Donald C. Cook Nuclear Plant Units 1 & 2
Engineering Analysis of Temperature and Humidity Effects On Foxboro Spec 200 Instrumentation
Reactor Protection and Control System Replacement Project
Report Number 2985-HEI-12, Rev. 0

Subject:

This report shall document results of the Engineering Analysis performed to evaluate temperature and humidity effects on the Foxboro Spec 200 and Spec 200 Micro instrumentation to be utilized in the Donald C. Cook Reactor Protection and Control System Replacement Project.

References:

1. Donald C. Cook Nuclear Plant Specification No. DCC-IC-500-QCN; Revision 0; Reactor Protection and Control Instrumentation.

2. Foxboro Report QOAAA01 - Revision A; Program For Class 1E Qualification of Spec 200 Instrumentation Equipment.

3. Foxboro Report Q0AAA02 - Revision A; Performance Tests and Operating Influence Test for Rack-Mounted Modules.

4. Foxboro Report Q0AAB01 - Revision A; Class 1E Qualification of Spec 200 Instrumentation Equipment To Generic Service Conditions Per IEEE 323-1974 & IEEE 344-1975.

5. Donald C. Cook Nuclear Plant UFSAR; Sections 7.2.3, 7.5.3 and 9.10.1; Current Revisions.

6. Foxboro Qualification Reports for various Spec 200 instrumentation; (Reference Attachment 1).

7. Foxboro Report Q0AAA24 - Revision B; Heat Rise Test on N-2ES Rack.

8. Hurst Engineering Report 2985-HEI-09 - Revision 0; Exploratory Heat Rise Testing of Amco Rack Containing Spec 200 Equipment.

Issue:

The Foxboro Spec 200 and Spec 200 Micro Instrumentation to be utilized in the Reactor Protection and Engineered Safeguards Systems upgrade must be designed to operate within the design tolerance when subjected to normal ambient environments of the control rooms as specified in the Donald C. Cook Nuclear Plant UFSAR.

Scope:

The scope of this analysis is to ensure that the Foxboro instrumentation will operate without loss of protective function over the range of environmental conditions that envelop the Donald C. Cook specific requirements. This report is limited to the review of Foxboro Qualification documents with respect to the requirements specified in Reference Number 1 above and the Donald C. Cook licensing basis as defined in the UFSAR.

Discussion:

Specification DCC-IC-500-QCN Revision 0, requires that the Reactor Protection System instrumentation operate in a mild environment under the following parameters:

Temperature:	0 - 50 °C (32 - 122 °F)
Humidity:	10 - 90 % RH
Pressure:	Ambient
Location:	Indoors (control room)

UFSAR sections 7.2.3 and 9.10.1 state that the control room and adjoining equipment room is maintained at 70 °F +\- 15 °F and is designed to maintain a temperature of 75 °F dry bulb and 50 % relative humidity under normal conditions. The system is designed to operate during normal and emergency conditions as required.

Qualification of the Foxboro Spec 200 equipment to meet the intent of IEEE 323-1974 requires that operating influence testing be performed on the subject modules to ensure that they will perform their 1E functions under stated control room environments. This testing demonstrates that the individual modules will perform as required under reference environments and to the extremes of normal operating conditions. The modules have been qualified for Class 1E application by demonstration of module performance functions and of operating influences at service conditions to stated acceptance criteria before, during, and after the specified design basis event.

Foxboro has qualified all Spec 200 modules included in the qualification program, including rack mounted modules, and power supplies, over the range of 5 °C to 60 °C (40 °F to 140 °F). Qualification testing for temperature influence on the Spec 200 instrumentation was completed at these elevated temperatures to satisfy IEEE 323 requirements that margin be provided from operating conditions. To confirm the adequacy of the temperature margins, a variety of rack loading configurations were tested at ambient temperatures of 40 °C (104 °F).

Humidity influence testing has been completed at 50 to 95 % RH (86 °F (30 °C) max wet bulb) to envelop normal operating conditions and to document adequate margin.

Because the Spec 200 equipment to be utilized at the Donald C. Cook Nuclear Plant is to be installed in existing racks, additional supplemental testing is to be performed to confirm the assumption that the heat rise in the cabinets, combined with the worst case control room temperature of 122 °F, will not exceed the equipment qualification temperature of 140 °F. Based on the heat rise testing documented in report Q0AAA24 and the fact that the existing cabinets allow better ventilation than the tested Spec 200 racks, a high level of confidence exists that the supplemental heat rise testing will confirm the heat rise assumptions stated previously.

The generic Foxboro program for qualification of Class 1E equipment is delineated in Test Procedure Q0AAA01. This document describes the procedures to be implemented and the acceptance criteria specified to ensure qualification of the Spec 200 equipment.

Foxboro Test Procedure Q0AAA02 defines the performance and operating influence tests to be conducted on the rack mounted modules prior to and following seismic qualification tests. This document outlines the specific reference conditions, test conditions and performance and operating influence tests to be on the subject modules.

Foxboro Test Report Q0AAB01 summarizes the qualification results achieved by Foxboro for the generic qualification of the Spec 200 racks, rack mounted modules, power supplies and cables.

Modules qualified by similarity to type tested equipment are described in Foxboro reports Q0AAA05 and Q0AAA06.

Equipment specific qualification test results are contained within the Foxboro documents identified in Attachment 1 of this report.

Conclusion:

Based on review of the Foxboro qualification test program and equipment specific test data, it is concluded that adequate documentation exists to demonstrate that the subject equipment will perform as required under reference environments and when subjected to extreme service conditions. Temperature and humidity influence testing has been satisfactorily performed and documented such that the Donald C. Cook Nuclear Plant operating environments are enveloped by the test profiles.

The temperature and humidity profiles to which the Spec 200 equipment was subjected, adequately address the normal and extreme service conditions which are anticipated at the Donald C. Cook Nuclear Plant control rooms. The qualification test results in conjunction with supplemental cabinet heat rise testing to be performed by Foxboro (reference Hurst Engineering Report 2985-HEI-09), should indicate that the Spec 200 equipment performance specifications exceed the worst case environmental conditions documented for the Donald C. Cook equipment.

Approvals:

David W. Clark — Prepared By — 11/18/92 — Date

Kirk R Nelson — Reviewed By — 11/18/92 — Date

W. J. Marshall — Approved By — 11/20/92 — Date

FOXBORO SPEC 200 / SPEC 200 MICRO DOCUMENTATION LIST

Equipment	Qualification Document	Similarity Document
N-2AI-C2L	Q0AAB15	
N-2AI-H2V	Q0AAA06	Q0AAB35
N-2AI-P2V(C)	1-01878	Q0AAB29
N-2AI-T2V	Q0AAB28	
N-2AX+VE	Q0AAA06	
N-2AX+P(C)	1-01833	Q0AAB21
N-2CCA-S	Q0AAB69	
N-2CCA-D	Q0AAB69	
N-2AO-L2C-R(C)	1-01830	Q0AAB34 & Q0AAB60
N-2AO-V2H(C)	Q0AAA06 (note 1)	Q0AAB17
N-2AX+DP11	Q0AAB69	
N-2AX+DP10-E	Q0AAA06	Q0AAB14
N-2ANU-DM	Q0AAB69	
N-2ARPS05-A6	Q0AAA37 Part 2	
P0300CQ	QOAAA20 Part 4	
TEST PANEL	Q0AAA20 Part 4	
WIRING	QOAAB61	

General Qualification Documents

Q0AAAO1
Q0AAA02
Q0AAA04 Parts 1-4
Q0AAA05
Q0AAA08
Q0AAA20 Parts 1-4, Appx. A
Q0AAA24
Q0AAA39
Q0AAA40
Q0AAB01
Q0AAB58

Notes:

1. This card will have a supplementary qualification report issued in the near future. This report will be reviewed for additional temperature / humidity concerns upon receipt.

Attachment #2

EQUIPMENT QUALIFICATION REPORT/ANALYSIS EVALUATION NO. 2985-HEI-12 Rev.0
(Typical)

Source	Document I.D.	Title	Rev.
Foxboro	QOAAA01	Program for Class 1E Qualification	A
Foxboro	QOAAA02	Performance Tests & Operating Influence	A
Foxboro	QOAAB01	Class 1E Qualification of Spec 200	A

* Also Multiple Test Reports/Documents As Identified in Attachment #1 of this Report.

PO No. C-8744 Specification No. DCC-IC-500 QCN

Equipment Identification: Foxboro Spec 200 - RPS Upgrade

Prepared By: David W. Clark Date: 11/17/92

Reviewed By: Kirk R. Nelson Date: 11/17/92

Approved By: [signature] Date: 11/20/92

The document preparer shall use this checklist to evaluate the qualification report/analysis per the following issues. Section 1 is the "Qualification Assessment/Summary." This section is a brief summary of the adequacy of the subject documents. This summary is based on the results of the answers to the questions listed in Section 2 of this document. Any additions or changes to the report(s)/analyses which are required in order to provide proper qualification should be listed in this section of this form. Approval will be subject to the open items listed in this section.

Section 2 of this form is the Report(s)/Analyses Evaluation Checklist. A "Y", "N", or "N/A" response should be given for each question listed. Each response shall be properly explained and justified, giving specific section references within the subject procedure(s).

SECTION 1 - QUALIFICATION ASSESSMENT/SUMMARY

Provide a comprehensive statement of device qualification for the parameters addressed by the report(s)/analyses. Include any clarifications, corrections, or changes necessary to provide proper device qualification per the report(s)/analyses.

Summary of Temperature / Humidity Effects Documentation is provided In the Body of this Report.

SECTION 2 - REPORT(S)/ANALYSES EVALUATION CHECKLIST

GENERAL QUALIFICATION ISSUES

1. Does the report/analysis properly identify the test specimens used, and the components, systems, or structures which are qualified based on the results. Y[✓] N[ ] N/A[ ]

QOAAA01, QOAAA02 & QOAAB01 Are Generic Documents which Outline the Test Program to Be Utilized in Qualifying Foxboro Spec 200 Equipment For Class 1E Applications. Performance & Operating Influence Test Procedure Identifies Specific Tests to Be Performed.

2. Were the same specimens used throughout the testing process? Y[✓] N[ ] N/A[ ]

This Report Evaluates Temperature & Humidity Effects on the Subject Equipment. As the Equipment is to be Utilized in a "Mild Environment" Application, Various Spec 200 Modules will be Qualified by Similarity (Ref QOAAA06).

3. Does the report address the testing of the proper components for qualification? (Identical components or adequate similarity proved?) Y[✓] N[ ] N/A[ ]

These Reports / Procedures Address Generic Qualification Program Attributes. Foxboro has provided Specific Test Reports For the "Type Tested" Modules and Similarity Documents For the Balance of Qualification.

4. Were the applicable interactions with other equipment properly simulated? Y[✓] N[ ] N/A[ ]

Testing is Performed on a Generic Basis. The Subject of this Review is Temperature / Humidity Effects on Specific Modules As Such, Interaction with other equipment is not Applicable.

5. Did the test parameters properly envelope the required environments for the components? Y[✓] N[ ] N/A[ ]

All Testing is Performed Utilizing Guidance From IEEE 323 & 344. Performance & Operating Influence Test Methodology Envelops the Range of Environmental conditions Expected at the D.C. Cook Plant.

6. Was the acceptance criteria properly chosen to demonstrate qualification?
Y[X] N[ ] N/A[ ]

Acceptance Criteria Was Selected By Foxboro Based on IEEE 323/344 Guidance. Performance & Operating Influence Test Acceptance Criteria Established as "Target" Criteria which Was Found to be Acceptable. Temperature & Humidity Criteria Overlap D.C. Cook Parameters. For Influence Testing, Temperature Effect Uncertainty was appropriately used as Acceptance Criteria.

7. Was equipment performance data recorded before, during and after the test to demonstrate qualified operation and functionality?
Y[X] N[ ] N/A[ ]

Testing Included Pre Test & Post Test Data. (Performance & Operating Influence) Which are the Areas of Concern Here. Test Sequence includes recording of Data During Test For Various Influence/Effect Runs

8. Were the test methods in general accordance with the test procedure and purchase specifications?
Y[X] N[ ] N/A[ ]

Test Procedure/methods Follow IEEE 323/344 Guidance. Specification Dcc-Ic-500-QCW Does not Specify Temp/Humidity Testing in Detail.

9. Were proper margin/safety factors applied to the test parameters per industry standards?
Y[ ] N[ ] N/A[ ]

Temperature & Humidity Testing Was Performed utilizing Parameters which Provided Adequate Margin (i.e. Temp 90-140°F & Humidity 50 to 95% RH). Temp. and Humidity Influence Testing was Performed utilizing 5-50°C operating Range.

10. Can qualification of the equipment be clearly determined based on this report/analysis?
Y[X] N[ ] N/A[ ]

Foxboro has provided well documented Test Programs, Test Procedures and Test Reports. While this document Does not Accept Qualification per se, the Qual. Documentation Envelops the Temp & Humidity Issues.

11. Were test sequences, logic and protocol acceptable?
Y[X] N[ ] N/A[ ]

The Test program Follows Guidance Provided By IEEE 323/344. Test Method is logical and ~~Achieves~~ Proven Achieves the desired results.

12. Was the testing performed in general accordance with IEEE Standards 323 and 344 per Reference 7.1? Y[✓] N[ ] N/A[ ]

The Foxboro Qualification Program / Procedures were developed to meet the intent of IEEE 323/344.

13. Are the analyses, logic, graphics, formulas, equations, and mathematics understandable and valid? Y[✓] N[ ] N/A[ ]

Test Methods, Acceptance Criteria and Analysis were correct and valid.

14. Are the variables identified? Y[✓] N[ ] N/A[ ]

The Test Procedure & Generic Test Program Documents Identify all Appropriate variables

15. Are uncommon or simplified formulas, equations, and mathematical procedures explained and bases documented? Y[ ] N[ ] N/A[✓]

There are no uncommon or simplified Formulas etc. Associated with the Temperature / Humidity Issues.

16. Are calculations numerically correct with units shown? Y[ ] N[ ] N/A[✓]

there are no calculations Associated with the Temperature & Humidity Testing Issues.

17. Are assumptions and judgments reasonable and acceptable with bases explained and documented? Y[✓] N[ ] N/A[ ]

Test Program & Methodology Follows the guidance established in IEEE 323/344. Test Report Data Adequately Documents assumptions & Judgements

18. Have inputs been correctly selected, referenced, interpreted, and used? Y[✓] N[ ] N/A[ ]

All modules tested for Temperature / Humidity Effects were energized and stabilized with simulated inputs for the Test sequence. Test Method Adequately Represents Typical Installation.

19. Are outputs and conclusions correct and justified? Y[ ] N[ ] N/A[ ]

All Modules Tested were monitored for shifts in Output due to Temp / Humidity Effects. Acceptance Criteria clearly Establishes Performance expectations.

20. Did the tested configuration appropriately match the to be installed configuration? Y[✓] N[ ] N/A[ ]

Test Program is Generic in Nature and represents the typical "Mild Environment" service conditions. Test Parameters envelop the D.C. Cook Requirements.

SEISMIC QUALIFICATION ISSUES

21. Is component seismic classification identified? Y[ ] N[ ] N/A[✓]

Seismic Qualification Issues are not Addressed By this Document!

22. Were physical interactions/spatial conflicts with other items considered? Y[ ] N[ ] N/A[✓]

Same as 21.

23. Did the equipment performance meet the acceptance criteria before, during and after each OBE and DBE/SSE event? Y[ ] N[ ] N/A[✓]

Same as 21.

24. Did the number and duration of OBE and DBE/SSE events incorporated into the testing meet the requirements of Reference 7.1? Y[ ] N[ ] N/A[✓]

Same as 21.

25. Did the testing envelope the necessary OBE and DBE/SSE response spectra that define the seismic input at the mounting/support? Y[ ] N[ ] N/A[✓]

Same as 21.

26. Was information necessary to assess or include amplification and dynamic response incorporated into the test? Y[ ] N[ ] N/A[✓]

Same as 21.

27. Was information necessary to assess or include mounting/support, weight and non-seismic loads incorporated into the test? Y[ ] N[ ] N/A[✓]

Same as 21.

28. Was information necessary to assess or include physical/structural strength been incorporated into the test report? Y[ ] N[ ] N/A[✓]

Same as 21.

29. Did the method used assess the postulated failure modes and associated critical characteristics? Y[ ] N[ ] N/A[✓]

Same as 21.

30. As applicable, has dynamic analysis performed on electrical components, systems, structures, been performed in accordance with the mathematical principles and procedures as required by Reference 7.1? Y[ ] N[ ] N/A[✓]

Same as 21.

31. For seismic analyses and testing, are computer programs, software, and firmware in accordance with NEP 2.6 and GP's 2.6, 3.7, 4.4, and 15.5? Y[ ] N[ ] N/A[✓]

Same as 21.

TEMPERATURE/HUMIDITY QUALIFICATION ISSUES

Rack Heat Rise Testing

32. Did the test/analysis appropriately consider the worst case temperatures in the environment which the installed device will experience? Y[✓] N[ ] N/A[ ]

Testing was Performed over the Range of 90-140°F which includes adequate Margin to Meet UFSAR 7.2.3 / 9.10.1 Requirements and Worst Case Control room Environments

33. Did the test allow enough settle time to adequately determine a steady state operating temperature? Y[✓] N[ ] N/A[ ]

Temperature / Humidity Influence Test Data was Typically recorded 24 Hours Following Stabilization (For Humidity) and Three (3) Hours For Temperature. Base line / Reference Data was also recorded Prior to the Test sequence.

34. Did the test/analysis take into account the required arrangements of the internal equipment? Y[✓] N[ ] N/A[ ]

Test was accomplished with Subject Modules Installed in a Host Assembly and Energized. Temperature / Humidity Influence Testing was Performed in a manner to address the Typical Configuration.

35. Were the temperature measurement points chosen appropriately to make determinations of the heat rise effects? Y[ ] N[ ] N/A[✓]

Heat Rise Tests were NOT Performed By this Sequence. The Subject of this Review is Temperature / Humidity Effects. Reference Report # 2985-HEI-09 For Data on Cabinet Heat Rise.

36. Does the test account for the ambient room humidity for the installed equipment? Y[✓] N[ ] N/A[ ]

Testing was Performed with Reference Conditions Specified @ 77°F (25°C ±2) and RH 40% ± 10% for Performance Tests. Temp 87°F (30°C ±2) and RH < 50% For Reference Conditions during Temp / Humidity Effects Sequence

37. Were the power supplies and other internal equipment appropriately loaded to show near worst case operational scenarios for heat loss? Y[ ] N[ ] N/A[✓]

This Test does not Address Heat Rise / Heat Loss Effects. Temperature / Humidity Effects Testing was performed in a Controlled Environment

EMI/RFI/ESD QUALIFICATION ISSUES

38. Were the appropriate industry standards referenced? Y[ ] N[ ] N/A[✓]
EMI/RFI/ESD Testing is not addressed by this document!

39. Were the installed configuration of cables, connectors, and internal wiring identical to or reasonably similar to the required installation configuration? Y[ ] N[ ] N/A[✓]
Same as 38

40. Did the test generally conform to the methods specified by the required industry standards? Y[ ] N[ ] N/A[✓]
Same as 38

41. Did the test perform a susceptible frequency search over the applicable frequency range? Y[ ] N[ ] N/A[✓]
Same as 38

42. Did the test perform susceptibility tests at the frequencies identified as present in the EMI/RFI site survey? Y[ ] N[ ] N/A[✓]
Same as 38

43. If the equipment experienced a processor lockup, did the equipment outputs go to a proper fail and restart state? Y[ ] N[ ] N/A[✓]

Same as 38

TEST ANOMALIES

List all anomalies, resolutions, and justifications below. If open items remain for justification of anomaly resolution, please indicate in the explanation.

① Foxboro Type Test Report # QOAAB17-Rev. B; 2AO-VAI+P Voltage to Current Converter (Basis For Similarity Qualification For N-2AO-V2H(c) Card)
Anomaly: Temperature Effect Test Criteria Specified a maximum error for change in ambient of ± 20°C within the normal operating limits of 5 to 50 & not to exceed ±0.5%. The Production Module Channel "B" output at 0% indicated +0.55% in Pre Seismic Testing.
Resolution: Post Seismic Shifts were within the specified Criteria For all outputs. The Naturally Aged Module also reflected test results within specification. The "specification" for output shift has been established by Foxboro as a "Target" criteria. Failure to meet the Target value does not represent a failure of the module. As the Post Seismic Test results were within tolerance and the results of a Naturally Aged Module Reflect no Age Degradation Effect it is concluded that this anomaly is non Significant. Foxboro States that the V/I converters were determined to be within the "Target Acceptance Criteria".