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Report to:
Consumer Product Safety Commission
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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, *Secretary*
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

Electrical Aspects of the CSA/NBS Weatherization Study

Introduction and Background

When electric service first came into common use, houses were generally not insulated and the electrical system was designed to utilize the air-space in the walls to conduct heat away from the wiring system, thereby maintaining temperatures within the system at or below those required by the National Electrical Code (NEC) for safe operation. In those cases where insulation was installed, the wires were to be placed above or outside the insulation, since covering the electrical system with thermal insulation interferes with the air-cooling effect. If the heat dissipation process is sufficiently impeded, the electric system operates at a temperature higher than that for which the system was designed. Operation of the wiring system at elevated temperatures could eventually cause deterioration of the electrical insulation and subsequent electrical system failure, thereby creating a potential fire hazard.

The current national emphasis on energy conservation has led to an increased use of thermal insulation for new homes and older homes. In many of these homes this means taking an electrical system designed to operate in free air and encapsulating it in thermal insulation. The National Bureau of Standards (NBS) has conducted studies for the Consumer Product Safety Commission (CPSC) on the effects of thermal insulation on residential electrical systems (1, 2). While this is a many-faceted problem, it became evident early in the study that the condition of the electrical system in homes was a major factor in determining the potential fire hazard involved in covering an electrical system with thermal insulation. Since data on the condition of electrical systems in existing homes was not available, this study was undertaken.

The houses involved in the Community Services Administration (CSA)/NBS weatherization study (3) were used in the present study. The nature of some of the electrical problems in these homes, as found by the residents and by inspectors having no formal training in electrical work, was outlined in a previous report to CPSC (4). The present report is based on the evaluations of electrical problems in the CSA homes by technically qualified persons. These evaluations will be referred to as the "technical inspections".

The CSA/NBS Weatherization Study

The Community Services Administration (CSA), in an effort to determine "how it might best help low-income families cope with the high and increasing costs of energy" (3) initiated a research program at the National Bureau of Standards (NBS) to determine "the maximum dollars that can be saved through weatherization of the homes occupied by the poor in all parts of the United States" (3). This program will determine "the typical energy consumption, in BTU's per square foot, of unweatherized and optimally weatherized homes in various climates. . .and the savings, expressed as a percent, that can be expected from optimally weatherizing" (3) homes. This, in turn, will allow the estimation of "the minimum energy use achievable in a given type of building in a given climate zone", and the "understanding (of) the range of expected savings that can be achieved independent of behavioral and other variables" (3). Currently, fifteen CSA sites are participating in this weatherization project (table 1). As shown in figure 1, these sites are in various parts of the United States, and their areas experience a variety of weather conditions. To be considered for inclusion in the project, a house had to meet the following conditions:

1. be owner occupied;

2. be in a structurally sound condition, requiring minor repairs at most; and

3. have at least two years of fuel records/bills available.

CPSC/CSA/NBS Collaboration

The Consumer Product Safety Commission (CPSC), in order to obtain data useful in assessing the current state of the electrical wiring system and associated problems existing in houses, collaborated with the CSA and NBS in their Weatherization Demonstration Project. Each of the fifteen participating sites agreed to obtain electrical information of interest to CPSC on the houses involved in the project, and to forward this data to NBS for analysis. In specifying the type of electrical data to be gathered, the sites were provided with a list of pertinent questions and suggested response formats (figures 2 and 3); they were not, however, provided with an electrical inspection procedure. Two booklets (Appendixes 1 and 2) were prepared and distributed to the participants as guides for recording and submitting the desired data for the non-technical electrical inspections and the technical electrical inspections, respectively.

Approach

It was decided that the effort to evaluate the state of household wiring should take a three-pronged approach:

1. non-technical inspections

2. technical inspections

3. detailed measurements

The first inspection was to be performed by a CSA non-technical inspector in order to test the theory that an electrically-untrained person, given suitable guidelines could (a) perform an electrical safety check of a structure, then (b) based on the observations, that individual could decide whether conditions warranted calling in an expert, such as an electrician. If this concept proved to be workable, the procedure might then be presented in a pamphlet which, in turn, could be used by the consumer to inspect his/her own home and determine whether the services of a professional electrician should be sought. A prototypal procedure which might be used by CPSC in the development of a consumer brochure to be used by the homeowner in inspecting the electrical system was outlined in an earlier report (4).

The technical inspection was designed to be performed by an electrical expert (such as a licensed electrician, a local electrical inspector or a local electric utility) and was intended to verify and expand the observations of the non-technical inspection. Since it was our objective that the inspectors report everything they considered to be a problem, only guidelines and suggested response formats, rather than precise inspection procedures, were provided to them. Contact with the CSA personnel involved in the study was maintained, providing continuous opportunity to answer questions from sites as they arose.

The purpose of making detailed electrical measurements in the homes was to assess the condition of those parts of the wiring system which, because of location or role in the system, cannot readily be checked by visual means. This latter phase of the program has not been implemented.

Results and Discussion

Data on the technical inspection was received from ten of the fifteen sites, as indicated in table 2. The ten sites for which data has been received provide a representative geographical sampling of the fifteen sites (figure 4).

The results of the analysis of the technical inspection data received from the ten sites are presented in tables 4 through 8. They include an analysis of responses by the technical inspectors to questions on 157 houses from these 10 sites. Table 3 lists the problem categories into which the technical responses were classified. Appendix 3 provides illustrative comments received on the technical inspection returns. Clearly, some of these comments are based on the inspector's judgment of hazard, which may vary among inspectors depending on their experiences; some hazards may therefore not have been reported. Moreover, it is conceivable that on the subjective aspects of the data some one else could perhaps develop interpretations somewhat at variance from those reported below.

Table 4 profiles the age of the houses checked while table 5 presents summary data concerning the fuse/circuit size relationship for the ten sites. The average age per site ranged from 29 years for the New Orleans site to 73 for the Portland site. Ages of individual houses (among all the sites) ranged from 3 to 150 years, the average age being 48 years (table 4). The number of houses in which overamping* was evident ranged from 27 percent at the Chicago site to 69 percent at the Albuquerque site. On the whole, the ten sites indicated the presence of overamping in 49 percent of the houses checked (table 5).

---

*The overcurrent protection device for a conductor is designed to open the circuit when the current reaches a value that will cause an excessive or dangerous temperature in the conductor or conductor insulation. The term "overamped" indicates the use of an overcurrent protection device (fuse or circuit breaker) that would allow the circuit to carry a higher current than that for which it was designed.

Table 6 presents an analysis of the technical inspectors' responses concerning the nature of the electrical problems found, such as overamped circuits, temporary and/or extension cord wiring, lighting system problems, branch circuit wiring problems, fuse/circuit breaker panel problems, and problems with service entrance conductors. Of the houses for which data was available, 39 (25%) had service entrance conductor problems, 26 (17%) had problems with the electric panel, 54 (34%) had reported branch circuit wiring problems, 59 (38%) used temporary or extension cord wiring, while 61 (39%) contained defective lighting systems. Overamping was found in 77 (49%) of the houses inspected. Among the 77 houses in which overamping was reported, 60 (78%) had other problems as well. If one disregards the data from the New Orleans site, which had a very low incidence of response to questions pertaining to problems other than overamping, the number of overamped houses having additional problems becomes 58 out of 65 or 89%. The graph in figure 5 summarizes the types of problem encountered and the relative frequencies of occurrence on a per-house basis.

Figure 6 shows the frequency of occurrence of one or more type of problem by reporting site. The percentage of houses for which problems were reported ranged from 56 for the Easton site to 100 for the Tacoma site. Of the 157 houses for which inspection reports were received, 122 (78%) were reported to have at least one type of electrical problem, and 86 (55%) were reported to have multiple problems. Only 14 of the 157 houses inspected were reported to have no problems with the electric system, while 21 did not respond to questions pertaining to one or more of the problem categories of interest (table 7). Of the 122 houses with reported electrical problems, 36 had a problem(s) in only one problem category, 29 had problems in two categories, 25 had problems in three categories, 17 had problems in four categories, 11 had problems in five categories, and 4 had problems in all six categories. Figure 7 depicts these results in the form of a bargraph.

Due to changes in participating houses and personnel at participating sites, the data received from the technical inspections was not necessarily on the same houses as the data received from the non-technical inspection. Nonetheless, a comparison of data received from the non-technical inspection (4) and the technical inspection shows that problems were reported for 70 and 78% of the houses in the non-technical and technical inspection data pool, respectively (table 8). The frequency of overamping indicated by the non-technical data set was 44%, while the technical data set showed the presence of overamping in 49% of the houses. Whereas only 53% of the houses were reported to have multiple problems in the non-technical inspection, 70% of the houses in the technical inspection were found to have more than one problem. This may indicate that non-technical inspections are useful as an alerting tool for potential electrical problems in houses, but that technical inspections are necessary to assess the actual extent and nature of the electrical problems.

Summary and Recommendations

Technical inspection data was received for 157 (49%) of the 319 homes included in the 15 sites that had initially volunteered to participate in our study. Analysis of this data indicates that electrical deficiencies appear to be present in 78% of the homes that were inspected and reported upon. The addition of thermal insulation to the space occupied by the electrical system of these homes could aggravate and/or accelerate some of the potential hazards found to date. Serious consideration should be given to further investigations of the problems and remedial actions that might be required, especially in connection with home insulating efforts, to avoid increased risks on a widespread basis.

Since the non-technical and technical inspections pointed to electrical problems in 70% or more of the houses it may be useful for CPSC to develop consumer guidelines for early detection of potential electrical problems and criteria for conducting electrical inspections.

Finally, it should be pointed out that the results reported upon here are based on the limited number of homes included in the CSA/NBS Weatherization study, and that the data base has some inherent and unavoidable uncertainties and subjective comments. Nonetheless, it appears that there is a considerable potential for hazard associated with the problems found and further study is indicated.

TABLE 1. Location of CSA Weatherization Demonstration Project Sites

Site Number	Location
1	Albuquerque, New Mexico
2	Atlanta (Forest Park), Georgia
3	Charleston, South Carolina
4	Chicago, Illinois
5	Colorado Springs, Colorado
6	Easton, Pennsylvania
7	Fargo, North Dakota
8	Miami, Florida
9	Minneapolis, Minnesota
10	New Orleans, Louisiana
11	Oakland, California
12	Portland, Maine
13	St. Louis, Missouri
14	Tacoma, Washington
15	Washington, D.C. (Hughesville, MD)

TABLE 2. Status of CSA Electrical Data Collection

Site	# of Houses In Program	Houses for Which Data Was Received			
		Non-Technical Evaluation		Technical Evaluation	
		#	%	#	%
Albuquerque New Mexico	26	17	65	16	62
Forest Park (Atlanta) Georgia	16	16	100	16	100
Charleston South Carolina	23	22	96	0	0
Chicago Illinois	28	22	79	22	79
Colorado Springs Colorado	23	23	100	14	61
Easton Pennsylvania	20	20	100	18	90
Fargo North Dakota	18	15	83	0	0
Miami Florida	19	0	0	0	0
Minneapolis/St. Paul Minnesota	28	0	0	0	0
New Orleans Louisiana	18	0	0	18	100
Oakland California	15	0	0	12	80
Portland Maine	23	0	0	17	74
St. Louis Missouri	37	28	76	0	0
Tacoma Washington	10	10	100	10	100
Hughesville Maryland	15	0	0	14	93
Total	319	173	54	157	49

TABLE 3. Problem Categories

CATEGORY	Some Examples of Problems Included in Category
SERVICE ENTRANCE CONDUCTORS	Poor insulation/extensive loss of insulation on cable to house. No weatherhead on service cable. Service cable loose/no straps/clamp needs to be replaced Service cable frayed Improperly wired No corrosion prevention on aluminum connections Inadequate service/undersize for load Service bad - needs to be replaced Etc.
FUSE/CIRCUIT BREAKER PANEL	Improper installation/improperly wired Loose fuse holders Unfused main/main breaker missing or poor Condensation in fuse box Box too small/crowded panel Poor condition of panel Panel unsatisfactory/inadequate/needs to be replaced Etc. (excludes overamping)
BRANCH CIRCUIT WIRING	Improper/defective/deteriorated wiring Switch/receptacle problems Junction box problems Etc.
TEMPORARY/EXTENSION CORD WIRING	Zipcord wiring Excessive use of extension cords Extension cord use because of bad/non-operating/non-existing receptacles Extension cord from lighting circuit to power refrigerator/freezer/other appliances/shop tools Extension cord from one room to power another room/from house to yard or other building Temporary wiring/use of extension cord for/or in place of permanent wiring Etc.
LIGHTING	Use of improper wire No junction box for ceiling lights Fixture needs replacing Bad switch Frayed wires Loose sockets Flickering light Overbulbed fixture Scorching damage/overheated wire Bare/exposed wire Unsupported fixtures/dangling from wire Improperly installed/wired Wiring needs to be replaced Condition of wiring is poor/bad Etc.
OVERAMPED CIRCUITS	-

TABLE 4. Age Profiles of CSA Weatherization Demonstration Project Sites

Demonstration Project Site	Age of Houses for Which Data Was Received (years)		
	Average	Median	Range
Albuquerque New Mexico	30	25	17-100
Atlanta (Forest Park) Georgia	31	25	7-100
Chicago Illinois	60	60	15-100
Colorado Springs Colorado	65+	67.5	30-100
Easton Pennsylvania	53	55	7-100
New Orleans Louisiana	29	27	13-44
Oakland California	59+	60+	40+ to 80+
Portland Maine	73	75	23-150
Tacoma Washington	32	27	8-80
Hughesville Maryland	37	40	3-70
All Sites	48 +	-	3-150

TABLE 5. Overcurrent Protection Device (OCPD) / Circuit Size Relationship for CSA Weatherization Demonstration Project Sites

Demonstration Project Site	OCPD/Circuit Size Relationship Percent (%) of Houses Checked			Number in Site	Number of Returns
	Overamped	Unknown	Correct OCPD		
Albuquerque New Mexico	69	6	25	26	16
Atlanta (Forest Park) Georgia	50	0	50	16	16
Chicago Illinois	27	0	73	28	22
Colorado Springs Colorado	43	29	29	23	14
Easton Pennsylvania	33	6	61	20	18
New Orleans Louisiana	67	5	28	18	18
Oakland California	50	0	50	15	12
Portland Maine	59	12	29	23	17
Tacoma Washington	30	0	70	10	10
Hughesville Maryland	64	0	36	15	14
All Sites	49	6	45		

TABLE 6

Electrical Problems Found

Problem Category	Houses With Problems		No Response or Satisfactory	
	#	%	#	%
Service entrance conductors	39	25	118	75
Fuse/circuit breaker panel	26	17	131	83
Branch circuit wiring	54	34	103	66
Temporary/ext. cord wiring	59	38	98	62
Lighting	61	39	96	61
Overamping	77	49	80	51
Total (one or more problems)	122	78	35	22
Total (more than one problem)	86	55	35	22
Total (overamping & other problems)	60	38	35	22

TABLE 7

Frequency of Electrical System Problems by Problem Category

Site/No. of Returns	Number of Houses with Problems in		No Response	0 Problems	Number of Houses with Problems in					
	1 or More Problem Category	2 or More Problem Categories			1 Problem Category	2 Problem Categories	3 Problem Categories	4 Problem Categories	5 Problem Categories	6 Problem Categories
Albuquerque New Mexico - 16	15	8	1	0	7	4	0	4	0	0
Forest Park (Atlanta) Georgia - 16	12	9	0	4	3	8	1	0	0	0
Chicago Illinois - 22	13	9	1	8	4	4	2	0	3	0
Colorado Springs Colorado - 14	12	10	2	0	2	4	1	4	0	1
Easton Pennsylvania - 18	10	7	8	0	3	1	3	3	0	0
New Orleans Louisiana - 18	12	2	6	0	10	1	1	0	0	0
Oakland California - 12	11	11	1	0	0	1	7	0	1	2
Portland Maine - 17	15	13	2	0	2	1	4	2	5	1
Tacoma Washington - 10	10	7	0	0	3	1	4	2	0	0
Hughesville Maryland - 14	12	10	0	2	2	4	2	2	2	0
Total - 157	122	86	21	14	36	29	25	17	11	4
% - 100	78	55	13	9	23	18	16	11	7	3

TABLE 8

Comparison of Data from the Technical and Non-Technical Inspection Returns on CSA Houses

Frequency of	Non-Technical Inspection (% of Houses)	Technical Inspection (% of Houses)
Electrical Problem(s)	70	78
Overamping	44	49
Multiple Problems	53	70

Figure 1. Distribution of CSA Weatherization Demonstration Project Sites*

*Data in parentheses designate the number of homes participating.

FIGURE 2. Suggested Format for Non-Technical Electrical Information

Page 1 of ___

LOCATION OF CAP OFFICE________________________________

CAP ID # OF HOUSE________ PERFORMED BY____________________

1. Have you had any problems with your electrical system in recent years? NO____ YES____

   If YES, describe:________________________________

   ____

2. Has a fuse blown or a circuit breaker tripped recently? NO__YES

   Do you know why? NO___YES___. Describe circumstances:________

   ____

3. Have you had any electrical work performed on the house in recent years? NO____ YES____

   If YES, describe:________________________________

   ____

ENTRANCE PANEL (FUSE BOX):

EDISON BASE FUSES______
TYPE S FUSES ______
CIRCUIT BREAKER ______
OTHER ______

PICTURE OR SKETCH OF FUSE BOX:

WIRING:
Indicate the # of circuits at each of the following values:

SIZE AMPS	15	20	25	30	40
NUMBER					

SIZE AMPS	50	75	100	150
NUMBER				

Does a visual inspection show any wiring defects? YES___NO___

If YES, describe:________________________________

____

Will wires be covered with insulation? YES___NO___

LIGHT FIXTURES:
Any RECESSED LIGHTING? NO___YES___IN WHAT ROOM(S)?____________

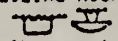
____

Is insulation to be installed on this surface? YES___NO___

What watt bulb(s) is in fixtures?______________________WATTS

For what watt bulb(s) is fixture designed? ______________WATTS

Any CEILING MOUNTED FIXTURES? YES___NO___



Are bulbs greater than 60 watts used in these fixtures? YES_NO_

ELECTRICAL EQUIPMENT USE:

Does this house have the following ELECTRICAL equipment?

INSTALLED	YES	NO
CEILING HEATERS (electric)		
DISHWASHER		
DRYER (electric)		
ELECTRIC HEAT		
FREEZER		
HEATER BLOWER		
HOT WATER HEATER (electric)		
OVEN (electric)		
REFRIGERATOR		
STOVE (electric)		
WALL HEATERS (electric)		
WASHING MACHINE		
WATER PUMP		
OTHER		

PORTABLE	YES	NO	HOW MANY
COFFEE MAKER			
HAIRDRYERS			
HEATER TAPES ON WATER PIPES			
HOT PLATE			
SPACE HEATERS (electric)			
TOASTERS			
VACUUM CLEANER			
WINDOW AIR CONDITIONERS			
OTHER			

COMMENTS: (use additional sheets as needed)

FIGURE 3. Suggested Format for Technical Electrical Information

ELECTRICAL SYSTEM INSPECTION

Location of CAP Office: ________________ CAP Identification No. of House ________

Inspection Performed by: ________________

(1) SERVICE ENTRANCE CONDUCTORS

Size ________
Material - Copper ___ Alum. ___
Other (specify) ________
Nom. Voltage 11/120 ___ 220/240 ___
Underground ______ Overhead ___
Condition and Comments:

(2) FUSE/CIRCUIT BREAKER ARRANGEMENT

Sketch (see instructions)

(3) BRANCH CIRCUIT INFORMATION (SEE INSTRUCTIONS)

Circuit No. (in Sketch)	3-A Type of Over-current Protection	3-B Size of Fuse or Circuit Breaker (Amperes)	3-C Size of Conductor (AWG)	3-D Conductor Material	3-E Insulation Material	3-F Wiring Method	3-G Grounding Conductor	3-H Nominal Voltage
#1								
#2								
#3								
#4								
#5								
#6								
#7								
#8								
#9								
#10								
#11								
#12								

(3-I) Notes/Comments on Branch Circuit Items Listed Above

(4) BACK-UP/OTHER OVERCURRENT PROTECTION (see instructions): ________

(5) NAMEPLATE INFORMATION/CONDITION/LOCATION OF FUSE/CIRCUIT BREAKER PANEL: ________

(6) RECESSED AND SURFACE-MOUNTED CEILING LIGHTS

Light No.	6A Location	6B Type of Fixture	6C No. of Lights	6D Size of Bulbs	6E Type of Bulbs	6F Scorching/ Damage	6G Condition of Wiring	6H Size of Enclosure	6I Distance of Bulbs to Top Surface	6J Is Warning on Fixture?	6K Is Thermal-Insulation Above Fixture Now?	6L Is Thermal-Insulation Above Fixture Likely?
#1												
#2												
#3												
#4												
#5												
#6												
#7												
#8												

(6-M) Notes/Comments on Lighting Items Listed Above: ________

(7) CONDITION OF BRANCH CIRCUIT WIRING: ________

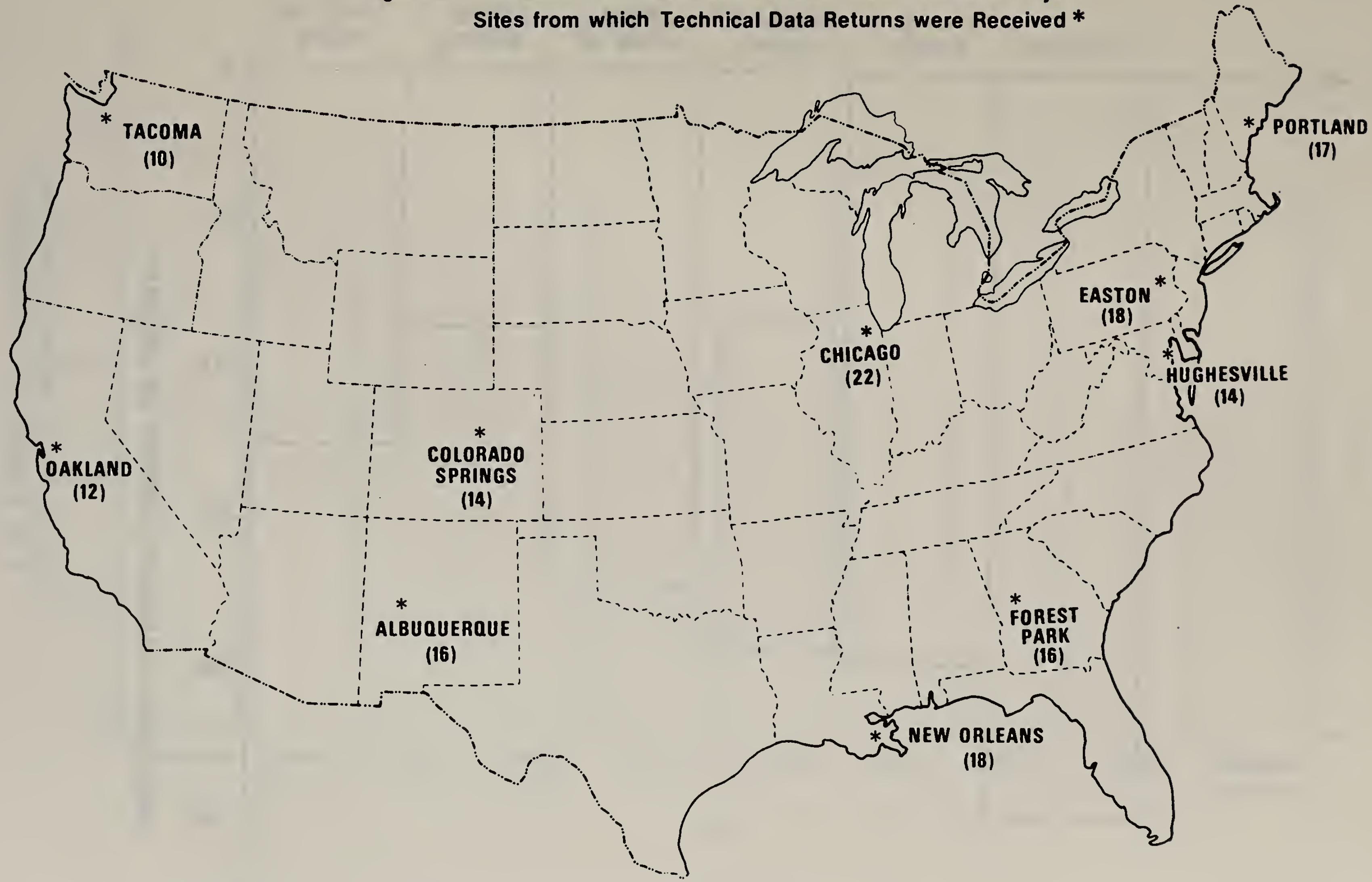
(8) TEMPORARY/EXTENSION CORD WIRING: ________

(9) DETAILS ON OTHER ELECTRICAL HAZARDS: ________

SUPPLEMENTARY NOTES/COMMENTS ON ELECTRICAL SYSTEM INSPECTION
(Please identify items on "Electrical System Inspection" for which comments apply)

Item No.	

Figure 4. Distribution of CSA Weatherization Demonstration Project Sites from which Technical Data Returns were Received *



*Data in parentheses indicate the number of houses from which data was received.

Figure 5. Electrical Problems

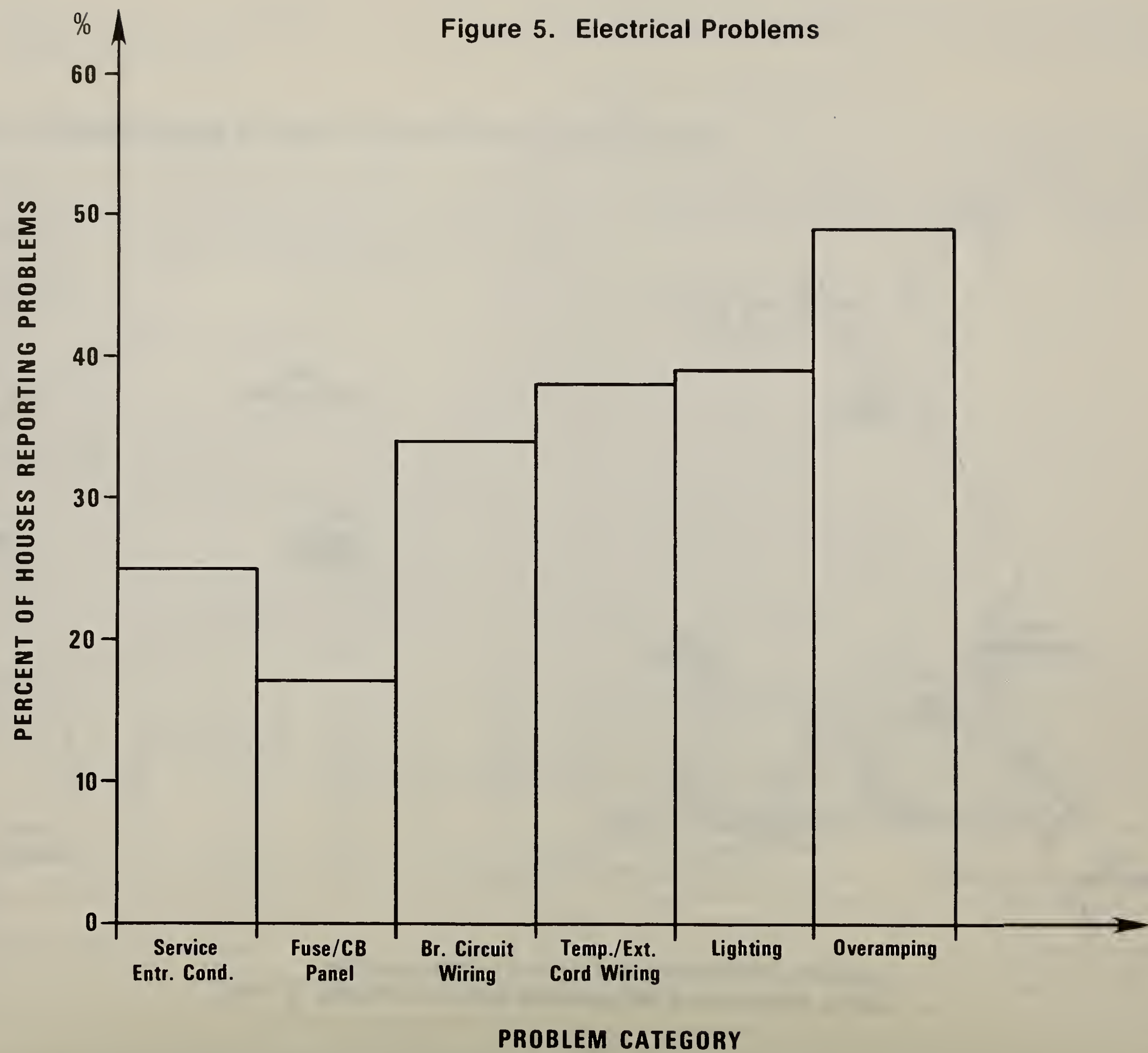


Figure 6. Problems with the Electrical System

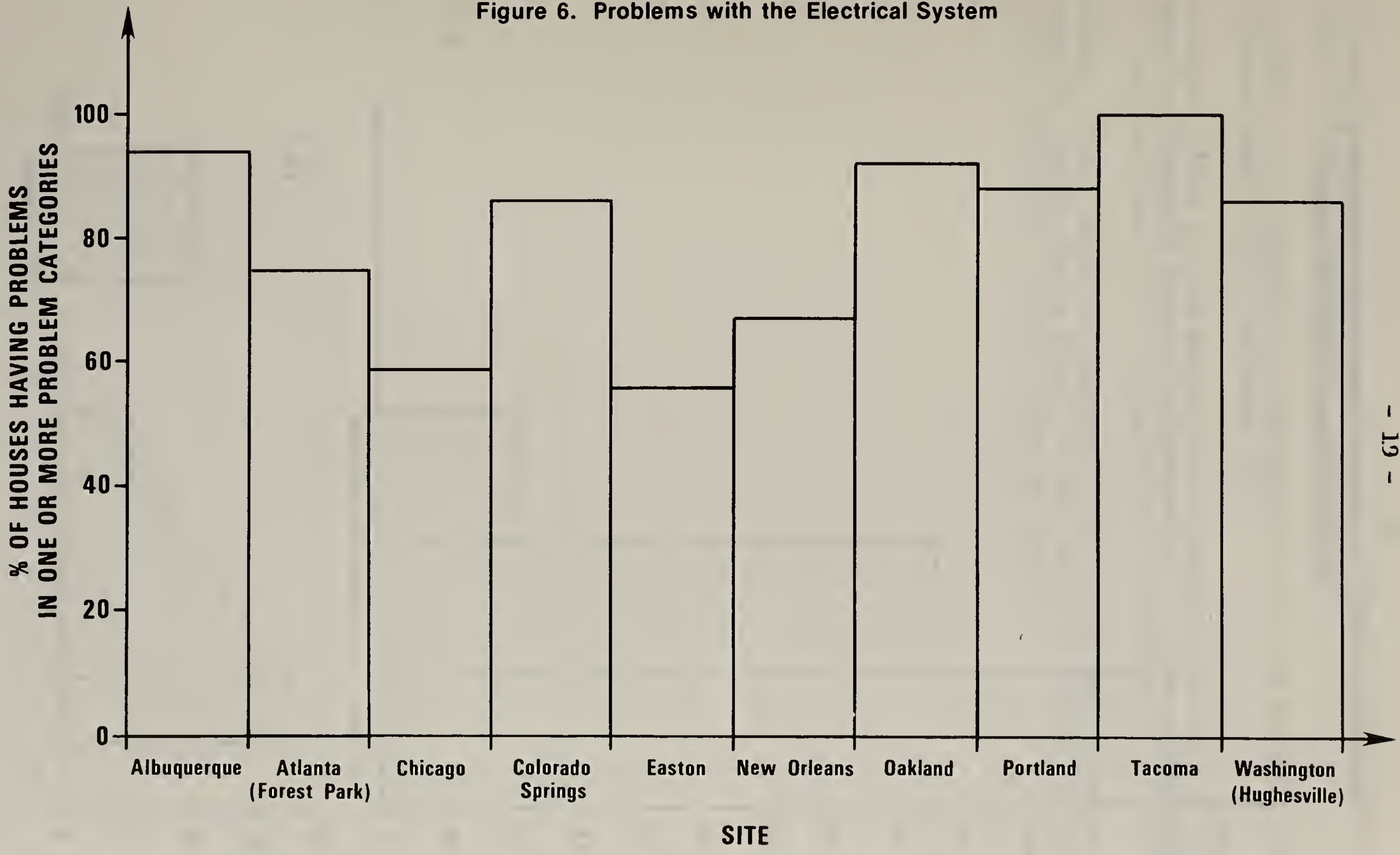
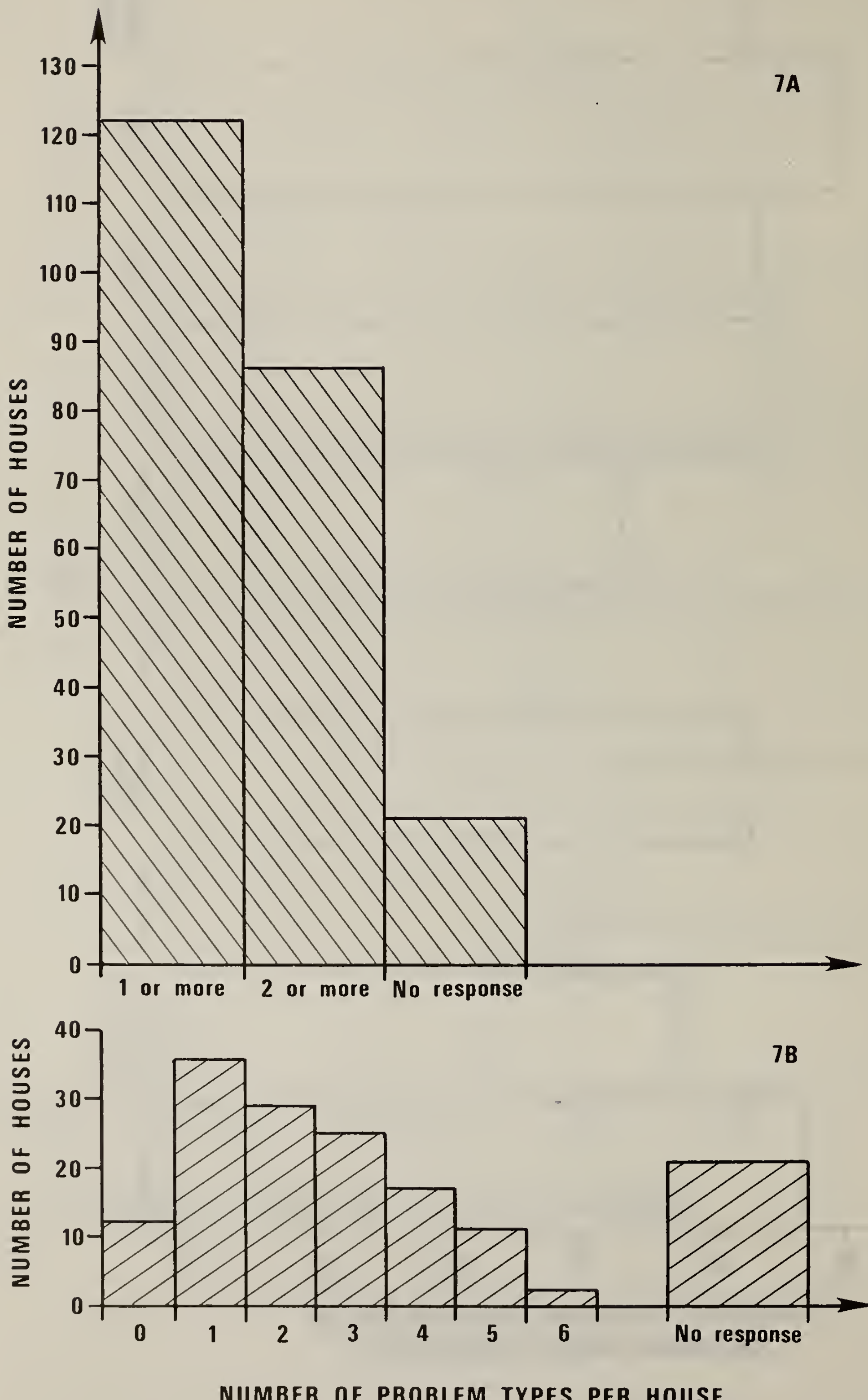


Figure 7A and 7B Frequency of Occurrence of Electrical System Problem Types Per House



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(2) Fulcomer, P.M., Temperature Measurement on Operating Recessed Lighting Fixtures, NBSIR79-1913, September 1979.

(3) Crenshaw, R., et al, CSA Weatherization Demonstration Project Plan, Report to Community Services Administration, 1-2, Nov. 1978, Center for Building Technology, National Bureau of Standards.

(4) Vaishnav, M.P., Electrical Aspects of the CSA/NBS Weatherization Study, An Interim Status Report to CPSC, May 1979, Center for Consumer Product Technology, National Bureau of Standards.

APPENDIX I

Potential Electrical Hazards in Housing - Sent to CSA Sites for "Non-Technical" Data Collection

POTENTIAL ELECTRICAL HAZARDS IN HOUSING

PURPOSE OF PAMPHLET

The purpose of this informal pamphlet is to present information concerning the need for assessing the condition of the residential electrical systems in the homes selected for the Weatherization Program, and describe the data needed by the Consumer Product Safety Commission/ National Bureau of Standards (CPSC/NBS) to assess the extent and nature of electrical system problems, which exist in today's homes. This pamphlet will be updated, based on your comments and other data.

It is anticipated that two types of potential electrical hazards will be encountered:

1) Those hazards which the Weatherization Program will aggrevate and thus should be fixed prior to weatherization.

2) Those hazards which will not be affected by the Weatherization Program.

The CPSC/NBS study is concerned with identifying both types of potential hazards. The (CSA/NBS) Weatherization Program is only technically concerned with the first type.

GENERAL BACKGROUND

In the United States, the evaluation and approval of electrical construction in housing primarily involves three entities, which are: (1) local authorities, (2) the National Electrical Code (NEC) and (3) Underwriters' Laboratories, Inc. (U.L.). The information presented below contrasts the usual safeguards taken with new installations with lack of safeguards for existing installations. There is generally no evaluation of existing electrical systems except when alterations or additions are made to them. When other alterations (e.g. installing thermal insulation) are made, electrical systems are usually ignored.

The inspection of electrical construction is usually done by local authorities, who generally determine the legal requirements which apply to electrical construction in their areas. In practice, local authorities usually follow the National Electrical Code (NEC) for installation requirements, and approve only manufactured electrical components which have been listed by Underwriters' Laboratories, Inc. In some cases, local authorities adopt the National Electrical Code with modifications. Such modifications usually make legal requirements more restrictive than corresponding NEC requirements. For example, some jurisdictions prohibit the installation of nonmetallic-sheathed cable or electrical cable with aluminum conductors. The National Electrical Code and any local amendments to the NEC are referred to in the event of any controversy concerning wiring methods or requirements; otherwise, the safety and adequacy of electrical installations are evaluated by the judgment of electrical inspectors.

The National Electrical Code is promulgated under procedures of the National Fire Protection Association (NFPA) and the American National Standards Institute (ANSI) as a voluntary standard. It is an "installation" code, stating in generic terms what may be installed for different types of construction and for given conditions, and it sets forth installation requirements. The NEC covers requirements for electrical construction except for the suppliers' or utilities part of electrical systems. (Requirements for electrical and communication utilities' facilities are generally covered by a different national voluntary standard, which is known as the "National Electrical Safety Code.")

Responsibility for revision of the NEC is divided among approximately 24 panels (subcommittees) with a correlating committee overseeing and coordinating the work of the panels. The panels consist of representatives from varied interests such as electrical manufacturers, electrical contractors, electrical utilities, electricians, insurance, electrical and building inspectors, and other governmental authorities. The NEC is revised on a three-year schedule and there are provisions for interim amendments. The Rules of Procedure for amending the NEC are detailed in an appendix to the NEC.

Even though the National Electrical Code is a voluntary standard it affects construction throughout the United States because of its adoption by State, local, or other enforcing authorities. In areas where there are very limited or no legal requirements, or where legal requirements are not rigidly enforced, some contractors still conform to the National Electrical Code. In the event of fire or accident, courts generally accept the National Electrical Code as acceptable good practice.

Nearly all testing for safety of manufactured electrical products is done by Underwriters' Laboratories (U.L.), a non-profit, private corporation. Underwriters' Laboratories lists manufactured products which they have tested and found satisfactory. U.L. develops its own test methods and standards. Underwriters' Laboratories has no legal authority to "approve" products for installation or sale. U.L. uses the word "list" and not "approve" in referring to products it has found satisfactory. Approval of products is the function of the enforcing authority having jurisdiction. The procedures of most enforcing authorities do not call for listing by Underwriters' Laboratories as the sole criterion for approving electrical products. However, in practice, listing by U.L. usually becomes tantamount to local approval provided local electrical regulations are not more stringent than those of the National Electrical Code, in which case the use of certain types of electrical products may be prohibited.

THE ELECTRICAL SYSTEM DEFICIENCIES

Electrical system components and equipment may have several types of deficiencies. Older houses in particular may have deficiencies which are potentially hazardous. Some of these deficiencies may be aggravated when thermal insulation is installed. Several categories of deficiencies in electrical systems are discussed here.

While the condition and other appropriate factors should determine the adequacy of a particular wiring system, the type(s) of systems used in each house should be noted. Illustrations of several common types are attached.

For various reasons, including ageing, abuse and dampness, the wiring and other parts of electrical systems may be in a deficient or potentially hazardous condition. There are numerous specific conditions which could present a hazardous situation. Examples of such conditions are listed below:

- Loose/broken light fixtures
- Exposed wiring
- Badly damaged/frayed wire
- Receptacles broken/loose
- Outside wires not properly buried or supported
- Exposed electrical conductors at outlets
- Electrical conductors in contact with metal frames of equipment
- Deteriorating electrical insulation

Generally weatherization itself does not aggravate these types of deficiencies in electrical systems. However, the process of installing thermal insulation may cause additional damage to deteriorated electrical systems. Stresses which are put on wiring with "cracking" or otherwise deteriorating electrical insulation may cause the electrical insulation to come off the wiring when it is moved to permit the installation of thermal insulation. Such stresses during the installation may cause "short-circuits" or cause ungrounded metal to become "electrically-hot" (a shock hazard).

A qualified electrical inspector should determine the necessary corrections to the electrical system before houses are weatherized. The electrical systems in older houses are not expected to be up-dated to the extent that they will conform with all provisions of the National Electrical Code or local electrical codes for new houses. However, imminent or potentially imminent hazards should be corrected.

Overloaded Branch Circuits/Overfusing

When houses are thermally insulated, it becomes extremely important that branch circuits not be overloaded. The National Electrical Code defines "branch circuit" as "The Circuit Conductors between the final overcurrent device ("fuse box" or "circuit breaker panel") protecting the circuit and the outlet(s)" (lights, receptacles, permanent appliances). In single family houses, or within housing units of apartment buildings, basically the entire electrical system consists of branch circuits only.

When wiring is encapsulated (surrounded) by thermal insulation it operates at higher temperatures than when it is exposed to the air. When a circuit is supplying electricity to lights, appliances, etc., power is lost in the wiring in the form of heat. If such heat cannot be readily dissipated, the wiring may reach very high temperatures. Such heat may shorten the life of the wiring and if the temperatures become high enough they may cause fires.

The higher the load (that is with too many lights and appliances) on a branch circuit, the chances of obtaining dangerously high temperatures increase. If thermal insulation prevents the dissipation of heat produced by self-heating in the wiring, the potential hazards becomes much more serious.

A common example of how branch circuit wiring may become encapsulated in thermal insulation is where an unfinished attic has some insulation, the wiring is usually on top of this existing insulation. The addition of more thermal insulation in the attic (because of recent increased energy conservation needs) usually results in the new insulation being installed on top of the wiring. This results in the wiring being "sandwiched" (encapsulated) between old and new thermal insulation.

Because of the chance of wiring being encapsulated in thermal insulation when houses are weatherized, it becomes extremely important that branch circuits not be overfused. Houses with edison base fuseholders (which includes most houses over 20 years old) may easily and inadvertently be overfused. (See page 6 concerning discussion of edison base fuses). In residential occupancies branch circuits are usually overfused if wire sizes are larger than shown below.

Wire Size (AWG)		Rated Size of Fuse (in amperes)
Copper	Aluminum	
#14	#12	15
#12	#10	20
#10	# 8	30

NOTE: Wires of a given size with some types of superior electrical insulation may be rated at higher ampacities (current carrying capacity in amperes) than shown above. However, nonmetallic-sheathed cable and most other wiring used in houses does not have these superior electrical insulations.

This is the reason for obtaining detailed data on overcurrent protection (fuses or circuit breakers). See Section on overcurrent protection.

Recessed and Surface Mounted Ceiling Lights/Overlamping

When thermal insulation covers recessed lights or the outlet boxes for surface-mounted ceiling lights, a potential hazard may be created. Thermal insulation tends to prevent heat produced by the lights from dissipating. This can result in high temperatures which may hasten deterioration of the lighting fixture and the wiring in the outlet box where connections are made to the lighting fixture. If temperatures become too high, insulation on wiring and other non-metallic parts of the electrical system may possibly ignite.

Thermal insulation in close proximity to the lights or their outlet boxes may also ignite if temperatures become to high.

The National Electrical Code contains the following provision:

"Thermal insulation shall not be installed within three inches of a recessed fixture enclosure, wiring compartment or ballast and shall not be installed above the fixture as to entrap heat and prevent the free circulation of air unless the fixture is otherwise approved for the purpose."

This potential hazard may be particularly acute when there is overlamping. This is the reason for obtaining detailed information on recessed and surface-mounted ceiling light fixtures. Overlamping occurs when a larger size lightbulb (in watts) is inserted into a light fixture than the light fixture is designed for. The excess heat produced by such lightbulbs in an installation where thermal insulation entrap heat may create a serious fire hazard. Unless otherwise marked, most light fixtures are overlamped if bulbs larger than 60 watts are used.

Service Entrance Capacity

Many older houses have insufficient electrical service capacity brought into them. While 150 and 200 ampere service entrance capacity is common in newer homes, many older homes have 60 ampere or less service entrance capacity. 60 ampere capacity may still be adequate in some houses, particularly when such heavy appliances as electric heaters, stoves, and air conditioners are not used.

A qualified electrical inspector should determine if houses have insufficient service entrance capacity. If there is need to rewire or add additional branch circuits, it may be necessary to also increase the service entrance capacity. Unless the electrical load is increased or additional branch circuits become necessary in weatherizing a house, weatherization may not increase hazards associated with a small service entrance capacity. However, if the service entrance cables become encapsulated in thermal insulation, they may overheat in the same manner as branch circuit cables.

Overcurrent Protection

Generally overcurrent protection consists of either fuses or circuit breakers. The purpose of fuses and circuit breakers is to open ("cut-off") the circuit if the load is too high (too many lights or appliances) or if a short-circuit develops. These hazards were discussed earlier. Generally there are three types of overcurrent protection used on branch circuits in housing: (A) circuit breakers; (B) type S fuses and (C) Edison base fuses are attached.

(A) Circuit Breakers

Circuit breakers have usually been used in housing only in the last 15 to 20 years. Circuit breakers which have been installed by qualified electricians should be correctly sized in accordance with the branch circuit wiring. However, it should be determined that the proper circuit breaker is used on each circuit before weatherizing a house.

Circuit breakers should be operated (tripped) by hand once or twice a year as corrosion may tend to prevent proper operation. Badly corroded circuit breakers should be examined to determine that they are in good operating condition.

(B) Type S Fuses (Fusestats)

While standards for type S fuses are not entirely universal in the U.S., generally it is much more difficult to overfuse circuits with this type of fuse. Type S fuses usually are rated 0-15, 16-20, and 21-30 amperes. They are designed so that it is difficult to put a type S fuse with a higher ampere rating into a fuse holder designed for a lower rated fuse. Adapters to convert Edison base fuseholders (see next Section) to hold type S fuses are readily available. See attached photos of type S fuse.

(C) Edison Base Fuses

Generally older houses are equipped with fuseholders for Edison base fuses. Edison base fuses rated at 15, 20, 25 and 30 amperes are readily available in many stores. An Edison base fuseholder will accept any of these fuse sizes, thereby making it extremely easy to "overfuse." Much "overfusing" may be unintentional. The hazards of overfusing, particularly when wiring may be encapsulated in thermal insulation was discussed earlier.

In recent years Edison base fuses have been prohibited by the National Electrical Code in new installations. It is recommended that the correct size adapters for type S fuses be installed in Edison base fuseholders. This is a very simple operation. However, only qualified electricians should make such alterations, for once the wrong size adapter is installed, it cannot be removed without damaging the system.

Converting any Edison base fuseholders to accept the proper size type S fuses should be the minimum acceptable electrical updating procedures for houses being weatherized. Overfusing may be particularly hazardous in houses retrofitted with thermal insulation. See attached photo of Edison base fuse.

CPSC/NBS STUDY

Energy conservation is a national policy. Part of this national program has been and will continue to be the saving of energy through home weatherization programs. The Administration and Congress through provisions in the Energy Bill have recognized this need and are working on means of accomplishing weatherization on a large scale. Congress has also recognized that inherent in any weatherization program are possible effects on health and safety and has taken steps to protect the public. One example of this is "The Emergency Interim Consumer Product Safety Standard Act of 1978" which directs the Consumer Product Safety Commission to issue and enforce the requirements for flame resistance and corrosion of the General Services Administration's specification for cellulose insulation.

CPSC has recognized that other safety hazards could result from insulating homes and has been examining data to identify possible problem areas. In addition, the Commission has initiated several insulation-related study programs. One of these studies is the "Effects of Thermal Insulation on Residential Electrical Systems," the topic of this pamphlet.

The current study is based on the premise that residential electrical systems, including lighting and other electrical components, constitute one of the primary ignition sources in fires, and the hypothesis that insulation represents an additional stress on the electrical system which could accelerate the fire-failure rate.

The purposes of the study are:

1) To determine the extent and nature of electrically-related hazards
2) To identify specific causes
3) To identify remedial strategies
4) To develop requisite data to allow discussions and support CPSC action

The study is divided into four task areas and approximately seven product areas. A pictorial of the study matrix which identifies the various components is shown in Figure 1.

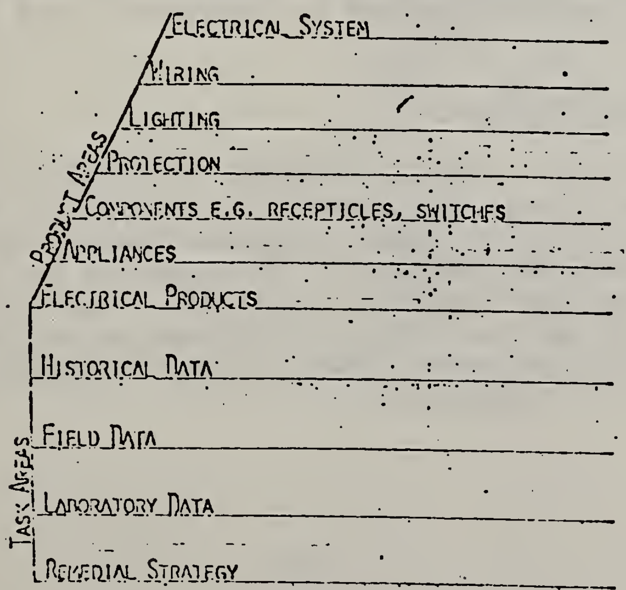


Figure 1

The first task, Historical Data, is an attempt to identify the potential problem areas by reviewing the emergence and changes in design standards, the electrical codes and other voluntary standards and comparison of this data with fire experience. The principal data base for the fire data is National Fire Incident Reporting System (NFIRS) which is under the auspices of the National Fire Protection and Control Administration (NFPCA).

The next task, Field Data, is an attempt to develop from inspection an accurate picture of the state of electrical systems in homes. One of the principal areas from which the Field Data is anticipated is through a cooperative effort among CSA-NBS-CPSC, in which the electrical systems in approximately 500 houses (spread climatically and geographically around the United States) will be examined.

The third task, Laboratory Data, has as its purpose the development of data which will explain and back-up the situations found in the field. Such data includes the effects of overfusing and overlamping under conditions simulating those in houses.

The last task concerns Remedial Strategy. One effort in this Task area is the gathering of background material and technical data for actions to be taken under the Consumer Product Safety Act.

Field Data

One of the principal difficulties in trying to assess potential hazards, particularly the increase in the number of electrically-caused fires associated with insulation, is a lack of definitive data on the present conditions of electrical systems in homes. Laboratory data may be used to predict potential hazards. With these predictions, changes could be made to appropriate standards (e.g. the National Electrical Code) for systems and components in homes to be built or rewired in the future. These changes, however, would not affect the potential hazards due to Weatherization, particularly those due to increasing the amount of insulation. The CSA/NBS weatherization study produces an opportunity to gather "real-world" data. The sample is statistically distributed according to age of homes and to geographical and climatical conditions.

The CSA/NBS Weatherization Program

The CPSC/NBS participation with the CSA/NBS Weatherization Program represents a two-pronged effort. The first is an identification of potential electrical problems which could be aggravated by insulation and thus assist local offices in their decision processes. The second is the opportunity to gather definitive data on the present conditions of residential electrical systems. While the first has the greatest importance in the success of the Weatherization Program, the potential impact of the second on possible National priorities must be recognized.

Use of the Data

The purpose of gathering this data is to form a definitive and, if possible, a statistically sound estimate of problems in residential electrical systems existing in homes today. The ability of the NBS/CPSC team to do this is dependent on the quality of the data gathered.

The NON-TECHNICAL Electrical System Inspection

Figure 2 indicates the type of information needed for a preliminary characterization of possible problems with the electrical systems in the houses involved in the weatherization project. The format in figure 2 may be used to record the data for transmission to NBS.

Please note that the format of figure 2 provides checklists as well as space for additional notes. Detailed notes and pictures, particularly of hazardous or unusual situations, would be most helpful. Writing on materials to be photographed needs to be in sharp focus, so that it will be readable in resulting prints. Please note precautions in the Electrical Safety paragraph which should be taken when making inspections.

LOCATION OF CAP OFFICE________________________

CAP ID # OF HOUSE_________ PERFORMED BY________________

1. Have you had any problems with your electrical system in recent years? NO____ YES____

   If YES, describe:________________________

2. Has a fuse blown or a circuit breaker tripped recently? NO__YES

   Do you know why? NO___YES___. Describe circumstances:__________

3. Have you had any electrical work performed on the house in recent years? NO____ YES____

   If YES, describe:________________________

ENTRANCE PANEL (FUSE BOX):

EDISON BASE FUSES______
TYPE S FUSES ______
CIRCUIT BREAKER ______
OTHER ______

PICTURE OR SKETCH OF FUSE BOX:

WIRING:
Indicate the # of circuits at each of the following values:

SIZE AMPS	15	20	25	30	40
NUMBER					

SIZE AMPS	50	75	100	150
NUMBER				

Does a visual inspection show any wiring defects? YES___NO___

If YES, describe:________________________

Will wires be covered with insulation? YES___NO___

LIGHT FIXTURES:
Any RECESSED LIGHTING? NO___YES___IN WHAT ROOM(S)?____________

Is insulation to be installed on this surface? YES___NO___

What watt bulb(s) is in fixtures?________________WATTS

For what watt bulb(s) is fixture designed? ____________WATTS

Any CEILING MOUNTED FIXTURES? YES___NO___

Are bulbs greater than 60 watts used in these fixtures?YES_NO_

ELECTRICAL EQUIPMENT USE:

Does this house have the following ELECTRICAL equipment?

INSTALLED	YES	NO
CEILING HEATERS (electric)		
DISHWASHER		
DRYER (electric)		
ELECTRIC HEAT		
FREEZER		
HEATER BLOWER		
HOT WATER HEATER (electric)		
OVEN (electric)		
REFRIGERATOR		
STOVE (electric)		
WALL HEATERS (electric)		
WASHING MACHINE		
WATER PUMP		
OTHER		

PORTABLE	YES	NO	HOW MANY
COFFEE MAKER			
HAIRDRYERS			
HEATER TAPES ON WATER PIPES			
HOT PLATE			
SPACE HEATERS (electric)			
TOASTERS			
VACUUM CLEANER			
WINDOW AIR CONDITIONERS			
OTHER			

COMMENTS: (use additional sheets as needed)

Figure 2

Figure 2 indicates the type of information needed for a preliminary characterization of possible problems with the electrical systems in the houses involved in the weatherization project. The format in figure 2 may be used to record the data for transmission to NBS.

The first three questions deal with electrical problems that the occupant of the house may have (or have had recently) with the electrical system such as flickering lights, hot receptacles, equipment where electric shocks have been felt, sparks, burnt or damaged cords, plugs or other components, fuses blowing, etc. It would be very helpful to know if there has been any rewiring (or additional wiring) since the house was originally wired.

Under the heading of ENTRANCE PANEL please indicate the type of overcurrent protection provided, such as Edison Base Fuses, Type S Fuses, Circuit Breaker, of Other. If the term Other is checked, please describe in detail the type of overcurrent protection found. Attached photos show the difference between the Edison Base Fuses and the Type S Fuses. A sketch or picture of the fuse box or circuit breaker panel should indicate the arrangement and size of the fuses or circuit breakers. If a picture of the fuse box or circuit breaker panel is taken, care must be taken to focus on the writing so it will be legible in the resultant print.

Under the heading of WIRING please indicate the number of circuits at each of the values indicated for both fuses and circuit breakers. If any wiring defects such as crumbling insulation on wires, loose wires, broken or inoperative switches or receptacles, etc., are found, please note and describe, but do not touch them - electricity can kill. Also note if any wiring would be covered with insulation during the weatherization process.

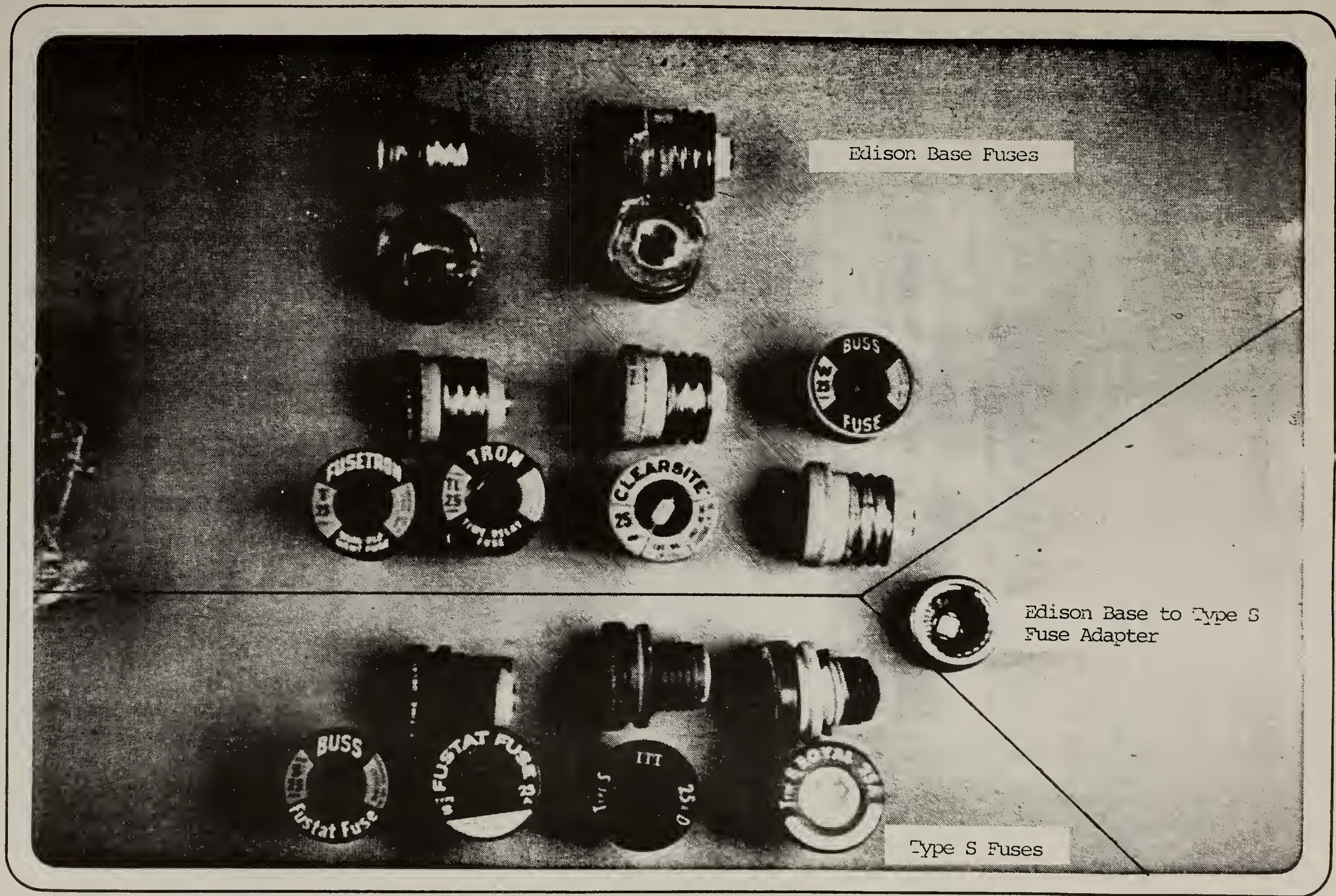
Under the heading of LIGHT FIXTURES please indicate if there are any recessed lights in the house. If there are recessed lights, please note in what room(s) they are, whether they will be covered with insulation as a result of the weatherization process, the size of the bulbs currently used in the recessed lights, and when possible the size bulbs that the recessed lights were designed for. If the recessed light fixture does not indicate the size of bulb for which it was designed, please note whether this information appears to have become illegible. Also record any ceiling mounted fixtures of type shown on form and indicate if bulbs greater than 60 watts are used in any of the ceiling mounted fixtures. Figures in the inspection form show those ceiling mounted fixtures that are of interest to us.

Under ELECTRICAL EQUIPMENT USE please indicate the type and number of electrical equipment/appliances found. Where possible, also indicate the wattage requirement of the electrical equipment or appliance noted.

Please use the COMMENTS space (and additional pages as needed) for any remarks, notes, sketches, etc. you feel may be of help to us in assessing any possible electrical hazard.

Electrical Safety of People Making Inspections

Except when inspections are strictly visual, the person performing them should be a qualified licensed electrician. ELECTRICITY CAN KILL.


Edison Base Fuses
Edison Base to Type S
Fuse Adapter
Type S Fuses
BUSS
FUSE
FUSETRON
TRON
CLEARSITE
BUSS
Fustat Fuse
FUSTAT FUSE
ITT

A P P E N D I X   I I

Instructions for Electrical Inspection Reports - Sent to CSA Sites for "Technical" Data Collection

INSTRUCTIONS FOR ELECTRICAL INSPECTION REPORTS

PURPOSE OF INSPECTIONS

These electrical inspections are made for two purposes, which are (1) safety, and (2) to obtain data to characterize electrical systems in houses needing weatherization.

SAFETY ASPECTS

The report on each house will be turned over to the local CAP office so that they can determine repairs, alterations, etc., which are needed to the electrical system.

ELECTRICAL DATA ASPECTS

The installation of thermal insulation may cause or aggravate hazards involving electrical systems. In particular oversized fuses (overfusing) and oversized light bulbs (overlamping) with indiscreminate use of thermal insulation may result in hazardous situations.

(a) OVERFUSING

Thermal insulation surrounding electrical cables will cause the cables to operate at higher temperatures (see NBS report NBSIR 78-1477). If circuits are overfused, the potential hazard may be acute when thermal insulation is installed. This is the reason for obtaining detailed data on overcurrent protection.

In residential occupancies branch circuits are usually overfused if wire sizes are larger than shown below.

Wire Size (AWG) Copper	Wire Size (AWG) Aluminum	Rated Size of Fuse (in amperes)
#14	#12	15
#12	#10	20
#10	# 8	30

NOTE: Wires of a given size with some types of superior electrical insulations may be rated at higher ampacities (current carrying capacity in amperes) than shown above. However, nonmetallic-sheathed cable (romex) and most other wiring used in houses does not have these superior electrical insulations.

(b) OVERLAMPING

When thermal insulation covers recessed lights or the outlet boxes for surface-mounted ceiling lights, a potential hazard may be created. This potential hazard may be particularly acute when there is overlamping. This is the reason for obtaining detailed information on recessed and surface-mounted ceiling light fixtures. Unless otherwise marked, most such light fixtures are overlamped if bulbs are larger than 60 watts are used.

RECORDING INFORMATION

A form on which to record information when making electrical system inspections is provided. Also provided are additional sheets on which to record notes or comments. Please identify item on the form to which the comment applies. Item No's are (1) through (9) and 3-A through 3-I, and 6-A through 6-M.

INSTRUCTIONS CONCERNING SPECIFIC ITEMS

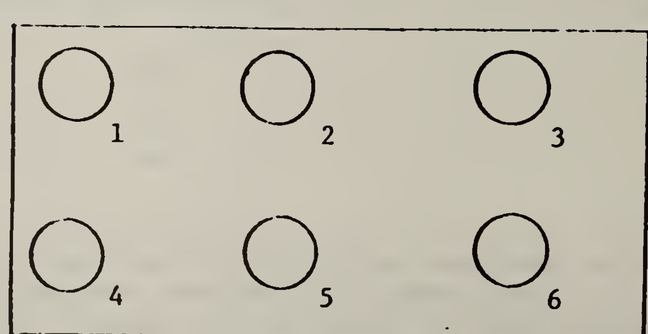
Item (1) - SERVICE ENTRANCE CONDUCTORS

Please give information requested. Assess condition of conductors, their fastenings, etc. Detail damage, any hazards, unusual situations, etc. If three-phase service is provided, please indicate under comments.

Please estimate the length of service entrance cable which is inside of the house. Indicate places within house (such as "unfinished attic", "exterior wall", "interior wall", etc.) where service entrance cables are located. (We are concerned about heat dissipation after thermal insulation is installed.)

Item (2) - FUSE/CIRCUIT BREAKER ARRANGEMENT

Please draw sketch.
Example for fuse panel:



Item (3) - BRANCH CIRCUIT INFORMATION

The cover of the fuse or circuit breaker panel(s) should be removed. Information recorded for each circuit should be in accordance with the numbering on the fuse or circuit breakers in the sketch prepared under Item (2).

Item 3-A - Type of Overcurrent Protection

Use the following symbols:

- CB - Circuit Breaker
- S - Type S Fuse
- E - Edison Base Fuse
- CART - Cartridge Fuse

Identify any hazards, blown fuses, unusual conditions, etc. in Items 3-I or on separate sheet.

Item 3-B - Size of Fuse or Circuit Breaker (amperes)

Record the size of each fuse or circuit breaker presently used.

Item 3-C - Size of Conductor

Please record (#14, #12, etc.) for each circuit.

Item 3-D - Conductor Material

Use abbreviations:

- C - copper
- AL - aluminum
- C-clad - Copper clad aluminum

Item 3-E - Insulation Material

Please try to determine if insulation is rubber or plastic (thermoplastic). Use R for rubber, T for plastic.

Item 3-F - Wiring Method

Use symbols:

- NM - nonmetallic - sheathed cable (romex)
- BX - armored cable
- EMT - electrical metallic tubing
- RC - rigid conduit
- FMC - flexible metal conduit
- Others - specify, use Item 3-I or separate sheet, if necessary.

Item 3-G - Grounding Conductor

Indicate "yes" or "no" for each circuit.

Item 3-H - Nominal Voltage

If circuit voltage is 110 to 125 indicate "120", if circuit voltage is 220 to 240 (single phase) indicate "240". If circuit is three phase, please indicate this. Most circuits will be "120".

Item 3-I - Notes/Comments on Branch Circuit Items Listed Above

Indicate applicable information from Items 3-A through 3-H above. Identify items being commented on.

Item (4) - BACK-UP/OTHER OVERCURRENT PROTECTION

List type, size and other applicable information on any fuses or circuit breakers not listed in Item 3 above. Give appropriate details such as "current from circuits #1, 2, 3 and 4 pass through this fuse".

Item (5) - NAMEPLATE INFORMATION/CONDITION/LOCATION OF FUSE/CIRCUIT BREAKER PANEL

Please give any legible nameplate data and assess condition of panel. Detail hazards, unusual situations, etc. Please indicate room (or basement) in house where panel is located and indicate whether it is on an interior or exterior wall.

Item (6) - RECESSED AND SURFACE-MOUNTED CEILING LIGHTS

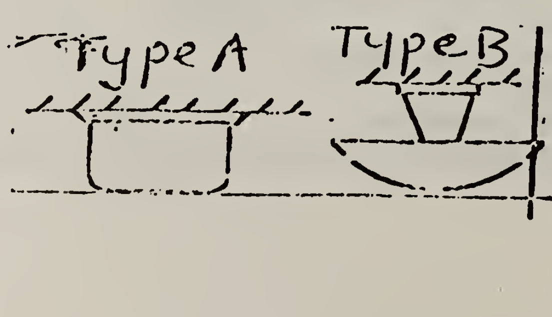
Please record data requested in Items 6-A through 6-M. Remove fixture glass, etc., so that lightbulbs and other items can be observed.

Item 6-A - Location

Indicate room such as "kit" (kitchen). If in bedroom indicate specific one, use Item 6-M if necessary.

Item 6-B - Type of Fixture

We are only interested in recessed light fixtures and surface-mounted ceiling light fixtures of the types shown below:



Where there is considerable distance between lightbulbs and the ceiling (such as with most chandeliers) do not list the fixture.

Use the following symbols:

R - Recessed light fixtures
A - Type A surface mounted ceiling fixture shown above
B - Type B surface mounted ceiling fixture shown above

Item 6-C - Number of Lights

List the number of lights which can be used in the fixture.

Item 6-D - Size of Lightbulbs

List the wattage of each bulb now in the fixture. Use Item 6-M if necessary.

Item 6-E - Type of Bulbs

Are lightbulbs incadescent (use symbol I), flourescent (use symbol F) or other (specify such as "heat" or "infrared").

Item 6-F - Scorching/Damage

Note if there is evidence of scorching or damage in fixture or ceiling or other surface above fixture. Indicate "yes" or "no". Detail any scorching or other damage in Item 6-M or on separate sheet.

Item 6-G - Condition of Wiring

Examine and assess the condition of the fixture wiring. If there is scorching or damage to the fixture wiring or to other parts of the fixture, the ceiling, etc., be sure to also examine the wiring (including the building supply wires) in the outlet box for the fixture. If the present condition of the wiring is not satisfactory or "OK", please give the details in Item 6-M or on separate sheet.

Item 6-H - Size of Enclosure

Please indicate approximate length, width and depth dimensions, respectively, of recessed and Type A surface-mounted ceiling light fixtures. If round, indicate diameter and depth (such as 9 1/2" d x 3 3/4"). For Type B indicate dimensions of glass or other bowl and its minimum distance to ceiling or other top surface.

Item 6-I - Distance of Bulbs to Top Surface

Measure minimum dimension from top of bulbs to the ceiling or top surface of the light fixture.

Item 6-J - Is Warning on Fixture?

Please indicate "yes" or "no". If "yes" please list warning in Item 6-M or on separate sheet (i.e. "Do not use bulbs greater than 60 watts", etc.).

Item 6-K - Is Thermal Insulation Above Fixture Now?

Indicate "yes" or "no". If "yes", describe amount of coverage, any scorching or damage to insulation, outlet box, supply wiring, etc., in Item 6-M or on separate sheet.

Item 6-L - Is Thermal Insulation Above Fixture Likely?

Indicate "yes" or "no" as to whether the addition of thermal insulation would cover the fixture or its outlet box unless precautions were taken. Generally, fixtures in or on the surface of top floor ceilings are subject to being covered by thermal insulation.

Item 6-M - Notes/Comments on Lighting Items Listed Above

If there is insufficient space for comments please use separate sheet of paper.

Item (7) - CONDITION OF BRANCH CIRCUIT WIRING

Please examine as much of the wiring as feasible and assess its general condition. Detail any hazards or unusual conditions. Use Item 9 or separate sheet, if necessary.

If wiring appears to approach the condition of new wiring and does not have fraying, cracking or other deterioration indicate "Good" or "G", if no excessive fraying, cracking or other deterioration and wiring appears to still be serviceable even though it looks old indicate "Satisfactory" or "S", if it is in such condition that it should be replaced indicate "unsatisfactory" or "U". If necessary indicate condition of each circuit.

Please indicate, if possible, whether grounding conductor is metallically continuous to the fuse or circuit breaker panel. Please also indicate whether receptacles have provisions to accept grounding-type attachment plugs. If some receptacles are the grounding type and some are not, please indicate locations of each type.

Item (8) - TEMPORARY/EXTENSION CORD WIRING

Please detail any unusual or extensive use of non-permanent wiring.

Item (9) - DETAILS ON OTHER ELECTRICAL HAZARDS

Please identify any other electrical hazard and their location. Some examples of such hazards are:

° Loose/broken light fixtures
° Exposed wiring
° Badly damaged/frayed wire
° Receptacles broken loose
° Outside wires not of outdoor type
° Outside wire not properly buried or supported
° Shock hazard situations
° Etc.

Two circuits of opposite polarity may share a common neutral. However, if two circuits of the same polarity share a common neutral, the current in the neutral will be the sum of the currents in the two circuits. Instances of the current in the neutral conductors being large enough to start fires have come to our attention. Three-wire (with ground) cables were used for the two circuits. If you see this situation please report it.

ELECTRICAL SYSTEM INSPECTION

Location of CAP Office:____________________ CAP Identification No. of House ____________

Inspection Performed by:____

(1) SERVICE ENTRANCE CONDUCTORS	(2) FUSE/CIRCUIT BREAKER ARRANGEMENT
Size________________________ Material - Copper ___ Alum.____ Other (specify)________________ Nom. Voltage 11/120___220/240__ Underground________Overhead____ Condition and Comments: ________________________________ ________________________________ ________________________________	Sketch (see instructions)

(3) BRANCH CIRCUIT INFORMATION (SEE INSTRUCTIONS)

	3-A	3-B	3-C	3-D	3-E	3-F	3-G	3-H
Circuit No. (In Sketch)	Type of Over-current Protection	Size of Fuse or Circuit Breaker (Amperes)	Size of Conductor (AWG)	Conductor Material	Insulation Material	Wiring Method	Grounding Conductor	Nominal Voltage
#1								
#2								
#3								
#4								
#5								
#6								
#7								
#8								
#9								
#10								
#11								
#12								

(3-I) Notes/Comments on Branch Circuit Items Listed Above

____

(4) BACK-UP/OTHER OVERCURRENT PROTECTION (see instructions): ______________________

____

(5) NAMEPLATE INFORMATION/CONDITION/LOCATION OF FUSE/CIRCUIT BREAKER PANEL: __________

____

(6) RECESSED AND SURFACE-MOUNTED CEILING LIGHTS

	6A	6B	6C	6D	6E	6F	6G	6H	6I	6J	6K	6L
Light No.	Location	Type of Fixture	No. of Lights	Size of Bulbs	Type of Bulbs	Scorching/ Damage	Condition of Wiring	Size of Enclosure	Distance of Bulbs to Top Surface	Is Warning on Fixture?	Is Thermal-Insulation Above Fixture Now?	Is Thermal-Insulation Above Fixture Likely?
#1												
#2												
#3												
#4												
#5												
#6												
#7												
#8												

(6-M) Notes/Comments on Lighting Items Listed Above: ______________________

____

____

____

(7) CONDITION OF BRANCH CIRCUIT WIRING: ______________________

____

____

____

(8) TEMPORARY/EXTENSION CORD WIRING: ______________________

____

____

____

(9) DETAILS ON OTHER ELECTRICAL HAZARDS: ______________________

____

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____

SUPPLEMENTARY NOTES/COMMENTS ON ELECTRICAL SYSTEM INSPECTION

(Please identify items on "Electrical System Inspection" for which comments apply)

Item No.	

A P P E N D I X I I I

Illustrative Comments Received
on Technical Inspection Returns

INFORMATION FROM THE "ELECTRICAL SYSTEM INSPECTION" PERFORMED ON CSA HOUSES: TEMPORARY/EXTENSION CORD WIRING

Site	House #	Age (Years)	Notes/Comments
Oakland	5	50	1. Zipcord wiring to second floor smoke detector. 2. Zipcord wiring to first floor smoke detector. 3 Zipcord wiring to light in back room of second floor.
	6	80	1. Extensive use of extension cords (upstairs); many rooms have one or no receptacles.
	9	65	1. No answer.
	19	70	1. Extensive use of cords in kitchen (only 1 receptacle). 2. Bedrooms have no receptacles - depend on cords plugged into light fixture.
	26	50+	1. Extensive use of extension cords in living room, bedroom and kitchen.
	28	50+	1. Kitchen extension cord feeding refrigerator. 2. Extensive use of cords in bedrooms - only one receptacle per room.
	31	60+	1. No answer.
	33	60+	1. Kitchen has extension cord feeding refrigerator.
	34	40+	1. Illegal Zipcord wiring in front bedroom feeding receptacles.
	35	40+	1. Living room extension cord to TV (need another receptacle).
	36	80+	1. None.
	38	60+	1. Extension cords used extensively in bedrooms - only 1 or 2 receptacles per bedroom.

INFORMATION FROM THE "ELECTRICAL SYSTEM INSPECTION" PERFORMED ON CSA HOUSES:
DETAILS ON OTHER ELECTRICAL HAZARDS

Site	House #	Age (Years)	Notes/Comments
Portland	2	55	1. Washer should be put on separate circuit. 2. Furnace circuit should be separate. 3. Kitchen - refrigerator - needs separate outlet. 4. Dining room floor outlet 5. Living room - 2 floor outlets 6. Bath - outlet does not work. 7. Attic - exposed contacts on light.
	4	100	1. Bedroom - electric blanket, TV, clock radio, lamp, iron, etc. off one duplex and extension cords - need two new duplex. 2. New GFI outlet needed in bathroom. 3. Need globe or vapor barrier in fixture over bath. 4. New outlets in kids room. 5. Poor wiring - shed and ? - replace w. new circuits.
	7	75	1. Overcrowded box over washer - get another circuit together. 2. Take out socket on post w. chimney. 3. Undersized box on ceiling in back of furnace. 4. Questionable knob and tube near stairway. 5. Refrigerator in kitchen should be on its own circuit - priority - ungrounded and overloaded. 6. Attic - no positive protection for recessed fixture.

INFORMATION FROM THE "ELECTRICAL SYSTEM INSPECTION" PERFORMED ON CSA HOUSES:
SERVICE ENTRANCE CONDUCTORS

Site	House #	Age (Years)	Notes/Comments
Portland	2	55	Good shape.
	4	100	Good condition;well connected.
	7	75	No comment.
	9	150	Excellent.
	10	75	No comment.
	11	50	Good shape, good ground connections. Main breaker poor - no overload protection beyond a switch. No nameplate or rating on switch.
	12	70	Overload.
	15	75	Fairly new.
	16	23	Good shape; crowded inside w #6????
	17	55	Terrible - replace service.
	18	80	Box too small.
	20	40	Unfused main; box good for 100A cable service.
	21	30	Fuse/Circuit breaker panel - too small.
	23	80	Four fuses and subpanel; good shape.
	25	100	Brand new.
	26	100	No comment.
	28	75	Overloaded by nine circuits.

INFORMATION FROM THE "ELECTRICAL SYSTEM INSPECTION" PERFORMED ON CSA HOUSES: BRANCH CIRCUITS

Site	House #	Age (Years)	Circuit #	Overcurrent Protection Type*	Overcurrent Protection Size (Amps)	Conductor Size**	Conductor Material	Insulation Material	Notes/Comments
Easton	22	60	4	FS	15	14	C	T	
			5	FS	15	2-14	C	T	
			6	FS	15	14	C	T	
			7	cart	30	6	C	T	120/240 volt
	23	75	1	cart	?	bus	C	none	120/240 volt
			2	cart	?	bus	C	none	120/240 volt
			3	FE	15	14	C	T	1) Circuit #3 has 2 branch circuits
			4	FE	15	14	C	T	connected to single overcurrent
			5	FE	20	14	C	T	device by tap
			6	FE	15	14	C	T	
	25	100	1	cart	30	bus	C	-	120/240 volt
			2	cart	30	bus	C	-	120/240 volt
			3	FE(TD)	20	14	C	T	1) Circuits 3, 4 and 5 overfused.
			4	FE	20	14	C	T	2) Circuit 5 has two #14 branch circuits
			5	FE	20	2-14	C	T	connected on load side.
			6	FE	20	12	C	T	
	27	43	1	cart	?	bus	C	none	124/240 volt
			2	cart	30	10	C	none	120/240 volt
			3	FS	15	14	C	T	1) Circuit #4 has two branch circuits
			4	FS	15	2-14	C	T	connected to one overcurrent device by direct connection

* CB=CIRCUIT BREAKER; F=FUSE; FE=FUSE, EDISON BASE; FS=FUSE, TYPE S; FO=FUSE, OTHER; O=OTHER; T=THERMOPLASTIC; R=RUBBER; CART=CARTRIDGE; C=COPPER

** AWG

INFORMATION FROM THE "ELECTRICAL SYSTEM INSPECTION" PERFORMED ON CSA HOUSES: BRANCH CIRCUITS

Site	House #	Age (Years)	Circuit #	Overcurrent Protection Type*	Overcurrent Protection Size (Amps)	Conductor Size**	Conductor Material	Insulation Material	Notes/Comments
Hughesville	02	29	1	F	20	12	C	R	1) Too many wires under/fuse.
			2	F	20	12	C	R	2) Not enough circuits in panel.
			3	F	20	14	C	R	
			4	F	20	14	C	R	
			5	F	12&35	12	C	R	220V line
	05	55	1	F	20	14	C	R	1) Needs to be fused correctly.
			2	F	20	14	C	R	2) Too many wires under/fuse.
			3	F	20	14	C	R	
			4	F	20	12	C	R	
			5	F	20&35	12	C	R	220V line
	07	45	1	FS	15	14	C	T	1) Two circuits are overfused.
			2	FS	20	12	C	T	
			3	FS	20	14	C	T	
			4	FS	20	10	C	T	
			5	FS	15	14	C	T	
			6	FE	30	10	C	T	
			7	FE	30	10	C	T	
			8	FS	20	14	C	T	
			9	FS	20	10	C	T	
			10	FS	20	12	C	T	

* CB=CIRCUIT BREAKER; F=FUSE; FE=FUSE, EDISON BASE; FS=FUSE, TYPE S; FO=FUSE, OTHER; O=OTHER;
T=THERMOPLASTIC; R=RUBBER; CART=CARTRIDGE; C=COPPER

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15. SUPPLEMENTARY NOTES

[ ] Document describes a computer program; SF-185, FIPS Software Summary, is attached.

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

Results of a study to determine the present condition of the electrical wiring system in existing houses at ten sites across the country are presented in this report. The aim of the investigation was to develop information to assess the potential safety impact that the addition of thermal insulation to residential structures could have on their electrical systems. A previous study indicated the nature of some of the technical problems found in selected homes as identified by the residents and by inspectors having no formal training in electrical inspections. The present study is based on the evaluation of electrical problems in 157 houses by technically qualified persons. It appears that a rather large percentage of the homes studied had one or more electrical problems related to overamping of circuits, service entrance conductors, fuse/circuit breaker panels, branch circuit wiring, extension cord wiring or lighting.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Branch circuit wiring problems; fuse/circuit breaker panel problems; electrical problems; electrical wiring system; extension cord wiring; overamping; residential structures; safety; thermal insulation

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