October 2, 2000

TO: Fred Emerson
Nuclear Energy Institute

From: Joseph Birmingham**/RA/**
Nuclear Regulatory Commission

Subject: DRAFT PRELIMINARY STAFF COMMENTS ON THE PROPOSED FIRE TEST PROTOCOLS (September 15, 2000)

Fred, these are the staff's preliminary comments on the proposed fire test protocols that you sent to us September 15, 2000. Although the comments are preliminary, they are being sent to you to facilitate discussions on the Fire Test Protocols during a planned work meeting with NEI on October 3, 2000. The comments are from NRR, RES, and there is input from the RES contractor.

Please contact me (301) 415-2829 or Ed Connell (301) 415-2838 if you have any questions.

Attachment: As stated

Accession#ML003755784

DRAFT NRC COMMENTS ON
PRELIMINARY EPRI/NEI TEST PLAN FOR EVALUATION OF FIRE-INDUCED CIRCUIT FAILURES, REVISION D, 9/14/00

General Comments

The objective and scope of the fire test program, the use of the test results, the issues to be resolved under the test program related to the CARP, the role and selection of the expert panel and the level of detail provided in the final product needs to be clarified. This will be discussed in detail at the upcoming public meeting.

Specific Comments

1. The minimum duration of the fire test should be extended from 30 minutes to 60 minutes from the ignition of the burner, with a provision that following the initial 60 minute exposure if any circuit failures occur an additional 30 minutes of fire exposure will be conducted following the last circuit failure identified. This is useful data regardless of the timing of the failure. The staff does not concur in the stated assumption that 30 minutes represents the time required for the fire brigade to “put out the fire” as there have been several fire events in the industry where the plant fire brigade took significantly longer than 30 minutes to suppress a fire. In addition, the test should not be terminated upon indication of multiple spurious actuations or multiple hot shorts, this is also useful data to be recorded.

2. EPRI/NEI should provide the NRC with the complete test results, including all the test data collected during the fire tests. The test reports should be made publicly available. If the intent is to make any of the information proprietary or withhold full disclosure from the staff, further discussions with the staff will be required.

3. Tests of a random cable fill (unbundled) to varying levels of tray fill should be included in the test plan (10% - 80%). The use of bricks to weigh down the cables should be deleted from the test plan as it is not representative of actual plant configurations.

4. Tests should be conducted with the HRR from the burner varied at a minimum of 3 different levels between 70KW and 500KW (e.g. 70, 200, 500). The burner should be stabilized at a constant HRR during each fire test and should not attempt to follow a time-temperature curve as proposed in the draft test plan. This is consistent with the constant HRR assumptions typically used in the licensee’s IPEEE submittals.

5. The staff does not concur with the assumption that erroneous operator actions based on erroneous indications are unlikely. It is not clear what purpose this statement serves in a fire test plan and should be deleted.

6. In lieu of direct flame impingement on the cable tray, the cable trays and conduits should be located in the fire plume above the flame region, in the ceiling jet at a reasonable horizontal distance (e.g. 1 meter) from the plume centerline, and in the hot gas layer at a reasonable horizontal distance (e.g. 2 meters) from the plume centerline.

7. The cable trays in the test program should be randomly filled to varying percentage of cable fills in lieu of the bundling configuration described in the draft test plan which is not representative of actual plant installed configurations.

8. Multi-conductor cables with more/less than 7 conductors should be included in the test plan (e.g. 3 &12) and different conductor sizes (e.g. 8-20 AWG) should also be included to be more representative of the cable population present in the industry.

9. The water spray portion of the test should be deleted from the plan unless it can be conducted immediately following the fire exposure with the cables energized, otherwise it serves no purpose. The staff realizes that these conditions may be a safety concern for laboratory personnel.

10. The proposed electrical circuit is designed to mimic an actual control circuit. This is an interesting approach with some clear advantages. However, as the only test circuit it will not meet the stated objective of the tests. In particular, the circuit is too complicated to allow for calculation of conductor insulation resistance values (stated as a goal in Section 2 of the plan). There are simply too many leakage paths (some monitored and some not), too many different voltage potentials, and too many current flow paths (some with base loads and others without) to allow for a definitive assessment. It is recommended that some of the exposed cables should be monitored using a circuit that is specifically designed to assess conductor insulation resistance. (Several potential circuits of this type have been suggested in the past.)

11. The proposed electrical circuit has inadequate electrical monitoring instrumentation to assure that we will detect various cable fault modes. A number of short-circuit paths might be created that will not be detected.

12. No discussion of the actual wiring of the cable conductors to the circuit is provided. A seven-conductor cables is an arrangement of six conductors around a seventh central conductor and the proximity of one conductor to another will be maintained for the entire length of the cable. The selection of which conductors are connected to specific legs of the circuit will have a strong influence on the resulting actuation potential, particularly given one conductor is grounded and one conductor will see an imposed baseline current load (conductors 1 and 6 in Figure 2 of the plan). This aspect of the circuit needs to be considered and specified.

13. Related to Comment #12, the combination of the proposed circuit and a seven conductor cable is, in fact, mixing two variables that we would prefer to keep separate. These are the likelihood that some hot short will occur and the likelihood that a specific pair of conductors will short together. That is, in this circuit it takes short circuits between specific pairs of conductors to result in a spurious actuation while other shorts will not be detected and yet others will trip out the circuit. A different wiring of the conductors within the cable may lead to different results but the number of tests and sample cables is not sufficient to explore both two factors. "Luck of the draw" becomes dominant, and this in not desirable in a test program. Some systematic consideration of our need to understand both of these two factors should be incorporated into the test scheme.

14. Conductor 2 should be separately fused rather than fused in common with conductor 1 (see Figure 2 of the plan).

15. There is no description of energizing and/or monitoring circuits for the single conductor cables that will surround each of the seven conductor cables. It these are source cables, they should be separately fused and energized so that the correct cable-to-cable hot short would actuate the circuits. They should also be monitored for current flow and voltage.

16. The effect on the occurrence and mode of circuit failures of using thermoset vs. thermoplastic insulation/jacketing should be evaluated as part of the test program.

17. The voltage and current monitoring scheme, shown in Figure 2, raises a number of troubling concerns:

- "voltage sense" and "current sense" instruments are applied only to the two energized conductors (current sensors only) and the two conductors connected to the actuating devices (current and voltage sensors).
- as presently configured, the proposed monitoring circuit will not detect a number of conductor-to-conductor interactions. Any combination of shorts only involving conductors 3, 4, 5, 6, 7 and the cable tray will have no immediate effect on the circuit and are undetectable.
- any combination of shorts involving conductors 1 or 2 with either conductor 6 or the cable tray will result in blowing the fuse, thus eliminating any further usefulness of this circuit during the fire test. This may be mitigated by fusing the two energized conductors separately.
- since neither conductor 1 or 2 is being monitored for voltage, no insulation resistance data will be gained prior to blowing the fuse.
- it appears that forcing a current flow between conductors 1 and 6 through one of the burden resistors during the tests will unnecessarily complicate the determination of insulation resistance values between the various conductors in the cable bundle.

- the circuit does not specify the fusing criteria, the baseline current to be imposed on conductors 1 and 6, nor the actuation current required for the devices on conductors 4 and 5. These factors need to be carefully balanced and specified.

It is recommended that the proposed circuit be more explicitly specified and/or redesigned. Additional monitoring of voltage and current on the other conductors is recommended. Consideration should also be given to use of a second test circuit designed to measure insulation resistance for some cable bundles.

18. The purpose of the single conductor cables in the test needs to be clarified. Appropriate energizing and/or monitoring circuits should be provided.

19. The proposed conductor wiring scheme(s) should be indicated in Figure 3.

20. With regard to Section 6.7.1, does the 2 meter cable length imply that each bundle will make two passes through the 1-meter tray/conduit? It is recommended that each cable should make only a single pass through the tray.

21. With regard to Section 6.7.3, the discussion of temperature derated circuit protection seems unnecessary. The control cable fuses shown in Figure 2 should represent values typically used in a control circuit and should be appropriate to accommodate the anticipated loads, including that of the actuation devices and with margin typical of a plant design. This would likely imply fuses of at least 15 A. It will certainly be desirable to have the actuation devices, fuses, etc. outside the fire room. If you use reasonable length lead wires from the instrument racks to the test samples, heating due to conduction down the lead wires will not be an issue.

22. Section 6.7.4 states that “fuses shall not be used as current limiting devices or as circuit failure indicators.” This statement should be explained. What is the purpose of the fuses shown in the circuit Figure 2 if not as a current limiting device?

23. With regard to Section 6.7.6, how will the operation, if any, of the actuating device(s) be determined and recorded during the tests? What are the pickup voltage/current levels for each of the actuating devices proposed (starters, solenoids, and relays) for Tests 1-5, as well as the operating characteristics of the transmitter and trip unit combinations to be included in Test 6? Have these been considered in the design of the power supply and fusing?

24. With regard to Section 6.7.7, it would be useful to have a figure (similar to Fig. 1) showing the thermocouple locations for these tests. How many thermocouples will be used for each test? Will they be Type K thermocouples, or some other standard?

25. What are the dimensions of the “sandbox-type” burner and what will be the exposed length of the cable trays and conduits to the fire environment

26. Provide the specific details of the test furnace (e.g. dimensions, ventilation during the test, lining materials, etc.).

27. The test plan appears to use the term “circuit” differently in different parts of the plan. In some cases the plan identifies a “circuit” as <u>a single-conductor</u> and at others as <u>a grouping of individual conductors providing a control function.</u>

28. Section 4.5 appears to refer to insulation resistance as a property of a circuit. IR is actually a property of a conductor’s insulation. That is, the insulation resistance is between a conductor and ground or conductor-to-conductor. Some care is needed because, for example, conductor-to-ground would typically be through one layer of insulation only (e.g., conductor-to-tray or conduit) whereas conductor-to-conductor reflects the insulation resistance of two layers of insulation (that for each conductor) even if one conductor is grounded as is the case in this circuit.

29. Table 6.1 should include a specific reference which shows which of the data gaps identified by SNL are being addressed by this test program.

30. Tests should include ungrounded DC (e.g. 125 volt) control circuits. AC and DC voltage has a different impact on electrical cable insulation. A DC circuit breaker should be included as the actuating device.

31. The actuating devices should not impact the electrical monitoring of the exposed cables or act as a thermal load in the test (Sect. 6.7.3 refers to heat derating of breakers).

32. The entire process of thermal decomposition, combustion and fire propagation is best described in terms of three scales: micro, marco and mass. For the subject circuit failure modes we are concerned with the physics of failure applies to the micro scale. Although the Sandia Report has identified most of the parameters and their significance level the subject test plan’s experimental design is weak. Listed below is a table of the proposed tests versus SNL and industry parameter/significance level (SL).

Parameter	SL	Test 1 (T1)	Test 2	Test 3	Test 4	Test 5	Test 6
Insulation Type	LW	XLPE EPR Hypalon PVC	SAME AS T1	SAME AS T1	N/A	SAME AS T1	SAME AS T1
Jacket Properties	LW	Hypalon or Neoprene	SAME AS T1	SAME AS T1	SAME AS T1	SAME AS T1	SAME AS T1
Cable Qualification	LW	IEEE 383 Non-IEEE 383	SAME AS T1	SAME AS T1	N/A	SAME AS T1	SAME AS T1
Cable Size	LS	#12 or #14	SAME AS T1	SAME AS T1	SAME AS T1	SAME AS T1	TBD
Cable Tray Type	LS	Horizontal	SAME AS T1	Vertical	SAME AS T1	SAME AS T1	SAME AS T1
Cable Function	LS	Control	SAME AS T1	SAME AS T1	SAME AS T1	SAME AS T1	Instrument
Tray Height Above Flame	*LS	Height 1 (TBD)	Height2 (TBD)	TBD	SAME AS T1	SAME AS T1	SAME AS T1
Water Spray	LS	NO	NO	NO	NO	YES	NO
Conduit	LS	YES	YES	YES	YES	YES	YES
Air Drop	LS	NO	NO	YES	NO	NO	NO
Raceway Orientation	LS	90^0 Bend	SAME AS T1	Vertical	SAME AS T1	SAME AS T1	SAME AS T1
No. of Conductors	S	7 Bundle / 1	SAME AS T1	SAME AS T1	SAME AS T1	SAME AS T1	SAME AS T1
Armoring	S	NO	NO	NO	YES	NO	NO
Shield Wraps	S	As Applicable?	?	?	?	?	?

Drain Wire	S	As Applicable?	?	?	?	?	?

LW:	Likely Weak	TBD:	To Be Determined
LS:	Likely Significant	?:	No specific information in Test Plan
S:	Significant	*:	Multiple parameters are represented

Note the lack of variability in the test configurations for several LS (likely significant) and S (significant) parameters. LW parameters should be representative of the installed cables and confirmation should be derived that the parameter has weak significance. LS parameters should have median or average variability among the test configurations and S parameters should have the maximum variability. For example, the Number of Conductors which Sandia has judged to have significance in terms of circuit failure dependency should have the range of conductor sets (e.g., 3, 7, and 12 conductor bundles in different tests) (See Comment #8).

33. The cables condition and installation should be visually inspected, recorded and evaluated as necessary prior to, and immediately following the completion of each test in order to determine the failure mode(s) if possible. Given the limited number of tests to be performed, a manufacturing or installation error may significantly skew the results and lead to a false positive or negative conclusion by the expert panel and the NRC staff.

34. The NEI/EPRI test plan lists the "insulation type" parameter as "likely weak." EEIB has reviewed about five or more Wylie test reports on the results of tests done to establish separation distances during plant licensing. Based on those reviews we tend to agree with this characterization, with the exception of TEFZEL cable. In the Wylie tests done for Clinton the TEFZEL cable failed in two of the configurations while the other tested target cables passed. As a result, Clinton established larger separation distances for this type cable than the other type tested (EPR/HYPALON). The NEI/EPRI proposed test plan does not indicate that it intends to test TEFZEL cable. In general, the test of insulation types should confirm the weak significance of this parameter in terms of circuit failure frequency. If testing indicates that insulation type is not a “weak” parameter then additional testing may be necessary for insulation types not tested.