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GFCI-Protected Flexible Cord Fire Attack Study

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GAI ENGINEERS

GAI Engineers is a forensic engineering firm specializing in origin and cause investigation, failure analysis, accident reconstruction, damage assessments, and other technical support for insurance companies, law firms, fire investigators, manufacturers and private parties throughout New England. Since our founding in 1934, GAI has investigated and resolved thousands of cases involving property loss, premise liability, personal injury, and product liability.

At GAI, our mission is clear: Through rigorous investigation, objective analysis, reliable reporting, accurate assessment, and unassailable expert testimony —we assist each client to understand and solve complex technical problems, resolve claims and litigation, and mitigate or eliminate loss. Working on behalf of insureds, claimants, plaintiffs, and defendants, GAI understands that client needs usually stem from the demands of an insurance contract or legal dispute. Our engineers have helped countless clients achieve cost-effective resolution of claims, maximum recovery from subrogation, strong defense on insured liability, and favorable settlements on behalf of private parties.

Experienced in litigation, GAI professionals provide legal support and expert testimony for prosecutors, plaintiffs and defendants, product manufacturers, utilities, and insurers. Our engineers assist as non-testifying experts in preparing and reviewing depositions, and evaluating technical documents obtained through discovery. We also help determine the underlying cause of a loss, and whether a reasonable basis for subrogation exists. As testifying witnesses, GAI effectively renders opinions on topics ranging from electrical and mechanical engineering issues, to electrical fires, gas explosions, and product design, manufacture, service, and installation. With valid scientific methodology our hallmark, we successfully withstand Daubert motions and consistently qualify as expert witnesses in state and federal courts on civil and criminal matters.

Since our inception, GAI has been continuously operated and locally owned by only two families — a system that has ensured reliability, quality, and continuity of service for our clients. Today, under the direction of Andrew J. Williams, P.E., GAI continues a longstanding tradition of responsive service, accurate analysis, thorough reporting, and defensible presentation of findings and opinions for insurers, attorneys, and private parties throughout New England and beyond.

INTRODUCTION

Since the clothes iron was introduced in the early 1900's, power supply cords and cord sets have provided the crucial connection between premises wiring and utilization equipment. Though the terms "power supply cord" and "cord set" are sometimes used interchangeably, power supply cords are typically part of a portable appliance, while cord sets are known as extension cords.

The industry standard for power supply cords and cords sets is issued by Underwriter's Laboratories, UL 817 *Standard for Safety of Cord Sets and Power Supply Cords*. Presently, the standard is in its 11th edition, last revised in July of 2014. The standard covers typical UL requirements, such as construction and performance, as well as particular requirements for the various types of flexible cords.

The ground-fault circuit interrupter (GFCI) has become an integral part of shock-protection in premises wiring. The technology was developed in the early 1960's by Professor Charles Dalziel of the University of California at Berkeley.

The industry standard for GFCI's is issued by Underwriter's Laboratories, UL 943 *Standard for Safety of Ground-Fault Circuit Interrupters*. Presently, the standard is in its 4th edition, last revised in June of 2012. The standard covers typical UL requirements, such as construction and performance, as well as particular requirements for the various types of devices.

In fire investigation, power supply cords and cord sets are found in almost every room of a building. Whether it be an extension cord running along the floor of a living room, or a toaster power supply cord on a kitchen countertop, flexible cords are routinely attacked by fire.

Throughout the years, GAI has heard various theories of how two-wire or three-wire cords should arc fault during a fire when protected by a GFCI device. Scenarios included there cannot be a line-to-ground arc fault, or that an over-current protective device (OCPD) should trip before a GFCI device.

GAI set out to understand how various flexible cords will arc fault when protected by a typical GFCI device and OCPD, during fire attack. A test protocol was developed to encompass a wide variety of flexible cord types and GFCI devices. The trip scenarios and arcs were recorded.

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PROTOCOL

1.0 PROTOCOL TITLE: GFCI Operation during Flexible Cord Fire Attack

2.0 PROTOCOL LOCATION(S): GAI Engineers
378 Page Street – Building 10
Stoughton, MA

3.0 PROTOCOL DATE & TIME: To Be Determined

4.0 ORIGINATOR(S): Andrew J Williams, P.E.

5.0 ORIGINATION DATE: August 1, 2013

6.0 PURPOSE/SCOPE:

The purpose of this protocol is to study the operation of ground-fault circuit interrupters (GFCI's) during fire attack to flexible cords typically found on electrical appliances and electronic devices. Various brands of GFCI devices and cord sets will be used.

7.0 TOOLS/ EQUIPMENT:

7.1 One GFCI Device - 15 Amp, Cooper, VGF15W
7.2 One GFCI Device - 20 Amp, Cooper, VGF20W
7.3 One GFCI Device - 15 Amp, Hubbell, GF15WLA
7.4 One GFCI Device - 20 Amp, Hubbell, GF20WLA
7.5 One GFCI Device - 15 Amp, Leviton, N7599RW
7.6 One GFCI Device - 20 Amp, Leviton, N7899KW
7.7 Six 14-3 Type SPT-3 Cord Sets, 6' Length, Southwire
7.8 Six 16-2 Type HPN Power Supply Cords, 6' Length, Woods
7.9 Six 17-2 Type SVT Power Supply Cords, 30' Length, Eureka
7.10 Six 18-2 Type SPT-2 Power Supply Cords, 6' Length, Cables-To-Go
7.11 Six 18-3 Type SVT Power Supply Cords, 6' Length, Cables-To-Go
7.12 One 6' Length of 14-2 w/ground Type NM-B Cable
7.13 One 6' Length of 12-2 w/ground Type NM-B Cable
7.14 One Metal Workbox, 3" Depth
7.15 Two Attachment Plugs, NEMA 5-15P
7.16 GAI Flexible Cord Burning Fixture
7.17 GAI Test Panelboard

8.0 PROCEDURE:

8.1 Photograph each type of GFCI device, including packaging, documents and device itself. Document manufacturer's information for each device, including date code.

8.2 Photograph each Cord Set. Create bag for each Cord Set and label by type and GFCI device used.

8.3 Measure line voltage and ambient temperature at start of testing. If testing goes multiple days, record these parameter each day.

8.4 Wire each GFCI device to each OCPD using appropriate gauge of Type NM cable as well as attachment plug and workbox. Plug-In each type of Cord Set into each type of GFCI devices and each type of OCPD's. Secure each Cord Set to GAI Flexible Cord Burning Fixture. If parallel configuration, twist Cord Set three times to ensure arcing-through-char will occur. Apply flame to Cord Set until GFCI device activates, OCPD activates, or cable arc-severs.

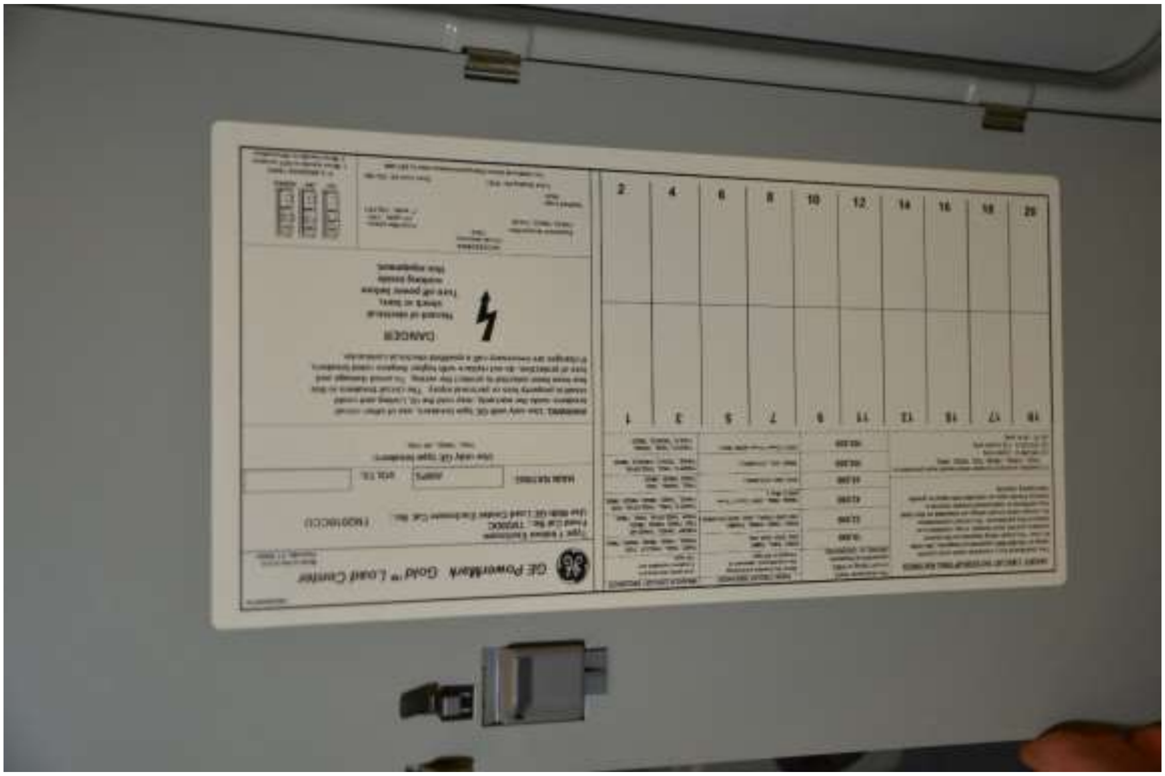
8.5 Record results of testing using attached Data Sheet

STUDY SET-UP PHOTOGRAPHS

1. GAI Laboratory, showing Study Set-Up.

2. Study Set-Up, showing GAI Test Panelboard. (NOTE: Side view)

STUDY SET-UP PHOTOGRAPHS



3. GAI Test Panelboard, showing Manufacturer’s Information. (NOTE: Side view)

4. Study Set-Up, showing GAI Flexible Cable Burning Fixture.

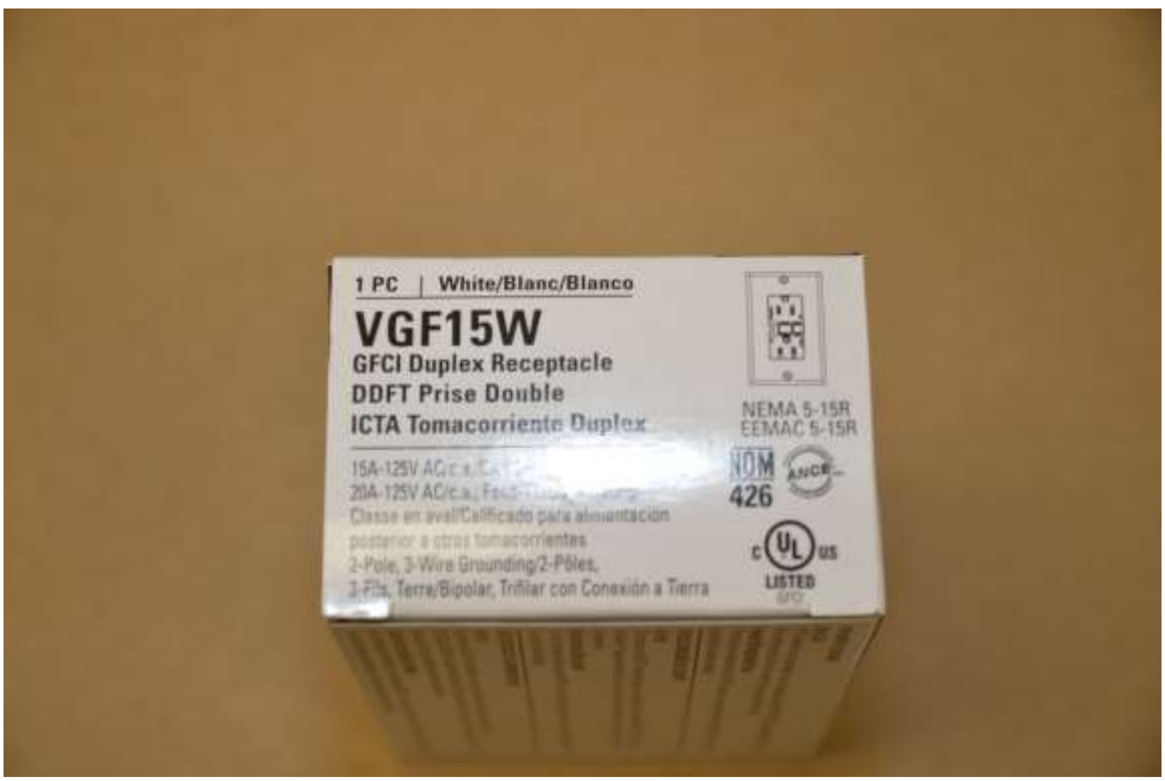
STUDY SET-UP PHOTOGRAPHS

5. Study Set-Up, showing NEMA 5-15P Attachment Plugs, Type NM-B Cables and Metal Workbox.

6. Study Set-Up, showing GFCI Devices.

STUDY SET-UP PHOTOGRAPHS

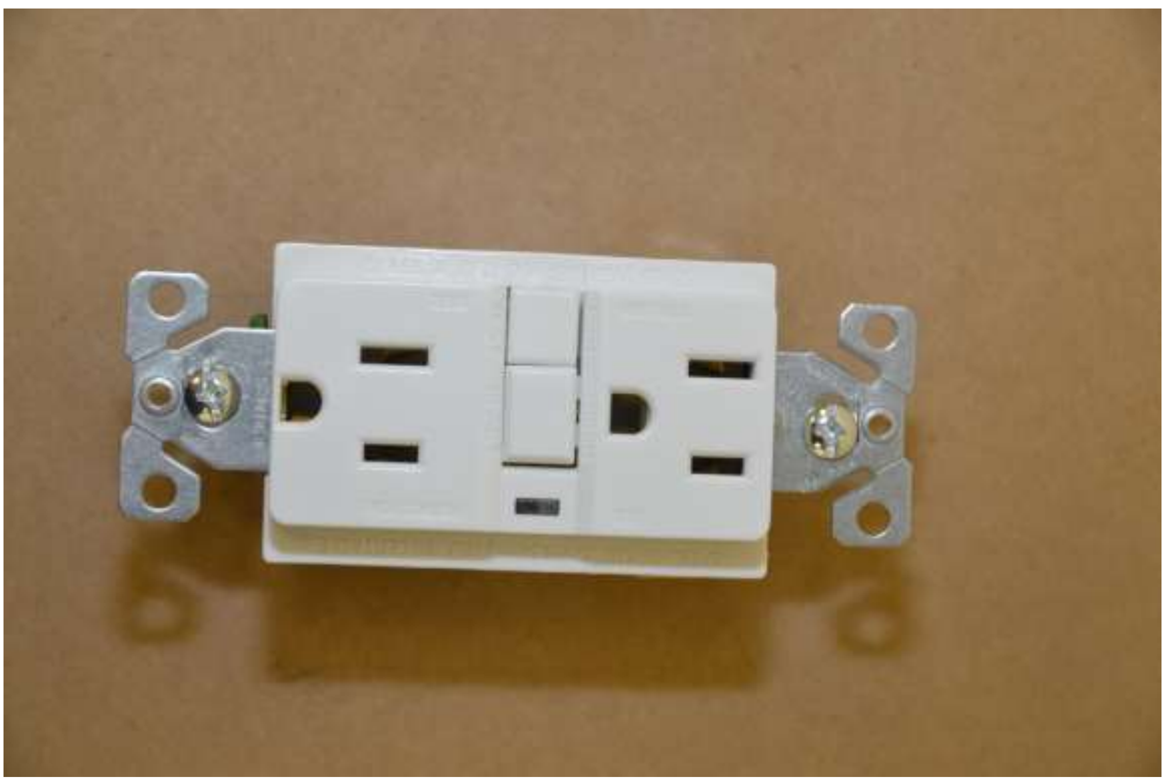
7. GFCI Devices, showing Cooper 15 Amp Device.



8. GFCI Devices, showing Cooper 15 Amp Device.

STUDY SET-UP PHOTOGRAPHS

9. Cooper 15 Amp Device, showing Packing Materials.



10. Cooper 15 Amp Device, showing Face.

STUDY SET-UP PHOTOGRAPHS

11. GFCI Devices, showing Cooper 20 Amp Device.

12. GFCI Devices, showing Cooper 20 Amp Device.

STUDY SET-UP PHOTOGRAPHS

13. Cooper 20 Amp Device, showing Packing Materials.

14. Cooper 20 Amp Device, showing Face.

STUDY SET-UP PHOTOGRAPHS

15. GFCI Devices, showing Hubbell 15 Amp Device. (NOTE: Side view)

16. GFCI Devices, showing Hubbell 15 Amp Device.

STUDY SET-UP PHOTOGRAPHS

17. Hubbell 15 Amp Device, showing Packing Materials.

18. Hubbell 15 Amp Device, showing Face.

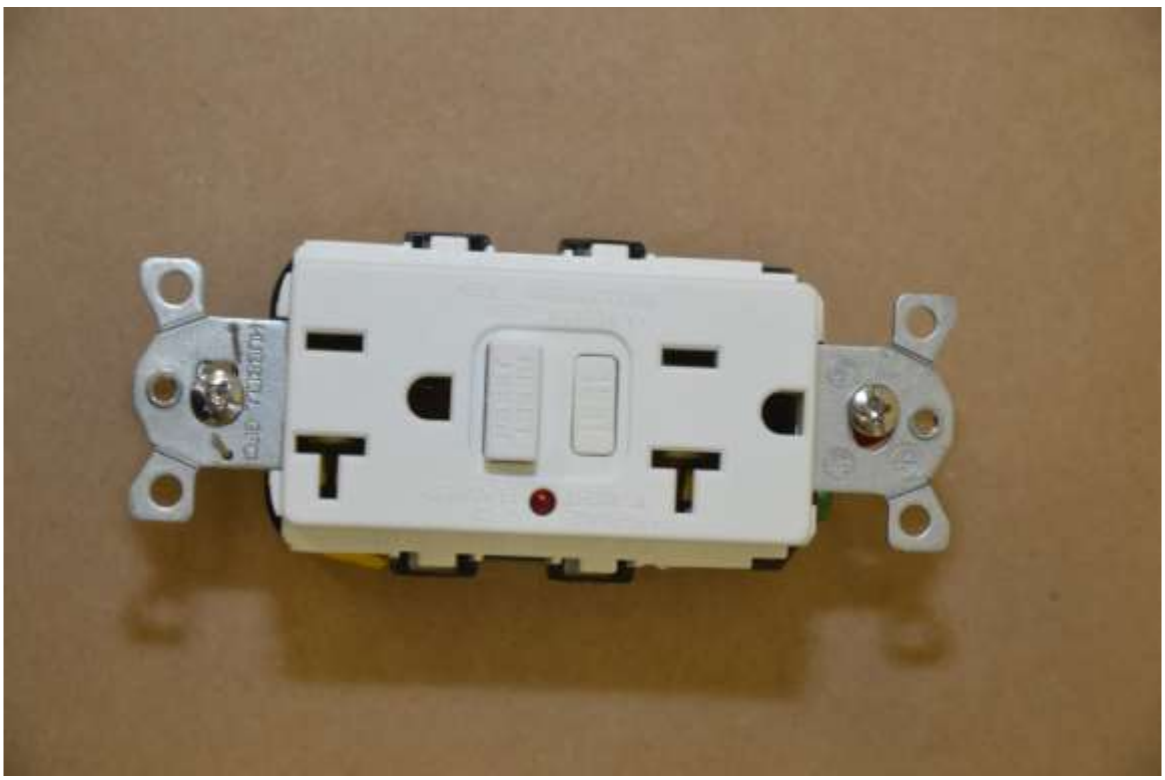
STUDY SET-UP PHOTOGRAPHS

19. GFCI Devices, showing Hubbell 20 Amp Device. (NOTE: Side view)

20. GFCI Devices, showing Hubbell 20 Amp Device.

STUDY SET-UP PHOTOGRAPHS

21. Hubbell 20 Amp Device, showing Packing Materials.



22. Hubbell 20 Amp Device, showing Face.

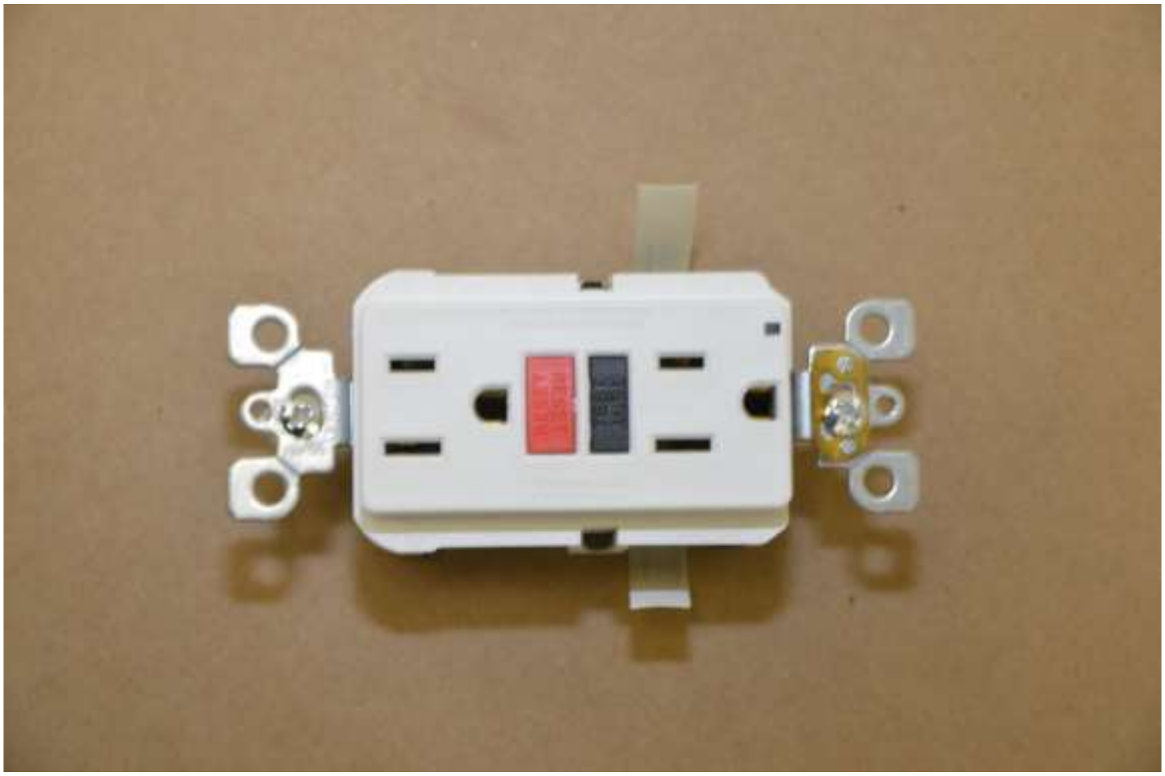
STUDY SET-UP PHOTOGRAPHS

23. GFCI Devices, showing Leviton 15 Amp Device. (NOTE: Side view)

24. GFCI Devices, showing Leviton 15 Amp Device.

STUDY SET-UP PHOTOGRAPHS

25. Leviton 15 Amp Device, showing Packing Materials.



26. Leviton 15 Amp Device, showing Face.

STUDY SET-UP PHOTOGRAPHS

27. GFCI Devices, showing Leviton 20 Amp Device. (NOTE: Side view)

28. GFCI Devices, showing Leviton 20 Amp Device.

STUDY SET-UP PHOTOGRAPHS

29. Leviton 20 Amp Device, showing Packing Materials.

30. Leviton 20 Amp Device, showing Face.

STUDY SET-UP PHOTOGRAPHS

31. Test Set-Up, showing Southwire 14-3 Type SPT-3 Cord Sets.

32. Southwire 14-3 Type SPT-3 Cord Sets, showing Packaging.

STUDY SET-UP PHOTOGRAPHS

33. Southwire 14-3 Type SPT-3 Cord Set, showing Packaging.

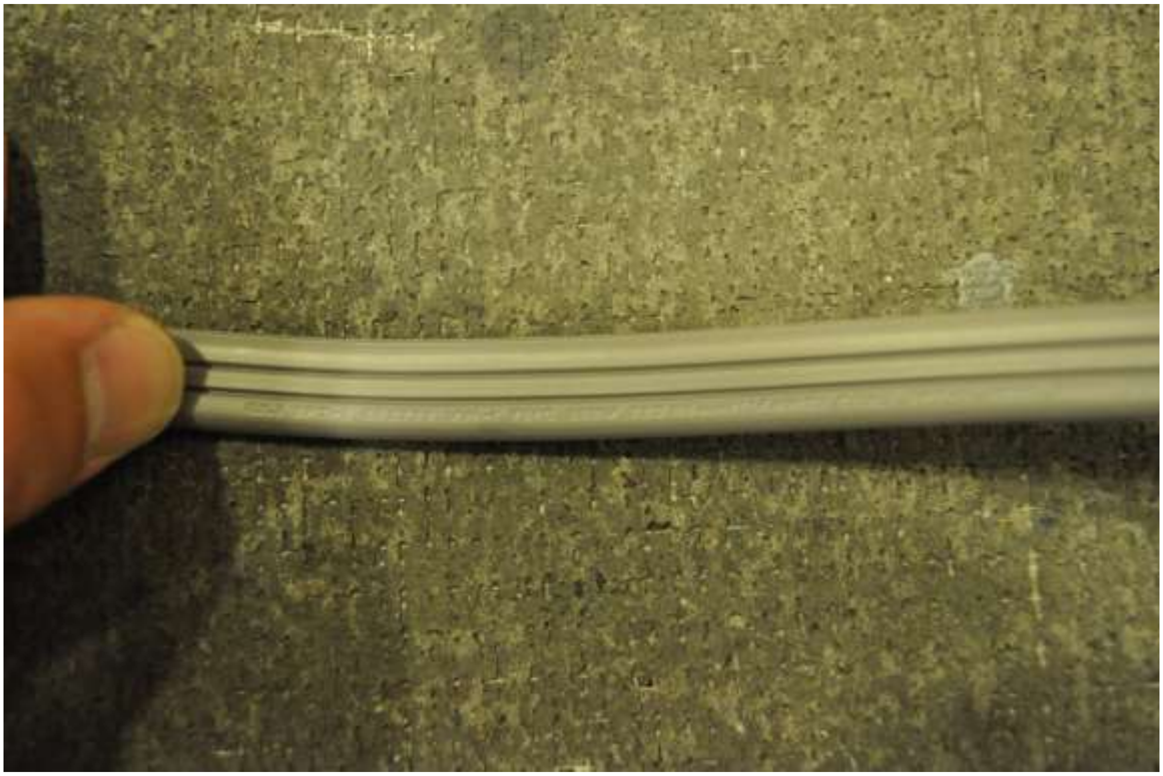
34. Southwire 14-3 Type SPT-3 Cord Set, showing Unpackaged.

STUDY SET-UP PHOTOGRAPHS

35. Southwire 14-3 Type SPT-3 Cord Set, showing NEMA 5-15P Attachment Plug.

36. Southwire 14-3 Type SPT-3 Cord Set, showing NEMA 5-15R Receptacle.

STUDY SET-UP PHOTOGRAPHS



37. Southwire 14-3 Type SPT-3 Cord Set, showing Flexible Cord Information.

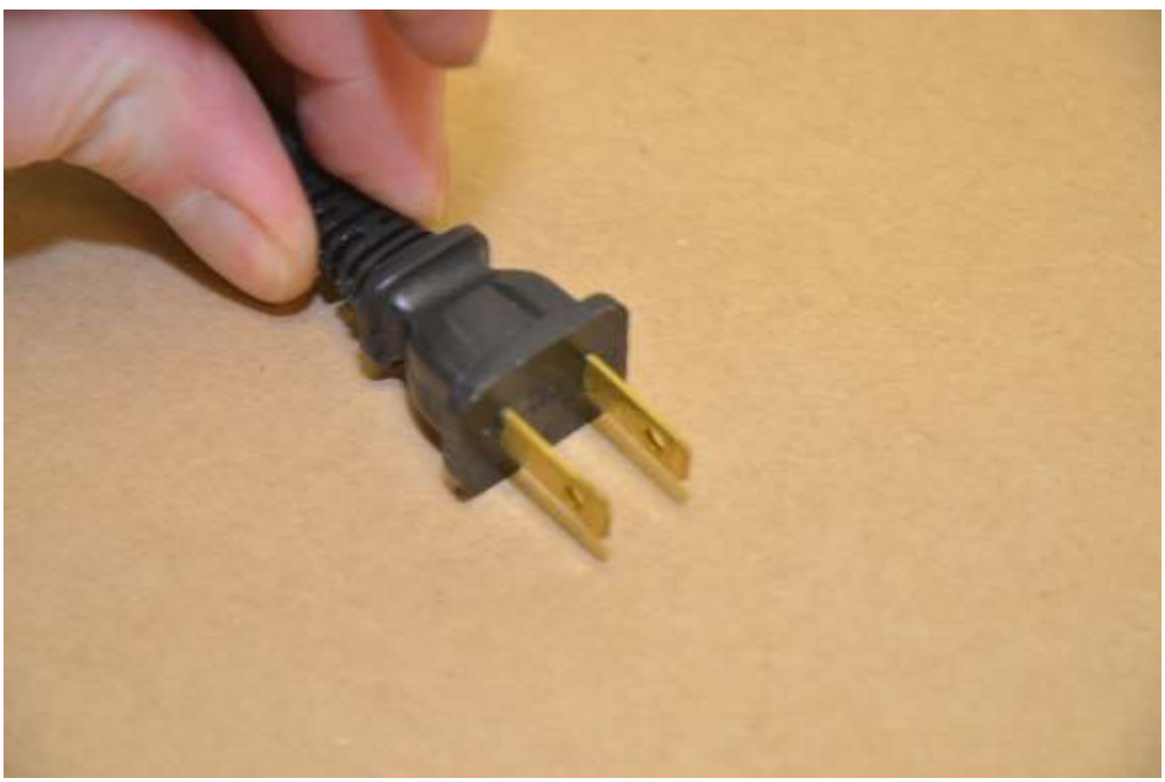
38. Test Set-Up, showing Woods 16-2 Type HPN Power Supply Cords.

39. Woods 16-2 Type HPN Power Supply Cord, showing Packaging.

40. Woods 16-2 Type HPN Power Supply Cord, showing Packaging.

STUDY SET-UP PHOTOGRAPHS

41. Woods 16-2 Type HPN Power Supply Cord, showing Unpackaged.



42. Woods 16-2 Type HPN Power Supply Cord, showing NEMA 1-15P Attachment Plug.

43. Woods 16-2 Type HPN Power Supply Cord, showing Appliance Connector.

44. Woods 16-2 Type HPN Power Supply Cord, showing Flexible Cord Information.

STUDY SET-UP PHOTOGRAPHS

45. Test Set-Up, showing Eureka 17-2 Type SVT Power Supply Cords.

46. Eureka 17-2 Type SVT Power Supply Cord, showing Packaged.

STUDY SET-UP PHOTOGRAPHS

47. Eureka 17-2 Type SVT Power Supply Cord, showing Unpackaged.

48. Eureka 17-2 Type SVT Power Supply Cord, showing NEMA 1-15P Attachment Plug.

STUDY SET-UP PHOTOGRAPHS

49. Eureka 17-2 Type SVT Power Supply Cord, showing Appliance Connector & Conductor.

50. Eureka 17-2 Type SVT Power Supply Cord, showing Flexible Cord Information.

STUDY SET-UP PHOTOGRAPHS

51. Test Set-Up, showing Cables-To-Go 18-2 Type SPT-2 Power Supply Cords.

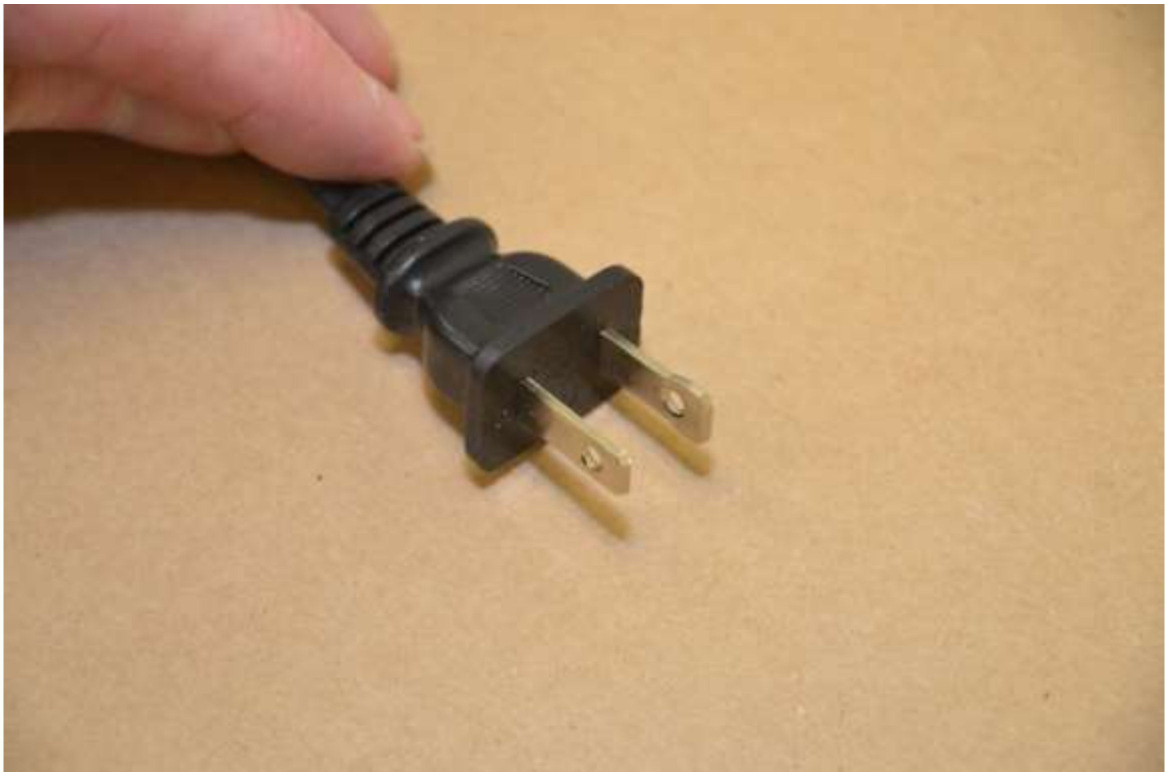
52. Cables-To-Go 18-2 Type SPT-2 Power Supply Cords, showing Packaging. (NOTE: Side view)

STUDY SET-UP PHOTOGRAPHS

53. Cables-To-Go 18-2 Type SPT-2 Power Supply Cords, showing Packaging.

54. Cables-To-Go 18-2 Type SPT-2 Power Supply Cords, showing Unpackaged.

STUDY SET-UP PHOTOGRAPHS



55. Cables-To-Go 18-2 Type SPT-2 Power Supply Cords, showing NEMA 1-15P Attachment Plug.

56. Cables-To-Go 18-2 Type SPT-2 Power Supply Cords, showing IEC C7 Connector.

STUDY SET-UP PHOTOGRAPHS

57. Cables-To-Go 18-2 Type SPT-2 Power Supply Cords, showing Flexible Cord Information.

58. Test Set-Up, showing Cables-To-Go 18-3 Type SVT Power Supply Cords.

STUDY SET-UP PHOTOGRAPHS

59. Cables-To-Go 18-3 Type SVT Power Supply Cord, showing Packaging. (NOTE: Side view)

60. Cables-To-Go 18-3 Type SVT Power Supply Cord, showing Packaging. (NOTE: Side view)

STUDY SET-UP PHOTOGRAPHS

61. Cables-To-Go 18-3 Type SVT Power Supply Cord, showing Unpackaged.

62. Cables-To-Go 18-3 Type SVT Power Supply Cord, showing NEMA 5-15P Attachment Plug.

STUDY SET-UP PHOTOGRAPHS

63. Cables-To-Go 18-3 Type SVT Power Supply Cord, showing IEC C13 Connector.

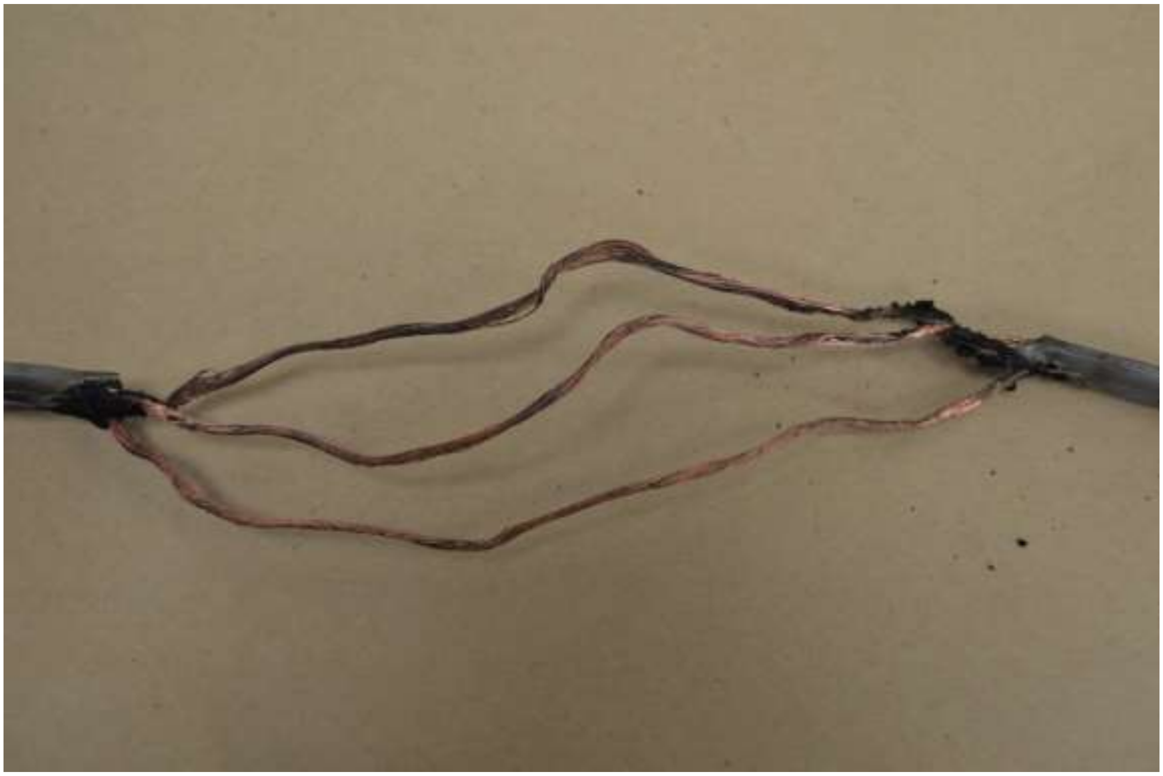
64. Cables-To-Go 18-3 Type SVT Power Supply Cord, showing Flexible Cord Information.

GFCI-Protected Flexible Cord Fire Attack Study - Data

Run Number	Day	Line Voltage (Volt AC)	Ambient Temperature (Deg. F)	GFCI Type	OCPD Type	Flexible Cord	GFCI Trip	OCPB Trip	Visible Arcing
1	5	132	78	Cooper 15 Amp	15 Amp C.B.	14-3 SPT-3	Yes	No	No
2	5	132	78	Cooper 20 Amp	20 Amp C.B.	14-3 SPT-3	Yes	No	No
3	7	133	75	Hubbell 15 Amp	15 Amp C.B.	14-3 SPT-3	Yes	No	No
4	7	133	75	Hubbell 20 Amp	20 Amp C.B.	14-3 SPT-3	Yes	No	No
5	6	135	76	Leviton 15 Amp	15 Amp C.B.	14-3 SPT-3	Yes	Yes	Line-Ground-Neutral
6	6	135	76	Leviton 20 Amp	20 Amp C.B.	14-3 SPT-3	Yes	Yes	Line-Ground
7	1	132	83	Cooper 15 Amp	15 Amp C.B.	16-2 HPN	No	Yes	Line-Neutral
8	1	132	83	Cooper 20 Amp	20 Amp C.B.	16-2 HPN	No	Yes	Line-Neutral
9	2	131	79	Hubbell 15 Amp	15 Amp C.B.	16-2 HPN	No	Yes	Line-Neutral
10	2	131	79	Hubbell 20 Amp	20 Amp C.B.	16-2 HPN	No	Yes	Line-Neutral
11	3	133	80	Leviton 15 Amp	15 Amp C.B.	16-2 HPN	No	Yes	Line-Neutral
12	3	133	80	Leviton 20 Amp	20 Amp C.B.	16-2 HPN	No	Yes	Line-Neutral
13	4	132	78	Cooper 15 Amp	15 Amp C.B.	17-2 SVT	No	Yes	Line-Neutral
14	4	132	78	Cooper 20 Amp	20 Amp C.B.	17-2 SVT	No	Yes	Line-Neutral
15	4	132	78	Hubbell 15 Amp	15 Amp C.B.	17-2 SVT	No	Yes	Line-Neutral
16	4	132	78	Hubbell 20 Amp	20 Amp C.B.	17-2 SVT	No	Yes	Line-Neutral
17	4	132	78	Leviton 15 Amp	15 Amp C.B.	17-2 SVT	No	Yes	Line-Neutral
18	4	132	78	Leviton 20 Amp	20 Amp C.B.	17-2 SVT	No	Yes	Line-Neutral
19	1	132	83	Cooper 15 Amp	15 Amp C.B.	18-2 SPT-2	No	Yes	Line-Neutral
20	1	132	83	Cooper 20 Amp	20 Amp C.B.	18-2 SPT-2	No	Yes	Line-Neutral
21	2	131	79	Hubbell 15 Amp	15 Amp C.B.	18-2 SPT-2	No	Yes	Line-Neutral
22	2	131	79	Hubbell 20 Amp	20 Amp C.B.	18-2 SPT-2	No	Yes	Line-Neutral
23	3	133	80	Leviton 15 Amp	15 Amp C.B.	18-2 SPT-2	No	Yes	Line-Neutral
24	3	133	80	Leviton 20 Amp	20 Amp C.B.	18-2 SPT-2	No	Yes	Line-Neutral
25	5	132	78	Cooper 15 Amp	15 Amp C.B.	18-3 SVT	Yes	No	No
26	5	132	78	Cooper 20 Amp	20 Amp C.B.	18-3 SVT	Yes	No	No
27	7	133	75	Hubbell 15 Amp	15 Amp C.B.	18-3 SVT	No	Yes	Line-Ground-Neutral
28	7	133	75	Hubbell 20 Amp	20 Amp C.B.	18-3 SVT	No	Yes	Line-Ground
29	6	135	76	Leviton 15 Amp	15 Amp C.B.	18-3 SVT	Yes	Yes	Line-Neutral
30	6	135	76	Leviton 20 Amp	20 Amp C.B.	18-3 SVT	Yes	Yes	Line-Neutral

STUDY RESULTS PHOTOGRAPHS

1. Run #1, showing Southwire 14-3 Type SPT-3 Cord Set, Cooper 15 Amp GFCI Sample.



2. Run #1, showing Burned Section.

STUDY RESULTS PHOTOGRAPHS

3. Run #2, showing Southwire 14-3 Type SPT-3 Cord Set, Cooper 20 Amp GFCI Sample.

4. Run #2, showing Burned Section.

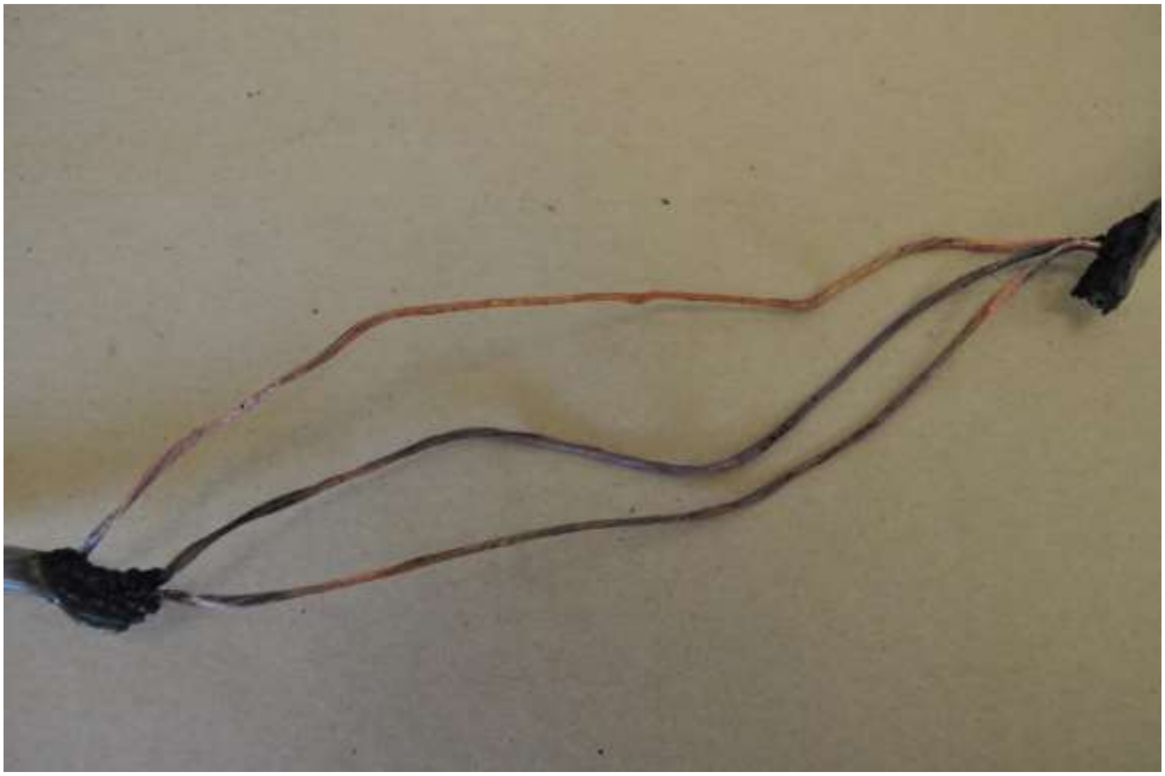
STUDY RESULTS PHOTOGRAPHS

5. Run #3, showing Southwire 14-3 Type SPT-3 Cord Set, Hubbell 15 Amp GFCI Sample.

6. Run #3, showing Burned Section.

STUDY RESULTS PHOTOGRAPHS

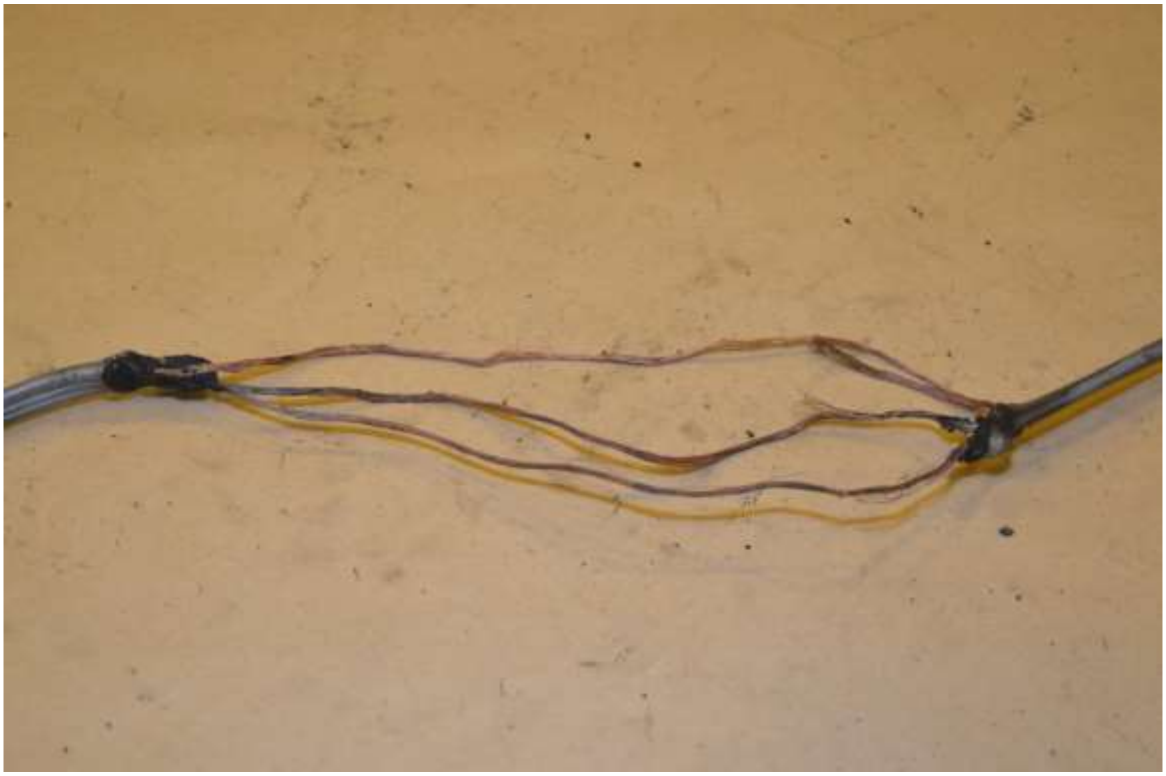
7. Run #4, showing Southwire 14-3 Type SPT-3 Cord Set, Hubbell 20 Amp GFCI Sample.



8. Run #4, showing Burned Section.

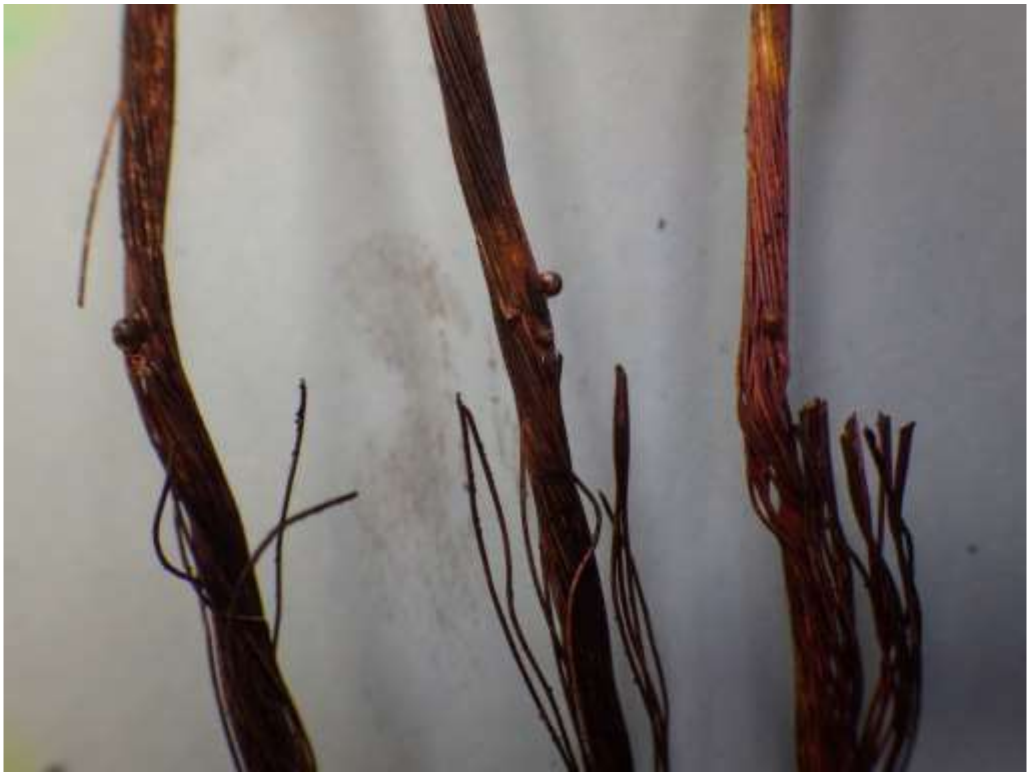
STUDY RESULTS PHOTOGRAPHS

9. Run #5, Southwire 14-3 Type SPT-3 Cord Set, Leviton 15 Amp GFCI Sample.



10. Run #5, showing Burned Section.

STUDY RESULTS PHOTOGRAPHS



11. Run #5, showing Line-Ground-Neutral Conductor Arcing.

12. Run #6, showing Southwire 14-3 Type SPT-3 Cord Set, Leviton 20 Amp GFCI Sample.

STUDY RESULTS PHOTOGRAPHS

13. Run #6, showing Burned Section.

14. Run #6, showing Line-Ground Conductor Arcing.

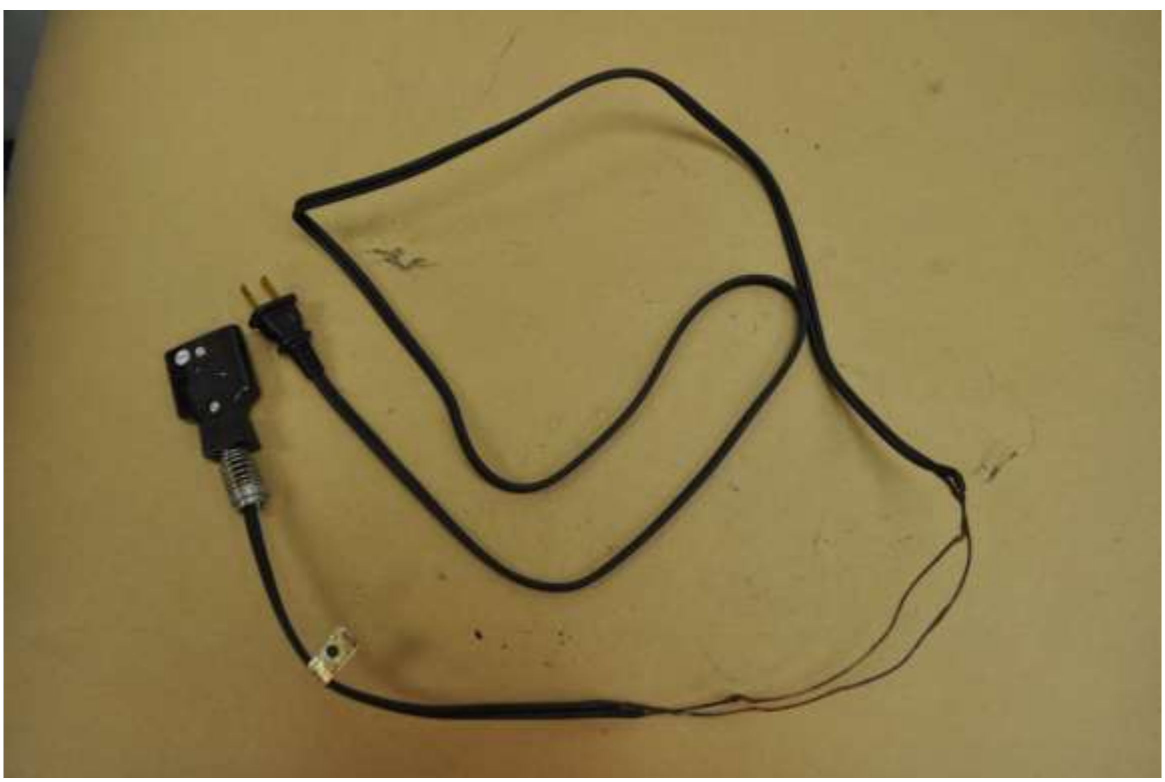
STUDY RESULTS PHOTOGRAPHS

15. Run #7, showing Woods 16-2 Type HPN Power Supply Cord, Cooper 15 Amp GFCI Sample.

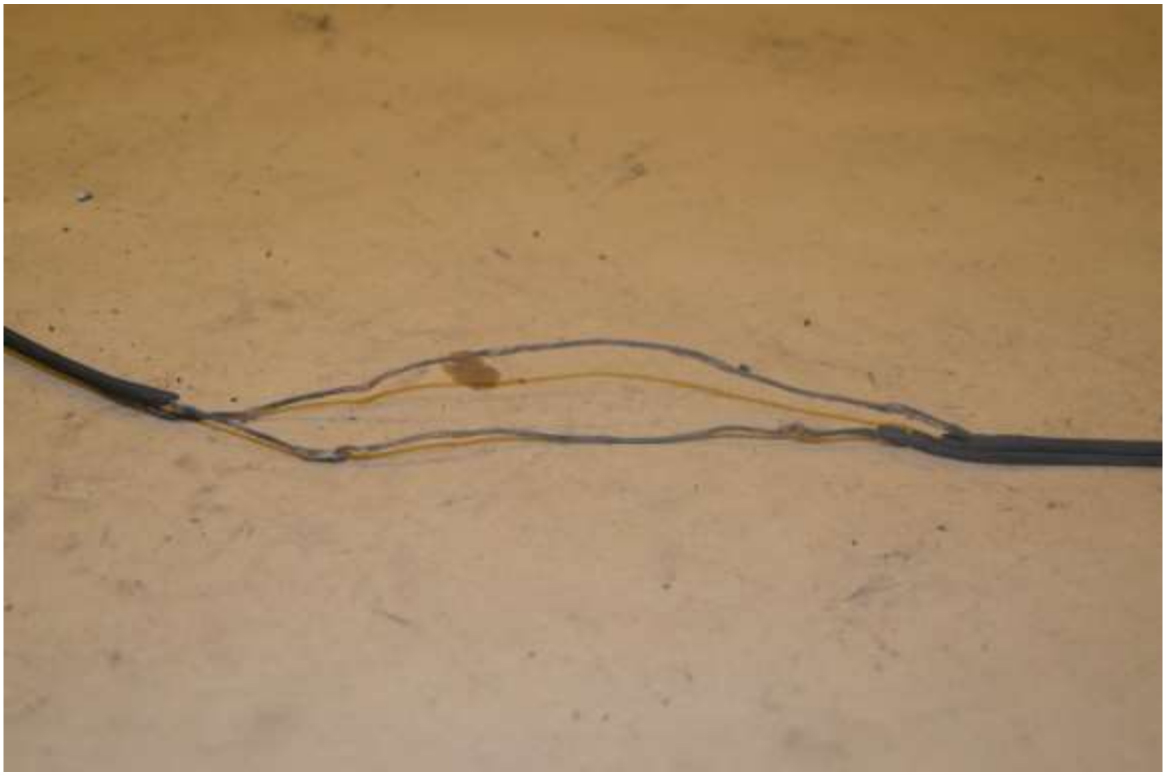
16. Run #7, showing Burned Section.

STUDY RESULTS PHOTOGRAPHS

17. Run #7, showing Line-Neutral Conductor Arcing.



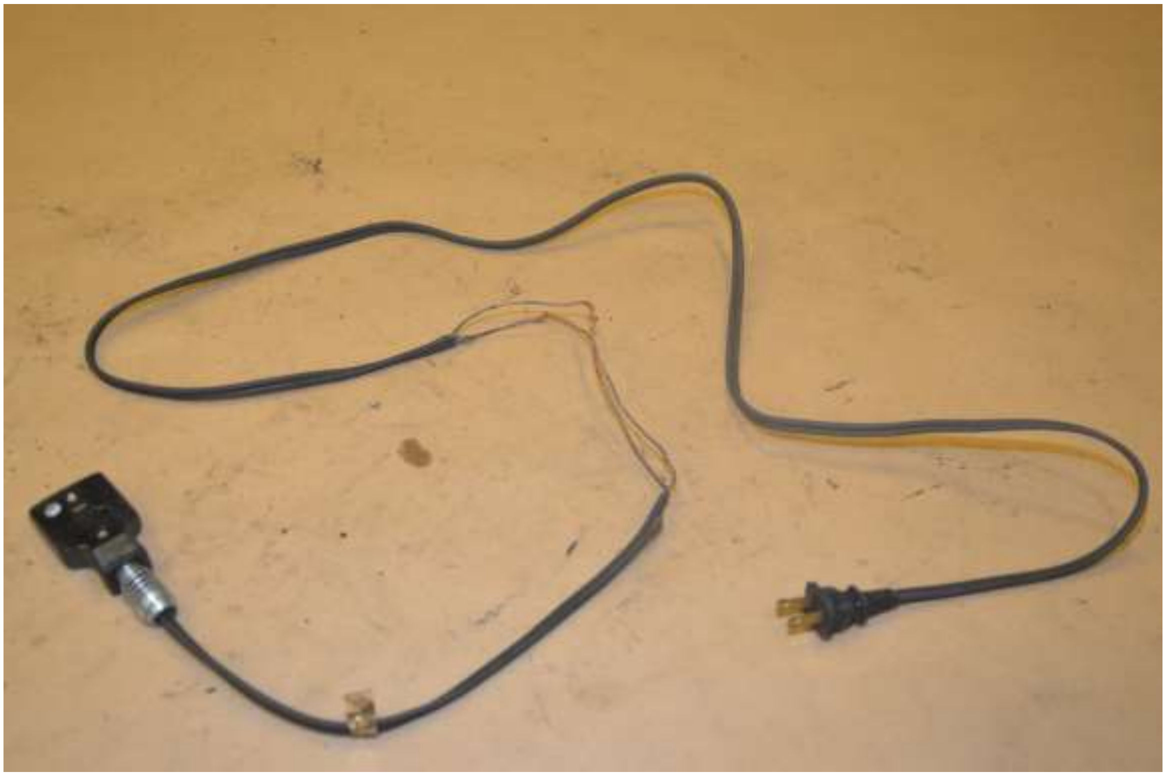
18. Run #8, showing Woods 16-2 Type HPN Power Supply Cord, Cooper 20 Amp GFCI Sample.



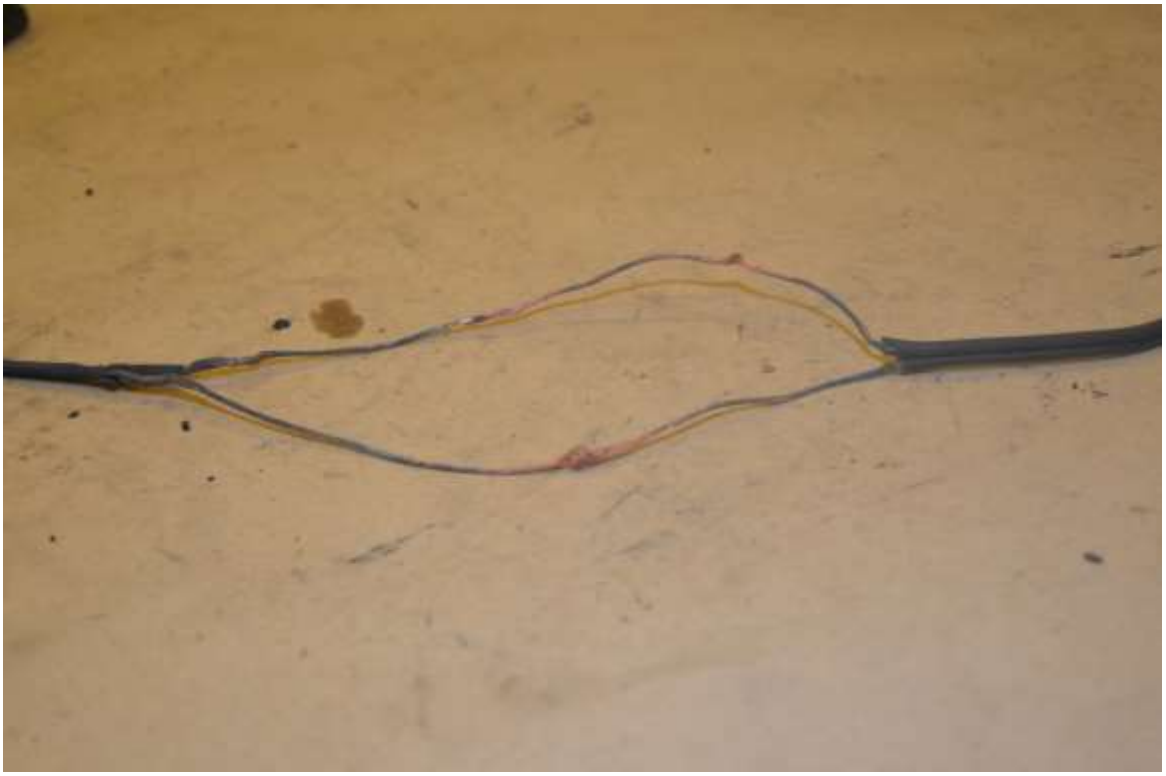
19. Run #8, showing Burned Section.

20. Run #8, showing Line-Neutral Conductor Arcing.

STUDY RESULTS PHOTOGRAPHS



21. Run #9, showing Woods16-2 Type HPN Power Supply Cord, Hubbell 15 Amp GFCI Sample.



22. Run #9, showing Burned Section.

STUDY RESULTS PHOTOGRAPHS

23. Run #9, showing Line-Neutral Conductor Arcing.

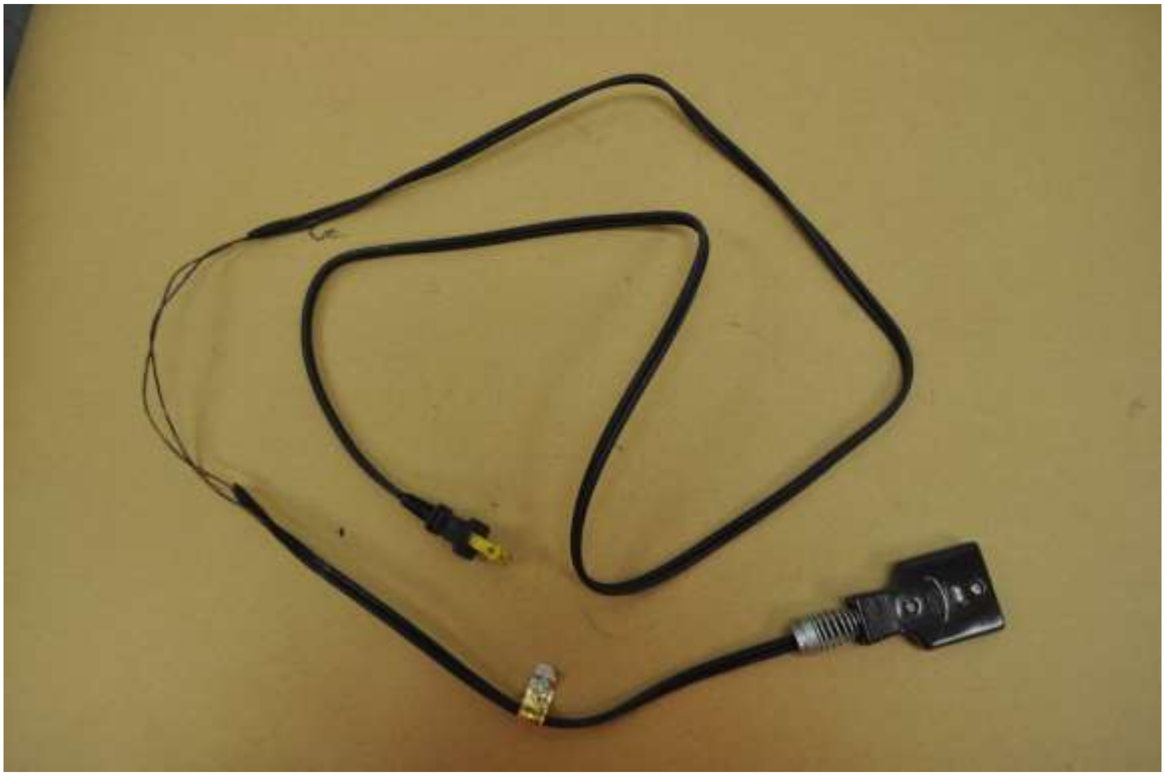
24. Run #10, showing Woods16-2 Type HPN Power Supply Cord, Hubbell 20 Amp GFCI Sample.

STUDY RESULTS PHOTOGRAPHS

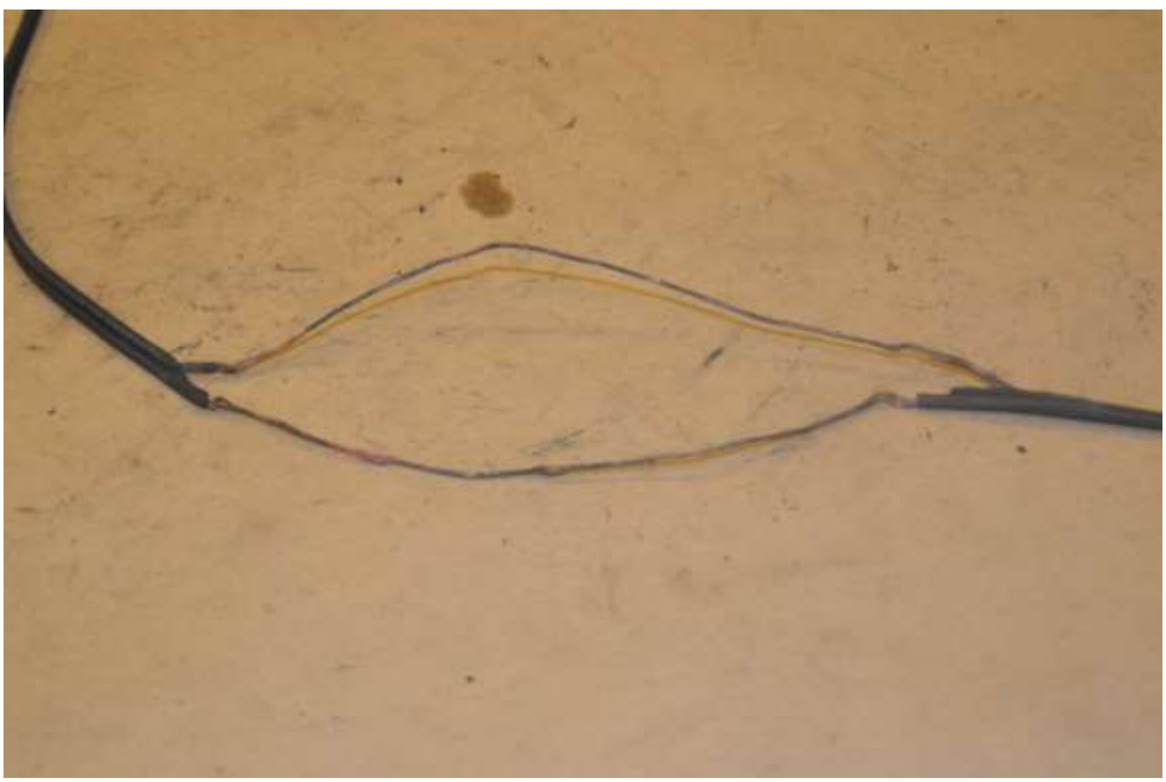
25. Run #10, showing Burned Section.

26. Run #10, showing Line-Neutral Conductor Arcing.

STUDY RESULTS PHOTOGRAPHS



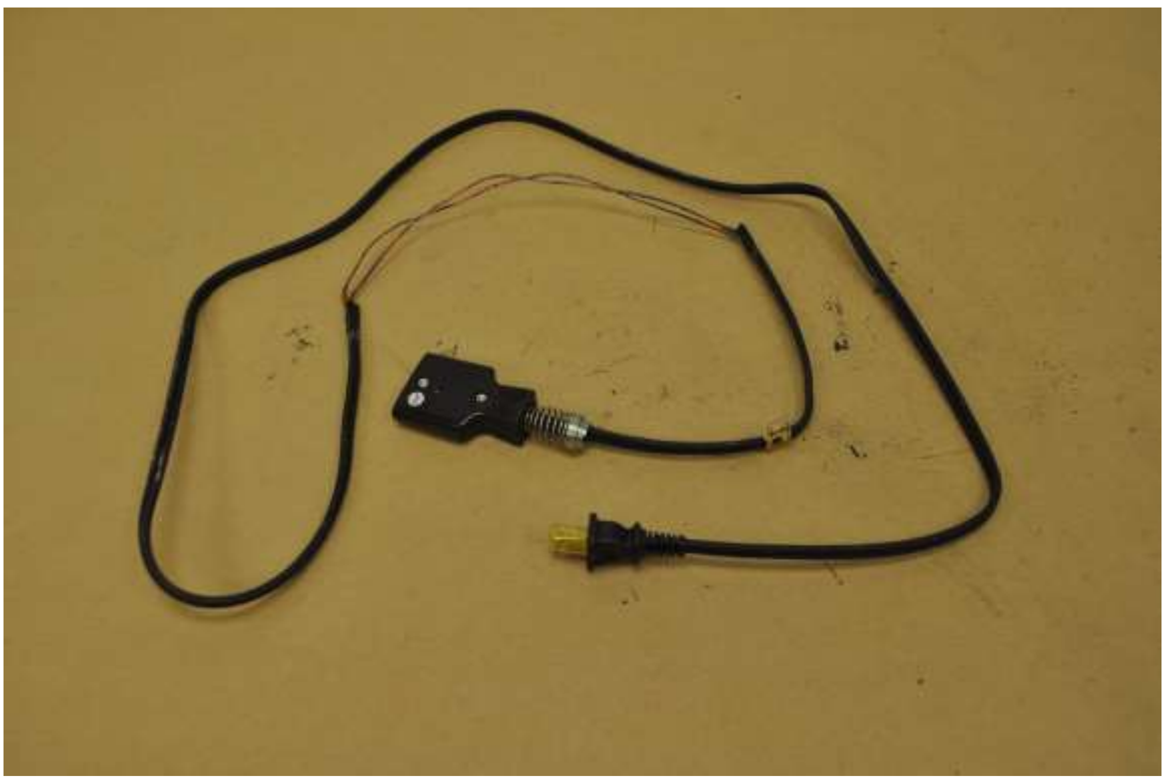
27. Run #11, showing Woods16-2 Type HPN Power Supply Cord, Leviton 15 Amp GFCI Sample.



28. Run #11, showing Burned Section.

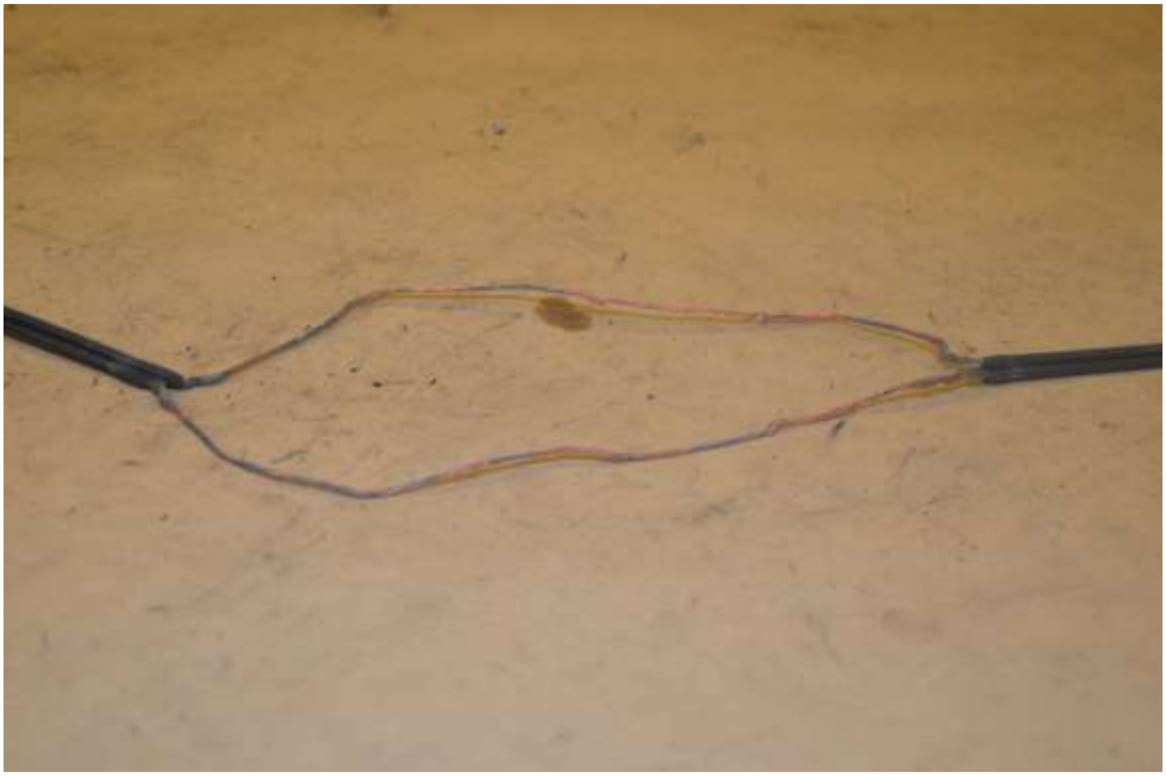
STUDY RESULTS PHOTOGRAPHS

29. Run #11, showing Line-Neutral Conductor Arcing.



30. Run #12, showing Woods16-2 Type HPN Power Supply Cord, Leviton 20 Amp.

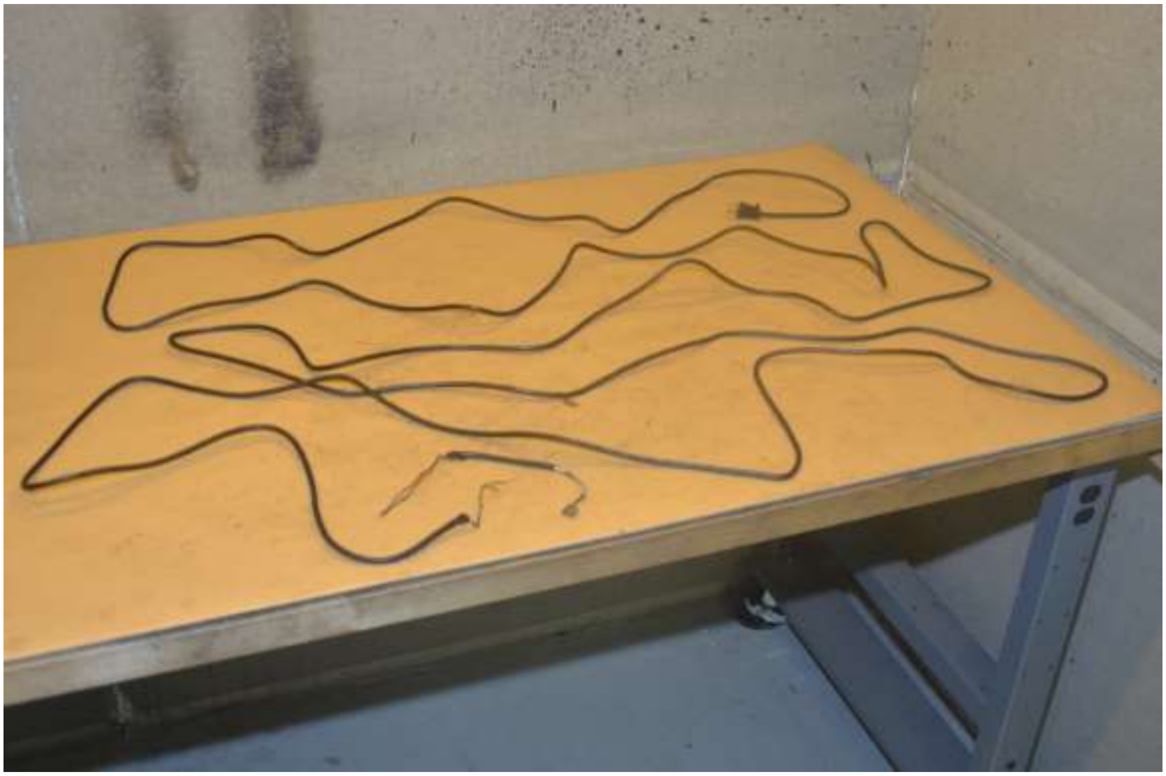
STUDY RESULTS PHOTOGRAPHS



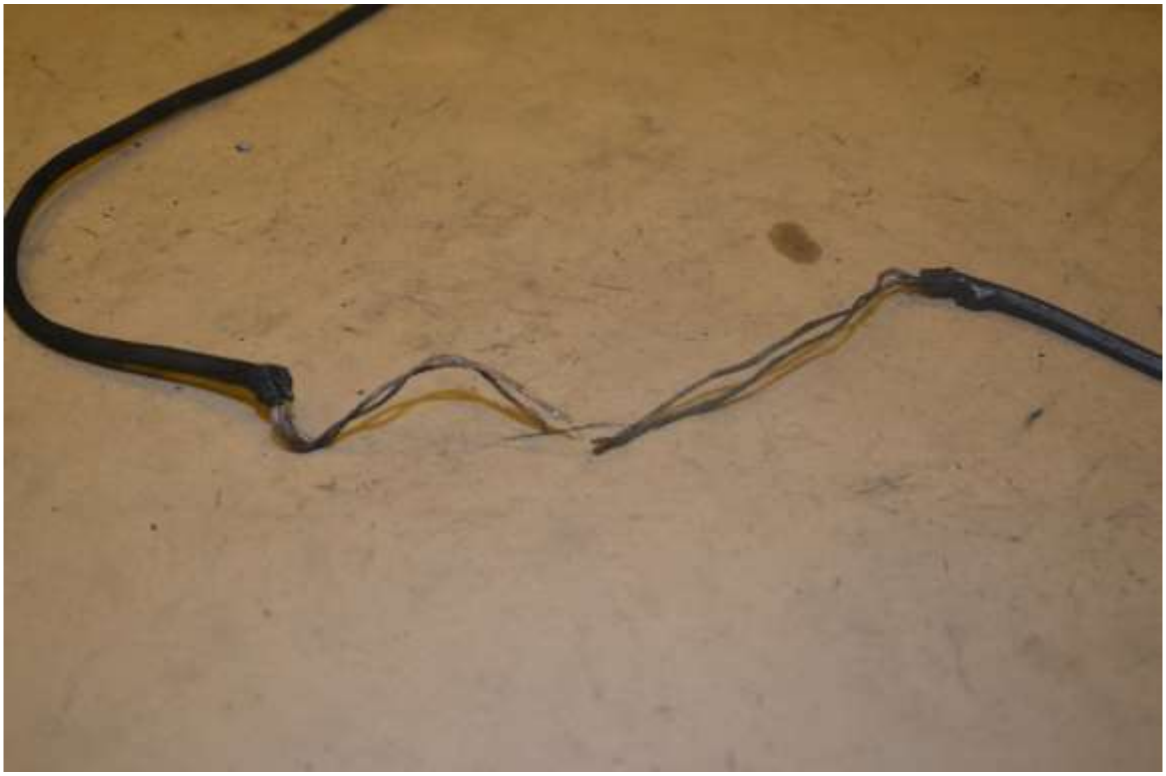
31. Run #12, showing Burned Section.

32. Run #12, showing Line-Neutral Conductor Arcing.

STUDY RESULTS PHOTOGRAPHS



33. Run #13, showing Eureka 17-2 Type SVT Power Supply Cord, Cooper 15 Amp.



34. Run #13, showing Burned Section.

STUDY RESULTS PHOTOGRAPHS

35. Run #13, showing Line-Neutral Conductor Arcing.

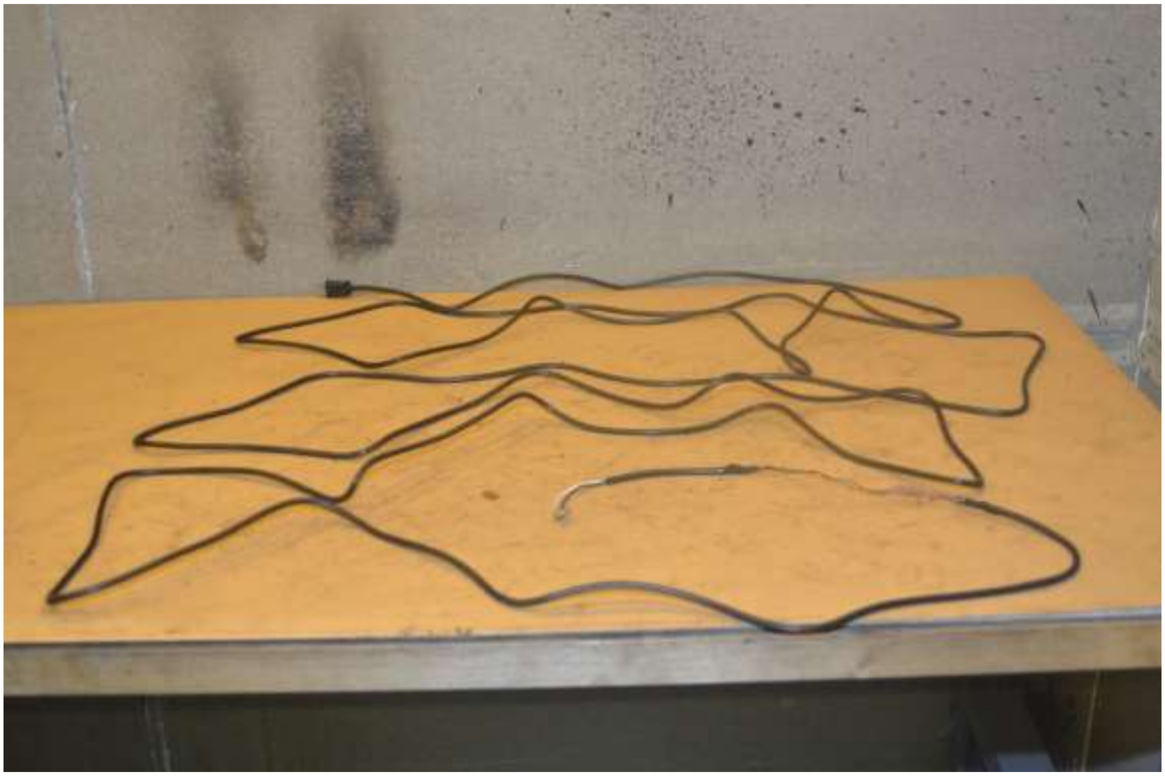
36. Run #14, showing Eureka 17-2 Type SVT Power Supply Cord, Cooper 20 Amp.

STUDY RESULTS PHOTOGRAPHS

37. Run #14, showing Burned Section.

38. Run #14, showing Line-Neutral Conductor Arcing.

STUDY RESULTS PHOTOGRAPHS

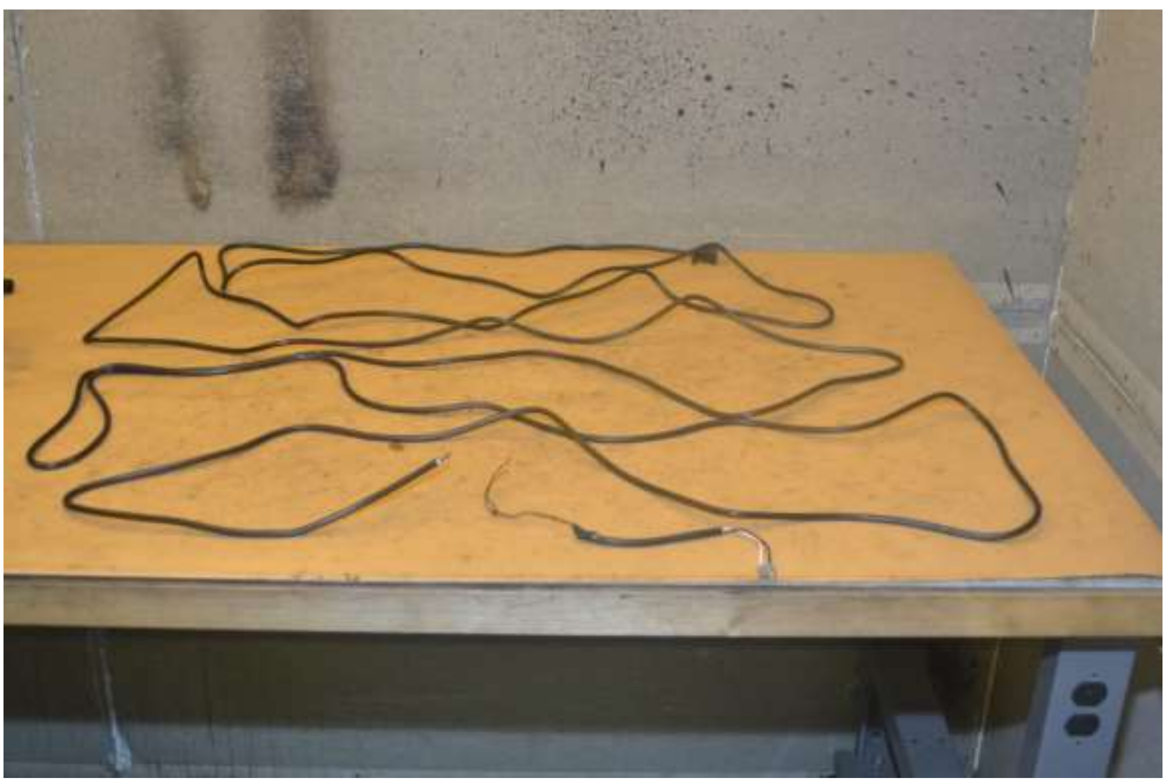


39. Run #15, showing Eureka 17-2 Type SVT Power Supply Cord, Hubbell 15 Amp.

40. Run #15, showing Burned Section.

STUDY RESULTS PHOTOGRAPHS

41. Run #15, showing Line-Neutral Conductor Arcing.



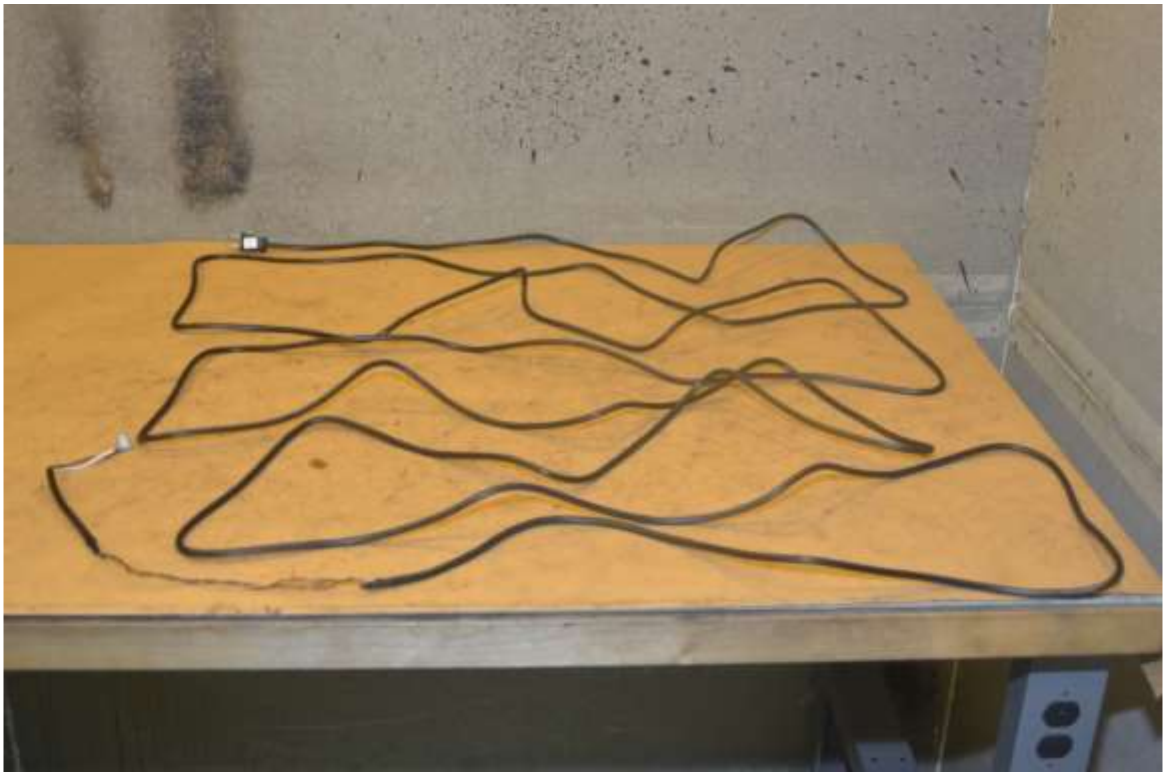
42. Run #16, showing Eureka 17-2 Type SVT Power Supply Cord, Hubbell 20 Amp.

STUDY RESULTS PHOTOGRAPHS

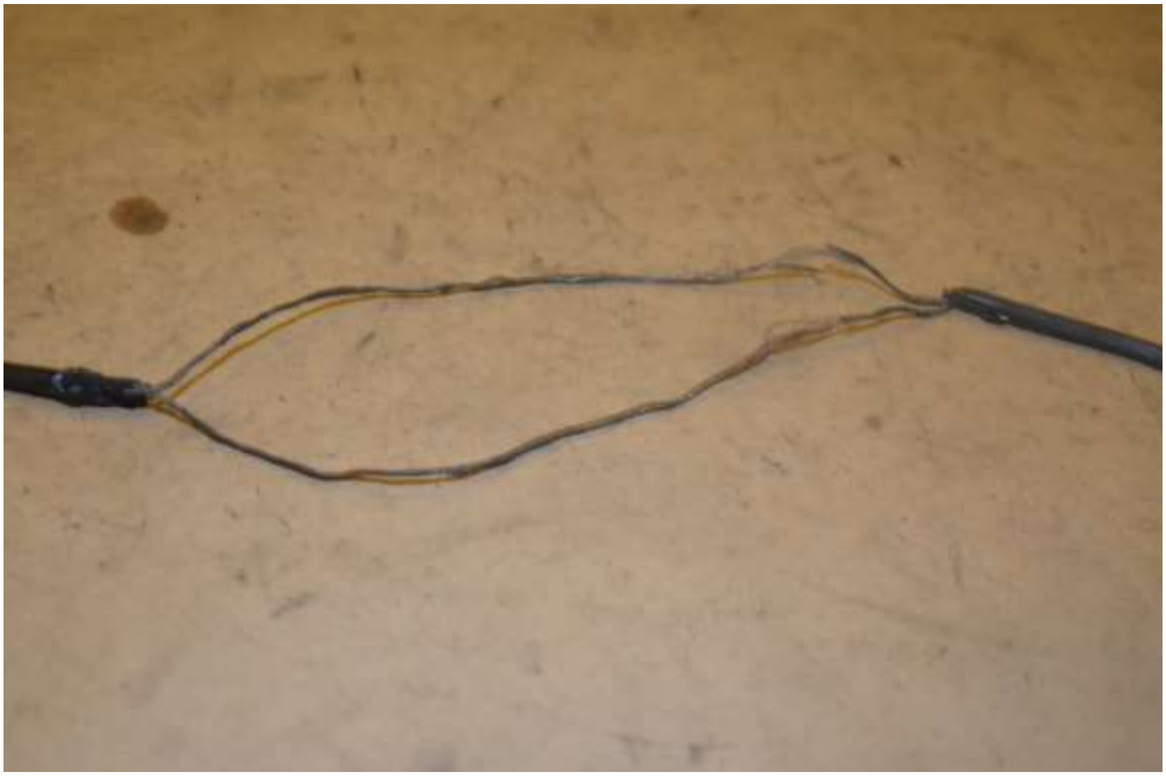
43. Run #16, showing Burned Section.

44. Run #16, showing Line-Neutral Conductor Arcing.

STUDY RESULTS PHOTOGRAPHS



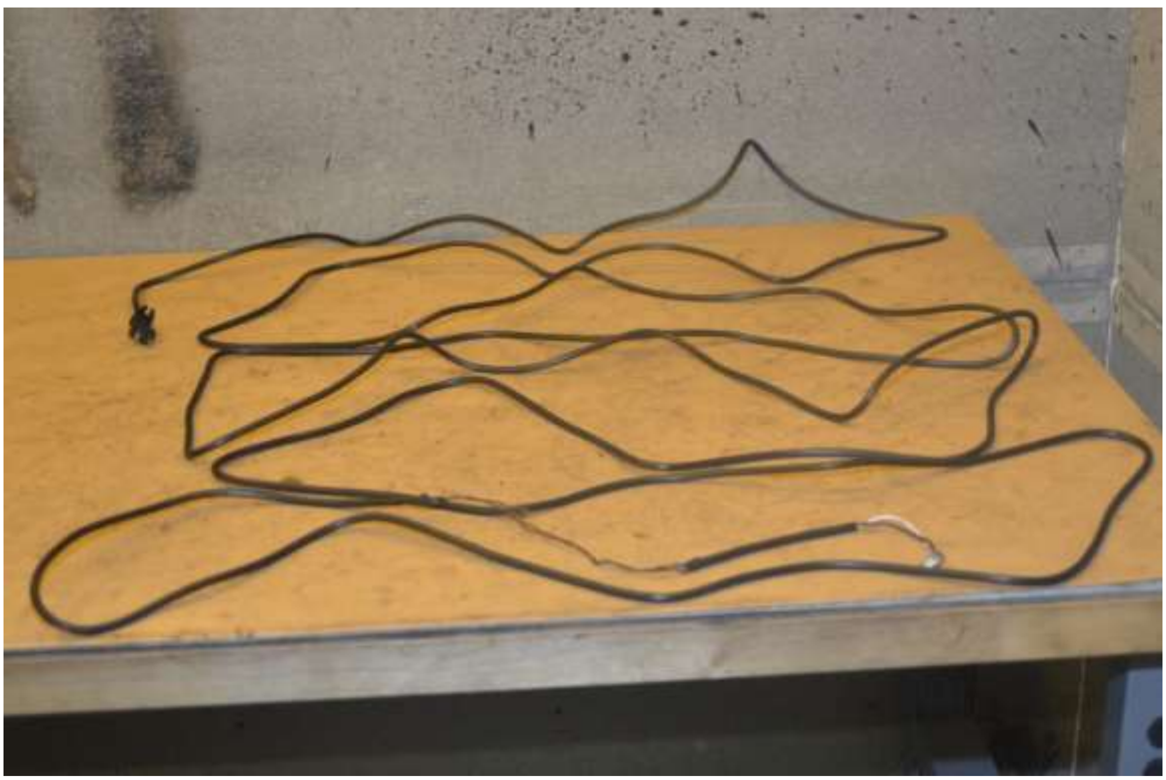
45. Run #17, showing Eureka 17-2 Type SVT Power Supply Cord, Leviton 15 Amp.



46. Run #17, showing Burned Section.

STUDY RESULTS PHOTOGRAPHS

47. Run #17, showing Line-Neutral Conductor Arcing.



48. Run #18, showing Eureka 17-2 Type SVT Power Supply Cord, Leviton 20 Amp.

49. Run #18, showing Burned Section.

50. Run #18, showing Line-Neutral Conductor Arcing.

51. Run #19, showing Cables-To-Go 18-2 Type SPT-2 Power Supply Cord, Cooper 15 Amp.

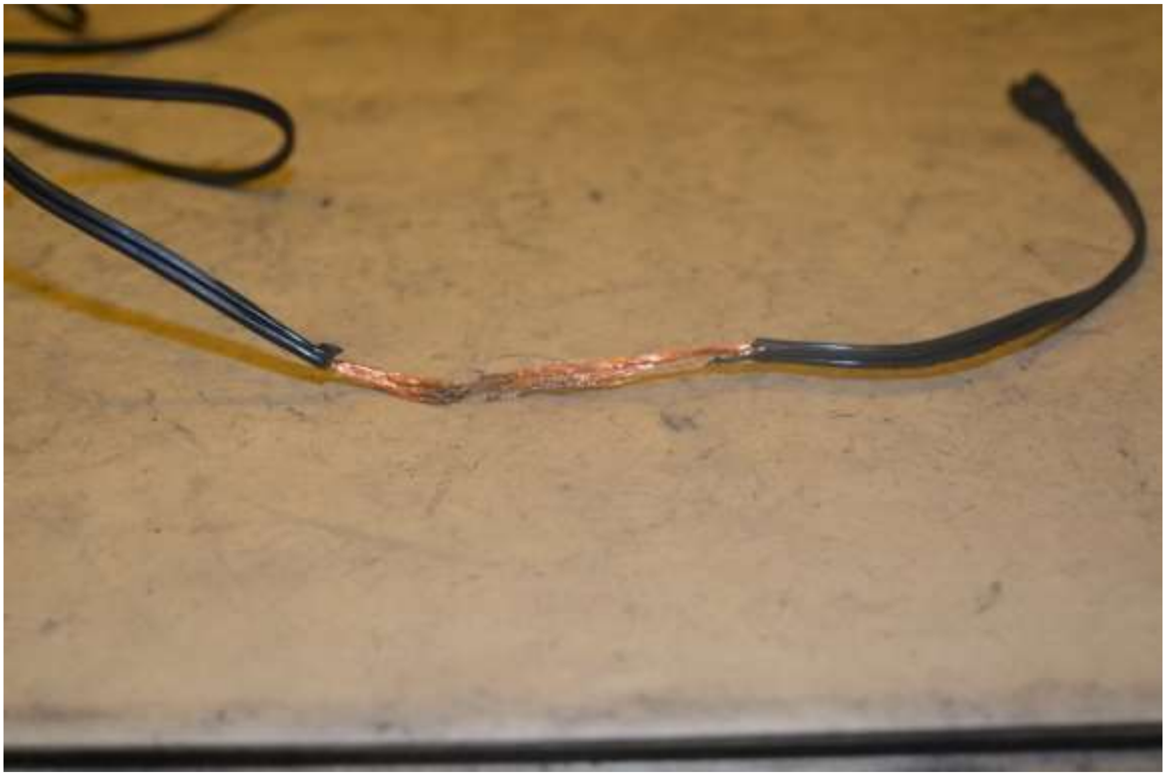
52. Run #19, showing Burned Section.

STUDY RESULTS PHOTOGRAPHS

53. Run #19, showing Line-Neutral Conductor Arcing.

54. Run #20, showing Cables-To-Go 18-2 Type SPT-2 Power Supply Cord, Cooper 20 Amp.

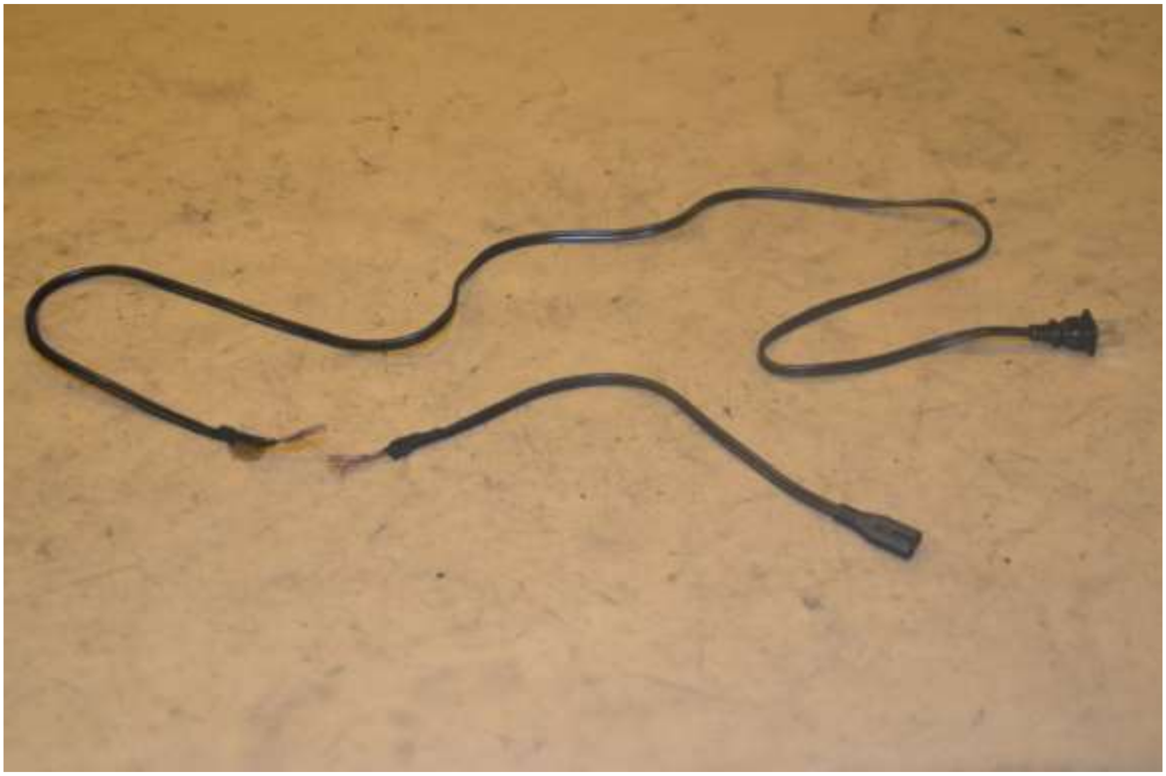
STUDY RESULTS PHOTOGRAPHS



55. Run #20, showing Burned Section.

56. Run #20, showing Line-Neutral Conductor Arcing.

STUDY RESULTS PHOTOGRAPHS



57. Run #21, showing Cables-To-Go 18-2 Type SPT-2 Power Supply Cord, Hubbell 15 Amp.

58. Run #21, showing Burned Section.

STUDY RESULTS PHOTOGRAPHS

59. Run #21, showing Line-Neutral Conductor Arcing.

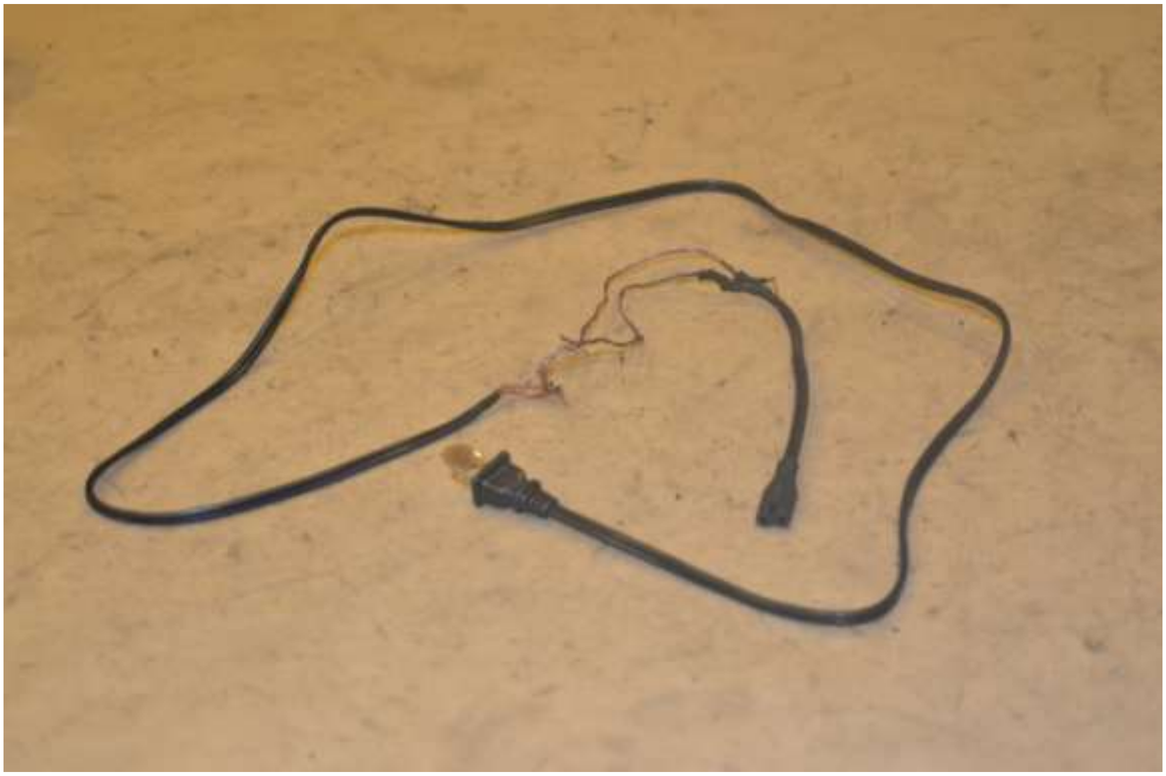
60. Run #22, showing Cables-To-Go 18-2 Type SPT-2 Power Supply Cord, Hubbell 20 Amp.

STUDY RESULTS PHOTOGRAPHS

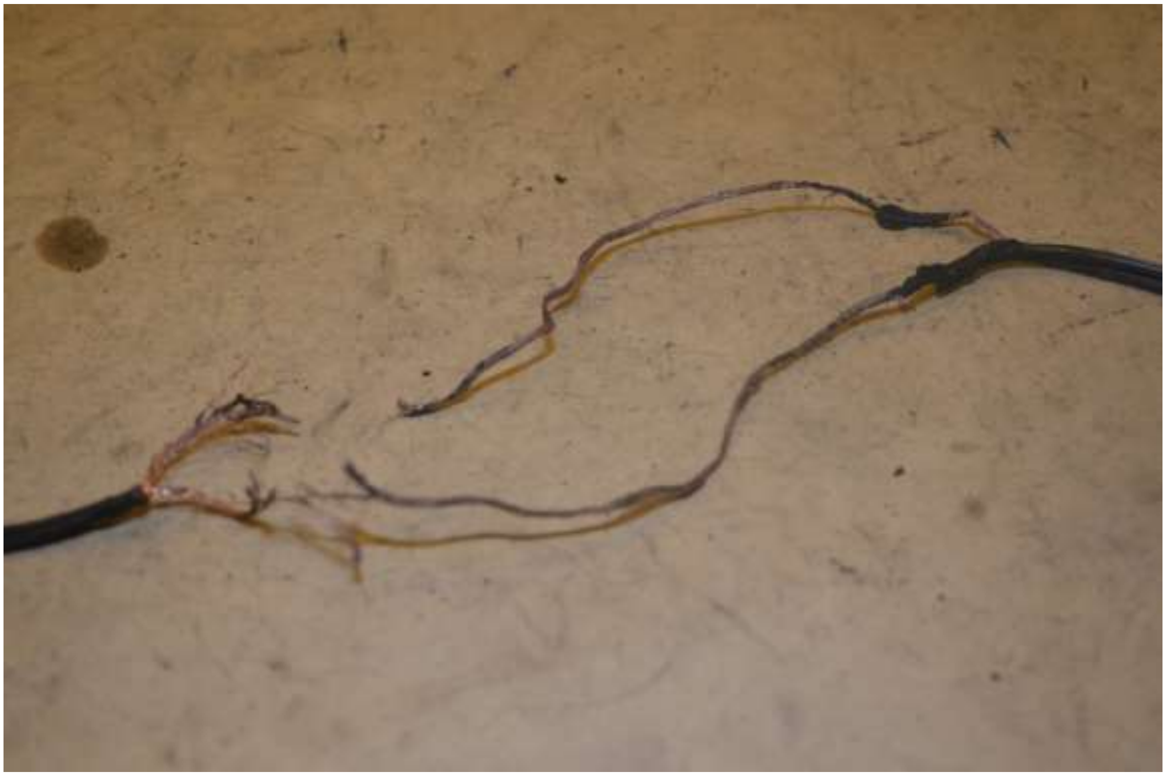
61. Run #22, showing Burned Section.

62. Run #22, showing Line-Neutral Conductor Arcing.

STUDY RESULTS PHOTOGRAPHS



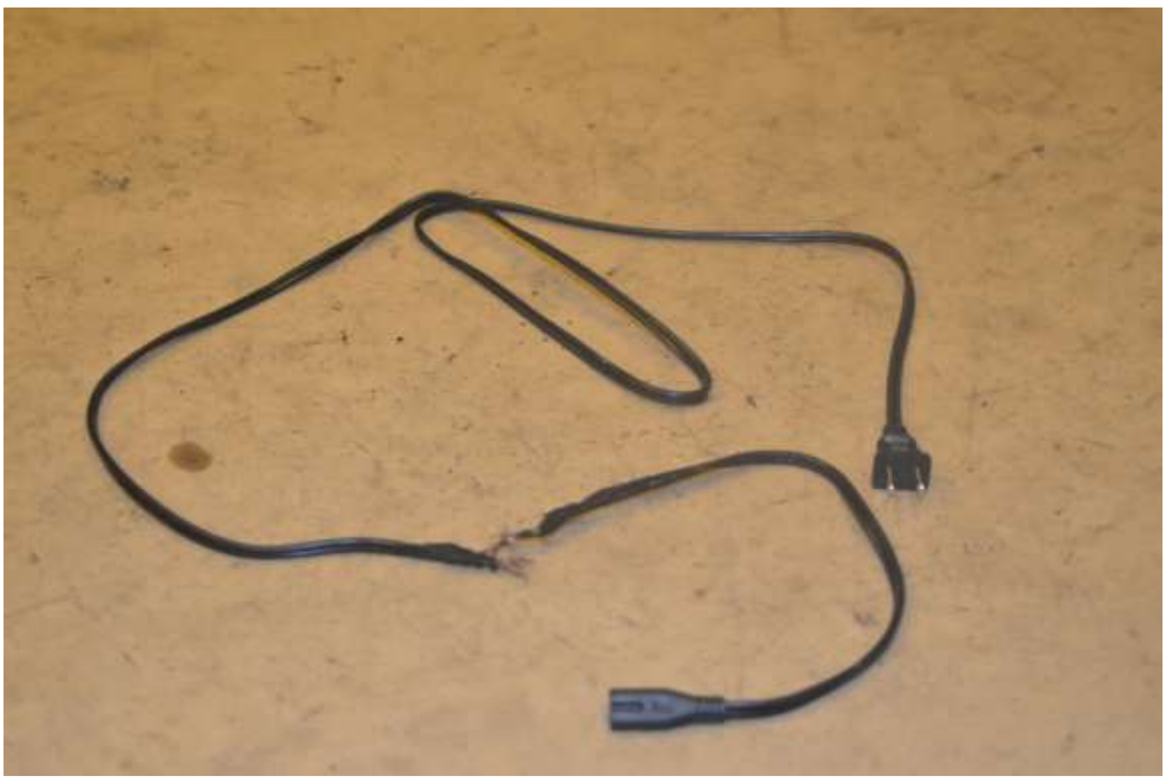
63. Run #23, showing Cables-To-Go 18-2 Type SPT Power Supply Cord, Leviton 15 Amp Sample.



64. Run #23, showing Burned Section.

STUDY RESULTS PHOTOGRAPHS

65. Run #23, showing Line-Neutral Conductor Arcing.



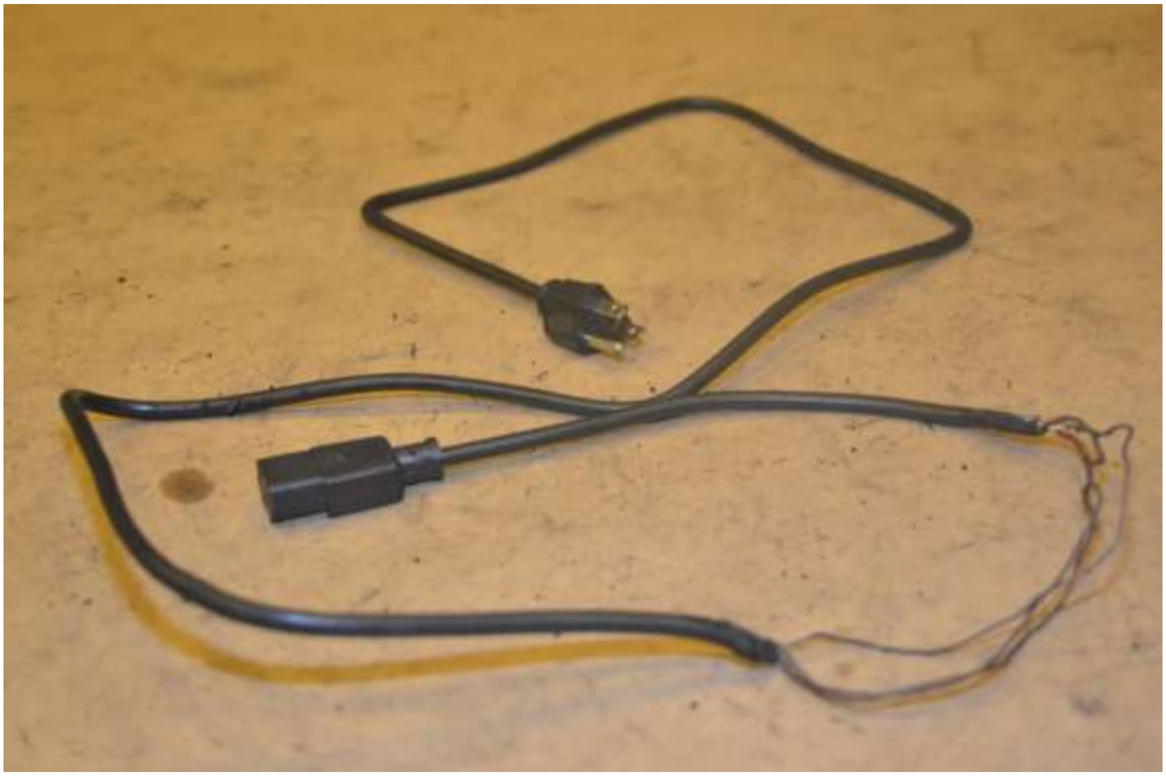
66. Run #24, showing Cables-To-Go 18-2 Type SPT Power Supply Cord, Leviton 20 Amp Sample.

STUDY RESULTS PHOTOGRAPHS

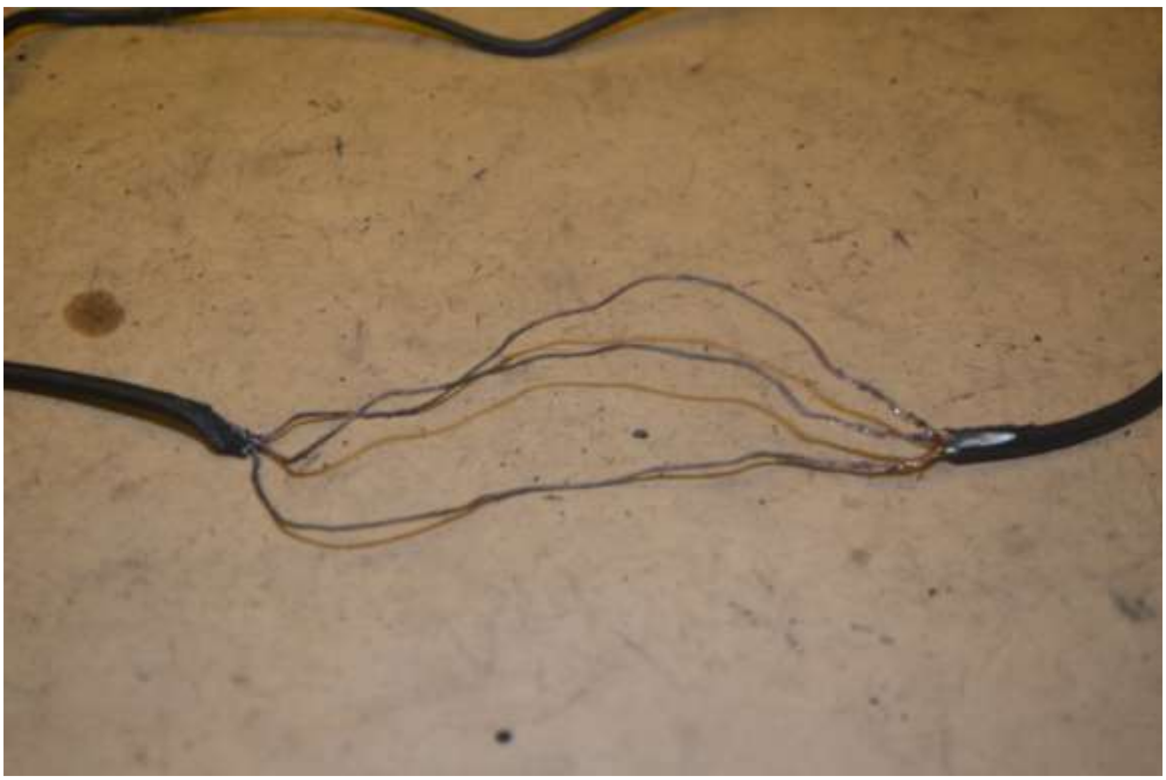
67. Run #24, showing Burned Section.

68. Run #24, showing Line-Neutral Conductor Arcing.

STUDY RESULTS PHOTOGRAPHS

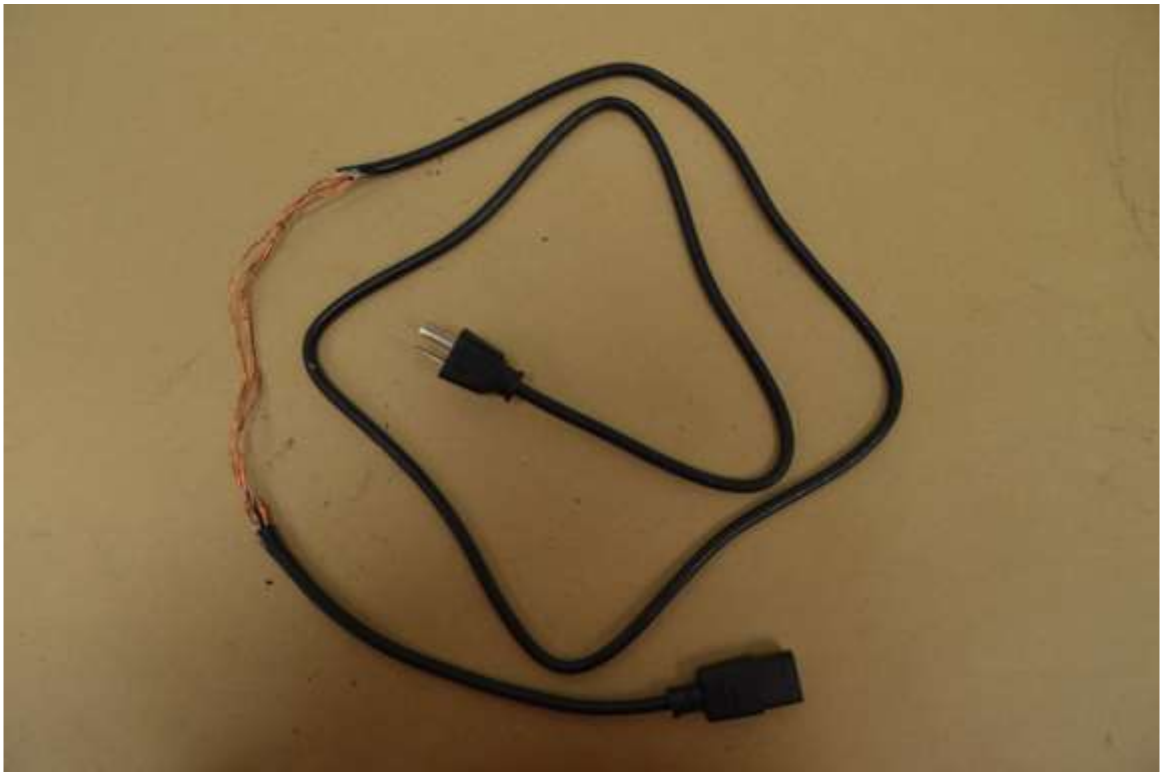


69. Run #25, showing Cables-To-Go 18-3 Type SVT Power Supply Cord, Cooper 15 Amp Sample.

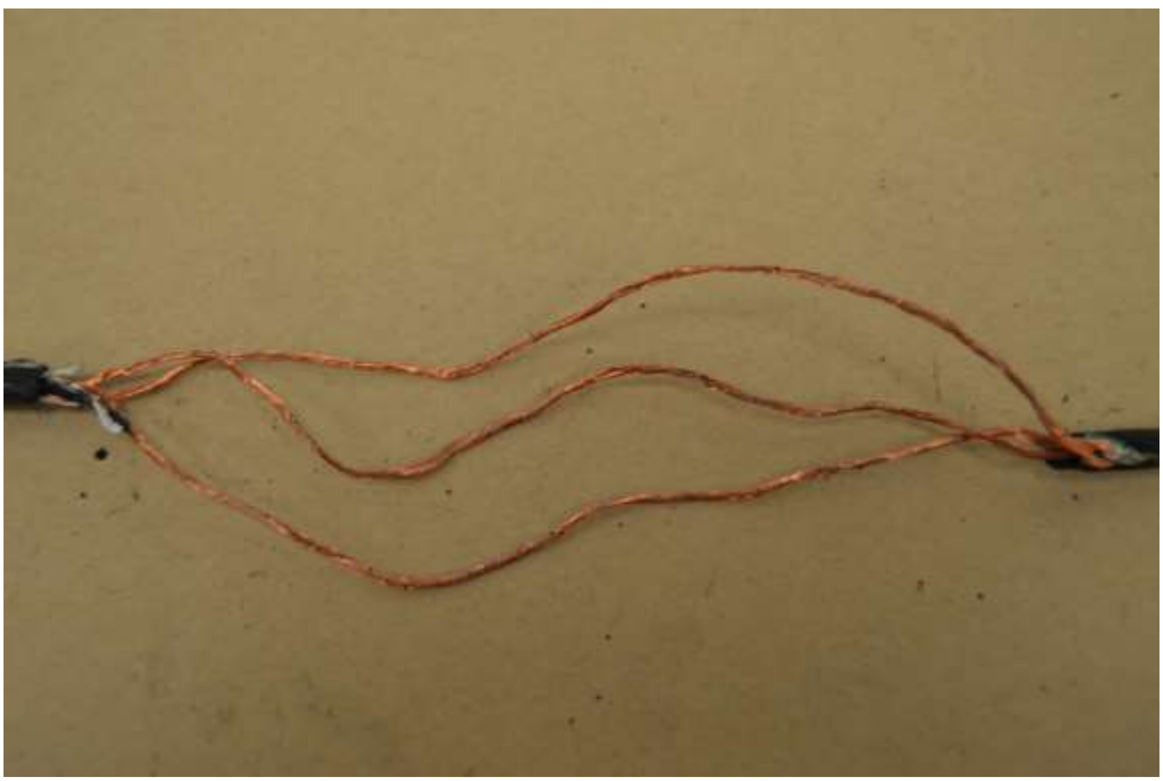


70. Run #25, showing Burned Section.

STUDY RESULTS PHOTOGRAPHS



71. Run #26, showing Cables-To-Go 18-3 Type SVT Power Supply Cord, Cooper 20 Amp Sample.



72. Run #26, showing Burned Section.

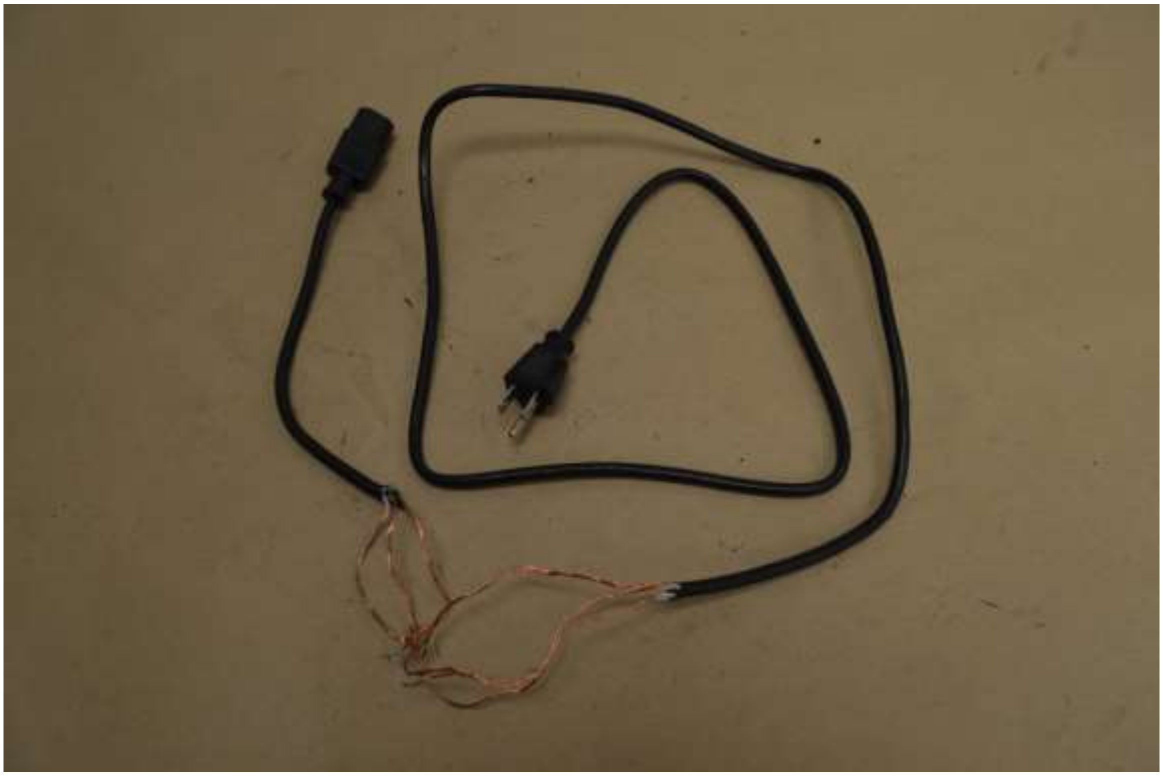
STUDY RESULTS PHOTOGRAPHS

73. Run #27, showing Cables-To-Go 18-3 Type SVT Power Supply Cord, Hubbell 15 Amp Sample.

74. Run #27, showing Burned Section.

STUDY RESULTS PHOTOGRAPHS

75. Run #27, showing Line-Ground-Neutral Conductor Arcing.

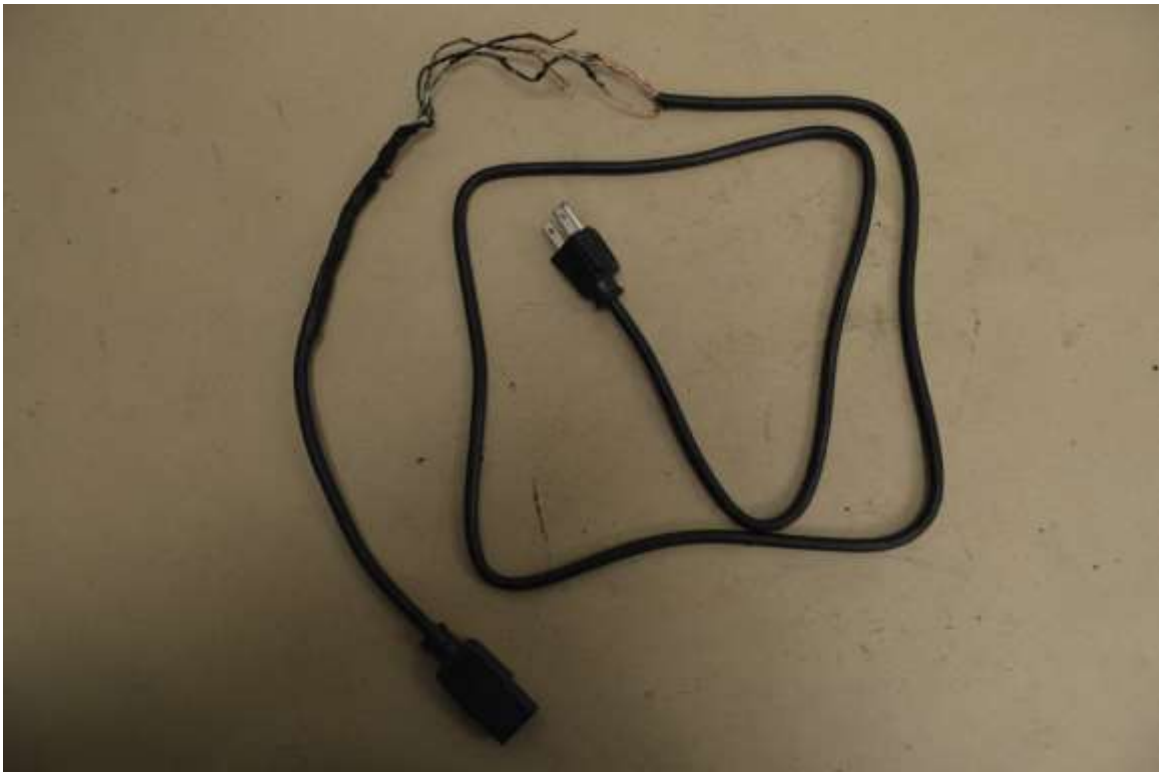


76. Run #28, showing Cables-To-Go 18-3 Type SVT Power Supply Cord, Hubbell 20 Amp Sample.

STUDY RESULTS PHOTOGRAPHS

77. Run #28, showing Burned Section.

78. Run #28, showing Line-Ground Conductor Arcing.

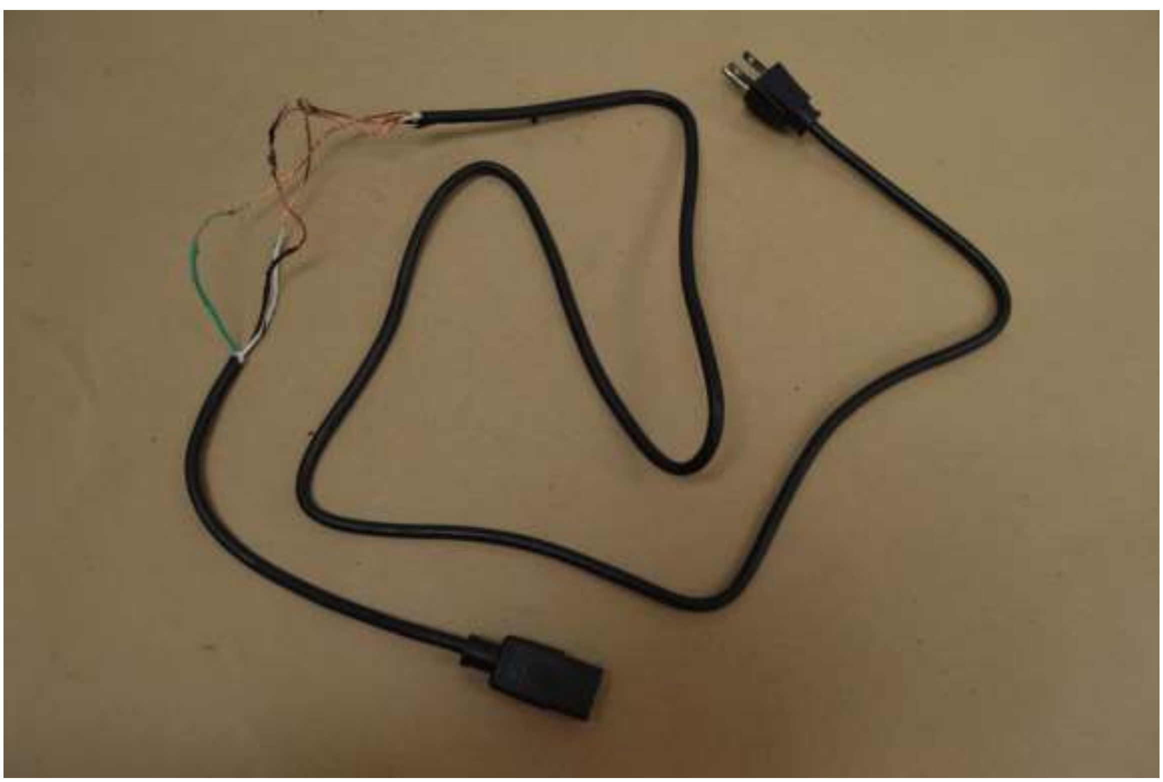


79. Run #29, showing Cables-To-Go 18-3 Type SVT Power Supply Cord, Leviton 15 Amp Sample.

80. Run #29, showing Burned Section.

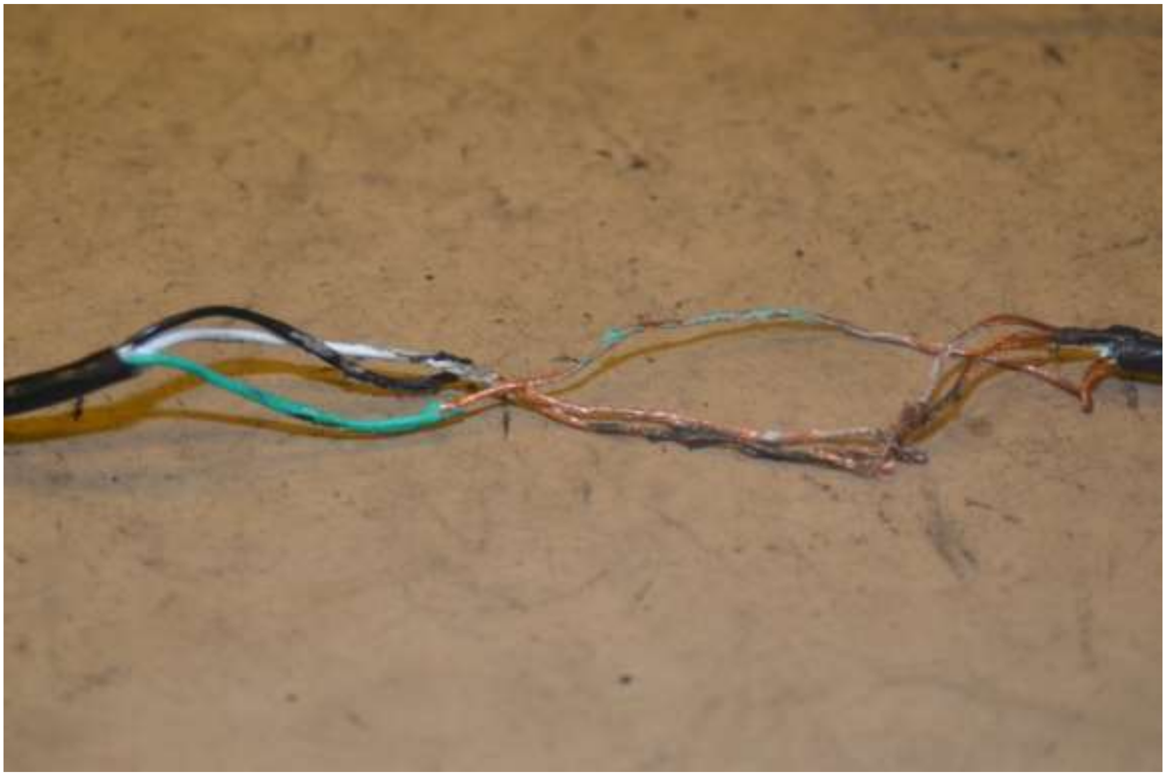
STUDY RESULTS PHOTOGRAPHS

81. Run #29, showing Line-Neutral Conductor Arcing.



82. Run #30, showing Cables-To-Go 18-3 Type SVT Power Supply Cord, Leviton 20 Amp Sample.

STUDY RESULTS PHOTOGRAPHS



83. Run #30, showing Burned Section.

84. Run #30, showing Line-Neutral Conductor Arcing.

CONCLUSIONS

The results of fire attack to flexible cords demonstrate that some of the common perceptions of the fire investigation community are not so clear.

Of the 12 three-wire flexible cords runs, six had visible arcing, with four involving the grounding conductor. This demonstrates that arcing-through-char involving the energized and grounding conductors can occur prior to activation of the GFCI protection. In two of these arcing events, the over-current protection cleared the fault prior to the GFCI protection activating. These results would seem to contradict the perception that a GFCI outlet will prevent arcing-through-char involving the grounding conductor of a flexible cord.

Of the 18 two-wire flexible cords runs, the arcing-through-char did not activate the GFCI protection. This would seem to support the perception that arcing-through-char involving the energized and neutral conductors of a flexible cord will not trip a GFCI outlet.

In summary, this study has established some initial results to provide clarity on common perceptions of GFCI outlet performance during arcing-through-char events of flexible cords. As with any study, a larger sample size with different power supply cords & cord sets would further support these findings.

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