THE
FIRE PROTECTION
RESEARCH FOUNDATION

Residential Electrical System Aging Research Project

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Aging Residential Electrical Systems

Research Project Sponsors

- Fire Protection Research Foundation
- UL, CSA
- Consumer Product Safety Commission
- Insurance companies
- Wire and electrical device manufacturers

Aging Residential Electrical Systems

Project Plan – Part 1

Gather detailed information at fire scenes regarding electrical components that were at the fire's point of origin

Part 1 Project Activities

- How does aging of electrical systems relate to fire incidence

- Review insurance company written case studies and the physical evidence

Aging Residential Electrical Systems

Project Plan – Part 2

Independent analysis of the condition of samples of various age groups (e.g. – 1930’s, 1940’s, etc.) of residential electrical system components

Aging Residential Electrical Systems

Part 2 Project Activities

- Identify older homes ready for demolition
- Recover electrical components (wiring, receptacles, luminaires, etc.)
- Send to UL for laboratory analysis

Local “Champions”

Local "Champions"

Andy Cartal - Pennsylvania
Tim Owens - California
Dave Hill - Oregon
Bob McCullough - New Jersey
Bob Meier - Wisconsin
Donny Cook - Alabama
Lanny McMahill - Phoenix
Nelson Mongomery - Florida

Identification of Older Homes Ready for Demolition

Volunteers Assisting in the Recovery

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Residential Electrical System Aging Research Project

These instructions and data sheets are intended for use in conjunction with the FPRF's ***Residential Electrical System Aging Research Project***. The goal of this project is to improve residential electrical fire safety by more thoroughly understanding the effects that aging may have on the safety of electrical system components. One aspect of this project is to characterize the condition of various age groups of residential electrical components by surveying, recovering, and analyzing representative samples of actual installed wiring systems, wiring devices, and similar distribution and utilization equipment.

The following are procedures for selecting and surveying the residential building that will be used for the purposes of recovering and analyzing selected electrical components.

Data Collection and Recovery Process

Describe and Photograph Problems

- poor or unqualified workmanship
- damage to devices
- lack of Code compliance
- overlamping
- permanent use of extension cords

Room (or Area):________________

Dimensions of room: ___________________

Number of outlet receptacles:________ Number of wall switches: __________

Describe number and type of luminaires:

____

____

____

____

Describe and photograph any problems in this room or area relating to poor or unqualified workmanship, damage to devices, lack of Code compliance, and/or other hazards such as overlamping, permanent use of extension cords, etc.:

____

____

____

____

____

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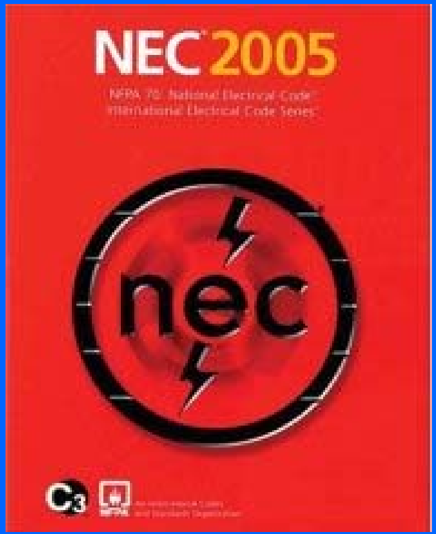
Data Collection and Recovery Process

Poor or Unqualified Workmanship

110.12 Mechanical Execution of Work

"Electrical equipment shall be installed in a neat and workmanlike manner."



Poor or Unqualified Workmanship

Poor or Unqualified Workmanship

Duct Tape has Many Uses

Poor or Unqualified Workmanship

Don’t throw away your popsicle sticks

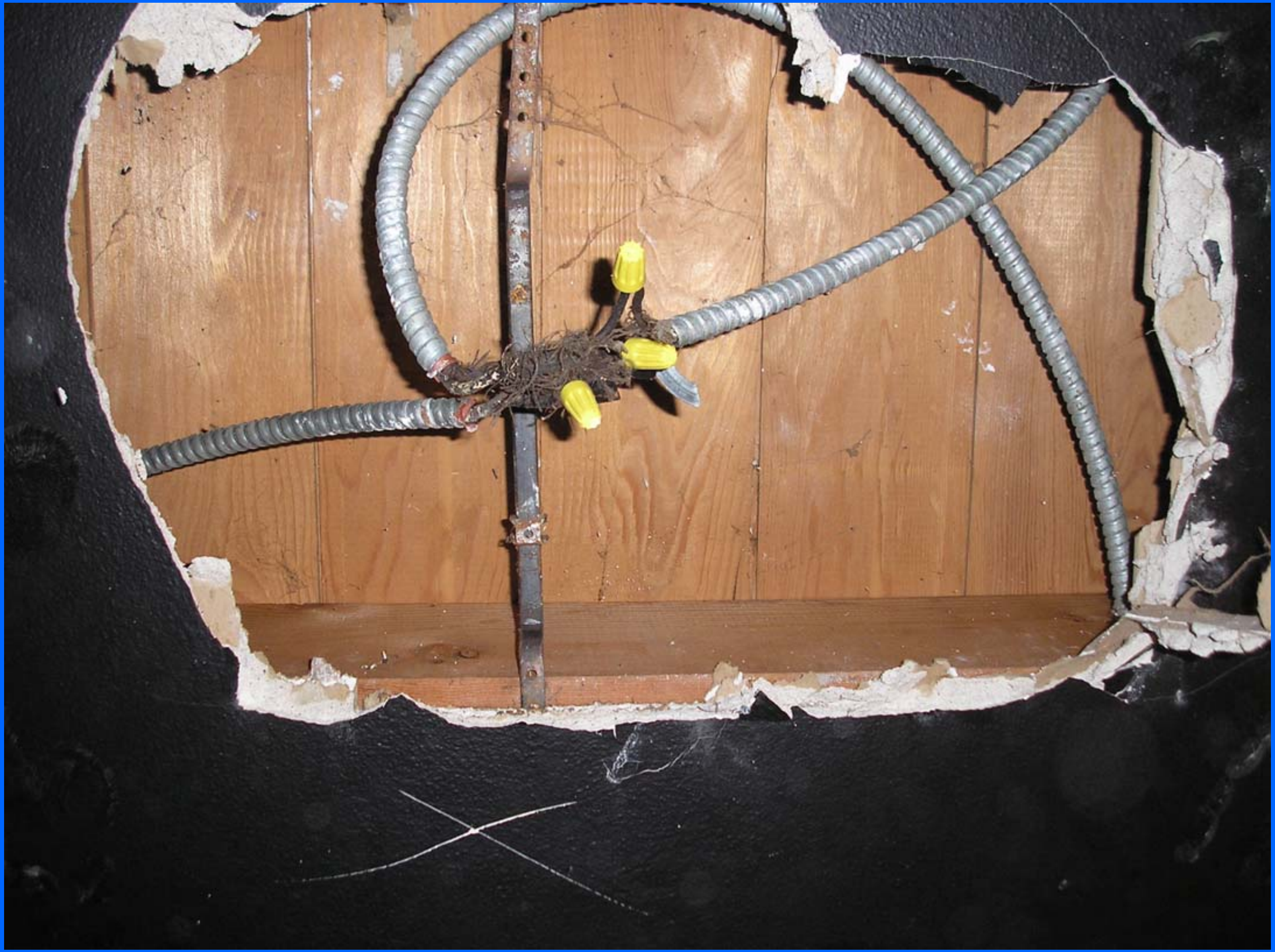
Poor or Unqualified Workmanship

Grounding Electrode Conductor Connection

Poor or Unqualified Workmanship

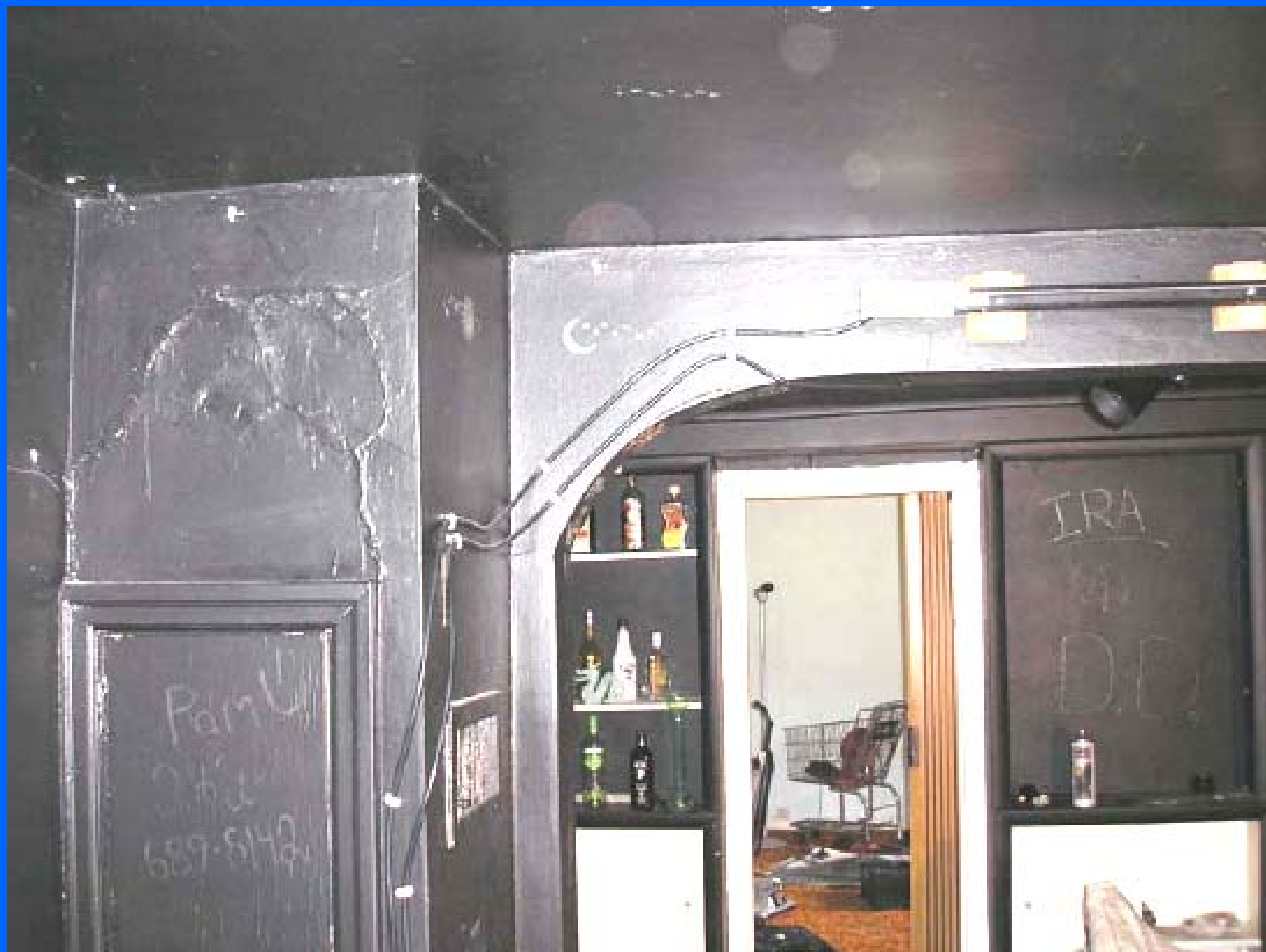
Dining room fixture location

Poor or Unqualified Workmanship



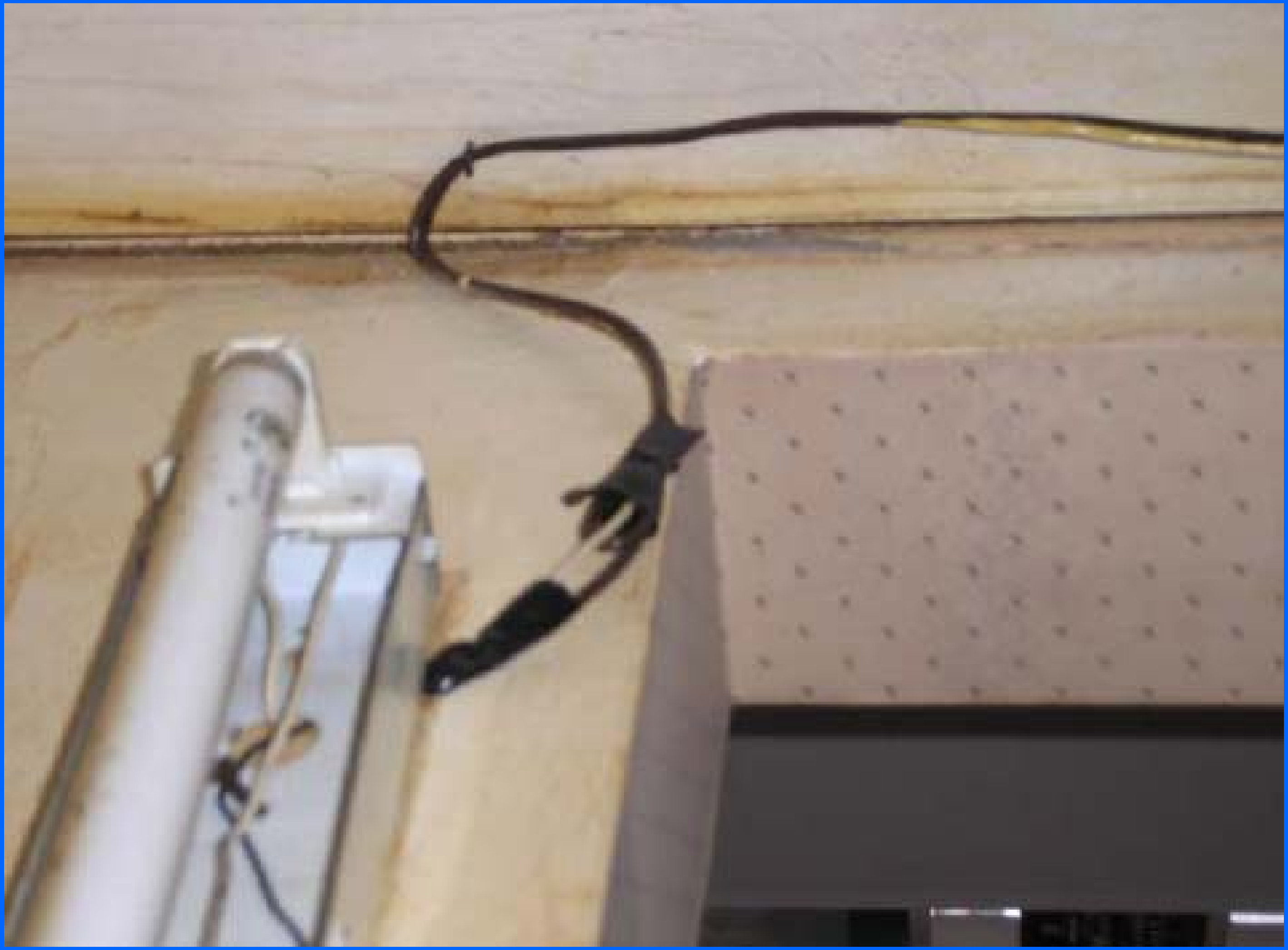
Nice splice

Poor or Unqualified Workmanship



Track Lighting Conductors Stapled to Wall

Poor or Unqualified Workmanship



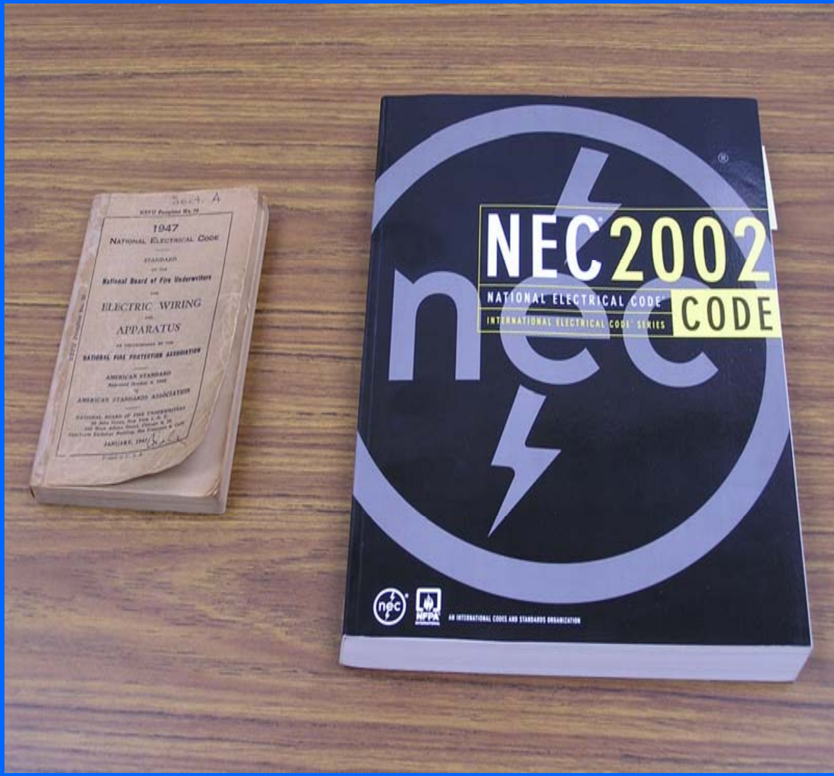
Fluorescent Light Wiring Splice

Data Collection and Recovery Process

Lack of Code Compliance

90.1 Purpose

(A) Practical Safeguarding The purpose of this Code is the practical safeguarding of persons and property from hazards arising from the use of electricity.



Code Compliance Issues

Few Receptacle Outlets Provided

Code Compliance Issues

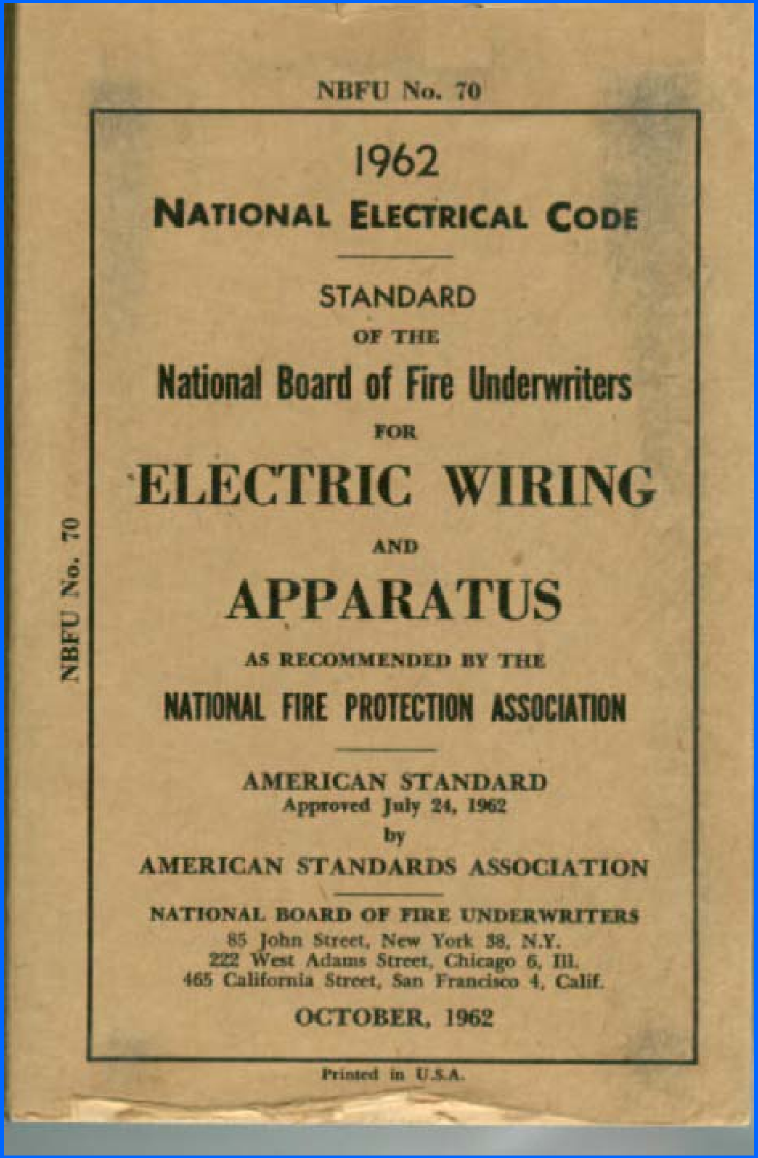
Circuit Extension

Code Compliance Issues

No Grounding Type Receptacles

Code Compliance Issues

All branch circuits were required to be grounded in the 1962 NEC.



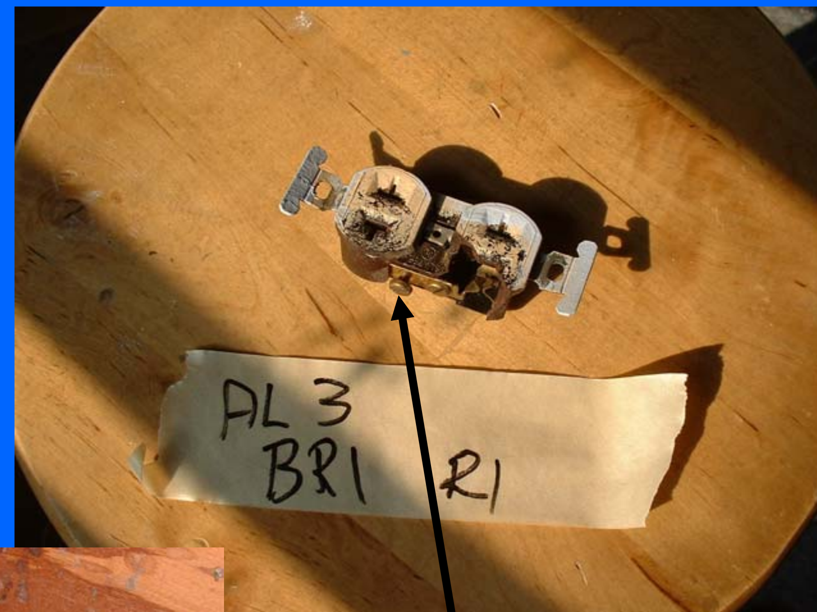
Code Compliance Issues

Receptacle over bathtub.

406.8 Receptacles in Damp or Wet Locations

C) Bathtub and Shower Space Receptacles shall not be installed within or directly over a bathtub or shower stall.

Damaged Equipment



1971 - Double T receptacles no longer permitted

Data Collection and Recovery Process

Recovery of Selected Devices

- service drop and entrance cable
- fuses and circuit breakers
- wire and cable systems
- outlet receptacles
- luminaires
- junction boxes and wire splices

Recovering Service Drop

Recovering Service Panel

Recovering Interior Wiring

Fuses and Circuit Breakers

Wire and Cable Systems

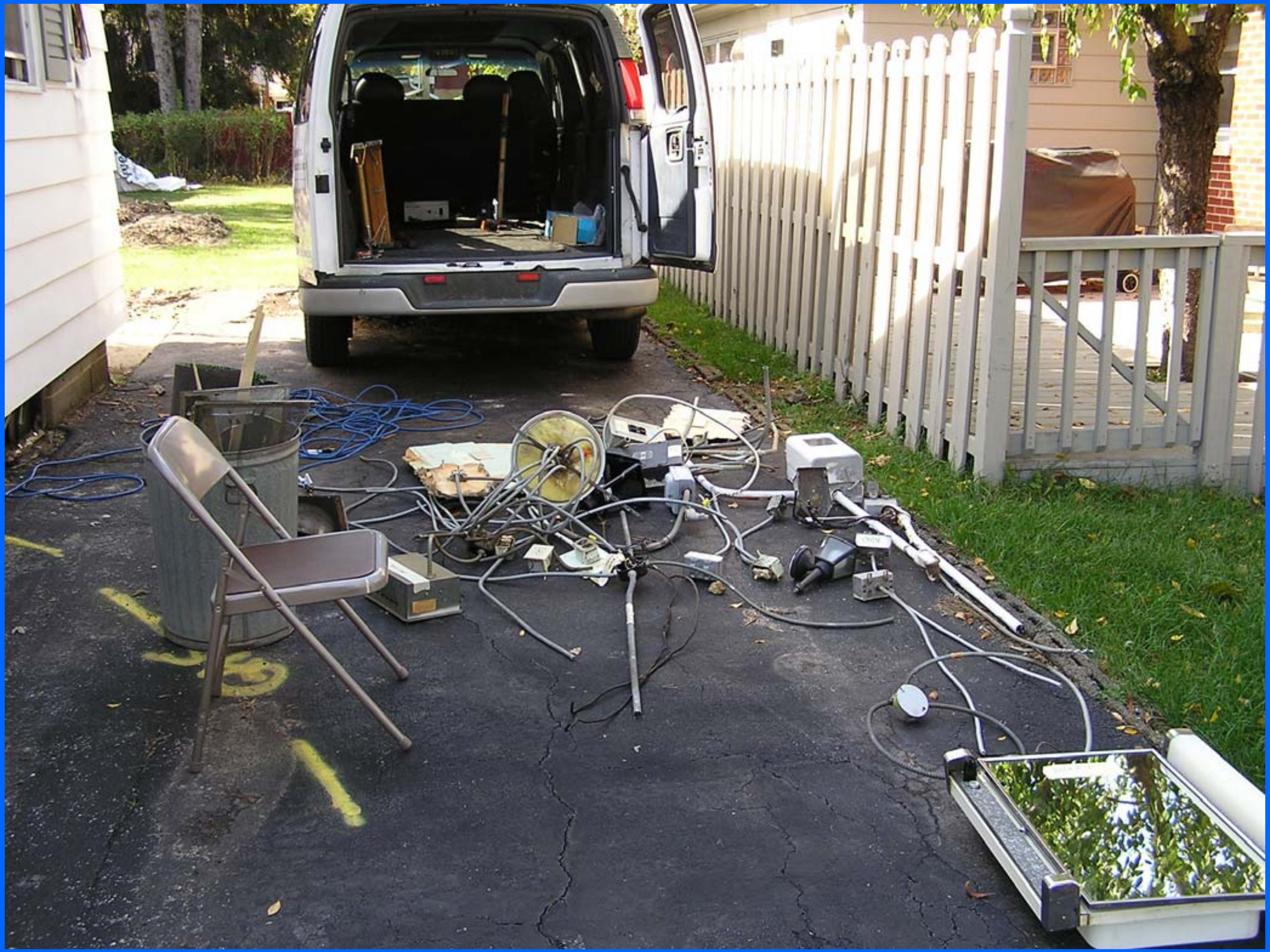
Knob & Tube

Outlet Receptacles

Luminaires

Junction boxes and splices

Recovered items sent to laboratory

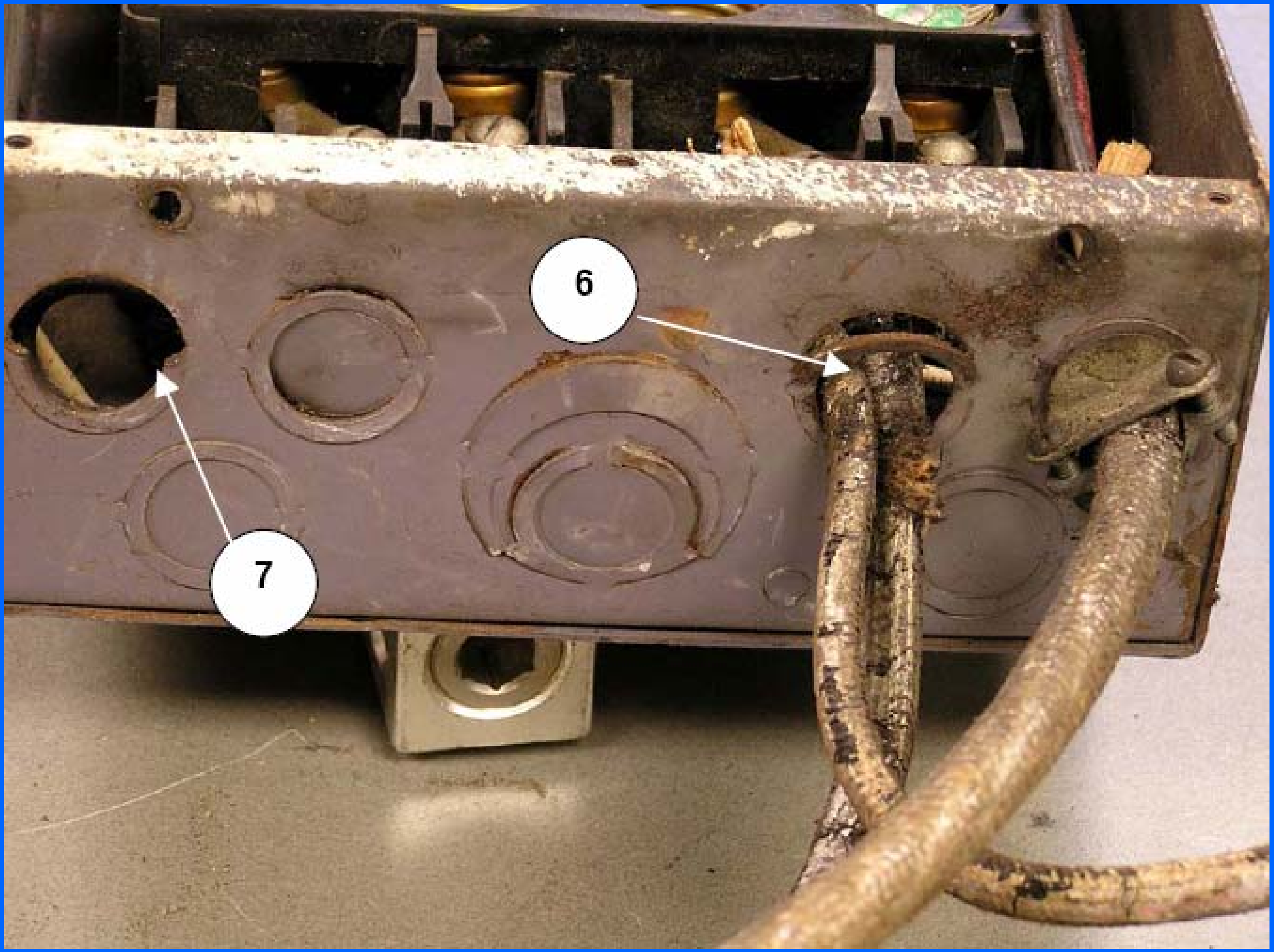


Laboratory Analysis

Recovered Devices Sent to UL Labs

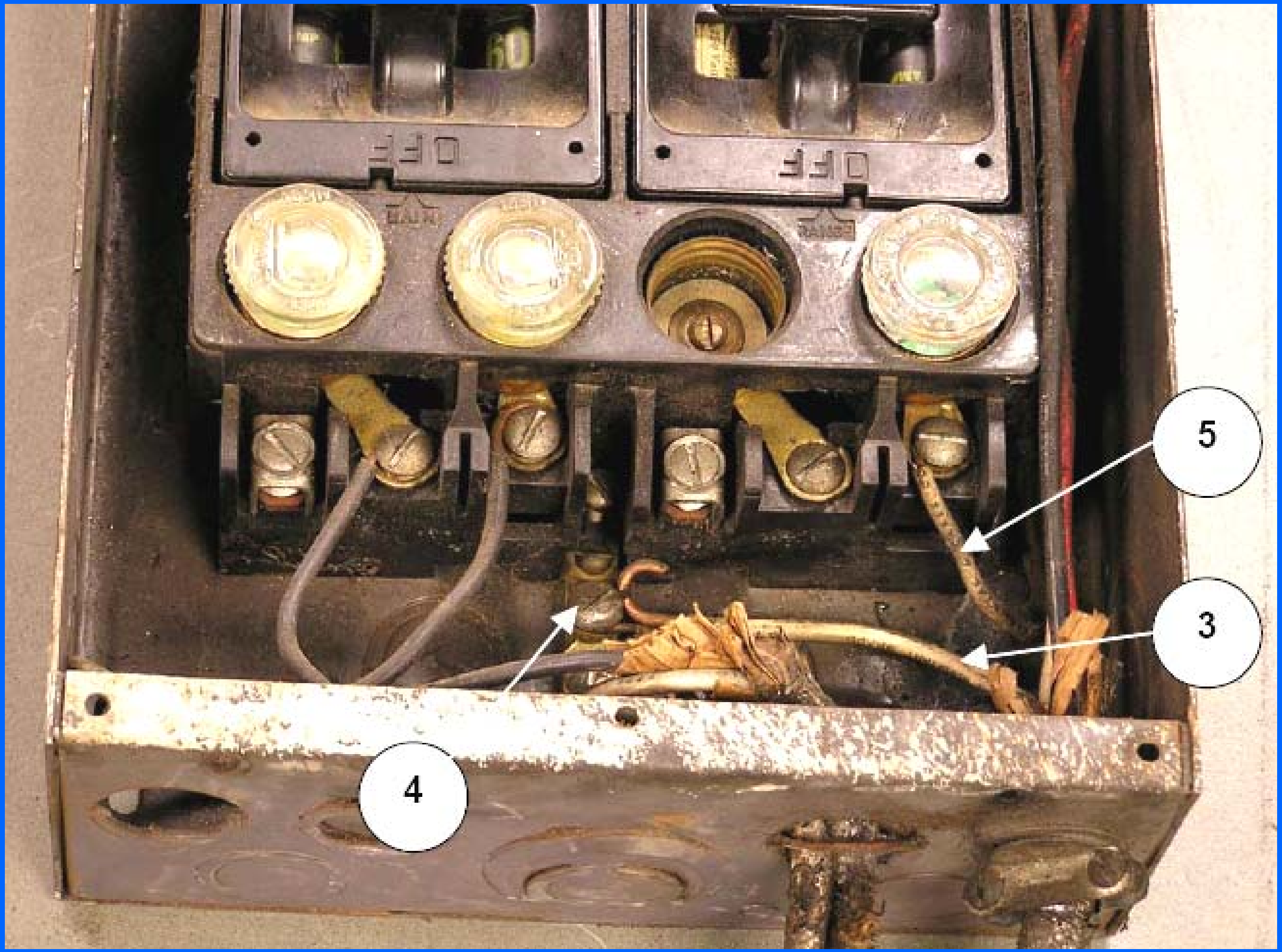
- **visual inspection for damage**
- **temperature and dielectric testing of devices**
- **test of wire and cable insulation**
- **calibration of fuses and circuit beakers**

Laboratory Analysis and Inspection



Missing Cable Clamp and Unused Opening

Laboratory Analysis and Inspection

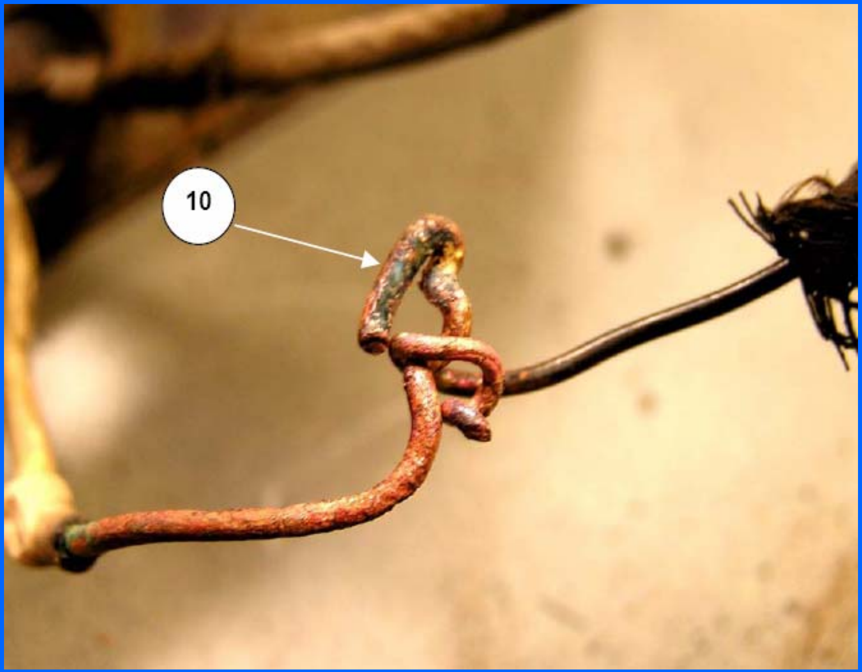


White Insulation Used for Ungrounded Conductor

Laboratory Analysis and Inspection

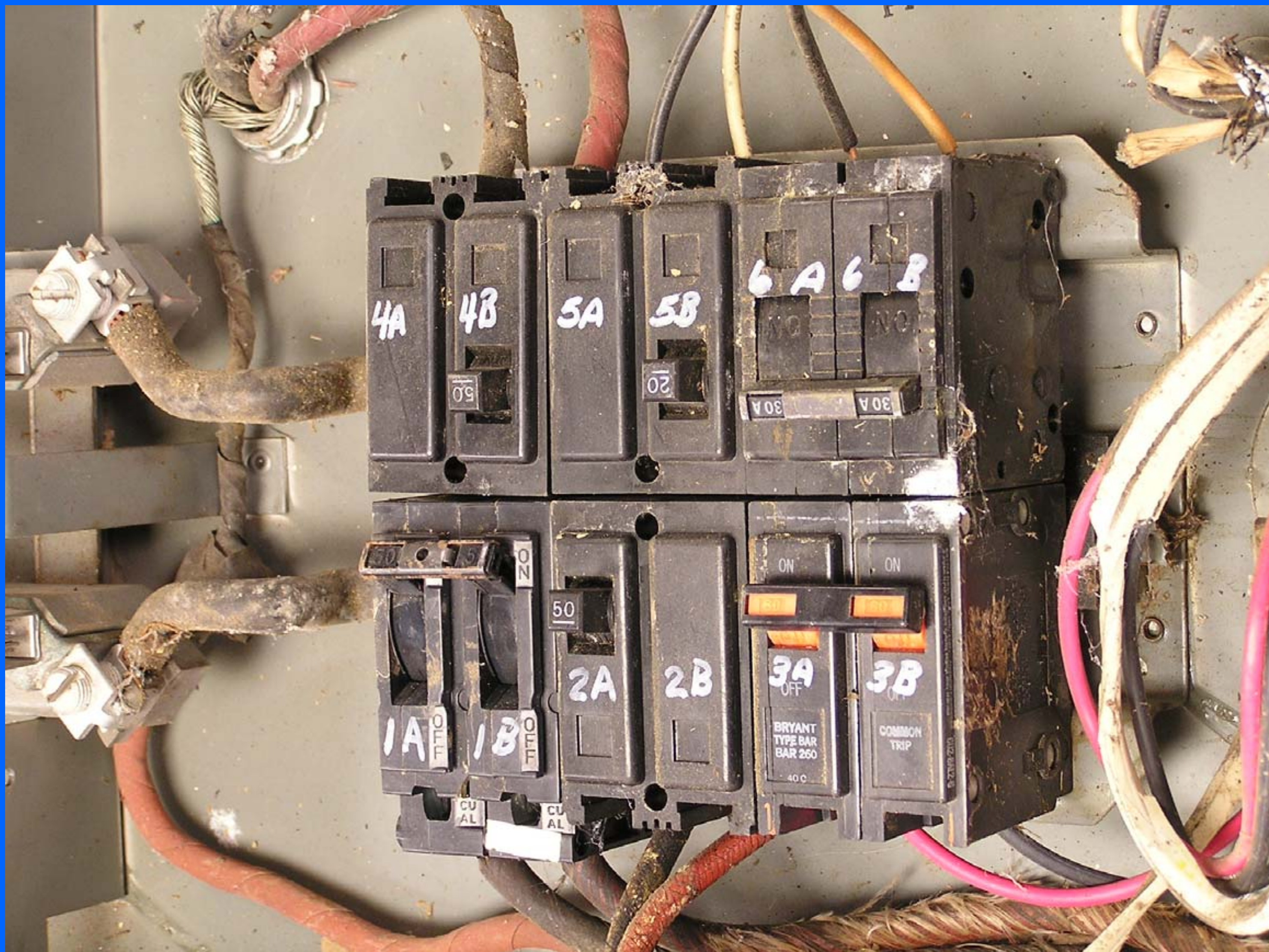
Evidence of Arcing

Laboratory Analysis and Inspection



Improper Splice Glowing Red-Hot

Calibrating Circuit Breakers



Circuit Breaker and Fuse Calibration

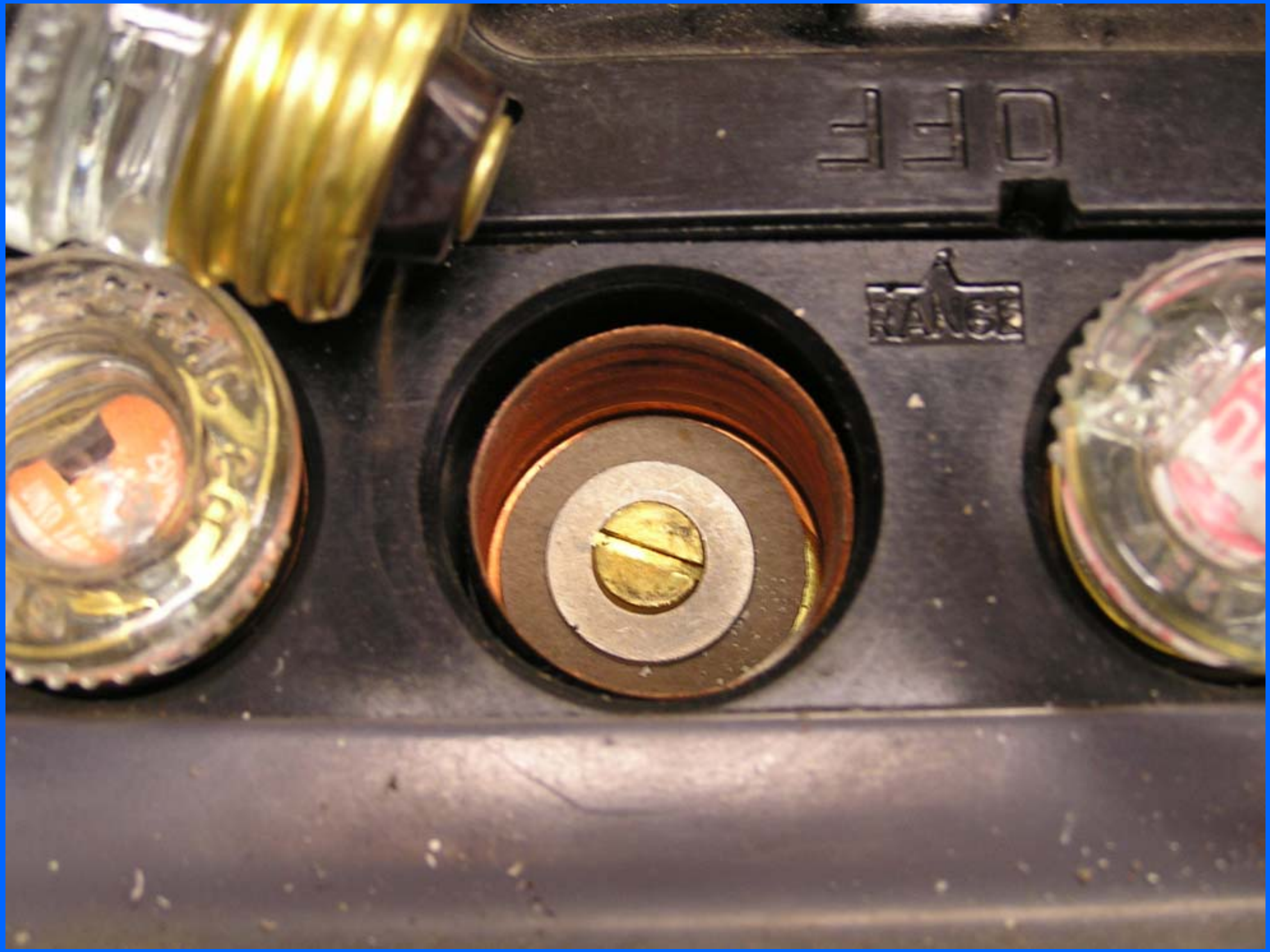
circuit breakers

Rating (Amps)	300% Calibration Test Amps	300% Calibration Allowable Min:Sec
15	45	0:50
20	60	0:50
30	90	0:50
40	120	1:20
50	150	1:20
60	180	2:20
70	210	2:20
100	300	2:20
125	375	3:20
150	450	3:20
200	600	3:50
225	675	3:50

fuses

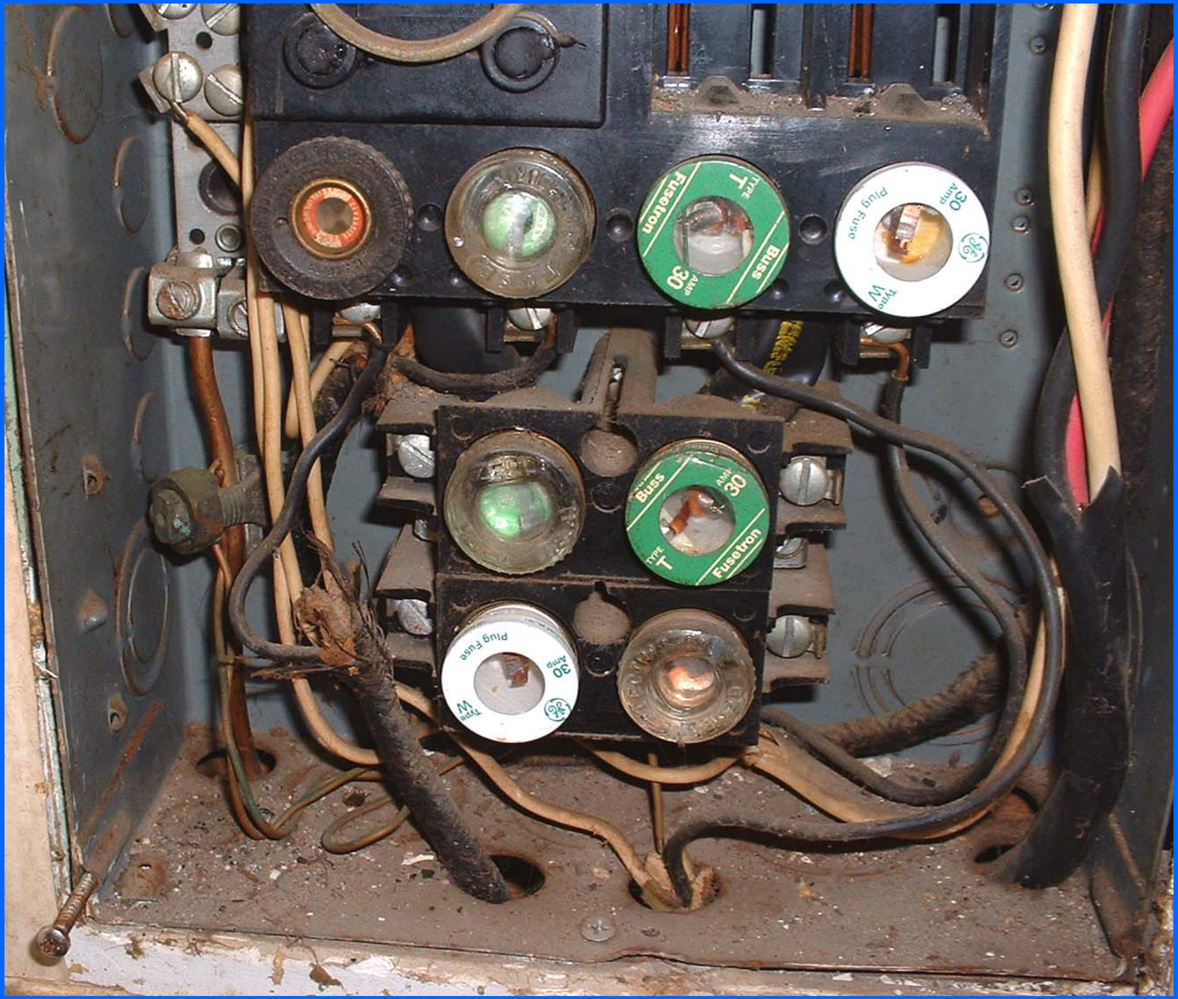
Rating (Amps)	200% Calibration Test Amps	200% Calibration Allowable Minutes
15	30	4
20	40	4
30	60	4
40	80	6
50	100	6
60	120	6
70	140	8
100	200	8

Fuse Inspection



Looking for pennies

Fuse Inspection



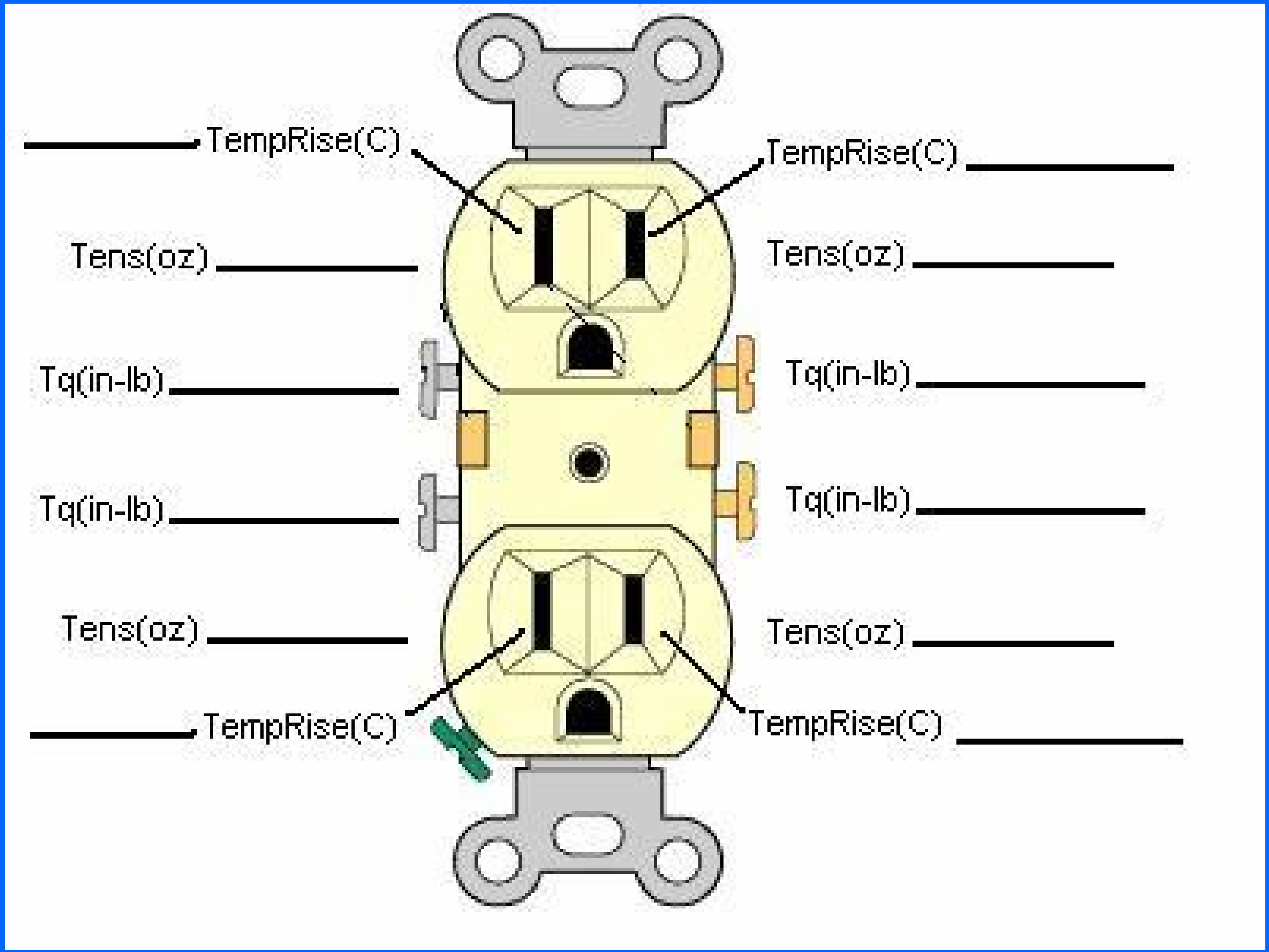
30 Amp Fuses?

Fuse Inspection

Corrosion?

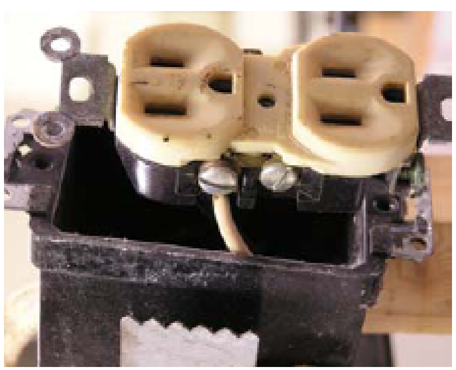
Testing a Recovered Receptacle

Testing a Recovered Receptacle

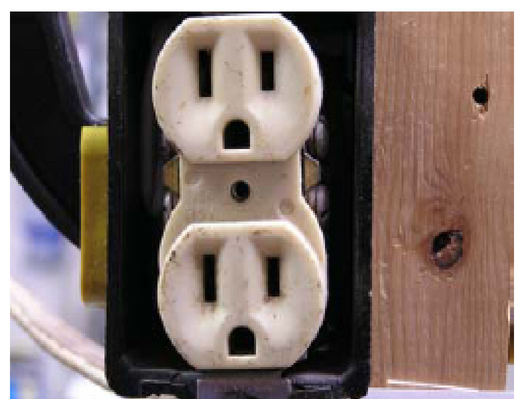


Testing a Recovered Receptacle

ID		Amp Rating	Polarized	Grounding	Wire Size (Awg)	Min Torque (in-lb)	Min retention (oz)	Max Temp Rise (C) - As Received	Max Temp Rise (C) - After Clean Blade Insertions	Max Temp Rise (C) - After Tightened Terminals
BATH-R1		15	yes	yes	12	5	+24	41	32	38
BATH-R2		15	yes	yes	12	4	<4	108	115	110
KIT-R1		15	yes	yes	12	4	16	14		
KIT-R3		15	yes	yes	14	10	24	41	40	47
OUT-R1		15	yes	yes	12	2	4	91	43	52
UNK-R1		15	yes	yes	12	1	+24	51	41	33



BATH-R1

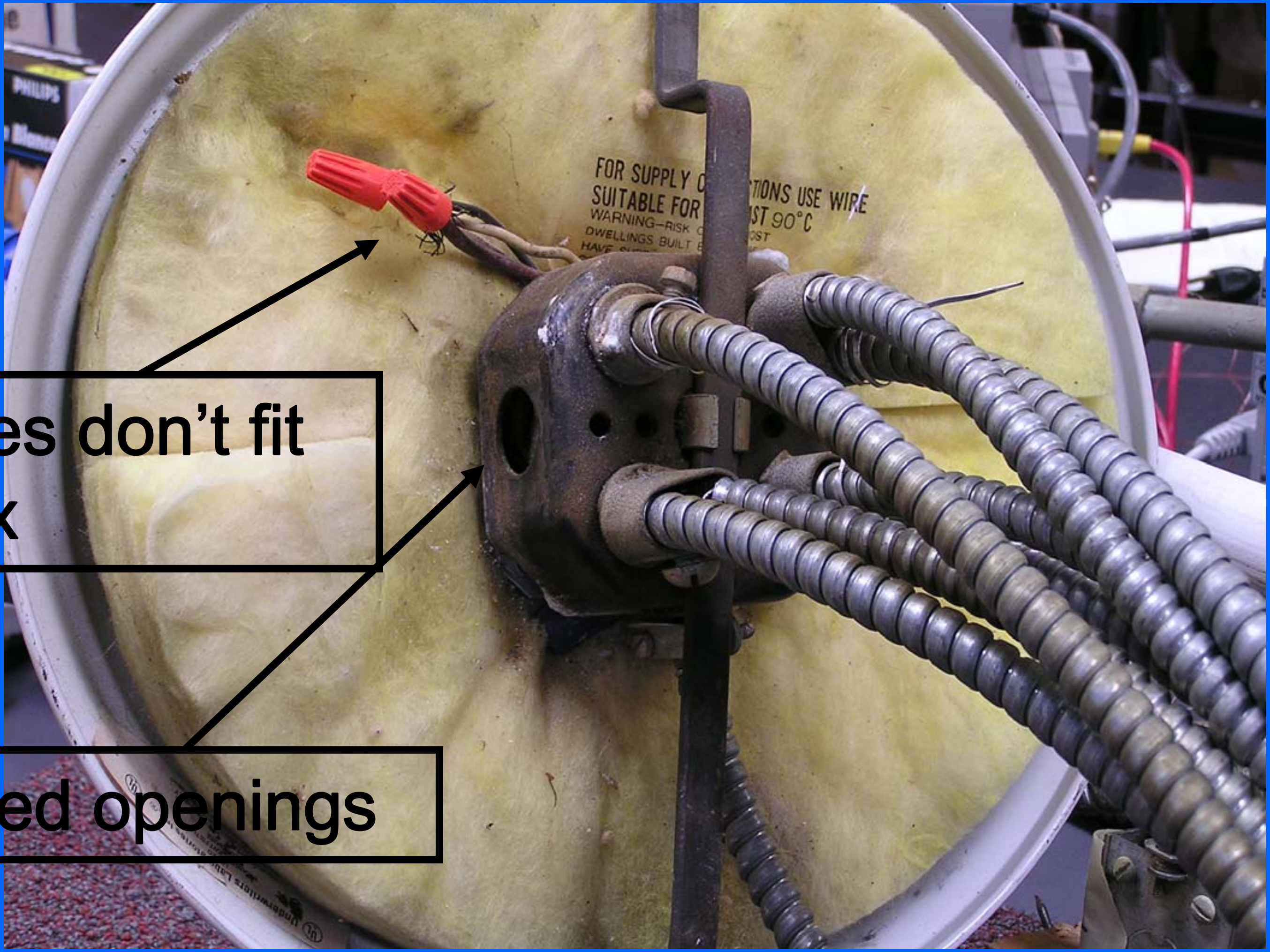


UNK-R1

Luminaires

100 W - Overlamping?

Luminaires



Splices don't fit in box

Unused openings

What about fill?

Luminaires

90 C Supply Wire?

Fluorescent Luminaires

Conductor Damage

Wire and Cable Dielectric Testing

5000 Volts Withstand L-L & L-G for 1 Minute
Maximum Voltage to Breakdown L-L & L-G

Resistance of Cable Armor

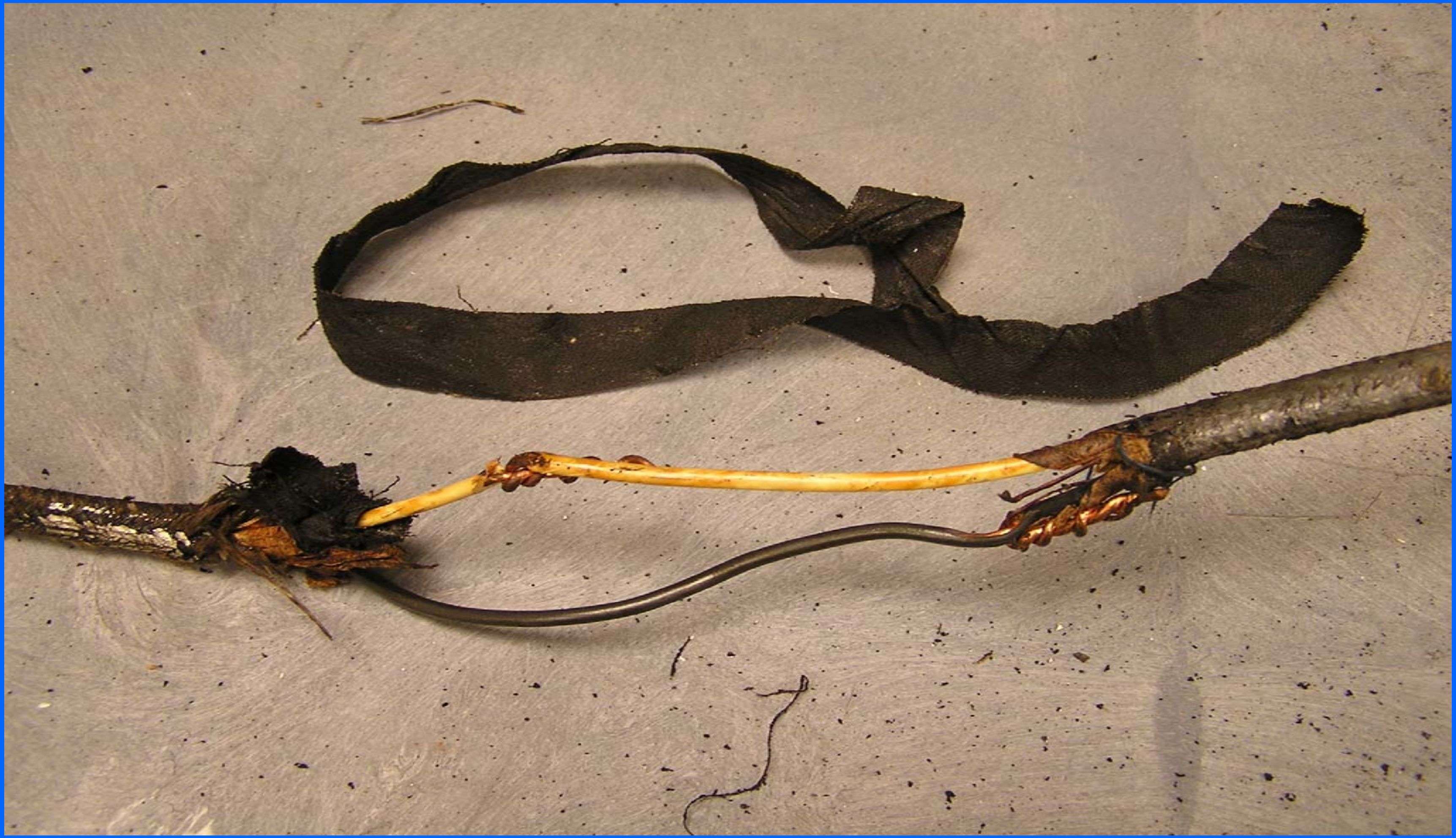
Sample	Awg	Bonding Strip	Measured Ohms/100 ft	Max Permitted Ohms/100 ft
1	14	yes	0.790	0.75
2	14	no	2.068	1.50

Analyzing Wire Splices

110.14 Electrical Connections

(B) Splices. Conductors shall be spliced or joined with splicing devices identified for the use or by brazing, welding, or soldering with a fusible metal or alloy. Soldered splices shall first be spliced or joined so as to be mechanically and electrically secure without solder and then be soldered. All splices and joints and the free ends of conductors shall be covered with an insulation equivalent to that of the conductors or with an insulating device identified for the purpose.

Analyzing Wire Splices



No Solder, Friction Tape?

Reporting the Findings

Residential Electrical System Aging Research Project

Project House AL-1

The following report describes Project House AL-1, an older residential occupancy that was secured for use as part of the Fire Protection Research Foundation's (FPRF) *Residential Electrical System Aging Research Project*. Access to the building was obtained and permission granted for removal of selected electrical system devices and wiring system components. The recovered items were then sent to the UL laboratories for further testing and analysis. This field recovery project was conducted in August of 2004.

Initial Description and Survey of Project House AL-1

Project House AL-1 was located at 4844 S. Shades Crest Rd., Helens, AL. The house was built in 1960. It was a single-family ranch style wood house, with a an accessible crawl space and a non-accessible attic. The house had three bedrooms, one bathroom, kitchen, living room, and laundry area with approximately 1100 square feet of living space. The electrical service consisted of a 100 Amp main fusible pull-out switch located in the bathroom, provided with 60 Amp main fuses. It had eight branch circuits protected by Edison base plug fuses, and a range circuit, however the range pull-out and fuses were missing. NM cable was the predominant wiring method for the house.

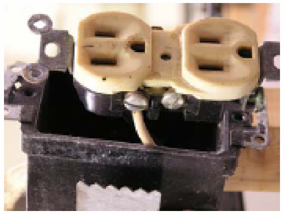
4844 S. Shades Crest Rd., Helens, AL

Electrical Survey of the Building

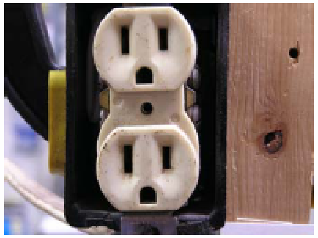
Although the power to the house had been disconnected, power was temporarily restored by the local utility in order to make some electrical measurements. The house had a mixture of grounding and non-grounding type receptacles. Some grounding type receptacles were found that did not have an equipment ground

installed in the outlet, a temperature test was conducted for 10 minutes at 15 amps. The test was also repeated on the other outlet position. The temperature rise at each blade was measured. The maximum temperature rise is indicated in the table. If a temperature rise exceeded 20C, the test was repeated after inserting and withdrawing a clean blade 10 times. If a temperature rise still exceeded 20C, the test was repeated with the wiring terminals tightened to 9 in-lb.

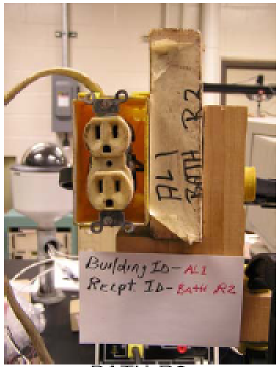
ID	Manufacturer	Amp Rating	Polarized	Grounding	Wire Size (Awg)	Min Torque (in-lb)	Min retention (oz)	Max Temp Rise (C) - As Received	Max Temp Rise (C) - After Clean Blade Insertions	Max Temp Rise (C) - After Tightened Terminals
BATH-R1	Leviton	15	yes	yes	12	5	+24	41	32	38
BATH-R2	Eagle	15	yes	yes	12	4	<4	108	115	110
KIT-R1	GE	15	yes	yes	12	4	16	14		
KIT-R3	unknown	15	yes	yes	14	10	24	41	40	47
OUT-R1	Leviton	15	yes	yes	12	2	4	91	43	52
UNK-R1	Leviton	15	yes	yes	12	1	+24	51	41	33



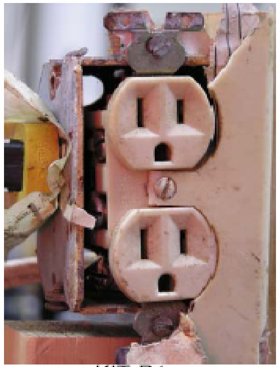
BATH-R1



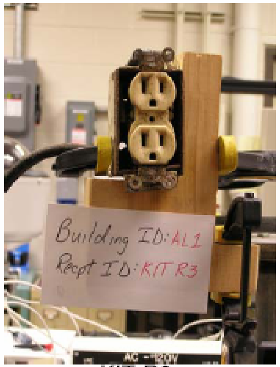
UNK-R1



BATH-R2



KIT-R1



KIT-R3

Project Goal

100 houses
(12 from each Champion's area)

20's and older

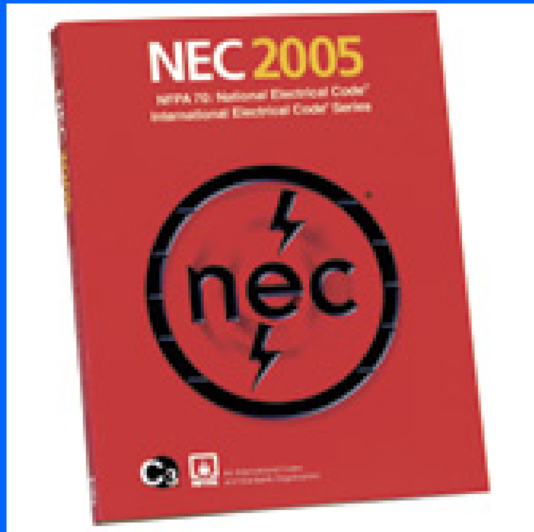
30's

40's

50's

60's

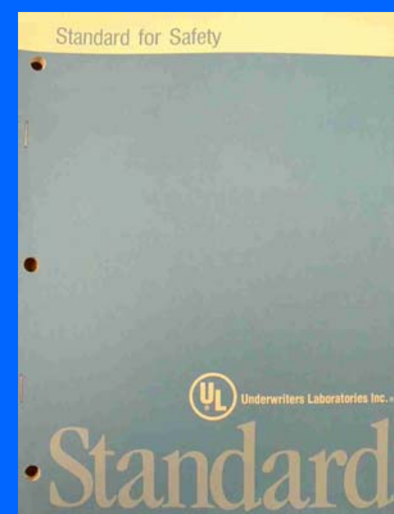
70's and newer



NEC

NFPA 73

Safety Brochures



Product Standards

What Have We Found So Far –
and
What Might be Recommended

(Top 5 List)

Aging Residential Electrical Systems

1. Install GFCIs as required per Code

Aging Residential Electrical Systems

1. Install GFCIs as required per Code

- Bathrooms
- Kitchens
- Outdoors / Garage
- Unfinished Basements / Crawl Spaces
- Laundry and Utility Sinks

Aging Residential Electrical Systems

2. Replace Old Receptacles

- Especially before ~ 1965
- Especially if damaged or broken
- Especially of low retention force
- If no Ground – Install GFCI

ID	Manufa[illegible]r	Amp Rating	Polarized	Grounding	Wire Size (Awg)	Min Torque (in-lb)	Min retention (oz)	Max Temp Rise (C) - As Received	Max Temp Rise (C) - After Clean Blade Insertions	Max Temp Rise (C) - After Tightened Terminals
BATH-R1	[illegible]	15	yes	yes	12	5	+24	41	32	38
BATH-R2		15	yes	yes	12	4	<4	108	115	110
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OUT-R1		15	yes	yes	12	2	4	91	43	52
UNK-R1		15	yes	yes	12	1	+24	51	41	33

Aging Residential Electrical Systems

3. Install Plug Fuse Adaptors / Proper Size Fuses

Aging Residential Electrical Systems

4. Use Proper Wiring / Surface Raceway to Add Outlets & Receptacles

- Especially before 1960

Aging Residential Electrical Systems

5. Armored Cable (BX) Before ~1960

- Probably does not have have bonding wire

Sample	Awg	Bonding Strip	Measured Ohms/100 ft	Max Permitted Ohms/100 ft
1	14	yes	0.790	0.75
2	14	no	2.068	1.50

Aging Residential Electrical Systems

5. Armored Cable (BX) Before ~1960

- Probably does not have have bonding wire
- Consider protecting entire circuit with AFCI or GFCI (GFP)

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Thank you!

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