UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
E	var.

Product	Device
# 9	Supplemental Protective Device

Test Summary

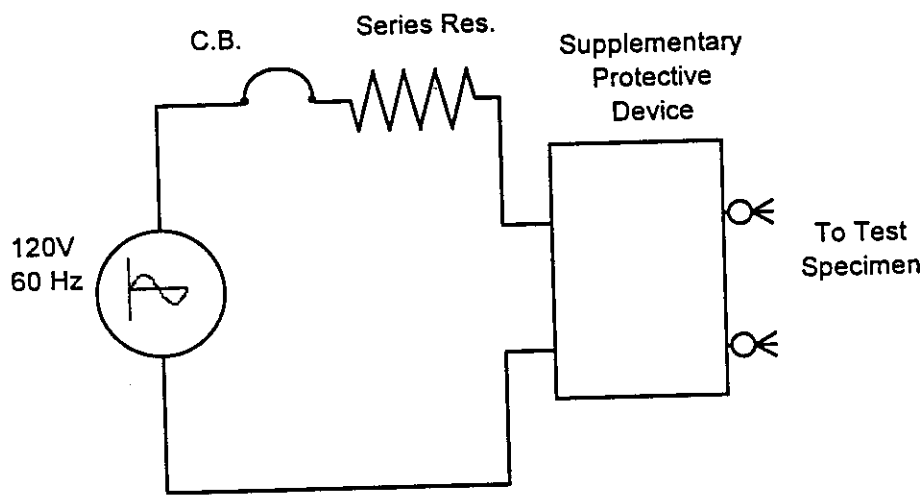
Partial Carbonized Path Fault

Run	Volts	Short-Circuit Current	Trip? (Y / N)	F.I. Ignite? (Y / N)	Time (msec)	Max (volts)	Min (volts)	Comments
1	119	300	N	N	13.0	2.08	2.32	Cord fused open
2	119	300	N	N	4.0	1.12	0.00	Cord fused open
3	119	300	N	Y	38.9	2.48	2.32	Multiple bursts
4	119	300	N	Y	22.5	2.40	2.16	
5	119	300	N	Y	20.3	2.16	2.40	
6	119	300	N	Y	28.0	2.40	2.64	Multiple bursts

Notes:

Runs 1-6 performed on sample # 36

Circuit:



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UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
E	var.

Product	Device
# 10	Supplemental Protective Device

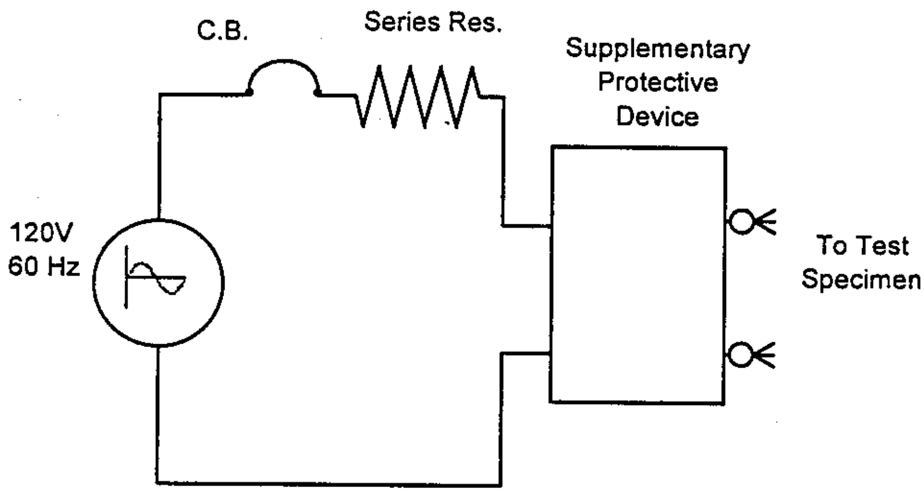
Test Summary

Partial Carbonized Path Fault

Run	Volts	Short-Circuit Current	Trip? (Y / N)	F.I. Ignite? (Y / N)	Time (msec)	Max (volts)	Min (volts)	Comments
1	119	300	Y	N	3.9	1.20	0.08	
2	119	300	Y	N	2.0	2.14	0.02	
3	119	300	N	N	-	-		Scope false trigger
4	119	300	Y	N	-	-		Scope false trigger
5	119	300	Y	N	11.6	1.64	0.08	
6	119	300	Y	N	5.9	2.00	0.04	

Notes:

Circuit:



Rotational Flexing:

This test was conducted for two purposes. The first was to demonstrate that degradation of cords can result in carbonized paths, without using high voltage to establish such a path, and eventually result in a fire. The second was to evaluate Product No. 8.

For the purpose of the demonstration, a No.16 AWG SPT-2 power supply cord was flexed in a circular cranking motion (stress concentrated in two right-angle bends about six inches apart) until one of the conductors broke resulting in a series fault. Then, 16.5 A (110% of a 15 A circuit-breaker rating) was passed through the cord periodically, a few hours at a time, from a 120 V circuit having approximately 300 A short-circuit capacity. The current passed through the series fault.

Product No. 8 incorporates ground-fault protection technology as an integral part of a cord set construction. This product was subjected to the Rotational Flexing Test in order to determine if the ground-fault interrupting technology would detect and respond to the fault prior to ignition.

Key to Headings and Abbreviations Used in the Presentation of Data Pages 80-81

Volts -- Open-circuit supply voltage.

Load Current -- Refers to the load current in the circuit.

F.I. Ignite? (Y or N) -- "F. I." means "fire indicator". Indicates whether the cheesecloth fire indicator ignited.

Time - Time of day.

Total Elapsed Time - Time in hours.

UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
C	20 A

Product	Device
(none)	

Test Summary

Rotational Flexing

Date	Volts	Load Current	Start/Stop	Time	Comments
6/8/95	119	16.5	start	1:45 PM	SPT-2, 16 AWG cord
	119	16.5	stop	4:00 PM	
6/9/95	119	16.5	start	9:45 AM	
	119	16.5	stop	11:45 AM	
	119	16.5	start	1:00 PM	
	119	16.5	stop	3:30 PM	
6/12/95	119	16.5	start	7:45 AM	
	119	16.5	stop	10:00 AM	
	119	16.5	start	1:00 PM	
	119	16.5	stop	3:30 PM	
6/13/95	119	16.5	start	7:20 AM	
	119	16.5	stop	11:45 AM	
	119	16.5	start	12:30 PM	
	119	16.5	stop	4:30 PM	
6/14/95	119	16.5	start	8:00 AM	
	119	16.5	stop	11:30 AM	
	119	16.5	start	12:30 AM	
	119	16.5	stop	4:30 PM	
6/15/95	119	16.5	start	7:30 AM	Immediate arcing & ignition of F.I.

UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used

Product	Device
# 8	Ground Fault Protection

Test Summary

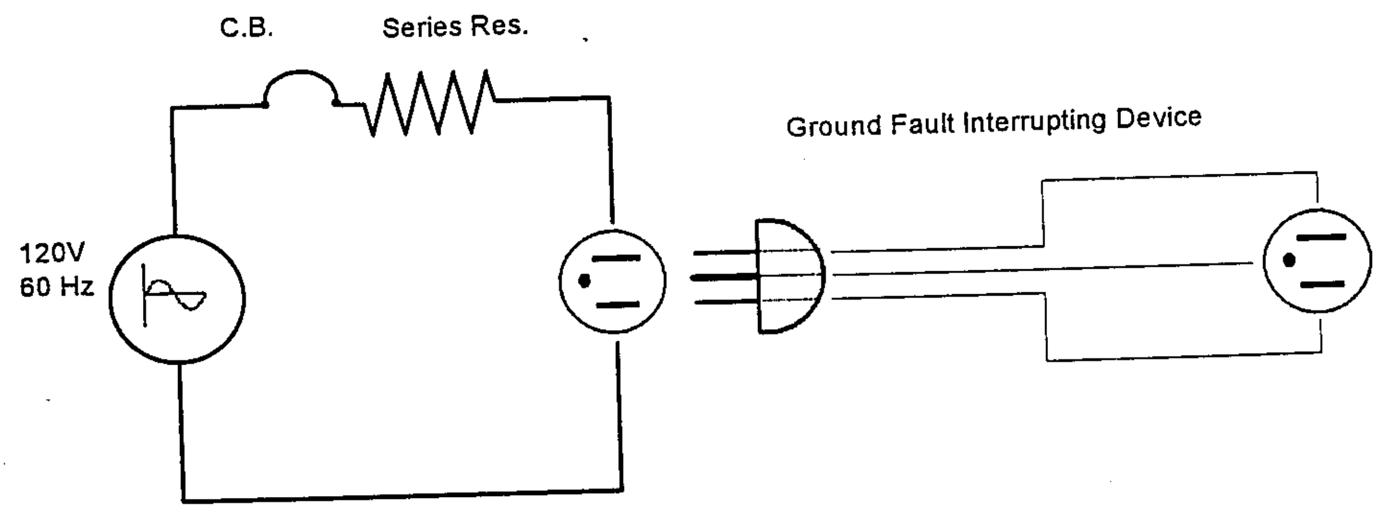
Rotational Flexing

Volts	Load Current	Total Elapsed Time	F.I. Ignite? (Y / N)	Comments
120	13	1h		
120	15	2h		
120	17	3h		
120	19	4h		
120	21	5h	N	Device tripped w/o ignition of F.I.

Comments:

This test run on cord specimen integral with ground fault protection technology.

Circuit:



Wet Track Arc Fault:

Wet/dry cycling of certain insulating materials can slowly build carbon tracks, spot by spot, on the surface of insulation material between live parts of opposite polarity. Each wetting of the insulating material causes a small current to flow between the live parts across the surface of the insulating material. The current warms the current path, and promotes evaporation of the water. When the current path through the moisture is no longer continuous between the conductive parts, the interruption of the current causes a small spot of carbon to remain on the surface of the insulating material. Generally, the interruption of current will occur at a location where the electrical resistance of the insulating material is still high -- that is, where carbonization has not yet occurred. Eventually, after many repeated wetting/drying cycles, the carbon spots form a track that connects the live parts through carbon. When this happens, a high current flows and the material rapidly overheats and can cause a fire.

This test is designed to evaluate the ability of a protective device to sense the creation of the carbon track in the incipient stages before it develops to the extent that the carbon track bridges completely across the live parts. The insulating material used in this test procedure is a printed wiring board, although the phenomenon can occur in many electrical parts including switches mounted in products used near water. Examples include kitchen appliances that may be operated by wet hands dripping water into the switch and electrical products left outdoors in rain or that are exposed to temperature excursions through the dew point producing condensation. Contamination can increase the conductivity of the water. This is sometimes represented in the test by the addition of a salt such as ammonium chloride to the water used in the test.

For ground-fault interrupting devices, the current is returned to the supply without going through the differential transformer on the protective device so that all of the current appears as *ground-fault current*. Line voltage is supplied to the input of the ground-fault interrupting device to energize the device, when necessary to operate the trip circuitry.

Note: The European ground-fault interrupting device is rated 240 V, but it was operated on a 120 V circuit to determine its relevance to branch circuits in the United States (rather than 230 V European circuits). Since this device functions solely as a current-sensitive device that does not need voltage across its line terminals to function, line voltage was not applied across the input terminals of the device during this testing.

Key to Headings and Abbreviations Used in the Presentation of Data Pages 84-86

Volts -- Open-circuit supply voltage.

Maximum Current or Wattage - Series-load current or wattage.

Trip? (Y or N) -- Indicates whether the protective device opened the circuit.

F.I. Ignite? (Y or N) -- "F. I." means "fire indicator", which was a phenolic composition printed wiring board. Indicates whether the fire indicator ignited.

UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V

Product	Device
# 1	Arc Fault detector

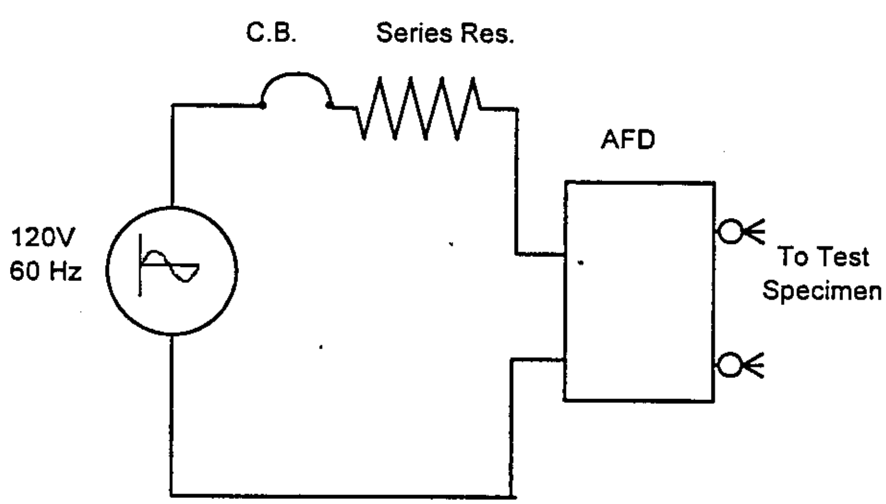
Test Summary

Wet Track Arc Fault

Run	Volts	Max. Current/ Wattage	Trip ? (Y / N)	F.I. Ignited ? (Y / N)	Comments
1	118	150 W	Y	Y	Tungsten Filament Lamp
2	118	3 A	N	Y	Resistive Load

Notes:

Circuit:



UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V

Product	Device
# 2	Arc Fault Detector

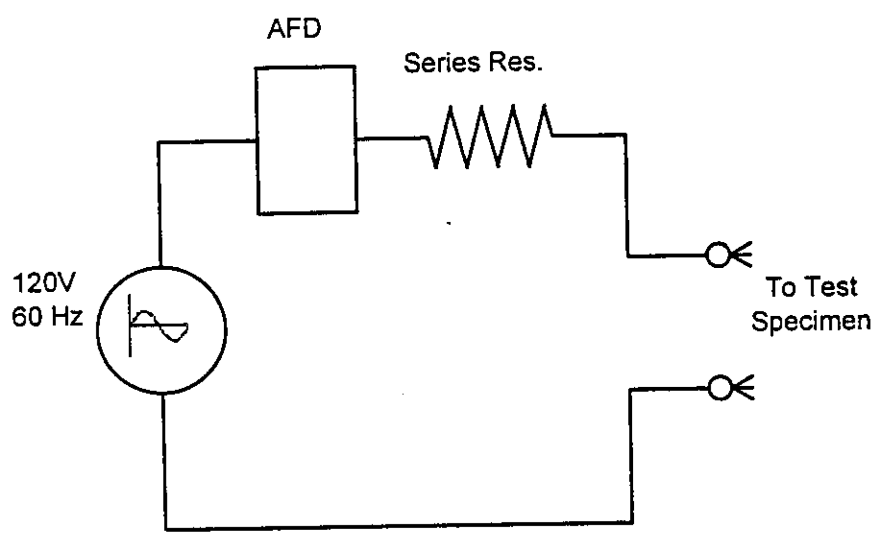
Test Summary

Wet Track Arc Fault

Run	Volts	Max. Current/ Wattage	Trip ? (Y / N)	F.I. Ignited ? (Y / N)	Comments
1	118	15 A	Y	N	Resistive Load
2	118	150 W	Y	N	Tungsten Filament Lamp
3	118	3 A	N	Y	Resistive Load

Notes:

Circuit:



UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V

Product	Device
# 6	Ground-Fault Interrupting Device

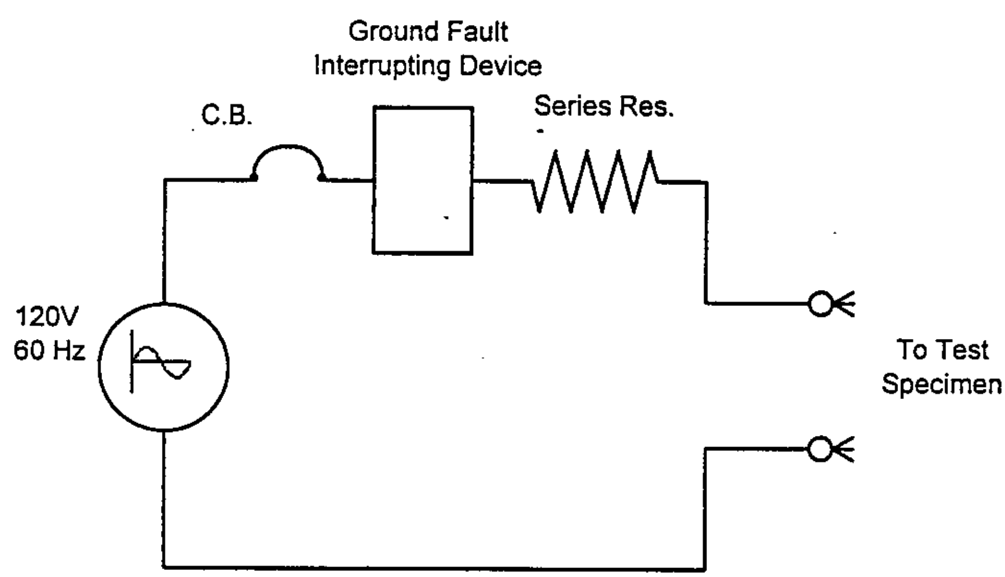
Test Summary

Wet Track Arc Fault

Run	Volts	Max. Current/ Wattage	Trip ? (Y / N)	F.I. Ignited ? (Y / N)	Comments
1	118	30 mA	Y	N	Fault to ground

Notes: Numerous trials were conducted. It was not possible to cause printed wiring board to arc track at current levels below trip level.

Circuit:



Arc Simulators:
The arc simulators were supplied by two of the participants.

Arc Simulator No. 1 - A 120 V source with a short-circuit capability of approximately 300 A is used to supply a load through the test fixture. The load can be a lamp bank, resistor, or any appliance ranging from a few amperes to the maximum pern.itted by the overcurrent device. The test fixture consists of a graphite rod and a phosphor bronze rod meeting end-to-end. The test begins with the two rods touching. The load current is broken by slowly separating the rods with the use of a screw. Several seconds of arcing occurs in the gap formed between the rods. When the current stops, the rods are rejoined and the separation process is repeated a few times. It is determined whether the protective device under test can sense the arcing and interrupt the circuit.

Arc Simulator No. 2 - This test fixture is similar to Arc Simulator No. 1 except that the shape, size, and material of the rods and contacts are different. The end-to-end rods are larger in Arc Simulator No. 2 and made of carbon and copper. Another difference is that electrode separation includes rotation in Arc Simulator No. 1, but is nonrotational in Arc Simulator No. 2.

Key to Headings and Abbreviations Used in the Presentation of Data Pages 88-98

Volts -- Open-circuit supply voltage.

Current -- Refers to the current in the circuit with the contacts of the arc simulator together, prior to separation.

Trip? (Y or N) -- Indicates whether the protective device opened the circuit.

Time (sec) -- The duration of the run, from the time the contacts on the simulator were first separated to the time of tripping, in seconds. If tripping did not occur within 30 seconds, the run was terminated.

UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	2 A, 5 A, 10 A, 20 A

Product	Device
# 1	Arc Fault Detector

Test Summary

Series arc using arc simulator #1

Run	Volts	Current	Trip (Y / N ?)	Time (sec)	Comments
1	119	0.92	Y	2	
2	119	0.92	Y	4	
3	119	0.92	Y	3	
4	119	0.92	Y	3	
5	119	0.92	Y	3	
6	119	0.92	Y	3	
7	119	2.9	Y	3	
8	119	2.9	Y	3	
9	119	2.9	Y	2	
10	119	2.9	Y	7	
11	119	2.9	Y	3	
12	119	2.9	Y	3	
13	119	4.9	Y	3	
14	119	4.9	Y	3	
15	119	4.9	Y	3	
16	119	4.9	Y	2	
17	119	4.9	Y	3	
18	119	4.9	Y	2	
19	118.5	9.8	Y	2	
20	118.5	9.8	Y	2	
21	118.5	9.8	Y	3	
22	118.5	9.8	Y	3	
23	118.5	9.8	Y	3	
24	118.5	9.8	Y	2	
25	118	15	Y	3	
26	118	15	Y	3	
27	118	15	Y	2	
28	118	15	Y	2	
29	118	15	Y	2	
30	118	15	Y	2	

Notes:

Continued on next page.

UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	2 A, 20 A

Product	Device
# 1	Arc Fault Detector

Test Summary

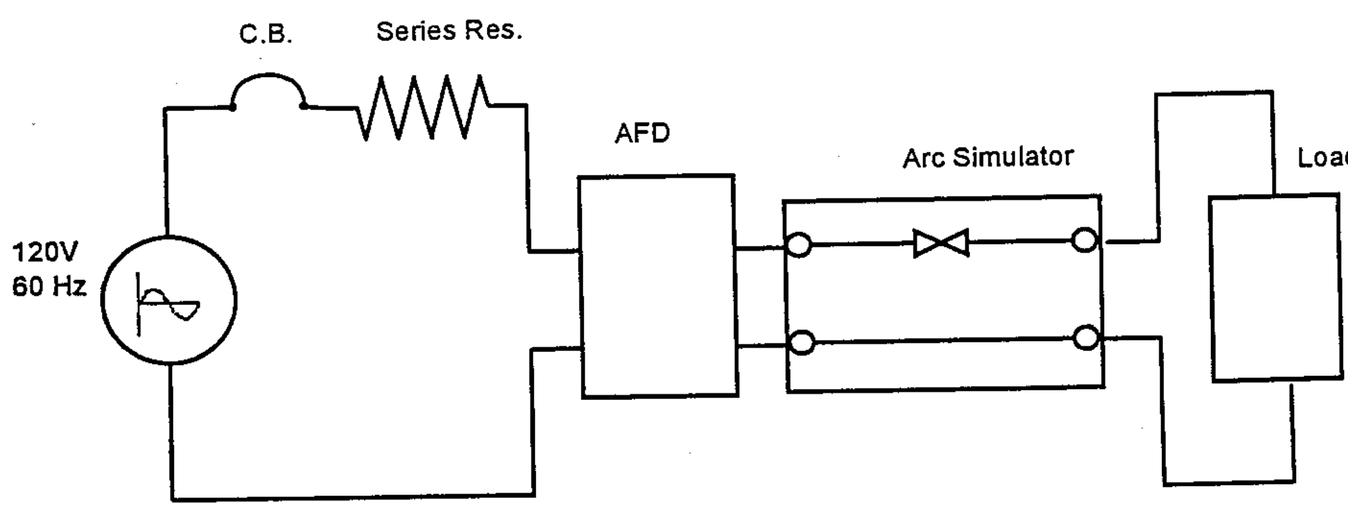
Series arc using arc simulator #1

Run	Volts	Current	Trip (Y / N ?)	Time (sec)	Comments
31	117.5	15	Y	3	
32	117.5	15	Y	3	
33	117.5	15	Y	2	
34	117.5	15	Y	2	
35	117.5	15	Y	4	
36	117.5	15	Y	2	
37	118	0.91	Y	14	
38	118	0.91	Y	3	
39	118	0.91	Y	30	
40	118	0.91	Y	2	
41	118	0.91	Y	5	
42	118	0.91	Y	3	

Notes:

Electrodes on arc simulator were cleaned before each run. Electrodes were s-l-o-w-l-y separated. If electrode separation became too big to support arcing, electrodes were closed and slow separation repeated.

Circuit:



UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	2 A, 5 A, 10 A, 20 A

Product	Device
# 2	Arc Fault Detector

Test Summary

Series arc using arc simulator #1

Run	Volts	Current	Trip (Y / N ?)	Time (sec)	Comments
1	118	0.92	N	>30	
2	118	0.92	N	>30	
3	118	0.92	N	>30	
4	118	0.92	N	>30	
5	118	0.92	N	>30	
6	118	0.92	N	>30	
7	118	2.9	N	>30	
8	118	2.9	N	>30	
9	118	2.9	N	>30	
10	118	2.9	N	>30	
11	118	2.9	N	>30	
12	118	2.9	N	>30	
13	118	4.9	N	>30	
14	118	4.9	N	>30	
15	118	4.9	N	>30	
16	118	4.9	N	>30	
17	118	4.9	N	>30	
18	118	4.9	N	>30	
19	118	9.8	N	>30	
20	118	9.8	N	12	
21	118	9.8	N	>30	
22	118	9.8	N	>30	
23	118	9.8	N	>30	
24	118	9.8	N	>30	
25	118	15	Y	12	
26	118	15	Y	13	
27	118	15	Y	28	
28	118	15	Y	5	
29	118	15	Y	12	
30	118	15	Y	14	

Notes:

Electrodes on arc simulator were cleaned before each run. Electrodes were s-l-o-w-l-y separated.
If electrode separation became too big to support arcing, electrodes were closed and slow separation repeated.

Circuit:

See next page.

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Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

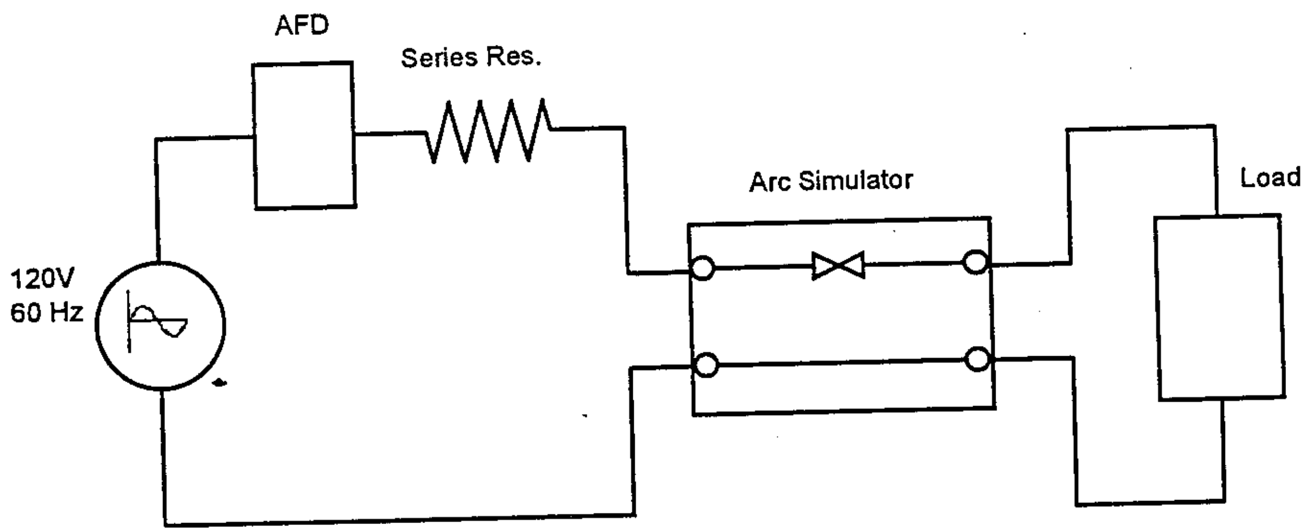
Instr.	Range Used
A	150 V
B	2 A, 5 A, 10 A, 20 A

Product	Device
# 2	Arc Fault Detector

Test Summary

Series arc using arc simulator #1

Circuit:



UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	20 A

Product	Device
# 4	Modified Trip Circuit Breaker

Test Summary

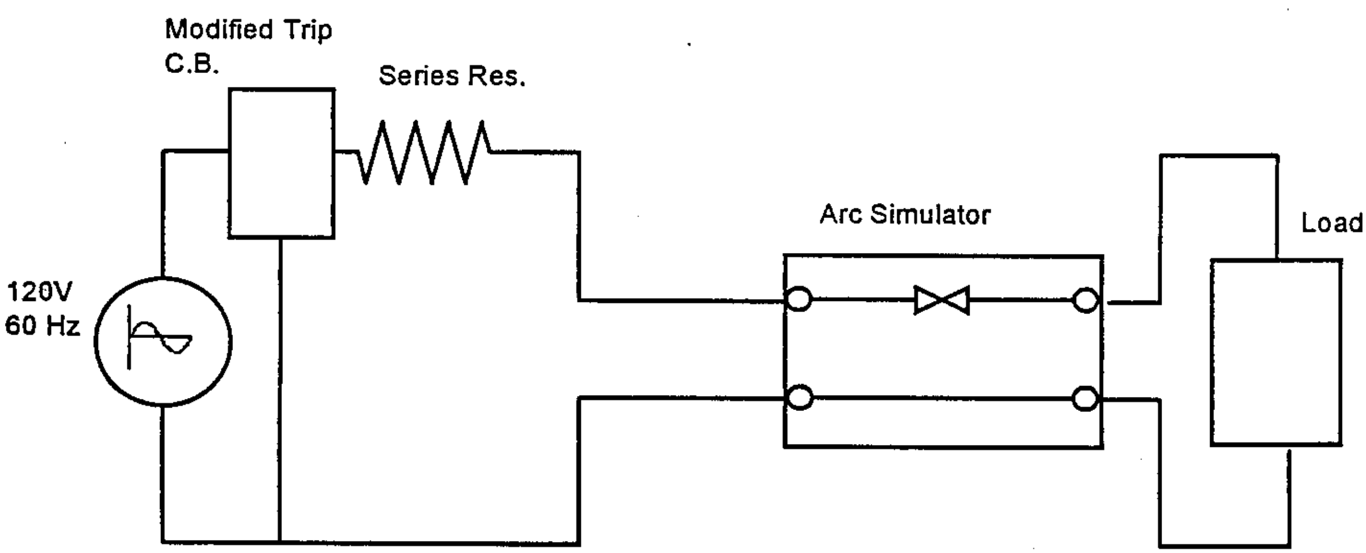
Series arc using arc simulator #1

Run	Volts	Current	Trip (Y / N ?)	Time (sec)	Comments
1	120	15	N	>30	
2	120	15	N	>30	
3	120	15	N	>30	
4	120	15	N	>30	
5	120	15	N	>30	
6	120	15	N	>30	

Notes:

Electrodes on arc simulator were cleaned before each run. Electrodes were s-l-o-w-l-y separated. If electrode separation became too big to support arcing, electrodes were closed and slow separation repeated.

Circuit:



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Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	2 A, 5 A, 10 A, 20 A
E	var.

Product	Device
# 1	Arc Fault Detector

Test Summary

Series arc using arc simulator #2

Run	Volts	Current	Trip (Y / N ?)	Time (sec)	Comments
1	119	0.92	Y	12	
2	119	0.92	Y	1	
3	119	0.92	Y	1	
4	119	0.92	Y	5	
5	119	0.92	Y	2	
6	119	0.92	Y	2	
7	119	2.9	Y	3	
8	119	2.9	Y	2	
9	119	2.9	Y	3	
10	119	2.9	Y	11	
11	119	2.9	Y	2	
12	119	2.9	Y	2	
13	118	4.9	N	>30	
14	118	4.9	Y	28	
15	118	4.9	Y	4	
16	118	4.9	N	>30	
17	118	4.9	Y	2	
18	118	4.9	Y	22	
19	118	9.8	N	>30	
20	118	9.8	N	>30	
21	118	9.8	N	>30	
22	118	9.8	N	>30	
23	118	9.8	N	>30	
24	118	9.8	N	>30	
25	118	14.9	N	>30	
26	118	14.9	N	>30	
27	118	14.9	N	>30	
28	118	14.9	N	>30	
29	118	14.9	N	>30	Ignited electrode holder on arc simulator

Continued on next page.

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TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	2 A, 5 A, 10 A, 20 A
E	var.

Product	Device
# 1	Arc Fault Detector

Test Summary

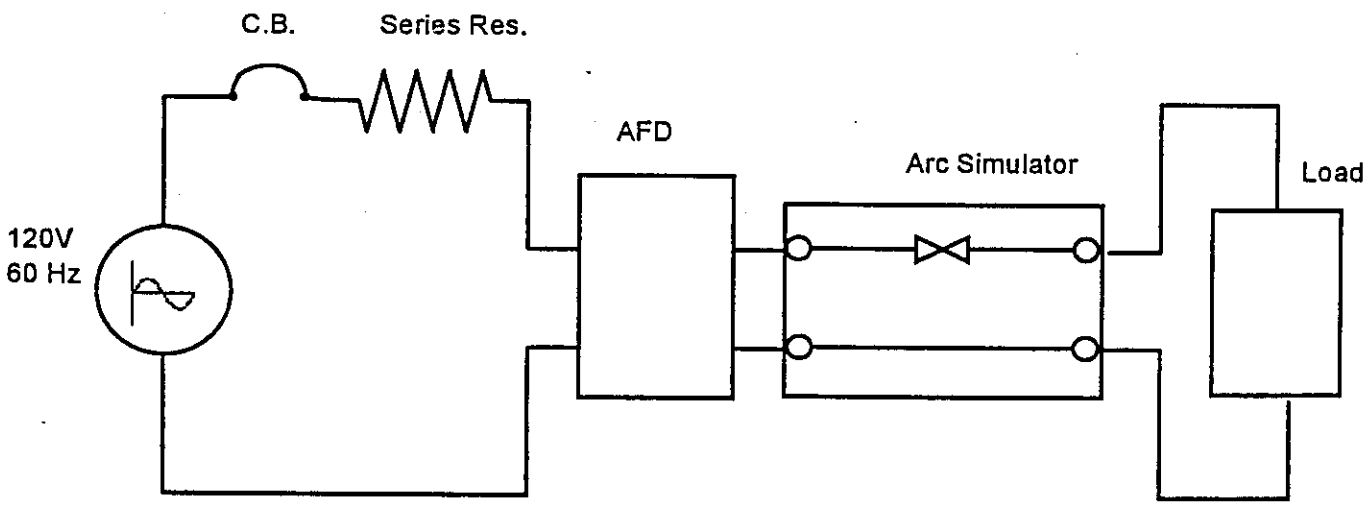
Series arc using arc simulator #2

Run	Volts	Current	Trip (Y / N ?)	Time (sec)	Comments
31	119	67	N	-	Back up CB tripped
32	119	67	N	>7.05	Ignited electrode holder on arc simulator
33	119	67	N	>7.68	Back up CB tripped

Notes:

Electrodes on arc simulator were cleaned before each run. Electrodes were s-l-o-w-l-y separated.
If electrode separation became too big to support arcing, electrodes were closed and slow separation repeated.

Circuit:



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Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	2 A, 5 A, 10 A, 20 A
E	var.

Product	Device
# 2	Arc Fault Detector

Test Summary

Series arc using arc simulator #2

Run	Volts	Current	Trip (Y / N ?)	Time (sec)	Comments
1	118	0.92	N	>30	
2	118	0.92	N	>30	
3	118	0.92	N	>30	
4	118	0.92	N	>30	
5	118	0.92	N	>30	
6	118	0.92	N	>30	
7	118	2.89	N	>30	
8	118	2.89	N	>30	
9	118	2.89	N	>30	
10	118	2.89	N	>30	
11	118	2.89	N	>30	
12	118	2.89	N	>30	
13	118	4.9	N	>30	
14	118	4.9	N	>30	
15	118	4.9	N	>30	
16	118	4.9	N	>30	
17	118	4.9	N	>30	
18	118	4.9	N	>30	
19	118	9.8	Y	4	
20	118	9.8	Y	4	
21	118	9.8	Y	12	
22	118	9.8	Y	6	
23	118	9.8	Y	4	
24	118	9.8	Y	2	
25	118	14.9	Y	2	
26	118	14.9	Y	2	
27	118	14.9	Y	2	
28	118	14.9	Y	2	
29	118	14.9	Y	2	
30	118	14.9	Y	3	

Continued on next page.

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Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	2 A, 5 A, 10 A, 20 A
E	var.

Product	Device
# 2	Arc Fault Detector

Test Summary

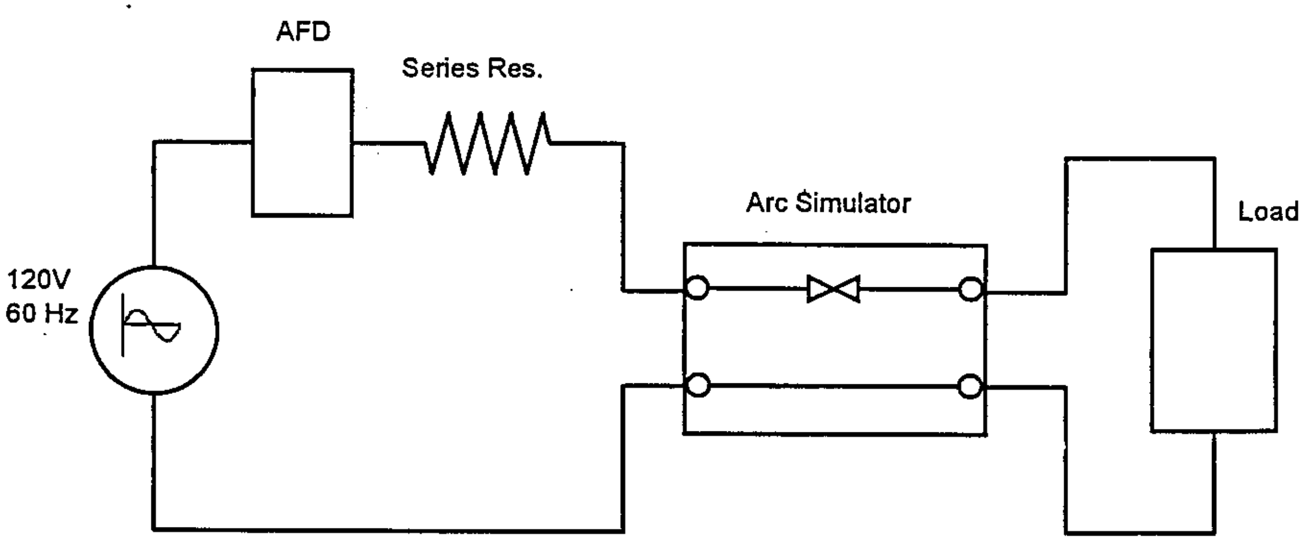
Series arc using arc simulator #2

Run	Volts	Current	Trip (Y / N ?)	Time (sec)	Comments
31	119	67	Y	0.177	
32	119	67	Y	0.458	
33	119	67	Y	0.052	
34	119	67	Y	0.201	
35	119	67	Y	0.343	
36	119	67	Y	0.752	

Notes:

Electrodes on arc simulator were cleaned before each run. Electrodes were s-l-o-w-l-y separated. If electrode separation became too big to support arcing, electrodes were closed and slow separation repeated.

Circuit:



UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	20 A
E	var.

Product	Device
# 3	Arc Fault detector

Test Summary

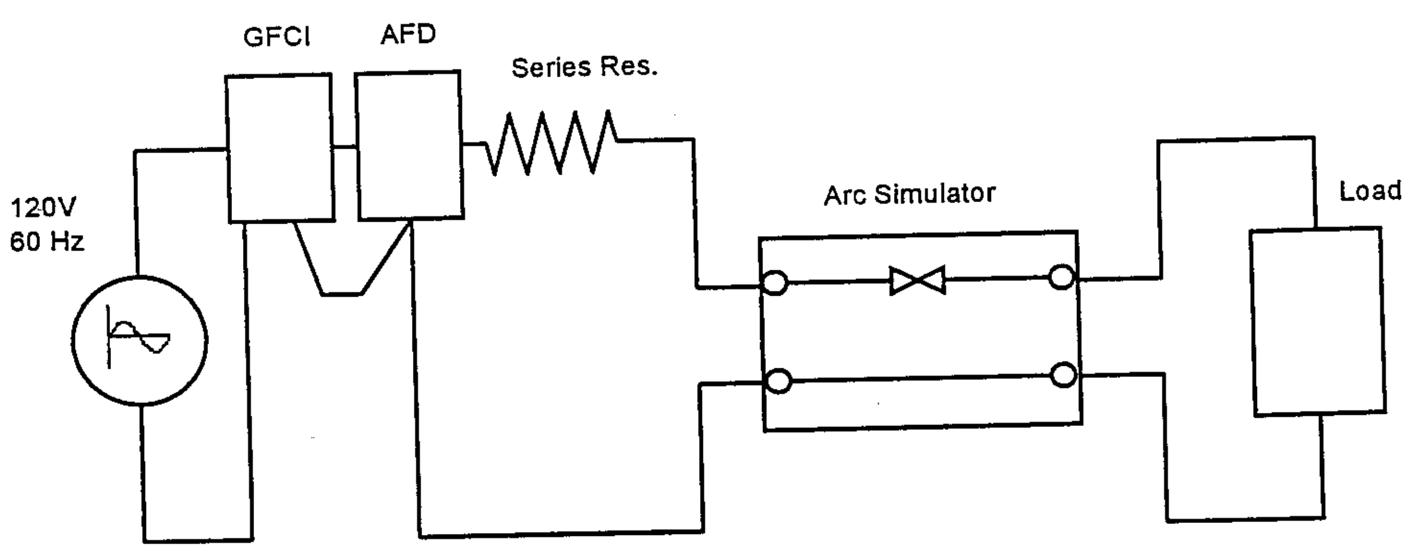
Series arc using arc simulator #2

Run	Volts	Current	Trip (Y / N ?)	Time (sec)	Comments
1	119.5	15	N	>30	
2	119.5	15	N	>30	
3	119.5	15	N	>30	
4	119.5	15	N	>30	
5	119.5	15	N	>30	
6	119.5	15	N	>30	
7	119	67	Y	>7.68	
8	119	67	Y	2.77	
9	119	67	Y	5.78	

Notes:

Electrodes on arc simulator were cleaned before each run. Electrodes were s-l-o-w-l-y separated. If electrode separation became too big to support arcing, electrodes were closed and slow separation repeated.

Circuit:



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UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	20 A
E	var.

Product	Device
# 4	Modified Trip Circuit Breaker

Test Summary

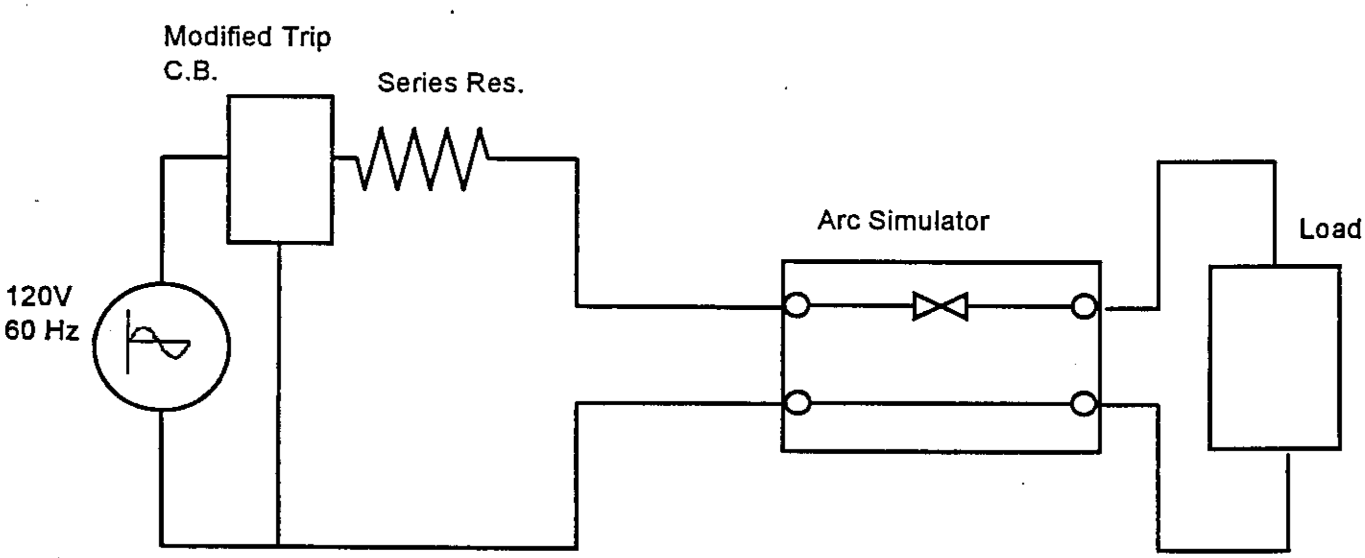
Series arc using arc simulator #2

Run	Volts	Current	Trip (Y / N ?)	Time (sec)	Comments
1	120	15.1	N	>30	
2	120	15.1	N	>30	
3	120	15.1	N	>30	
4	120	15.1	N	>30	
5	120	15.1	N	>30	
6	120	15.1	N	>30	
7	119	67	Y	0.023	
8	119	67	Y	0.102	
9	119	67	Y	0.102	
10	119	67	Y	0.114	
11	119	67	Y	0.128	
12	119	67	Y	0.106	

Notes:

Electrodes on arc simulator were cleaned before each run. Electrodes were s-l-o-w-l-y separated. If electrode separation became too big to support arcing, electrodes were closed and slow separation repeated.

Circuit:



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Series Make/Break Contact Arc:
These tests involve examples of practical loose or broken connections in a current-carrying circuit. One case involves a No. 14 AWG solid copper wire formed around a loose wire-binding screw. Another case involves a broken cord conductor that is pushed back together in such a way that arcing occurs between the broken strands that are brushed together in a "teasing" fashion. The current through the circuit ranged from 3 A to 15 A while the teasing contact and resulting arcing occurs.

Loose Wire Termination Test:
A No. 14 AWG solid copper wire is formed into a single loop around a wire-binding screw on a receptacle. The wire-binding screw is not tightened, and is left fully extended. Resistive load current is passed through the loose terminal. Initially, make/break arcing is created by jiggling the loose wire with a tool. The current and movement causes arcing between the wire and the screw. Unless a protective device opens the circuit, the arcing eventually will sustain itself without further mechanical manipulation, and progresses into a glowing connection.

Broken Conductor Test:
A length of No. 16 AWG SPT-2 cord is cut through one conductor, and placed in circuit conducting current to a resistive load. The cord is then manually manipulated to rapidly make and break the load current continuously. Following this, an attempt was made to create a persistent arc by making a teasing contact between the broken strands. Arcing occurs at the severed part of the cord. Unless a protective device opens the circuit, cord insulation begins to carbonize around the area of the arcing. This process is continued for several minutes before the test is terminated.

Key to Headings and Abbreviations Used in the Presentation of Data Pages 100-102

Volts -- Open-circuit supply voltage.

Load -- Refers to the current through the connection when a good contact is established.

Trip? (Y or N) -- Indicates whether the protective device opened the circuit.

UNDERWRITERS LABORATORIES INC. - TEST RECORD

Dept.: 216U Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	5 A, 20 A

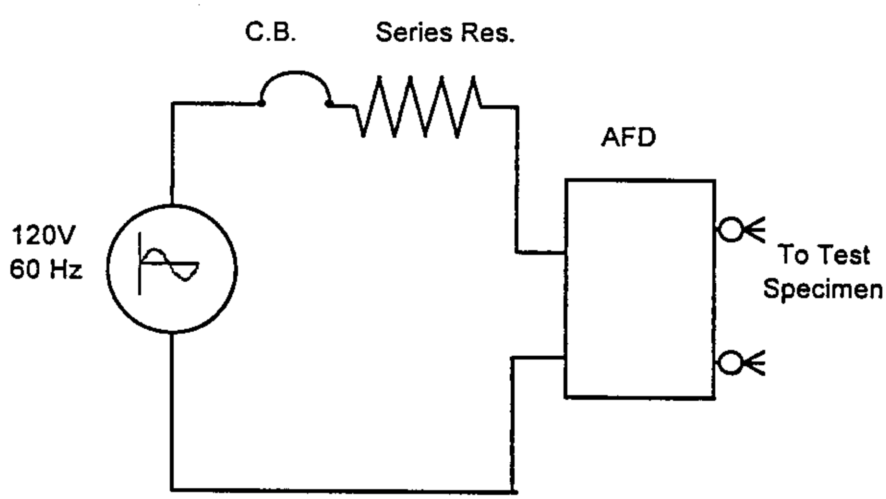
Product	Device
# 1	Arc Fault Detector

Test Summary

Make/Break at a Contact

Run	Volts	Available Load Current	Trip (Y / N ?)		Comments
1	119	14.6	N		Part of glowing connection at receptacle.
					Steel binding screw rotated CW & CCW to make
					and break electrical contact between copper wire
					and binding screw.
2	120	3	N		One conductor of type SPT-2 cord cut at mid-point.
					Specimen was connected to a series load w/o opposite
					polarity available. Cut ends of conductor were manipulated
					to produce repeated arcing at make/break contact.
3	120	10	N		One conductor of type SPT-2 cord cut at mid-point.
					Specimen was connected to a series load w/o opposite
					polarity available. Cut ends of conductor were manipulated
					to produce repeated arcing at make/break contact.
4	120	15	N		One conductor of type SPT-2 cord cut at mid-point.
					Specimen was connected to a series load w/o opposite
					polarity available. Cut ends of conductor were manipulated
					to produce repeated arcing at make/break contact.

Circuit:



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UNDERWRITERS LABORATORIES INC. - TEST RECORD

Dept.: 216U Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	20 A

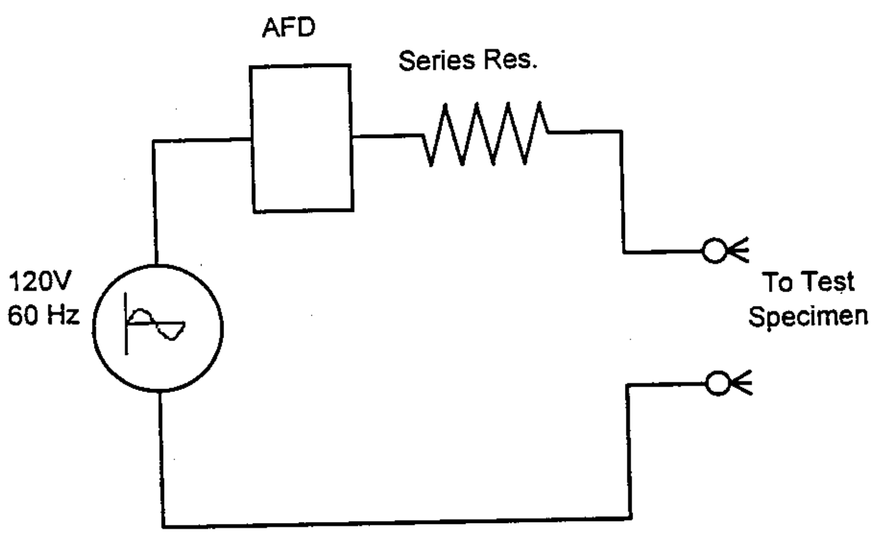
Product	Device
# 2	Arc Fault Detector

Test Summary

Make/Break at a Contact

Run	Volts	Available Load Current	Trip (Y / N ?)		Comments
1	119	14.6	N		Part of glowing connection at receptacle.
					Steel binding screw rotated CW & CCW to make
					and break electrical contact between copper wire
					and binding screw.
2	120	15	Y		One conductor of type SPT-2 cord cut at mid-point.
			(one trip		Specimen was connected to a series load w/o opposite
			out of		polarity available. Cut ends of conductor were manipulated
			several		to produce repeated arcing at make/break contact.
			attempts)		
3	120	10	N		One conductor of type SPT-2 cord cut at mid-point.
					Specimen was connected to a series load w/o opposite
					polarity available. Cut ends of conductor were manipulated
					to produce repeated arcing at make/break contact.

Circuit:



UNDERWRITERS LABORATORIES INC. - TEST RECORD

Dept.: 216U   Project No.: 94ME78760   File No.: USNC233   Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	20 A

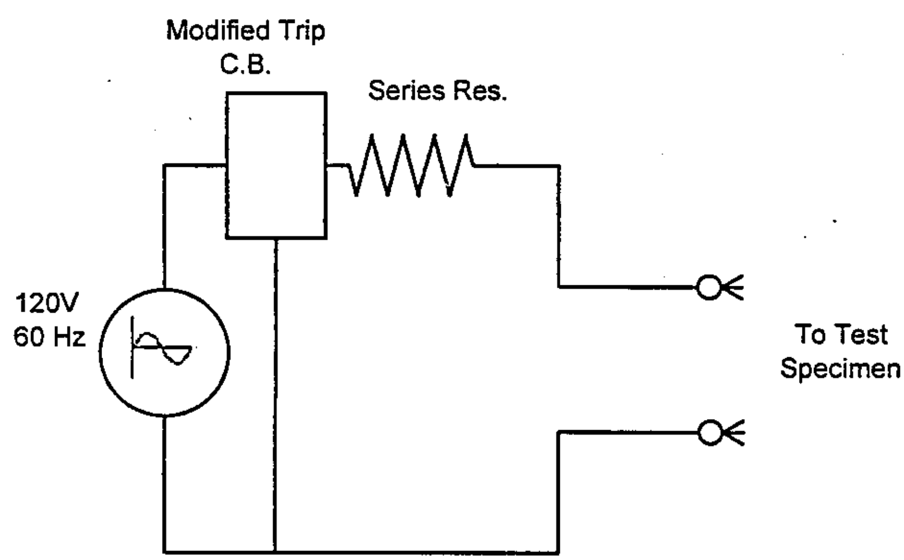
Product	Device
# 4	Modified Trip Circuit Breaker

Test Summary

Make/Break at a Contact

Run	Volts	Available Load Current	Trip (Y / N ?)		Comments
1	119	14.8	N		Part of glowing connection at receptacle.
					Steel binding screw rotated CW & CCW to make
					and break electrical contact between copper wire
					and binding screw.

Circuit:



Overheating Conductors

Conductors overheat due to *joule heating*. In this testing, the source of heating is an abnormally high resistance in the circuit. It can be assumed that the current is within the normal range, that is, lower than handle-rating of the overcurrent device since the protective devices being studied contain the overcurrent protection. Glowing connections and hot plugs are associated with overheating conductors.

Glowing Connections:
A glowing connection is a loose connection that has developed into a high-resistance connection. Several amperes through the connection can be sufficient to cause the connection to attain temperatures that glow -- hence the name glowing connection.

A glowing connection can be created in the laboratory by making a loose connection on a receptacle wire-binding screw terminal. The loose wire is wiggled with current flowing to cause heating of the terminal by continual arcing. A current of approximately 15 A or less will suffice. Having dissimilar metals in the connection like copper wire and a steel screw, enhances joule heating. The heat from the arcing raises the temperature of the connection and within a few minutes, a low-pressure connection between the wire and the binding screw can begin glowing. Once established, a high-resistance terminal is fairly stable if it is not mechanically disturbed. The current through the high-resistance connection can be cycled without disrupting the high-resistance property. It will continue to glow when the current is high, but lower than the handle-rating of a 15 or 20 A overcurrent device.

The plug-in devices were plugged into a receptacle that was prepared to have one glowing connection. The terminal chosen was the one that had the best chance of transferring heat to the temperature-sensitive element in the protective device. Again, because of the low ratings of the prototype specimens available, a test could not be performed at the higher current levels typical of devices like heaters and air-conditioners.

Key to Headings and Abbreviations Used in the Presentation of Data on Pages 104 - 107

Volts -- Open-circuit supply voltage.

Load -- Refers to the current through the glowing connection.

Trip? (Y or N) -- Indicates whether the protective device opened the circuit.

F.I. Ignited? (Y / N) -- No fire indicator was used.

UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	20 A

Product	Device
# 1	Arc Fault Detector

Test Summary

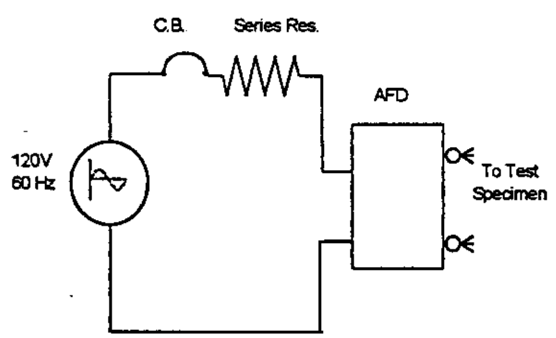
Receptacle Glowing Connection

Run	Volts	Load Current	Trip (Y / N ?)		Comments
1	119	14.6	N		Circuit #1
2	119	14.6	N		Circuit #2

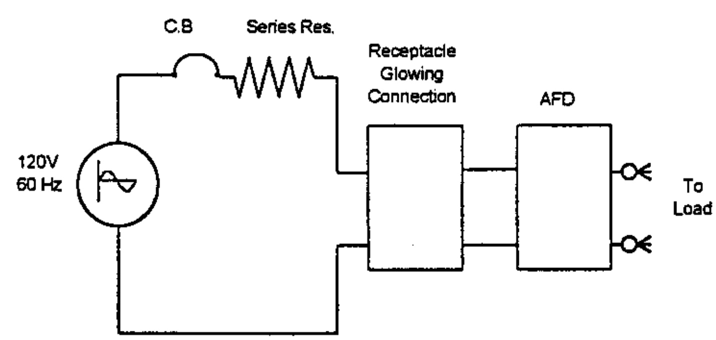
Notes:

A 15 A duplex receptacle having steel binding screws was wired with 14 AWG Type NM-B cable. A resistive load was connected to the receptacle and adjusted to approx. 15 A. One of the steel binding screws was loosened such that conduction was made through the steel screw. The screw and wire connection were manipulated to produce arcing and sparking. After a period of manipulation, a glowing connection was produced at the interface between the copper wire and the steel screw. Intense localized heating resulted in the wire glowing red, the insulation on the wire melting and discoloration of the receptacle body. The receptacle was left in free air for this test (it was not mounted in a box).

Circuit: #1



#2



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UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	20 A

Product	Device
# 2	Arc Fault Detector

Test Summary

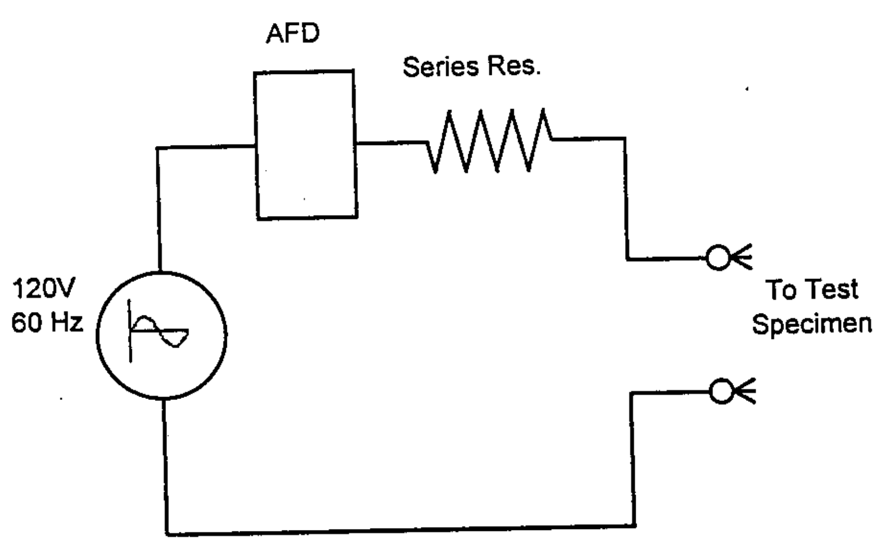
Receptacle Glowing Connection

Run	Volts	Load Current	Trip (Y / N ?)		Comments
1	119	14.6	N		

Notes:

A 15 A duplex receptacle having steel binding screws was wired with 14 AWG Type NM-B cable. A resistive load was connected to the receptacle and adjusted to approx. 15 A. One of the steel binding screws was loosened such that conduction was made through the steel screw. The screw and wire connection were manipulated to produce arcing and sparking. After a period of manipulation, a glowing connection was produced at the interface between the copper wire and the steel screw. Intense localized heating resulted in the wire glowing red, the insulation on the wire melting and discoloration of the receptacle body. The receptacle was left in free air for this test (it was not mounted in a box).

Circuit:



UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	20 A

Product	Device
# 4	Modified Trip circuit Breaker

Test Summary

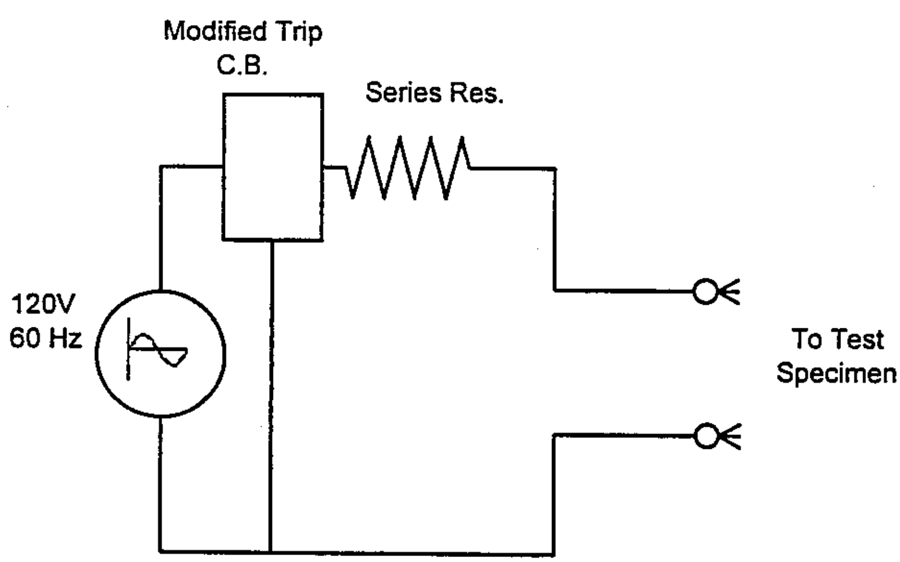
Receptacle Glowing Connection

Run	Volts	Load Current	Trip (Y / N ?)		Comments
1	119	14.8	N		

Notes:

A 15 A duplex receptacle having steel binding screws was wired with 14 AWG Type NM-B cable. A resistive load was connected to the receptacle and adjusted to approx. 15 A. One of the steel binding screws was loosened such that conduction was made through the steel screw. The screw and wire connection were manipulated to produce arcing and sparking. After a period of manipulation, a glowing connection was produced at the interface between the copper wire and the steel screw. Intense localized heating resulted in the wire glowing red, the insulation on the wire melting and discoloration of the receptacle body. The receptacle was left in free air for this test (it was not mounted in a box).

Circuit:



Strategy 1:
This strategy is the most effective since it reduces or eliminates the underlying causes of electrical fires. The use of properly sized wiring, reliable and compatible electrical construction materials, proper installation practices, adequately sized electrical service to meet demands, flexible cords of sufficient ampacity and ruggedness for the intended application, and so on are but a few of the means to accomplish this. In the case of older residences, especially older tenant occupied urban residences, it is likely that one of the primary underlying causes of electrical fires is inadequate electrical service to meet modern electrical demands. This condition is then coupled with "time-worn" electrical construction materials and devices (fatigued, perhaps, in part due to excessive demand). In such residences there is little motivation to upgrade electrical service. Consequently, proper overcurrent protection is either replaced with overrated devices or, worse yet, defeated altogether. The use of extension cords, makeshift permanent wiring, zip cords, speaker wire, and the like to extend the fixed wiring system and add outlets increases the potential sources of faults and overloads. Reinspection of older residences can help locate and correct such problems. Given this, it must be stressed that there is no substitute for upgrading the electrical service of older residences.

Strategy 2:
Once the root causes of fires of electrical origin are reduced as far as practicable, the next strategy involves monitoring and detecting the presence of conditions that may not be an immediate threat but which, if left unattended, may become an immediate threat. Moreover, this strategy has been identified in this project as a primary objective. It poses particular challenges since the number of conditions and combinations of conditions that may lead to a primary threat of fire tend to be complicated and not fully understood. Some of these conditions and combination of conditions along with a consideration of the sequence of events are described in the Section IV of this report.

The arc detection and ground-fault interrupting technologies can potentially detect low current level abnormal arcing conditions. Although the packaging of the prototype devices submitted in this project all involved circuit interruption, that does not preclude the possibility of including a warning/signaling feature in lieu of or in addition to the interrupting feature. In the case of Strategy 2, in which the condition does not involve an immediate threat of fire, signaling of an early condition may be sufficient and preferable at the time of the early condition especially where any type of interruption of service is unwelcome, whether warranted or not.

Although basic overcurrent-protection technology is intended to interrupt the circuit under conditions of overload, if such protection has unknowingly been defeated, sustained overloading can occur undetected. An example is where a new occupant is

VIII. APPLICATION OF THE TECHNOLOGIES TO RESIDENTIAL WIRING SYSTEMS

The objective of this project was to conduct an in-depth study of technologies to detect and monitor precursory conditions that could lead to fires in residential electrical wiring systems. The study involved an assessment of products and technology that could be applied to existing residences to decrease the likelihood of fires. The technologies sought are conceived as supplementary devices to the existing wiring materials and electrical distribution system apparatus.

To achieve this objective, the previous sections of this report 1) identified the basic conditions or mechanisms that can lead to electrical fires, 2) developed simple tests to broadly represent such conditions, 3) identified technologies that could potentially monitor and detect the conditions, 4) demonstrated the potential capabilities of the technologies by subjecting them to a limited set of tests, and 5) assessed the potential scope of protection that one or more of the technologies might provide singly, or in combination. This section examines how the technologies evaluated in this project could be applied in the form of practical, physical products in residential wiring systems, starting with a review of some basic strategies for reducing incidents of fires of electrical origin in the residential wiring system.

<u>Basic Strategies for Reducing the Incidents of Fires of Electrical Origin</u>

The basic strategies for reducing the likelihood of fires of electrical origin include:

1. Reducing or eliminating the root causes of fault and overload events.

2. Monitoring and detecting conditions that do not pose an immediate threat of fire, but that can initiate or contribute to conditions that do involve an immediate threat of fire. In this case, devices that signal the presence of the threat may be sufficient without the need for circuit interruption.

3. Mitigating the consequences of a fault or overload event that could otherwise pose an immediate threat of fire by attempting to interrupt the energy source prior to ignition. Since the threat of fire is imminent, devices that interrupt circuit operation are essential. Since circuit interruption prior to ignition may not always result or the significance may not be fully understood, consideration should be given to adding a signaling feature that indicates the occurrence of a significant fault event.

Finally, since surge-protection technology has the capability of limiting the exposure of the distribution wiring insulation to transient overvoltages, it can preclude one of the mechanisms by which insulation can fail resulting in arcing faults. None of the other technologies addresses this mechanism.

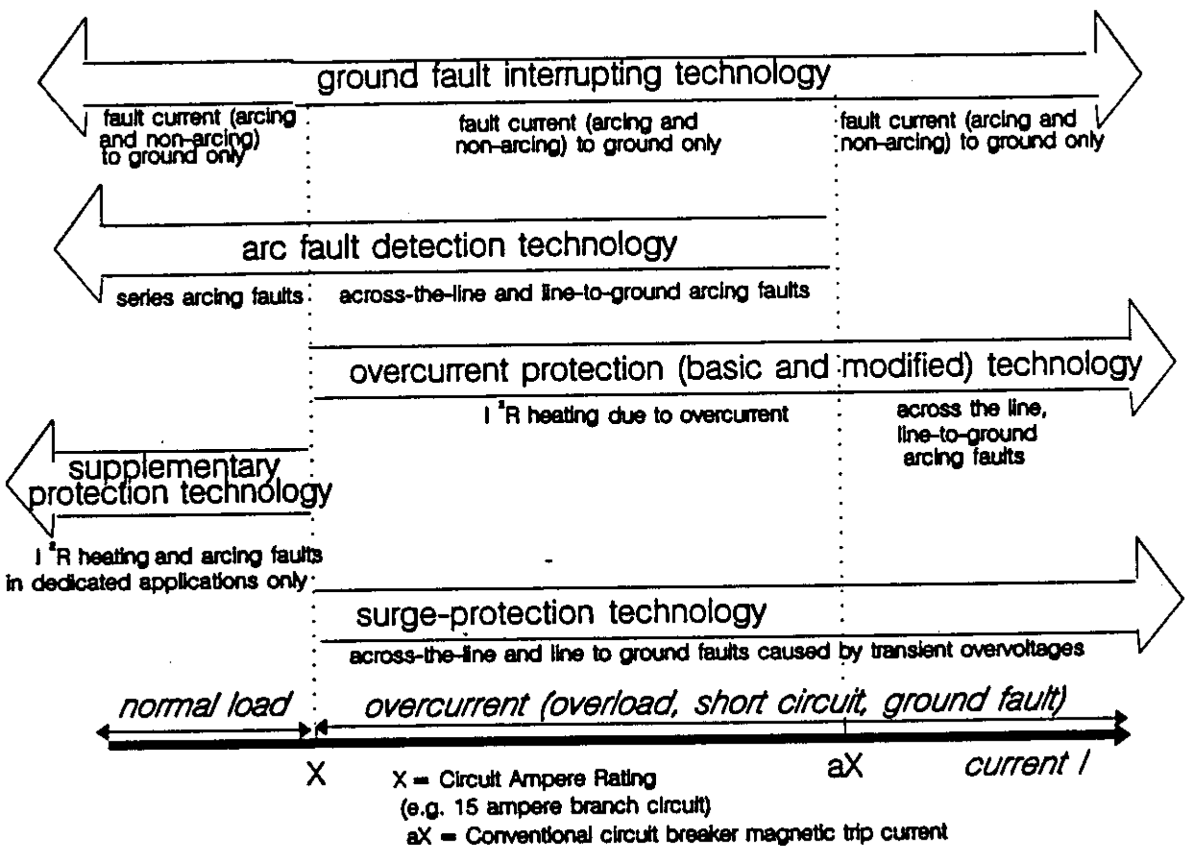


Fig. 12 - Conceptual Protection Scheme From Combined Technologies.

Conceptual Protection Scheme By Combining Technologies

From the previous discussion it is evident that no single product or technology in the examined state of development was found to provide protection against all electrical overheating mechanisms, as shown in Fig 4, that might directly or indirectly lead to ignition. However, our evaluation of the technologies indicates that the potential exists to combine certain technologies, when fully developed, as summarized in Figure 12 in order to reduce the risk of electrically caused fire in the distribution wiring beyond the scope of present conventional overcurrent protection technology alone, thus moving towards an ultimate goal of "seamless" protection.

Ground-fault interrupting technology appears to be an optimal approach towards reducing the risk of fire over the entire range of current in those cases where at least part of fault current goes to ground. This suggests a potential benefit in combining ground-fault technology with AFD technology so that the former may provide optimal results for line-to-ground faults and the latter for across-the-line arcing faults and in-line series arcing faults. As such, it appears that this technology should be an integral part of any overall protection scheme even though not all faults will involve current to ground. In older residences employing two wire electrical distribution systems such faults may be infrequent and additional forms of protection are needed. Arc fault detection technology can help fill this need by detecting across-the-line and series arcing faults that do not involve current to ground.

AFD technology is not limited at the upper end of the current range as might be implied from Figure 12. Once the magnetic trip current setting of a circuit breaker is reached, whether it be a conventional breaker or one to which modified-trip circuit-breaker technology has been applied, the operation of the breaker appears to address across-the-line arcing faults as well as any of the other technologies in the examined state of development. Moreover, since AFD technology does not address overcurrent conditions that do not involve arcing and since ground-fault interrupting technology is, once again, limited to faults involving current to ground, basic overcurrent protection technology is needed to prevent excessive I^2R heating in the distribution wiring caused by overloads and across-the-line faults not involving arcing.

Abnormal conditions that involve normal load current levels but that do not involve arcing or current to ground (e.g., high resistance series faults, usage of undersized conductors, etc.) will not be detected by arc-fault detectors, fault interrupters, or overcurrent protection until and unless such conditions lead to overcurrent, ground faults and/or arcing faults. Supplementary protection devices can potentially address such conditions. However, since the range of protection is generally limited to a specific location in the distribution system and/or specific loads, many devices employing the technology would need to be used.

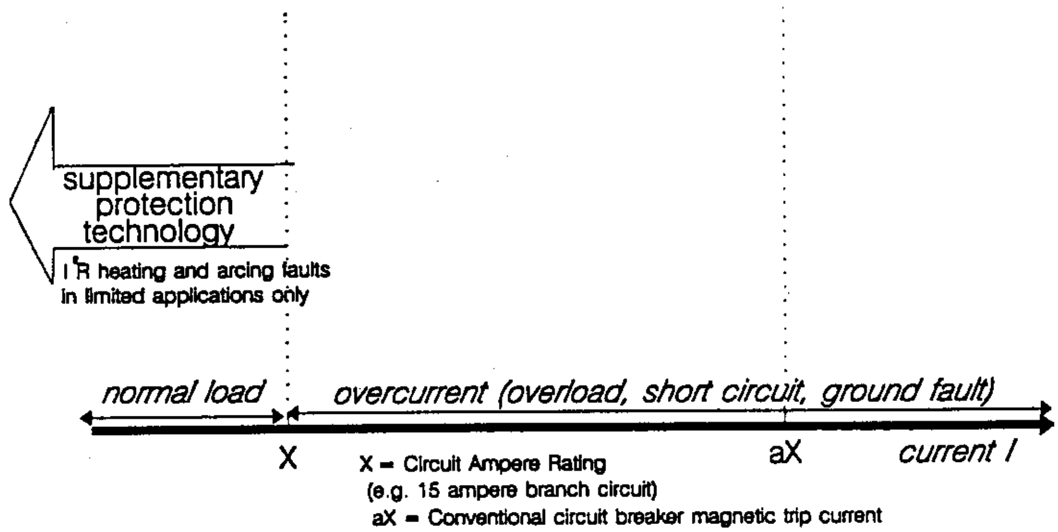


Fig. 10 - Potential Protection Afforded by Supplementary Protection Technology.

Surge Protection Technology

Although surge-protection technology does not detect power frequency overcurrent or arcing faults, it can reduce the exposure of the wiring distribution system to transient overvoltages that may damage insulation and lead to fault conditions. Figure 11 shows the potential protection afforded by surge protection technology.

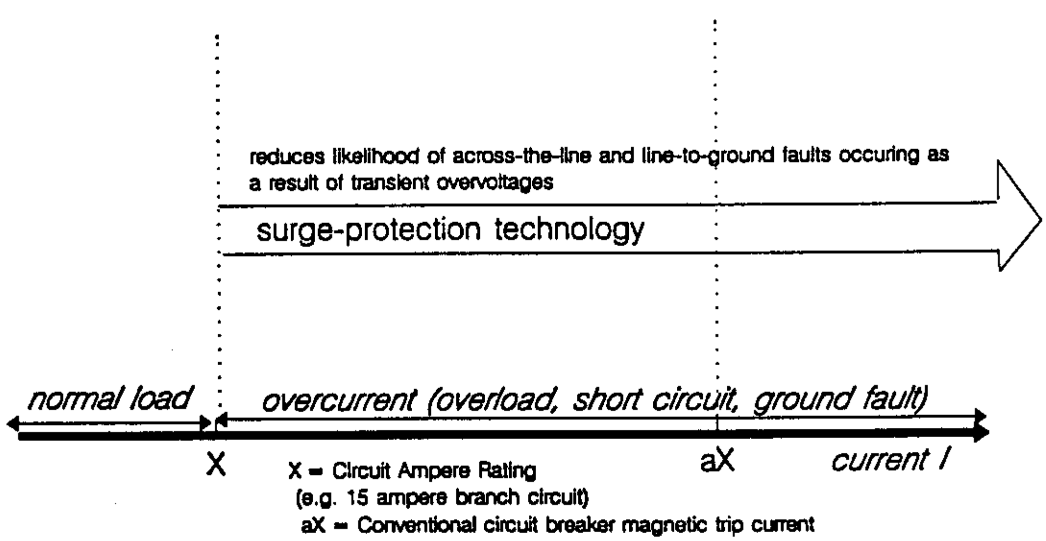


Fig. 11 - Potential Protection Afforded by Surge Protection Technology.

response to operational arcing that may be coupled with inrush currents, and operation inhibition due to the presence of other devices in the distribution system such as EMI filters. The limited tests conducted suggest the need for more research. Figure 9 illustrates the potential protection afforded by AFD technology.

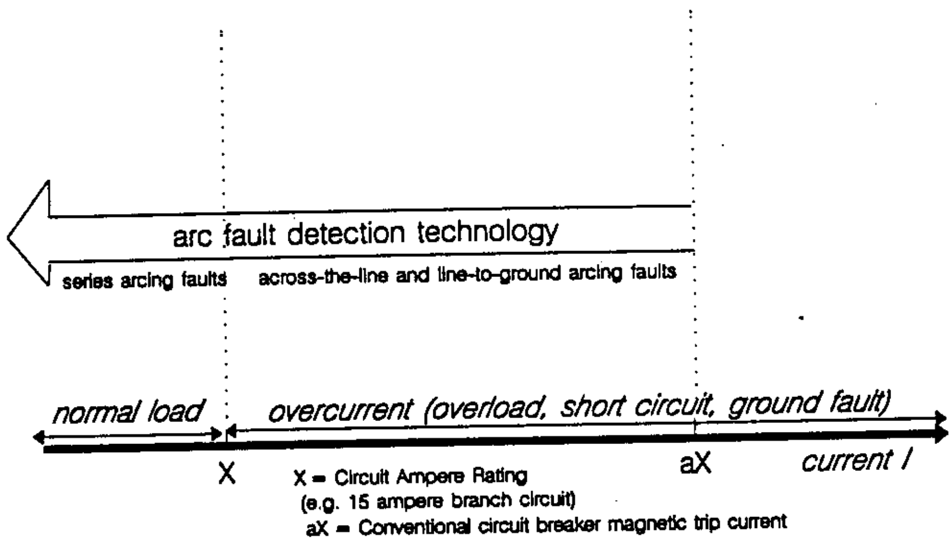


Fig. 9 - Potential Protection Afforded by Arc-Fault Detection Technology.

Supplementary Protection Technology

None of the previously discussed technologies has the capability to detect or respond to excessive I^2R heating at normal load current unless it involves, or leads to, an arcing fault or current to ground. The glowing connection and hot plug are two examples. Supplementary thermal protection technology can potentially provide protection in this area. Supplementary overcurrent protection by limiting load current an also reduce heating. Although supplementary overcurrent protection can also respond to overcurrents and faults caused by a load connected to a specific receptacle, the zone of protection is generally limited to a specific location in the distribution wiring system. Supplementary overcurrent protection rated below the branch-circuit rating, when used, limits the loads that can be connected. Figure 10 shows the potential protection afforded by supplementary protection technology.

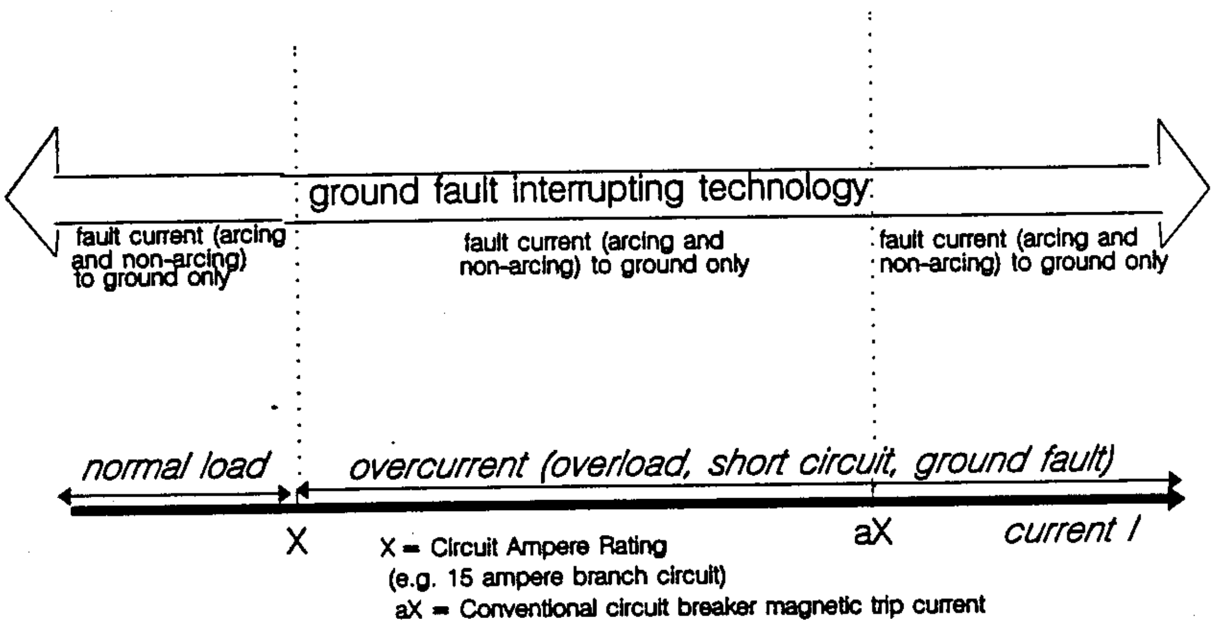


Fig. 8 - Potential Protection Afforded by Ground-Fault Detection Technology.

faults unless the faults also involve current to ground. In those cases where the ground-fault current is a by-product of an across-the-line or in-line series fault, tests showed that operation of the ground-fault function may or may not preclude ignition. Ground-fault interrupting technology will also protect against excessive I^2R heating where the current I is to ground.

Arc-Fault Detection Technology

Arc-fault detection technology is intended to respond to arcing faults by looking for specific "signature" characteristics unique to such faults, as opposed to simply responding to the magnitude of current. The technology, as exemplified by the products tested, showed the potential to address arcing faults involving fault currents below the magnetic trip current setting of conventional circuit breakers as well as below the circuit breaker "handle rating" (i.e. branch-circuit current rating, X). Since AFD technology is not intended to respond to pure overcurrent conditions, it will not prevent excessive I^2R heating at any current level that is not accompanied by a recognizable arcing condition. Although each product reacted to open the circuit and to apparently prevent ignition of the test indicators in a significant number of cases, none of the products did so in all cases nor for all types of arcs. In addition there is the potential for unwanted tripping and operation inhibition. There may be tripping in response to operational (normal) arcing at below breaker handle rating, tripping in intent of the delay is to handle inrush currents without unwanted tripping. This was discussed in Section VII. The end result is a circuit breaker that trips quicker than with a thermal response, but slower than a fast magnetic trip response. The delayed magnetic trip reduces its effectiveness in preventing arcing-fault ignitions. On the other hand, there is a potential benefit in providing some protection for undersized wiring (e.g., makeshift wiring extension, small gauge supply cords) that conventional thermal trip breakers might not provide. This is illustrated in Figure 7.

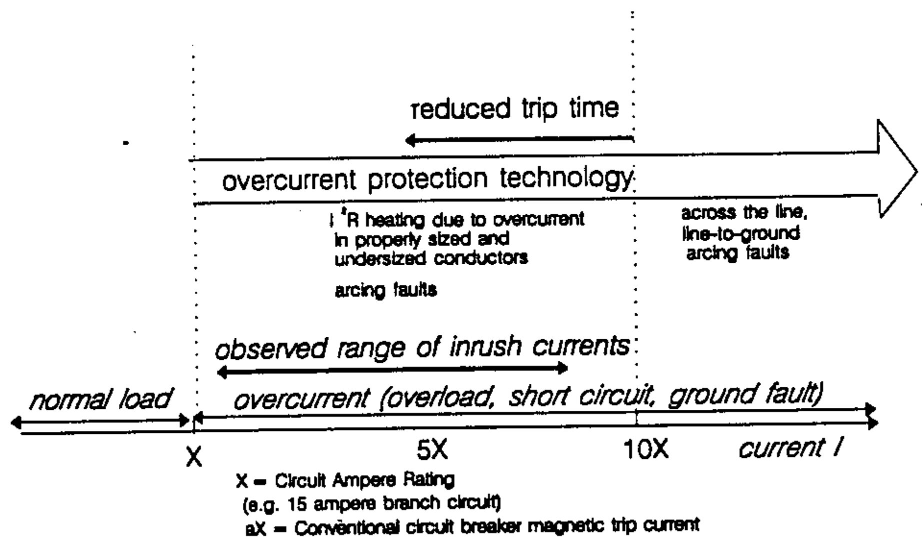


Fig. 7 - Potential Protection Afforded by Modified Trip Circuit Breaker Technology.

As in the case of conventional branch-circuit overcurrent protection technology, this technology does not address fault conditions at normal load currents.

Ground-Fault Interrupting Technology

The limited tests conducted under this project demonstrated that ground fault interrupting technology has the potential to react to a broader range of *line-to-ground fault current*, including *line-to-ground arcing fault current*, prior to ignition of a fire indicator, than either the magnetic trip function of a circuit breaker or AFD technology in the examined state of development. This appears to be due to the low trip current level (nominal 5 mA for GFCIs and 30 mA for RCDs) combined with the relatively fast operating time of within 1-2 cycles.

Since the devices only detect currents to ground, the concerns for unwanted tripping are limited to leakage current to ground and not load currents. On the other hand, since ground fault detection technology only responds to a fault that involves current to ground, it may not operate in response to across-the-line or in-line series arcing

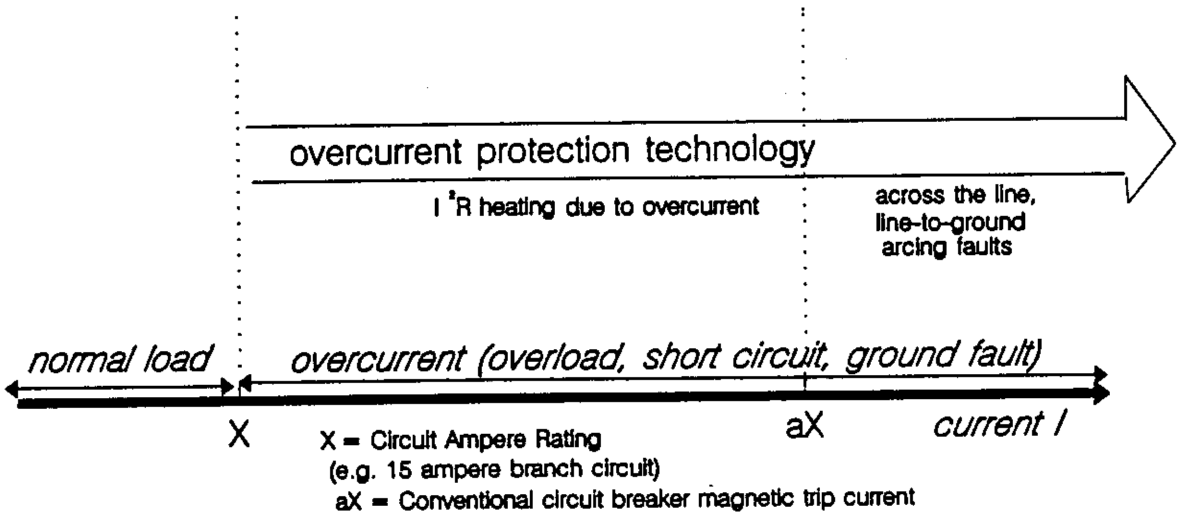


Fig. 6 - Potential Protection Afforded by Overcurrent Protection Technology.

Modified-Trip Circuit-Breaker Technology

Modified-trip circuit-breaker technology essentially takes a conventional circuit breaker and alters its response to levels of overcurrent to which the circuit breaker normally responds thermally. Two approaches were taken in the example products.

One approach was to simply lower the magnetic trip current to 5X, thereby extending the fast (nominal ½ cycle) magnetic response of the circuit breaker to lower currents. European circuit breakers are often designed to magnetically trip at the 5X level. While effective at reducing the likelihood of arcing faults and possibly also preventing overheating of undersized conductors and high resistance faults subjected to overcurrent, unwanted tripping to inrush currents will occur as demonstrated by the tests[11].

The second approach essentially involves a technology that creates a delayed magnetic trip in a range of overcurrent in which a breaker normally responds thermally; roughly 1.5 X to aX where aX is the magnetic trip level current as shown in Figure 4. The

[11]This appears to be less of a problem in Europe where lower inrush currents occur due to higher operating voltages and where there appears to be a desire to have the home protective device operate before the power company protective device.

site of the arcing fault. This is due to the potentially rapid rate of release of thermal energy in a relatively small volume. Although manufacturers of present conventional branch circuit-breaker devices have indicated that such devices are not intended to protect against ignition at the site of an arcing fault, previous work[9] has shown that the instantaneous magnetic trip function (operation in approximately ½ cycle of power frequency) of a circuit breaker has the capability to respond to certain arcing fault conditions and reduce, though not eliminate, the likelihood of arc ignition at the site of an arcing fault. This is due primarily to the speed of operation in the magnetic mode.

The effectiveness of these devices diminishes at the upper end of the range of available fault current in branch circuits (e.g., > approximately 500 A rms) where the trip is fixed but the level of overcurrent and energy released (proportional to $I^2 \times t$) continues to increase, eventually overwhelming even a fast response. In theory, the magnetic trip current could be extended down to cover the entire range of arcing faults involving overcurrent (for all $I > X$), provided there is acceptance of tripping in response to inrush currents associated with some electrical products and temporary overloads. Although there are no specific U.S. requirements for magnetic trip current levels at present, some circuit breakers in use have magnetic trip current levels of about 10 times handle rating (in Fig 6 below, a = 10). Information on inrush currents[10] suggests that a 10 X magnetic trip level would probably not result in any significant number of unwanted tripping events. Figure 6 illustrates this discussion.

[9] UL Fact-Finding Report, "An Evaluation of Branch-Circuit Breaker Instantaneous Trip Levels". Underwriters Laboratories Inc. for the Electronics Industry Association, Washington, D.C. October 25, 1993.

[10] ibid

Conventional Overcurrent Protection Technology

In considering the nature of protection afforded by present conventional branch-circuit overcurrent protection technology and the other technologies considered under this project, it is helpful to distinguish between the effects of a fault condition at the fault location itself (e.g., the effects of an arcing fault at the site of arcing) and the effects that a fault or overload may have at locations away from the fault or overload. This is illustrated in Figure 5.

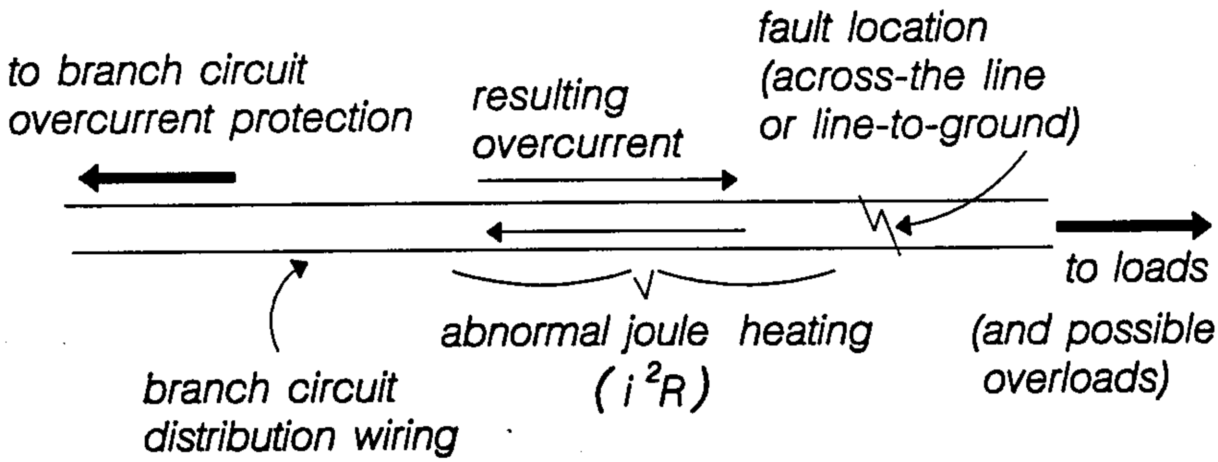


Fig. 5 - Effects of Overloads and Faults.

Present branch-circuit overcurrent protection technology is primarily intended to mitigate the effects of overcurrent that an overload condition or fault of unspecified nature or origin may have on the distribution wiring located between the protective device and the location of the fault or overload that created the overcurrent condition. In essence, present branch-circuit overcurrent protection technology protects properly sized distribution wiring against the potentially injurious effects of excessive Joule (I^2R) heating that may be caused by overcurrent. It accomplishes this by limiting the duration of the overcurrent condition. Abnormal and fault conditions that do not involve overcurrent (i.e., where $I < X$) are outside the scope of conventional overcurrent protection technology. Since present branch-circuit devices are only intended to protect properly sized wire against damage from overcurrent, they may not protect undersized conductors or high resistance series faults under overcurrent conditions.

Across-the-line and line-to-ground arcing faults are particularly onerous events with respect to their capacity to directly cause the ignition of combustible materials at the

VII. ASSESSMENT OF PRODUCTS AND TECHNOLOGY

In this section an overall assessment of the potential capabilities of the technologies evaluated is given based on the result of the tests and observations made in the previous two sections. The objective of the assessment is to provide a conceptual overview of the types and ranges of protection that might be achieved with the application of one or more present and new technologies. With the test results and observations, the range of potential protection that the different technologies evaluated might provide can be related to the electrical heating mechanisms shown in Figure 4 that was developed in Section IV of this report. Section VIII explores the possible application of physical products employing these technologies in residential wiring systems.

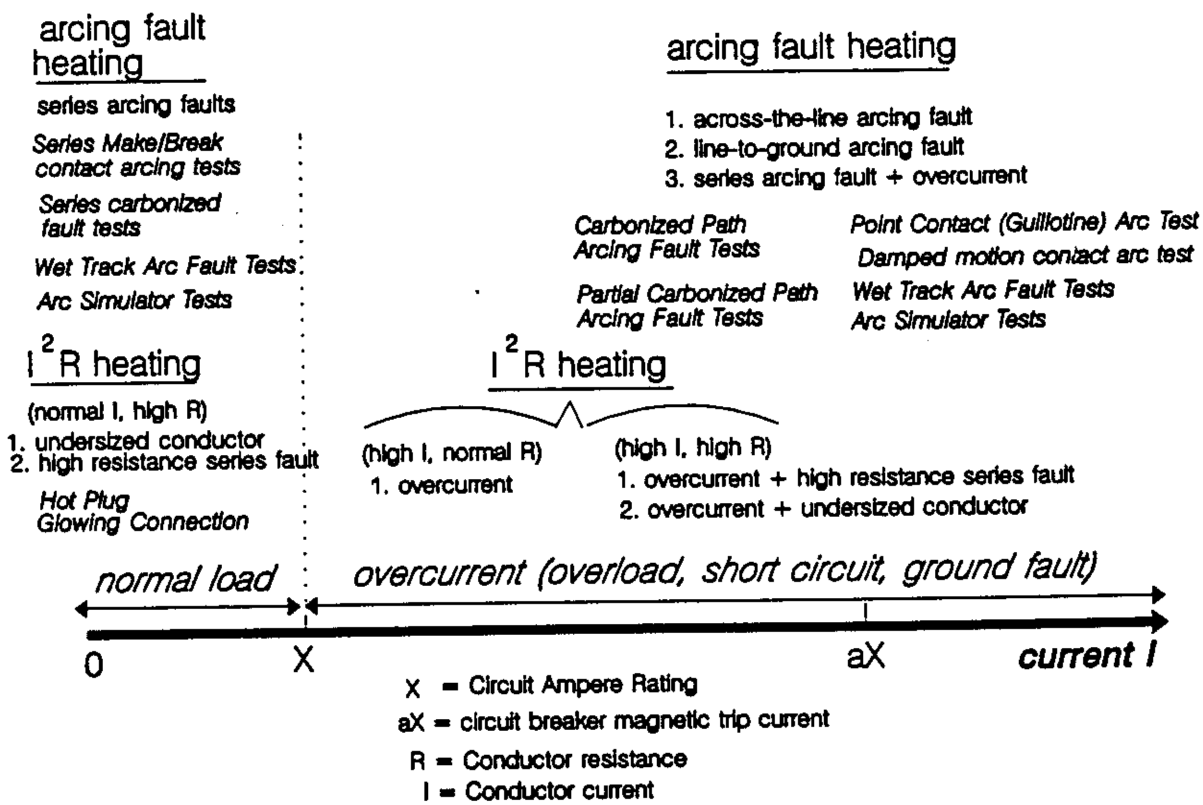


Fig. 4 - Electrical Heating Mechanisms and Representative Tests.

OPERATION INHIBITION

AFD technology that operates below handle-rating of the overcurrent device, as exemplified by Product Nos. 1 and 2, were tested. Under the test conditions of operating an arc simulator in conjunction with an electric drill, Product No. 1 did not trip until the drill was turned off. Product No. 2 responded to the arcing independent of the drill operation.

In both cases, introducing an EMI filter between the arc simulator and the arc-fault detector inhibited operation of the AFD devices. When the 100-foot extension cord was introduced instead of the EMI filter, Product No. 1 did not respond to the arcing, while Product No. 2 did respond.

Modified-Trip Circuit-Breaker Technology - Modified-trip circuit-breaker technology, as exemplified by Product Nos. 4 and 5, would not be expected to respond to these below handle-rating conditions. This was confirmed by the example test performed on Product No. 4.

Supplementary Protection Technology - Thermal sensing technology as exemplified by Product No. 9 showed a capability to detect and respond to the heat generated by a glowing connection. However, since it is not possible to separate the thermal sensing feature from the current sensing feature, the effectiveness of the thermal sensing technology alone cannot be explored throughout the range of currents normally permitted by 15 or 20 A branch-circuit receptacles.

Overheating Conductor - Hot Plug

Supplementary Protection Technology - The hot-plug test is intended to represent joule heating in a high-resistance fault that may develop in a plug as a consequence of cycling high load currents. If sufficient load current is then passed through the plug, the plug overheats. This condition does not necessarily involve arcing or overcurrent. The only technology to which this test is applicable is thermal sensing technology, that is, technology that senses the heat generated by a high-resistance plug.

Hot plugs are generally associated with appliance loads in excess of approximately 10 A. The specimens of Product No. 9 submitted were calibrated to respond to currents in excess of 8.75 A in a 40° C ambient. This device would prevent operation of the kind of loads likely to cause a defective plug to become hot. The results of this test are therefore inconclusive.

Product No. 10 was rated 5 A and also did not permit operation of loads that would cause defective plugs to become hot.

UNWANTED TRIPPING

Some unwanted tripping of products containing AFD technology was observed, although the testing was limited in scope. Both products containing modified-trip circuit-breaker technology produced unwanted tripping when starting motor loads. Product No. 4 tripped in response to the starting current of a 1-hp air-compressor; Product No. 5 tripped in response to the starting current of both a 10 A vacuum cleaner and a 1-hp air-compressor.

No other technology was evaluated for unwanted tripping.

interrupting technology as exemplified by Product Nos. 3, 7, and 8 which are rated at nominal 5 mA trip levels, would perform as well.

Arc Simulators

The arc simulators produced an intermittent arcing that sustained as long as the control for the gap between electrodes was manipulated. The AFDs demonstrated a capability of responding to the arcing produced by the simulators. The range of response of each device to arcing current levels was similar to that observed for the carbonized-path arcing tests.

Although modified-trip circuit-breaker technology, as shown by Product Nos. 4 and 5, does not respond to arcing directly, it is capable of responding to arcing faults that involve overcurrent in less time than would be expected for a conventional branch-circuit circuit-breaker. This was exemplified by the trip times observed for Product No. 4 which were consistent with trip times for a bolted-fault (non-arcing) condition.

Series Make/Break Contact Arc - Loose Terminal and Broken Wire

Arc-Fault Detectors - Since these tests represent series below handle-rating arcing faults isolated from ground, they were applicable to only two of the three AFD devices (Product Nos. 1 and 2). With the exception of one trial out of many, the AFD technology as exemplified by the products tested, did not respond to the conditions. It is possible that the duration of each arcing event was insufficient for the detectors to respond even though the arcing was done in a rapid make/break fashion -- as fast as could possibly be done manually.

Modified-Trip Circuit-Breaker Technology - Modified-trip circuit-breaker technology, as exemplified by Product Nos. 4 and 5, would not be expected to respond to these below handle-rating conditions. This was confirmed by the test performed on Product No. 4.

Overheating Conductor - Glowing Connection

Arc-Fault Detectors - The receptacle glowing connection test is a continuation of the series make/break contact arc test at a loose terminal in which deliberate manipulation of the terminal has stopped, but arcing was observed to continue. The visible signs of arcing cease, and a constant glowing connection develops. Since these phases (see the test description) were observed to contain arcing phenomena, it was of interest to determine whether AFD technology can detect the arcing.

The AFD technology as exemplified by the products submitted did not respond to these phenomena.

Modified-Trip Circuit-Breaker Technology - The results of this test provided no new information regarding the modified-trip circuit-breaker technology beyond that learned from the carbonized-path arcing fault test.

Ground-Fault Interrupting Technology - The results of the partial carbonized-path arcing test and the results of the carbonized-path arcing test are the same. The current/time combinations related to ground-fault interrupting technology products are low, and the variability did not affect the results.

Supplementary Protection Technology - There are differences among supplementary protective devices. Some require more time to operate than others. In this case, response time is critical in order for the device to clear a fault prior to ignition of the fire indicator. This is shown in the data.

Rotational Flexing Test

The test conducted on the SPT-2 cord for demonstration purposes resulted in localized heating at the location of the series fault. After approximately four periods of "on" time (approximately 9 hours on), insulation began melting. After approximately eight periods of on time, the insulation became noticeably darker in color and visible copper at the break became green in color (possibly copper chloride). When the current was turned on for the tenth time, an across-the-line arcing fault occurred at the site of the series fault and a cheesecloth fire indicator ignited.

It is not clear whether the series fault consisted of a high-resistance fault, an arcing fault, or a combination thereof. In any case, carbonization occurred at normal operational voltages and precipitated an across-the-line fault similar to that which is formed by the high-voltage process of preparing specimens for arc-detection tests.

Ground-Fault Interrupting Technology - The ground-fault interrupting technology incorporated integral to the cord set of Product No. 8, detected the faulted condition when it progressed to a ground fault (fault to the shield around one of conductors without ignition of a fire indicator).

Wet-Track Arc Fault

In some cases, the AFD devices responded, but in other cases they did not. Based on a limited number of tests, the results showed that AFD technology has the capability of responding to the formation of a carbon track by this mechanism.

The ground-fault interrupting technology exemplified by Product No. 6 precluded the formation of a carbon track. The current required to establish the carbon track exceeded the trip rating of this 30 mA device. It is anticipated that ground-fault to detect overcurrent conditions which can include arc faults. It was of interest to determine whether or not these devices could interrupt a carbonized-path arcing fault (line-to-line or line-to ground), and if so, would they prevent ignition of the fire indicator.

The modified-trip circuit-breaker technology as exemplified by Product Nos. 4 and 5 showed a capability to decrease the time to trip of a conventional circuit breaker. The results of these tests confirm the results reported in the EIA report[8] with regard to preventing ignition of the fire indicator. The shorter the response time, the less likely it is to ignite the fire indicator. However, these benefits have to be weighed against the concerns for unwanted tripping of the device due to inrush and starting currents.

Ground-Fault Interrupting Technology - Since these devices do not detect across-the-line faults, these tests are intended to represent only faults to ground. The ground-fault interrupting technology as exemplified by the products tested demonstrated a capability to detect and terminate a line-to-ground carbonized-path arcing fault without ignition of the indicator on a highly consistent basis.

Supplementary Protection Technology - A supplementary overcurrent protective device can provide overcurrent protection at values of current less than the rating of the branch-circuit overcurrent device. This may help further reduce the risk of fire caused by overcurrent, however, it does not eliminate the possibility of fire due to arcing faults. The test results demonstrate that a series carbonized-path arcing fault at currents as low as 3 A (the lowest current evaluated) can result in ignition of the fire indicator. The test current was selected to be lower than the rating of the product representing the supplementary protection technology.

Partial Carbonized-Path Arc Fault

The purpose of the test was to try to represent an across-the-line or line-to-ground arcing fault at an earlier stage of development than represented by the carbonized-path arcing fault test. The degree of carbon path formation varied to a greater extent with this test.

Arc-Fault Detectors - The results of this test provided no new information regarding the AFD technology beyond that learned from the carbonized-path arcing-fault test.

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[8] UL Fact-Finding Report, "An Evaluation of Branch-Circuit Circuit-Breaker Instantaneous Trip Levels". Underwriters Laboratories Inc. for the Electronics Industries Association, Washington, D.C. October 25, 1993.

and will be lower than the available current values. No fire indicator was used in this test.

Arc-Fault Detectors - At the 300 A level, based on the observed time to trip, devices are likely to have tripped because of the magnetic trip function of the circuit breaker used in combination with the AFD. At the 100 A level, the magnetic trip function is not likely to operate, leaving either the thermal function or the AFD to respond. Both types of responses were observed.

Modified-Trip Circuit-Breaker Technology - Both of the products employing technology that modifies circuit-breaker trip characteristics (Product Nos. 4 and 5) responded as intended due to the technology modifying the magnetic trip function of the circuit breaker.

Carbonized-Path Arc Fault

Arc-Fault Detectors - (Series Carbonized-Fault) - AFD technology that is intended to respond to arcing faults not requiring fault current to ground, as exemplified by Product Nos. 1 and 2, demonstrated a capability to detect and respond to some series carbonized-path arcing faults where the fault current is below the circuit breaker handle rating. This is significant since detection of below handle-rating arcing faults is outside the scope of present branch-circuit overcurrent protection. However, the technology exemplified by the products evaluated either did not detect some below handle-rating currents or did not terminate some below handle-rating currents prior to ignition of the fire indicator. Product No. 3 is subsequently discussed under ground-fault interruption technology.

Arc-Fault Detectors - (Across-the-Line Carbonized-Fault) - The test showed that in some cases, there was no response to the complete carbonized path test. In other cases, there was a response but there was ignition of the fire indicator. In yet other cases, there was a response and no ignition of the fire indicator. The technology is shown to have the capability of responding to and preventing ignition of the fire indicator, but not in all cases.

The carbonized-path fault test is intended to consist of three complete steps of carbon formation. The two below-handle-rating AFD detectors (Products No. 1 and 2) tripped during Step 3 of the process. This is an indication of the ability of these devices to intercede at an earlier stage of this particular type of carbonization process. In order to complete Step 3 conditioning, these two devices were bypassed. The AFD's were then placed back into the circuit and the test was completed.

Modified-Trip Circuit-Breaker Technology - Although the modified-trip circuit-breaker technology devices do not employ arc-fault detection technology, they are intended

1. Three-hundred amperes was found to be the average value of the short-circuit current available as determined by a survey of 943 receptacles on 15 A branch circuits in homes.

2. Below 300 A, there is little melting of the blade to cause molten metal which can be an additional source of ignition supplementary to arcing.

3. Above 300 A, the operation of the device is more likely to be within the region of magnetic tripping of the circuit-breaker. Evaluation of magnetic tripping of circuit breakers has been covered in previous studies.

Nine of the products that were tested under this project included technology that might address this type of fault. Therefore, these products were subjected to the point contact arc (guillotine) test.

<u>Arc-Fault Detectors</u> - All of the products employing AFD technology (Product Nos. 1, 2, and 3) tripped under these test conditions without ignition of the fire indicator. However, it should be noted that based on the observed time to trip, devices may have tripped because of the magnetic trip function of the circuit breaker used in combination with the AFD rather than the AFD itself.

<u>Modified-Trip Circuit-Breaker Technology</u> - Both of the products employing technology that modifies circuit-breaker trip characteristics (Product Nos. 4 and 5) tripped under these test conditions without ignition of the fire indicator. In the case of these devices, it is clear on the basis of the observed time to trip, that operation was due to the technology modifying the magnetic trip function of the circuit-breaker.

<u>Ground-Fault Interrupting Technology</u> - With the exception of one out of 18 trials, the products employing ground-fault interrupting technology (Product Nos. 3, 6, and 7) tripped under these test conditions without ignition of the fire indicator. In one case, the device tripped, but the fire indicator ignited. In all cases, the circuit was configured such that the fault current flowed to ground, acknowledging the fact that these devices do not address across-the-line faults.

<u>Supplementary Protection Technology</u> - All of the products employing supplementary protection technology (Product Nos. 9 and 10) tripped under these test conditions without ignition of the fire indicator. In the case of Product No. 9, the fault current permanently damaged all three specimens tested.

<u>Damped-Motion Contact Arc</u>

Testing was performed with the source impedance adjusted to limit the available current to 100 and 300 A. The actual current flowing through the fault was a variable

VI. TEST OBSERVATIONS

This section provides observations of the tests conducted and data collected. The new technologies and the new applications of existing technologies were still being developed at the time of this project. In some cases, it became known that new versions of the products were being developed as the project was underway. It is possible that the new versions may address scenarios that were not addressed by the samples submitted, but time did not permit the new versions to be evaluated under this contract.

The purpose of the testing was not to evaluate the acceptability or unacceptability of a particular product, nor was it intended to compare specific products. Instead, its purpose was to identify and evaluate possible promising technologies that the products exemplified, and not the products themselves. The tests should not be construed as constituting requirements for the technologies evaluated.

Not all of the tests used in this work are applicable to all of the technologies evaluated. Each technology has its own area of effectiveness. In some cases, it was obvious that a product would not respond to a particular test and the test was not performed. There are no standard requirements covering the new technologies, and standard tests still have to be developed. In some cases, products were tested beyond their design envelopes to explore whether they could address more than they are "advertised" to do.

A measurement was made of the trip time with a bolted fault (no arcing) for each case where AFD technology devices were tested with a current value above the handle-rating of the overcurrent device. This measurement served as a reference value to help determine whether the new AFD technology affected the tripping of the device. For the modified-trip circuit-breaker technology, a measurement of the trip time with a bolted fault was made. During this measurement, the new technology feature was disconnected. This measurement determined whether the trip time was affected by the modified-trip technology.

EFFICACY TESTS

Each of the technologies exemplified by the products submitted for this project demonstrated the potential for reducing the numbers of fires in residential wiring systems.

Point Contact Arc (Guillotine)

The available current used in this test was nominally 300 A. This current was selected for the following reasons.

UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
E	var.

Product	Device
# 5	Modified Trip Circuit Breaker

Test Summary

Unwanted Tripping

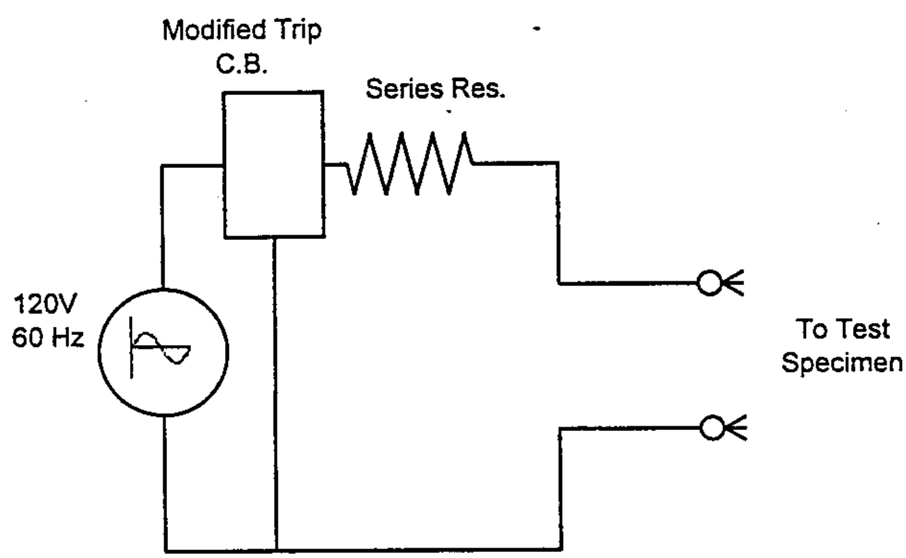
Run	Volts	Available Short-Circuit Current	Load	Closing Angle	Trip (Y / N ?)	Comments
1	119	300	Air Compressor	R	Y	Tripped 3 out of 3 trials
2	119	300	Vacuum Cleaner	R	Y	Tripped 1 out of 3 trials
3	119	300	625 W Lamps	90°	N	Did not trip on 3 trials

Notes:

Closing Angle

R=random closing on the voltage waveform

Circuit:



UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
E	var.

Product	Device
# 4	Modified Trip Circuit Breaker

Test Summary

Unwanted Tripping

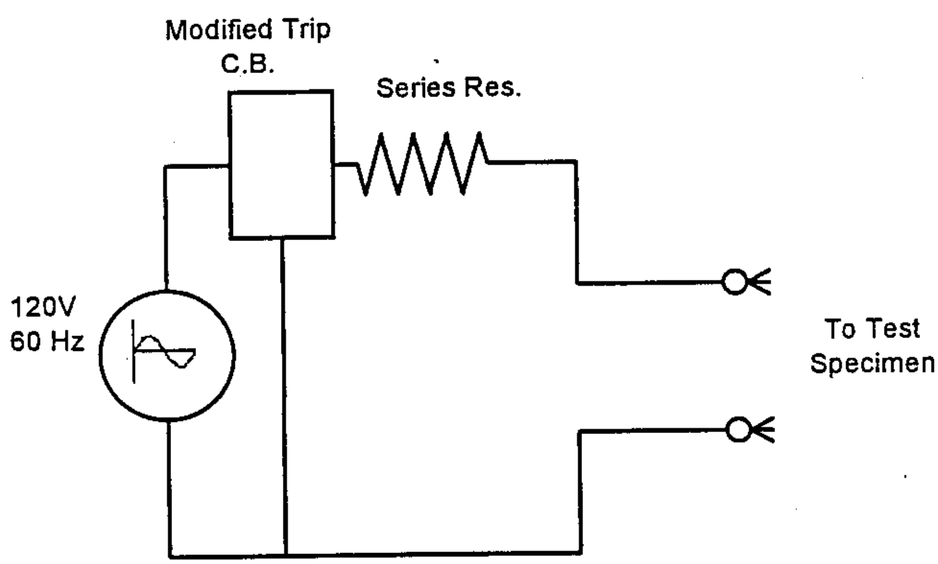
Run	Volts	Available Short-Circuit Current	Load	Closing Angle	Trip (Y / N ?)	Comments	
1	119	300	Air Compressor	R	Y	Class I device	Tripped 3 out of 3 trials
2	119	300	Vacuum Cleaner	R	N	Class I device	Did not trip on 3 trials
3	119	300	625 W Lamps	90°	N	Class I device	Did not trip on 3 trials
4	119	300	Air Compressor	R	Y	Class II device	Tripped 1 out of 3 trials
5	119	300	625 W Lamps	90	N	Class II device	Did not trip on 3 trials

Notes:

Closing Angle

R=random closing on the voltage waveform

Circuit:



TRO2.XLS

UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
E	var.

Product	Device
# 3	Arc Fault Detector

Test Summary

Unwanted Tripping

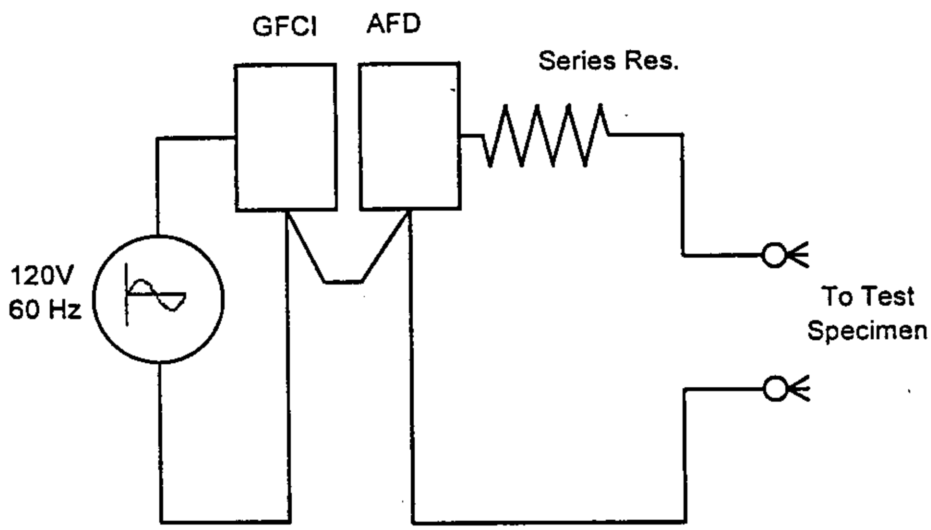
Run	Volts	Available Short-Circuit Current	Load	Closing Angle	Trip (Y / N ?)	Comments
1	119	300	Air Compressor	R	N	Repeatedly plugged & unplugged
2	119	300	Electric Drill	R	Y-A	Varied speed while rotating drill
3	119	300	625 W Lamps	90°	N	Did not trip on 3 trials
4	119	300	625 W Lamps	45°	N	Did not trip on 3 trials

Notes:

Closing Angle : R=random closing on the voltage waveform

Trip : A=AFD tripped

Circuit:



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UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
E	var.

Product	Device
# 1	Arc Fault Detector

Test Summary

Unwanted Tripping

Run	Volts	Available Short-Circuit Current	Load	Closing Angle	Trip (Y / N ?)	Comments
1	119	300	Air Compressor	R	N	Repeatedly plugged & unplugged
2	119	300	Electric Drill	R	Y	Varied speed while rotating drill

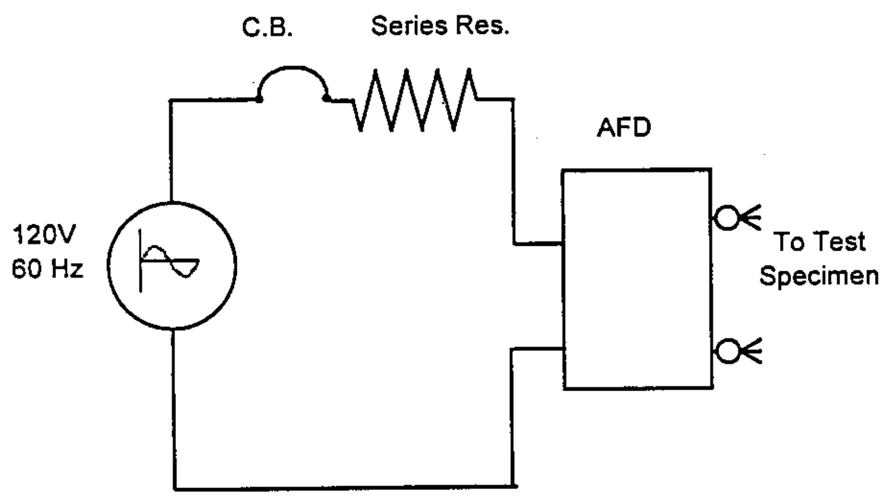
Notes:

Electric drill initially caused tripping of device, but this could not be repeated after using drill to evaluate other arc fault detectors.

Closing Angle

R=random closing on the voltage waveform

Circuit:



Key to Headings and Abbreviations Used in the Presentation of Data on Pages 116-119

Volts -- Open-circuit supply voltage.

Trip? (Y or N) -- Indicates whether the protective device opened the circuit.

Short-Circuit Current -- Available current to the test terminals under a bolted fault condition at the terminals. "Test terminals" are either wire-binding posts or a receptacle connected to these posts. A "bolted fault" is a low-impedance, high-integrity connection with no arcing. The addition of the test specimen cord and any impedance associated with the protective device in the circuit reduces the test current.

Unwanted Tripping

To determine whether operation of some ordinary products around the home can initiate false tripping of a protective device, household appliances were operated with the current drawn through the protective device. These household appliances included those which cause high starting current and those which have high-frequency current components while they run.

Starting Loads with High *Inrush Current*:
A tungsten load bank consisting of 625 W of lamps was used to represent loads that start with a very high magnitude of current. Tungsten draws approximately 10 to 13 times normal running current when it is first turned on cold.

A 1-hp air compressor was used to represent loads with long starting current. The air-compressor motor is a capacitor-start type, and draws approximately seven times its normal running current for approximately seven cycles of 60 Hz as it starts with no initial pressure in the reserve tank.

Running Loads with High-Frequency Current Components:
A vacuum cleaner rated 10 A was used. It contains two universal motors for the vacuum and beater brush. An electric drill was also used that contains an SCR speed control.

Other Loads to Consider:
Although the following loads were not used in this investigation, they are known to exhibit characteristics that could produce the effect of unwanted tripping.

- Electronic fluorescent light ballast
- Video recorder with a switching power supply
- Lamp controlled by a triac dimmer
- Aquarium heater with a slow-make/slow-break thermostat
- Flatiron with a Slow-Make/Slow-Break Thermostat
- Bench Grinder (inductive load) switched on & off while starting and not up to speed
- Incandescent lamp bulbs when they burn out
- Lightning-induced line transients
- Power-line carrier-current devices including intercoms
- RF transmitting devices including
  - cordless telephones
  - remote-control toys
  - garage-door openers
- Switch arcing of many types from load interruption

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Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used	Product	Device
A	150 V	#2	Arc Fault Detector
E	var.	Test Summary	
		Operation Inhibition	

Volts 119 Available Short-Circuit Current 300

Run Comments

1. A 5 A resistive load was connected to arc simulator #2. A variable speed electric drill and the arc simulator were connected to the AFD which was in turn connected to a 120 V AC supply. Without the drill operating (switched off), the AFD detected the arcing produced by the resistive load as the electrodes on the arc simulator were slowly separated. With the drill operating, the electrodes on the arc simulator were again separated. The AFD tripped.

2. An EMI filter was interposed between the arc simulator and the AFD. With a 5 A resistive load connected to the arc simulator, the electrodes were slowly separated. The AFD did not respond to the arcing across the electrodes on the arc simulator. This test was repeated several times.

3. A 100' coiled length of 16 AWG Type SJT-3 extension cord was interposed between the AFD and the arc simulator. With a 5 A resistive load connected to the arc simulator, the electrodes were slowly separated. The AFD tripped.

UNDERWRITERS LABORATORIES INC. -TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
E	var.

Product	Device
# 1	Arc Fault Detector

Test Summary
Operation Inhibition

Volts 119 Available Short-Circuit Current 300

Run Comments

1. A 75 W tungsten filament lamp was connected to arc simulator #1. A variable speed electric drill and the arc simulator were connected to the AFD which was in turn connected to a 120 V AC supply. Without the drill operating (switched off), the AFD detected the arcing produced by the lamp load as the electrodes on the arc simulator were slowly separated. With the drill operating, the electrodes on the arc simulator were again separated. In this case the AFD did not respond to the arcing. With the drill again switched off, the electrodes on the arc simulator were slowly opened and the AFD tripped.

2. An EMI filter was interposed between the arc simulator and the AFD. With a 75 W tungsten filament lamp load connected to the arc simulator, the electrodes were slowly separated. The AFD did not respond to the arcing across the electrodes on the arc simulator. This test was repeated several times.

3. A 100' coiled length of 16 AWG Type SJT-3 extension cord was interposed between the AFD and the arc simulator. With a 75 W tungsten filament lamp load connected to the arc simulator, the electrodes were slowly separated. The AFD did not respond to the arcing across the electrodes on the arc simulator. This test was repeated several times.

Operation Inhibition

Masking the Signal to Trip:
This condition may occur when an appliance which produces electrical noise is operated concurrently with an arc fault. The protective device may not be capable of detecting the arc fault because the arc fault signature is masked by the electrical noise. The devices in this study were tested for masking by placing them in a circuit with loads that produce continuous electrical noise such as appliance with a brush-type motor and an electric drill with an SCR speed control. With the noise present, the arc simulator that caused tripping in previous testing was introduced.

Decrease of Signal to Trip:
A common method of connecting products is through a power strip. These devices are used throughout homes for many products even though they might be intended for certain loads such as computers, printers, and so on. Many power strips contain filters to reduce the effects of electromagnetic interference (EMI), in electronic products. If the current between an arcing fault and a protective device passes through an EMI filter, it is possible that the frequencies involved in the signal indicating the presence of an arc will be decreased to the extent that the protective device will not trip. It is determined whether this is the case for the products in this study.

Disabling the Protective Device - Conductor Impedance:
When a low-impedance fault occurs in a building and high fault current flows, the source voltage is dropped in the conductors in the service entrance conductors and in the building wiring to the fault. While the fault current flows, the voltage between the ungrounded and the grounded conductors is decreased -- the lowest voltage between the source and the fault being at the fault location. If the fault location is close to the service equipment, the voltage on the affected circuit during the fault might be severely decreased inside the building. A protective device that needs voltage across its input terminals in order to trip might be adversely affected by a situation where the impedance associated with the service entrance conductors is high relative to the impedance of conductors in the building between the device location and the fault location. Testing was performed with the impedance in the circuit adjusted to simulate a typical distribution system in the United States, with low impedance between the voltage source and the service equipment relative to the impedance inside the building. In no case was the circuit impedance adjusted to preclude the operation of a protective device by virtue of insufficient voltage to operate. However, this consideration should be a part of the design of protective devices and should be included in the design of test circuitry for standard requirements.

UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	20 A
D	

Product	Device
# 10	Supplement^ry Protective Device

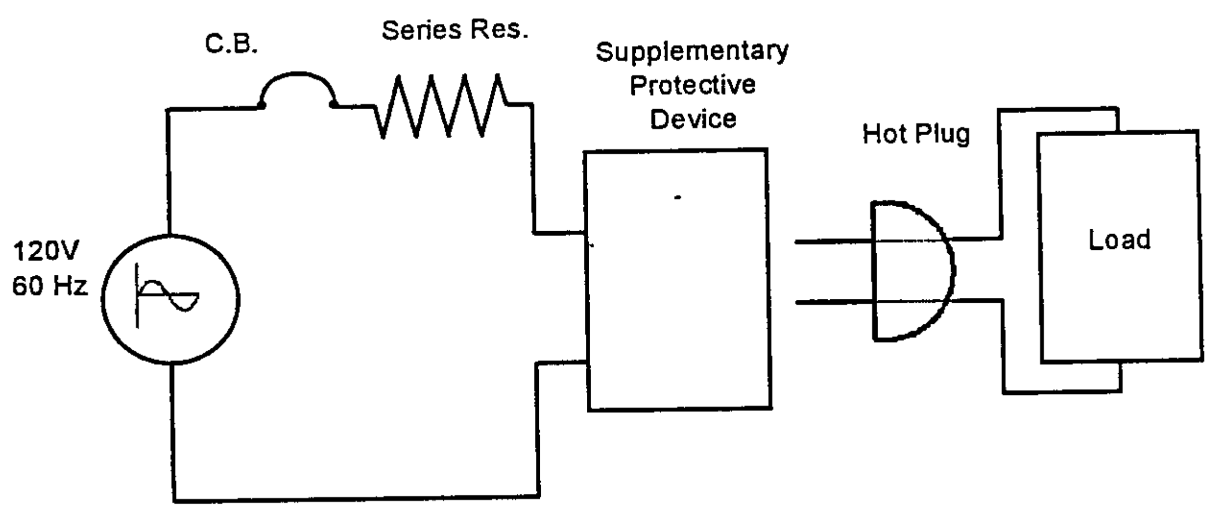
Test Summary

Hot Plug

Run	Volts	Load Current	Trip (Y/N)	Time	Comments
1	119	5	N	1h 20m	Plug body temp = 34 deg. C

Notes:

Circuit:



TRM2.XLS

UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	20 A
D	

Product	Device
# 9	Supplementary Protective Device

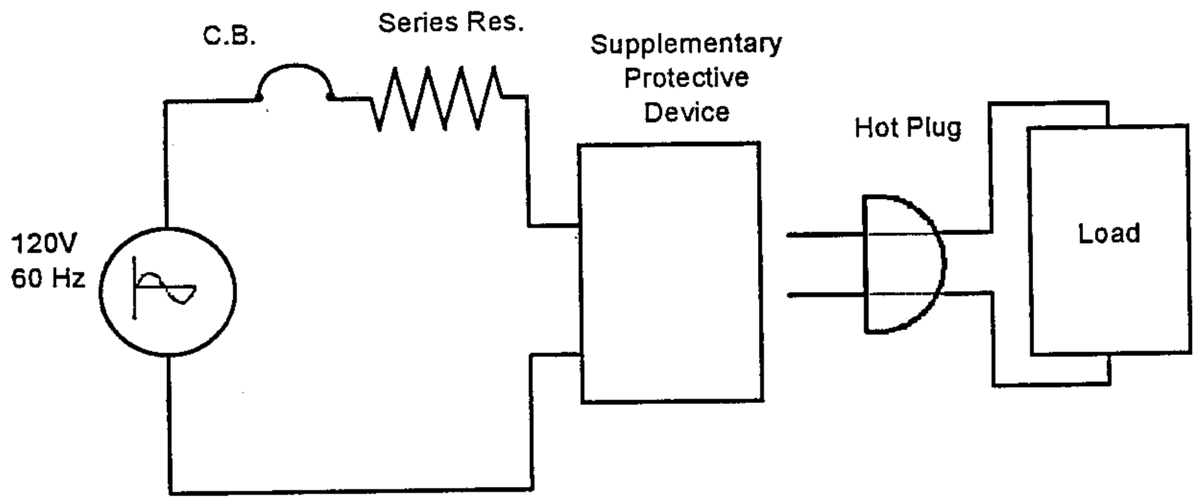
Test Summary

Hot Plug

Run	Volts	Load Current	Trip (Y/N)	Time	Comments
1	120	9.4	N	1h 40m	Plug body temp = 46 deg. C
2	119	9.8	Y		Cycled within 1 min. after increasing load current to 9.8A

Notes:

Circuit:



TRM1.XLS

Hot Plugs:
One source of high resistance and heating in the power distribution system is the hot plug. A hot plug can develop when current cycling (and thermal cycling) causes a crimp to increase its electrical resistance inside the molded-on plug of a power supply cord or extension cord. For this test program, a plug with high resistance taken from the field was used. Only the plug-in devices were subjected to this part of the study. These are the only devices submitted that can detect high temperatures in plugs and receptacles.

One at a time, the plug-in devices were plugged into a receptacle and the high-resistance plug was inserted into them. Current up to the maximum that could be drawn without tripping the device was drawn through the assembly. The ratings of the available prototypes was 5 A for the fused device and 8.5 A for the thermal device.

Unfortunately, the plug-in specimens that were available for this study were not rated high enough to test a hot plug at high enough current to represent air heaters and air-conditioners which are the types of loads that draw sufficient current to get a high-resistance plug hot. At lower currents the effect is much less dramatic. The devices submitted were not designed to address the circuits with higher-current loads.

Key to Headings and Abbreviations Used in the Presentation of Data on Pages 109-110

Volts -- Open-circuit supply voltage.

Load -- Refers to the current through the plug.

Trip? (Y or N) -- Indicates whether the protective device opened the circuit.

F.I. Ignited? (Y / N) -- No fire indicator was used.

Time -- Total test time per run.

UNDERWRITERS LABORATORIES INC. - TEST RECORD

Project No.: 94ME78760 File No.: USNC233 Applicant: CPSC

TECHNOLOGY FOR DETECTING AND MONITORING CONDITIONS THAT COULD CAUSE ELECTRICAL WIRING SYSTEM FIRES

Instr.	Range Used
A	150 V
B	20 A

Product	Device
# 9	Supplementary Protective Device

Test Summary

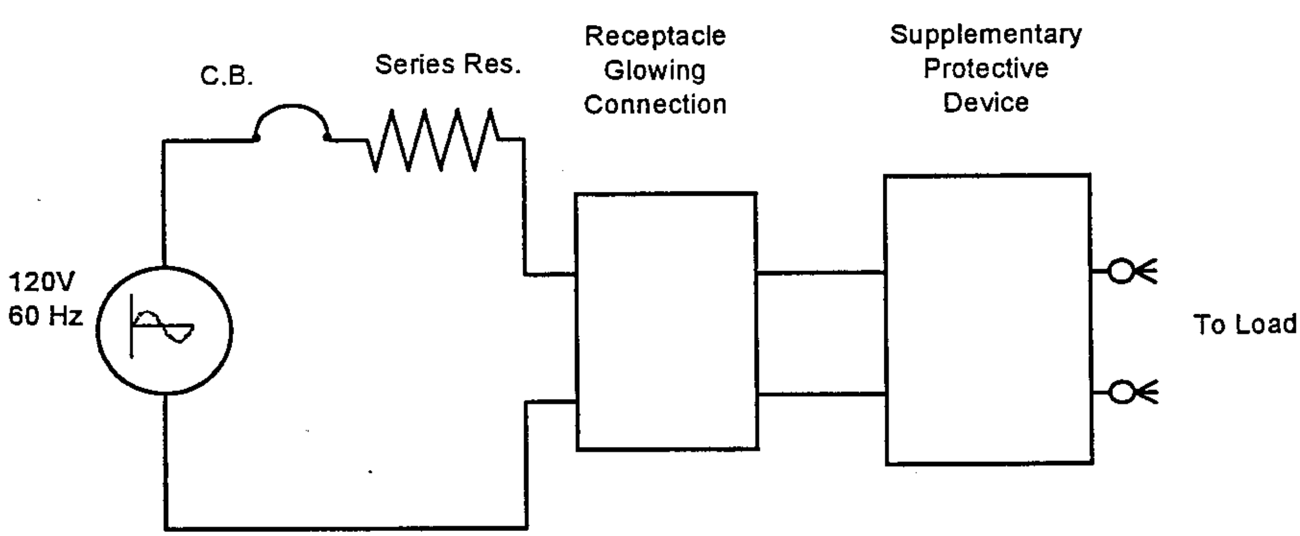
Receptacle Glowing Connection

Run	Volts	Load Current	Trip (Y / N ?)		Comments
1	119	8.9	Y		

Notes:

A 15 A duplex receptacle having steel binding screws was wired with 14 AWG Type NM-B cable. A resistive load was connected to the receptacle and adjusted to approx. 15 A. One of the steel binding screws was loosened such that conduction was made through the steel screw. The screw and wire connection were manipulated to produce arcing and sparking. After a period of manipulation, a glowing connection was produced at the interface between the copper wire and the steel screw. Intense localized heating resulted in the wire glowing red, the insulation on the wire melting and discoloration of the receptacle body. The receptacle was left in free air for this test (it was not mounted in a box).

Circuit:



TRL4.XLS

unaware that the previous occupant has over fused or defeated overcurrent protection. An overload monitoring and signaling device which alerts the occupant to an overload condition at least provides the occupant with an opportunity to have the problem investigated.

Supplementary overcurrent and overtemperature devices can serve the same purpose, but with many limitations.

The "early detection" strategy presents a number of challenges for the examined technologies. Some of the challenges are a follows.

1. For AFD technology, of critical importance is *arc discrimination*, like the ability to distinguish between arcing faults and normal operational arcing (e.g., operation of a wall switch).

2. For GFI technology, to distinguish between normal ground leakage current versus low-level fault current to ground (e.g., the incipient stages of electrical tracking along the surface of insulation).

3. For both AFD and GFI technology, a failure to be effective can result in false signals which can create the "cry wolf syndrome."

4. For both AFD and GFI technology, balancing the desirability of a large zone of monitoring/detection with the ability to locate the source of the problem detected.

5. For supplementary overcurrent and thermal protection, the ability to readily locate the source of the problem may be at the sacrifice of a larger zone of protection, unless many such devices are installed. Devices that limit the current available at an outlet to below normal load levels runs counter to the demand for power associated with older residences having inadequate service.

<u>Strategy 3</u>:
Since this strategy is directed at conditions which pose an immediate threat of electrical ignition, any device incorporating technology that detects the conditions needs to also intervene by terminating the condition. This generally means interrupting the energy source. All the example products incorporating the technologies evaluated under this project employed a circuit interrupting device to open the circuit upon detecting the condition. This included those devices that incorporate technologies capable of detecting and responding to the precursory conditions discussed in Strategy 2 (e.g., below handle rating AFDs, and GFIs). In the case of a number of these

devices, there may have been some reduction in sensitivity in order to balance the concerns with unwanted tripping.

Combining Strategies 2 and 3:
Devices that only warn or signal the presence of an early fire condition may be ignored or turned off by the occupant. Also, depending on the particular circumstances, locating and fixing the problem may not be possible. On the other hand, devices that interrupt the circuit may not be sensitive to early conditions because of the unwanted tripping concerns.

The above indicates the potential desirability of combining an early detection feature which only signals, with a circuit interrupting feature that kicks in should the conditions be allowed to persist for whatever reason. The first provides the occupant with an opportunity to have the problem investigated without unnecessary disruption of service. The second attempts to terminate an imminent ignition scenario. Finally, since interruption of a circuit prior to electrical ignition may not always be successful, perhaps Strategy 3 should also include a signaling feature that alerts the occupant that a serious fault has occurred.

DETAILS OF PACKAGING, LOCATION, AND INSTALLATION

As previously indicated, all of the technologies studied during this project have the potential to reduce the risk of fires of electrical origin in residential wiring systems. The strategies discussed have to be considered along with constraints associated with the details of packaging, location, and installation. Designs of products developed from the technologies evaluated under this project need to consider the following items:

Compatibility with Existing Residential Wiring Systems

The products that are being and that will be developed from the technology studied in this project, will need to be compatible with existing residential wiring systems. In order to maximize the usage of the new technology in existing buildings, it is desirable to have the installation as simple and inexpensive as possible. A major renovation of the wiring system in many old buildings is probably not an economically viable option and, therefore, it is assumed that most of the installations of the devices will not include major renovations of the wiring systems.

Characteristics of residential wiring systems that will need to be considered include the following:

- the size of the service -- e.g. 30 A or 200 A
- the number of branch-circuits, and the number of receptacles
- whether the panel contains fuses or circuit-breakers
- the location of the fuses or circuit-breakers
  - how accessible are they?
- is it a single-family or multiple-family dwelling?
- is it a rented or owned dwelling unit?
  - this status affects the attitude of the residents
- are extension cords and undersized extensions of the wiring used in place of permanently wired branch-circuits?
- are equipment grounding conductors provided with the branch circuits?

Product Packaging

Most of the products studied under this project were prototypes in an early stage of development. Therefore, comments about the packaging of these prototypes into a commercial product would be premature.

A product that requires major modifications to the existing system and is, therefore, expensive to install is not likely to gain public acceptance. A product that is too easy to "uninstall" (defeat), is probably less likely to be effective. To be successful in old buildings, the product should fit existing old buildings, should be unobtrusive, and should rarely draw any unwarranted attention once installed.

The final packaging of a product will have to comply with codes and standards covering the equipment and its installation. For example, devices that are intended to be installed in existing panels or outlet boxes should not reduce wiring space below required levels. Any additional wires that need to be connected should be possible to connect in a proper manner. The need for wiring space does not change when the new device is added in an old crowded panel or outlet box. In addition, a device that is used in combination with an existing device should be investigated to ensure that it will not adversely affect the operation of the existing device.

The various technologies can be packaged in any of a number of ways. Examples are given below of forms of packaging along with attributes and concerns that are characteristic of these packaging forms.

Meter Socket Adapter:

- For dwelling units with either fuses or circuit breakers
- Protects entire dwelling unit which entails
  - tripping interrupts power to entire dwelling
  - diagnosis of tripping can be complex and difficult[12]
  - inconvenient access to reset device (outside?)
  - zone of protection from meter throughout dwelling unit
- Simple installation (but with power company cooperation)
- Precludes ground-fault interruption feature (not workable)

Main Circuit-Breaker Replacement:

- Not usable for dwelling units with fuse panels
- Not applicable to panels without a main breaker
- There are many designs of main circuit breakers:
  - some are physically difficult to replace
  - would need a large variety of parts to fit all panels
- Protects entire dwelling unit which entails
  - tripping leaves whole house dark
  - diagnosis of tripping can be complex and difficult
  - may be inconvenient to reset (basement, yard pole, etc.)
  - zone of protection from service equipment throughout dwelling unit
- Probably cannot retrofit to include ground-fault protection

Circuit-Breaker Replacement:

- Protects entire branch circuit including permanently wired equipment
- Not usable for dwelling units with fuse panels
- Branch-circuit protection device entails:
  - tripping leaves a limited part of house dark
  - fault is more easily located (in one branch circuit)
  - may be inconvenient to reset (basement, yard pole, etc.)
  - zone of protection from service equipment throughout branch circuit
- Greater chance of fitting any circuit-breaker panel
  - more interchangeability of circuit breakers
- Can be selective in choosing circuits to be protected
- Can include ground-fault and/or arc-fault protection
- Requires replacement of many breakers to cover entire house

[12] It is not identified in a specific circuit.

Receptacle Replacement:

- Easily installed[13]
- Can protect from first receptacle downstream on a branch circuit
- Will not protect individual branch circuits feeding permanently wired equipment
- Fault is easily located (in one branch-circuit)
- Reset can be handy, not outside dwelling unit
- Adaptable to dwelling units with either
  - fuse panels or circuit breakers
- Follows the popular pattern of GFCI receptacle replacement
- Do-it-yourself owners can install
- Usable with dwelling units having fuses or circuit breakers
- Can be selective in choosing circuits to be protected
- Can include ground-fault and/or arc-fault protection
- Requires replacement of many receptacles to cover entire house

Plug-In Devices:

- Easily installed in any dwelling, new or old
- Can be installed by homeowner, but cooperation is necessary
- Easily uninstalled, defeated or dismissed
- May reduce load capability on the receptacle
  - unusable for some products (high current)
- Limited zone of protection
  - must match load served (limited interchangeability)
  - ineffective against receptacle through current
  - requires a device for each receptacle
- Usable in dwelling units having fuses or circuit breakers
- Can be selective in choosing circuits to be protected
- Can include ground-fault and/or arc-fault protection

Warning Device:

- Does not interrupt, warning signal only
- Can respond to nonspecific source of "arcing" signal
- Can be difficult to diagnose the reason for the alarm
- Easily installed in any dwelling, new or old
- Can be installed by homeowner, but cooperation is necessary
- Easily uninstalled, defeated or dismissed
- Does not reduce load capability on the receptacle

---

[13] Ease of installation is dependent upon sufficient room in the outlet box unless it is permissible to design the device with a cover that protrudes beyond the outlet box into the room.

- Limited protection
  - depends on action taken by resident
  - no protection without presence of resident
  - might require a device for each branch-circuit
- Usable in dwelling units having fuses or circuit breakers
- Can be selective in choosing circuits to be monitored

Ground-Fault Interrupting Devices in the Main Circuit Breaker

Replacing the main circuit breaker in an existing panel with a design that has a differential transformer to sense ground-fault current can be more difficult than it might first appear. One reason is that the location of the differential transformer in the circuit must be downstream of the grounding connections involving the grounded circuit conductor in the service equipment. If it is not downstream of these connections, part of the load current will continually cause tripping. Under normal conditions, part of the current flowing between the neutral bus in the service equipment and the neutral point on the secondary of the utility transformer flows through grounding paths. Unless the panel is designed to contain a ground-fault interrupter in the main, the proper connections for this special application will probably not be provided for the grounding electrode conductor and the main bonding jumper.

If the electric range and/or electric clothes dryer is wired such that grounding is accomplished by means of the grounded circuit conductor, which has been permitted by the National Electrical Code (ANSI/NFPA 70) for a half century, then this also interferes with the operation of ground-fault devices.

Ease of Installation including Cost of Parts & Labor

Ease of installation is related to the installation cost. Installation cost is high when the installation requires special skills and/or many hours of labor. Other factors to be considered are the number of devices needed to protect a building, and the purchase price of each device.

The plug-in devices are the easiest to install. They simply plug into an existing receptacle and the electrical loads are plugged into them. To adequately provide protection in a building, though, the number of plug-in devices needed is likely to be large. Each device can only cover a small number of loads. The devices can be inexpensive since they need only handle electrical loads up to the rating of a single branch circuit, not the whole building, with capability to safely interrupt the electricity to an entire building.

Many older buildings have fuses rather than circuit breakers. The products that were studied under this project that are intended to be installed in the service equipment are either 1) replacement circuit breakers, 2) accessories for existing circuit breakers, or 3) replacement service equipment panels of the circuit-breaker type. None of the products analyzed would fit into existing fuseholder-type panels. The service-equipment panels would need replacement to accommodate the circuit-breaker format. In cases where the electrical service is old but adequate, replacing the service equipment in a building with an ordinary new circuit-breaker panel can be expensive. The new technology protective equipment would be in addition to that cost.

The type, location, and socio-economic conditions of the dwelling unit often determines which type of product is appropriate. The following few examples are considered.

Example 1 - A single-family dwelling in a low-crime area. It has a kilowatt-hour meter located on an outside wall, and the 150 A service equipment is in the basement. The service equipment panel has a main circuit-breaker and many branch-circuit circuit breakers. Not all the positions on the panel are occupied by circuit breakers -- there is space for future expansion. It has equipment grounding conductors in all cables running to receptacles. The dwelling is occupied by its owner.

Any of the types of packaging previously described would be usable in this example, although some might be more desirable than others. A design that permits ground-fault detection would be advantageous. It would also be advantageous not to remove power from the entire building when the protective device trips. Being without power can lead to unsafe conditions such as the danger of stumbling and falling in the dark, and undesirable conditions such as loss of refrigeration and heating. In addition, diagnosing the reason for tripping is made practical when only one branch circuit is affected at a time. Some technologies that protect an entire building without the likelihood of interruption, such as surge arresters, can be beneficial without the disadvantages discussed above.

Example 2 - An apartment in a low-crime area. It has a kilowatt-hour meter in a large meter socket that contains meters for several apartments. Each apartment has its own panel of branch-circuit circuit breakers, and the service equipment with the main disconnect and main overcurrent protection is in the basement. All receptacles are of the grounding type, and all cables contain an equipment grounding conductor. The apartment is occupied by tenants who rent in accordance with the terms of a lease. The basement is a common area, usually secured at night, and is not accessible without the resident manager.

This situation is similar to Example 1 except that it is likely to be more inconvenient to reset a device that is not located inside the apartment. For example, many apartment complexes have multiple meter sockets that make it difficult for the resident to determine which is for his/her apartment. Again, the best choice of protective device would be a branch-circuit device or a receptacle device similar to a receptacle type GFCI located within the apartment.

Example 3 - An apartment in an old building in a high-crime area. When the building was built, it was provided with gas service but no electric service. Electricity was retrofitted later. It has a kilowatt-hour meter in a large meter socket that contains meters for all the apartments in the building. The service equipment is located in the basement of the building, along with a fuse panel that contains a plug fuse for each single branch circuit that serves each apartment. Each branch circuit is rated 15 A, but most of the plug fuses in the panel are 30 A rated. The fuses are located in common space in the basement that is not well secured, and can be occupied at times by unsavory and sometimes threatening characters. Having to replace the fuse is inconvenient, and can be a stressful experience because of the threat of crime. A 30 A fuse is not as likely to open. The permanent wiring is knob-and-tube wiring installed in the 1930s, and contains no equipment grounding conductors. Power distribution within the apartment has been modified by the tenants to extend it beyond the original installation through the use of surface-mounted receptacles, wired with No. 16 AWG SPT-2 power supply cord clipped to the baseboards and plugged into one of the few receptacles available.

Example 3 is more of a challenge. On one hand, the wiring system in this dwelling is overburdened, and in addition, the parts of the power distribution system added by the tenant to provide receptacles around the rooms are undersized. The system is barely adequate to properly handle the demands of the tenants.

In those cases where the electrical service in an old building is overburdened, the addition of monitors, detectors, and interrupters is not a substitute for upgrading the electrical service. Protective mechanisms can be added to enhance the safety of a system, but the protective mechanisms will not improve the capacity of the system; they will only mitigate the effects of a failure when it occurs. If part of the problem is due to people defeating the overcurrent protection (penny behind the fuse), then it is questionable whether these same people would benefit by another protective device that might hinder operation of the system to satisfy their demands.

Adding lifeboats to a ship in poor condition will not improve the probability of it successfully crossing the ocean. The lifeboats will only reduce the severity of the disaster by saving lives when the ship sinks.

In the case of buildings in a crime-ridden area, it is essential that the protective device be resettable from inside of the apartment. A device that must be reset in the basement will almost certainly be defeated after the first few experiences with tripping, especially if the tripping occurs at night and the threat of fire is perceived by the tenant to be minor relative to the threat of becoming a victim of crime by leaving the apartment at night.

A device that protects an entire building without the likelihood of interruption, such as surge arresters, can be beneficial. Receptacle type devices and warning type of devices can be beneficial if the tenant is knowledgeable and properly self-motivated.

Undersized Conductors:
Example 3 refers to the common practice of using a power supply cord to extend the wiring in old apartments to provide surface mounted receptacles in rooms in the apartment where no permanently installed receptacles exist. To be sure, these undersized conductors would be better protected by the modified-trip circuit breakers studied under this project that have faster trip times than conventional overcurrent devices. It should also be noted that these devices are in the form of circuit breakers, and that many of the older buildings have fuse panels. In addition, it should be realized that improved overcurrent protection might exacerbate the problems associated with inadequacy of the wiring system in the older residence that cannot satisfy the demands for electricity. As previously mentioned, the same person who was motivated to defeat or compromise the overcurrent protection that existed in the building, is likely to also defeat any new overcurrent device that interferes with demanded performance. There is no substitute for upgrading the electrical service of older residences.

Unnecessary Outages:
It is assumed that one of the major problems associated with a protective tripping device is that people will usually blame a tripping device for nuisance tripping when it interrupts service. People don't normally attribute the tripping of the device with an averted disaster. This is true even when they are knowingly overloading the system. Overloading has become a way of life for most people in the older buildings with inadequate electrical service. Too often, a device that repeatedly trips will be blamed for "crying wolf", and will be ignored (if possible) or defeated despite the fact that it might be doing its intended job properly. Our experience has been that some people blame the tripping of a GFCI as a "nuisance" when the GFCI is performing its intended function.

It is important for the device to be able to properly discern characteristics that threaten fire from those that do not. This needs to be done accurately under adverse conditions when many appliances are being used, some of which emit electrical "noise" that can either be incorrectly interpreted as threatening when it is not, or that can mask a threatening situation to make it very difficult to detect. The larger the number of products protected by a device, the more inconvenience is realized when the device trips, and the more likely the device will be carrying complex current that can cause unwanted tripping or can confuse or blind the device in situations when it should trip.

The need to avoid unwanted tripping is more critical for devices that interrupt service to a larger portion of a building. It also is more critical when the process involved in resetting the device and investigating the problem that caused tripping is inconvenient. For example, if a device trips in the basement of an apartment building and the resident has to make a trip downstairs to an unsecured public area to reset it, the process is much more painful and stressful than simply resetting a device that is located wholly within the apartment. The risk of being the victim of a crime in the basement of many apartment buildings is foremost in the minds of many city apartment dwellers, and far surpasses this person's assessment of the risk of fire. This is evident by the proliferation of bars and locks commonly installed over all doors and windows in many city apartments. These security measures against crime are barriers in the exits if fire were to break out, keeping the people trapped inside.

Especially for city apartment dwellers, it is essential that a device located outside the confines of one's apartment must very rarely "cry wolf." If it nuisance trips, it has a very high likelihood of being defeated.

Where unnecessary outages are of particular concern, consideration should given to devices that produce an alarm (audible, visual, etc.) without automatically interrupting the electricity. Again, for this type of device to be effective, the resident should be knowledgeable and properly self-motivated.

Split-Bus Panels:

One of the products studied in this project was a split-bus panel, which means that it has two separate sections for the attachment of circuit breakers. One section is fed from the other section through a ground-fault interrupting device. All of the branch circuits in the second section of the panel are protected by the ground-fault interrupting device. If the ground-fault interrupting device trips, only those circuits connected to the second section of the split-bus panel are affected. The building is not completely without power, but the problem of diagnosing the reason for tripping can be more difficult to determine and correct as compared to a scheme where more branch circuits are protected individually.

A negative feature of the split-bus panel is that in many buildings its installation represents a major renovation. In order to take advantage of the split-bus feature, the branch circuits need to be sorted out to try to get only certain ones protected in a logical scheme. It will not be possible to divide the existing branch circuits in some buildings according to a logical plan in this regard. For example, the apartment building in Example 3 has one branch circuit to each apartment. A split-bus panel can be very useful in new construction where the branch circuits can be designed to take advantage of the feature.

Reliability:
Reliability encompasses a number of concepts. It is reasonable to expect that a device will operate as intended without failing over its anticipated lifetime. At this stage of development for these new technologies, and estimate of this reliability would be difficult to make, and any estimate that is made would be premature. At this time, some of the outside influences that may affect reliability can be discussed with more confidence.

Maintenance:
Equipment that is maintained by a building superintendent or resident manager could have a higher likelihood of being kept in good repair than equipment that is maintained by ordinary residents. Residents who could be interested in the novelty of a new "gadget" may lose interest with time. Plug-in devices that are secured to existing receptacle outlets or that are replacement receptacles, have a better chance of remaining in service than plug-in devices that can be moved around from receptacle to receptacle. Many of them will be lost. Protective devices mandated by codes or regulations should be part of the permanent wiring system, not portable devices that can be lost.

Supervisory Testing Means:
Automatic testing on a periodic basis where people are not involved has definite advantages. It also has some disadvantages, however. Unless the test includes the entire device, it is not a complete test. For example, if the test only includes the electronic controls without actually opening the switching contacts, the device can be in the failed condition of having its contacts welded closed, but it can pass the test.

If the automatic test includes parting the contacts, it will momentarily interrupt power to many different types of loads. Opening certain loads, even momentarily, can be a nuisance that will not be tolerated by consumers. For example, any product that has a digital clock and no back-up battery (alarm clocks, VCR's, microwave ovens, etc.) will have to be reset. This can be quite inconvenient and a strong motivation to defeat the cause of the inconvenience.

If the automatic test includes parting the contacts, it must also reset them in order for the load(s) to continue to function. Presumably, the automatic closure will occur only immediately after the contacts are opened during the test (e.g. to avoid surprise motor starts and the like), and only if the device passes the test.

Diagnostics is an important part of testing. If a circuit is dead, the identity of the device that tripped should be readily apparent to the consumer, and the probable reasons for tripping should be familiar to the consumer so that proper actions can be taken.

Plug-in Devices:
The value of plug-in devices is that they bring current and temperature sensing to the locations in the circuit where abnormal heating is more likely to occur. For example, a high-current product such as a heater or air-conditioner can be plugged into a protective device that matches its current rating. Overcurrent or overtemperature can be sensed and interrupted at the plug should the plug or receptacle overheat.

The plug-in device cannot always interrupt the current that is the source of the overtemperature at a particular receptacle. Receptacles are wired in parallel in such a configuration that the terminals or twist-on connectors in the outlet box of a receptacle in a branch-circuit carries all the current being drawn from all downstream receptacles in that branch circuit. These connections can carry considerable "through-current" independent of whether anything is plugged into the receptacle or not. The devices in this project were configured to interrupt only the current that was drawn from the receptacle the device was plugged into and not the through current from downstream receptacles.

Economic Considerations:
Although information on cost was requested from the companies and inventors who participated in this project, little information was received. This was probably due to the preliminary state of development and of the technology.

IX. SUMMARY OF FINDINGS

Based on the engineering analysis performed and the limited sample testing conducted under this project, the most promising new technology evaluated is arc-fault detection (AFD) technology. This technology has the potential to reduce the incidents of arcing-fault ignitions where the level of fault current would not result in an instantaneous or near instantaneous trip of a circuit breaker, whether it be a conventional circuit breaker or one whose trip characteristics have been altered by modified-trip circuit-breaker technology. AFD technology is capable of detecting and responding to arcing-fault currents below normal load currents as well as above and, therefore, has the potential to monitor and detect precursory arcing conditions that may not constitute an immediate threat of ignition, but which could eventually lead to ignition. AFD technology needs to be "hardened" with respect to operation inhibition, detecting and responding to various types of arcing faults, and the ability to discriminate between arcing faults and operational arcing. This is based on the observation that some AFD devices would not respond to at least one arcing condition if an EMI filter was connected between the arcing source and the devices, whereas they would respond when the EMI filter was not present. The use of EMI filters is increasing in response to emerging electromagnetic compatibility (EMC) requirements for electrical distribution systems. Additional research is needed to better define the nature of residential electrical ignition sources, the levels of arc-fault protection required, and standardized test methods to verify the effectiveness of practical products that would utilize this technology.

Since AFD technology does not respond to overcurrent unless associated with arcing, AFD can not replace basic overcurrent (overload) protection such as fuses and circuit-breakers.

Ground-fault interruption technology, due to the low-trip current levels that are possible, coupled with a fast response was shown to be very effective in interrupting arcing-fault currents to ground. This suggests that it should be combined with AFD technology, since AFD technology does not require current to ground to operate. As a fire prevention device, as opposed to a device intended to provide protection from electric shock, there is greater flexibility with respect to trip-current levels. The effectiveness of ground-fault technology is enhanced by increasing the probability that a fault will involve ground.

Though not providing broad protection in the fixed wiring system, supplemental protection (overcurrent/overtemperature) technology in the form of plug-in devices or similar devices, can be useful with respect to addressing specific applications and dedicated loads where specific protection needs have been identified.

As indicated in Section VIII of this report; in order to apply the technologies in the residential wiring system, a basic strategy to reduce the risk of fire must be determined. Any strategy to reduce the incidents of fires will be a function of the specific residential wiring system environment, which in turn may place constraints on the packaging of the product and where it can be located in the wiring system.

The most effective and fundamental strategy is to reduce or eliminate the root causes of overloads and faults. Once this is accomplished, the next strategy is to address the failure of the first by preventing the root causes from progressing to a fault condition. The last strategy is to mitigate the consequences of a fault event by attempting to terminate the condition prior to ignition.

Devices that detect conditions that do not involve an immediate threat of fire but that may lead to conditions that could eventually cause a fire, may only need to provide warning signals and not necessarily disconnect the circuit. For example, low current level AFD technology and GFI technology as applied to reducing risk of fire and not electric shock could be part of such devices. Warning signals without interruption may be more appropriate in those environments where any circuit interruption is highly unwelcome whether warranted or not. It is critical in this case to be able to reliably distinguish between an immediate threat and an early indication of a problem.

It is essential that a device detect and terminate a condition that may involve an immediate threat of fire in addition to any "early warning" device or device feature that does not interrupt the circuit. Since circuit interruption is not always a guarantee of success in preventing ignition, however, consideration should also be given to provide warning signals, such as audible signals, to alert the occupant that an immediate threat may exist and that the protective device should not be reset without further investigation. A "blue sky" example would be a "smart" circuit breaker that differentiates between a thermal response to a simple overload and a magnetic response to a short circuit or ground fault. Although the circuit breaker trips in both cases, an audible signal accompanying a magnetic trip could alert the occupant that a serious fault condition potentially exists and, therefore, the breaker should not simply be reset without further investigation.

As part of this project, an effort was made to determine the percentage reduction in fires of electrical origin that could be achieved by the application of one or more of the technologies evaluated. The reduction ratio could not be determined at the present time based on the large gap that exists between the basic underlying causes of electrical fires such as those discussed in Section V of this report, and the descriptions in fire reports included in fire statistics. The fire report descriptions specify the device/product level, but rarely include the level of underlying causes. The technologies, on the other hand, are intended to respond to underlying causes of electrical fires.

X. RECOMMENDATIONS

Although no one device or practical technology was found that would detect and monitor all precursory conditions that could lead to fires in residential wiring systems, it may be feasible to combine some existing and emerging technologies into a product that would greatly enhance wiring system protection at fault locations, and avoid many fires.

Arc-fault detection appears to be a very promising technology especially when added to residential branch-circuit breakers and combined with other proven technologies, such as ground-fault protection. It is recommended that additional research be considered to better define the nature of residential electrical ignition sources, the levels of arc-fault protection needed, and standardized test methods to verify the effectiveness of practical products that would utilize this technology.

XI. GLOSSARY

This glossary is intended to facilitate the understanding of terminology used in this report. Where possible and applicable, terms are defined in essentially the same manner as shown in published standards and codes, as noted. The definition of terms in this glossary are not necessarily applicable outside the context and scope of this project and associated report. Terms in italics shown in a particular definition are defined elsewhere within the glossary.

Abnormal Joule (I^2R) Heating - *Joule heating* in excess of operational joule heating.

Abnormal Operational Arcing - *Operational arcing* under abnormal system conditions, such as switching under conditions of *overcurrent*.

Across-the-Line Arcing Fault - An *across-the-line fault* at which *arcing* occurs. May also be referred to as *parallel arcing fault*.

Across-the-Line Arcing Fault Current - The current flowing through an *across-the-line arcing fault.* Also referred to as *parallel arcing fault current*.

Across-the-Line Fault - An *insulation fault* between an ungrounded circuit conductor and either a 1) grounded circuit conductor, or 2) another ungrounded circuit conductor. Also referred to as *parallel fault.*

Across-the-Line Fault Current - The current flowing through an *across-the-line fault*. Also referred to as *parallel fault current.*

Arc (arcing) - A continuous luminous discharge of electricity across an insulating medium, usually accompanied by the partial volatilization of the electrodes (IEEE/ANSI Std 100).

Arc Discrimination - Refers to the ability of an *arc-fault detector* to distinguish between an arcing fault and *operational arcing*.

Arc Fault Detector (AFD) - A device that detects the presence of an *arcing fault.*

Arc Heating - Thermal energy generated by an *arc.*

Arcing Fault - A *fault* at which arcing occurs.

Note: Arcing Faults are thus differentiated from *operational arcing* in that the former is associated with abnormal conditions in circuits and equipment whereas the latter is associated with normal conditions in circuits and equipment.

Arcing Fault Circuit - A circuit that includes an *arcing fault.*

Arcing Fault Heating - Heat generated at the site of an *arcing fault.*

Note: In addition to *Joule heating* and *arc heating,* dielectric heating and induction heating are two other mechanisms of electric heating, with induction heating being a special case of joule heating. At power frequencies and low voltages these other mechanisms are generally insignificant insofar as involving risk of ignition.

Contact Arcing - *Arcing* that develops as a result of there being, or having been, either direct physical contact between two conductors or indirect contact due to bridging the conductors by an additional, electrically conductive object.

Fault - A partial or total local failure in the insulation or continuity of a conductor (ANSI/IEEE Std 100- modified).

Fault Circuit - A circuit that includes a *fault.*

Fault Current - The current flowing through a *fault.*

Fault Heating - Heat generated at, or as a consequence of, a *fault.*

Note: Fault heating at a *series fault* may or may not additionally involve *overcurrent.*

Ground-Fault Circuit - A circuit formed as a result of a *line-to-ground fault.*

Ground-Fault Current - See *line-to-ground fault current.*

High Resistance Series Fault - A *series fault* characterized by the presence of abnormally high resistance (high resistance in comparison to the normal resistance of the normal conductor but not high in comparison to the infinite resistance of a completely severed conductor) in a wire, at a wire termination, or wire splice, resulting in a reduction of ampacity and excess of heat dissipation at the fault. Examples are a partially severed stranded conductor with only a small percentage of the strands intact and a corroded wiring terminal or splice.

Inrush Current - Load current that temporarily exceeds steady-state load current and that occurs as a result of the initial energization or start up of certain utilization equipment such as certain motor operated and lighting equipment. Inrush current exceeds the steady-state load current of the equipment and may or may not exceed "handle rating" of a branch-circuit breaker or current rating of a fuse.

Insulation Degradation - The total or partial loss of the electrical insulating properties of electrical insulation. The degradation may be temporary, as in the case of dielectric breakdown of air, or permanent, as in the case of degradation of solid insulating material as a result of thermal or electrical stress. In the case of solid insulating material, the end state of degradation may be the partial or total carbonization of the material.

Insulation Displacement - The total or partial physical loss of electrical insulation resulting from thermal and/or mechanical stress. Examples are; 1) displacement of solid insulation or an air clearance due to cutting, nailing, stapling, drilling, or abrasion; 2) displacement of solid insulation between conductors due to the application of heat and pressure causing the insulation to soften, flow, and allow the conductors to contact each other; and 3) the bridging of an air clearance between two conductors, or between a conductor and grounded metal, due to movement of the conductor(s) and/or grounded metal.

Insulation Fault - A partial or total local failure in the insulation of a conductor resulting from either *insulation displacement,* or *insulation degradation*.

Note 1: Insulation includes air clearances between bare conductors or between bare conductors and bare grounded metal.

Note 2: An *insulation fault* may contribute to the development of a *continuity fault.*

I^2R Heating - See *Joule heating.*

Joule Effect - The evolution of thermal energy produced by an electric current in a conductor as a consequence of the electric resistance of the conductor (ANSI/IEEE Std 100).

Joule Heat - The thermal energy resulting from the *Joule effect* (ANSI/IEEE Std 100).

Joule Heat Source - The electrical conductor that has acquired thermal energy as a result of the *Joule effect.*

Joule Heating - Energy transfer, in the form of heat, from a *Joule heat source* to a material at lower temperature than the Joule heat source. Also referred to as *resistance heating* or *I^2R heating.*

Line-to-Ground Arcing Fault - A *line-to-ground fault* at which arcing occurs.

Line-to-Ground Arcing Fault Current - The current flowing through a *line-to-ground arcing fault.*

Line-to-Ground Fault - An *insulation fault* between an ungrounded circuit conductor and either 1) an equipment grounding conductor or 2) grounded metal. May also be referred to as ground fault.

Line-to-Ground Fault Current - The current flowing through a *line-to-ground fault.* May also referred to as ground-fault current.

Load Fault - A *fault* that occurs in a power consuming device.

Non-Contact Arcing - Arcing that occurs between two conductors without requiring physical contact between the two conductors.

Normal Load Current - The current resulting from the normal operation of equipment.

Operational Arc Heating - *Arc heating* associated with operational arcing in the absence of *overcurrent*. For example, arc heating produced by the normal operation of gap type switching devices in the absence of overcurrent.

Operational Arcing - *Arcing* associated with the intended operation, connection, or disconnection of electrical equipment. Examples are arcing at gap-type switching devices, arcing associated with motor brush commutation, and the arcing associated with plugging and unplugging appliance loads.

Operational Heating - Heat intentionally generated by, or generated as a normal by-product of, the normal functioning of power distribution devices and power consuming devices.

Overcurrent - Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from an *overload, short circuit,* or *ground fault* (NFPA 70).

Note: Although not in the NFPA definition, overcurrent can also result from power frequency system overvoltages.

Overcurrent Heating - Heating caused by conditions of *overcurrent.*

Overload - Operation of equipment in excess of normal, full-load rating, or a conductor in excess of rated ampacity which, when it persists for a sufficient length of time, could cause damage or dangerous overheating. A *fault,* such as a *short circuit* or *ground fault,* is not an overload (NFPA 70).

Overload Current - The current resulting from an *overload* condition.

Parallel Arcing Fault - See across-the line arcing fault.

Parallel Arcing Fault Current - See across the line arcing fault current.

Parallel Fault - See across-the-line fault.

Parallel Fault Current - See across-the-line fault current.

Residential Wiring System - An electrical system comprised chiefly of power distribution components beginning with the service meter and ending at utilization equipment. It includes (but is not necessarily limited to) components such as circuit breakers and fuses in the service panel; branch-circuit wiring; wiring and wire connectors in boxes intended to accommodate switches, receptacles, lighting fixtures, permanently wired equipment; switches and receptacles; extension cords and power supply cords and cord sets of electrical appliances and equipment.

Resistance Heating - See Joule heating.

Series (Continuity) Fault - A partial or total local failure in the intended continuity of a conductor characterized by either infinite resistance (a completely severed conductor) or by resistance that alternates between infinite resistance and high or normal resistance such as intermittent connection at a loose wiring terminal or splice.

Note: A series fault may contribute to the development of an *insulation fault.*

Series Arcing Fault - A *series fault* at which arcing occurs.

Series Arcing Fault Current - The current flowing through a *series arcing fault.*

Series Fault Current - The current flowing through a *series fault.*

Series Fault Heating - Heat generated at the site of a *series fault.*

Short Circuit - An abnormal connection (including an *arc*) of relatively low impedance, whether made accidentally or intentionally, between two points of different potential (ANSI/IEEE Std 100).

Spark (Electrical) - A brilliantly luminous phenomenon of short duration that characterizes a disruptive discharge (IEEE/ANSI Std 100).

Note 1: A disruptive discharge is the sudden and large increase in current through an insulating medium due to the complete failure of the medium under electric stress.

Note 2: The distinction between an electrical arc and an electrical spark is not sharp. One possible distinction is the statement found in the definition of an arc is that an arc is "usually accompanied by the partial volatilization of the electrodes" which contributes metal ions to the plasma between electrodes, in contrast to the *spark* in which the electrical discharge need only involve electrons and ions of the insulating material between electrodes.

Spark (Nonelectrical) - A small mass of hot and glowing liquid or solid material expelled from a larger mass of the same material. Although the spark is not electrical in nature, it may be caused by electrical heating (definition adapted from Webster's Collegiate Dictionary).

Note 1: Electrical arcing is differentiated from non electrical sparking in that the heat and light associated with the former results from energy dissipated in the electrical discharge in a plasma whereas the heat and light associated with the latter results from a liquid or solid at elevated at high temperature.

Utilization Equipment - Electrical equipment that employs power consuming devices for the express purpose of converting electrical energy into other useful forms such as purposeful heat, work, light and sound.

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APPENDIX A

Announcement Letter

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Underwriters Laboratories Inc.®

December 12, 1994

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ANNOUNCEMENT

UL Is Working With the Consumer Product Safety Commission to Identify New Technology Products for Reducing Residential Electrical Fires

You're Invited to Participate

The U.S. Consumer Product Safety Commission (CPSC) is examining residential electrical system fires in an effort to reduce the incidence of injuries, deaths and property loss associated with such fires. The CPSC recently awarded a contract to Underwriters Laboratories Inc. (UL) for the purpose of identifying and evaluating new technologies capable of detecting and monitoring conditions in residential electrical systems that can lead to fire.

Products with new technology (or innovative products using existing technology) that may help reduce fires associated with residential electrical wiring systems will be evaluated. The study will emphasize devices and systems that can be used in older homes where the frequency of electrical system fires appears to be disproportionately high. UL is seeking information (published or unpublished) on devices or technology which may be responsive to these objectives.

If your company has or is developing products that could be considered within the scope of this project and you would like the opportunity to have your technology evaluated, please respond by contacting either:

At UL's Northbrook Office:
Mr. Peter Boden
333 Pfingsten Road
Northbrook, IL 60062
(708)272-8800, Ext.42011

or at UL's Melville Office:
Mr. Richard Wagner
1285 Walt Whitman Road
Melville, LI, NY 11747
(516)271-6200, Ext.22275

For the first phase of our work, descriptive information such as a theory of operation, patents, photographs, drawings, installation instructions, etc. would be of interest to us. After reviewing all of the descriptive information sent to UL, samples of some products may be requested or purchased for further evaluation. This evaluation will involve examining characteristics such as efficacy, reliability, ease and cost of installation, maintenance, operating costs, and possible side effects.

UL has undertaken this project under contract with the Consumer Product Safety Commission (CPSC), an agency of the United States government. Consequently, UL will be sharing the information obtained from this project with the CPSC and a final report of the project will be prepared for them.

If you desire to submit confidential or trade secret information for consideration in this project, UL will follow all of its internal procedures for protecting that information from disclosure to unauthorized persons. Upon request, the CPSC will also give special treatment to any information which you identify as confidential or trade secret. To request special treatment by the CPSC of any information claimed to be confidential or a trade secret, please take the following steps:

1. Include a statement in your submission that you are authorized to make a request for special treatment of any confidential or trade secret information contained in the information you are providing.

2. Identify the specific portions of the information which is confidential or trade secret.

3. State whether any of the information identified as confidential or trade secret has ever been released to any person other than an employee or a person in a confidential relationship with your firm.

4. State whether any of the information identified as confidential or trade secret is commonly known within the industry or is readily ascertainable by others in the industry.

5. Describe how the release of the information identified as confidential or trade secret would be likely to harm your firm.

Like all other agencies of the United States government, the CPSC is subject to the provisions of the Freedom of Information Act (FOIA). If the CPSC receives a request for disclosure of information under the FOIA for information identified as confidential or trade secret, the person or firm claiming that the information is confidential or a trade secret will be requested to assist the Commission in any legal action the requestor may bring for disclosure of the information under the FOIA.

The full text of the CPSC's procedural regulation relating to requests for special treatment of information identified as confidential or trade secret is found at 16CFR§1015.18. A copy is attached. If you have questions about submitting confidential or trade secret information to CPSC, please contact Mr. Al Brauninger, CPSC Office of the General Counsel, at 301 504-0980 x2216.

To be consistent with the schedule of the project, all information should be received by January 31, 1995 to be considered for this work.

Thank you for your interest.

UNDERWRITERS LABORATORIES INC.

§ 1015.18 Information submitted to the Commission; request for treatment as exempt material.

(a) A person who is submitting information to the Commission, after being notified by the Commission of his/her opportunity to request confidential treatment for information, must accompany the submission with a request that the information be considered exempt from disclosure or indicate that a request will be submitted within 10 working days of the submission. The failure to make a request within the prescribed time limit will be considered an acknowledgment that the submitter does not wish to claim exempt status.

(b) A person who has previously submitted information to the Commission, that is now the subject of a Freedom of Information request, after being notified by the Commission of his/her opportunity to request confidential treatment for the information, must submit a request that the information be considered exempt from disclosure within 5 working days from receipt of notification. The failure to make a request within the prescribed time limit will be considered an acknowledgement that the submitter does not wish to claim exempt status.

(c) Each request for exemption from disclosure under 5 U.S.C. 552(b)(4) as trade secret or privileged or confidential commercial or financial information must:

(1) Specifically identify the exact portion(s) of the document claimed to be confidential;

(2) State whether the information claimed to be confidential has ever been released in any manner to a person who was not an employee or in a confidential relationship with the company;

(3) State whether the information so specified is commonly known within the industry or is readily ascertainable by outside persons with a minimum of time and effort;

(4) State how release of the information so specified would be likely to cause substantial harm to the company's competitive position; and

(5) State whether the submitter is authorized to make claims of confidentiality on behalf of the person or organization concerned.

(d) Material received with a request that it be considered exempt shall not be maintained in a public file. If, in complying with a request for the disclosure of records, it is determined that some or all of the material relative to the request has been claimed to be exempt from disclosure, the requester will be supplied with a list of this material and informed that those portions found not to be exempt will be made available as soon as possible.

(e) No request for exemption from disclosure under 5 U.S.C. 552(b)(4) should be made by any person who does not intend in good faith to assist the Commission in the defense of any judicial proceeding that might thereafter be brought to compel the disclosure of information which the Commission has determined to be a trade secret or privileged or confidential commercial or financial information.

§ 1015.19 Decisions on requests for exemption from disclosure under 5 U.S.C. 552(b)(4).

(a) The Commission generally will not decide whether material received with a request for exemption from disclosure under 5 U.S.C. 552(b)(4) is entitled to be withheld until a request for production or disclosure is made for that information. The determination will be based on the most authoritative judicial interpretations available at the time a request for disclosure or production is considered. Any reasonably segregable portion of a record will be disclosed to any person requesting such record after deletion of any portions determined to be exempt under 5 U.S.C. 552(b)(4). The requester will be given a brief description of any information found to be exempt.

(b) If material received with a request for exemption from disclosure under 5 U.S.C. 552(b)(4) is found to be disclosable, in whole or in part, the person submitting the material will be notified in writing and given 10 calendar days from the receipt of the letter to seek judicial relief. In no event, however, will the material be returned to the person submitting it.

APPENDIX B

Trends article

"UL/CPSC Work to Reduce Residential Electrical Fires"

Underwriters Laboratories Inc.®

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trends

Vol. 15, No. 1 1994

UL, SACI sign Memorandum of Understanding to open doors for U.S.-China trade

In a major unprecedented effort to facilitate trade between the United States and China, UL and the State Administration of Import and Export Commodity Inspection (SACI) of the People's Republic of China signed a Memorandum of Understanding to help manufacturers and exporters in both countries receive certification services needed to sell products in China and the United States.

SACI was established by the State Council of China to be in charge of the inspection and certification of import and export commodities for China. The Memorandum of Understanding, signed Nov. 11, 1994, is an umbrella agreement that allows UL to establish operational agreements with SACI and testing, certification and quality assessment organizations accredited by SACI.

One such agreement, between UL and the China National Import and Export Commodities Inspection Corporation (CCIC), allows CCIC to test products to the applicable UL Standards and requirements and then submit test data to UL for evaluation and review. UL verifies that the test results meet UL requirements; performs any other required tests, if necessary; and issues UL certification for the product. The product manufacturer is then authorized by UL to use the appropriate UL Mark. In addition, UL and SACI have agreed in principle for UL to produce test data packages that will be used by SACI — or a testing organization recognized by SACI — to issue certification for China to UL clients.

(Left to right) SACI Chief Administrator Tian Runzhi, Liu Weijun, SACI Deputy Director of Division, and UL President Tom Castino prepare to sign a Memorandum of Understanding on Nov. 11.

Another operational agreement, between UL and SACI, authorizes UL to conduct follow-up inspections for SACI in the United States for designated product categories. The categories include refrigerators, refrigerator compressors, air conditioners, air conditioner compressors, televisions, cathode-ray tubes (CRT), automobiles, motorcycles and motorcycle engines intended for export from the United States to China. SACI has conducted follow-up inspections in China for UL over the past several years.

A third operational agreement, between UL and the CCIB Quality Certification Centre (CCIB-QCC), allows either organization to co-register companies to ISO 9000 Standards based on quality assessments conducted by the other organization, subject to review by both organizations.

"These agreements will help facilitate trade between the United States and China," says UL President Tom Castino. "Manufacturers need every advantage possible to compete in today's global marketplace.

(Continued on page 2)

Summary of UL/SACI Operational Agreements

Organization	**Scope of Agreement**
China National Import and Export Commodities Inspection Corporation (CCIC)	*CCIC tests to UL Standards; data submitted to UL for UL certification*
State Administration of Import and Export Commodity Inspection (SACI)	*UL conducts follow-up inspections for SACI in the United States*
CCIB Quality Certification Centre (CCIB-QCC)	*co-registration by UL and CCIB-QCC to ISO 9000 standards*

facelift

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The screened Client Information section contains the information you said you need to see first when you open the invoice. This includes the invoice number, date and amount, your company's purchase order number, and other related items.

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As before, all charges are calculated and payable in U.S. currency.

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New look for Recognized Components Directories

Starting in April 1995, UL's Recognized Component Directories (yellow books) will be published in a new size and format. The Directories will measure 8⅛ by 9¼ inches in size and use a two-column format for easy reference and readability. There will be a two-volume set of Recognized Components with its own indices that costs $52, and a volume that can be ordered separately for plastics at a cost of $40. The 3-volume set will be available at a discounted price of $87.

The plastics volume will include the following product categories: QMFZ2 Plastics; QMJU2 Coatings for Use on Recognized Printed Wiring Boards; QMMY2 Fabricated Parts; QMOT2 Flame Retardant Coatings; QMQS2 Flame Retardant and/or Color Concentrates; QMQU2 Flammability Reducing Coating for Enclosures; QMRS2 Metallized Processes; QMRX2 Metallized Parts; QMSS2 Supplier Components for Use in the Fabrication of Metallized Parts; QMSX2 Mold Release Lubricants; QMTR2 Plastics — Proprietary; QOQY2 Polymeric Materials for Use in Domestic Hot and Cold Water Systems; QORU2 Polymeric Parts; QOQU2 Polymeric Adhesive Systems; and QMTS2 Polymeric Materials — Filament Wound Tubing, Industrial Laminates, Vulcanized Fiber, and Materials for Use in Fabricating Recognized Printed Wiring Boards.

To order these Directories, telephone Publications Stock in UL's Northbrook, Ill., office at (708) 272-8800, ext. 42612 or 42622, or send a fax to (708) 272-0293. For an in-depth look at Recognized Components today, see the Vol. 14, No. 4 issue of ***Trends.*** ■

UL/CPSC work to reduce residential electrical fires

You could be a part of this important work

UL was recently awarded a contract from the U.S. Consumer Product Safety Commission (CPSC) to research technology for detecting and monitoring conditions that could cause electrical wiring system fires. The purpose of this project is to reduce the rates of death, injury and property loss from residential fires associated with electrical wiring systems. The study will center on devices and systems that can be used to decrease the likelihood of fires in older homes where the frequency of electrical system fires appears to be disproportionately high.

During the one-year project, UL will conduct an in-depth study of the practical technologies that might have the ability to detect and monitor precursory electrical conditions that could lead to fires in older residential wiring systems. This will be accomplished by conducting a comprehensive review of literature on devices and systems of this type; by surveying industry organizations and manufacturers for new products and systems that could decrease the fire potential; and by acquiring and analyzing the most promising devices to determine ease and cost of installation, effectiveness, and possible problems that might be associated with their installation and use.

And this is where you could help. If you have developed or are developing a new product that might be used to detect or monitor problems in electrical wiring systems and would like the opportunity to have your technology considered in this project, we would like to hear from you. To help us protect your proprietary information, contact us before you send your product or product description. Call either Pete Boden in Northbrook, Ill., at (708) 272-8800, ext. 42011, or Richard Wagner in Melville, N.Y., (516) 271-6200, ext. 22275, **before Jan. 31, 1995.** Your participation in this project could help the CPSC and UL in their efforts to reduce property damage, injuries and deaths associated with residential electrical system fires. ■