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ACRS SCRAM SYSTEMS RELIABILITY SUBCOMMITTEE
MEETING MINUTES
JULY 17, 1985
WASHINGTON, DC

PURPOSE: The purpose of the meeting was to discuss the topic of scram breaker reliability.

ATTENDEES: Principal meeting attendees included:

ACRS	NRC
W. Kerr, Chairman	F. Hebdon
J. Ebersole, Member	R. Hernan
D. Ward, Member	S. Minor
C. Wylie, Member	F. Rowsome
P. Davis, Consultant	
W. Lipinski, Consultant	

Westinghouse
J. Little
M. Hitchler

A complete list of attendees is attached to the office copy of these Minutes.

MEETING HIGHLIGHTS, AGREEMENTS, AND REQUESTS

1. In opening comments, Dr. Kerr noted the following: (1) the ATWS issue has been resolved via rulemaking, but the ACRS felt that prudence and recent operating experience seemed to dictate another look at the issue of scram reliability; (2) to date, no scram failure has occurred although precursors have been seen; (3) there have been a high number of spurious scrams; this is of concern, because of the challenge to the RPS and the possibility that we may be testing the RPS too frequently; (4) we "may be asking too much" of our scram systems, in that we seem to be requiring a RPS

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reliability that cannot be demonstrated; (5) future reactors should consider design features that would accommodate an ATWS; (6) it appears that ~ 23% of the BWR core melt-risk is due to ATWS; for PWRs the figure is ~9%; this may suggest some actions are needed here; (7) we don't have any performance criterion on the RPS or its components. In consideration of the above, the Subcommittee decided to focus on the topic of scram breaker performance and whether it could be determined if this performance is acceptable.

Mr. Ebersole made comments to the effect that he feels the present breaker systems should be more rugged. Mr. Lipinski agreed with Mr. Ebersole noting that, in general, electrical components are more reliable than mechanical components. Further Subcommittee discussion centered on the issue of how one demonstrates that a given system design has the desired reliability and how one communicates to a designer what reliability is acceptable. Mr. Lipinski noted that in working on a recent scram system design they selected a reliability criterion that was ~ 10^{-4} more reliable than needed in order to accommodate common mode failure (CMF) potential.

2. Mr. Hernan (NRR) noted that due to NRR activities surrounding the recent Davis-Besse event, certain key individuals from NRR were not available for today's meeting.

Mr. Hernan discussed NRR actions taken to improve and assure acceptable RPS and breaker reliability following the Salem ATWS events. He detailed the requirements specified to licensees in Generic Letter 83-28. The Generic Letter specified a number of actions in four areas: (1) post trip review; (2) equipment classification and vendor interface; (3) post-maintenance testing; and, (4) reactor trip system reliability improvements. Full compliance with these requirements by all Licensees should be complete by early FY 1986.

NRR also noted that consideration is being given to requiring modifications to the W SSPS (solid-state protection system) as a result of the recent failure of a scram channel at Sequoyah. This proposal is under review by NRR as Generic Issue 115-"Reliability of the W Solid State Protection System". In response to Mr. Ebersole, Mr. Rosa (NRR) said NRC does not specify competency requirements for maintenance technicians.

Dr. Kerr questioned the rationale behind the requirement for life-testing of scram breakers per GL 83-28. Mr. Hernan said he would research this point and respond later. Mr. Little (W) said he would discuss this topic during his presentation. Further discussion noted that NRR will establish breaker replacement requirements after they have received and evaluated data on breaker life cycle tests. Mr. Rosa indicated that the Staff will likely accept almost any improvement in breaker reliability and/or be satisfied if the current reliability is better quantified. In response to Mr. Wylie, Mr. Hebdon (AEOD) noted that failures of single components during maintenance (e.g. breakers), will generally not be reported to the NPRDS or AEOD, since AEOD relies on NPRDS for collection of component failure data.

3. S. Minor (NRR) discussed aspects of the recent RTB breaker failure seen at Ranco Seco. The plant scram breakers had recently been refurbished at GE-Atlanta and certified operable by B&W-Lynchburg. After re-installation, a breaker failed on test, prior to plant start-up. It is not known where the damage and/or maintenance error occurred that disabled the breaker. It is also not clear just what the details of the maintenance activities were. Mr. Wylie suggested that the reporting requirement for RTB failures are too ambiguous. He indicated the NRC Staff should investigate this matter with the breaker vendors.

4. F. Hebdon (AEOD) discussed work performed on breaker failure rates after the Salem incident. Their investigations indicated that failures rates were about as expected. AEOD does not now have any studies on-going vis-a-vis RTB or RPS reliability, given the intense interest in this topic by NRR after the Salem event. In response to Mr. Ebersole, Mr. Hebdon said there is no AEOD work on-going regarding the BWR scram system. In response to Mr. Ward, AEOD said the on-going program to collect failure data relies on the NPRDS. Further discussion noted that before Salem, there were not enough RTB failures seen to "flag" a problem with breaker reliability.

   Mr. Davis noted that plant PRA's he has been indicate that there is a large variability in the reliability values assigned to the RTB function.

   Dr. Kerr asked if AEOD has given thought to elimination of the UV trip. Mr. Rosa said GE has informally proposed a modification to the RPS that would result in elimination of the UV trip. AEOD has not however recommended such an action.

5. F. Rowsome made the following observations:

   - NRC is increasingly depending on PRA assumptions vis-a-vis regulatory decisions and the Agency is not getting sufficient real-world component and system reliability data to confirm that the assumptions in the PRAs are valid.

   - Studies he has seen show that equipment designated "nuclear safety grade" is not showing significantly higher reliability than identical equipment in service in fossil plants. Further discussion brought out the fact that nuclear qualification centers on <u>design adequacy</u> not <u>functional reliability</u>.

In response to Mr. Ward, Mr. Little (W) said W data shows that the only failures seen in W DB- and DS-breakers were in the UV trip attachment. Overall, W does not see any differences in the reliability of equipment designated "safety-grade" vs non-safety grade. In response to a Subcommittee question, Mr. Little indicated that the extra money one pays for "nuclear grade" equipment is spent to assure the expected equipment quality is really there. In response to Dr. Kerr, Mr. Rowsome said NRC has not formally considered establishing reliability or performance criteria for the RPS, or RTBs in particular.

6. The subject of W reactor trip system and RPS reliability was discussed by J. Little and M. Hitchler of W. Three items were discussed: (1) response to the Salem event; (2) W protection system reliability analysis; and (3) implications of the Sequoyah event.

Mr. Little said there has never been a failure of the DB- or DS-breakers to function on demand. The failures have been confined to the UV trip attachment. Upon questioning by Dr. Kerr, Mr. Little said he is not aware of any DB- or DS-breaker failing to function upon demand (excluding the UV trip attachment failures).

W surveyed the operating experience of the DB-breakers over 20 years use which includes $\sim$ 250 RYs. Figure 1 shows the results. The UV trip attachment (UVTA) failure rate was given as 1.7×10^{-3}/demand. W concluded that: (1) breaker reliability rates are higher than initially assumed and failure rates are consistent with values used in PRA's; and (2) no failures have been reported in shunt trip devices or reactor trip breakers excluding UVTAs. In response to Mr. Ward, Mr. Little said UVTA maintenance

considerations were not well thought out at the time these breakers were originally designed (~10 years ago).

For the DS-breakers, a design error in the UVTA was discovered and new UVTA's were installed on all W DS-breaker plants (Figure 2).

W performed confirmation tests on the UVTAs for the DB-50 breakers. The results (Figure 3) showed no design deficiencies and that the UVTA replacement life is ~16 years, based on 75 trip demands/year. This life was arbitrarily chosen as one-half the number of test demands. In response to Mr. Ebersole, Mr. Little said that breaker reliability tends to rely on proper maintenance.

W has compiled a catalogue of proper maintenance practices and issued this information to W Owners Group members (Figure 4).

Turning to the Sequoyah incident, W has proposed adding a fusible link in series with the UV driver card output transistor. This will disconnect the UV coil from the card (Figure 5).

Mr. Little addressed the issue of interruption of the M/G set field current as a diverse scram function. He said Duke Power studied this proposal for their Catawba plant. Duke found the reliability increase was small (factor of 2), and the fix introduced complications to the RPS and M/G set design. Duke concluded the modification was not cost beneficial. After further discussion, Mr. Little said W has considered both prevention and mitigation in their assessment of acceptable RPS system and component reliability.

M. Hitchler (W) outlined the results to date of the W TOP (technical specification optimization program) which included a study of RPS unavailability for alternate component/system

surveillance intervals, test and maintenance times, and equipment bypass.

Results (Figure 6) show a typical RPS unavailability, considering CMF, of 1.5×10^{-5}/demand. CMF accounts for 90% of RPS unavailability. The largest CMF contributors for the RPS were in the trip breakers and logic cabinets. Results of this work are being used by W to argue for relaxation of test intervals for the RPS bistable channels, due to their small CMF failure contribution.

Discussing the CMF issue, W indicated that staggered testing of components tends to reduce CMF potential.

TOP analysis shows a negligible impact on both RPS unavailability and core melt probability as a result of an event similar to the Sequoyah incident (Figure 7).

Dr. Kerr asked W if they have considered where empnasis should be put to increase RPA/breaker reliability. Mr. Little said the emphasis should be on the maintenance of these systems. In response to a question from Dr. Kerr, W said they do look at the natural ability of operators/maintenance technicians employed by the Company.

7. Dr. Kerr requested comments from the Subcommittee Members and Consultants as to what future actions the Subcommittee should take with this issue.

8. The meeting was adjourned at 1:45 p.m.

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NOTE: Additional meeting details can be obtained from a transcript of this meeting available in the NRC Public Document Room, 1717 H Street, N.W., Washington, D.C., or can be purchased from Ann Riley & Associates, Ltd., 1625 I Street, N.W., Suite 921, Washington, DC 20006 (202/293-3950).

DB BREAKERS

WESTINGHOUSE RELIABILITY SURVEY

- SPONSORED BY WESTINGHOUSE OWNERS GROUP

- 26 PLANTS (99 UVTA DEVICES)
  - 10,000 DB-50 UVTA CYCLES REPORTED
    - TESTING
    - PREVENTIVE MAINTENANCE
    - AUTOMATIC TRIPS
  - 22 REPORTED EVENTS
    - 18 INDEPENDENT (13 DURING TESTING OR PM)
    - 4 COMMON CAUSE (SALEM)

- UVTA FAILURE RATE: APPROXIMATELY 1.7×10^{-3} FAILURES/DEMAND

- CONCLUSIONS:
  - RELIABILITY RATES HIGHER THAN INITIALLY ASSUMED
  - FAILURE RATES CONSISTENT WITH VALUES USED IN PRA'S AND TOPS
  - 11 OF 13 MALFUNCTIONS REPORTED WITH IDENTIFIABLE CAUSES WERE MAINTENANCE-RELATED
  - DIFFERING MAINTENANCE AND TESTING PHILOSOPHIES CAN YIELD ACCEPTABLE RELIABILITY
  - NO REPORTED FAILURES IN SHUNT TRIP DEVICES OR REACTOR TRIP BREAKERS EXCLUDING UVTAs

FIG. 1

DS BREAKERS

- FIVE PLANTS
  - 2100 CYCLES
  - 7 FAILURES (BINDING)
- FAILURE RATE: $\sim 3.0 \times \bar{10}^{3}$ FAILURES/DEMAND

CONCLUSIONS

- MALFUNCTIONS WERE ASSOCIATED WITH
  - MANUFACTURING TOLERANCE ANOMALIES DUE TO INADEQUATE SPECIFICATION AND INSPECTION
- NEW DS UVTA DEVICES INSTALLED AT ALL WESTINGHOUSE PLANTS
- REVISED INSPECTION PROCEDURES INSPECTS 100% OF CRITICAL PARTS

FIG. 2

RESULTS OF DB-50 UVTA CONFIRMATION TESTING

- FORCE RATIOS:
  - UVTA: 2-TO-1; SHUNT: GREATER THAN 6-TO-1

- INITIAL UVTA TESTING:
  - 2 FAILURES-TO-TRIP IN 7000 INTEGRATED TRIP DEMANDS (ATTRIBUTED TO EXCESSIVE FRICTION DUE TO INADEQUATE LUBRICATION -- LUBRICATION PROCEDURE CHANGED
  - ADDITIONAL INSIGNIFICANT WEAR POINT IDENTIFIED -- CAN BE EASILY ELIMINATED BY A CAPTIVE PIN MODIFICATION
  - 2 FAILURES-TO-LATCH (FAILSAFE) DUE TO LATCH HOOK WEAR (BOTH OCCURRED IN NON-PERIODIC LUBRICATION TESTS)

- TESTS REPEATED ON 4 NEW UVTA's WITH IMPROVED LUBRICATION PROCEDURE AND CAPTIVE PIN MODIFIATION:
  - 1 FAILURE-TO-TRIP IN 9800 INTEGRATED TRIP DEMANDS (OCCURRED IN NON-PERIODIC LUBRICATION TESTS)
  - PERFORMANCE IMPROVEMENT ATTRIBUTED TO LUBRICATION PROCEDURE AND NOT TO THE CAPTIVE PIN MODIFICATION

- CONCLUSIONS
  - NO DESIGN DEFICIENCIES FOUND -_ DEVICE IS SUITABLE FOR ITS APPLICATION -- ADEQUATE FORCE MARGINS EXIST
  - WEAR WAS NOT A FACTOR IN FAILURE-TO-TRIP -- WEAR TENDS TO BE IN FAIL-SAFE DIRECTION
  - PERIODIC FORCE AND RESPONSE TIME MEASUREMENTS DID NOT PREDICT FAILURES
  - LUBRICATION GUIDANCE CAN BE IMPROVED (BASED ON LIMITED TEST SAMPLE) -- REVISED PROCEDURE SENT TO UTILITIES
  - REPLACEMENT LIFE IS APPROXIMATELY 16 YEARS (BASED ON 75 TRIP DEMANDS/YEAR)

F16.3

WESTINGHOUSE INITIATIVES IN SWITCHGEAR MAINTENANCE

- WESTINGHOUSE PERFORMED A COMPILATION OF ALL RECOMMENDATIONS ON SWITCHGEAR MAINTENANCE FOR THE WESTINGHOUSE OWNERS GROUP

- RECOMMENDATIONS INCLUDE RESULTS OF CONFIRMATION TESTING, SPECIFICATION OF REPLACEMENT LIFE, AND CAUTIONS AGAINST FIELD ADJUSTMENTS

- CLARIFICATION ISSUED ON DB-50 UVTA LUBRICATION

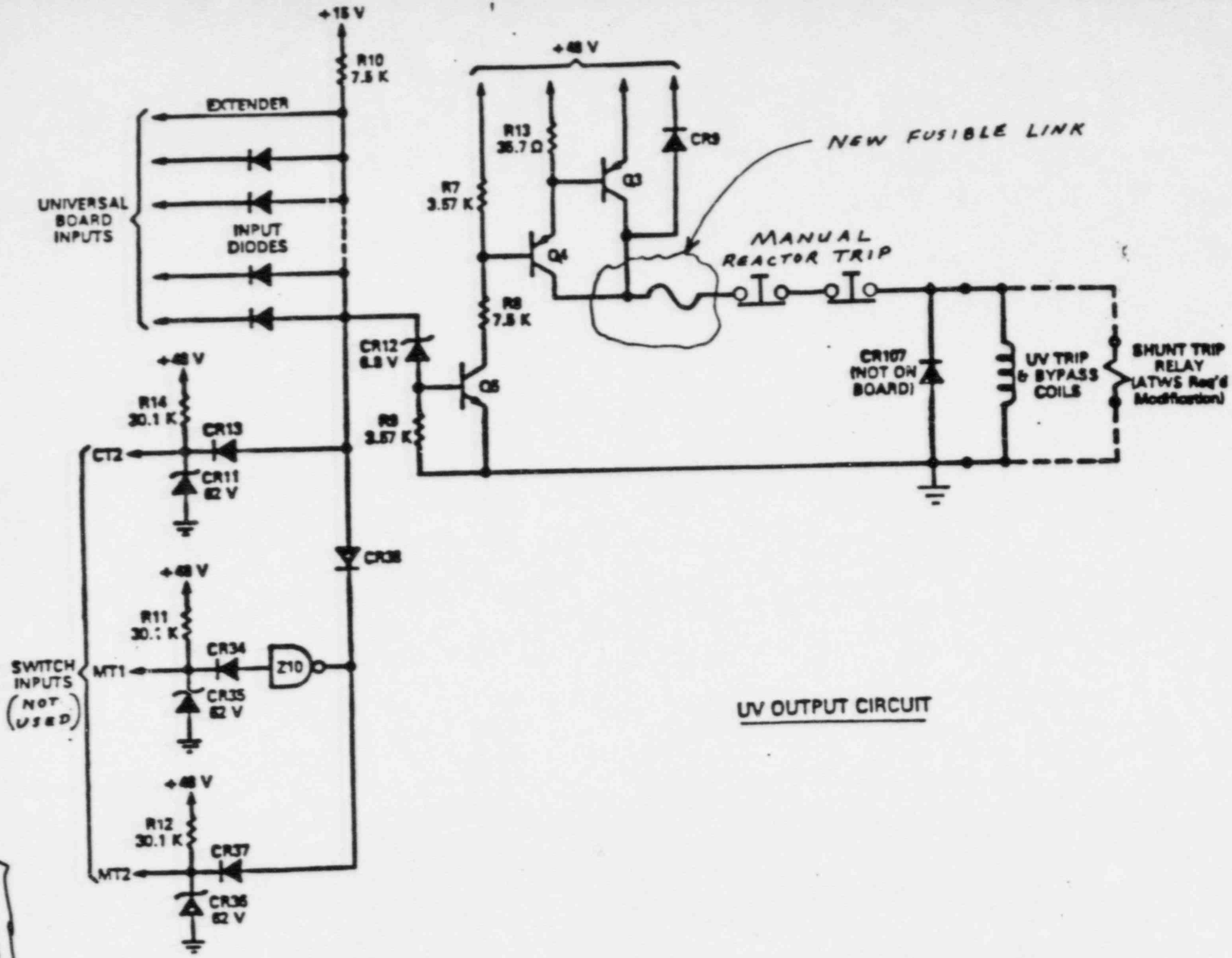
  - ADDITIONAL LUBRICATION POINTS IDENTIFIED

  - LUBRICANT AND SOURCES SPECIFIED

  - WESTINGHOUSE SUPPLIED LUBRICATION KITS TO UTILITIES

- DOCUMENT COMPLETED FOR DB-50 AND DS-416 AND ISSUED TO WOG MEMBERS

FIG. 4



UV OUTPUT CIRCUIT

REACTOR PROTECTION SYSTEM - TOP ANALYSIS

D. TYPICAL RPS UNAVAILABILITY

- O UNAVAILABILITY WITH CCF = 1.5E-05
- O UNAVAILABILITY WITHOUT CCF = 1.4E-06
- O CCF ACCOUNTS FOR 90% OF UNAVAILABILITY
- O CCF CONTRIBUTORS
  - i. TRIP BREAKERS AND LOGIC CABINETS - LARGE CONTRIBUTION
  - ii. BISTABLE CHANNELS - SMALL CONTRIBUTION
- O DOMINANT CUTSETS
  - i. TRIP BREAKERS AND LOGIC CABINETS CCF - LARGE EFFECT
  - ii. TRIP BREAKER AND LOGIC CABINET RANDOM FAILURE, TEST, AND MAINTENANCE - SMALL EFFECT
  - iii. BISTABLE CHANNELS - NEGLIGIBLE EFFECT

FIG. 6

IMPACT ASSUMING FIELD EXPERIENCE AS MAINTENANCE RELATED

A. TOPS ANALYSIS

- UNAVAILABILITY BASED ON INTERVAL AND TIME FOR MAINTENANCE
  - i INTERVAL = 1 YEAR
  - ii TIME = 6 HOURS
- HUMAN ERRORS DURING MAINTENANCE ASSUMED NEGLIGIBLE
- UNAVAILABILITY PER TRAIN = 6.85E-04

B. ESTIMATE OF INCREASED UNAVAILABILITY TO ACCOUNT FOR HUMAN ERRORS DURING MAINTENANCE

- BASED ON 1 EVENT - SEQUOYAH INCIDENT
- FAULT TREE ANALYSIS
- ASSUMPTIONS/PARAMETERS
  - i 88.4 YEARS OF EXPERIENCE ON RPS
  - ii TWO UV DRIVER CARDS PER PLANT
  - iii PROCEDURES REQUIRE TESTING FOLLOWING MAINTENANCE
  - iv TWO MONTH TEST INTERVAL
- RESULTS
  - i UNAVAILABILITY PER TRAIN = 6.90E-04 (ACCOUNTS FOR NORMAL MAINTENANCE ROUTINE AND ERRORS)
  - ii INCREASED UNAVAILABILITY - LESS THAN 5E-06 I.E. NEGLIGIBLE
  - iii THE ASSUMPTION OF COMMON CAUSE COUPLING OF 1.0 FOR MAINTENANCE ERRORS BETWEEN TRAINS HAS NO EFFECT ON TOPS CONCLUSIONS

FIG. 3