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**EMERGENCY DIESEL GENERATOR
ENGINE AND AUXILIARY
MODULE WIRING AND TERMINATION
QUALIFICATION TO IEEE-383-1974**

**Prepared for:
TDI OWNERS GROUP**

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EMERGENCY DIESEL GENERATOR
AUXILIARY MODULE CONTROL
WIRING AND TERMINATION
QUALIFICATION REVIEW

Prepared for
TDI EMERGENCY DIESEL GENERATOR
OWNERS GROUP
April, 1984

Prepared
by
STONE & WEBSTER ENGINEERING CORPORATION

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SECTION 1

APPLICABILITY

This report is applicable to the TDI diesel generators (and the engine auxiliary module control wiring and terminations,) utilized at the Shoreham Nuclear Power Station. Diesel generators utilized at other plants will be evaluated separately. This review included identification of the specific wire/cable and termination types used for connecting auxiliary module class IE skid mounted devices.

SECTION 2

EXECUTIVE SUMMARY

An overall evaluation of all electrical cable and wire supplied with the emergency diesel generators at Shoreham was undertaken as a result of Transamerica Delaval Inc.'s Service Information Memo (SIM) 361, Rev. 1. This memo notified LILCO of two potentially defective engine mounted cables associated with the Woodward governor/actuator and the Air-Pax magnetic pick-up.

A field survey was conducted of all class IE auxiliary module wiring and terminations presently installed on the engines. Each circuit's service characteristics were identified and compared to the service ratings of the cable and termination types used. The evaluation of wiring also addressed flame retardancy of the insulation, qualification to industry standards, routing in conduit, and the need for special requirements, such as shielding.

Additionally, although there are no specifications or licensing requirements that Shoreham's emergency diesel engine mounted wire and cable meet the qualification requirements of IEEE 383-1974, surveyed wire and cable was reviewed for qualification to this standard.

As a result of this investigation, it is recommended that some wiring associated with the crankcase vacuum fan and the two

starting air supply solenoid valves be replaced, because the temperature rating of the wire insulation system is not compatible with expected ambient temperatures. The investigation also confirmed that qualified replacement cable was provided by TDI and installed by LILCO in accordance with SIM 361, Rev. 1.

SECTION 3

OBJECTIVES

The objective of this review was to evaluate the functional attributes of the electrical wiring and terminations supplied with the emergency diesel generators as detailed in the Component Design Review Task Description. The wiring and terminations considered were those shown on Reference and task description details include:

1. Review of wiring insulation for compatibility with circuit requirements.
2. Determine whether insulating material is known to have generic fire retardant characteristics and is qualified to IEEE-383 or some other industry standard.
3. Review the wiring installation method for routing in order to determine the actual physical environment for each cable.
4. Evaluate any special circuit requirements to determine if special cable construction is required (i.e., shielded cable).
5. Compare the termination type, material, size and insulation ratings with characteristics required for application.

SECTION 4

SUMMARY OF SERVICE CONDITIONS

The electrical metallic tubing (EMT) installed on the skid and supported away from the engine was considered to be at the same temperature as the maximum room ambient of 140°F. (60°C.) (see Reference). The junction box, EMT and cable which are directly attached to the engine block may be exposed to temperatures greater than 140°F. (60°C.). The engine block surface temperature, during full load operation, was conservatively assumed to be equal to the jacket water and lube oil maximum normal operating temperature of 180°F. (82.2°C.) (see Reference). The jacket water and lube oil temperatures were based on actual field readings during start up testing.

Typical installation configurations are shown on Sketch A. This sketch identifies those components at the maximum room ambient and those which may experience a temperature of 180°F. (82.2°C.).

Electrical requirements for cables and terminations are provided in Table B.

SECTION 5

METHODS OF ANALYSIS

5.1 Determination of Circuit Electrical Requirements

Each component listed in Table B was inspected for pertinent nameplate data. Manufacturer's catalog information contained in Reference was also reviewed. This review established the circuit requirements for each component which are listed in Table B.

5.2 Determination of Wire Insulation Rating

Each wire and cable was inspected for manufacturer information on the insulation or jacket. An investigation was then performed for each cable to determine its insulation properties, flame retardancy, and electrical rating. These results are listed in Table A.

5.3 Determination of Termination Type

All terminations and terminal blocks were inspected to identify manufacturer, type and model number. Additional design and vendor documents were utilized as required to determine the model or rating of each component. This information is listed in Table A. A comparison was made to the circuit requirements in Table B.

5.4 Determination of Wiring and Termination Acceptability

The evaluation for the acceptability of cable and wire included reviews for the following:

1. Voltage rating for the insulation system as compared to the service voltage.
2. The maximum allowable operating temperature of the wire as compared to the sum of the expected ambient and the expected conductor temperature rise.
3. The insulation system characteristics relative to flame retardancy and industry standards.
4. Routing.

Additionally, a review was made of cable manufacturer data for evidence of qualification to IEEE 383-1974. These results are listed in Table A.

SECTION 6

DISCUSSION OF RESULTS

I. Termination

All termination components and terminal blocks are acceptable, as demonstrated in Tables A and B.

II. Wiring and Cables

A. Cable Ampacity and Temperature Rating

- (1) Even though PVC is rated at 90°C in a dry location by U.L., ICEA Publication S-61-402 rates it at 75°C in wet or dry locations. The ICEA temperature rating is more appropriate for nuclear-grade installations and therefore, a 75°C rating for MTW PVC materials is assumed for the purposes of conservatism.

The type MTW insulated wires associated with the crankcase vacuum fans (1R43*FN081A, B, C) must be replaced because the operating temperatures are expected to exceed the rated temperature of the existing wire. The electrical metallic tubing enclosing the wire is directly in contact with the engine block. During engine

operation, the crankcase vacuum fan is operating continuously to remove vapors and gases from the crankcase. At rated loads and speed, this fan maintains vacuum of 0.2 to 0.5 in. - H₂O in the crankcase. It should be noted that these fans are rated at 6.0 full load amps. The selected replacement wire (E&DCR F-27380A) is Okonite 1/C#12-19X copper cable Black Okozel (Tetzel Insulation) type ZW rated at 125°C. This selected wire is acceptable since the I²R temperature rise of the wire under full load condition is 5°C. This will result in a final operating temperature of 87.2°C. (82.2°C. ambient plus 5°C. rise).

- (2) The Starting Air Supply Solenoid Valves (1R43*SOVO46A, B, C and SOVO47A, B, C) are required to operate during engine starting only. These solenoid valves, one for each of two separate independent air supply system, are connected to the ends of the starting air header on each diesel generator. To start the engine, starting air is admitted to the air header via the solenoid valves and, in turn, to the starting air valves for the cylinders, as well as two starting air distributors. During normal operation, these solenoid valves are closed (deenergized).

The insulated cables associated with the starting air supply solenoid valves are of the type MTW. These cables

must be replaced because the operating temperatures are expected to exceed the temperature rating of the existing cables. Existing cables will be replaced by Okonite, Okozel wire described in (1) above.

- (3) Replacement cables provided by TDI per SIM 361 Rev. 1 are acceptable for expected ampacities and temperature.
- (4) Existing cables associated with the D.C. motor driver Fuel Oil Booster Pump and Motor Starter (1R43*P109A, B, C; 1R43*MST03A, B, C) are considered acceptable for temperature and ampacity. Operation of the fuel oil booster pump is controlled by pressure switch. This pump operates during engine start up and when the engine driven fuel oil pump and the associated fuel oil strainer fuel oil header pressure falls below the minimum level. During normal operation this pump will not be running, therefore the temperature during this condition will not exceed 140°F. The wires will not be carrying current. Therefore, a wire rating of 75°C. or 90°C. are acceptable.
- (5) All other wiring in Table B has a rating of 90°C. and associated components operate either intermittently or draw currents which do not appreciably affect conductor temperature rise. Therefore, the use of 90°C. rated wire in a maximum room ambient of 60°C. is acceptable.

B. Cable/Wire Routing

All cable was routed in EMT or flexible conduit, except as noted for the cable going from the engine mounted junction box to the governor.

C. Special Considerations

Shielded cable, when required, was provided by TDI or the field. Reference Table A items 5 and 7.

D. Cable Insulation System

Upon replacement of the Carol type MTW wire (Item 2 of Table A), for the crankcase vacuum fans and the starting air supply solenoids valves all wire and cable types used are of an acceptable flame retardant construction for their application. Except for the D.C. motor driven fuel oil booster pumps and their motor starters, all wire and cable used is qualified to IEEE-383-1974 (see Table B). The wire used internal to the motor starter and feeding the D.C. motor driven booster pump motor is acceptable based on the fact that it is self contained in raceway and has no way of propagating a flame to any other class IE components.

SECTION 7

CONCLUSION/RECOMMENDATIONS

Item 2 of Table A will be replaced with Item 1 on all three emergency diesel generator skids as indicated in Table B. Upon replacement, all functional attributes of this component design review will be satisfied.

TABLE A

EMERGENCY DIESEL GENERATOR AUXILIARY MODULE CONTROL WIRING

AND TERMINATION MATERIAL LIST

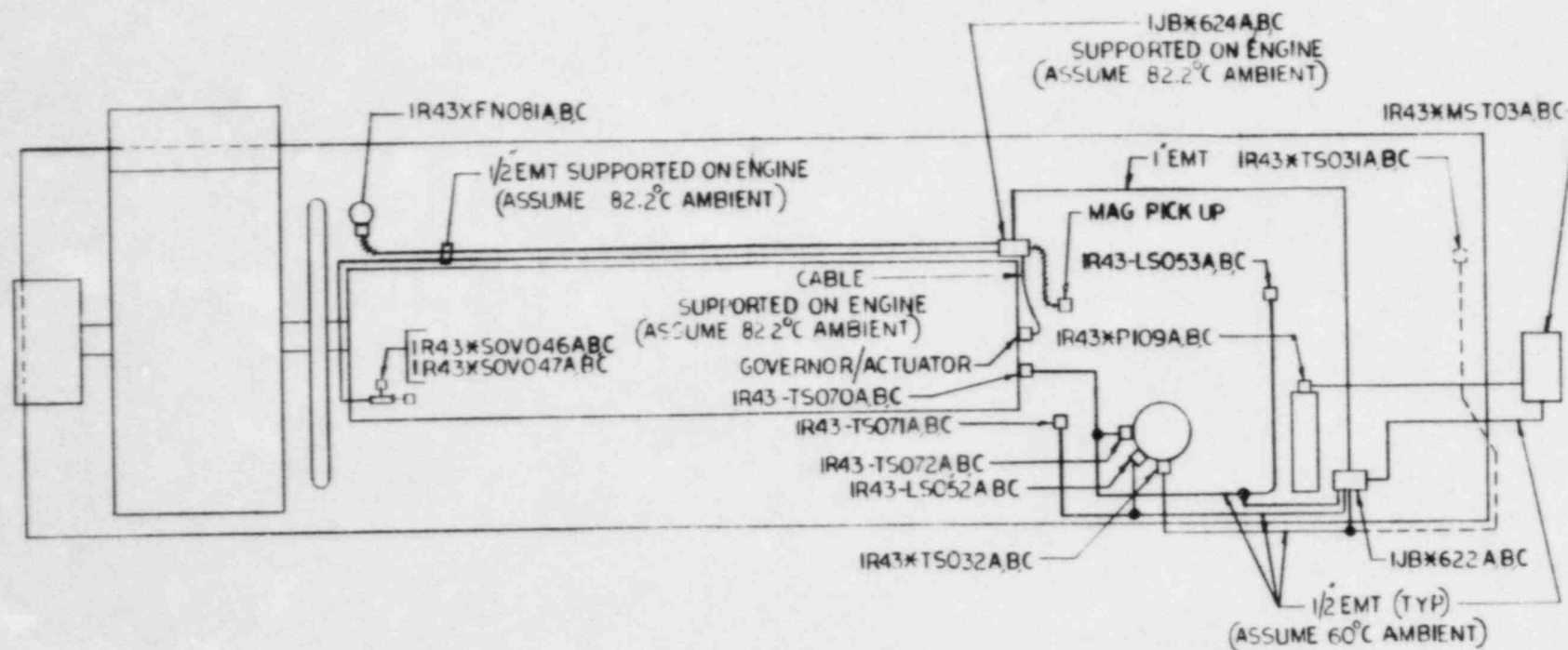
| <u>Item</u> | <u>Description</u> | <u>TDI Part No.</u> | <u>Manufacturer</u> | <u>Technical Data</u> | <u>Reference</u> |
|-------------|-----------------------------------|---------------------|----------------------------|---|------------------|
| 1. | 14 AWG SIS Wire | N/A | Rockbestos | 600V, 25 amps, Operating Temperature 90°C. Cross-linked Synthetic Polymer Insulation Qualified to IEEE-383-1974 | 10, 12 |
| 2. | 14 AWG Type MTW or TW or AWM Wire | F-509-104 | Carol-C | 600V, Operating Temperature 75°C. Flame Retardant Moisture Resistant Thermoplastic Insulation | 17, 19 |
| 3. | 14 AWG Type SIS Wire | N/A | Continental Wire and Cable | 600V, 90°C. Operating Temperature Heat Resistant Rubber Insulation (UL) | 17 |
| 4. | 12 AWG Type MTW | N/A | G.E. | 600V, 90°C. Operating Temperature Flame-Retardant, Moisture, Heat and Oil Resistant Insulation, Nylon Jacket (UL) 5158110 | 17 |
| 5. | Cable | F-509-494 | BIW Cable Systems | Part No. 13292-H-002, 2/C, 16 AWG, Shielded 600V., Inst. 90°C. XLPE Insulation CSPE Jacket. Qualified to IEEE-383-1974 | 8, 9 |
| 6. | Cable | F-509-495 | BIW Cable Systems | Part No. 13258-H-002 2/C, 14AWG 600V, Control, 90°C. XLPE Insulation CSPE Jacket. Qualified to IEEE-383-1974 | 8, 9 |
| 7. | Cable | N/A | Rockbestos | SWEC Mark No. NFP-44, 2/C, 16 AWG, Shielded 90°C., 300V, Inst. XLPE Insulation. Qualified to IEEE-383-1974 | 6 |

| <u>Item</u> | <u>Description</u> | <u>TDI Part No.</u> | <u>Manufacturer</u> | <u>Technical Data</u> | <u>Reference</u> |
|-------------|--------------------|-----------------------|------------------------|--|------------------|
| 8. | Cable | N/A | Rockbestos | SWEC Mark No. NFP-20, I/C, 14 AWG, 600V., 90°C. cont. XLPE Insulation. Qualified to IEEE-383-1974 | 6 |
| 9. | Terminal Block | N/A | G.E. | Cat. No. CR151B2, 600V., 30 amps | 14 |
| 10. | Terminal Block | N/A | TPW | Cinch Series 141 1100V., 20 amps | / |
| 11. | Terminal Lug | N/A | AMP Special Industries | Nuclear PIDG terminal pre-insulated ring tongue lug, 150°C. | 13 |
| 12. | Terminal Lug | N/A | Burndy | Type TN, Nylon Insulated Ring-Tongue terminal | |
| 13. | Connector Plug | Part of 74010-110 | ITT | Cannon No. MS3108E-18-15 MIL-C-5015, 1750 VDC, 1250 VAC, 22 amps Environmental Resistant Construction | 11, 4 |
| 14. | Connector Plug | Part of EA-004-000 | Amphanol | MS3106A-10SL-4S MIL-C-5015, 700 VDC, 13 amps, solid shell construction | 15 |
| 15. | Cable | | Hatfield | Permolene, 10 AWG, XHHW, XP 600V (UL) | |
| 16. | Cable | | Okonite | X-olene, XHHW, 10 AWG Copper 600V (UL) | |
| 17. | Cable | | Okonite | 1/C #12-19X Copper cable, black okozel (Tefzel insulation) type ZW rated 125°C. | |

TABLE B

EMERGENCY DIESEL GENERATOR AUXILIARY MODULE COMPONENT LIST

| IDENTIFICATION NO. | DESCRIPTION | CIRCUIT REQUIREMENTS | WIRE/CABLE TYPE (see Table A) | TERMINATION TYPE | COMMENTS/RECOMMENDATIONS | REF. |
|---|---|--|----------------------------------|---------------------|--|-------|
| 1R43*FN081A,B,C | Crankcase Vac Fan | 1/3 H.P. Continuous Duty, 115 VAC, 6.0 FL amps | 1, 2 | 9,10,11,12 | Replace Item 2 with Item 17, Item 17 is IEEE-383 qualified | 2 |
| 1R43*SOV046A,B,C | Forward and Aft Start Air Supply Solenoid Part of TDI Part No. KR 001-000 | Circle Seal Control Model SV 13532P4PE 115 VDC, .6 amps maximum | 1, 2 | 9,10,11,12 | Replace Item 2 with Item 17; Item 17 is IEEE-383 qualified | 2,3,4 |
| N/A | Woodward Governor Actuator TDI Part No. KR 001-000 | Transducer coil 0 to 1.75 volts 400 max. allowable current | 1, 6 | 1,10,11,13 | Item 1 and 6 are IEEE-383 qualified | 2,4 |
| N/A | Magnetic Pick-up TDI Part No. EA-004-000 | Air-Pax Output Signal Average 50 Volts P-P | 5, 7 | 9,10,11,14 | Item 5 and 7 are IEEE-383 qualified | 1,5 |
| 1R43*MST-03A,B,C 1P43*P-109A, B, C | Fuel Oil Booster Pump and Motor Starter | 2.0 H.P. Continuous Duty 125 VDC, 17 FL amps. Starter Control Circuit 125 VDC, 10 amps fused | 1, 2, 3, 4, 15, 16 | 9,11,12 | Item 1 and 8 are IEEE-383 qualified. Items 2, 3 and 4 are acceptable for this application. | 1,5 |
| 1R43*TS031A,B,C 1P43*TS032A,B, C | Lube Oil and Jacket Water Heater Thermostats TDI Part No. BD-003-000 | Chromalox Industries Thermostat Type AR Contacts open or close 120 VAC, 5.6 amp fused control circuit | 1 | 9, 11 | Item 1 is qualified to IEEE-383 | 1,3 |
| 1R43-TS070A,B,C 1R43-TS071A,B,C 1R43-TS072A,B,C 1P43-LS053A,B,C 1R43-LS052A,B,C | High Temp. Lube Oil High Temp. Jack. Water Low Temp. Jack. Water Low Level Lube Oil Low Level Jack. Water | Contacts Open or Close 125 VDC, control circuit which energize relay coils and alarm lights which draw a total of .03 amps maximum | 1 | 9 | Item 1 is qualified to IEEE-383 | 1,3 |



EMERGENCY DIESEL GENERATOR

AUXILIARY MODULE LOCATIONS &
RACEWAY ROUTING

| POWER INDUSTRY GROUP | | TITLE | | | | | SCALE |
|----------------------|---|-------|---|---|--|--|---------------|
| CHECKED | | | | | | | DATE |
| CORRECT | | | | | | | |
| APPROVED | | | | | | | SKETCH NUMBER |
| REVISIONS | 2 | 3 | 4 | 5 | | | A |

APPENDIX A

10-03-688B

COMPONENT DESIGN REVIEW TASK DESCRIPTION

WIRING & TERMINATION
PART NO. 03-688B

Classification A
Completion 3/9/84

PRIMARY FUNCTION: The wiring and terminations interconnect instrument, control and power circuits on diesel generator skid and within the control panels.

FUNCTIONAL ATTRIBUTES:

1. Conductors, insulation, and termination must be suitable for specified amp rating.
2. Conductors and insulation must be flame retardant.
3. Material and insulation rating should be appropriate for engine and generator applications.

SPECIFIED STANDARDS: IEEE-383

EVALUATION:

1. Review wiring insulation for compatibility with circuit requirements.
2. Flame retardant insulation:
 - a. Determine whether insulation is qualified to IEEE-383, UL or some other industry standard.
 - b. Determine whether insulation is a material known to have generic fire retardant characteristics.
 - c. Determine whether wiring need be installed in individual conduit to minimize insulation damage.
3. Evaluate any special circuit requirements, such as shielded cable.
4. Compare termination type, material, size and insulation ratings with characteristics required for application.

REVIEW/TAI ANALYSES: Review if available

INFORMATION REQUIRED:

1. Cable type test reports or other approved quality control method for each cable type supplied with the engine

APPENDIX B - REFERENCES

- Reference 1: TDI Drawing 52122, Auxiliary Module Control Wiring
- Reference 2: TDI Drawing 52076, Engine Electrical Schematic
- Reference 3: TDI Drawing 52072, Panel Electrical Schematic
- Reference 4: Transamerica Delaval Associated Publications Manual
- Reference 5: S&W Drawing No. 11600.02-FE-14A, B and C External Connection Diagram Emergency Generator Control Panel 1R43*PNL-GP1, 2 and 3
- Reference 6: Specification SH1-129, Rev. 3, March 9, 1983, 300V and 600V Fire Resistant Control and Instrument Cable
- Reference 7: IEEE Std. No. 383 1974, Standard for Type Test of Class 1E Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations
- Reference 8: TDI Service Information Memo (SIM). 361, Rev. 1; Subject: IE Nuclear Qualified Cable dated October 13, 1983
- Reference 9: Boston Insulated Wire and Cable Co. Report No. B716, dated April 1980
- Reference 10: Rockbestos Report No. QR 1807 "Qualification of Firewall III Class IE Electric Cables" dated December 8, 1980
- Reference 11: Cannon Catalog MS-21, Standard Circular Connector dated December 1978
- Reference 12: Rockbestos specification RSS-4-002 "Firewall SIS 600 Volt Switchboard Wire Specification" dated October 24, 1979
- Reference 13: AMP Special Industries Catalog Nuclear Terminals and Splices
- Reference 14: General Electric Catalog GEP-1260B

Reference 15: Ampharol Catalog AID-5

Reference 16: Stone & Webster Letter to LILCO LIL-22805 April 11, 1983

Reference 17: The National Electric Code Handbook 1984 Table 310-13

Reference 18: TDI Instruction Manual 1R43-1 Volume 1

Reference 19: ICEA Publication S-61-402 Thermoplastic - insulated Wire and Cable for the Transmission and distribution of Electrical Energy