# EPRI/NEI Test Plan
# For
# Evaluation of Fire-Induced Circuit Failures
# Revision D, 9-14-00

## 1 SCOPE

This test plan describes the methods and guidelines to be used for evaluating fire effects on typical cables and electrical circuits used in nuclear plants. The test program will be performed under the auspices of EPRI, in support of initiatives by NEI to resolve fire-induced circuit failure issues on behalf of the industry. EPRI will have management responsibility for this test program. This draft is subject to revision after review and comment from NRC, potential testing laboratories, and other industry sources. The final version addressing these comments will be issued as Revision 0.

This plan is intended to address technical fire-induced circuit failure issues of concern to NRC staff, principally the potential for multiple equipment impacts and mechanistic damage to safe shutdown equipment from fire-induced circuit failures. The test results are expected to provide information in the following areas to assist in the resolution of these issues.

Likelihood of spurious actuations from hot shorts in multiconductor control cable
Likelihood of spurious actuations from cable-to-cable hot shorts
Likelihood of spurious actuations in instrument cable
Likelihood of multiple spurious actuations
Effects on different types of actuated devices
Differences in effects between horizontal and vertical trays and air drops
Plume/hot gas layer effects vs. direct flame impingement effects
Likelihood of shorts-to-ground vs hot shorts
Likelihood of open circuits
Insulation resistance in damaged cable
Voltage and current values in damaged cable
Differences in effects among cables of different qualification types and insulation types
Effects on armored cable
Impact of water spray

The table in Section 6.1 provides more information on parameters considered. EPRI and NEI will address the likelihood of multiple high impedance faults separately from this test program.

## 2 OBJECTIVE

The objective of this test program is to determine the electrical response of typical nuclear plant cables and electrical circuits to fires. The response will be measured in terms of actuation of typical control devices in these circuits, and by measurements of voltage and current in monitored circuits leading to calculation of insulation resistance in fire-damaged cable.

## 3 TEST CRITERIA

Each test will consist of the application of flame to a test apparatus as detailed later. This application of flame will continue until one of the following criteria is met. These criteria are intended only to determine at what point each test will be terminated, not to assess the "success" or "failure" of the test.

1. Thirty minutes has elapsed without adverse response, as defined in 2 and 3 below. This time frame simulates that available to the plant for the fire brigade to respond and put out the fire, and for operators to take manual actions to mitigate the effects of the fire.

   If it is obvious from monitoring the test that adverse effects may occur after thirty minutes, the test (application of flame) will be extended another thirty minutes. This will allow the gathering of useful data on fire effects, even though a circuit failure under actual plant fire conditions could have been prevented through the brigade or operator actions described above.

2. More than one device has actuated from a fire-induced circuit failure. This allows the determination of whether a single fire can affect multiple components. If one device actuates before thirty minutes has elapsed, the test will be continued for another fifteen minutes to determine if a second device actuates, unless it is obvious from monitoring the test that this cannot happen.

3. More than one monitored circuit has experienced a circuit failure (hot short, short to ground, or open circuit). This allows the determination of whether a single fire can affect multiple circuits. If one circuit failure occurs before thirty minutes has elapsed, the test will be continued for another fifteen minutes to determine if a second failure occurs, unless it is obvious from monitoring the test that this cannot happen.

## 4 DEFINITIONS

### 4.1 CIRCUIT FAILURE

A circuit failure consists of a hot short, a short to ground, or an open circuit.

### 4.2 HOT SHORT

A hot short is a fire-induced insulation breakdown between conductors of the same cable, a different cable, or from some other external source resulting in a compatible but undesired impressed voltage on a specific conductor.

### 4.3 SHORT TO GROUND

A short to ground is a fire-induced breakdown of a cable's insulation system resulting in the potential on the conductor being applied to ground potential.

### 4.4 OPEN CIRCUIT

An open circuit is a fire-induced break in a conductor resulting in a loss of circuit continuity.

### 4.5 INSULATION RESISTANCE

Insulation resistance is the calculated resistance of intact or damaged insulation between conductors in different circuits, based on measurements of voltage and current in those circuits.

### 4.6 TEST FRAME

To be provided by the selected test laboratory.

### 4.7 TEST ASSEMBLY

A test assembly is an assembly of horizontal or vertically run ladderback steel cable tray, along with a 5-inch conduit run in close proximity to the tray (see Figure 1). The tray and conduit will contain cables as specified later.

### 4.8 THERMOCOUPLE

A thermocouple is a fast-response electrical assembly used to measure temperature, consisting of an electrically welded fused junction of dissimilar metals, and their respective leads to the data acquisition system.

### 4.9 DATA ACQUISITION SYSTEM

A data acquisition system is a computer-based system for monitoring voltage and current in selected circuits, as well as temperature in selected locations. Further information will be provided as necessary in subsequent revisions to this test plan.

## 5 RESPONSIBILITIES

### 5.1 EPRI

EPRI will assume total management responsibility for this testing. They may select a contractor to interface with the test laboratory for arranging the test, monitoring the test, and evaluating test results. They will provide, through supporting utilities, the actual materials to be tested, including cable, cable tray, and conduit.

### 5.2 NEI

NEI will advise EPRI on the planning and conduct of the test as necessary, and interpreting the test results for inclusion in NEI 00-01. They will assist EPRI in interfacing with NEI committees and NRC staff during these phases of the testing project. They will be responsible for incorporating the test results and any probabilistic conclusions therefrom into NEI 00-01 following test completion.

### 5.3 NRC

NRC will provide input prior to, during, and following the test program as may be arranged through EPRI and NEI. EPRI and NEI understand that all NRC input (NRR, RES, and contractor) will be coordinated through a single point of contact. A limited number of NRC personnel or contractors representing the Offices of Research and Nuclear Reactor Regulation will be provided the opportunity to observe the actual testing.

### 5.4 Selected Test Laboratory

The test laboratory will work with EPRI to finalize the test plan. They will provide the necessary facilities and data acquisition system, prepare the test assembly and data acquisition system for each test, and will conduct the actual tests. They will provide timely input to EPRI on changes needed during the testing program to optimize the usefulness of the results, or address unforeseen contingencies. They will provide VHS video and 35mm color photographic coverage of each test as requested by EPRI. They will provide test reports, and assist interpreting the results, as may be arranged in the final contract with EPRI.

### 5.5 Laboratory QA/QC

The testing should be conducted under the test laboratory's standard QA program. EPRI does not intend at this time to require a full Appendix B QA program for these tests. Further information will be provided as necessary in subsequent revisions to this test plan.

## 6 SPECIFIC TEST PARAMETERS

### 6.1 Parameters Considered

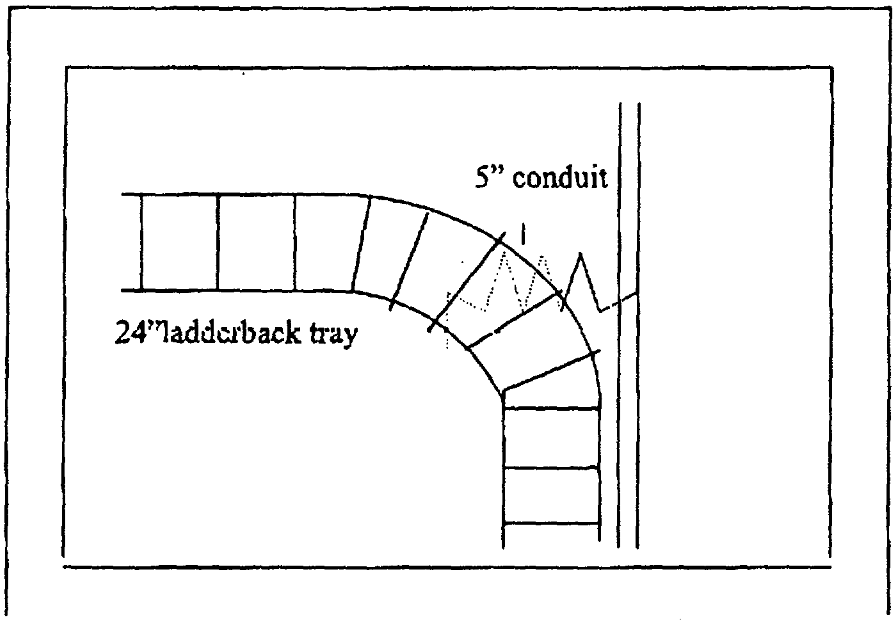
In their report "Circuit Analysis – Failure Mode and Likelihood Analysis," dated May 8, 2000, Sandia National Laboratories has identified a number of parameters for consideration during testing of the type to be performed under this plan. The parameters and their significance (as identified by Sandia), and the proposed EPRI/NEI resolution of their application to the testing, are summarized in the table below.

| Parameter | Significance | NEI Proposed Application During Industry Tests |
|---|---|---|
| Insulation Type | Likely weak | Several types of insulation and jacket materials will be tested. |
| Jacket properties | Likely weak | Several types of insulation and jacket materials will be tested. |
| Number of conductors | Significant | Control cable: One 7 conductor cable bundled with three single-conductor cables (see sketch below). Configuration will reflect typical NPP control cable circuit. Multiple tests likely.<br><br>Instrument cable: At least one test of instrument cable will be conducted, the configuration to be specified further in a later revision to this plan. |
| Armoring | Significant | At least one test with armored cable |
| Shield wraps | Significant | To be addressed in the instrument cable test |
| Drain wire | Significant | To be addressed in the instrument cable test |
| Cable age | Likely weak | Not addressed |
| Cable size | Likely significant | Control cable and instrument cable gauges to be typical of NPP use (#12 or #14 AWG control cable; instrument cable TBD) |
| Cable qualification status | Likely weak* | Unqualified, IEEE-383 cable, and armored cable will be tested in separate bundles (see cable bundling below)<br><br>* unless cables of different qualification standards are tested without differentiation in the same tray or conduit |
| Cable tray type | Likely significant | Ladderback tray will be used |
| Conduit | Likely significant | A conduit run will be tested along with each tray as sketched below. The conduit run will simulate exposure of tray-run cables to a plume or hot gas layer (in that the cables within conduit are not directly subjected to flame impingement), as well as directly testing the potential for fire-induced circuit failures in conduit |
| Air drop | Likely significant | In at least one test, at least one cable bundle in the vertical tray segment will be run outside the tray to simulate an air drop. |
| Raceway load | Significant | For most tests, cables will be bundled as described above for "Number of Conductors." This will simulate the pressure applied to free-run cables in trays with significant fill. Four cable bundles will be tested in each tray. A weight will be placed on top of the bundled cables to simulate the weight of conductors in a partially filled tray. One test will evaluate potential cable failures in a typically filled tray |
| Spacing | Significant | See above for "Raceway load" for control and instrument cable. This issue applies primarily to power cables, which will not be addressed in this round of testing. |
| Coatings | Likely weak | Not addressed |
| Raceway orientation | Likely significant | A horizontal run tray with a 90 degree horizontal bend is planned. One test with vertical tray and conduit will be run. |
| Cable bundling | Likely significant | See "Number of Conductors" and Raceway load." |
| Circuit type | Likely significant | Control circuits will be the primary focus; at least one instrument circuit will be tested as indicated above |
| Base ampacity | Likely significant for open circuits | Not addressed because the principal focus will be hot shorts and shorts to ground. |
| Circuit voltage | Significant | 120 VAC for control circuits; to be determined for instrument circuits |
| Direct flame impingement | Likely significant | Variable tray heights above the flame are planned to simulate both direct flame impingement and plume or hot gas layer effects on cables in open tray. Conduit-run cables will also serve to simulate hot gas or plume effects. |
| Convective exposure | Likely significant | Tray and conduit arrangements with direct flame tests will address this |
| Exposure duration/ | Likely significant | Variations of flame energy and duration are not planned at this time. |

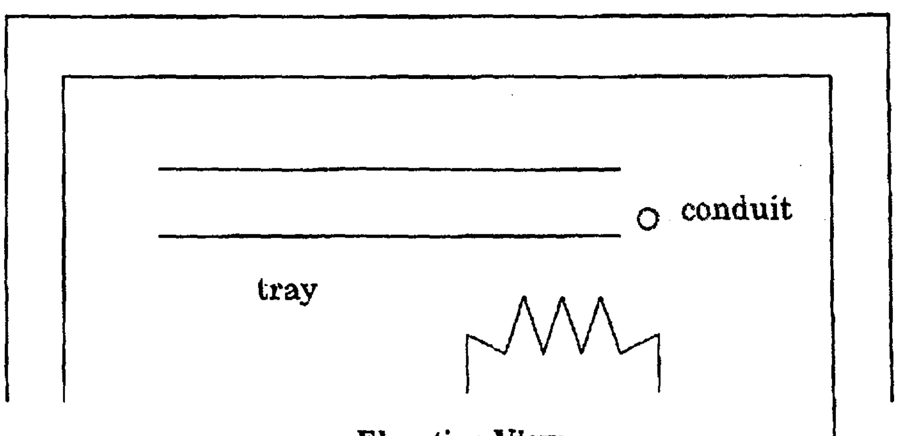
| Parameter | Significance | NEI Proposed Application During Industry Tests |
|---|---|---|
| intensity | | Flame effects can be varied with changing the relative height of the tray/conduit and flame as noted above. |
| Relative fire elevation | Likely significant | To be addressed as noted above for "Direct flame impingement" |
| Application of suppressants | Likely significant | At least one test with a water dousing at 0.3 liter per square meter per second is planned. |

### 6.2 TRAY AND CONDUIT CONFIGURATION

The planned conduit and tray configuration is as follows. It reflects cables to be tested in a horizontal configuration. The open ends of the conduit should be stuffed with Kaowool to limit the fresh air available for burning the cable. Only a straight run of conduit should be used so that the cable can be removed from the conduit for examination without destroying it (it may thermoset during the test).




**Plan View**




**Elevation View**

**Figure 1 Horizontal Tray/Conduit Arrangement**

A vertical configuration is also planned but not shown in this revision of the test plan. The vertical configuration will utilize a straight run of cable tray with a vertical segment of conduit in close proximity, without any bends in either the conduit or the tray. The vertical configuration will include a provision for testing cable in an air drop configuration. The flame will be located at an appropriate point near the base of the tray and conduit run.

The resolution of other testing parameter issues was as follows:

- Circuits should include a power source that is representative of power sources for actuated components in nuclear plants, such as a control power transformer for each powered circuit. This will allow a fault to result in tripping a circuit protective device (a fuse) to clear an overcurrent condition as it would in an actual control circuit.

- For most tests, tray fill will be simulated through the use of bundled cables as shown in Figure 3. In each test, four bundles (including at least three bundles of IEEE-383 qualified and one of non-qualified cables) will be included in the actual tray, or as many bundles as can be supported with monitoring instrumentation. One IEEE 383 qualified cable bundle will be run in conduit. A ceramic brick or similar device will be laid on top of the bundles to simulate the weight of additional cable above the monitored ones. One test will utilize a tray approximately half full of IEEE 383 qualified cables to determine if failure modes from bundled cables differ significantly from loose cables under normal configurations.

- The tray test will demonstrate the effects of actual flame impingement, and possibly plume or hot gas layer exposure, depending on the height of the tray above the flame. The conduit test will demonstrate the fire effects on cable in conduit, as well as simulate the effects of plume or hot gas layer exposure (in that there is no direct contact with flame).

- Flame energy should approximate 100 kW. Flame height, or the height of the tray and conduit above the flame, should be variable for the horizontal tray and conduit configurations if possible. In an open flame test of this type the temperature profile is not easily controllable; however, to the extent possible, the temperature profile seen at the cables in the tray should approximate the "Recommended" profile below. That profile is a variation of the "normal" profile from UL-2196. The UL-2196 profile, also shown below, has a more rapid ramp at the beginning of the test but follows the same profile after 30 minutes:

| | "Recommended" | UL-2196 "Normal" |
|---|---|---|
| 0 minutes | 50 to 90 °F | 50 to 90 °F |
| 5 minutes | 500 °F | 1000 °F |
| 10 minutes | 1000 °F | 1300 °F |
| 20 minutes | 1300 °F | ---- |
| 30 minutes | 1550 °F | 1550 °F |
| 1 hour | 1700 °F | 1700 °F |

- Based on input from NRC at a meeting on July 21, and prevailing views from industry representatives, EPRI does not plan to test power cables.

## 6.3 VOLTAGE AND CURRENT MONITORING

The voltage and current monitoring of control cable will use the scheme in Figure 2.

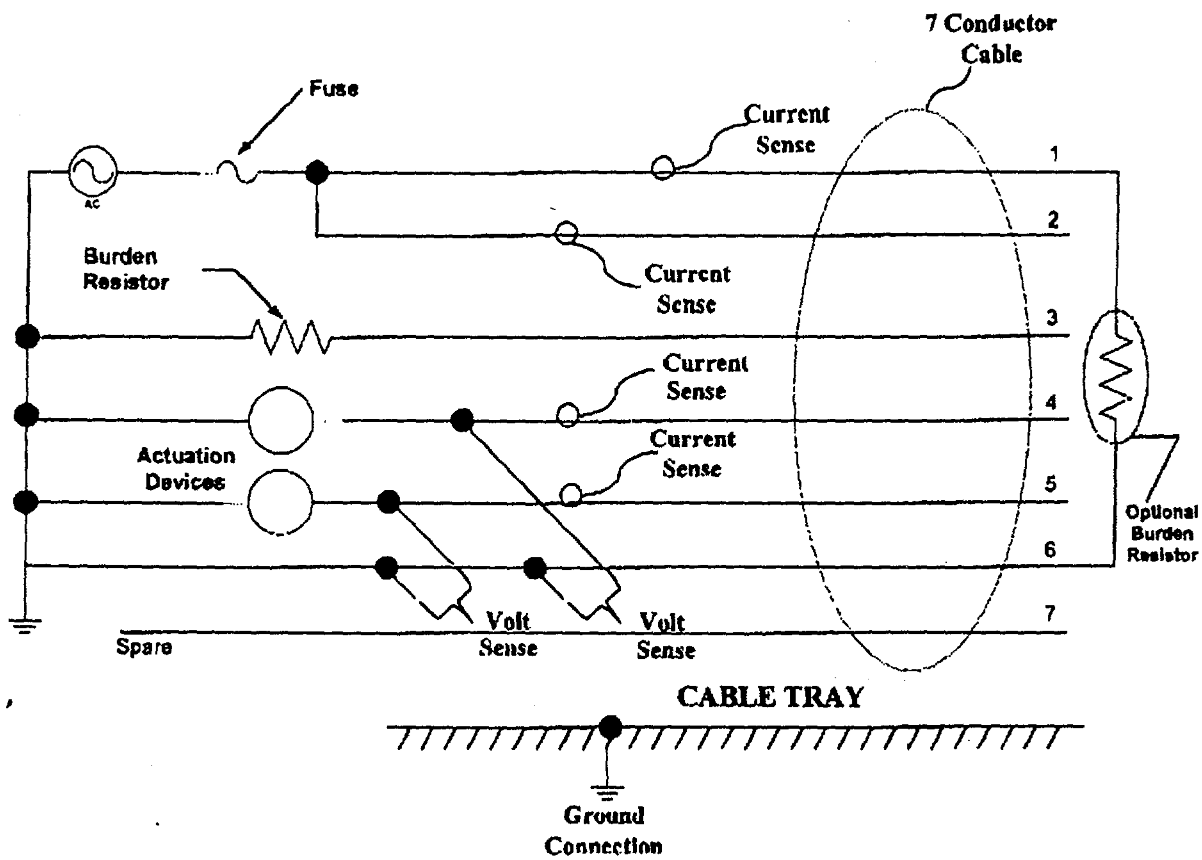



**Figure 2**
**Monitoring and Device Connection for Control Cable**

## 6.4 CONTROL CABLE TESTING

The control cable bundle configuration to be tested is represented in Figure 3:

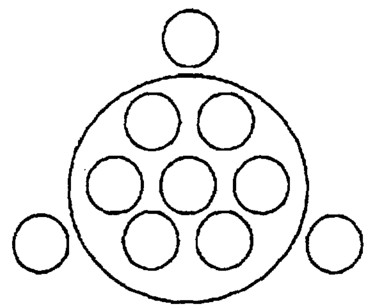


**Figure 3 Control Cable Bundling Arrangement**

One 7-conductor control cable will be bundled with three single-conductor control cables, and bound with tie wraps every 50 centimeters (exception: see Test 5). The single conductors will not be wound around the 7-conductor cable; the relative locations of the four cables will remain essentially the same for the length of the cable.

Within the 7-conductor cable, two conductors will be connected to two separate actuation devices with no power source. Two additional conductors will be powered from a 120VAC power source, one through a burden resistor. One conductor will be spared (no connections). One conductor will be connected to a burden resistor, but not connected to the power source. The seventh conductor will be grounded. The conductors in the single-conductor cables will form a circuit with an actuation device, but not powered. All circuits will be monitored for voltage and current. This represents the fairly typical control circuit shown in Appendix A.

## 6.5 INSTRUMENT CABLE TESTING

Industry is concerned only about spurious control logic signals from instrument circuit failures, not erroneous indication. Most plants address in their pre-fire plans which instruments are protected and can be relied upon during a fire in any fire area. Thus, erroneous operator actions based on erroneous indications are unlikely.

EPRI and NEI will conduct one instrument cable test.. This test will determine whether a short to ground occurs on any shield before any hot shorts occur. It is anticipated that the configuration tested will be a twisted shielded pair, with 25-30 VDC / 4-20 milliamp circuits and 0-10 VDC circuits. Further details will be specified in a subsequent revision to this test plan.

## 6.6 TEST APPARATUS

The test shall be conducted using a sandbox-type flame source whose distance from the tray and conduit can be varied. The horizontal segments of ladderback tray and conduit, shown in Figure 1, shall be 1 to 1.25 meters in length. The vertical segments shall be the same length.

## 6.7 OTHER TEST SPECIFICATIONS

### 6.7.1 Cable

Cable length for all test samples will be 2 meters. Control cable will be 7-conductor, 14 AWG. It is expected that insulation will be IEEE-383 qualified insulation such as EPR or XLPE with Hypalon or Neoprene jacketing material. Non-qualified cable and jacketing material is expected to be PVC. Armored cable will also be tested. Cables may be used or new, since cable age is not deemed a significant factor.

### 6.7.2 Cable Termination

The ends of test sample cable conductors shall be separated from each other, from the shield and drain wire as applicable, and sealed. Sealing shall consist of wrapping in silicone/glass tape and/or encapsulation in a high temperature resistant, silicone based compound such as General Electric RTV to a minimum depth of 4 cm or 1.5 inch. This is intended to prevent circuit failures at the otherwise unprotected ends of the cables.

### 6.7.3 Protective Devices

For control cable, select circuit breakers or slow blow fuses properly to account for temperature derating by heat conducted through cable conductors from the fire exposure sample. No protective devices are needed for instrument cable.

### 6.7.4 Source Impedance Burden

For control cable, circuits should be supervised by a source impedance or resistance burden to limit maximum current flow to 1.5 to 2.0 amperes. Fuses shall not be used as current limiting devices or as circuit failure indicators.

For instrument cable, supply shielded pair circuits from separate current limited sources or supervised by a source resistance burden to limit maximum current flow to 0.5 to 1.0 ampere. Fuses shall not be used as current limiting devices or as circuit failure indicators. Shields and drain wires shall be connected to a common single point grounding system.

### 6.7.5 Voltage and Current Monitoring

For control circuits, monitoring of voltages and currents shall be of a continuous sampling type through a multi-channel event recorder or PC computer based system. Voltage and current monitoring points for control and instrument cable test circuits shall be located at the load terminal connections between the source burden impedances or resistances and the test cable conductors. Use high accuracy current sensors, preferably Hall based, thermally isolated and temperature stabilized.

The same applies for instrument cable. In addition, the drain wire of shielded instrument cable may optionally be current monitored at the single grounding point for each shielded pair circuit.

### 6.7.6 Actuating Devices

For control cable, potential actuating devices to be used are NEMA-1 starters, ASCO solenoids, and MCC breaker, trip, or actuation relays. These devices shall be connected as shown in Figure 2. For instrument cable, actuated devices may include transmitter and trip unit combinations. All such devices will be supplied by EPRI/NEI.

### 6.7.7 Temperature Monitoring

Thermocouples shall be of the rapid response type. Multiple thermocouples should be used to record accurate temperature profiles, including any possible hot spots. Thermocouples should be used without sleeves capable of introducing reading errors or compensated to null-out any such errors. Thermocouples should not be embedded in cable jackets, but placed at least every foot in close proximity to the tray segments and conduit.

## 7 TESTS TO BE CONDUCTED

The tests to be conducted are listed below.

| Test number | Cable function & design | Tray height above flame | Water spray | Tray/ conduit/ air drop config | Bundle desig-nation | Cable qualifi-cation and type | Actuated device type & size |
|---|---|---|---|---|---|---|---|
| 1 | 7/C & 1/C control | Ht 1 (TBD) | N | Horizontal tray & conduit | 1-A | 383 XLPE / Hypalon | NEMA 1 |
| | | | | | 1-B | 383 EPR / Hypalon | Asco TBD |
| | | | | | 1-C | 383 type 3 TBD | TBD |
| | | | | | 1-D | Non-383 PVC | TBD |
| | | | | | 1-E (conduit) | 383 XLPE / Hypalon | TBD |

| Test number | Cable function & design | Tray height above flame | Water spray | Tray/ conduit/ air drop config | Bundle desig-nation | Cable qualifi-cation and type | Actuated device type & size |
|---|---|---|---|---|---|---|---|
| 2 | Same as 1 | Ht 2 (TBD) | N | Horizontal tray and conduit | 2-A | 383 XLPE / Hypalon | NEMA 1 |
| | | | | | 2-B | 383 EPR / Hypalon | Asoo |
| | | | | | 2-C | 383 type 3 TBD | TBD |
| | | | | | 2-D | Non-383 PVC | TBD |
| | | | | | 2-E (conduit) | 383 XLPE / Hypalon | TBD |
| 3 | Same as 1 | Flame location TBD | N | Vertical tray & conduit, 1 air drop | 3-A | 383 XLPE / Hypalon | Asco |
| | | | | | 3-B | 383 EPR / Hypalon | NEMA 1 |
| | | | | | 3-C | 383 type 3 TBD | TBD |
| | | | | | 3-D | Non-383 PVC | TBD |
| | | | | | 3-E (conduit) | 383 XLPE / Hypalon | TBD |
| | | | | | 3-F (air drop) | 383 XLPE / Hypalon | TBD |
| 4 | Same | Ht 1 (TBD) | N | Horizontal tray & conduit | 4-A | Armored | Asco |
| | | | | | 4-B | Armored | NEMA 1 |
| | | | | | 4-C | Armored | TBD |
| | | | | | 4-D | Armored | TBD |
| | | | | | 4-E (conduit) | Armored | TBD |
| 5 | Same | Ht 1 | Y | Horizontal tray & conduit, tray half full of cables surrounding bundles (bundles placed but not tied) | 5-A (resting on tray) | 383 XLPE / Hypalon | Asco |
| | | | | | 5-B (resting on tray) | 383 EPR / Hypalon | NEMA 1 |
| | | | | | 5-C (top of tray fill) | 383 type 3 TBD | TBD |
| | | | | | 5-D (top of tray fill) | 383 EPR / Hypalon* | TBD |
| | | | | | 5-E (conduit) | 383 XLPE / Hypalon | TBD |

| Test number | Cable function & design | Tray height above flame | Water spray | Tray/ conduit/ air drop config | Bundle desig-nation | Cable qualifi-cation and type | Actuated device type & size |
|---|---|---|---|---|---|---|---|
| 6 | Instrument type TBD | Ht 1 | N | Horizontal tray & conduit | 6-A | 383 XLPE / Hypalon | Transmitter and trip unit |
| | | | | | 6-B | 383 EPR / Hypalon | Transmitter and trip unit |
| | | | | | 6-C | 383 type 3 TBD | Transmitter and trip unit |
| | | | | | 6-D | Non-383 PVC | Transmitter and trip unit |
| | | | | | 6-E (conduit) | 383 XLPE / Hypalon | TBD |

Each test is described in more detail below.

## 7.1 TEST 1

Test 1 represents Base Case 1 (see the Sandia report described in Section 6.1 for a description of the "Base Case" concept), which is typical 7-conductor control cable. Three bundles each of different types of IEEE-383 qualified cable and one of non-qualified cable of types typically found in nuclear plant control circuits will be run in the tray, and one bundle of non-IEEE 383 qualified cable will be run in the conduit. The tray and conduit will be at (height 1 - TBD) above the flame, which provides direct flame impingement on both.

Each bundle will be connected to both actuation devices and voltage and current monitors, as described earlier. The test will determine whether the devices shown actuate from either conductor-to conductor interactions within the same multi-conductor cable, or from cable-to-cable interactions (conductors in different cables). Voltage and current measurements will be used to calculate insulation resistance between conductors subject to hot shorts. After the test insulation resistance will be calculated and plotted, and correlated with actual device actuations, if any. If there are no actuations, insulation resistance will be plotted to determine how close the devices might have come to actuation. Voltage and current data will also be compared with the pickup voltage and current values for other devices that may not be evaluated directly in this test, such as Agastat relays.

## 7.2 TEST 2

Test 2 represents a variation on Base Case 1. This variation is the height of the conduit and tray above the flame (Height 2, which places both the tray and conduit outside of direct flame impingement in the fire plume or hot gas layer). This variation evaluates the possibility of differing effects on cable damage between direct flame impingement and plume or hot gas layer temperatures. No other variables will be introduced.

### 7.3 TEST 3

Test 3 represents another variation on Base Case 1. This variation evaluates the impact of vertical cable runs in tray and conduit, and air drops, on the potential for cable damage. The flame source is located at (location TBD) to allow direct flame impingement on the bottom of the vertical runs of tray, conduit, and air drop.

### 7.4 TEST 4

Test 4 represents another variation of Base Case 1. This test is identical to Test 1 except that armored control cable is used instead of IEE-383 qualified and unqualified cable.

### 7.5 TEST 5

Test 5 represents two other variations of Base Case 1. In this test, IEEE-383 qualified control cable will be used with 50% tray fill, instead of the bundling arrangement. IEEE-383 qualified and unqualified cable will not be mixed in the same tray, so qualified cable alone will be used. Within the tray, a cable configuration similar to the bundled arrangement (one 7-conductor control cable with three single-conductor cables in close proximity, but not strapped together) will be used for monitoring, and other cables that are not monitored will surround these. Two "bundles" (as described above) each of two different types of IEEE-383-qualified cable will be placed on the bottom of the tray with other cables on top of them. Fire effects on these cables will be compared with fire effects on the 383-qualified cable in Test 1. Two other 383-qualified "bundles" will be placed on the top of the tray fill. Fire effects on these cables will be compared with the cables on the bottom of the tray to ascertain the balance of shielding effects vs. enhanced potential for grounding (on the bottom of the tray). The destruction of cables being not being monitored will be visually observed for relative damage of cables in various locations of the tray.

Another variable introduced in this test is the use of a water spray immediately after the test. This will determine the extent to which water impacts the circuit failure modes. If it is not practical to conduct the water spray portion of the test while the circuits are energized, the circuits will be de-energized and removed from the test area, then sprayed, then meggered to evaluate insulation resistance in adjacent conductors.

### 7.6 TEST 6

Test 6 represents Base Case 2, instrument cable. The test will employ generally the same configurations as Test 1 except that instrument cable will be tested instead of control cable. EPRI and NEI anticipate that the actuated devices will be transmitter and trip unit pairs. Further information will be specified in the next revision to this test plan.

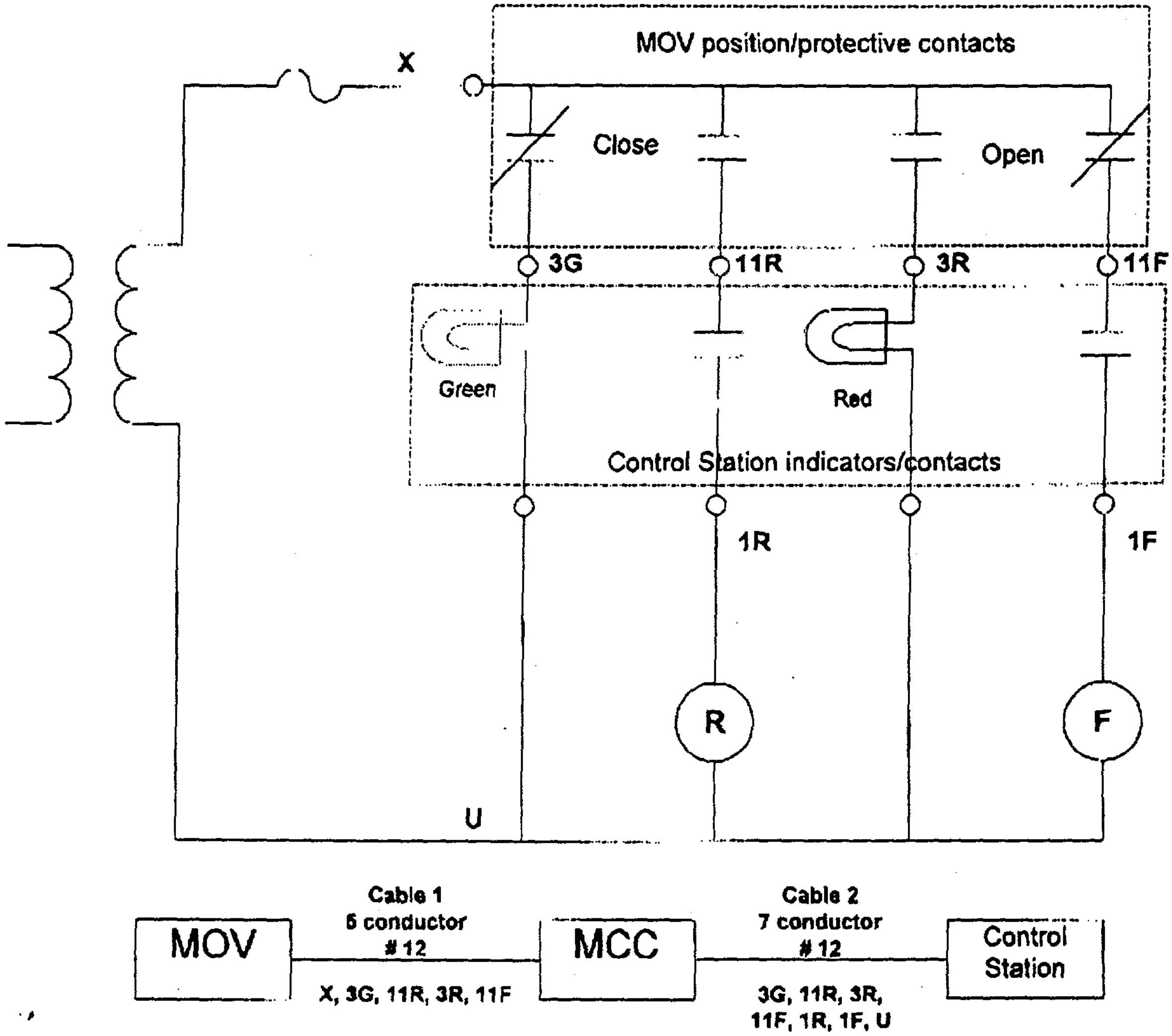
## 8.0 USE OF TEST RESULTS

The test results will include the following data:

Actuation data in various devices
Voltage and current data
Plots of insulation resistance
Temperatures at various locations in the test apparatus

This data will be evaluated by a panel of experts, and it is anticipated that probabilities of circuit failure will be calculated from this information through an expert elicitation process. This process is described in a separate EPRI/NEI draft document, also to be provided to NRC for review. It should be noted that the number of tests reflected in this test plan will not likely provide a statistically significant amount of data. However, combined with the limited data from other tests discussed in the Sandia report, this test data should be sufficient to substantially address the likelihood of circuit failures for the Base Cases tested, when evaluated by a team with expertise in the following areas:

Probabilistic analysis
Circuit analysis
Test development and analysis
Cable construction and failure modes




# Typical MOV control circuit

## APPENDIX A

**Typical Control Circuit**