CALCULATION COVER SHEET

Calculation No: PTN - BFJE - 93 - 001

Title: AMPACITY DERATING RESPONSE to NRC GL 92-08 for CABLES ROUTED in CONDUIT and TRAY with THERMO-LAG 330-1 FIRE BARRIER SYSTEM COATING

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AMPACITY DERATING RESPONSE to NRC GL 92-08 for CABLES ROUTED in CONDUIT and TRAY with THERMO-LAG 330-1 FIRE BARRIER SYSTEM COATING

1.0. PURPOSE

The purpose of this calculation is to provide a tabulation of power cable ampacity calculations performed for derating of power cables used in Turkey Point Nuclear (PTN) 3 and 4. Power cables that are not evaluated in previous calculations will be addressed within this calculation. The results of this calculation will be referenced in the engineering response to NRC "Thermo-Lag 330-1 Fire Barriers (Generic Letter 92-08)".

2.0. REFERENCES

1. FPL Document 5610-M-722, Turkey Point Plant-Units 3 & 4, Appendix R Safe Shutdown Analysis, Revision 1, Dated July 17, 1992.
2. FPL Document 5610-M-723, Turkey Point Plant-Units 3 & 4, Appendix R Essential Equipment List, Revision 1, Dated July 17, 1992.
3. FPL Document 5610-E-2000, Turkey Point Plant - Units 3 & 4, Appendix R Essential Cable List, Revision 1, Dated July 17, 1992.
4. Bechtel Power Corporation Calculation 5177-304-E-04, Revision 1, Dated January 23, 1984.
5. Bechtel Calculation 5177-EF-01, Revision 2, Dated November 10, 1989.
6. Bechtel Calculation 5177-EF-09, Revision 1, Dated November 10, 1989.
7. Bechtel Calculation 5177-EF-10, Revision 1, Dated November 10, 1989.
8. Bechtel Calculation 5177-EF-12, Revision 1, Dated November 10, 1989.
9. Bechtel Calculation 5177-EF-13, Revision 0, Dated November 7, 1985.
10. Bechtel Calculation 5177-EF-15, Revision 1, Dated November 10, 1989.
11. Bechtel Calculation 5177-265-EF-25, Rev. 1, Dated November 10, 1989.
12. EBASCO Calculation EC-50, Revision 1, Dated March 9, 1990.
13. EBASCO Calculation EC-127, Revision 6, Dated June 25, 1991.
14. EBASCO Calculation EC-128, Revision 6, Dated June 25, 1991.
15. EBASCO Calculation EC-129, Revision 7, Dated June 28. 1991.
16. EBASCO Calculation EC-130, Revision 5, Dated June 17, 1991.
17. EBASCO Calculation EC-132, Revision 6, Dated July 9, 1991.
18. EBASCO Calculation EC-164, Revision 3, Dated May 19, 1991.
19. EBASCO Calculation EC-182, Revision 0, Dated April 20, 1990
20. Thermal Science, Incorporated (TSI) Technical Note 11781, Rev. 5
21. Industrial Testing Laboratories (ITL) Report No 84-10-5, Dated October, 1984.
22. FPL Drawing 5613-E-10, Revision 4, Dated September 12, 1992.
23. FPL Document 5613-E-320, Revision 4, Dated November 12, 1992.
24. FPL Document 5614-E-320, Revision 3, Dated June 23, 1992.
25. FPL Document 5613-E-321, Revision 6, Dated November 12, 1992.
26. FPL Document 5614-E-321, Revision 4, Dated June 23, 1992.
27. FPL Document 5610-E-305, Revision 38, Cable and Raceway Schedule
28. FPL Drawing 5610-T-E-1592, Revision 36, Dated July 29, 1991.
29. FPL Drawing 5610 E-25, Sheet 99A, Revision 1, Dated August 28, 1989.
30. FPL Drawing 5614-E-10, Revision 0, Dated December 14, 1991

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	31. FPL Drawing 5610-T-E-1591, Revision 46, Dated December 30, 1992. 32. FPL Drawing 5613-E-11, Revision 1, Dated October 28, 1992. 33. FPL Drawing 5613-E-12, Revision 0, Dated December 12, 1991. 34. FPL Drawing 5614-E-11, Revision 2, Dated November 12, 1992. 35. EBASCO Calculation EC-138, Revision 4, dated March 31, 1992. 36. FPL Drawing 5614-E-1713, Revision 1, Dated June 18, 1992.

3.0. METHODOLOGY

2.0.1, 2.0.2, 2.0.3 — This calculation is prepared in two parts; a tabulation which was compiled from a review of calculations referenced in Section 2.0 which evaluated cable sizing and derating of PTN power cables and a section which evaluates power cables that are not specifically identified within previous calculations. The population of power cables to be evaluated was determined from a review of power cables at PTN which had been specifically evaluated for the PTN Safe Shutdown Analysis (SSA) and those power cables affected by the Thermo-Lag 330-1 Fire Barrier System. Power cables from the following distribution sources were evaluated:

4160 Volt AC Switchgear:	3A(3AA), 3B(3AB), 3D(3AD), 4A(4AA), 4B(4AB), 4D(4AD), and
480 Volt AC Load Centers :	3A(3B01), 3B(3B02), 3C(3B03), 3D(3B04), 3H(3B50), 4A(4B01), 4B(4B02), 4C(4B03), 4D(4B04), 4H(4B50), and
480 Volt AC Motor Control Center:	3A(3B05), 3B(3B06), 3C(3B07), 3D(3B08), 3K(3B52), 3L(3B53), 3M(3B54), 4A(4B05), 4B(4B06), 4C(4B07), 4D(4B08), 4J(4B51), 4K(4B52), 4L(4B53), 4M(4B54), and
125 Volt DC Bus:	3A(3D01), 3B(3D23), 4A(4D23) and 4B(4D01)

4.0. ASSUMPTIONS/BASES

2.0.20 — 1. Fire protective coatings used at PTN are the Thermal Science, Inc. (TSI) Thermo-Lag 330-1 Fire Barrier System (fire wrap). Based on testing conducted by TSI, a power cable; i.e., two single #00 American Wire Gage (2-1/c #2/0 AWG), in a two inch (2") magnetic conduit coated with one hour TSI protection will be derated by 7.47%. The same type cable within a two inch (2") conduit coated with three hour TSI protection will be derated by 9.72%.

2.0.5 — 2. The scope of this calculation applies to conduit and tray sections inside and outside containment. For cables inside containment, the ambient air temperature is assumed to be 50 °C. Outside containment, the ambient temperature is assumed to be 40 °C.

3. Basic data from the calculations referenced in Section 2.0 applies to this calculation where required because this calculation is essentially a tabulation of data from previous calculations.

4. Control and Instrumentation cables are not included in this evaluation because ampacity derating is not of concern for these types of cable service.

REF.	
	5. This calculation does not size any new cables. Evaluations performed within this calculation use data and tables from the referenced calculations as noted.
	6. The following assumptions were used in the original calculations for sizing cables at PTN.
2.0.5	• Calculation 5177-EF-01
	1) for 600, 5000 and 8000 volt insulation rated cables, the conductor temperature is assumed to be 90°C and the cable load factor is 100%,
	2) Thermo-Lag derating factors from TSI based on testing of 2-1/c #2/0 AWG cable in a 2" conduit are: 1-hour = 7.47%; i.e., $I' = I_C \times (1 - 7.47\%) = 0.9353 I_C$ 3-hour = 9.72%; i.e., $I' = I_C \times (1 - 9.72\%) = 0.9028 I_C$ that is, the allowable ampacity (I') of a cable is the rated ampacity of the cable (I_C) reduced by the derating factor
	3) for 600 volt AC cables connected to Motor Control Centers (MCC), the capacity is equal to 125%
2.0.6	• Calculation 5177-EF-09
	1) used TSI derating factors (1-hour = 7.47%, 3-hour = 9.72%)
	2) calculation for cables outside containment ambient temperature is 40°C
	3) evaluated all cable ampacity based on 3-hour coating for conservatism
	4) based on conclusions in calculation 5177-304-E-04, derating factor was 0.5 assuming a worst case cable tray fill (> 43 power cables in tray)
	5) an additional derating factor of 0.9132 was used to account for Flammastic coatings
	6) cable in tray was assumed to have conductor temperature of 85°C
	7) for cables sizes #10 AWG and #12 AWG, an added derating factor of 0.9 was required per ICEA; therefore, the overall derating factors to be used in cable sizing based on ampacity in a full tray with Flammastic coating of the cables were: (#10 and #12 AWG) = 0.9 x 0.5 x 0.9132 = 0.411 (#8 and larger AWG) = 0.5 x 0.9132 = 0.457
	7. For circuits which are evaluated within this calculation, the source of design bases and background information is referenced within each section for the affected circuit.
	8. Note that for cable sizing purposes, ampacity is only one factor, along with circuit voltage drop at normal and degraded grid voltage and cable short circuit fault withstand capability. Additionally, cable sizing used 'standard' cable sizes which were cables that were already available on site that were as large or larger than the designed cable required.

REF.	
2.0.6 4.0.6.2	For worst case analysis of cable ampacity derating, cables that were sized per calculation 5177-EF-09 used a derating factor created for the calculation by dividing the ampacity of three single conductors (3-1/c) routed in rigid steel (magnetic) conduit by the ampacity of one single (1-1/c) conductor in free air. The resultant factors varied from 0.653 to 0.769. The value of 0.653 was used to size cable for conservatism. Then the derating factor for three hour fire wrap on conduit became: (0.653) x (0.9028) = 0.590.
	Comparing the derating factor for cable ampacity within conduits to the worst case derating factor for cables in tray sections filled to a maximum hypothetical fill limit and coated with Flammastic fire retardant, the derating factor for the coated tray becomes the most restrictive and conservative for use in calculations. Therefore, because cables were sized based on worst case ampacity derating in filled tray (#8 AWG or larger = 0.457), it was concluded that cable in conduit with fire wrap (worst case factor = 0.590) was acceptable.
	5.0. CALCULATION
	5.1. Tabulation of Cable Sizing and Ampacity Derating
	The results of calculations which were performed to size cables and provide derating factors for power cables at PTN are listed in the table in Section 6.0. No changes or enhancements were made to the values obtained from the engineering review of the calculations listed in Section 2.0.
	In addition to the cables within conduits at PTN, there are six (6) tray sections which have been coated with Thermo-Lag 330-1 fire wrap. These tray sections are: 3AUT10 - located in Switchgear Room 3A; (Circuits 3B0406/1, 2 & 3; 3B0408/1 & 2) 3AXT10 - located in Switchgear Room 3A; (Circuits 3B0204/1 & 2; 3B0206/2; 3D2302/1) 4AXT10 - located in Switchgear Room 4A; (Circuits 4B0202/1, 2 & 6; 4B0203/1; 4B0206/1 & 2; 4D0106/1) 4LAT20 - located outdoors adjacent to Lube Oil Storage Tank; (Circuits 4AB21/OP, OQ & OR; 4AD06/OP & OQ) 4LAT30 - continuation of 4LAT20 4LAT40 - continuation of 4LAT30
2.0.7 2.0.9 2.0.7	Tray sections 3AUT10 and 3AXT10 are evaluated in calculation 5177-EF-10 using cable sizing calculation 5177-304-E-005 for voltage drop and a maximum derating factor of 22.6% (i.e., 20.55% from I.T.L. Report No. 84-3-275A plus 10% for conservatism). Tray section 4AXT10 was evaluated within calculation 5177-EF-13 with the same maximum derating factor; i.e., 22.6%, that was used for the Unit 3 tray (5177-EF-10).
	Tray sections 4LAT20, 4LAT30 and 4LAT40 are a continuous run of tray outdoors at the lube oil storage area containing the power cables from the

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2.0.19	Unit 4B EDG to Switchgear 4B and the power cables from Switchgear 4B to Load Center 4D. Cable ampacity derating factors for these cables were evaluated within calculation EC-182. This calculation determined a derating factor based on analysis and then compared the results to a published value from TSI (compilation of Underwriters Laboratories, Inc. Project No. 86NK23826 results). Based on a lower value from TSI, the cable within this tray was derated 28%. The allowable ampacity of the cable after being derated was determined to be more than was required of the load on the circuit.
	5.2. Individual Case Study Calculations
	The following circuits have not been specifically identified in previous calculations but will affect essential equipment in the PTN Safe Shutdown Analysis.
	5.2.1. Power cable to MOV-3-536, Pressurizer Power Operated relief Block Valve (A-3B0713/P)
2.0.12 2.0.22	This circuit is powered from MCC 3C. Motor rating = 0.33 hp; Service factor = 1.0 Full load amps = 0.75 A; Locked rotor amps = 5.5 A Starter (MCC 3C) = 40°C; Breaker rating = 3.0 A
	Cables to motors are sized to have ampacity equal to 125% of full load current of the load. In addition, the ampacity of the cable size selected shall be higher than the overcurrent rating or trip setting of the feeder breaker provided for protection of the feeder cable. For the motor, ampacity is 0.75 x 1.25 = 0.9375 Amps and for the feeder breaker, ampacity = 3.0 x 1.25 = 3.75 Amps. For conservatism, the locked rotor current (5.5 Amps) is used for the load current (I_L) in this evaluation.
2.0.27 2.0.5	The existing cable is 1-3/c #10 AWG which is rated at (I_C) 36 amps in exposed conduit in free air. Multiplying by the (existing) derating factor for 3-hour fire wrap, the allowable ampacity (I') becomes: 36 x 0.9028 = 32.5 amps.
	The allowable ampacity (I') is larger than the ampacity of the load by 3366% and larger than the breaker overload rating by 491%. The additional margins from the load and breaker rating are due to the fact that the cable size was evaluated and selected based on either the circuit voltage drop or the short circuit withstand capabilities of the circuit.

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	5.2.2. Power Feeder to Unit 3 Train A Sequencer Panel - 3C23A (A-3D0104/P)
	Panel current loads to the 3A Sequencer Panel are calculated based on the individual device loads as identified in the Bus 3A DC Load List (5613-E-321, Rev. 6).
2.0.25 2.0.32	Total loads = 2941.5 Watts @ 125 volt DC = 23.53 Amps Breaker rating = 70 Amps, Cable protection = 70x1.25 = 87.5A
2.0.27 2.0.5	The existing cable is 2-1/c #2 AWG which is rated at (I_C) 130 amps in exposed conduit in free air (reference 2.0.5). Multiplying by the (existing) derating factor for 3-hour fire wrap, the allowable ampacity (I') becomes: 130 x 0.9028 = 117.36 amps.
	The allowable ampacity (I') is larger than the ampacity of the load by 399% and larger than the breaker overload rating by 34.1%. The additional margins from the load and breaker rating are due to the fact that the cable size was evaluated and selected based on either the circuit voltage drop or the short circuit withstand capabilities of the circuit.
	5.2.3. 125 volt DC Power to EDG 3A Exciter Cabinet - 3E04A (A-3D0147/P & A-3D0147/Q)
	These circuits are parallel power feeders required to supply the exciter cabinet and account for voltage drop from the DC bus to the cabinet. The exciter cabinet rating is based on the tabulation of individual loads within the cabinet as provided in the Bus 3A DC Load List.
2.0.25 2.0.32	Total load (I_L)= 1929.6 Watts @ 125 volt DC = 15.44 amps Breaker rating = 125 amps, Cable protection = 125 x 1.25 = 156.25 amps
2.0.27 2.0.5	The existing cables are 2-1/c #1/0 AWG each rated at (I_C) 179 amps in exposed conduit in free air. Multiplying by the (existing) derating factor for 3-hour fire wrap, the allowable ampacity (I') becomes: (179 x 0.9028 = 161.6 amps) x 2 = 323.2 amps.
	The allowable ampacity (I') is larger than the ampacity of the load by 1993% and larger than the breaker overload rating by 106.8%. The additional margins from the load and breaker rating are due to the fact that the cable size was evaluated and selected based on either the circuit voltage drop or the short circuit withstand capabilities of the circuit.

REF.	
	5.2.4. 125 volt DC Power to Miscellaneous AFW and Condensate Valve Distribution Panel 3D06 (B-3D2306/A)
	Power to the DC solenoid valves and miscellaneous loads from 3D06 are tabulated from the Bus 3B DC Load List. This list assumes that the circuits are continually energized to 100% load capacity.
2.0.23 2.0.33	Total load (I_L)- 610.3 Watts @ 125 volt DC - 4.88 amps Breaker rating - 20 amps, Cable protection - 20 x 1.25 - 25 amps
2.0.27 2.0.5	The existing cable is 1-2/c #12 AWG which is rated at (I_C) 27 amps in exposed conduit in free air. Multiplying by the (existing) derating factor for 3-hour fire wrap, the allowable ampacity (I') becomes: 27 x 0.9028 x 0.9 - 21.94 amps.
	The allowable ampacity (I') is larger than the ampacity of the load by 349% and larger than the breaker rating by 10%. The additional margins from the load and breaker rating are due to the fact that the cable size was evaluated and selected based on either the circuit voltage drop or the short circuit withstand capabilities of the circuit.
	5.2.5. 125 volt DC Power to EDG3B Exciter Cabinet 3E04B (B-3D2328/P & B-3D2328/Q)
	These circuits are parallel power feeders required to supply the exciter cabinet and account for voltage drop from the DC bus to the cabinet. The exciter cabinet rating is based on the tabulation of individual loads within the cabinet as provided in the Bus 3B DC Load List.
2.0.23 2.0.33	Total load (I_L)- 1768.8 Watts @ 125 volt DC - 14.15 amps Breaker rating - 125 amps, Cable protection - 125 x 1.25 - 156.25 amps
2.0.27 2.0.5	The existing cables are 2-1/c #1/0 AWG each rated at (I_C) 179 amps in exposed conduit in free air. Multiplying by the (existing) derating factor for 3-hour fire wrap, the allowable ampacity (I') becomes: (179 x 0.9028 - 161.6 amps) x 2 - 323.2 amps.
	The allowable ampacity (I') is larger than the ampacity of the load by 2184% and larger than the breaker overload rating by 107%. The additional margins from the load and breaker rating are due to the fact that the cable size was evaluated and selected based on either the circuit voltage drop or the short circuit withstand capabilities of the circuit.

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	5.2.6. Power cable to MOV-4-535, Pressurizer Power Operated Relief Block Valve (B-4B0606/P)
2.0.12	This circuit is powered from MCC 4B. Motor rating = 0.33 hp . Service factor = 1.0 Full load amps = 1.0 A Locked rotor amps = 5.5 A
2.0.30	Starter (MCC 4B) = 22°C Breaker rating = 3.0 A
	Cables to motors are sized to have ampacity equal to 125% of full load current of the load. In addition, the ampacity of the cable size selected shall be higher than the overcurrent rating or trip setting of the feeder breaker provided for protection of the feeder cable. Therefore, for the motor, ampacity = 0.75 x 1.25 = 0.9375 amps and for the feeder breaker, ampacity (I_L) = 3.0 x 1.25 = 3.75 Amps. For conservatism, calculation EC-50 assumed the load current (I_L) to be the locked rotor current (5.5 amps).
2.0.27 2.0.5	The existing cable is 1-3/c #12 AWG which is rated at (I_C) 27 amps in exposed conduit in free air. Multiplying by the (existing) derating factor for 3-hour fire wrap, the allowable ampacity (I') becomes: 27 x 0.9028 = 24.4 amps.
	The allowable ampacity (I') is larger than the ampacity of the load by 1850% and larger than the breaker overload rating by 550%. The additional margins from the load and breaker rating are due to the fact that the cable size was evaluated and selected based on either the circuit voltage drop or the short circuit withstand capabilities of the circuit.
	5.2.7. 480 volt AC to Battery Charger 4B1 (4D02) (B-4B0614/A)
2.0.36	The current load of the battery charger is based on the maximum rating of the charger. The battery charger can supply 400 amps at 125 volts DC = 50 kw. In all situations except for Station Blackout (SBO) scenarios, PTN battery chargers work as pairs on each DC bus and supply one-half of the bus load. From the SBO diesel load tabulation, the maximum expected load on this single battery charger = 56.46 kw. Assuming a ten percent (10%) voltage drop during SBO scenarios, the load current to 4D02 is as follows:

	kw load on AC side = 56.46 kw,
	voltage (V)at battery charger = 480 - 480(0.1) = 432 volts;
	assuming P.F. (efficiency) = 0.8;
	full load current (FLC) = $\frac{kw \times 1000}{\sqrt{3} \times V \times eff.}$ = 94.32 amps

2.0.30	Breaker rating = 150 amps, Cable protection = 150 x 1.25 = 187.5 amps

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2.0.27 2.0.5		The existing cable is 3-1/c #4/0 AWG which is rated at (I_C) 278 amps in exposed conduit in free air (reference 2.0.5). Multiplying by the (existing) derating factor for 3-hour fire wrap, the allowable ampacity (I') becomes: 278 x 0.9028 = 251 amps.
		The allowable ampacity (I') is larger than the ampacity of the load by 166% and larger than the breaker overload rating by 34%. The additional margins from the load and breaker rating are due to the fact that the cable size was evaluated and selected based on either the circuit voltage drop or the short circuit withstand capabilities of the circuit.
	5.2.8.	125 volt DC Power to AFW Trip & Throttle Valve K3B (B-4D0104/R)
2.0.12 2.0.26 2.0.34		Valve motor rating = 0.33 hp = 246.18 Watts Motor current = 246.18W @ 125 volt DC = 1.969A Breaker rating = 30 amps, Cable protection = 30 x 1.25 = 37.5 amps
2.0.27 2.0.5		This cable is 2-1/c #6 AWG which is rated at (I_C) 75 amps in exposed conduit in free air. Multiplying by the (existing) derating factor, the allowable ampacity (I') becomes: 0.9028 x 75 = 67.74 amps.
		This cable is the same size, type and spliced to circuit B-4D0104/Q which is evaluated in calculation 5177-EF-15 as follows: cable current = 75 amps, allowable derated ampacity (I') = 44 amps, and load current (I_L) = 24 amps.
2.0.10		Based on the evaluation in calculation 5177-EF-15, the allowable ampacity (I') is larger than the ampacity of the load by 83% and larger than the breaker overload rating by 17%. The additional margins from the load and breaker rating are due to the fact that the cable size was evaluated and selected based on either the circuit voltage drop or the short circuit withstand capabilities of the circuit.
	5.2.9.	125 volt DC Power for Alternate Shutdown Panels 3(4)C264 Emergency Lighting (B-4D0107/P)
2.0.29		This cable feeds parallel emergency lighting circuits to the Unit 3 and Unit 4 Alternate Shutdown Panels 3(4)C264. The circuits are parallel fused for 15 amp service and the DC Bus 4B feeder breaker is rated for 50 amps.
2.0.33		Load rating = 15 amps x 1.25 = 18.75 amps Breaker rating = 50 amps, Cable protection = 50 x 1.25 = 62.5

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	The existing cable is 2-1/c # 2 AWG which is rated at (I_C) 130 amps in exposed conduit in free air. Multiplying by the (existing) derating factor for 3-hour fire wrap, the allowable ampacity (I') becomes: 130 x 0.9028 = 117.36 amps.
	The allowable ampacity (I') is larger than the ampacity of the load by 526% and larger than the breaker overload rating by 88%. The additional margins from the load and breaker rating are due to the fact that the cable size was evaluated and selected based on either the circuit voltage drop or the short circuit withstand capabilities of the circuit.
	5.2.10. 125 volt DC Power for Sequencer 4B Control Power (B-4D0129/P)
	The sequencer load rating is based on the tabulation of individual loads within the cabinet as provided in the Bus 4B DC Load List.
2.0.26 2.0.33	Total load (I_L)= 537.98 Watts @ 125 volt DC = 4.304 amps Breaker rating = 30 amps, Cable protection = 30 x 1.25 = 37.5 amps
2.0.27 2.0.5	The existing cables are 1-2/c #12 AWG each rated at (I_L) 27 amps in exposed conduit in free air. Multiplying by the (existing) derating factor for 3-hour fire wrap, the allowable ampacity (I') becomes: 27 x 0.9028 x 0.9 = 21.93 amps.
	The allowable ampacity (I') is larger than the ampacity of the load by 410% and is not larger than the breaker overload rating. The breaker trip setting must be set to provide protection for this cable. The additional margins from the load and breaker rating are due to the fact that the cable size was evaluated and selected based on either the circuit voltage drop or the short circuit withstand capabilities of the circuit.
	5.3 Worst Case Circuit Ampacity Derating Evaluation
2.0.6	After a review of previously issued ampacity derating calculations and the evaluation of circuits in Section 5.2 above, two circuits were identified which have calculated margins above the derating factor which engineering concluded were not as conservative as would be expected. These circuits are 3AB09/1 and 3AB14/1. Circuit 3AB09/1 feeds power to the Load Center 3B transformer from Switchgear 3B. Circuit 3AB14/1 feeds power to Load Center 3D transformer from Switchgear 3B. Existing calculation 5177-EF-09, Section 5.B.2, evaluated these circuits based on the transformer power rating and derated for 3-hour fire wrap (0.9028). Based on the calculation with load current of 214.5 amps, the allowable

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	derated ampacity is 17% over the required load ampacity with 9.72% derating.
2.0.35	Calculation EC-138; Switchgear, Load Center and MCC Load Study, evaluated the loading on the 480 volt AC load center transformers and 4160 volt AC switchgear units for Turkey Point Nuclear Units 3 and 4 under various normal and shutdown conditions. This calculation determined that the normal Mode 1 power operation loading on Load Center 3B was 384 kVA and the loading on Load Center 3D was 752 KVA. Based on these load values the following ampacity loads will be applied to the affected cables feeding the primary side of the load center transformers:
2.0.35	• Load Center 3B = 384 KVA
	$KVA = (V \times I \times \sqrt{3})/1000$; where V = Bus voltage (480 or 4160)
	Solving for I; $I = \underline{KVA \times 1000} / (V \times \sqrt{3})$
	then; $I_{LC\text{-}3B} = 384000 / (480 \times 1.732) = 461$ amps
	The load center transformer is 'stepping down' the bus voltage from 4160 to 480 volts or 4160:480. For transformers, the current on the primary (line side) is equal to the current on the secondary (load side) multiplied by the inverse (step up) ratio of the transformer or in this case 480:4160. Therefore, the current ampacity on the cables from the switchgear to the load center is:
	$I_P = I_S \times (480/4160) = 461\ A \times (480/4160) = 53.29\ A$,
	Assuming a transformer efficiency of 0.8, the ampacity for circuit 3AB09/1 = 53.29 / 0.8 = 66.6 amps;
	With a derating factor of 9.72% for 3-hour fire wrap, the allowable ampacity for this circuit was 251 amps. Based on the calculated load of 66.6 amps, the margin between allowable and load ampacity becomes 277%.
2.0.35	• Load Center 3D = 752 KVA
	$KVA = (V \times I \times \sqrt{3})/1000$; where V = Bus voltage (480 or 4160)
	Solving for I; $I = \underline{KVA \times 1000} / (V \times \sqrt{3})$
	then; $I_{LC\text{-}3D} = 752000 / (480 \times 1.732) = 904.5$ amps

REF.	

The load center transformer is 'stepping down' the bus voltage from 4160 to 480 volts or 4160:480. For transformers, the current on the primary (line side) is equal to the current on the secondary (load side) multiplied by the inverse (step up) ratio of the transformer or in this case 480:4160. Therefore, the current ampacity on the cables from the switchgear to the load center is:

$I_P = I_S \times (480/4160) = 904.5\ A \times (480/4160) = 104.4\ A,$

Assuming a transformer efficiency of 0.8, the ampacity for circuit 3AB14/1 = 104.4 / 0.8 = 130.5 amps;

With a derating factor of 9.72% for 3-hour fire wrap, the allowable ampacity for this circuit was 251 amps. Based on the calculated load of 130.56 amps, the margin between allowable and load ampacity for Load Center 3D becomes 92%.

The margin between the previously evaluated allowable ampacity for Load Centers (LC) 3B and 3D and the load ampacity of 17% was of concern to engineering. By evaluating the load center loading based on the values in calculation EC-138, the margin for these cables feeding the load center transformers;i.e., LC 3B = 277% and LC 3D = 92%, can be concluded as adequate to provide sufficient margin to handle ampacity loads based on postulated more rigorous derating factors.

6.0. RESULTS

The following table includes the results of the engineering review of the previously prepared calculations referenced in Section 2.0 and the individual calculations prepared in Section 5.2 above.

SCHEME	AFFECTED DEVICE	CABLE SIZE	LOAD AMPS I_L	DERATING FACTOR	CABLE AMPS I_c	DERATED AMPS I'	MARGIN %	CALCULATION
3AB09/1	3X05	3-1/c #4/0	214.5 66.6	0.9028	278	251	17 277	5177-EF-09 Sect 5.3
3AB14/1	3X07	3-1/c #4/0	214.5 130.5	0.9028	278	251	17 92	5177-EF-09 Sect 5.3
3AB17/1	3P9B	3-1/c #4/0	46.0	0.9253	287	266	478	5177-265-EF-25
3B0105/P 's	3P201A	3-1/c #350	50	0.457	384	175.5	251	5177-EF-09 EC-130

REF.

SCHEME	AFFECTED DEVICE	CABLE SIZE	LOAD AMP I_L	DERATING FACTOR	CABLE AMP I_c	DERATED AMPS I'	MARGIN %	CALCULATION
3B0112/1 'g	3B05 †	3-1/c #750	200	0.457 0.9028	598 598	273 540	36.5 170	5177-EF-09 5177-265-EF-25
3B0112/2 'g	3B05 †	3-1/c #750	200	0.457 0.9208	598 598	273 540	36.5 170	5177-EF-09. 5177-265-EF-25
3B0203/H	3P201B	3-1/c #350	181	0.9253	384	355	96	5177-265-EF-25
3B0204/P	3V1B	3-1/c #4/0	155	0.897	278	249.4	61	5177-EF-15
3B0407/OP	3B52	3-1/c #750	48.2	0.72	588	423	776	EC-132
3B0610/OP	3P203B	3-1/c #2	18	none	60		(233)	EC-130
3B0713/P	MOV-3-536	1-3/c #10	5.5	0.9028	36	32.5	491	Sec. 5.2.1
3B0715/A	3D02	3-1/c #1/0	104.5	0.897	179	162	55	5177-EF-09
3B5001/OP	LC3D-LC3H	3-1/c #750	208	0.925	598(3)	1659.6	698	EC-130
3B5001/OQ	LC3D-LC3H	3-1/c #750	208	0.925	598(3)	1659.6	698	EC-130
3B5001/OR	LC3D-LC3H	3-1/c #750	208	0.925	598(3)	1659.6	698	EC-130
3B5202/OP	3V65B	1-3/c #10	3.38	.7x .897	36	22.6	569	EC-132
3D0104/P	3C23A	2-1/c #2	23.5	0.9028	130	117.36	399	Sec. 5.2.2
3D0106/A 'g	3B01	2-1/c #1/0	1.0 ---	.8x.9028 0.457	179 179	129 81.8	12800	5177-265-EF-25 5177-EF-09
3D0108/A 'g	3B03 *	2-1/c #1/0	1.0 *12.34	.8x.9028 0.457	179 179	129 81.8	12800 563	5177-265-EF-25 5177-EF-09
3D0114/E	3C10 *	2-1/c #8	30 *.9392	0.8	55	41	37 4265	5177-265-EF-25
3D0147/P	3E04	2-1/c #1/0	15.4	0.9028	179	161.6	949	Sec. 5.2.3
3D0147/Q	3E04	2-1/c #1/0	15.4	0.9028	179	161.6	949	Sec. 5.2.3
3D2301/A 'g	3B04 *	2-1/c #1/0	*17.78	0.457	179	81.8	360	5177-EF-09
3D2302/A	3B02	2-1/c #1/0	100	0.9028	179	162	62	5177-EF-09

REF.

SCHEME	AFFECTED DEVICE	CABLE SIZE	LOAD AMPS I_L	DERATING FACTOR	CABLE AMPS I_C	DERATED AMPS I'	MARGIN %	CALCULATION
3D2303/A 'g	4AB20 *	2-1/c #1/0	*33.16	0.457	179	81.8	147	5177-EF-09
3D2304/A 'g	3AB01 *	2-1/c #1/0	*33.16	0.457	179	81.8	147	5177-EF-09
3D2305/P 'g	3C23B	2-1/c #2	2.0 2.0	0.9253 .5x.9253	130 130	120 67	5900 3250	5177-265-EF-25 5177-EF-09
3D2306/A	3D06	1-2/c #12	4.88	.9028x.9	27	21.94	349	Sec. 5.2.4
3D2316/A	K3C	2-1/c #6	1.0	.5x.9253	75	39	3800	5177-EF-15
3D2328/P	4E04	2-1/c #1/0	14.15	0.9028	179	161.6	1042	Sec. 5.2.5
3D2328/Q	4E04	2-1/c #1/0	14.15	0.9028	179	161.6	1042	Sec. 5.2.5
3D2334/OP	4S77	2-1/c #2/0	13.8	0.925	204	188.7	1267	EC-129
3D2335/OP	4S75	2-1/c #750	34.85	0.9253	598	553	1486	EC-128
4AB17/1	4P9B	3-1/c #4/0	46	.8x.9253	287	212	361	5177-EF-15
4B0105/OP	4P201A	3-1/c #350	211.85	none	384		(81.3)	EC-129
4B0112/1	4B05 †	3-1/c #750	200	.9x.9028	570	473	137	5177-EF-12
4B0112/2	4B05 †	3-1/c #750	200	.9x.9028	570	473	137	5177-EF-12
4B0204/P	4V1D	3-1/c #4/0	120 155	.8x.9253 0.897	278 278	206 249.4	72 61	5177-EF-15 EC-129
4B0407/OP	4B52	3-1/c #750	94.83	0.897 0.72	598	536 423	465 346	EC-132 EC-182
4B0407/OQ	4B52	3-1/c #750	94.83	0.897 0.72	598	536 423	465 346	EC-132 EC-182
4B0606/P	MOV-4-535	1-3/c #12	1.0	0.9028	27	24	2300	Sec. 5.2.6
4B0614/A	4D02	3-1/c #4/0	104.5	0.9028	278	251	140	Sec. 5.2.7
4B0624/P	MOV-4-1418	1-3/c #10	2.63	0.5	36	18	584	EC-164
4B0639/P	MOV-4-716B	1-3/c #10	3.0	0.5	36	18	500	EC-164
4D0104/OQ	K3B	2-1/c #6	24	.6x.9253	75	44	83	5177-EF-15
4D0104/OR	K3B	2-1/c #6	24	0.9028	75	67	179	Sec. 5.2.8

REF.

SCHEME	AFFECTED DEVICE	CABLE SIZE	LOAD AMPS I_L	DERATING FACTOR	CABLE AMPS I_c	DERATED AMPS I'	MARGIN %	CALCULATION
4D0106/P	4B02	2-1/c #1/0	1.0	.6x.9253	179	106	10500	5177-EF-15
4D0107/P	3(4)C264	2-1/c #2	50	0.9028	130	117.36	135	Sec.5.2.9
4D0108/P	4B04 *	2-1/c #1/0	1.0 *17.79	.6x.9253	179	106	10500 496	5177-EF-15
4D0109/A &B	4AB01 *	2-1/c #1/0	*33.16	0.457	260	160	*382	5177-EF-01
4D0112/P	4C23B	2-1/c #2	2.0	.6x.9253	130	77	3750	5177-EF-15
4D0129/P	SV4-479B-499B	1-2/c #12	4.3	0.9028	27	21.93	410	Sec. 5.2.10
4D0133/P	4D06	1-2/c #10	6.25	0.897	36	32.29	417	EC-164
4D0147/OP	EDG4B	2-1/c #750	43.75	0.897 0.72	598	536 423	1125 867	EC-132 EC-182
4D0158/OP	3S75	2-1/c #750	34.85	0.9253	598	553	1487	EC-127

The following circuits are routed through cable tray sections and were originally evaluated based on the worst case tray ampacity derating and subsequently, the Thermo-Lag derating factor available at the time of design:

REF.	SCHEME	TRAY SECTION	CABLE SIZE	LOAD AMPS I_L	DERATING FACTOR	CABLE AMPS I_c	DERATED AMPS I'	MARGIN %	CALCULATION
	3B0204/1	3AXT10	1-2/C #12	control circuit	N/A				5177-EF-10
	3B0204/2	3AXT10	1-2/c #12	control circuit	N/A				5177-EF-10
	3B0206/1	3AXT10	3-1/c #750	200	0.774	698	540.2	170	5177-EF-10
	3B0206/2	3AXT10	3-1/c #750	200	0.774	698	540.2	170	5177-EF-10
X	3B0406/1	3AUT10	3-1/c #500	267	0.774	540	417.9	57	5177-EF-10
X	3B0406/2	3AUT10	3-1/c #500	267	0.774	540	417.9	57	5177-EF-10
X	3B0406/3	3AUT10	3-1/c #500	267	0.774	540	417.9	57	5177-EF-10
	3B0408/1	3AUT10	3-1/c #500	209	0.774	540	417.9	100	5177-EF-10
	3B0408/2	3AUT10	3-1/c #500	209	0.774	540	417.9	100	5177-EF-10

REF.

SCHEME	TRAY SECTION	CABLE SIZE	LOAD AMPS I_L	DERATING FACTOR	CABLE AMPS I_c	DERATED AMPS I'	MARGIN %	CALCULATION
3D2302/1	3AXT10	2-1/c #1/0	100 * 12.46	0.774	165	127.7	27.7 * 925	5177-EF-10
4AB21/OP	4LAT20, 30 & 40	1-1/c #1250	166	0.72	790	568	242	EC-132, EC-182
4AB21/OQ	4LAT20, 30 & 40	1-1/c #1250	166	0.72	790	568	242	EC-132, EC-182
4AB21/OR	4LAT20, 30 & 40	1-1/c #1250	166	0.72	790	568	242	EC-132, EC-182
4AD06/OP	4LAT20, 30 & 40	3-1/c #750	250	0.689	689	480 411	92 64	EC-128, EC-182
4AD06/OQ	4LAT20, 30 & 40	3-1/c #750	250	0.689	689	480 411	92 64	EC-128, EC-182
4B0202/1	4AXT10	3-1/c #4/0	spare	0.774	256.8	198.74		5177-EF-13
4B0202/2	4AXT10	3-1/c #4/0	spare	0.774	256.8	198.74		5177-EF-13
4B0202/6	4AXT10	3-1/c #4/0	spare	0.774	256.8	198.74		5177-EF-13
4B0203/1	4AXT10	3-1/c #350	spare	0.774	387.3	299.73		5177-EF-13
4B0206/1	4AXT10	3-1/c #750	200	0.774	629.4	487.09	144	5177-EF-13
4B0206/2	4AXT10	3-1/c #750	200	0.774	629.4	487.09	144	5177-EF-13
4D0106/1	4AXT10	2-1/c #1/0	5.0	0.774	126.7	98.05	1861	5177-EF-13

NOTES: * Load current tabulated from Reference 2.0.23, 2.0.24, 2.0.25 and 2.0.26.
† Load current to MCCs shown as MCC feeder breaker ampacity and not specific to any load on the MCC. For multiple feeder circuits, the breaker load rating is divided between the circuits
'g This value taken from Generic portion of calculation

Percent Margin (%) is determined by: $[(I'/ I_L) - 1] \times 100$

Conclusion:

The original design selection of power cables for use at Turkey Point Nuclear (PTN) 3 and 4 used conservatism created by the selection of cables using voltage drop and short circuit withstand capability analysis and then by evaluating worst case scenarios for cable ampacity derating based on cables in a filled tray section. In addition to the evaluation of cable sizes by design, to reduce the inventory and purchasing of new cable sizes, cables for several circuits were selected and installed as the next larger 'standard' size if that size met the design and installation requirements and was readily available on site and in the inventory system.

REF.	

Calculations which evaluated cable ampacity concluded that the derating factor (0.457) for power cables in a tray section with the maximum hypothetical tray fill and coated with Flammastic fire retardant was more conservative than the derating factor for cables in conduit with Thermo-Lag fire wrap. Calculations that evaluated ampacity loss in covered conduit also used individual derating factors independent of the vendor information. These values, which were lower and more conservative than the vendor values, were uses to verify the applicability of the cable sizing design assumptions.

Based on the results of previously issued calculations for the derating of cable ampacity, the smallest margins (17% plus derating factor of 0.9028) identified for any circuits at PTN were for those cables supplying power to Load Center 3B and 3D transformers (3X05 and 3X07). These loads are evaluated based on assuming that the circuit load is equal to the feeder breaker load rating with the breaker load being at 100% of its rating continuously. Actual loads on these power sources were evaluated in Section 5.3 based on a transformer loading study and determined to have a larger margin between the load ampacity (I_L) requirement and the allowable derated ampacity (I') for the affected circuits.

The smallest margin between derated cable ampacity (I') and load ampacity (I_L) requirements as determined by this calculation for any cable in a Thermo-Lag covered tray is 57% (with a Thermo-Lag derating factor of 0.774). For any cable in conduit with Thermo-Lag covering, the smallest margin is 55% (with a Thermo-Lag derating factor of 0.897). Therefore, as noted in the table above and comparing cable ampacity (I_C) values with the derated ampacity (I') values and the circuit ampacity load (I_L), the cables installed at Turkey Point Nuclear Units 3 and 4 were conservatively design with adequate margin to provide allowances for ampacity derating which encompass the vendor issued values of derating and for the more rigorous values that are currently being proposed.