OPERABILITY DETERMINATION UPDATE (Rev. 2)
CR 96-385
POTENTIAL FAILURE OF
REDUNDANT SAFETY RELATED CIRCUITS,
WITHIN THE MAIN CONTROL BOARD

I. Degraded or potentially non-conforming equipment:

There are instances where Train A and Train B circuits (wires) or circuits from more than one instrument channel run in the same wireways or risers within main control boards, thus making possible a potential failure of redundant safety-related (SR) functions due to a single failure.

II. Safety Function(s) performed:

The purpose of physical separation of train A and train B circuits or circuits of more than one instrument channel is to maintain independence of safety-related circuits. Give such separation, no credible potential source of damage (other than a fire) would result in damage to redundant Class 1E circuits beyond an acceptable level. In the event of a fault within one train or channel circuit the integrity of the other train or channel circuits would not be damaged to the point of not being capable of performing their safety function. Thus the functionality of one train of safety-related Equipment and the minimum required number of instrument channels would be maintained at all times.

III. Circumstances of potential non-conformance, including possible failure mechanisms:

A fault on an inadequately protected circuit in the main control board could damage that circuit and any adjacent safety-related circuits, potentially affecting the functionality of both trains or multiple channels of redundant safety- related equipment. This would occur if circuits required for redundant components from both A and B trains or multiple instrument channels are run together in the same wireway in the main control boards.

Based on this, there is a potential for single failure of internal control board wiring to disable selected safety related functions on redundant trains or channels.

Note: The ability to achieve and maintain plant shutdown in the event of a control room fire as required by 10CFR50 Appendix R is not affected by the above described situation.

IV. Requirement established for the equipment, and why it may not be met:

The main control boards contain the control circuitry for proper manipulation of safety-related and Non-safety related equipment and displays of safety-related and non-safety related equipment status. Westinghouse Engineering Change Notice, ECN-WEP-70083, states that, "wires requiring separation shall use separate routing of wireways between devices. In no case shall wiring requiring separation be bundled together." The draft of the PBNP Design Basis Document (DBD) position paper on electrical separation indicates that the design basis for PBNP includes requirements for physical separation of electrical wiring.

As discussed in this determination, review of internal design documentation clearly indicates Wisconsin Electric's intent to maintain separation. A review of design and licensing basis requirements in the Final Safety Analysis Report Chapters 7, "Instrumentation and Control," and Chapter 8, "Electrical Systems," was performed. The following statements concerning separation of redundant safety related circuits were identified.

Section 8.2.2, "Station Distribution," evaluates layout and load distribution and discusses the routing of control, instrumentation and power cables. The following statement is made: "Wire and cables related to engineered safeguard and reactor protective systems are routed and installed to maintain the integrity of their respective redundant channels and protect them from physical damage. Later discussions in Chapter 8 discuss the verification of physical separation of emergency power cables. The wiring that is the subject of this operability determination is not emergency power cable. Therefore, the means of providing integrity to redundant channels within the control board is not limited to physical separation. Other means can be employed to protect the main control board circuits of redundant trains and channels.

Chapter 7 was reviewed for discussions of separation. Analog instrumentation and associated wiring requires separation from the process sensor to the instrumentation racks. This does not require the wiring in question to be physically separated.

Also included in Section 7.5.2 of the FSAR is the following statement, "The same channel isolation and separation criteria as described for the reactor protection circuits are applied to the engineered safety features actuation circuits."

The following question and answer were included in our response to AEC questions concerning the FFDSAR dated 1/16/70.

" Question 7.6

Submit your cable installation design criteria for preserving the independence of redundant reactor protection system and engineered safety feature circuits (instrumentation, control, and power). For the purpose of cable installation, the protection system's circuits should be interpreted in their broadest sense to include sensors, instrument cables, control cables, power cables, (both a.c. and d.c.), and the actuated devices (e.g., breakers, valves, and pumps):

a. Cable separation should be considered in terms of space and/or physical barrier between redundant cables. Please address (1) the separation of power cables from those used for control and instrumentation, (2) the intermixing of control and instrument cables within a tray, conduit , or ladder, (3) the intermixing within a tray, conduit, or ladder, of cables for different protection channels, and (4) the intermixing of non-vital cabling with protection system cabling."

[Parts b, c, and d of the question not provide here since they are not relevant to this issue.}

"Answer

A. (3) Separation is maintained such that redundant protection channels are not intermixed within the same wireway."

[Remaining portions of the answer to question part (a) and the repossess to parts b, c, and d are not provided here since they are not relevant to this issue.]

In conclusion, separation of wiring associated with redundant safety related functions is required within the main control board.

V. How and when the potentially non-conforming equipment was first discovered:

While performing evaluations for the walkdowns to resolve LER 301/91-001-01 Action #23, it was determined from the DBD position paper that the design basis for Point Beach Nuclear Plant includes requirements for separation of redundant wiring in the Main Control Board. This was noted during an update to the LER on 3/4/96.

A detailed review of all safety related (SR) wire routing in the main control board was initiated on 6/17/96 to identify routing of wires which support redundant functions in the same raceway. The approach taken was to first identify the raceways that would have the highest potential for containing wires which support redundant safety-related functions. This was done based on knowledge of what was identified during as-builting of the Main Control Boards, knowledge of basic control board routing, panel layout and engineering judgment. Of 68 raceways to review 4 were picked for the initial review. The approach was to first determine if the raceway included wires which support safety-related functions. If wires which support redundant safety-related functions were identified, the existence of adequate fault protection for all wiring in the raceway as described later in this evaluation would be verified. This process assured that conditions were within those defined as necessary for operability as define in this evaluation. Any design deviations would require a specific operability evaluation and appropriate compensatory and corrective actions.

During the review process on 8/14/96 it was discovered that Lo-Lo steam generator automatic start circuitry for both P38A and P38B (motor-driven auxiliary feedwater pumps) were routed through a common raceway. Fault protection for these wires was determined to be adequate, however, a wire associated with 1P-29 (Unit 1 turbine-driven auxiliary feedwater pump) mini-recirc valve and trip indication was determined to not be adequately protected. Immediate action was to enter the applicable Technical Specification (TS) Limiting Condition For Operation (LCO) for P38A and P38B out of service. The LCO was exited when the supply breaker to the inadequately protected circuit was opened. 1P-29 would remain out of service until adequate fault protection was installed. Modifications were subsequently completed to resolve this specific problem.

On 8/15/96 it was discovered that cabling in the main control board associated with 1MS-2019 and 1MS-2020, 1AF-4000 and 1AF-4001 (turbine-driven auxiliary feedwater pump supply and discharge valves) also did not have adequate fault protection. Cabling for 1MS-2019 and 1AF-4001 are routed through the same riser as the automatic start circuitry for P38A and P38B. Immediate action was to enter the applicable TS LCO for P38A and P38B out of service. The LCO was exited when the supply breakers to the inadequately protected circuits were opened. Modifications were subsequently completed to resolve this specific problem.

Based on these findings, the original operability determination (Revision 0)for this was questioned and the MSS (Manager's Supervisory Staff) was convened on the morning of 8/16/96 to review:

- The original operability evaluation
- The conditions being identified
- The corrective actions
- And to make an operability call on the main control board

Summary of MSS Meeting

The approach being taken for evaluation/resolution of the redundant function potential lack of adequate wire separation issue:

1. Initially identified 4 of 68 wireways that had the highest potential for the problem to exist.

2. Initially focused resources on evaluation of the wireways identified in 1. above.

a. During the initial wireway evaluations low voltage dc control circuitry associated with dc valves was the only circuitry in which fault protection problems were identified.

3. A specific operability call for the equipment affected was made and prompt short term corrective actions have been taken for the identified instances of inadequately protected low voltage dc control circuitry.

a. Unit 1 turbine-driven auxiliary feedwater pump applicable circuitry was deenergized to eliminate the potential fault source and the pump declared out of service.

4. Immediate follow-up actions are currently in progress to install lower rated breakers and fuses, where applicable, to provide adequate protection to prevent an identified fault from adversely affecting the wiring.

a. Installation of adequate wire protection associated with the Unit 1 turbine-driven auxiliary feedwater pump is currently in progress and is expected to be completed today (8/16/96). Upon completion of this modification, the pump will be properly returned to service and the LCO exited.

b. Installation of adequate wire protection on the Unit 2 turbine-driven auxiliary feedwater pump will commence upon return to service of the Unit 1 turbine-driven feedwater pump and will be completed by 8/17/96.

5. A review of all similar dc valve applications that could impact the wireways under review was completed with no other concerns identified.

6. The focus of the review and evaluation process is being shifted to evaluate all dc cabling within the main control board for adequate fault protection. This evaluation will be completed by 8/23/96. A similar review of all ac wiring will be completed by 9/30/96.(Note: both of these reviews were subsequently completed as described below.)

7. The completion of the full evaluation of the initial 4 wireways will be completed by 8/30/96 and the evaluation of the balance of the wireways will be completed by 12/31/96. (Note: It was subsequently determined that this review was not required. It was instead assumed that each of these raceways did contain wires which supported redundant functions)

8. Long term correction of wire separation deviations will be implemented during the next respective refueling outage. (Note: A limited number of circuits were rerouted during the Fall 96 Unit 2 outage to attain adequate separation. Remaining circuits will be rerouted during future outages. A schedule for such work is presently being developed.)

The staff concluded in this meeting that the main control board remains operable based on the following:

A. Wire separation within the main control board is a design basis but not a licensing basis commitment. Thus, for operability considerations demonstrating adequate protection of redundant safety function wires from the potential of being affected by a common mode failure in place of physical wire separation, is acceptable. (Note: It has subsequently been determined by the NRC that lack of wiring separation within the main control board is contrary to the PBNP licensing basis. This does not however change the basis for considering the main control board operable.)

B. The original operability basis in Section VI remains valid with the exception of the fact that a specific family of outliers have been identified. Continued operability while the review progresses with this known fact is considered justified because of the following:

1. Specific deviations are addressed when identified including an operability determination, immediate compensatory action and follow-up deviation resolution.

2. A focused review to evaluate all dc cabling within the main control board for adequate fault protection is being performed and will be completed by 8/23/96.

3. All known cases are in the process of being corrected or scheduled to be corrected within the next day.

4. Many *conservatisms* were/are built into the evaluation of wire protection.

a. Used a short circuit temperature rating of 250°C when the actual short circuit temperature rating for damage to the wire insulation is 350°C

b. Only considered insulation breakdown in the faulted wire. Did not consider the insulation of any potentially affected wire's ability to protect that wire.

c. Assumed that the faulted wire and the potentially affected wire were bundled and in direct contact with each other.

- Low probability by engineering judgment due to the large number of cables in each wireway
- Low probability of being "bundled" (tie wrapped tightly together) because tie wraps were severed to eliminate bundling during the main control board wiring evaluations for the design basis document development project.

d. Wire heatup dampening due to increase in wire resistance was not included.

C. Short term corrections are being implemented to maintain operability when deviations are identified. Long term correction to meet design basis wire separation in the main control board will be implemented during the next respective unit refueling outage.

Based on the above analysis, summary of findings and actions to date, summary of ongoing evaluations and corrective actions, and assurance of safety summary, the main control board was considered to be operable.

The operability determination of the main control boards by the MSS at this meeting was based on the understanding that the review process included all safety related wiring in the main control boards. However detailed routing information was not available for panel C02.

A review of DC control circuits for diesel generators G-01 and G-02 revealed that circuits entering the main control may have inadequate protection. These circuits consist of #14 AWG SIS wiring in C02 and are protected by 30A or 40A breakers with no fuses. Inspection of breaker time-current characteristic curves and the conductor thermal damage curve indicates that conductor damage could occur prior to breaker operation for some short circuit faults. Since the possibility exists that the underprotected A Train G01 circuits are not physically separated from non-EDG B train circuits within main control board C02, a single fault in a G-01 control circuit has the possibility of affecting A train and non-EDG B train circuits in C02.

Although the possibility exists for A train and non-EDG B train circuits to be affected by a single fault, safety related control circuits in C02 are considered operable. Safety related wiring in panel C02 primarily consists of control circuits for diesel generators G-01, G-02, G-03, G-04 and safety related 4160V and 480V switchgear. Recent modifications involved rewiring main control board internal wiring for diesel generators G-02, G-03 and G-04. Separation of main control board wiring was part of the design process for these modifications and this wiring is expected not to contribute to the risk of faulting redundant safety related circuits.

VI. Basis for declaring affected equipment operable

The following analysis demonstrates why redundant safety-related circuits would not be degraded by a single source of damage, and, why in the event of a failure within one train or channel the circuits of the other train or channel routed in the same wireway or riser within control room panels, would not be degraded below an acceptable level. Thus the functionality of one train or the required minimum number of channels of redundant equipment would be maintained at all times. The analysis considers the effect of circuit isolation by protective devices, maximum temperature of faulted conductors, wire insulation and the potential for hazards in the specific area involved.

ANALYSIS

1. Wire Terminations

For all cases where potential failures of safety related functions are identified, all train or channel wires are terminated on a terminal block separate from those of redundant train or channel wire Terminations.

2. Wire Insulation

The wires are rated 600 volts, 90°C, with the short circuit temperature rating of 250°C, utilize heat resistant rubber insulation, and are applied in a control circuit with a system voltage of 125 V dc or 120 V ac, thus providing a conservative design margin between rated and applied voltage.

3. Potential for Mechanical Damage of Wiring within the Main Control Board

All of the wiring within the Main Control Board is located in a non-hazard area having the following characteristics:

a. The area does not contain high energy equipment such as switchgear, transformers, rotating equipment, or potential sources of missiles or pipe failure hazards.

b. Most circuits in the area are limited to control and instrument functions.

c. With the exception of a few isolated cases of power feed cables sized #6 AWG, there are no power circuit cables larger than #8 AWG in this area, and all cables providing control power feed are protected meeting NEC requirements.

d. Administrative control of operations and maintenance activities exist in this area that limit introduction of potential hazards into the area.

Thus, there exists no potential source for causing mechanical damage to a wiring within the main control board which would result in physically damage to redundant trains or channels.

4. Effect of Short Circuits

A review of all AC and DC circuits routed through the Main Control Board has been completed. This review concluded that no single failure would result in the loss of redundant safety-related wiring .

The following demonstrates why redundant safety-related circuits inside the Main Control Board will not be degraded by a conductor fault. In every case in which redundant safety related circuits are routed within the same wireway, all conductors within the wireway have fault protection that is adequate to prevent damage to adjacent conductors. Therefore the potential does not exist for a faulted conductor to simultaneously damage redundant circuits, thus ensuring the functionality of one train or three channels of equipment at all times.

The following conservative assumptions were made in predicting the maximum wire insulation temperature:

a. All potential affected safety-related wiring is in physical contact with the faulted conductor.

b. All energy due to fault induced Joule resistive heating is contained within the faulted conductor. No credit is taken for energy dissipation to other adjacent conductors, or to surrounding air or wireway.

c. Insulation temperature of the faulted conductor will increase to a value equal to the peak conductor temperature. No credit is taken for the thermal mass of the insulation of the faulted conductor or adjacent conductors.

d. No decrease in the fault current due to the increase in conductor temperature occurs.

e. Most conductors will not experience a temperature greater than the short circuit rating of 250 degrees C. At this temperature, the insulation on the faulted conductor will not be degraded. Conductor temperatures were predicted in accordance with Attachment #1.

Tests were conducted to verify the survivability of the insulation used on wiring in the Main Control Board. The purpose of these tests was to support the above conclusions that if two conductors were in physical contact, and if one of the conductors was faulted , the second conductor would not be damaged as the peak temperature the second conductor would experience would be less than its rated temperature. An implicit assumption of this conclusion is that there is no gross mechanical failure mechanism associated with the faulted conductor that would introduce nonlinear heat transfer transients. These tests indicate that the insulation will not experience gross mechanical failure or ignition for a period of at least one minute when exposed to a temperature of 410 degrees C. The tests also demonstrate that the faulted wire will not fail in a fashion that would cause an adjacent wire to be damaged.

A. DC Control Circuits

A review was performed of all 125 VDC circuits to determine if a single faulted cable could damage control board wiring required for the operation of redundant safety-related equipment. Circuits were determined to be acceptable if they satisfied at least one of the following criteria:

1. The circuit does not include any wires inside the Main Control Board

2. The maximum calculated conductor temperature reached during short circuit conditions of any wires in the main control board was determined to be less than the wire short circuit temperature rating of 250 degrees C. This was done by comparing the rise in conductor temperature at the maximum available fault current to the time current characteristics of the protective device for the conductor. This criterion is bounded by criteria #3. It is included as a separate category to illustrate the fact that the majority of conductors have fault protection that is adequate to ensure that peak conductor temperatures will not exceed this more conservative criterion.

3. The maximum calculated conductor temperature reached during short circuit conditions of any wires in the main control board was determined to be less than the insulation ignition temperature, thus ensuring that insufficient energy is available for ignition of the conductor insulation. This was done by comparing the rise in conductor temperature at the maximum available fault current to the time current characteristics of the protective device for the conductor.

This analysis demonstrates the survivability of conductors adjacent to a faulted conductor. This analysis demonstrates that a wire in the Main Control Board adjacent to and in contact with a faulted conductor will not be degraded below an acceptable level. All wires adjacent to the faulted conductor will remain fully functional if the faulted conductor temperature reaches the maximum conductor temperature predicted for a worst case fault. Therefore no fault on a DC system conductor in the Main Control Panel will result in the loss of wires required for the performance of redundant safety functions. This analysis is conservative due to the fact that it assumes that a worst case fault occurs and redundant conductors are in direct contact with the faulted conductor.

A total of 281 DC circuits were analyzed. The results of this analysis is summarized below:

73 Circuits:	No MCB Wiring: The circuit does not contain any wiring which enters the Main Control Board
61 Circuits:	Spare Circuits
88 Circuits:	Fused < 250 degrees C: The circuit has adequate fuse protection to ensure that faulted wires in the main control board will not attain a temperature greater than its rated temperature (250 degrees C.)
29 Circuits	Breaker < 250 degrees C: The circuit has adequate breaker protection to ensure that faulted wires in the main control board will not attain a temperature greater than its rated temperature. (250 degrees C.)

20 Circuits	Separated: It has been determined by physical inspection that wiring associated with this circuit is adequately separated from that of redundant safety-related circuits.
10 Circuits	Breaker<Damage Temperature: The circuit has adequate protection to ensure that faulted wires in the main control board will not attain a temperature that could damage a adjacent conductor.

The above reflects the effect of several modifications to replace circuit breakers or add in line fuses.

B. 120 VAC Circuits

A review was completed of all 120 VAC circuits. This review determined if there is a potential for damaging redundant safety related wiring in the main control board due to a fault on a 120 VAC circuit. The review included all circuits listed in Master Data Book Section 3.2.11. A total of 888 breaker positions were analyzed. In addition, the control circuits for 25 motor control centers were reviewed for adequate overcurrent protection. For all of the MCC control circuits reviewed , 15 amp or smaller fuse protection was provide for the control circuits. Circuits were determined to be acceptable if they satisfied at least one of the following criteria:

1. The circuit does not include any wires inside the Main Control Board

2. The circuit is protected per the requirements of the National Electrical Code. Table 310-121 of the 1965 NEC states that insulated copper, #14 SIS wire has an ampacity of 25 amperes. There is a 50% departing factor for installations where 42 or more conductors are installed in the same raceway (exception #8 from the notes to table 310-12). This would create a final ampacity of 12.5 amperes. Exception #10 from the notes to table 310-12 states, "Where the standard ratings and settings of overcurrent devices do not correspond with the ratings and settings allowed for conductors, the next higher setting may be used." This allows installation of a 15 ampere overcurrent protective device to protect #14 SIS wire. Therefore, a circuit protected by a 15 ampere or smaller fuse or breaker is deemed acceptable.

3. A number of circuits have wires which only enter the 1C-20 and 2C-20 control boards. Adequate separation of redundant circuits in these boards has been maintained during design and installation of these panels.

The results of this analysis is summarized below:

174 Circuits:	No MCB Wiring: The circuit does not contain any wiring which enters the Main Control Board
470 Circuits:	Spare Circuits
30 Circuits:	Circuit is protected by a fuse rated 15 amperes or less

204 Circuits	Circuit is protected by a circuit breaker rated 15 amperes or less. (Note: 14 breakers were replaced per modifications 96-069 and 96-070 to replace larger breakers.)
10 Circuits	Circuits have wires which only enter the 1C-20 and 2C-20 panels.

VII. Additional actions necessary to demonstrate operability:

The information included in section VI above adequately demonstrates that the potential for failure of wiring in the Main Control Boards which would affect redundant safety-related functions is essentially non-existent. Additional actions are not required to demonstrate operability of the control boards and the wiring therein. The above, however, does not demonstrate conformance to the licensing or design basis for separation in the main control boards. Rerouting of wiring in the main control boards to obtain such separation needs to be completed.

Prepared By: P. J. Katers Date: 3/10/97

Reviewed By: T.R. Branam TRB Date: 3/10/97

Reviewed By: J K... J K... Date: 3-10-97
Active SRO

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Duty and Call Superintendent

ATTACHMENT 'A'

THE ROCKBESTOS COMPANY

Date 7/11/96 Number of Pages Including Cover Sheet 8

To MR. RAHMAN - OFFICE COC. FS MSC. ELECT INC

FAX Number 414 221 2010

From: Bob Gehm, Sr.

FAX Number: 860-653-8301 Telephone: 860-653-8315

Message ATTACHED ARE SHORT CIRCUIT CURVES. I HAVE INCLUDED A DELTA POINT AT 0.16 SECONDS. ALSO ATTACHED ARE EXCERPTS FROM UL FOR 1971 WHICH DESCRIBE SIS AS A "HEAT RESISTANT RUBBER" (COULD BE XLPE AS WELL) IN ALL PROBABILITY, YOUR 1960'S SIS WAS A 90°C XLPE COMPOUND.

I HAVE NO INFORMATION ON FLAME RETARDANCY OR TEST VOLTAGE. IF YOU CAN FIND AN EARLY VERSION OF UL STD 44 IT MAY HAVE THAT INFORMATION

Bob Gehm

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SHORT CIRCUIT CURRENT VALUES FOR AWG SIZE CONDUCTORS (COPPER)

BASED ON MAXIMUM CONDUCTOR TEMPERATURE OF 250° C

The attached tables and curves show the allowable short circuit currents vs. time to reach a conductor temperature of 250° C from a starting point of 20°, 60°, or 90° C.

The assumptions used in the calculations are:

1) The current is constant with time.

2) The conductor resistance increases as the temperature increases.

3) The specific heat of the conductor is constant over the temperature range of interest

4) The process is adiabatic - that is; the process is so rapid that no heat is dissipated to the surrounding environment (insulation or air). The results are therefore valid for single or multi-conductor cables with any insulation configuration.

R. J. Gehm 9/7/94

SHORT CIRCUIT CURVES - 250 DEG C MAX CONDUCTOR TEMPERATURE

FOR #14 AWG CONDUCTORS

S/CIRCUIT DURATION SECONDS	ALLOWABLE S/C CURRENT FOR INITIAL COND. TEMPERATURE OF: 20 DEG C	60 DEG C	90 DEG C
0.0083 (1)	4115	3560	3172
0.0090	3959	3425	3052
0.0100	3736	3249	2895
0.0167 (2)	2909	2517	2242
0.0200	2655	2298	2047
0.0300	2166	1876	1672
0.0333 (3)	2058	1781	1587
0.0400	1873	1625	1448
0.0500	1680	1453	1295
0.0600	1533	1327	1182
0.0700	1420	1228	1094
0.0800	1329	1149	1024
0.0900	1252	1083	965
0.1000	1188	1028	916
0.1600	939	812	724
0.2000	840	727	647
0.3000	686	593	529
0.4000	594	514	458
0.5000	531	460	409
0.6000	485	420	374
0.7000	449	388	346
0.8000	420	363	324
0.9000	395	343	305
1.0000	376	325	290

(1) ONE HALF CYCLE - 60 Hz
(2) ONE CYCLE - 60 Hz
(3) TWO CYCLES - 60 Hz

SHORT CIRCUIT CURRENT - 14 AWG
FOR 250 C MAX CONDUCTOR TEMP