unable to attend the hearings but wished to present written comments for the Commission's consideration were invited to do so.

PRINCE GEORGE'S COUNTY, MARYLAND

The chief electrical inspector of Prince George's County testified at the public hearings held by CPSC on March 27, 1974; he had become aware of the problem in 1971 and maintained a special file documenting 18 incidents involving aluminum wiring in single family dwellings between July 1971 and August 1973. Additional reports from the County have been obtained. Aluminum branch-circuit house wiring was banned in Prince George's County by March 1972.

FOUNTAIN VALLEY, ORANGE COUNTY, CALIFORNIA

Two fire marshals from Orange County testified about incidents brought to their attention since July 1967 at the public hearings held by CPSC on aluminum wiring in Los Angeles. They submitted a summary of 26 cases of electrical incidents.

The Commission arranged for investigators in their Los Angeles Field Office to trace the original records of these incidents in order to validate the information. The investigators were unable to find records of all the incidents; in addition, five of the original case records had no mention of aluminum wire and had to be eliminated from the analysis. At the same time, the investigators were able to find records of 10 additional aluminum wiring problems in the Orange County area. A total of 31 cases are included in the summaries. Orange County banned aluminum branch-circuit wiring in January 1971.

HUNTINGTON BEACH, CALIFORNIA

The data from Huntington Beach, California, was submitted by the Captain of the Huntington Beach Fire Department serving as a Deputy Fire Marshal. He testified at the public hearings held by CPSC in California,

April 17, 1974, that he had noted a marked increase in electrical faulting conditions in residential wiring systems since June 1970. He submitted a list of 25 such incidents that occurred between May 1970 and June 1971. There was a bare minimum of information for each case mentioned. Commission staff contacted the Huntington Beach Fire Department to obtain additional documentation, but included these cases in this analysis because of the awareness and concern of the officials in that jurisdiction. Huntington Beach banned alum in September 1970.

NATIONAL FIRE PROTECTION ASSOCIATION

Except for fires occurring in mobile homes or recreational vehicles, reports of most fires attributed to electric wiring or equipment did not indicate whether the wire involved was aluminum or copper. For this reason, summaries of fire incidents taken from the files of the NFPA Fire Record Department related almost entirely to mobile homes. The reports often were not sufficiently specific in technical details; qualified electrical experts were not usually consulted in fire investigations even when the cause of fire was reported to be electrical in nature. Structural damage was reported in many of the incidents since this was the type of data the NFPA collected.

CITIZENS' GROUPS

Tammy Brook Apartments Weymouth, Massachusetts

Headed by a tenant who had experienced a series of electrical difficulties since 1968, this tenant group is suing the owners of the development based on the alleged unsafe nature of the apartments. Twelve apartments have evidenced problems with the electrical system. One electrical contractor noted that "the original installation of receptacles was backwired with aluminum." According to UL standards, backwiring was not considered an acceptable method of connection at anytime. Therefore, these cases were considered separately in the analysis.

Twelve Pines Civic Association Medford, Long Island, New York

The president of the Twelve Pines Civic Association wrote to the Commission about an electrical incident at his home and testified at the Aluminum Wire Hearings, CPSC, about the other cases. Upon hearing of the Hampton Bays fire, he was instrumental in bringing it to the attention of the Commission (see page 9.)

Montgomery Village Civic Association
Gaithersburg, Maryland

A representative of the civic association testified at the Aluminum Hearings, CPSC, in Washington, D. C., about a survey in Montgomery Village, a housing development in Maryland. Fires with damage limited to the electrical components were reported. He related an incident in his own home and mentioned others he had heard about.

Fire reports were obtained by the Commission to verify the information about three incidents in Montgomery Village.

CONCERNED INDIVIDUALS

Most homeowners do not have the expertise to document the incidents but often can provide a great deal of information relating to their personal experiences. Some sent in the damaged electrical components. A few of the complainants at the public hearings were electrical engineers and were able to give details about the condition of the wire, the terminal device and the termination as well as associated conditions.

CPSC - IN-DEPTH INVESTIGATION

An active program to locate fire incidents involving aluminum wire was initiated in June 1974. Directors of the 14 CPSC Area Offices were requested to contact local fire departments, county electrical inspectors and other appropriate outside organizations for assistance in identifying current fire incidents involving aluminum wire for possible follow-up investigation.

In certain cases, such as the Hampton Bays fire, a team of experts visited the scene of the incident to obtain pertinent information on the circumstances.

Hampton Bays, Long Island, New York

This fire involving aluminum wire was brought to the attention of the Commission soon after the Aluminum Wire Hearings of the CPSC. About a week later, a team of experts including representatives from the Commission and the local fire and police departments, and a local electrician visited the scene of the fire in which two fatalities occurred. They were able to obtain photographs and samples of electric devices from the house before the evidence had been disturbed.

"HOT-LINE" CALLS

The Consumer "Hot-line" reports are one source of information collected by the Injury Surveillance Desk, Division of Injury Surveillance, Bureau of Epidemiology, CPSC. Toll-free phone calls from any area nationwide are received in one central office in the Consumer Education Division of the Bureau of Information and Education. Information collected by the Injury Surveillance Desk is unverified.

Between August 6 and October 30, 1974, the "Hot-Line" received telephone calls regarding aluminum wiring from 659 homeowners (Table 4). The majority of telephone calls came from the New York area where a local paper, Newsday, had been publicizing the hazard; only 35 telephone calls came from other areas of the country; however, 16 states were represented. While half the homeowners in the New York area reported problems with aluminum wiring, only 4 of the 35 homeowners from other areas had complaints. Other callers were interested in further information.

The first article in Newsday, dated August 29, described the dangers of aluminum wiring in detail and suggested that concerned homeowners call the "Hot-Line" of the CPSC. The article gave the toll-free "Hot-Line" number and stated: "If the Commission ever decides to order some member of the industry to pay for corrective action, your report will have let the Commission know about your house." This may have motivated many homeowners in the New York area to phone. (According to Newsday, over 100,000 homes and apartments in Long Island were wired with aluminum between 1966 and 1972.) During the following three weeks, the "Hot-Line" received 404 telephone calls from the New York area relating to aluminum wire; over half the calls were made during the first two days after the article appeared.

A follow-up article was published in Newsday on October 2; the renewed publicity generated another 220 telephone calls by October 30.

TABLE 4

"HOT-LINE" CALLS RE ALUMINUM WIRING
August - October 1974

MONTH	AREA OF COUNTRY			
	NEW YORK		OTHER	
	TOTAL	COMPLAINTS	TOTAL	COMPLAINTS
August	282	114	17	1
September	122	65	4	1
October	220	118	14	2
TOTAL	624	297	35	4

SOURCE: U.S. CONSUMER PRODUCT SAFETY COMMISSION/Bureau of Epidemiology

III. RESULTS

The information in 186⁺ cases submitted to the Commission was used to determine the hazard patterns in the aluminum wire failures. While the cases are not a statistical sample, even for the area represented, they do give evidence of the existence of a possible hazard. The extent of this possible hazard cannot be evaluated from these data, but certain elements common to the incidents can be identified. It is noteworthy that the electrical failures have occurred from coast to coast with more than 20 states and 60 cities or townships represented.

HAZARD PATTERNS

The 186 reports include 128 in single family dwellings, 44 in mobile homes, and 14 in multifamily dwellings. Table 5 presents the hazard patterns in the 186 electrical incidents by type of dwelling.

TABLE 5
HAZARD PATTERNS BY TYPE OF DWELLING
IN 186 ELECTRICAL INCIDENTS

HAZARD PATTERN	TOTAL	TYPE OF DWELLING		
		SINGLE FAMILY	MOBILE	MULTI FAMILY
Failure	44	38	5	1
Overheating	16	11	3	2
Evidence of Burning	27	23	3	1
Smoke	12	7	4	1
Arcing	25	21	4	
Fire	62(39)*	28(11)	25(21)	9(7)
TOTAL	186	128	44	14

* () Fires with structural damage.

+ 12 incidents at Tammy Brook Apartments are excluded.

SOURCE: U.S. CONSUMER PRODUCT SAFETY COMMISSION/Bureau of Epidemiology

The hazard patterns, usually the conditions that brought attention to the problems, were defined as follows:

. Failure	Electrical component was inoperative.
. Overheating	Electrical component was described as warm, hot, etc.
. Evidence of burning	Smell of burning was mentioned or electrical component was described as charred, melted, or burned.
. Smoke	Smoke was mentioned in report.
. Arcing	Arcing at terminal device was seen.
. Fire	Fire or structural damage was mentioned in report.

The 128 incidents in single family dwellings represented all types of hazard patterns. The 44 mobile home incidents and 14 multifamily dwellings had a large proportion of fires with structural damage: 21 of the 25 mobile home fires had structural damage as did 7 of the 9 fires in multifamily dwellings. This reflected the way the reports were obtained--through fire marshals and the NFPA (see Methodology, p. 5). While the events indicated electrical failures can lead to fire, they did not give a quantitative estimate of the risk involved.

Many reports gave the alerting condition or type of failure without reporting the underlying cause of the condition. Other respondents have examined the terminal, the conductor, the connection, and even the circuit carefully and supplied facts pertinent to the problem. The amount of information in each report was anywhere between these two extremes.

One point in particular must be kept in mind when analyzing the data. While the defective conditions mentioned can be counted, non-mention of a condition does not mean it did not exist. Even with these limited data, certain common elements were present. Table 6 indicates the condition of components of the electrical systems and other information about the circuitry for incidents resulting in failure, overheating, evidence of burning or smoke, arcing, and fire.

Failures

Most cases designated as failure involved a wall receptacle that did not work. In one case, a dishwasher failed to complete the cycle; junction box wires and wire nut were charred; oxidation was visible on the wire; the circuit breaker did not trip. The few cases that gave additional information reported loose screws or improper wiring.

TABLE 6

REPORTS OF CONDITION OF COMPONENTS BY HAZARD PATTERN

CONDITION OF ELECTRICAL COMPONENTS**	HAZARD PATTERN				
	FAILURE	OVERHEATING	SMOKE OR EVIDENCE OF BURNING	ARCING	FIRE*
Connection Loose screw, Disconnected wire, or Faulty connection	15	5	9	8	13
Conductor Wire or Insulation Hard Oxidized Melted or burned	1 2	1 5	1 5 19	1 4	1 10
Terminal Device Oxidized Melted or burned Steel screw	3	5	2 25 1	15	20 1
Circuit Conditions Appliance on circuit Receptacle not used Short circuit Circuit breaker tripped Circuit breaker not tripped Lights on circuit flickered or off	10 1 3 1 3 3	5 2	19 1 3 5 4	7 1 1 3 2	11 6 5 2 1

* Obvious damage in fires with structural damage not listed in table
 21 mobile homes were 10-100 percent destroyed
 7 multifamily homes with >\$500 damage
 11 single family homes with >\$100 damage

** An incident may be tabulated for more than one condition

SOURCE: U.S. CONSUMER PRODUCT SAFETY COMMISSION/Bureau of Epidemiology

Overheating

A loose screw was mentioned in one report along with blistered wire insulation. Burned or melted wire and terminal devices were reported. Appliances such as a refrigerator or vacuum were on the circuit involved in five incidents; in two of them, the receptacle involved was not in use at the time of the incident.

Smoke or Evidence of Burning

Loose screws, a steel screw, hard wire, oxidized wire or terminal devices were mentioned. Melted and burned wire, insulation, receptacles, switches or junction boxes were found. Lights on the circuit operated intermittently. Appliances on the circuit included a dryer, oven, dishwasher, and refrigerator. The receptacle involved was not being used in one instance.

Arcing

Loose screws, melted or burned wire, insulation and receptacle were noted. Appliances on the circuit included a television, refrigerator, oven, water heater, and heat pump. The receptacle involved was not being used in two instances.

Fire

Fires with structural damage totaling a quarter of a million dollars were reported in 39 dwellings: 11 single family dwellings, 21 mobile homes and 7 multifamily dwellings. Many of these reports did not give details necessary to trace the origin of the fire. Reports mentioned loose screws, steel screws, hard wire, melted or burned conductors and terminal devices. Appliances on the circuit involved included an air conditioner, boiler pump, exhaust fan, range, furnace, humidifier, disposal, dishwasher, and baseboard heater.

The electrical components involved in the fires in single family houses were often receptacles or panel boxes; in mobile homes they were receptacles, junction boxes, or the wiring; in multifamily dwellings, wiring, panel boxes, and service equipment were mentioned.

Circuit conditions mentioned repeatedly for all the hazard patterns included:

- . The receptacle involved was not in use but was on a circuit in which another receptacle was in use.
- . An appliance was being used on the circuit affected. Most of the appliances mentioned used current intermittently, so that there would be alternate periods of heating and cooling of the aluminum wire and wiring devices.
- . The circuit breaker had not tripped (or fuse had not blown).

WIRE SIZES

Aluminum branch circuitry in homes involves #10 and #12 AWG wire for 20 and 15 amp circuits, respectively. Circuits connected to furnaces, ovens, clothes dryers, and water heaters usually require heavier gauge #6 or #8 AWG wire. The 186 electrical malfunctions were categorized by wire size in Table 7. Failures in circuits using #8 or heavier gauge wire occurred in 36 of the 186 incidents. Problems with fixed equipment usually occurred at the junction box and often involved twist-on insulated wire connectors (wire nuts).

TABLE 7

ELECTRICAL MALFUNCTIONS INVOLVING ALUMINUM WIRE
BY WIRE SIZE AND TYPE OF DWELLING

WIRE SIZE AWG	ELECTRICAL APPLIANCE OR COMPONENT	TOTAL	TYPE OF DWELLING		
			SINGLE FAMILY	MOBILE HOME	MULTI- FAMILY
#10 or #12	Receptacle/ Switch	132	90	37	5
#8 or larger	Oven/range	36	<u>25</u>	<u>5</u>	<u>6</u>
	Furnace		3	2	2
	Water Heater		10	2	
	Dryer		1		
	Panel box/ Service Equip.		2		
Unknown	Heater	18	8	1	4
			1		
			<u>13</u>	<u>2</u>	<u>3</u>
	Panel Box		7		
	Humidifier		1		
	Air Conditioner	1			
	Heater	1			
	Miscellaneous	3		2	3
TOTAL		186	128	44	14

SOURCE: U.S. CONSUMER PRODUCT SAFETY COMMISSION/Bureau of Epidemiology

IMPROPER WIRING

In a number of reports, "possible code violations" or "improper wiring" were mentioned by respondents including consumers, electricians, and fire inspectors. These terms were used to designate a variety of conditions ranging from poor workmanship to obvious code violations in the home, but not necessarily in the electrical component involved in the incident.

Poor workmanship might reflect poor judgment in the amount of force required to tighten a screw connection, or minor faults such as overlapping wire at the screw terminal or wire wrapped around the screw in the wrong direction. In some cases, the misapplication of terminal devices was observed in the use of "pressure lock connectors" or "backwiring."

Code violations refer to an infraction of the electrical code of the local jurisdiction reporting, for example, a branch circuit in which the wire size used was inadequate for the load. As a result of repeated changes in UL recommendations for the installation of aluminum wire since 1965, standards considered acceptable at the time a home was built could have been unacceptable at the time these incidents occurred (1970-1975).

Identifying an improper wiring or code violation requires an expertise which the homeowner could not be expected to have. As shown in Table 8, the proportion identified by consumers was as low as 5 percent while field investigators of the Commission or electrical inspectors uncovered such conditions in approximately 30 percent of the single family homes with electrical malfunction.

TABLE 8

IMPROPER WIRING IN SINGLE FAMILY DWELLINGS

SOURCE OF REPORT	HOMES WITH ELECTRICAL MALFUNCTIONS	HOMES WITH IMPROPER WIRING	
	NUMBER	NUMBER	PERCENT
In-Depth Investigations	25	8	32%
Electrical Inspectors	18	3	17%
Fire Marshals	52	3	6%
Concerned Individuals	33	2	6%
TOTAL	128	16	12%

SOURCE: U.S. CONSUMER PRODUCT SAFETY COMMISSION/Bureau of Epidemiology

An illustration of confusion surrounding proper wiring procedures is found in the case reports of a tenant group from Massachusetts.

Tammy Brook Apartments

Tenants in twelve apartments in this development complained of problems with wall receptacles, switches, and light fixtures. Overheating and arcing were described, as well as a few electrical fires which had been contained within receptacles.

Reports from an electrical contractor who had checked the wiring in four apartments (September 1973 and February 1974) indicated he had found "receptacles backwired with aluminum conductors." This wiring method has never met UL standards for aluminum wire (Appendix E). The conditions found in the development might have been due to improper wiring.

In direct contradiction to these findings was a statement, dated December 1973, by the wiring inspector of the town of Weymouth, Massachusetts. In his opinion, the original installation was done in accordance with what then prevailed as good design and installation practices with respect to aluminum wiring.

The confusion with respect to specifications for wiring with aluminum in Massachusetts may be representative of similar conditions throughout the United States.

HOT-LINE CALLS - NEW YORK

Between August 29 and October 30, 1974, the Consumer Product Safety Commission "Hot-Line" received telephone calls from 624 residents of the Long Island, New York, area in response to two articles published in Newsday concerning the hazards of aluminum wire. Following the first article, dated August 29, the "Hot-Line" received 404 telephone calls: 179 calls from homeowners who had observed danger signals or had experienced electrical malfunctions involving aluminum wire (Table 9). Using the following objective criteria, the analyst classified about half of the incidents as hazardous, almost 20 percent as potential hazards and approximately 30 percent as possible hazards:

HAZARDS: Ninety-six homeowners (54%) reported burned wires or receptacles, fires in receptacles or wall switches, odor of burning wires or smoldering in walls, arcing, etc.

POTENTIAL
HAZARDS: Thirty homeowners (17%) spoke of potential hazards such as overheated receptacles or wall switches, scorched walls, melted receptacles or wiring.

TABLE 9

ALUMINUM WIRING - CPSC "HOT-LINE" CALLS
1974

	AUGUST 29 - SEPTEMBER 17	SEPTEMBER 30 - OCTOBER 30	TOTAL
<u>TOTAL CALLS</u>	<u>404</u>	<u>220</u>	<u>624</u>
INFORMATION	225	102	327
COMPLAINTS	<u>179</u> (100%)	<u>118</u> (100%)	<u>297</u> (100%)
<u>Hazards</u>	96 (54%)	59 (50%)	155 (52%)
Fires	(28)	(14)	(42)
Evidence of burning	(56)	(41)	(97)
Burned wire or receptacle			
Odor of burning wire or smoldering			
Miscellaneous Problems	(12)	(4)	(16)
Circuit breaker malfunction			
Arcing			
Circuits rewired			
<u>Potential Hazards</u>	30 (17%)	2 (18%)	51 (17%)
Overheated receptacle or wall switch			
Scorched walls			
Melted receptacles or wiring			
Backwiring			
<u>Possible Hazards</u>	53 (29%)	38 (32%)	91 (31%)
Flickering lights			
Failure of receptacles or switches			
Short circuit			

POSSIBLE FIFTY-three homeowners (29%) mentioned possible
HAZARDS: hazards such as flickering lights or failure
of receptacles or switches.

A follow-up article in Newsday, dated October 2, precipitated phone calls to the "Hot-Line" from another 220 New York residents, 118 reporting breakdowns in electrical systems wired with aluminum. As shown in Table 9, the distribution of 118 reports by hazard risk was similar to that of the 179 incidents reported after the initial article was published. Most of the 42 fires reported were confined to outlet boxes of receptacles or wall switches, but in a few cases the caller indicated wiring in the walls burned. One caller stated a quilt was ignited from an outlet near a bed. There was only one report of a fire with extensive damage to structure or contents. Although a relative of the man killed in the Hampton Bays fire called the "Hot-Line," this incident had already been investigated by the Commission and was not counted as a "Hot-Line" call. This incident is discussed in detail in the next section.

FIRE - HAMPTON BAYS, LONG ISLAND, NEW YORK

Shortly after the Aluminum Hearings of the Commission in March and April of 1974, a tragic fire occurred in Hampton Bays in a single family home wired with aluminum cable.

The owner of the home and his wife were asleep in their bedroom, with their daughter asleep in an adjoining room. At about 3:15 a.m., the fire aroused the owner who proceeded from his room to a guest room directly across the hall. Both doors had been closed. When he opened the guest room door he was met by a wall of heat or flame and fell down.

His wife apparently phoned the police department (in error) and forgot to give her address. A neighbor called the fire department at 3:30 a.m. A 10-12 minute delay in responding to the call was the result.

A fireman who lives in the neighborhood arrived at the scene first, but was unable to enter due to the heat and heavy smoke. When the fire department arrived, the firemen found the owner in the hall, and his wife in the bedroom with the phone still off the hook. The daughter was found lying near a window in her bedroom.

The father and daughter could not be revived and were pronounced dead on the scene. The mother responded to resuscitation and was hospitalized. After removal of the occupants, the fire was put out by 3:45 a.m.

An immediate investigation was made by the town fire department and the county arson squad. Arson was eliminated as a cause of the fire. The cause was determined to be an aluminum wiring connection which may have arced and ignited the wall.

The Commission was notified of the fire by two concerned individuals who had testified at the Aluminum Hearings, CPSC, in Washington, D. C. Within two weeks, a team of experts from the Commission and the National Bureau of Standards visited the scene of the fire to determine its cause. This group was joined by two surviving sons who were not in the house on the night of the fire and Fire Inspectors and State Police from the area.

The origin of the fire was determined to be a receptacle outlet blocked by a bookcase in the guest room. The burned receptacle, while not being used, transmitted electricity along the circuit to another receptacle from which a humidifier was receiving current. The outlet box for the receptacle had burned but was assumed to be plastic, since other outlet boxes in the house were made of plastic.

Pictures were taken of the house. A number of the receptacles (with wiring still attached) were removed from other rooms in the home to be tested by NBS. These receptacles were found to have burned insulation on the wire, charring and discoloration of the receptacle. The deterioration of these receptacles provides evidence that any defect in the receptacle outlet responsible for the fire was not an isolated defective condition.

IV. DISCUSSION

Why do some connections result in failure of a wiring device while others result in heating--or burning or arcing--or fire? Are these conditions a factor of time--of temperature--of use? The answers to these questions are being sought by NBS⁹ whose preliminary research in the mechanism of failure has already determined that fires can be started in household type circuits if:

1. loose connections are present so that arcing can be induced,
2. the loose wire is vibrated, and
3. combustible material is placed near the connection.

It was noted that this can occur with copper as well as aluminum wire. NBS is currently engaged in further experiments to duplicate environmental conditions in the home.

There is an awareness among research laboratories, manufacturers, and electricians that these problems exist. More than a dozen changes have been made in the specifications for aluminum conductors and terminal devices in the last 9 years. In the wake of each change, thousands of homes were left wired with potentially unsafe aluminum branch circuits. The latest recommendations (March 1973) of the Ad Hoc Committee of manufacturers, aluminum producers and researchers (Appendix I) may be superseded by yet another set of safety standards.

According to the latest recommendations of UL, only wiring devices labeled CO/ALR are recommended for use with aluminum wire. Testimony at the CPSC Aluminum Wire Public Hearings in Washington, D. C., by a concerned individual from New York, indicated that these devices are not readily obtainable in this area for the replacement of defective receptacles. A consumer in the Montgomery County area checked and found the device was stocked by one electrical supply center but not by neighborhood hardware stores, even the large chains. Jurisdictions that have restricted aluminum would be even less likely to stock this type of device even though installations prior to the restriction may need replacements.

The 198 incidents summarized by the Commission (Appendix A-D) present multiple examples of the conditions that are known to be associated with aluminum wiring: loose screws...loose connections...burned and melted wires, insulation, and receptacles. Receptacles that are not

being used burn up when electricity passes through them to other outlets that are being used. Receptacles overheat, burn, and arc without the circuit breaker tripping.

Among the parameters to be considered in aluminum wire branch circuits is the integrity of the installation. Reliable workmanship and adherence to the electrical code depend on the judgment of the workman. As shown in Table 8, examples of poor workmanship and code violations were found among the incidents reported. The frequency with which there was mention of installation procedures that violated good practice was highly correlated with the expertise of the respondent in recognizing the problem. However, even those most aware of the recommended procedures identified improper wiring in less than 30 percent of the reports; this figure referred to violations in the premises, not necessarily in the electrical component involved. While these conditions admittedly compounded the potential hazards surrounding the aluminum wire branch circuitry, it is notable that the majority of reports did not implicate improper wiring, poor workmanship, or code violations as a factor in the incident.

One of the insidious aspects of many aluminum wire connection failures is that the circuit breaker is not tripped. Circuit breakers are activated when too much current is going through the circuit.¹⁵ Similarly, in a fuse box, the fuse will blow to prevent high currents from doing damage. With the aluminum wire, resistance at a connection causes a heat buildup but does not result in excessive current flowing through the circuit.

The same conditions found in incidents in which a failure occurred have been found when an overheated receptacle or a smoking or arcing receptacle alerted the consumer. They have also been found when a fire occurred with no warning to the consumer. Twelve deaths were reported in the fires; property damage has reached a quarter of a million dollars.

Many jurisdictions have placed restrictions on aluminum wiring since 1971. This may solve future problems but not correct existing ones. The conclusions of an electrical contractor with almost 10 years of experience in the Maryland area were summarized in the following statement: "No one knows yet the average longevity of connections where proper torque and wire wrap were used and instructions followed...but where workmanship was careless, failures begin in a few months."¹⁰ The problem is further complicated by homes wired with different types of aluminum wire and different types of terminal devices. There appears to be a need for more research--more safeguards--before a new material is widely distributed on the market--not after potentially unsafe conditions become widespread.

In the fall of 1974, following the publication of two articles describing the hazards of aluminum wiring, 624 residents of the Long

Island, New York, area telephoned the "Hot-Line" of the CPSC. Electrical malfunctions were reported by 297 homeowners; 155 of the incidents were categorized by the Commission staff as hazardous; i.e., resulting in fire or evidence of burned wire or other electrical components. Few of the 42 fires reported spread beyond the confines of the electrical outlet box to ignite wiring in the walls or the contents of the room, but one fire caused extensive damage. The immediate and overwhelming response to these articles is indicative of the concern of the consumer regarding the solution to the problems of aluminum wiring.

The extent and severity of the aluminum wire problem is not yet known. Valid statistics on the number of fires, deaths, and casualties caused by aluminum wiring are not available. Attempts have been made by Underwriters' Laboratories, Inc. to survey users of electrical equipment and electrical inspectors in 1969, 1972, and 1974. In each of these surveys, the low response rate, ambiguity of the questions and inaccuracy of the numerical values supplied by the respondents have made any analytic interpretation of the data unreliable.⁵ The surveys have succeeded in focusing the attention of manufacturers, electrical inspectors, and research organizations on the potential hazards.

In countless homes nationwide, there are warnings of danger, but they are silent warnings. A receptacle overheats--a light flickers intermittently. Unless the homeowner is aware of the significance of these signals, he may do nothing. Alerting the consumer to the signals of failure is of primary importance. Providing interim information on correcting electrical problems as they occur is an immediate concern; determining the long-term solution for homes with aluminum wiring is one of the major efforts being undertaken by the Consumer Product Safety Commission.

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Appendix A

Summarization of 128 In-Depth Investigations
of Electrical Failures Involving Aluminum Wire in Single Family Dwellings

April 1975

U.S. CONSUMER PRODUCT SAFETY COMMISSION

Bureau of Epidemiology

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN SINGLE FAMILY DWELLINGS
1967 - 1975

APPENDIX A

I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Failure</u>						
PGM9	4/17/73	Rosaryville, Maryland	Aluminum wiring problem. All receptacles checked after electrician made repairs.	Receptacles		
PGM6	3/14/73	Brandywine, Maryland	Loose aluminum connections at receptacle and switch; two loose receptacles in upstairs bedroom 9/25/73.	Receptacles and switch		
CF3	2/ 9/73	Greenbelt, Maryland	Poor workmanship on kitchen appliance receptacle box caused short circuit. The overcurrent device did trip out.	Receptacles		IMPROPER WIRING
CC27	1973**	Sacramento, California	Receptacle failed because of charring of the receptacle from overheating at the receptacle terminal.	Receptacle		Multiple Incidents IMPROPER WIRING
	5/ 1/74		A receptacle on a bedroom circuit failed. A vacuum cleaner (7.0 amp., 120 volts) was operating from another receptacle in the same room, downstairs from the outlet involved. Owner smelled burning and traced odor to receptacle (mailed to CPSC). Circuit breaker (15 amp) did not trip. Wire was found to be incorrectly wrapped around screw on receptacle, overlapping of end of wire. Problem was due to loose contact resulting in generation of heat, not to an overload condition. Home was built in 1968.			Owner could not locate receptacle or switch approved for aluminum wire in retail stores (Receptacle submitted)
PGM10	1/ 9/73	Bowie, Maryland	Lights were flickering because screws were loose on plug. Owner was advised to have electrician check wiring in house.	Receptacle and lights		
PGM17	2/ 5/72	Prince George's County, Maryland	A loose aluminum wire caused a short circuit in a garage receptacle.	Receptacle		

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN SINGLE FAMILY DWELLINGS
1967 - 1975

I.D. NO.	DATE	LOCAL	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Failure (Cont'd.)</u>						
741003 BOS5019	1971**	Randolph, Mass.	Multiple incidents in 5-6 year old house involving short circuits, power failure, melting wires and plastic wall plates, sparking, warm wall plates. Electrician indicated possible electrical code violations in installation and wiring layout.	Receptacle		Multiple Incidents POSSIBLE CODE VIOLATIONS
HBC8	12/20/71	Huntington Beach, California	Wall receptacle failure.	Receptacle		
HBC23	8/20/71	Huntington Beach, California	Wall receptacle failure.	Receptacle		
HBC24	5/20/71	Huntington Beach, California	Wall receptacle failure.	Receptacle		
HBC25	5/31/71	Huntington Beach, California	Wall receptacle failure.	Receptacle		
HBC26	5/15/71	Huntington Beach, California	Wall receptacle failure.	Receptacle		
HBC17	5/12/71	Huntington Beach, California	Wall receptacle failure.	Receptacle		
HBC16	5/17/71	Huntington Beach, California	Wall receptacle failure.	Receptacle		
HBC15	5/12/71	Huntington Beach, California	Wall receptacle failure.	Receptacle		

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN SINGLE FAMILY DWELLINGS
1967 - 1975

APPENDIX A 28

I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE TO STRUCTURE (CONTENTS)	COMMENTS
PATTERN: Failure (Cont'd.)						
HBC14	3/ 8/71	Huntington Beach, California	Wall receptacle failure.	Receptacle		
HBC13	3/ 4/71	Huntington Beach, California	Wall receptacle failure.	Receptacle		
HBC12	2/21/71	Huntington Beach, California	Wall receptacle failure.	Receptacle		
HBC9	1/10/71	Huntington Beach, California	Wall receptacle failure.	Receptacle		
HBC7	12/ 4/70	Huntington Beach, California	Wall receptacle failure.	Receptacle		
HBC6	10/26/70	Huntington Beach, California	Two wall receptacle failures (separate locations).	Receptacle		
HBC5	9/1/70	Huntington Beach, California	Wall receptacle failure.	Receptacle		
HBC3	8/11/70	Huntington Beach, California	Wall receptacle failure	Receptacle		
FRC2	7/ 1/67	Fountain Valley, California	Trouble in receptacle affected circuit; loose wires under screw caused intermittent current in circuit.	Receptacle		
HBC19	5/28/71	Huntington Beach, California	Light switch failure.	Light switch		

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN SINGLE FAMILY DWELLINGS
1967 - 1975

APPENDIX A

I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Failure (Cont'd.)</u>						
CF-6	4/--74	Sacramento, California	Failure of built-in oven was attributed to connection of copper wire from appliance to aluminum wire from home to outlet box. Wood debris in outlet box could have provided the combustible material to start a fire.	Junction (oven)		
CF-8	10/31/73	Gaithersburg, Maryland	Six months after final inspection of wiring, furnace would not come on and owner noticed a slight smell like electric motor. Fuse in panel box did not blow. Connection of copper furnace wire to aluminum house wire nut had separated. A compression type fitting was used as a replacement.	Junction (furnace)		
CF-15	7/24/73	Gaithersburg, Maryland	Air conditioner stopped. Electrician repaired faulty connections.	Junction (air conditioning unit)		
AHW1*	1972**	Columbia, Maryland	Dishwasher failed to complete cycle; circuit breaker did not trip; box containing branch circuit and appliances power junction was opened--inside of box was scorched and blackened; white appliance lead and branch wires were burned and charred; wire nut charred; wire bare for 3.5 inches from wire nut junction; no short circuit apparent; surface oxidation visible on bare aluminum wire and copper wire near junction. All local/national NFPA electrical codes were satisfied by that circuit, yet a potential fire hazard did exist. House built in January 1972. Junction box located on dishwasher; vibration may have occurred.	Junction box (dishwasher)		
PGH3	10/17/72	Piscataway, Maryland	Aluminum cable was hooked to terminals of furnace. Electrician stated that armored cable was needed. Complaint regarded operation of furnace.	Junction (furnace)		IMPROPER WIRING

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN SINGLE FAMILY DWELLINGS
1967 - 1975

I.D. NO.	DATE	LOCALITY	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Failure (Cont'd.)</u>						
PGN2	2/ 6/72	Lanham, Maryland	Owner had complained of excessive electric bill in July 1971, but Pepco could not find the problem. Owner complained again. Six months later fault was found in furnace feed.	Junction (furnace)		IMPROPER WIRING
CC26	7/--/69	Carmichael, California	Water heater branch circuit failed at connection one year from move-in date.	Junction box (water heater)		Multiple Incidents
	1970**		Eight months later, electric oven splice connection behind oven overheated and opened the connection by arcing.	Junction box (oven)		
	1971**		In 1971, the heat pump circuit failed at the junction box.	Junction box (heat pump)		
	1972**		In 1972, the connection terminals at the meter socket of the service entrance burned apart, causing extensive damage to the service.	Service equipment		
A00389	8/25/74	East Windsor, New Jersey	When complainant checked why there was no hot water in his home he found that the 30 amp. circuit breaker controlling the electrical power to the water heater had been thrown to "off." He tried to reset the breaker, but could not; upon further investigation he found that the feeder cable coming into the box was too hot to touch. Both the hot line and neutral line were found to have seven strands and each strand had a diameter of .23 in. An electrician replaced the entire aluminum wiring system in the town house (built 1971) by changing the feeder cable, circuit breakers, branch circuits, outlet boxes, and switch cables with copper components. The complainant did not discard the aluminum wiring.	Circuit breaker (water heater)		Feeder Cable *** Branch Wire *** (UL) (Photos included)

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN SINGLE FAMILY DWELLINGS
1967 - 1975

I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
PATTERN: Failure (Cont'd.)						
PGM1	3/14/73	Brandywine, Maryland	Defective circuit breaker and loose terminal screws.	Circuit breaker		
PGM4	1/5/72	Oxon Hill, Maryland	Owner found a loose wire connection in 125 amp. panel. Panel was overloaded.	Circuit breaker		
PGM7	7/3/73	Brandywine, Maryland	Upstairs lights did not light when switch was turned on. Fixed by electrician. Two weeks later, light in bathroom was inoperative and others were blinking; electrician was recalled to correct defects.	Lights/switch		
PGM8	4/17/73	Upper Marlboro, Maryland	Defective wire termination was found.	Termination		
PATTERN: Overheating						
CG41	1/10/75	Newark, New Jersey	Respondents noticed a peculiar odor in their home just as they were preparing to leave children with babysitter. With help of the local fire department, they found an overheated electrical outlet that served as a junction box to outdoor floodlights. The outlet had been badly damaged and the insulation on the wires had begun to deteriorate. Home had been built during 1971.	Receptacle		
750115 NYC5035	12/--/74**	Shoreham, Suffolk County, New York	Respondent had heated electric hair curlers using a bathroom outlet. About 10-15 minutes after the curlers were unplugged, the bathroom light switch would not operate. The faceplate was hot. The respondent smelled smoke. The fire department sent the police who checked the switch and found no fire. Prior to this incident the same receptacle had been replaced by the consumer because light would not go on. At present respondent states that lights flicker periodically and dim when a major appliance is turned on.	Light switch (hair curlers)		Wall switch: 600 watt maximum Pull/push *** Builder and electrical contractor known (Photos included)

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN SINGLE FAMILY DWELLINGS
1967 1972

APPENDIX A

I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
PATTERN: Overheating (Cont'd.)						
CC-43	9/--/74**	Suffolk County, New York	Wiring was examined when CPSC team investigated CC42. Owner had recently had branch circuit binding screw connection pigtailed because of overheated receptacles. Investigators found oil burner circuit was not pigtailed.	Receptacle		Wire nut ***
CC-45	9/--/74**	Suffolk County, New York	Wiring was examined when CPSC team investigated CC42. Flickering lights, garage light wall switch overheating, loose screw, loose wire nut. Team observed evidence of improper wiring by consumer.	Light switch		IMPROPER WIRING
CC-46	9/--/74**	Suffolk County, New York	Wiring examined when CPSC investigated CC-42. Vacuum cleaner was drawing current from a receptacle whose faceplate was found to be hot. Loose screw caused arcing when receptacle was moved. CPSC team found evidence of degradation of wire insulation and receptacle body.	Receptacle (vacuum)		
741226 BEP7006	9/14/74	Alden, New York	Homeowner was in the habit of touching to test wall receptacles which had a heavy load. He had had a duplex burn out on him before. He noticed that this outlet was warm and upon opening the box he found the termination showed signs of arcing, loose wires, burnt screw terminal, burned plastic on receptacle, melted insulation on wire, and burned and pitted wire. Receptacle was used by a washing machine, gas dryer and sump pump for the laundry tub.	Receptacle (Washer & Gas Dryer) #10 AWG		Wiring *** Duplex receptacle *** (Photos included)
AHC2*	1973**	Westlake Village, California	Plug from lamp was hot, although lamp was not on. Owner is electrical engineer. Receptacle was very hot due to loose termination screw inside. Aluminum wire (#10) was in feed-through-type circuit with four binding screws. The wiring insulation at one termination was blistered from the heat. Tightening the screw, although it did not feel loose, eliminated the overheating problem.	Receptacle		

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN SINGLE FAMILY DWELLINGS
1967-1975

I. D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Overheating (cont.)</u>						
ISS-75-0482	11/--/73	Chicago, Illinois	<p>This complainant had three incidents of aluminum wire failure in his home (built 1971). (1) He noticed the odor of burning rubber in his kitchen receptacle and that the wall around it was turning brown. He immediately turned off the circuit breaker. Upon inspection the electrician found that the insulation on the wiring was burning off. The "backwired" receptacle was replaced.</p>	Receptacle (television/furnace)		Multiple incidents CODE VIOLATIONS Electrical contractor known
	1/--/74		<p>(2) Complainant was out of town and had left two lamps on. When he returned he found he had no heat or electrical power. Upon inspection it was found that the electrical system had shorted out causing 220 volts to go through the 110 volt system. The wire breakage occurred at a bedroom receptacle (the neutral wire was broken). This burned out the furnace, relay box, television, power transformer and the two lamps left on.</p>			
	9/--/74		<p>(3) This time the television and the furnace went off at the same time. No burning odor was noted. The complainant noticed a high intensity glow from the lamps and a chattering of the relays in his furnace and thus pulled the circuit breaker to prevent further damage. A team of experts found that disapproved push-in wired receptacles were being used and noted improper splicing. The following Sunday another failure was experienced; inspection showed the cause was a broken neutral wire with insulation melted back (6 inches) in a closet light fixture that was never used.</p>			

APPENDIX A

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN SINGLE FAMILY DWELLINGS
1967-1975

I. D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Overheating (cont.)</u>						
FRC7	5/10/72	Arroyo Grande, California	Occupants had problems with heating occurring in receptacles wherever an appliance was used that was turned on and off frequently.	Receptacle		
FRC8	3/ 3/72	Arroyo Grande, California	When the wall-hung electric heater was switched on, the duplex outlets in living room became hot--one of them too hot to touch. Loose connections were causing the problem. A switch was also found to have a "pressure lock connector."	Receptacle (electric heater)		IMPROPER WIRING
CC24	1970**	Irvine, California	Electrical outlets in kitchen became hot when appliance was plugged in. In 1972, new ceiling fixture installed by licensed electrician; light flickered and went off for as long as 10 minutes. Electrician found loose aluminum wiring in receptacle. Receptacle was fixed by copper "pigtailing."	Receptacle		

APPENDIX A

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN SINGLE FAMILY DWELLINGS
1967 - 1975

I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE TO STRUCTURE (CONTENTS)	COMMENTS
PATTERN: Evidence of Burning						
CC42	9/23/74	Huntington Station, New York	CPSC team investigated report made to "Hot-Line." Both the kitchen TV and refrigerator failed to operate after periodic interference had been noticed on the TV for about a month. The receptacle used by both appliances was hot. The owner temporarily replaced the receptacle with another outlet removed from the counter upstream from the refrigerator and taped the exposed wires. At 4 A.M. that night, the smell of burning caused the owner to investigate. Although the circuit breaker had not tripped, he found a receptacle in the dining room wall was hot, wallpaper on the cover plate was charred and insulation on the wire melted. This receptacle was upstream from the two kitchen receptacles and on the same branch circuit. Investigators also found burned terminals at oil burner control.	Receptacle		CODE VIOLATION Wire: No. 12 AMG aluminum wire on 20 amp. circuit Receptacle *** Wiring *** Oil burner control *** plastic outlet box
	1971		Prior incident occurred about 3 years after the home was built, when arcing was observed in switches and receptacles. In replacing kitchen receptacle, owner found burned insulation around conductors.			
CC=47	9/--/74**	Suffolk County, New York	Wiring was examined when CPSC team investigated CC42. Owner reported past experiences of trouble including burned out receptacle which had been replaced.	Receptacle		Wiring ***

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN SINGLE FAMILY DWELLINGS
1967 - 1975
APPENDIX A

I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Evidence of Burning (Cont'd.)</u>						
CC-44	8/--/74**	Medford, New York	Wiring was examined when CPSC team investigated "Hot-Line" call. Respondent smelled burning and found that outlet and wall in living room was hot. After throwing the circuit breaker, he inspected the outlet and discovered that some paper backing of the wall insulation was burned away. He also found that the plastic coating of one of the conductors was melted back about six inches from the connection. A window air conditioner in bedroom was operating from another receptacle downstream on the same branch circuit. Respondent also states that he had replaced one outlet due to overheating and flickering lights in 1972. [Wood chips, a potential fuel for ignition were found in the main circuit breaker box].	Receptacle		Wiring *** Receptacle *** Plastic outlet box
A04118	2/--/74**	Denver, Colorado	Light switch in kitchen shorted out. Electrician stated switch box was hot. Unit had 1/4" hole burned in back of switch. Wire in fuse box was also replaced.	Wall switch		Multiple Incidents (Photos included)
	6/--/74**		Basement light had been flickering for a few weeks; then noticed a scorched smell when light did not operate when switch was turned on. Scorch burn on ceiling was noted, pigtail connection had been used. Electrician rewrapped the wires. He also repaired melted wire in fuse box. Circuit breaker had not tripped.			
AHC4*	4/--/74	Palos Verdes, California	Owner had problems with receptacles that heated intermittently. At a later date, a socket melted and the aluminum wire was oxidized. The aluminum wire was attached to a brass fitting. The back of the fixture was oxidized to a green color. The insulation on wire to a washer and dryer, which pulls 8 amps., had burned, yet 20 amp. circuit breaker did not trip.	Receptacle (washer, dryer)		
CC13*	11/22/73	Medford, Long Island	Duplex receptacle, aluminum wiring and steel screw terminal burned. Insulation on wiring and plastic on receptacle melted.	Receptacle		Receptacle ***

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN SINGLE FAMILY DWELLINGS
1967 - 1975

L.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
PATTERN: Evidence of Burning (Cont'd.)						
741011 BEP7005	10/--/73**	East Northport, New York	Victim noticed a strong odor in his home. Upon inspecting he found that a kitchen receptacle which had been used by a rotisserie had overheated and 3" to 4" of insulation had burned off the end of the wire leading to the receptacle. No fire started and all the receptacles were subsequently replaced using pigtailing.	Receptacle (rotisserie)		Receptacle *** Building contractor known (Photos included)
CUL5*	8/--/73	Medford, Long Island	Owner smelled burning odor in son's room. Plug from lamp was melting and wall near outlet was hot. Outlet and wiring melted by the time current could be stopped. A 7.5 amp. air conditioner had been running for a few days in master bedroom on same circuit.	Receptacle (air conditioner)		7.5 amp. air conditioner running on same circuit
PCML4	5/ 6/72	Upper Marlboro, Maryland	Receptacle wiring was wrapped in wrong direction, causing loose connections. Receptacle burned.	Receptacle		IMPROPER WIRING
FRC3	3/ 1/71	Stml, California	Wire leading to a connection on a duplex outlet had lost its insulation as a result of excessive heat for about 2-1/2 to 3 inches back from the connection; the outlet itself was burned slightly.	Receptacle		
FVCS	1/13/71	Fountain Valley, California	Trouble at 20 amp. plug and light circuits; 20 amp. breaker in "off" position still feeding through. Wires burned off 30 amp. dryer circuit at dryer receptacle due to loose connection.	Receptacle (dryer)		
FVC6	12/29/70	Fountain Valley, California	Wall receptacle behind refrigerator had burned up. Plastic box was broken off. Loose connection of wire (bad workmanship on original installation).	Receptacle (refrigerator)		IMPROPER WIRING

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I. D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Evidence of Burning (Cont'd.)</u>						
FV01	11/--/70	Fountain Valley, California	At connection to 30 amp. dryer, receptacle had become hot and burned off. It appeared to be a poor connection.	Receptacle (dryer)		
CC33	After 1967**	Scotch Plains, New Jersey	Owner experienced several burned out outlets.	Receptacle		
CC37	4/--/74	Hampton Bays, New York	Electrical outlets were examined after fire in neighborhood. In metal junction box for electric range, #12 copper wire connected to heavy rubber-covered #8 solid aluminum wiring with wire nuts. Brown plastic of wire melted, exposing base connection; melted plastic adhered to metal box. Junction box submitted to CPSC.	Junction box (electric range) #8 AWG		(Junction Box submitted)
CC-10	2/--/73	Gaithersburg, Maryland	Owner smelled burned plastic when furnace went on. He turned off furnace and called an electrician who replaced plastic spring connectors. Oxidation of aluminum wiring was listed as probable cause of incident.	Junction (furnace)		
CF-12	10/28/73	Gaithersburg, Maryland	Owner became aware of odor of burning plastic; he found power to furnace had been cut off automatically. Electrician attributed problem to poor workmanship and replaced plastic wire nut with compression-type fitting.	Junction (furnace)		
CF-13	8/4/72	Gaithersburg, Maryland	Scorched marks. Evidence of burning on wall brought attention to problem with wiring: original light fixture not used-different light required correction of wiring and fuse connections.			

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1967 - 1975

I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Evidence of Burning (cont.)</u>						
CF-16	1972 & 1973	Gaithersburg, Maryland	Owner heard popping sound and noticed burning smell. He turned off furnace. After the second incident, the electrical contractor replaced all plastic wire nuts with compression-type fittings.	Junction (furnace)		
FVC2	11/12/70	Fountain Valley, California	The 30 amp. oven connection was burned off on a junction box. Wire burned off just below stak-on. Wires appear to have become oxidized, overheated and burned up.	Junction box (oven)		
CF5	11/10/72	Clinton, Maryland	Occupant smelled odor from bedroom. It was coming from a fuse panel. The main plastic fuse was burned and causing the odor.	Panel box		
CF-7	11/--/72	Gaithersburg, Maryland	Fuses to furnace began to smell, then burned, destroying the plastic pull-out housing. The electrician was called twice. He replaced a fuse on the first visit, and tightened a loose aluminum connection on the second visit (a week later) after the owner had been without heat for 3 days.	Panel box		
<u>PATTERN: Smoke</u>						
741210 BCF 7001	12/11/74	Shoreham, Suffolk County, New York	Fire department was called when kitchen wall light switch started smoking after it was turned on. The wall switch was repaired, but still becomes hot when in use.	Light switch		Multiple Incidents
	10/31/74		Respondent noticed smoke coming from receptacle above kitchen counter. Toaster and refrigerator were operating from other receptacles in the kitchen at the time. However, the refrigerator was on the same branch circuit as the smoking receptacle. Burning receptacle was extinguished by fire department before a serious fire could develop. Receptacle has not worked since being repaired by fire department electrician.	Receptacle (refrigerator, toaster)		

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I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
PATTERN: Smoke (cont.)						
CC-7*	1973**	Medford, Long Island, New York	Vacuum cleaner heated up and started to smoke. The wall was hot and electric wire in receptacle was charred. Electrician found loose connection.	Receptacle		
FVCL9	12/25/72	Fountain Valley, California	Wall receptacle was hot and smoking.	Receptacle		
FVCL7	9/21/72	Fountain Valley, California	Smoke odor emitting from outlets in house.	Receptacle		
FVCL5	5/18/72	Fountain Valley, California	Wall receptacle arcing and smoking.	Receptacle		
FRC6	5/ 7/72	Arroyo Grande, California	Occupants observed kitchen outlet smoking and burning. The cause appeared to have been a conductor. The insulation on the wires had burned and one conductor had separated.	Receptacle		
CF-11	1973**	Gaithersburg, Maryland	Explosion and smoke caused owner to call fire department. Owner cut off power manually. Electrician attributed incident to aluminum wire and humidifier.	Junction (humidifier)		
CF-14	12/--/72**	Gaithersburg, Maryland	Two incidents occurred six months after wiring inspection. The circuit breaker to furnace tripped off in first instance; in the second incident the circuit breaker was smoking but did not go off. The circuit was replaced.	Junction (furnace)		

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I. D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
PATTERN: Arcing						
STL-74-0703	9/--/74**	Collegeville, Pennsylvania	Arcing was noted at the junctions in the circuit breaker box. Tightening screws eliminated arcing temporarily, but problem reappeared 8 weeks later. Wiring in the home required periodic retightening of the terminal screws in the circuit breaker control box and also in the wall receptacles due to "creeping" of the aluminum.	Circuit breaker, receptacle		Multiple incidents Wiring *** Circuit breaker ***
750115 NYC5034	8/--/74**	Shoreham, Suffolk County New York	The respondent noticed sparking from an outlet on the patio when a pool filter was plugged into it. An electrician determined the sparking was due to loose wire, and pigtailed copper wire to the aluminum wire at every wall receptacle in the home. No evidence of scorched wire was found. The circuit breaker box was rewired with copper also. Home was first occupied in November 1971.	Receptacle (pool filter)		Builder and Electrical Contractor known
740010 BLP 7006	6/--/72**	Port Jefferson Station, N.Y.	Complainant has had multiple problems with the wiring in her home (built 1970). In the first incident (1972) she noticed that when she unplugged her vacuum cleaner in the den, sparks were emitted. All receptacles in den were corroded, melted and burnt on the back faces. Part of the wiring to the outlets were burnt and the junction boxes were corroded. All three receptacles and the burnt wires were replaced. There were no fires or damage to the walls.	Receptacle (vacuum)		Multiple Incidents Receptacles ***
	6/--/74**		The complainant noticed that the receptacles in her dining room wall were unusually warm when she used her three types of vacuum cleaners. She used a plastic type of safety plug on the bottom connection and used the top for the vacuum cleaners only. The safety plug was burnt on the tips. The receptacles were replaced and it was discovered that wires were burnt 8" in back of the wall.			

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I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
PATTERN: Arcing (cont.)						
CC34	1974**	Bowie, Maryland	Receptacle in bedroom sparked and overheated, causing circuit breaker to trip. This was preceded by flashing of light fixtures on the same circuit. Receptacles overheated; loose screws were found when receptacles were replaced.	Receptacle		
CC16	1974**	Medford, Long Island, N.Y.	Sizzling sound came from the wall near the TV. Wall was hot; TV plug was hot and burning. Condition was fixed by electrician.	Receptacle (television)		
FVC 26	12/15/73	Fountain Valley, California	Arcing wall receptacle.	Receptacle		
FVC25	10/2/73	Fountain Valley, California	Arcing wall receptacle.	Receptacle		
FVC23	2/12/73	Fountain Valley, California	Arcing wall receptacle.	Receptacle		
CC12	7/--/73	Denver, Colorado	Refrigerator went off too frequently and too long. Bathroom wall outlet was arcing. Circuit breakers were still on, but 15 amp. breaker case was partially melted and wire clamp had fallen out. Breaker case was partially melted. Refrigerator, kitchen lights, bathroom lights and wall outlet were on lower breaker. Combined amperage of kitchen and bathroom lights plus refrigerator should not approach the 15 amps. the breaker was designed to protect.	Receptacle (refrigerator, circuit breaker)		Circuit breaker not tripped
FVC22	2/10 73	Fountain Valley, California	Sparking wall receptacle.	Receptacle		
FVC21	1/16/73	Fountain Valley, California	Sparking wall receptacle.	Receptacle		

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I. D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
PATTERN: Arcing (cont.)						
FVC20	1/3/73	Fountain Valley, California	Sparking wall receptacle.	Receptacle		
CF1	12/12/72	Brandywine City, Maryland	Poor connection of aluminum wire to screw terminal of receptacle caused heating and arcing.	Receptacle		
FVC18	10/27/72	Fountain Valley, California	Dryer wall receptacle arcing.	Receptacle (dryer)		
FVC16	8/12/72	Fountain Valley, California	Wall receptacle arcing.	Receptacle		
PRC9	12/15/71	Arroyo Grande, California	Wiring in outlet box had burning insulation. Evidently, when the receptacle had been pushed back into the wall, the wire bent and broke, causing arcing. Wall material did not ignite.	Receptacle		
FVC10	2/17/71	Fountain Valley, California	Owner observed living room wall receptacle arcing. Five receptacles were not working in living room, bedroom and garage. Neutral wire had become loose from one of the receptacles in the living room. All receptacles worked when wire was reconnected.	Receptacle		
PRC1	2/2/71	Fountain Valley, California	Trouble in receptacle affected the circuit. When receptacle in bathroom was used, sparks would be emitted. Also, two receptacles in bedroom and one in living room would not work. Receptacle was pulled from box and it was found to be burned on the hot side. Screw was loose. It was tightened and circuit worked properly.	Receptacle		

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I.D. NO.	DATE	LOCAL	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Arcing (cont.)</u>						
FRG5	12/22/70	Simi, California	Arcing occurred between aluminum wire and the outlet screw at point of attachment. The wire was not wrapped fully around the screw and the connection was not tight. Nothing was plugged in the receptacle, although a TV and Christmas tree were operating on the same circuit.	Receptacle		
CCL9*	9/--/73	Gaithersburg, Maryland	Owner heard explosive noise and observed smoke and arcing from furnace. He turned off electric power to furnace. Junction box wires were black and wire nut had melted. Wires were touching furnace. Furnace subcontractor wrapped connection with tape to the size of a baseball.	Junction box (furnace)		
CF-9	9/--/73	Gaithersburg, Maryland	Owner heard an explosion and found smoke and sparking near furnace. Electrician replaced plastic spring connectors with pressure connectors. Probable cause of incident was oxidation of aluminum wire causing heat which melted the connectors.	Junction (furnace)		
<u>PATTERN: Fire</u>						
750114 BEP7004	12/14/74	Shoreham, Suffolk County, New York	Repondent reported that a fire occurred in a living room wall receptacle. The fire department concluded that the outlet had overheated. Nothing was plugged into the outlet at the time of the fire. The entire home has been pigtailed since the incident and it was noted by the electrician that three other fires might have occurred shortly after the first: one in the switch box and two in wall receptacles. Home was built about 1971.	Receptacle		

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I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
PATTERN: Fire (cont.)						
741024 DAL5025	-/--/72** 10/23/74	Dallas, Texas	<p>Within a year after home was built, a fire broke out in a standard 110 volt, 60 cycle A C outlet and damaged the wall paneling. Owners (in bed) became aware of the odor of rotten fish. Upon finding one of the bedroom walls hot, the husband investigated further and located smoke coming from the receptacle on the other side of wall in the bathroom. An electric comb was plugged in the outlet but was not turned on. A Building Inspector stated the house was wired in compliance with the building code. Investigators found loose connections on receptacles and switches.</p>	Receptacle		Multiple incidents Switches *** Receptacles *** Wiring *** (Photos included)
740930 B035016	9/26/74	Springfield, Massachusetts	<p>Owner experienced numerous electrical malfunctions since home was built in 1971. Electrical problems in kitchen area included arcing at wall outlets, heating up of wall outlets, flickering lights when garbage disposal started, failure in kitchen. In September 1974, owner switched on cellar light; bulb lighted then burst and fire started. Fire extinguished by fire officials. Electrical Inspector attributed fire to faulty installation in violation of electrical code, not aluminum wiring. (Kitchen, cellar and disposal on one circuit).</p>	Ceiling light		Multiple Incidents CODE VIOLATIONS (Photos included)
741127 BEP7007	9/5/74	Montgomery County, Maryland	<p>Fire in children's upstairs bedroom was noticed by neighbor who called fire department and alerted children playing in recreation room. Mother was not home, but oldest child rescued baby sleeping in another bedroom. Extensive damage to bedroom contents and walls. Circuit breakers were not tripped. Home owner had replaced malfunctioning receptacles since occupying home in April 1974. (Home built 4-1/2 years ago.) Faulty aluminum wiring was reported as cause of fire by fire department, fire marshal's report stated possible cause as "children playing with matches," but consumer rejected the latter possibility.</p>	Receptacle		Receptacle and wall switch *** CODE VIOLATIONS (Photos included)

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I.D. NO.	DATE	LOCALE	DESCRIPTION	DAMAGE		COMMENTS
				ELECTRICAL COMPONENTS	STRUCTURE (CONTENTS)	
PATTERN: Fire (cont.)						
CC36	4/28/74	Hampton Sags, New York	Family awoke to smell of smoke. Father went across hall to the guest room and opened the door. He was met by a wall of flame. Firemen arriving removed the parents and daughter, all not breathing. Mother responded to resuscitation. Others were pronounced dead at scene. Fire origin was plastic wall receptacle in guest room. The receptacle was not in use, although there was a humidifier in use connected to the same circuit. The aluminum wiring had cracked and caused a short. There was burning in the wall for some time before the actual outbreak of fire. Receptacles in home had been discovered to be hot in the past. NBS lab examined other receptacles from the home and described the workmanship as "generally poor" compared to recommended UL wiring practices.	Receptacle (humidifier)	Extensive	2 DEATHS, 1 SEVERE SMOKE INHALATION Some problems found were: low torque on screws; wire wrapped improperly around screws; charred wires; signs of overheated receptacles; steel screws.
CC18*	1974	Medford, Long Island, N.Y.	Fire started in wall receptacle. Two receptacles were replaced by electrician. Lights flickered constantly and owner was afraid to use too many things.	Receptacle		IMPROPER WIRING
A01075	12/31/73	Everett, Washington	Fire occurred in circuit of aluminum wiring being used to feed a 220 volt electric baseboard heater. The wire overheated in the wall, causing ignition. Fire spread to attic full of stored items. Victim died of carbon monoxide poisoning.	Receptacle (baseboard heater)	\$2,000 (\$1,000)	1 DEATH
PGMS	1/10/72	Laurel, Maryland	Loose wire at receptacle caused fire which was confined to receptacle box. Other outlets in recreation room had loose wires; screws were not torqued properly	Receptacle		Receptacle ***

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I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
PATTERN: Fire (cont.)						
FVC12	5/8/71	Fountain Valley, California	Fire was caused by loose connection, aluminum wire or receptacle. Damage was limited to receptacle. Fire department was called.	Receptacle		
FVC11	5/3/71	Fountain Valley, California	Wall receptacle burned out. Fire was caused by loose connection. Fire department was called. Damage was contained to receptacle.	Receptacle		
FVC7	1/4/71	Fountain Valley, California	Wall receptacle in garage burned out while occupant was vacuum-cleaning in the house. Owner heard crackling from garage and found flames emitting from wall receptacle.	Receptacle (vacuum)	\$100	
GC23	1970**	Irvine, California	Fire occurred in wall outlet to which garbage disposal and dishwasher were connected. Directly caused by aluminum wiring being too hard and the vibration from the appliances loosening the screws. This caused wires to disconnect and short circuit.	Receptacle (disposal, dishwasher)		
750116 BEF7005	1/17/75	Montgomery County, Maryland	Fire in circuit breaker destroyed the connectors and interior of main electrical panel. Fire department called electric company to cut off current to the house. Two days before, odor of burning caused owner who is an electrical engineer to check the circuit breaker. He found the circuit breaker and service wires were hot and the connector and buss bar were discolored. Flickering lights on the day of the fire alerted the owner to fire. Home is five years old; owner is second occupant (1972).			
A32903	7/5/74	Portland, Oregon	Noise heard in garage area of one year old home alerted owner to sparking circuit breaker. Fire department was called. Fire damaged circuit box, wiring and wall, but was quickly extinguished by firemen. Furnace had been turned on minutes prior to the fire. Owner had previously observed lights blinking when refrigerator cycled. Reports by various officials indicated the cause of fire to be a short circuit in breaker box, insulation on wire, aluminum wire and/or installation of wiring.			

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I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
PATTERN: Fire (cont.)						
HBC22	8/15/71	Huntington Beach, California	Branch circuit failure.	Receptacle	\$1,500	
HBC4 *	8/28/70	Huntington Beach, California	Investigation indicated that a receptacle on wall between living room and bedroom was point of origin of fire. Mounting nails with an attached piece of outlet box were all that remained of outlet; wall stud was charred. Electrical arcing had generated heat which deteriorated outlet box, face plates, etc. and extended fire into wall and room.	Receptacle	\$40,000	1 DEATH
HBC2 *	6/7/70	Huntington Beach, California	Short circuit caused arcing in wall receptacle, fire spread to bed and other contents in bedroom. Smoke damaged second floor.	Receptacle	\$2,900	
FVC24.	10/1/73	Fountain Valley, California	Fire in sub-electrical panel.	Panel box		
CF2	12/11/72	Brandywine, Maryland	Aluminum wire failed at panel cage resulting in fire.	Panel box		
NFP30	9/7/72	Austin, Texas	A loose connection of a No. 4/0 aluminum wire in the service equipment panelboard was the reported cause of this fire which ignited the wall in this single family house. It was not determined whether or not the terminal was suitable for aluminum wiring.	Panel box # 4/0 AWG		
CC20	2/--/72	Gaithersburg, Maryland	Owner investigated noise in basement to find panel box showering sparks. No smell of burning, overheating or flickering of lights previous to fire. Aluminum service cable arced at connection to distribution panel. Fire extended via vertical pipe spaces through first and second floor to attic. Electrical inspectors advised overheating of circuit breaker caused by loose connection of Pepco's aluminum wire to electrical panel. Verified by fire marshal's report.	Panel box	\$7,000	

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I. D. NO.	DATE	LOCALE	DESCRIPTION	DAMAGE		COMMENTS
				ELECTRICAL COMPONENTS	STRUCTURE (CONTENTS)	
<u>PATTERN: Fire (cont.)</u>						
NFP28	8/15/72	Creve Coeur, Missouri	A 40 amp. pull-out type fuse block was installed on the exterior surface of a wood frame wall covered with cedar shake-shingles to supply a 240 volt air conditioner on a concrete pad. The conductors were No. 6 aluminum. Arcing was found within the box, which had ignited the shingles and charred the 2 x 10 inch sill and the ends of the floor joists and subflooring. One of the terminal screws had been tightened so hard that one No. 6 conductor had been reduced to an estimated equivalent of a No. 18 conductor, resulting in overheating.	Panel box #6 AWG		Torque too tight.
CC21	1/17/72	Gaithersburg, Maryland	Owner heard noise and smelled odor like electric wires. Smoke was coming from electric panel. Top right hand feed was arcing; 1 foot of wire melted; electrical panel burned and wallboard was damaged. Electric bill had been steadily increasing for last several months. Fire was verified by fire marshal report.	Panel box	\$150	Panel box (200 amp) ***
PGM3	11/29/71	Prince Georges County, Maryland	Loose aluminum phase caused panel heat-up. (Fire-no structural damage). New panel installed.	Panel box		
PMG1	11/10/71	Oxon Hill, Maryland	Dryer was being used. Used #2/0 aluminum entrance cable for 300 amp. service. On side of meter, one phase was broken. Panel burnt, also cable; fire damage to garage.	Panel box # 2/0 AWG	\$1,000	IMPROPER WIRING
FVCL4	8/20/71	Fountain Valley California	Arcing connection in main panel caused wiring fire.	Panel box		

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I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Fire (cont.)</u>						
A01126	7/10/74	Longview, Washington	The furnace, installed in a closet under the stairs had been in operation for approximately eight years. A short circuit occurred of sufficient magnitude to "blow" the junction box off the wall and set fire to the underside of the stairs. The box was the main power feed to the furnace. The problem was attributed to a gradually increasing resistance between the aluminum wiring supply power to the box and the copper wiring on the furnace itself. The connection of the two dissimilar wires was improperly made and eventually resulted in fire.	Junction box (furnace) #1 AWG	Extensive property damage	IMPROPER WIRING
AHCl*	3/27/73	Thousand Oaks, California	A 3-wire non-metallic sheathed cable had all insulation burned off and 3-inch section burned out of it. Fire originated in junction box in false ceiling, spread into false ceiling and caused hanging lamp to fall into the room, bringing down burning debris with it. Fire spread through two-story wood frame, stucco-covered house.	Junction box (ceiling fixture)	\$20,000 (\$10,000)	

* Reported at Aluminum Wire Hearings, CPSC
** Approximate date
*** Brand name known

Appendix B

Summarization of 44 In-Depth Investigations
of Electrical Failures Involving Aluminum Wire in Mobile Homes

April 1975

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I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Failure</u>						
CC25	10/--/71	Sacramento, California	Lights in part of the home, as well as the heat went off. An electrician found a charred outlet.	Receptacle		
HBC11	6/13/71	Huntington Beach, California	Wall receptacle failure.	Receptacle		
HBC10	1/11/71	Huntington Beach, California	Wall receptacle failure.	Receptacle		
HBC1	5/6/70	Huntington Beach, California	Wall receptacle failure.	Receptacle		
CC19	2/--/72	Albuquerque, New Mexico	Bathroom lights would not come on when switch was activated. Circuit breaker was not tripped. Owner observed sparking in plastic outlet box. Owner discovered duplex receptacle was wired using screwless push-in terminal. He rewired receptacle using screws. After a second similar incident, he rewired all outlets and switches and has not had any trouble since.	Receptacle		IMPROPER WIRING Multiple Incidents
<u>PATTERN: Overheating</u>						
CC30	1974**	Hammors, Oregon	Owner discovered that two outlets were extremely hot, so they were replaced. In doing so, it was discovered that the insulation was burnt back several inches from the connection and the wire around the terminal was so brittle it broke instead of bending.	Receptacle		
NPF20	11/10/72	Santee, California	A receptacle overheated in a wall of this mobile home and it was reported by the occupant. No fire resulted.	Receptacle		

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I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Overheating (cont.)</u>						
A3577	1974**	Smithfield, Utah	Kitchen receptacle overheats whenever broiler is plugged in. Broiler plug and cord and receptacle are discolored. Another receptacle emitted crackling noise; tiny flame showed for 15 or 20 seconds after disconnecting toaster. Miscellaneous other problems mentioned.	Receptacle (Broiler, toaster)		Multiple Incidents Breaker box *** Mobile Home *** (Photos included)
	1972-73**		Trailer struck by lightning twice; electricians were unwilling to make repairs in aluminum wired mobile homes.			
<u>PATTERN: Evidence of Burning</u>						
FRC10	9/21/73	Atascadero, California	Occupant smelled odor for 24 hours prior to discovery of a burning outlet. Electrolysis had occurred under the screw connection, causing it to loosen and result in the burning of the outlet.	Receptacle		
NFP15	1/18/73	Cucamonga, California	An electric outlet in this mobile home's living room (possibly a receptacle) was burned by arcing or sparking at the terminal where aluminum wire was connected to it.	Receptacle		
FRC4	1/4/71	Simi, California	Occupants detected burning odor and found a smoking receptacle in bedroom that had a lamp plugged into it. They removed the lamp plug and looked in the slot of the receptacle. They could see a red glow. Upon removing the cover plate, the lower screw clamp on the unit was glowing red. They then shut off the circuit breakers and called the fire department. The receptacle was of molded plastic and deformed from heat. Aluminum leads burned back 1" to 2" from receptacle.	Receptacle		

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN MOBILE HOMES

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I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
PATTERN: Smoke						
024344P (A35763)	1/--/74	Roy, Washington	The owner smelled burning wire, but thought it was due to furnace burning out the previous week. Later, he found a spare bedroom filled with smoke. The wall receptacle was so badly burned that it fell from the wall when touched. Walls of spare room were scorched; they would have burned had owner not discovered problem. Two other receptacles smoked previously (1969 Parkway mobile home). Owner has been told to limit use of electricity in mobile home.	Receptacle		Multiple incidents, Receptacle *** Mobile home *** (Photos included)
NFP23	10/11/72	Marshalltown, Iowa	The occupant of this mobile home smelled smoke in the area of a bedroom wall receptacle. He turned off all the circuits and called the fire department. The home was wired with aluminum wiring and the wires were crossed over at the receptacle and switch terminals. The connections were loose and had signs of corrosion and overheating.	Receptacle		IMPROPER WIRING
NFP21	9/26/72	Lake Worth, Florida	The occupant smelled smoke while running the vacuum cleaner in the mobile home and called the fire department. Firefighters found smoke and a burned aluminum wire attached to a living room wall receptacle.	Receptacle (vacuum)		
A18197	1970** 11/--/73	Mountain View, California	There was a puff of smoke and a flash behind a kitchen receptacle. A repairman replaced the receptacle and found that the receptacle was completely burned out; wires carbonized, plastic box scorched. Smoke had damaged the wall. After the receptacle was fixed by pigtailing, the lights did not work. Plug cord from iron became very hot when plugged into another outlet. Furnace quit working when plug was inserted into receptacle on the same circuit; when the owner disconnected plug furnace would operate. Inoperative lights were on that circuit. Hair dryer did not work on a receptacle, but night light did.	Receptacle		Multiple Incidents CPSC investigators found receptacles and switches were not labeled for aluminum wiring. The wire was wrapped less than 2/3 around some terminal screws and counter clockwise on some screws. Burned insulation was found because wire had been wrapped almost completely around binding screw in clockwise direction on receptacle. (Photos included)
	12/--/73					IMPROPER WIRING

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN MOBILE HOMES
1967 - 1975

APPENDIX B

I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
PATTERN: Arcing						
740827 BEF7003	7/--/74**	Montgomery, (LeSeur County) Minnesota	Smoke, sparks, popping noises and smell of burning plastic brought owner's attention to receptacle in child's bedroom. Owner turned off electric current before any damage or injury occurred. Electrician has periodically replaced about eight receptacle outlets due to similar malfunctions in the 2-year-old mobile home.	Receptacle		Wiring *** Receptacles *** (Photos included)
741206	6/1/74	Syracuse, New York	As owner wiped kitchen receptacle with damp cloth sparks were emitted from the receptacle in all directions. Outlet continued to spark after fuses were removed from fuse box. Owner complained of flickering lights. New York State Inspector informed owner that wiring in trailer was a serious fire hazard; fourteen violations of electrical code. He reported loose receptacles, improper wiring, aluminum oxide buildup surrounding receptacles and improper binding screws for aluminum wiring.	Receptacle		CODE VIOLATIONS Trailer *** (Photos included)
8177	7/11/73	Lakewood, Washington	A loose terminal screw with aluminum wire in a hall wall receptacle of this mobile home resulted in an arc that burned the outlet. Occupant was present and turned off circuit before the wall ignited.	Receptacle		
8183*	1973**	Malibu, California	Lights flickered. Switches sizzled and snapped. The 220 wiring to oven had melted. Indications of poor wiring installation throughout entire home.	Switch and lights: wiring (oven)		IMPROPER WIRING

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN MOBILE HOMES
 1967 - 1975

APPENDIX B

I.D. NO.	DATE	LOCAL	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Fire</u>						
741010 REP7001	10/7/74	Penal County, Arizona	Fire broke out in early morning while mother and father were at work. There were conflicting details on the circumstances surrounding the fire but the origin was thought to be the living room. Because of problems with receptacles (bedroom receptacle had sparked and shorted the previous week) the father had purchased copper wire to replace all the aluminum wire in the trailer. His plans to do it the day before the fire were delayed by rain. He had closed the circuit breaker units affecting half the house. Five children were killed and one was injured in the blaze.		95% destroyed	5 DEATHS F - 10 mo. F - 5 F - 7 F - 9 F - 14 Injury: M - 1. Double Wide Mobile home *** 20' x 53'
740923 BEP7001	9/7/74	Ballston Spa, New York	Barking dog awoke neighbor who observed fire in mobile home about 5 A.M. Fire department was called, but firemen were unable to enter the flaming structure. A young couple and their 1-year-old son were asphyxiated in the blaze. The fire, described as thermal in nature and electrical and/or thermal in source, appeared to have started in a bathroom corridor area next to the bedroom. On the previous day an appliance repairman had checked a washer and dryer located in that corridor and stated he could not work on these appliances until a problem in the circuit wiring in the mobile home was fixed. Fire Chief stated the family had had prior problems with switches and/or receptacles.	Wiring (Washer/dryer)	100%	3 DEATHS Male - 29 - asphyxiation Female - 25 - asphyxiation Male - 1 - asphyxiation Mobile home 65' x 12' (1969) *** (Photos included)

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN MOBILE HOMES
1967 - 1975

I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE TO STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Fire (cont.)</u>						
NY-1	9/9/74	Waterford, New York	As respondents were watching television, they smelled a pungent plastic odor, saw smoke and a small flame "shoot out" from the outlet. Floor length nylon fiberglass curtains in front of the outlet became scorched before owner pulled plug. Similar electrical problems involving flickering lights and odors occurred on two previous occasions. Respondents are very fearful of electrical hazard and shut off main power switch before retiring. In addition, they take their child to wife's parents home to sleep at night. Replacement of outlets and switches and/or aluminum wire is expensive; cost cannot be met by the respondents.	Receptacle (television)		Brand name *** Model # unknown Purchased January 1973
CC31	12/22/73	Lewiston, Idaho	Occupant had difficulties with three receptacles that burned inside, two of them while nothing was plugged into them. The breaker switch has also caught fire.	Receptacle		
NY-1	9/21/73	Puyallup, Washington	There was an electrical fire in a wall receptacle six weeks after moving into this new mobile home. The fire smoldered inside the walls for a considerable time before source was located.	Receptacle	10 percent	
NY-1	9/21/73	Elkiston, Virginia	The occupants of this mobile home awakened to find the receptacles and walls smoldering. They turned off the electricity and called the fire department. Copper and aluminum wiring were used and the cause attributed to arcing or sparking of receptacles.	Receptacle	100 percent	
NY-1	9/21/73	Aunsaville, Oregon	Arcing or sparking at a bedroom receptacle wired with aluminum wiring was the attributed cause of this mobile home fire which ignited the wall while occupants were away.	Receptacle	100 percent	

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN MOBILE HOMES
1967 - 1975

APPENDIX B

I. I. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
PATTERN: Fire (cont.)						
NFP22	6/4/73	Marshalltown, Iowa	While the occupants were away, a neighbor reported a fire in this aluminum wired mobile home. The cause of the fire was a living room receptacle that had been improperly wired and it ignited the plywood wall paneling. The wire had been wrapped around the screw more than one complete turn so that the wire crossed over itself. The plastic body of the receptacle, as well as the plastic storage box were completely destroyed.	Receptacle	100 percent	IMPROPER WIRING
NFP6	5/6/73	Bellingham, Washington	Arcing or sparking of aluminum wiring connections to two receptacles in the bedroom was the cause of a fire in this mobile home. Owner discovered fire while watching TV.	Receptacle	10 percent	
NFP26	3/23/73	Southampton Township, New Jersey	An electric arc or spark in the aluminum wiring for a receptacle or switch, which ignited the bedroom wall, was the reported cause of this mobile home fire.	Receptacle	75 percent	
NFP16	2/8/73	Commetc'e City, Colorado	Arcing or sparking at a bedroom wall receptacle of this mobile home was the cause of the fire that ignited the bedroom wall.	Receptacle	10 percent	
NFP9	1/7/73	Redmond, Washington	A loose aluminum wire connection to a receptacle terminal screw was determined to be the cause of this mobile home bedroom fire.	Receptacle	<10 percent	
NFP18	12/19/72	Riverside, California	The fire in this mobile home was started by a short circuit of the aluminum wiring in a family room receptacle which ignited the wall.	Receptacle	75 percent	

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REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN MOBILE HOMES

1967 - 1975

I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE TO STRUCTURE (CONTENTS)	COMMENTS
PATTERN: P.P. (cont.)						
NFP25	12/11/72	Blain, Minnesota	An arc or spark from a kitchen wall receptacle, which ignited the wall, was the cause of this mobile home fire.	Receptacle	10 percent	
NFP19	11/16/72	Palm Springs, California	A receptacle in an exterior wall of this mobile home was the reported cause of a fire.	Receptacle (exterior)	10 percent	
NFP17	3/2/72	Paradise, California	Occupants of this mobile home were away at the time of this fire. The home was wired with aluminum wiring and the fire appeared to have started in a kitchen receptacle. Nothing was plugged in. The kitchen wall was determined to have been ignited by an electric arc or spark.	Receptacle	75 percent	
NFP24	10/31/73	Tucson, Arizona	The fire in this mobile home was attributed to a short circuit in the aluminum wiring to a kitchen exhaust fan which ignited the wall.	Wiring (exhaust fan)	10 percent	
NFP4	10/7/73	Hermiston, Oregon	This mobile home fire was caused by arcing or sparking of aluminum wiring underneath the trailer which ignited wood floor joists and plywood flooring. The wiring supplied an electric range. Occupants of home had been gone for about 15 minutes when a passer-by reported the fire.	Wiring (range)	100 percent	
NFP27	5/1/73	Grassrange, Nebraska	A short circuit in the aluminum wiring in the ceiling which ignited wood beams was determined to be the cause of this mobile home fire.	Wiring (ceiling)	10 percent	

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN MOBILE HOMES
 1967 - 1975
 APPENDIX B

I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Fire (cont.)</u>						
NFP8	2/5/73	Public Forest, Washington	The attributed cause of this concealed ceiling roof space fire was aluminum wiring. Extent of spread in this mobile home was limited to the area of origin.	Wiring (ceiling roof)	25 percent	
NFP10	1/21/73	Corpus Christi, Texas	The cause of fire in this mobile home was attributed to excessive heat that caused a breakdown in the electrical system, resulting in arcing and sparking. Aluminum wiring was in use and whether the excessive heat was a result of loose connections or overload or other causes was not reported.	Wiring	75 percent	
NFP11	3/9/73	Nashville, Tennessee	An electric furnace that was adjacent to the kitchen was the cause of this fire which ignited the walls of this mobile home.	Furnace	75 percent	
NFP5	12/12/72	Albany, Oregon	Cause of fire in this mobile home was attributed to sparking or arcing from loose connection of aluminum wiring to a defective heating furnace. Occupants of home were out at time of fire.	Junction (furnace)	75 percent	
CC28	12/9/71	Linda, California	Heat generated by a bad electrical connection caused this fire. The aluminum wiring of the trailer was connected to the copper wiring of the ceiling light fixture.	Junction box (ceiling fixture)		
NFP12	10/27/73	Salem, Virginia	Arcing or sparking of the copper and aluminum wiring of the service equipment in the bedroom closet of this mobile home caused the fire. The occupants were away.	Service equipment	100 percent	

* Reported at Aluminum Wire Hearings, CPSC
 ** Approximate date
 *** Brand name known

Appendix C

Summarization of 14 In-Depth Investigations
Of Electrical Failures Involving Aluminum Wire in Multifamily Dwellings

April 1975

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REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN MULTIFAMILY DWELLINGS
1970 - 1974

I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Failure</u>						
740923	10/17/74	Needham, Massachusetts	The Needham Housing Authority after discovering that the aluminum wiring connected to an emergency generator failed, decided to have all the wiring in the housing project for the elderly changed to copper conductors. An electrician determined the probable cause of failure to be corrosion of the termination points due to dampness and inadequate splicing in underground installation.	Emergency generator		
<u>PATTERN: Overheating</u>						
CF4	11/29/72	Hyattsville, Maryland	A defective living room receptacle overheated.	Receptacle		
CC35	After 1967**	Kenmore, New York	Outlets became so hot that the plastic covers softened. At times, outlets became hot without anything plugged into them. Appliances caused lights to dim.	Receptacle		
<u>PATTERN: Evidence of Burning</u>						
CC32	12/20/71	Fort Meade, Maryland	Hot wall receptacle burned a hole in the drape. Receptacle was not being used.	Receptacle		
<u>PATTERN: Smoke</u>						
A35624	8/2/74	North Tonawanda, New York	Respondent and son noticed distinct odor of electrical burning while watching TV one morning. She called husband at work when she couldn't locate source. When husband came home, they checked living room and located smoke coming from a wall receptacle. They phoned firemen who turned the main power switch off, disconnected burned receptacle and advised owner to call an electrician. The electrician noted all wiring was aluminum and improper wall switches and receptacles were used; repairs were made using pigtailing.	Receptacle		Building contractor and original electrical contractor known. Wiring *** Receptacles and wall switches ***

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN MULTIFAMILY DWELLINGS
1970 - 1974

APPENDIX C

I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Fire</u>						
PGM15	8/21/72	W. Lanham Hills, Maryland	Fire spread to two apartments. Most intense burning occurred at 3 locations near outlets in one bedroom of one apartment. Connections to sockets were not made in accordance with UL specifications.	Receptacle	\$6,000 (\$3,000) (\$500)	IMPROPER WIRING
NFP1	3/28/73	Baltimore, Maryland	A first floor tenant smelled smoke and called the building maintenance engineer. The maintenance engineer found a first floor apartment filled with smoke but was able to enter the laundry room and turn off the electrical power. He found that all circuit breakers had tripped out. The only visible fire was in a laundry ceiling fan. The engineer was forced out of the building without being able to put out the fire. Firefighters found the fire extending to the second and third floor. Before being put out the fire spread to the attic. The fire had spread through the 12" x 12" vertical spaces and also through the screened openings of the eaves into the attic. Aluminum wiring was a possible cause of the accident.	Wiring	\$100,000	
HBC25	6/4/71	Huntington Beach, California	Branch circuit failed	Wiring	\$500	
PGM18	7/21/71	Silver Hill, Maryland	Fire inspector ordered evacuation of building. Firemen with masks went to each apartment and assisted people in leaving 8 story building. Pepco found short circuit in panel box (Leviton device) to air conditioners. Heat melted and ignited plastic insulation and gases spread through building shafts. Electrical inspector found one cable loose and touching another cable.	Panel box (air conditioner)	\$3,000	Panel Box ***

APPENDIX C

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN MULTI-FAMILY DWELLINGS
1970 - 1974

I.D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Fire (cont.)</u>						
PCM16	1/18/72	Glendale Woods, Maryland	Boiler room building fire involved disconnect panel and aluminum wiring for boiler pumps. Man tried to put out panel's fire with dry chemical, fire extinguisher--then called fire department. Power company turned off current until problem isolated.	Panel box (boiler pumps)	\$500	1 MINOR CASUALTY (smoke inhalation)
NFP2	4/18/73	Newark, Delaware	The fire appeared to start in a first floor utility storage room where aluminum conductors were used. The fire ignited wood framing and spread through the wall and a stairwell to the third floor. It burned in the concealed spaces before being observed by firefighters. This building was not fire-proof, but the fire wall between it and the next building prevented the fire from spreading.	Service Equipment	Extensive	
PCM2	8/21/72	College Park, Maryland	Main feeders burned or melted; lugs were loose on aluminum feeders in transformer room. Many lugs could be turned with fingers. Fire in basement.	Service Equipment	\$1,500	
NFP14	4/27/71	Taylors, South Carolina	Two story, wood-frame and stucco-veneered apartment house had aluminum service entrance. Cables and copper air conditioning tubing running through the hollow frame walls where the service entrance cables terminated in service equipment. The fire started in this hollow wall and a puddle of molten aluminum was found at the bottom of the wall where it had solidified. The copper tubing had also been damaged by the arcing cable. A primary fuse at the supply transformer was found blown. The cause was listed as undetermined since it could not be determined whether the arcing was caused by a fire or by a short circuit.	Service entrance cables		
NFP29	5/16/70	Lancaster, Pennsylvania	A 200 ampere meter socket and No. 400 kcmil (nec) wires were installed for the service for this 16 unit apartment house. The terminal lugs were too small for the wire, so some of the strands of the wire had been clipped off. The socket overheated and ignited the insulation on the wires.	Service equipment		IMPROPER WIRING

*** Brand name known

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Appendix D

Summarization of 12 In-Depth Investigations
of Electrical Failures Involving Aluminum Wire in Tammy Brook Apartments

April 1975

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REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN TANNY BROOK APARTMENTS
1968 - 1973

APPENDIX II

I.D. NO.	DATE	LOCALITY	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Failure</u>						
CC2	1973**	Weymouth, Massachusetts	Problem existed in outlet in kitchen and fluorescent light in bathroom.	Receptacle		
CC4	1973**	Weymouth, Massachusetts	Bedroom electrical switches are inoperative.	Wall switches		
CC8	1973**	Weymouth, Massachusetts	More than one electrical appliance on kitchen circuit blows circuit.	Receptacles		
CC9	1973**	Weymouth, Massachusetts	Counter top outlet shorted out.	Receptacle		
CC10	1973**	Weymouth, Massachusetts	Fuses would blow when living room outlets were used. In the kitchen, the outlet by the stove and disposal are worn out.	Receptacles		
<u>PATTERN: Arcing</u>						
CC6	1973**	Weymouth, Massachusetts	Kitchen counter top outlet sparks.	Receptacle		
CC7	1973**	Weymouth, Massachusetts	Outlet near kitchen sink sparks.	Receptacle		
CC11	1973**	Weymouth, Massachusetts	Living room and bedroom outlets were arcing. Outlets were fixed.	Receptacle		
CC14	9/18/73	Weymouth, Massachusetts	Duplex receptacles in living room were sparking. Original receptacle was installed incorrectly. Device was backwired with aluminum romex.	Receptacle		

REPORTS OF ELECTRICAL FAILURES INVOLVING ALUMINUM WIRE IN TAMMY BROOK APARTMENTS
1968 - 1973

I. D. NO.	DATE	LOCALE	DESCRIPTION	ELECTRICAL COMPONENTS	DAMAGE STRUCTURE (CONTENTS)	COMMENTS
<u>PATTERN: Fire</u>						
CC1	1968-73**	Weymouth, Massachusetts	Power shortages and power failures occurred for 1 week--management attributed electrical defects to living room wiring; 5 plug receptacles in living room arc--accompanied by noticeable drop in power. When receptacle plates were removed, wires were found burned and insulation melted. Disposal switch sparks. All wall sockets and switches heat up when used. Vacuum cord heats up too. Two electrical fires originated from electrical outlets. Light switches must be turned on a few times before they stay on--were replaced but problem exists. No main circuit breaker switch.	Receptacles & switches		
CC3	1973**	Weymouth, Massachusetts	Garbage disposal outlet caught fire when used. Lights blew out periodically.	Receptacle (disposal)		
CC5	1973**	Weymouth, Massachusetts	Counter top outlets spark at times. Disposal outlet caught fire once.	Receptacle (disposal)		

NOTE: Electrical contractor checked 3 apartments in February 1974 and noted the use of backwiring, a method which has never been considered suitable by UL for aluminum wiring.

** Approximate date

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APPENDIX E

UL RECOMMENDATIONS ON WIRING DEVICES

- . Prior to 1966. UL considered all general use receptacle and switch wiring devices (except those using screwless push-in terminals) as acceptable for either aluminum or copper conductors.
- . 1966. UL stated that wiring devices could be used with aluminum conductors only when "1) the terminal is of the wire binding screw type where the conductor is to be looped around the screw, or 2) on other types of terminals only when marked 'AL-CU'."
- . Effective September 1, 1971. UL required that all new devices eliminate the "AL" marking unless they had been listed under a new test program. (This action was announced in a July 1971 UL Bulletin.)
- . June 1972. UL listed the first "CO/ALR" wiring device. The CO/ALR designation was given to wiring devices listed for use with aluminum conductors under a new test program.
- . April 1973. UL proposed that wiring devices not listed for use with aluminum wire be provided with a precautionary notice, effective November 15, 1973.
- . Effective January 15, 1974. UL required wiring devices not marked CO/ALR be marked either "Notice--Use only copper or copper-clad wire with this device," or "Notice--Connect only copper or copper-clad wire to this device," or "Notice--Use only devices marked CO/ALR with aluminum wire."

APPENDIX F

RECOMMENDATIONS ON WIRING DEVICES FROM OTHER GROUPS

. Mid-1960's. Price increases resulted in changing metals used in screws of termination devices from brass to plated steel (usually zinc-plated).

Laboratory tests made by Battelle Memorial Institute¹² at a later date determined that the use of zinc-plated steel with aluminum wire was not to be recommended since there are basic metallurgical incompatibilities between the plated screws and the aluminum wire in this application.

. March 10, 1972. Leviton, a major manufacturer of devices, sent a bulletin to all of its distributors saying that all Leviton devices available at that time would be marked with a notice that they should be used only with copper or copper-clad wire.¹³

. March 21, 1972. The General Engineering Committee of NEMA concluded that wiring devices then being sold were suitable for use only with copper wire or wire having copper or tin-plated surfaces, and that those devices should not be used with other materials until their suitability had been established by extensive testing.¹⁴

APPENDIX G

REVISIONS OF SPECIFICATIONS ON ALUMINUM WIRING
1970 - 1973

- . September 1970. UL revised its test specifications for the labeling of aluminum wire and emphasized the need for care in making connections with aluminum wire.
- . May 1971. UL required that aluminum wire manufacturers include precautionary installation instructions on packages of aluminum wire in sizes 8, 10, and 12.
- . June 1971. UL again began revising its test specifications for the labeling of aluminum wire.
- . June 1972. An Ad Hoc Committee on Aluminum Terminations met with membership from industry and UL. Its purpose was to study and recommend procedures for improving the connectability of No. 12 and larger aluminum conductors.
- . September 1972. UL issued its revised test specifications for the listing of aluminum wire and approved the first wire to meet these specifications.
- . March 1973. Final recommendation of the Ad Hoc Committee on the Use of Aluminum Conductors was released by UL to the technical press and to various groups associated with the installation of receptacles and snap switches in residential occupancies.

APPENDIX H ⁵

RESTRICTIONS ON BRANCH CIRCUIT AND
SERVICE ENTRY WIRING OF ALUMINUM

This list must be regarded as incomplete and tentative, as explained in the text.

<u>Place</u>	<u>Effective date</u>	<u>Latest date known to be in effect</u>	<u>Type of restrictions</u>
Arizona: Tucson	12/21/71*	11/9/73	Bans Al nonmetallic-sheathed wire for branch circuits
**Calif: Huntington Beach Los Angeles	9/3/70 11/1/71	Present	Bans Al wire Requires UL approval of devices
** Orange Co. (9 jurisdictions)	12/70 & 1/71		Bans Al #6 and smaller
Sacramento	12/1/71	2/1/72	Requires UL approval of devices
District of Columbia	1/7/72	Present	Bans the old wire alloys Bans AL-CU devices unless body of connector is aluminum
Florida: Macclenny Tampa	8/14/73 5/15/72	11/9/73 11/9/73	Bans Al wire Bans Al #8 and smaller
Georgia: DeKalb Co.	8/10/71		Bans Al smaller than #8
**Idaho (state)	4/1/71	Present	Pigtails required unless UL-approved devices are used
Kentucky: Lexington & Fayette Cos.	4/1/72	11/9/73	Requires UL approval of devices
Louisiana: Baton Rouge		Ban lifted in 1973	However, UL approval of devices is now required
Maryland: Baltimore Co.	1/1/72		Requires pigtails or UL approval of devices
Montgomery Co.	5/26/72	Present	Bans Al #6 and smaller
Prince George's Co.	3/1/72	Present	Bans Al #6 and smaller

* Asterisk indicates the earliest date known, from present information, to be in effect.
** Double asterisk marks restrictions known to antedate UL's July 1971 announcement.

<u>Place</u>	<u>Effective date</u>	<u>Latest date known to be in effect</u>	<u>Type of restrictions</u>
Michigan: Dearborn		11/9/73	Bans A1 #10 and 12
Mississippi: Jackson area	9/6/73	11/9/73	Bans A1 in FHA-insured and HUD-financed housing
Nevada (state)		11/9/73	Bans A1 in mobile homes, except grounds and lead-ins
New York (state)	(a) 2/1/72 (b) 7/1/72	11/9/73	(a) Requires pigtail on #10 (b) Requires pigtail on #12
Village of Suffern, Rockland County	1975	Present	Bans A1 wire
**North Dakota (state)	1968	1970	Banned A1 wire
Ohio: Cincinnati	5/1/73	11/9/73	Requires pigtails
**Rhode Island: Providence	Approx. 1965	Present	Bans A1 smaller than #6
South Carolina: Myrtle Beach	2/29/72		Bans A1 wire
Tenn.: Murfreesboro, Lebanon, Franklin, Woodbury	Jan. 72*		Bans A1 smaller than #6
Texas: St. Bldg. Comm'n	1/12/72	Ban lifted 3/7/72	Banned A1 wire
Arlington	4/1/72		Requires UL approval of devices
Houston		Ban lifted in 1973	However, UL approval of devices is now required
Richardson	2/14/72		Requires UL approval of devices
Garland, Farmers Branch Plano, Lewisville, Carroleton, Mesquite	9/1/73	11/9/73	Ban A1 branch circuit wire in dwellings
Virginia: Arlington Co.	2/7/72		Bans A1 wire
Washington (state)	9/1/71	10/4/73	Requires pigtails

*Asterisk indicates the earliest date known, from present information, to be in effect.
**Double asterisk marks restrictions known to antedate UL's July 1971 announcement.

APPENDIX I

THE USE OF
**ALUMINUM
CONDUCTORS**
WITH WIRING DEVICES
IN ELECTRICAL WIRING SYSTEMS

A statement prepared under the auspices
of an Ad Hoc Committee sponsored by
Underwriters' Laboratories, Inc.

THE USE OF ALUMINUM CONDUCTORS WITH WIRING DEVICES IN ELECTRICAL WIRING SYSTEMS

A number of articles in trade magazines and other technical publications have pointed out the sensitivity of binding screw terminations for aluminum conductors to techniques used and the quality of workmanship employed, and to other factors which might cause unsatisfactory termination performance such as dangerous overheating. Such performance is influenced by:

- A. Incompatibility between aluminum conductor and device terminals.
- B. Workmanship and installation techniques.
- C. High incidence of vibration or mechanical disturbance in use.
- D. Wide temperature changes and high humidity environments.
- E. Variation in the mechanical characteristics of aluminum conductor material.

Recent revisions in Underwriters' Laboratories, Inc. requirements¹ for Listing solid aluminum conductor in sizes No. 12 and 10 AWG and for Listing snap switches and receptacles for use on 15 and 20 ampere branch circuits incorporate stringent tests which take the above factors into account.

Instructions describing proper installation techniques and emphasizing the need for following these techniques and for practicing good workmanship are required to be included with each coil of No. 12 and 10 AWG insulated aluminum wire or cable.

New product and material designs which provide for increased levels of safety of aluminum wire terminations have recently been developed by the electrical industry.

To assist all concerned parties in the proper and safe use of solid aluminum wire in making connections to wiring devices used on 15 and 20 ampere branch circuits, the following information is presented. Understanding and utilizing this information is essential to proper application of materials and devices now available.

FOR NEW INSTALLATIONS

Comply with Section 110-14(a) of the 1971 National Electrical Code (NEC) when aluminum wire is used in new installations.

NEW MATERIALS AND DEVICES

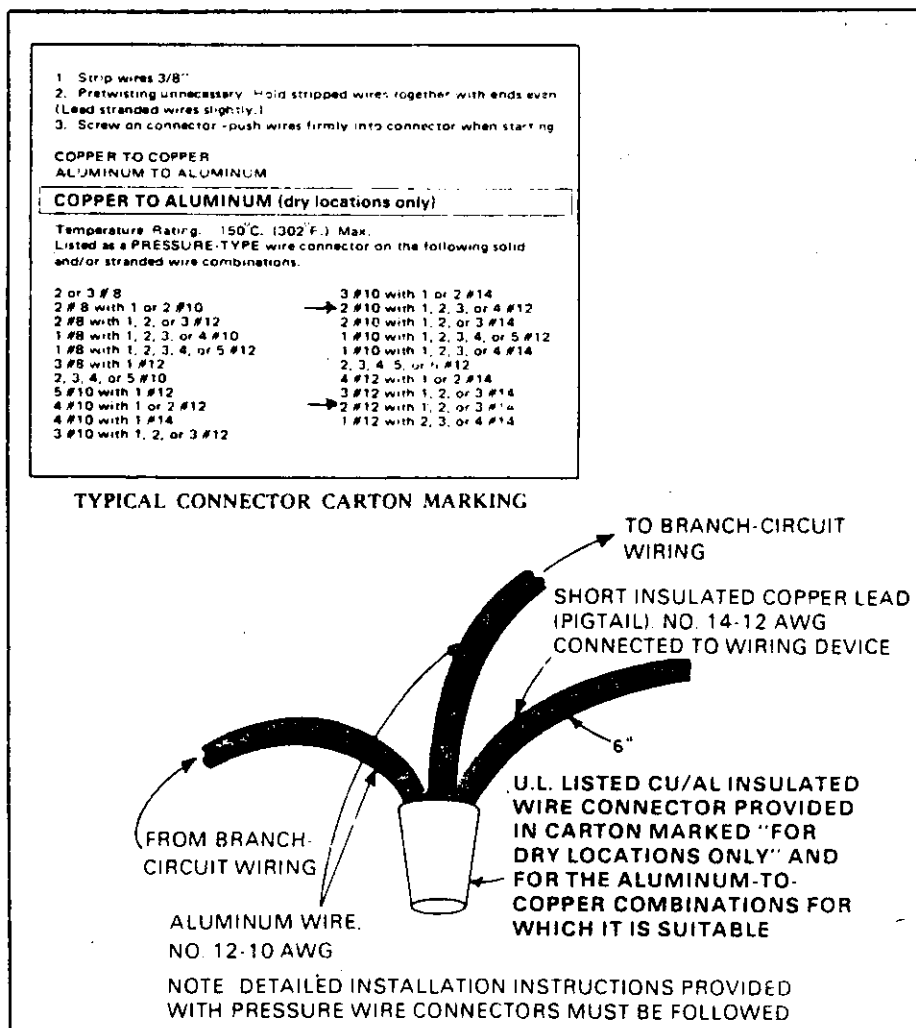
- a. For direct connection use only 15-amp and 20-amp receptacles and switches marked "CO/ALR" and connected as described under "Installation Method."

¹Available from UL upon request

The "CO/ALR" marking is on the device mounting strap. The "CO/ALR" marking means the devices have been tested to stringent heat cycling requirements to determine their suitability for use with UL labeled aluminum, copper, or copper-clad aluminum wire.

Note:

Pigtailing, either field or factory-wired, as illustrated in Figure 1 is recognized by the NEC.



- b. Use solid aluminum wire, No. 12 or 10 AWG marked with the Underwriters' Laboratories' new aluminum insulated wire label, as shown below. Follow the installation instructions packaged with the wire.

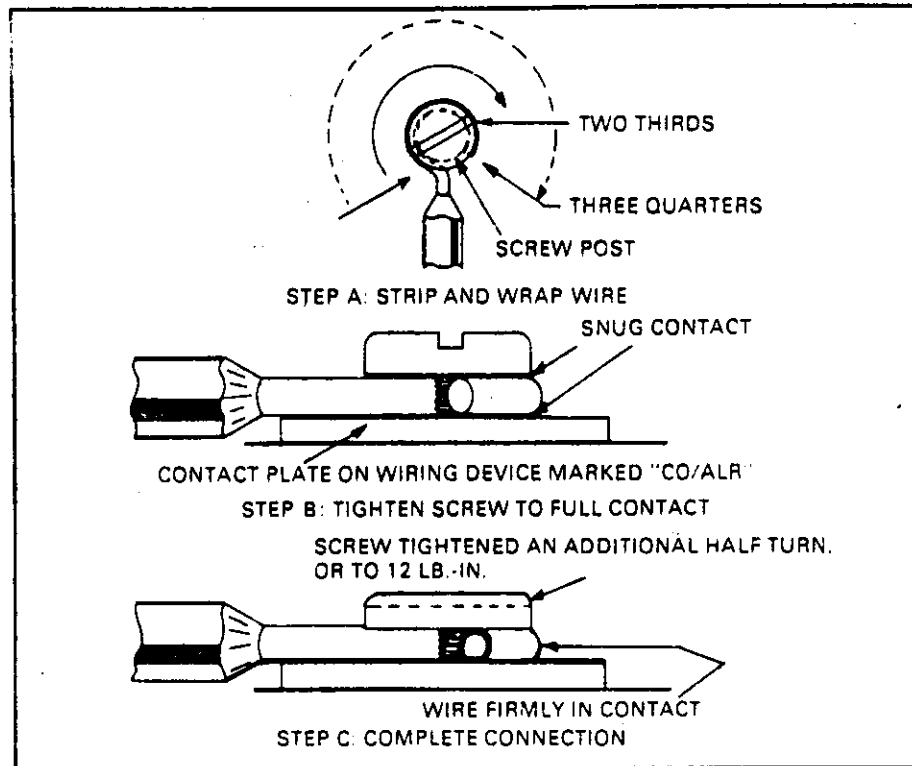


Conductor bearing this UL label is judged under the requirements for the chemistry, physical properties and processing of the conductor which became effective September 20, 1972.

INSTALLATION METHOD

Figure 2 illustrates the correct method of termination at wire-binding screw terminals of receptacles and snap switches.

1. Wrap the freshly stripped end of the wire $2/3$ to $3/4$ of the distance around the wire-binding screw post as shown in Step A.



CORRECT METHOD OF TERMINATING ALUMINUM WIRE AT WIRE-BINDING SCREW TERMINALS OF RECEPTACLES AND SNAP SWITCHES

FIGURE 2

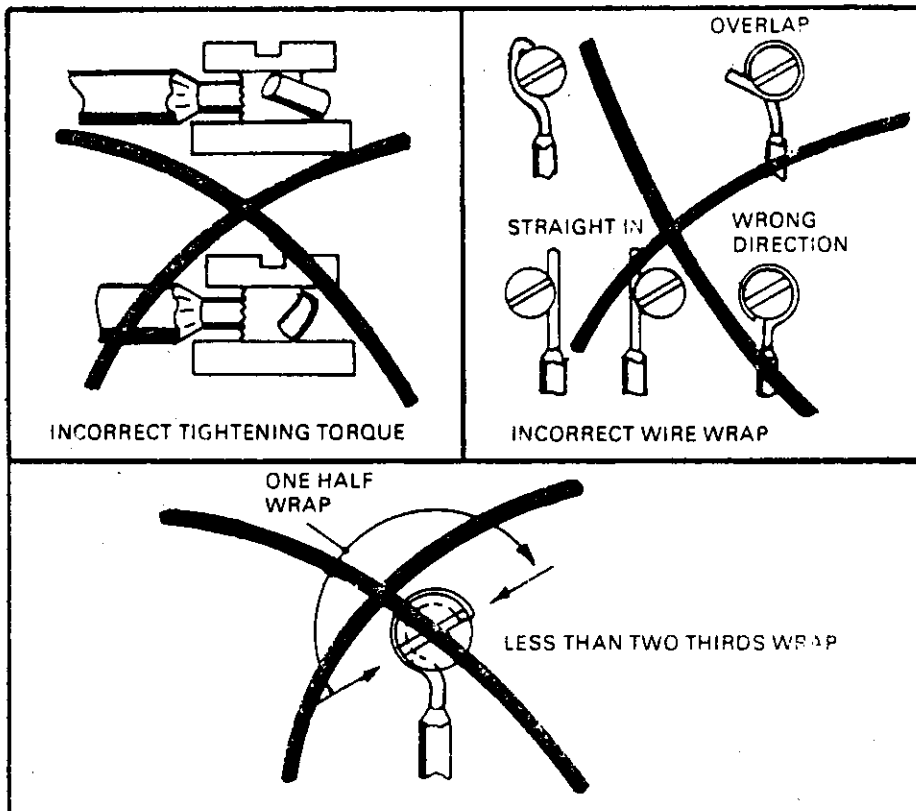
The loop is made so that rotation of the screw in tightening will tend to wrap the wire around the post rather than unwrap it.

2. Tighten the screw until the wire is snugly in contact with the underside of the screw head, and with the contact plate on the wiring device as shown in Step B.

3. Tighten the screw an additional 1/2 turn thereby providing a firm connection. Where torque screwdrivers are used, tighten to 12 pound-inches. See Step C.

4. Position the wires behind the wiring device so as to decrease the likelihood of the terminal screws loosening when the device is positioned into the outlet box.

Figure 3 illustrates incorrect methods for connection and should not be used.



INCORRECT METHODS OF TERMINATING ALUMINUM WIRE AT WIRE-BINDING SCREW TERMINALS OF RECEPTACLES AND SNAP SWITCHES

FIGURE 3

EXISTING INVENTORY

When UL labeled solid aluminum wire No. 12 and 10 AWG not bearing the new aluminum wire label (see page 4) is used, it should be used with wiring devices marked "CO/ALR" and connected as described in "Installation Method." This is the preferred and recommended method for using such wire.

Note:

Pigtailing, either field or factory-wired, as illustrated in Figure 1 is recognized by the NEC.

In the following types of devices the terminals shall *not* be directly connected to aluminum conductors but may be used with UL labeled copper or copper-clad conductors:

Receptacles and snap switches marked "AL-CU"

Receptacles and snap switches having no conductor marking

Receptacles and snap switches having back-wired terminals or screwless terminals of the push-in type

FOR EXISTING INSTALLATIONS

If examination discloses overheating or loose connections the recommendations described under *For New Installations - Existing Inventory* should be followed.

To help the property owner or occupant in identifying potential problems with materials that were available prior to the use of improved materials, the information in the accompanying "Safety Message" is being distributed through various print media or other forms of communication.

SAFETY MESSAGE

From various parts of the United States over the past few years have come reports of excessive overheating and even fires originating in the connections of wire to conventional wall receptacle outlets and snap switches. Such incidents can occur irrespective of the type of wire used—aluminum or copper—but field reports indicate that the possibility of such incidents is greater when certain combinations of aluminum wire, devices, and workmanship have been used. The electrical industry has recently developed improved products and re-emphasized the need for following good installation practices.

If your residence (house, apartment or mobile home), business or other property was built prior to 1965 and has had no additional or replacement wiring for receptacle outlets and snap switches since that date, there is little chance that aluminum wire was used.

If your property was built subsequent to 1965, or has had additional wiring since then, you should consult the builder or electrical contractor to determine if aluminum wire was used. **DO NOT ATTEMPT TO MAKE THIS DETERMINATION ON YOUR OWN.**

If aluminum wire was used, you should have a qualified contractor or electrician check connections on the most heavily-loaded or most constantly-loaded circuits to determine if they have been properly made or show evidence of possible problems.

Readily detectable signs of possible trouble are unusually warm face plates on switches and receptacles, or a distinctive or strange odor in the vicinity of the receptacle or switch. Persistent but intermittent flickering of lights not traceable to appliances or other external causes are also indications of possible wiring problems.

IF SUCH SIGNS ARE PRESENT, OR IF THEY SUBSEQUENTLY DEVELOP, YOU SHOULD CONSULT A QUALIFIED CONTRACTOR OR ELECTRICIAN WITHOUT DELAY.

REPRESENTATIVES OF THE FOLLOWING ORGANIZATIONS
SERVED ON THE AD HOC COMMITTEE ON THE USE OF
ALUMINUM CONDUCTORS WITH WIRING DEVICES
IN ELECTRICAL WIRING SYSTEMS

- The Aluminum Association
- Battelle-Columbus Laboratories
- Edison Electric Institute
- Fire Marshals Association of North America
- International Association of Electrical Inspectors
- National Bureau of Standards
- National Electrical Contractors Association
- National Electrical Manufacturers Association
- National Fire Protection Association
- National Joint Apprenticeship and Training Committee
(IBEW-NECA)
- Underwriters' Laboratories, Inc.

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Underwriters' Laboratories, Inc.
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