TEST REPORT
American Electric Power Service Corp.
Canton Laboratory
P.O. Box 487 Canton, Ohio 44701

Title: AMPACITY TEST FOR POWER CABLES	Test No. CL-542 Date December 16, 1983
Test By: L.J. Balanti;J. P. McCallin Report By: L. J. Balanti Approved By: A. P. Litsky	Made For: AEPS Corp. Sponsor: W. F. Wilson - New York Test Completed: November 18, 1983

For information of AEP System employees only. AK

I. INTRODUCTION

For compliance with 10CFR50, Appendix R at the D. C. Cook Nuclear Plant, tests were conducted on power and control cables enclosed in a TSI, Inc. one-hour fire barrier system. The results of the test will be compared to computer-generated data to determine the validity of the computer model on heat run flow and cable ampacity.

II. OBJECTIVE

The test objective was to simulate as closely as possible the actual conditions of tray and conduit runs proposed for Cook Plant and determine the final conductor temperature for the specified amperage and tray fill.

III. TEST METHOD

The generalized test method consisted of:

1. Installing cables.
2. Attaching thermocouples.
3. Enclosing the TSI fire barrier system.
4. Applying the specified amperages.
5. Maintaining a constant ambient temperature of 40°C.
6. Monitoring the temperature rise and final conductor temperature.

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PS-CABLE-001
REV 0
ATTACHMENT 4
1 of 23

I. TEST METHOD (Cont'd.)

The detailed test procedure was as follows:

1. Equipment

1.1 Cable Tray and Cover

1.1.1. Cable tray was galvanized steel, expanded metal bottom; size 12" x 6" x 8'-0" Long.

1.1.2. Cable tray cover was galvanized steel, ventilated 12" wide.

1.1.3. 10'-0" Original tray length cut to 8'-0" to accommodate installation in environmental chamber.

1.1.4. Tray cover attached to tray by using #10 x 3/8" Parker-Kalon type B (Z) with "H" head.

1.2. Conduit

1.2.1. 4" I.D. Galvanized rigid steel.

1.2.2. 1" I.D. Thinwall EMT

1.2.3. Conduits cut to 8'-0" to conform with cable tray length and installation in chamber.

1.3 Fire Barrier Envelope

1.3.1. Thermo-Lag 330-1 subliming coating manufactured by TSI, Inc. for a one hour barrier. Thickness of barrier was .500" (+.125", -.000").

1.3.2. Prefabricated panels 6'-0" x 4.6".

1.3.3. Prefabricated conduit sections.

1.3.4. Steel banding.

1.4. Cables

The following cables were used for testing:

B/M Item #	Description
324	3TC #12 Cu 600 V
339	3TC #6 Al 600 V
344	3TC #4 Al 600 V
348	3TC #2 Al 600 V
3101	3TC #4 Al 5 kV shielded
3102	3TC #2 Al 5 kV shielded
3103	3TC #2/0 Al 5 kV shielded
3104	3TC #4/0 Al 5 kV shielded
3120	4/C #12 Cu 600 V.

2. Test Setup

2.1 Raceway

2.1.1. Cable tray and conduit were supported approximately 2'-6" above floor to allow for natural ventilation.

2.1.2. Raceway ends were sealed during the test with thermal insulating material to prevent heat loss through these areas.

Note:

This procedure could cause excessive heating of the cables passing through the thermal seal; therefore, all temperature readings were taken a minimum of 1'-0" from the thermal seal.

2.2 TSI One Hour Fire Barrier System

2.2.1. The tray envelope was constructed of the prefabricated panels, cut so as to fit as shown in the Appendix (see Figure #1).

2.2.2. The conduits were encased in the prefabricated sections.

2.3 Thermocouples

2.3.1. T-Type thermocouples were used to measure temperatures of the following:

A. Ambient air
B. Top and bottom of the fire barrier envelope
C. Air space in tray
D. Conductors.

2.3.2. Thermocouples were installed on the inward side of the conductor in a triplex arrangement (see Figure 2). A hole was bored in the insulation and the thermocouples were placed on the conductor.

2.3.3. Thermocouples were imbedded in Omegatherm 201 high thermal conductivity paste.

2.3.4. Thermocouples were installed in a position located on the cables in the center of the tray where:

A. Heat generation is greatest.
B. Heat dissipation is the least (see Figure 3).

2.3.5. The minimum number of thermocouples used to measure the conductor temperature was two (2) per cable circuit installed in the tray and five (5) for single cables installed in the conduit.

2.4. Cables

2.4.1. Cables were positioned in the cable tray in a single layer in such a position that there was a minimum spacing of 1/3 the diameter of the larger adjacent cable. Cables were then secured with "Ty-Raps".

3. Test Procedure

3.1 Each test consisted of installing the cables in the tray in one of six (6) configurations as specified in the test request.

3.2 Once the proper setup was attained, cables were subjected to a load of three phase, 60 Hz sinusoidal current as specified in Section 4.

3.3. Ambient temperature was set to 40°C.

3.4. Temperature rise of the cables was recorded on an Esterline Angus Model PD-2064 data acquisition system at ½-hour intervals until the cable temperatures stabilized.

3.5. The voltage and amperage of each circuit was monitored periodically throughout the test.

4. Test Configurations

4.1 Test #1

Circuit No.	Item No.	Description	Runs in Tray	Ampacity
1	324	3TC#12 Cu	7	3.8
2	324	3TC#12 Cu	3	20.0
3	348	3TC#2 Al	1	60.0
4	324	3TC#12 Cu	1	0

4.2 Test #2

Circuit No.	Item No.	Description	Runs in Tray	Ampacity
1	324	3TC#12 Cu	2	.17
2	324	3TC#12 Cu	2	.71
3	324	3TC#12 Cu	4	2.8
4	348	3TC#12 Cu	1	6.8
4	3120	4/C#12 Cu	1	6.8
5	344	3TC#4 Al	1	53.0

4.3 Test #3

Circuit No.	Item No.	Description	Runs in Tray	Ampacity
1	324	3TC#12 Cu	5	.71
2	324	3TC#12 Cu	5	2.8
3	3120	4/C#12 Cu	1	6.8
3	324	3TC#12 Cu	2	6.8
4	3120	4/C#12 Cu	2	16.0
4	324	3TC#12 Cu	2	16.0
4	339	3TC#6 Al	1	16.0
5	339	3TC#6 Al	1	36.0
5	344	3TC#4 Al	1	36.0
6	344	3TC#4 Al	1	53.0
7	348	3TC#2 Al	2	60.0
8	324	3TC#12 Cu	1	0

4.4 Test #4

Cable Size: 3TC#12 Cu 600 V.
Conduit Size: 1" I.D. EMI
Ampacity: 2 amps.

4.5 Test #5

Cable Size: 3TC#2 Al 5 kV shielded with one end grounded.
Conduit Size: 4" I.D. Galv. rigid.
Ampacity: 72 amps.

4.6 Test #6

Circuit No.	Item No.	Description	Runs in Tray	Ampacity
1	3101	3TC#4 Al Sh.	2	20
2	3102	3TC#2 Al Sh.	2	25
3	3103	3TC#2/0 Al Sh.	2	40
4	3104	3TC#4/0 Al Sh.	1	50

IV. TEST RESULTS

The complete temperature recordings are tabulated along with test comments on computer printouts and listed under data sheets in the Appendix.

The final conductor temperatures for each test are listed below:

Test No.	Cable	Ampacity (Amps)	Runs in Tray	Highest Conductor Temperature (°C)
1	3TC#12 Cu	3.8	7	45.6
	"	20.0	3	59.7
1	3TC#2 Al	60.0	1	55.7
2	3TC#12 Cu	.17	2	42.6
	"	.71	2	42.7
	"	2.8	4	45.1
	" 3TC [illegible]	6.8	1	44.4
2	4/C#12 Cu	6.8	1	43.9
2	3TC#4	53.0	1	58.3
3	3TC#12 Cu	.71	5	54.6
	"	2.8	5	57.9
	"	6.8	2	60.4
	"	16.0	2	67.3
3	4/C#12 Cu	6.8	1	55.2*
	"	16.0	2	62.7*
3	3TC#6 Al	16.0	1	57.6
	"	36.0	1	65.9*
3	3TC#4 Al	36.0	1	57.9*
	"	53.0	1	68.8
3	3TC#2 Al	60.0	2	63.7
4	3TC#12 Cu	2.0	1	42.9
5	3TC#2 Al	72.0	1	65.0
6	3TC#4 Al	20	2	45.6
6	3TC#2 Al	25	1	45.4
6	3TC#2/0 Al	40	2	45.5
6	3TC#4/0 Al	50	1	44.5

* Thermocouple installed on insulation, not conductor.

V. DISCUSSION

Due to a limited supply of variable power sources, several circuits were consolidated. In all cases, the loads were met or exceeded those that were originally requested.

As per the original request, conductors were placed in the cable tray in a single layer in such a position that there was a minimum spacing of 1/3 the diameter of the larger adjacent cable. Although this probably is not the best simulation of actual conditions, it was one criterion of the test request. During Test #3, the amount of cables made it impossible to follow this criterion. It was followed as closely as possible and the results can be viewed in the Appendix under "Photographs".

All results contained in this report were forwarded to W. F. Wilson, New York, immediately upon completion of the test. Any questions pertaining to the actual test results as compared to the computer-generated data should be directed to him.

VI. APPENDIX

A. Data sheets
B. Test setup
C. Photographs.

COMMENTS - TEST No. 1

1.) TEST 1 CL 542 11/01/83 TIME IS 4:20 A.M.
2.) START A=.785V B=.796V C=.810V, ALL 3.8 AMP
3.) START A=.732V B=.657V C=1.02V, ALL 60 AMP
4.) START A=1.17V B=1.34V C=1.19V, ALL 20 AMP
5.) CHANNEL 39= AMBIENT
6.) CHAN 2=TRAY TOP, 3=TRAY BOTTOM, 4=AIR IN TRAY
7.) CHANNEL 6,7 ARE ON 60 AMP CIRCUIT
8.) CHANNEL 5,8 ARE ON 20 AMP CIRCUIT
9.) ALL OTHER CHANNELS ON 3.8 AMP CIRCUIT
10.) CURR END A 3.9 B 3.9 C 3.9
11.) VOLT END A .870 B .845 C .867
12.) CURR END A 59.2 B 59.5 C 59.3
13.) VOLT END A .816 B .713 C 1.03
14.) CURR END A 20.4 B 20.3 C 20.2
15.) VOLT END A 1.238 B 1.410 C 1.259
16.) END TEST #1 CL-542 11/1/83

PS-CABLE-001
Rev 0
ATTACHMENT 4
8 of 23

TEST No. 1

ESTERLINE ANGUS DATA

TIME	CH#0	CH#2	CH#3	CH#4	CH#5	CH#6	CH#7	CH#8	CH#9	CH#11	CH#12
04:20	17.3	25	25.3	25.7	25.5	25.6	25.6	25.3	25.5	25.6	25.6
04:45	19.4	33.4	35	28.9	43.4	36.4	35.7	43.3	29.8	29.3	29.2
05:15	21	37.2	38.1	34.1	49.5	44.1	43.2	49.8	35.4	35	34.5
05:45	23	39	39.5	38.7	53.5	48.9	48	53.9	39.5	39	38.5
06:15	24.8	40.4	41	41.6	55.9	51.7	50.4	56.1	41.9	41.2	40.8
06:45	26.4	40.5	40.7	43.3	57.3	53.5	52.4	57.6	43.3	42.5	42.1
07:15	27.5	41.2	41.2	44.1	57.8	54.4	53.3	58.2	44.2	43.2	42.8
07:45	28.2	40.8	40.7	44.6	58.8	54.9	53.9	59.2	44.4	43.3	43.2
08:15	28.7	41.3	41.4	44.8	58.6	54.8	53.6	59	44.4	43.6	43.2
08:45	29.2	41.4	41.9	45.4	58.9	55.2	54	59.2	44.7	43.8	43.5
09:15	29.5	41.3	42.1	45.5	59.1	55	54.1	59.3	44.8	44	43.7
09:45	29.8	41.1	41.8	45.6	59.1	55.3	54.1	59.3	44.9	44.1	43.7
10:15	30	41.1	41.6	45.8	59	55.5	54.4	59.2	44.9	44.1	43.8
10:45	30.2	41.4	42.1	45.6	59.2	55.3	54.3	59.4	44.9	44.3	43.7
11:15	30.3	41.6	42.3	45.8	59.3	55.3	54.2	59.5	45	44.2	43.8
11:45	30.5	41.6	42.5	45.9	59.7	55.5	54.6	59.5	45.2	44.2	43.9
12:15	30.6	41.2	41.9	45.9	59.3	55.6	54.5	59.4	45.2	44.1	44
12:45	30.9	41.2	41.8	45.9	59.2	55.6	54.5	59.2	45.3	44	44.1
13:15	31	41.5	42.1	46	59.3	55.6	54.6	59.4	45.4	44.2	44.1
[illegible]:15	31.1	41.6	42.3	45.9	59.3	55.6	54.5	59.3	45.3	44	44.1
[illegible]4:45	31.1	41.5	42.3	45.9	59.7	55.5	54.6	59.6	45.2	44.3	43.9
15:15	31.1	41.2	41.9	45.9	59.4	55.6	54.6	59.4	45.4	44.2	44.1
15:45	31.2	41.2	41.9	46	59.5	55.7	54.5	59.5	45.4	44.2	44.1

TIME	CH#17	CH#18	CH#20	CH#25	CH#26	CH#27	CH#28	CH#36	CH#37	CH#39
04:20	25.5	25.5	25.5	25.6	25.6	25.6	25.7	25.6	25.8	24
04:45	29.2	29.8	29.2	29.4	30.2	30.1	30	29.3	30.9	37.9
05:15	34.6	35.6	34.7	35	35.9	36.1	36	34.6	37	40.8
05:45	38.6	39.5	38.7	38.9	39.9	40.1	40.2	38.4	41.1	40.4
06:15	40.6	41.4	41.1	41	42.1	42.3	42.5	40.8	43.4	40.8
06:45	42	42.6	42.2	42.4	43.2	43.4	43.9	42.1	44.8	40.2
07:15	42.6	43.1	42.9	43.1	44	44.1	44.5	42.9	45.5	41
07:45	42.9	43.5	42.9	43.1	44.4	44	44.8	43.2	45.5	40.4
08:15	42.6	43.6	43.2	43.2	44.3	44.3	44.7	43.4	45.6	41.3
08:45	43.1	43.9	43.6	43.5	44.6	44.5	45.2	43.8	45.9	40.8
09:15	43.3	43.5	43.4	43.5	44.7	44.6	45.2	43.5	46.2	40.6
09:45	43.2	43.8	43.7	43.6	44.8	44.7	45.1	43.8	46.2	40.7
10:15	43.4	43.7	43.6	43.5	44.8	44.7	45.4	43.7	46.3	40.7
10:45	43.3	43.8	43.7	43.5	44.9	44.8	45.3	43.8	46.4	41
11:15	43.3	43.8	43.7	43.7	44.8	44.7	45.2	43.8	46.3	40.9
11:45	43.5	44	43.8	43.9	44.9	44.7	45.5	44.1	46.3	40.7
12:15	43.5	43.8	43.6	43.7	44.6	44.5	45.5	43.9	46.3	40.4
12:45	43.6	43.9	43.7	43.9	44.8	44.7	45.5	43.9	46.3	40.4
[illegible]:15	43.6	43.9	43.8	43.9	44.8	44.6	45.6	43.9	46.4	40.8
[illegible]:15	43.6	43.9	43.7	43.9	44.9	44.7	45.5	43.9	46.3	40.6
14:45	43.5	44.1	44	43.9	45	44.9	45.5	44.2	46.4	40.7
15:15	43.6	43.9	43.7	43.8	44.7	44.5	45.5	43.9	46.4	40.4
15:45	43.6	43.9	43.8	44.1	44.9	44.9	45.5	44	46.3	40.4

PS-CABLE-001
Rev 0
ATTACHMENT 4
9 of 23

COMMENTS - TEST No. 2

1.) THERM#1 AMBIENT (CH#39)
2.) THERM#2 TOP TRAY
3.) THERM#3 BOTTOM TRAY
4.) THERM#4 AIR SPACE
5.) CURR START A .2 B .2 C .2
6.) VOLT START A .015 B .018 C .026
7.) CURR START A .9 B .9 C .9
8.) VOLT START A .048 B .048 C .055
9.) CURR START A 6.8 B 6.8 C 6.8
10.) VOLT START A .471 B .470 C .550
11.) CURR START A 2.8 B 2.8 C 2.8
12.) VOLT START A .309 B .337 C .306
13.) CURR START A 53.0 B 53.0 C 53.0
14.) VOLT START A 1.507 B 1.378 C .805
15.) CL-542 TEST #2 11/3/93 START 0515
16.) VOLT END A .0109 B .0147 C.0240
17.) CUR END ALL .20AMP
18.) VOLT END A .0498 B .0495 C .0569 CUR
19.) CUR END A .80 B .90 C .90
20.) VOLT END A .495 B .50 C .50
21.) VOLT END A .323 B .353 C .323
22.) CURR END ALL 2.8AMP
23.) VOLT END A 1.572 B 1.462 C .839
24.) CUR END ALL 53.0 AMPS
25.) END TEST 2 CL 542 1600 TIME
26.) CH 9,18,26,27,28,37, ON 2.8 AMP CIRCUIT
27.) CH 5,8 ON 53 AMP CIRCUIT
28.) CH 6,7 ON # 2 CABLE, 6.8 AMP CIRCUIT
29.) CH 10,12 ON 4/C CABLE, 6.8 AMP CIRCUIT
30.) CH 17,36 ON .17 AMP CIRCUIT
31.) CH 11,20,25 ON .71 AMP CIRCUIT

PS-CABLE-001
Rev 0
ATTACHMENT 4
10 OF 22

TEST No. 2

ESTERLINE ANGUS DATA

TIME	CH#0	CH#2	CH#3	CH#4	CH#5	CH#6	CH#7	CH#8	CH#9	CH#10	CH#11
05:45	29.6	28.7	32.7	21.7	35.1	21.4	21.8	34.3	22.1	23.3	22
05:15	30	33.6	36.8	29	43.6	29.6	29.1	42.8	30	30.4	30
05:45	30.2	36.4	39.4	34.2	49.4	34.5	34.6	48.9	34.9	35.6	34.7
07:15	30.5	38.3	39.8	37.6	53.1	38.2	38.4	52.2	38.3	39.8	37.9
07:45	30.8	39.4	40.9	39.7	55.3	40.5	40.7	54.1	40.2	40.5	39.8
08:15	31	40	41.2	40.9	56.3	41.9	41.9	55.5	41.1	41.6	40.9
08:45	31.2	40.4	41.7	41.8	56.9	42.8	42.8	56	41.8	42.2	41.6
09:15	31.3	40.5	41.4	42.4	57.2	43.4	43.4	56.3	42.4	42.7	42
09:45	31.3	40.5	41.2	42.5	57.6	43.4	43.6	56.5	42.6	43.2	42
10:15	31.5	40.7	41.4	42.9	57.7	43.9	43.9	55.7	42.8	43.2	42.4
10:45	31.5	40.9	41.7	42.9	57.8	43.9	43.8	56.9	42.9	43.4	42.6
11:15	31.4	41	41.9	42.9	57.7	43.9	44.1	56.9	43.1	43.4	42.5
11:45	31.4	41.1	41.9	42.9	58.2	44	44.1	57.2	42.9	43.5	42.6
12:15	31.3	40.8	41.5	43.1	58	44	44.1	56.9	43.1	43.6	42.5
12:45	31.3	40.9	41.6	43.1	58	44.1	44.1	57.1	43	43.4	42.6
13:15	31.3	41.1	42	43	58.1	44	44.1	57	43.1	43.6	42.4
13:45	31.3	41.1	42	43.2	58.1	44.2	44.4	57.1	43.2	43.7	42.6
14:45	31.1	40.8	41.4	43.3	59.1	44.4	44.3	57.1	43.2	43.6	42.7
15:15	31	41.2	42	43.2	58.3	44.1	44.3	57.1	43.2	43.7	42.7

TIME	CH#12	CH#17	CH#18	CH#20	CH#25	CH#26	CH#27	CH#29	CH#36	CH#37	CH#39
05:45	23.2	22	23.5	22.1	21.7	23.3	23.3	22.7	22.1	24.1	35.8
06:15	30.7	29.5	31.5	29.4	29.4	31.5	31.4	30.4	29.6	32.3	39.6
06:45	35.8	34.4	36.4	34.5	34.6	36.7	36.4	35.4	34.6	37.4	39.8
07:15	39	37.6	39.1	37.5	37.6	39.5	39.5	38.8	37.7	40.6	40.3
07:45	40.8	39.3	40.6	39.4	39.3	41.1	41.1	40.5	39.5	42.5	40.6
08:15	41.8	40.2	41.4	40.4	40.4	42.1	42.1	41.5	40.6	43.4	40.7
08:45	42.5	40.9	42	41.2	41.1	42.7	42.7	42.2	41.2	44.1	40.8
09:15	42.8	41.2	42.4	41.6	41.5	43.1	43.1	42.5	41.8	44.4	40.5
09:45	43.2	41.5	42.4	41.7	41.8	43.3	43	42.8	41.9	44.4	40.3
10:15	43.2	41.7	42.7	42	42	43.5	43.4	42.9	42.2	44.7	40.7
10:45	43.5	41.8	42.7	42.1	41.9	43.4	43.5	43.1	42.3	45.1	40.9
11:15	43.5	41.8	42.9	42.2	42.1	43.6	43.4	43.1	42.5	44.8	40.7
11:45	43.7	42.1	42.7	42.1	42.1	43.6	43.5	43.3	42.3	45	40.7
12:15	43.8	42	42.8	42.2	42.2	43.7	43.3	43.3	42.4	44.9	40.5
12:45	43.5	41.9	42.8	42.2	42.2	43.7	43.7	43.2	42.4	44.9	40.7
13:15	43.8	42.1	42.8	42.1	42.4	43.8	43.4	43.3	42.4	44.8	40.5
13:45	43.8	42	42.9	42.3	42.4	43.9	43.5	43.3	42.5	44.8	40.7
14:45	43.6	42	43	42.4	42.4	43.8	43.7	43.3	42.5	45.1	40.7
15:15	43.9	42.1	43	42.3	42.4	43.8	43.5	43.4	42.6	45.1	40.8

PS-CABLE-001
Rev 0
ATTACHMENT 4
11 OF 23

COMMENTS - TEST NO. 3

1.) CL 542 TEST 3 11/11/83 TIME 0545
2.) CHANNEL 39 AMBIENT
3.) CHANNEL 2 TRAY TOP
4.) CHANNEL 3 TRAY BOTTOM
5.) CHANNEL 4 TRAY AIRSPACE
6.) CHANNELS 10,12,20,32,33,34,35,38 ARE
ON THE INSULATION, NOT THE CONDUCTOR
7.) CURR START A 53.0 B 53.0 C 53.0
VOLT START A .543 B .744 C .697
8.) CURR START A 36.0 B 35.0 C 36.0
VOLT START A 1.5 B 1.45 C 1.6
9.) CURR START A 2.9 B 2.9 C 2.9
VOLT START A .396 B .399 C .426
10.) CURR START A 16.2 B 16.3 C16.1
VOLT START A 1.997 B 2.02 C 1.98
11.) CURR START A 7.0 B 6.9 C 7.0
VOLT START A .62 B .61 C.62
12.) CURR START A .9 B .8 C .8
VOLT START A .16 B .16 C .16
13.) CURR START A 56.0 B 57.3 C 55 5
VOLT START A .64 B .64 C .67
14.) .71 AMP CKT #12 CHAN'S 11,17,25
15.) 2.8 AMP CKT #12 CH'S 9,18,21,26,27,28
29,37
16.) 6.9 AMP CKT 4/C CH'S 10,12
6.8 AMP CKT #12 CH'S 30,31
17.) 16 AMP CKT #6 CH'S 22,24
16 AMP CKT 4/C CH'S 32,33
16 AMP CKT #12 CH'S 36,16
18.) 35.0 AMP CKT #4 CH'S 20,38
35.0 AMP CKT #6 CH'S 34,35
19.) 53.0 AMP CKT #4 CH'S 5,8
20.) 50.0 AMP CKT #2 CH'S 6,7
21.) CURR END A 47.4 B 52.0 C 53.7
22.) VOLT END A .548 B .692 C .712
23.) CURR END A 36.6 B 36.7 C 36.2
24.) VOLT END A 1.529 B 1.465 C 1.607
25.) CURR END A 2.9 B 2.8 C 2.9
26.) VOLT END A .416 B .414 C .441
27.) CURR END A 16.2 B 16.3 C 16.1
28.) VOLT END A 2.40 B 2.04 C 2.26
29.) CURR END A 6.7 B 6.8 C 7.0
30.) VOLT END A .594 B .620 C .627
31.) CURR END A 0.9 B 0.9 C 0.8
32.) VOLT END A .117 B .122 C .115
33.) CURR END A 55.6 B 51.8 C 55.9
34.) VOLT END A .638 B .585 C .697
35.) END OF TEST #3 CL-542 11/11/83 1425

PS-CABLE-001
Rev 0
ATTACHMENT 4
12 OF 23

TEST NO. 3

ESTERLINE ANGUS DATA

TIME	CH#0	CH#2	CH#3	CH#4	CH#5	CH#6	CH#7	CH#8	CH#9	CH#10	CH#11
05:45	29.4	22.8	23.4	24.2	24.3	24.4	24.8	24.5	24.3	24.5	24.3
06:15	29.5	31.5	34.1	27.5	40.4	35.4	35.7	40.6	30.1	29.7	29
06:45	29.5	36.6	39.7	35.5	50.9	45.2	45.5	51.5	38.8	37.7	37.1
07:15	29	39.2	41.4	42.4	57	52	52.1	58.1	44.8	44	43.3
07:45	28.9	41.1	42.7	47.7	61.4	56.6	56.7	62.2	49.2	48.5	47.5
08:15	29.1	42.6	43.8	51.2	63.8	59.4	59.4	64.9	51.8	50.9	50.2
08:45	29.5	43.6	44.7	52.9	55.5	60.9	60.9	66.3	53.5	52.7	51.8
09:15	29.9	43.7	44.5	54.2	66.7	62.1	62.1	67.6	54.5	53.5	52.6
09:45	30.2	44.2	45	55	67.6	63	62.8	68.4	55	53.7	53.3
10:15	30.4	44.3	44.8	55.4	67.9	63.4	63.4	68.8	55.4	54	53.7
10:45	30.7	44.4	44.9	55.5	68.4	63.7	63.6	69	55.5	54.3	53.8
11:15	30.7	44.5	45.3	55.8	67.9	63.4	63.4	68.7	55.7	54.4	53.8
11:45	30.8	44.5	45.2	55.6	67.6	63.1	63.1	68.3	55.6	54.5	53.9
12:15	30.8	44.5	45.1	55.7	67.5	63	63.1	68.4	55.5	54.5	53.9
12:45	30.8	44.8	45.6	55.7	67.6	63.3	63.3	68.4	55.6	54.5	54
13:15	30.6	44.3	44.8	55.7	67.1	62.9	63.1	68.2	55.6	54.5	53.7
13:45	30.4	44.6	45.1	55.8	67	62.9	63	68.1	55.6	54.5	53.8

TIME	CH#12	CH#16	CH#17	CH#18	CH#20	CH#21	CH#22	CH#24	CH#25	CH#26	CH#27
05:45	24.4	24.5	24.3	24.5	24.5	24.4	24.3	24.4	24.3	24.4	24.3
06:15	29.8	36.7	29.3	29.3	32.9	31.1	31.8	31.7	30.2	29.4	29.2
06:45	38	45.4	35.9	39.7	41	40.5	41.4	41.2	38.3	38.7	38.7
07:15	44.3	51.8	41.4	45.2	46.9	46.8	48	47.7	44.4	45.5	45.5
07:45	48.9	56	45.3	49.7	51.2	51.3	52.1	51.9	48.4	49.8	49.7
08:15	51.3	58.4	47.6	52.3	53.5	53.9	54.1	53.6	51	52.5	52.3
08:45	53.3	60	49.2	53.7	55	55.5	55.9	55.1	52.7	54	54.1
09:15	54	60.8	49.7	54.6	55.6	56.3	56.4	55.6	53.3	55.1	54.7
09:45	54.4	60.2	50.8	55.2	56.9	57.2	56.3	55.8	53.9	55.5	55.5
10:15	54.6	60.5	50.9	55.5	57.2	57.3	56.5	55.8	54	55.8	55.5
10:45	55	61	51	55.6	57.3	57.6	56.7	56.2	54.5	56	56
11:15	55.2	61.1	51.2	55.5	57.4	57.7	56.9	56.3	54.6	56	56
11:45	55	61	51.2	55.6	57.5	57.4	56.8	56.2	54.5	56.1	55.8
12:15	55.1	60.9	51.3	55.6	57.5	57.4	57	56.1	54.6	56.1	55.8
12:45	55.2	61.2	51.2	55.6	57.5	57.5	56.9	56.3	54.5	56	55.9
13:15	55.1	60.8	51.2	55.4	57.3	57.4	56.7	56.2	54.5	55.9	55.8
13:45	55.2	60.8	51.3	55.4	57.4	57.3	56.7	56.2	54.5	55.8	55.7

PS-CABLE-001
Rev 0
ATTACHMENT 4
13 OF 23

CL-542

TEST NO. 3

TIME	CH#28	CH#29	CH#30	CH#31	CH#32	CH#33	CH#34	CH#35	CH#36	CH#37	CH#38
05:45	24.4	24.1	24.5	24.4	24	24.7	[illegible]	24.2	24.8	24.3	24.6
06:15	29.7	29.6	32.9	32.1	35	37.1	39.5	39.6	41.2	31.2	32.9
06:45	39	39.1	42.5	41.4	45.8	47.3	49.5	48.9	51.9	41.2	41
07:15	45.9	46	49.2	47.7	51.9	54.1	55.2	55.5	58.1	47.8	47.1
07:45	50.4	50.5	53.9	51.8	55.5	58.1	59.2	59.5	62.4	51.9	51
08:15	53.7	53.2	56.7	53.9	57.4	60.4	61.1	61.6	64.9	54.3	53.6
08:45	55.1	54.8	58.4	55	58.6	61.5	62.4	63.2	66.5	56.1	55.3
09:15	56.1	55.7	59.2	55.8	59.1	62.7	62.9	63.6	67.5	56.8	55.8
09:45	56.7	56.1	59.7	55.6	58	61.5	64.2	65.3	66.7	57.5	57.2
10:15	56.9	55.5	60.1	55.6	58	61.9	64.5	65.3	67	57.6	57.4
10:45	57.2	56.7	60.4	56	58.2	62	64.8	65.7	67.3	58.1	57.8
11:15	57.2	56.7	60.3	56.1	58.5	62.1	64.9	65.9	67.2	58.1	57.5
11:45	57.1	56.8	60.3	56	58.3	62.1	64.9	65.8	67.1	57.9	57.9
12:15	57.2	56.8	60.3	55.9	58.4	62.2	64.7	65.7	67.3	57.8	58
12:45	57	56.7	60.3	56.1	58.4	62.2	64.9	65.7	67.1	57.9	57.8
13:15	57	56.6	60.2	56.1	58.2	62	64.7	65.6	66.9	57.8	57.8
13:45	57	56.5	60.1	56.2	59.4	62	64.8	65.7	65.7	57.7	57.6

TIME	CH#39
05:45	23.5
06:15	36.6
06:45	40.3
07:15	40.4
07:45	40.5
08:15	40.7
08:45	40.7
09:15	40.7
09:45	40.7
10:15	40.7
10:45	40.8
11:15	40.8
11:45	40.9
12:15	41.1
12:45	41
13:15	40.9
13:45	41

PS-CABLE-001
Rev 0
ATTACHMENT 4
14 OF 23

TEST NO. 4

ESTERLINE ANGUS DATA

TIME	CH#0	CH#1	CH#2	CH#3	CH#4	CH#5	CH#6	CH#7	CH#8	CH#9
08:00	22.1	36.5	35.2	39.4	28.2	27.5	30.1	26.8	27.2	23.4
08:30	23.8	38.3	37.1	38.4	35.4	35	35.4	35.3	34.7	38.3
09:00	25.3	36.3	36.8	37.8	37.1	37	37.1	35.7	35.9	35.6
09:30	26.6	39.1	38.8	39.7	37.9	38	37.9	37.4	37.8	36.4
10:00	27.6	39.5	39.3	40.1	39.4	39.5	39.7	39.1	39.1	35.7
10:30	28.6	39.8	39.9	40.5	40.2	40.3	40.4	40.1	40.2	36.5
11:00	29.2	39.9	39.9	40.6	40.4	40.8	40.5	40.2	40.5	37..8
11:30	29.6	39.8	40.2	41.1	40.6	40.7	40.5	40.1	40.5	62.8
12:00	30	40	40.5	41.5	40.4	41	40.7	40.5	40.6	
12:30	30.3	40	40.7	41.9	40.8	41	41.2	40.1	40.8	40.5
13:00	30.4	40.1	40	40.5	40.8	41	42.9	40	40.9	38.4
13:30	30.6	40.1	40.3	41	41	41.1	40.9	41.7	40.9	39.1
14:00	30.7	40.2	40.8	41.7	40.9	40.9	41.1	40.2	41.1	38.7
14:30	30.7	39.9	40.3	41.7	40.5	41.1	40.9	40.6	40.9	35.7

COMMENTS

1.) TEST 4
2.) VOLT START A 119.5 B 119.4 C 121.8
3.) CURR START A 2.0 B 2.0 C 2.0
4.) CHAN 9 INVALID   CL 542 TEST 4
5.) CURR FINISH A 2.0 B 2.0 C 2.0

PS-CABLE-001
REV 0
ATTACHMENT 4
15 OF 23

TEST NO. 5

ESTERLINE ANGUS DATA

TIME	CH#0	CH#1	CH#2	CH#3	CH#4	CH#6	CH#7	CH#9	CH#10	CH#11	CH#12
07:54	19.2	36.7	32.3	35.6	27.7	30.1	32.3	29.8	30.2	31.7	29.3
08:15	20.2	39.1	34.7	37.1	32.5	35.5	38.6	35.2	35.7	37.4	34.6
08:45	21.9	39.7	37	38.7	38.5	42.2	45.9	41.8	42.6	44.5	41.5
09:15	23.4	39.6	38.4	39.7	42.9	47.4	51.1	46.7	48.1	50	46.8
09:45	24.8	39.7	39.3	40.4	46.2	50.7	55.2	50.6	52.2	54.2	50.8
10:15	25.8	40.1	40.2	40.8	48.4	53.5	58.1	53.5	54.8	56.9	53.5
10:45	26.8	40	41	41.5	50.4	55.3	59.9	55.3	57	58.7	55.4
11:15	27.8	40	41.3	42	51.8	56.5	61.9	56.4	58.2	50.4	56.8
11:45	28.6	39.9	41.5	42.4	52.7	57.8	63.1	57.4	59.2	60.9	57.8
12:15	29.2	40	41.8	42.5	53.3	58.6	63.3	58.3	60.2	62	58.5
12:45	29.6	39.8	41.7	41.9	53.7	59.1	63.8	58.6	60.5	62	58.9
13:15	29.8	39.8	41.4	41.7	53.9	59.2	64.5	58.8	50.9	52.8	59.4
13:45	30.1	39.7	41.7	42	53.9	59.5	64.3	58.9	50.9	52.4	59.5
14:15	30.4	39.9	42	42.5	54	59.7	64.4	58.9	60.9	52.4	59.5
14:45	30.7	39.9	42.2	42.7	54.4	59.9	64.8	59.1	51.2	52.7	59.6
15:15	30.9	39.6	41.6	41.9	54.3	60	64.8	59.3	51.2	62.8	59.7
15:45	31.1	40	42	42.1	54.5	60.3	65	59.5	61.5	63.3	59.9

COMMENTS

1.) TEST 5 CL-542 10/20/83 0730
2.) VOLT START A .589 B .844 C .611
3.) CURR START A 72.0 B 72.0 C 72.0
4.) CHNL 12 ON OUTSIDE INSULATION
5.) 1-AMBIENT 2-TOP CONDUIT
6.) 3-BOTTOM CONDUIT 4-AIR SPACE
7.) VOLT FINISH A .631 B :997 C :657
8.) CURR FINISH A 72.0 B 72.1 C 71.9
9.) END TEST 5 CL 542 10/20/83 1545

PS-CABLE-001
REV 0
ATTACHMENT 4
16 OF 23

COMMENTS - TEST NO. 6

1.) CL-542 TEST 6 2ND RUN 11/18 0515
2.) CHANNEL 39 AMBIENT
3.) CHANNEL 2 TRAY TOP
4.) CHANNEL 3 TRAY BOTTOM
5.) CHANNEL 4 AIR SPACE
6.) 20 AMP CKT CHANNELS 9, 12
7.) 25 AMP CKT CHANNELS 8, 10
8.) 40 AMP CKT CHANNELS 5, 7
9.) 50 AMP CKT CHANNELS 16, 20, 36
10.) CURR START A 20.3 B 20.4 C 20.3
11.) VOLT START A .746 B .769 C .786
12.) CURR START A 25.4 B 25.0 C 25.1
13.) VOLT START A 1.260 B 1.256 C 1.597
14.) CURR START A 40.3 B 40.0 C 40.3
15.) VOLT START A .226 B .214 C .245
16.) CURR START A 50.0 B 50.0 C 50.0
17.) VOLT START A .204 B .208 C .187
18.) END TEST 6 2ND 11/18/83 TIME 1545
19.) CURR END A 20.5 B 21.5 C 21.1
VOLT END A .796 B .836 C .837
20.) CURR END A 25.4 B 25.3 C 25.2
VOLT END A 1.315 B 1.397 C 1.265
21.) CURR END A 41. B 40.4 C 43.9
VOLT END A .240 B .225 C .256
22.) CURR END A 50.8 B 49.8 C50.4
VOLT END A .227 B.211 C.278

PS-CABLE-001
Rev 0
ATTACHMENT 4
17 OF 23

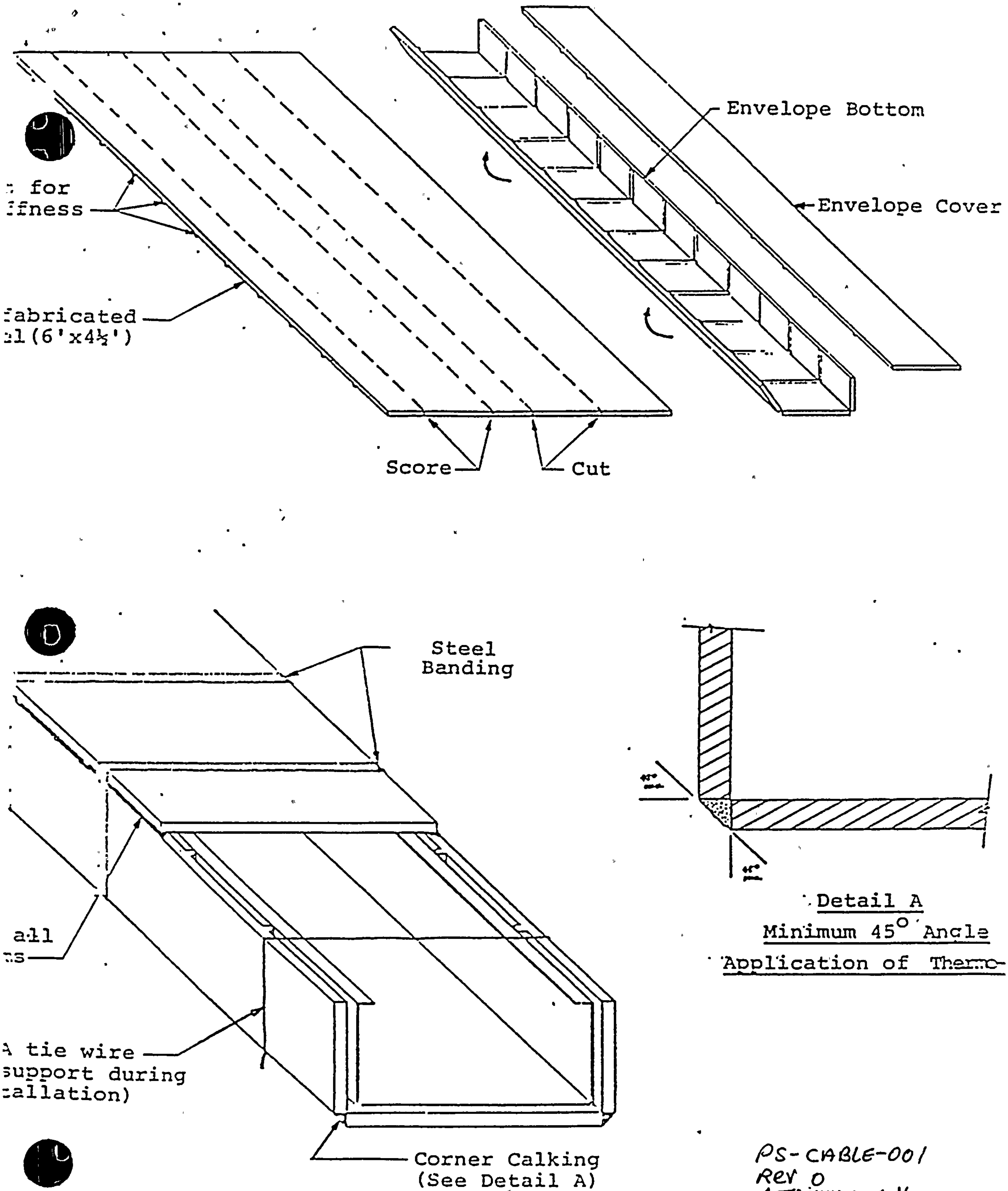
TEST No. 6

ESTERLINE ANGUS DATA

TIME	CH#2	CH#3	CH#4	CH#5	CH#7	CH#8	CH#9	CH#10	CH#12	CH#16	CH#20
05:15	21.5	23.9	25	25.2	25.3	24.9	25.3	25.6	25.5	25.3	25.6
05:45	37.7	35	25.7	26.9	27.1	26.5	27.3	27.1	27.4	26.7	26.7
06:15	39.7	39	28.8	29.9	30.1	29.8	30.3	29.7	30.2	29.6	29.6
06:45	39.8	39.8	32.3	32.5	32.9	33.1	33	32.7	33.3	32.8	32.6
07:15	40.2	39.6	34.5	35.3	35.6	35.8	36	35.1	35.7	35.7	35.4
07:45	40.6	40.1	36.5	37.4	37.8	37.9	37.8	37.4	37.9	37.7	37.3
08:15	40.7	40.4	38.1	39.2	39.7	39.4	39.6	39.1	39.4	39.2	39.4
08:45	39.4	40.2	39.4	40.6	41	41.1	40.9	40.7	41	40.4	40.5
09:15	39.3	40.7	40.2	41.9	42.2	41.8	42.3	41.6	41.8	41.5	41.5
09:45	40.1	41.3	41.1	42.8	43.1	42.4	43	42.4	42.5	42.1	42.3
10:15	40.9	41.5	41.8	43.3	43.4	43.2	43.4	43.3	43.4	42.5	42.7
10:45	40.2	41.2	42.2	43.6	43.8	43.4	44	43.7	43.7	42.9	43.2
11:15	39.2	41.1	42.4	44.1	44.1	43.5	44.4	43.9	44.2	43.1	43.5
11:45	40.1	41.6	42.7	44.5	44.6	43.8	44.8	44.3	44.5	43.5	43.8
12:15	40.9	41.8	43.1	44.8	44.8	44.1	45.1	44.6	44.8	43.5	44
12:45	40.3	41.6	43.2	45.2	45.1	44.2	45.2	44.6	44.9	43.9	44.2
13:15	39.4	41.2	43.3	44.9	44.9	44.4	45.2	45	45.1	43.8	44.2
13:45	40	41.5	43.4	45.3	45.1	44.5	45.5	45	45.2	43.9	44.3
14:45	39.1	41.7	43.6	45.4	45.2	44.6	45.4	45.3	45.5	44.1	44.4
15:15	40.1	41.6	43.5	45.4	45	44.5	45.6	45.4	45.5	44.1	44.4
15:45	39.7	41.5	43.5	45.5	45.3	44.6	45.6	45.2	45.5	44.3	44.5

TIME	CH#36	CH#39
05:15	25.5	24.5
05:45	26.7	36.7
06:15	29.8	39.5
06:45	32.7	39.9
07:15	35.4	40.2
07:45	37.3	40.3
08:15	39.3	40.2
08:45	40.5	40.2
09:15	41.4	40.5
09:45	42.1	40.6
10:15	42.7	40.7
10:45	43.2	40.1
11:15	43.4	40.2
11:45	43.7	40.5
12:15	43.9	40.5
12:45	44	40.5
13:15	44.2	40.4
13:45	44.3	40.5
14:45	44.4	40.4
15:15	44.4	40.7
15:45	44.2	40.5

PS-CABLE-001
Rev 0
ATTACHMENT 4
18 OF 23



PS-CABLE-001
REV 0
ATTACHMENT 4
19 OF 23

FIGURE 1

Typical Cable Tray Envelope Assembly

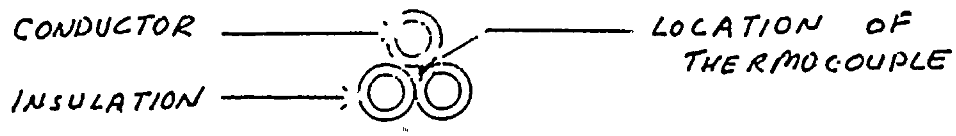


FIGURE 2

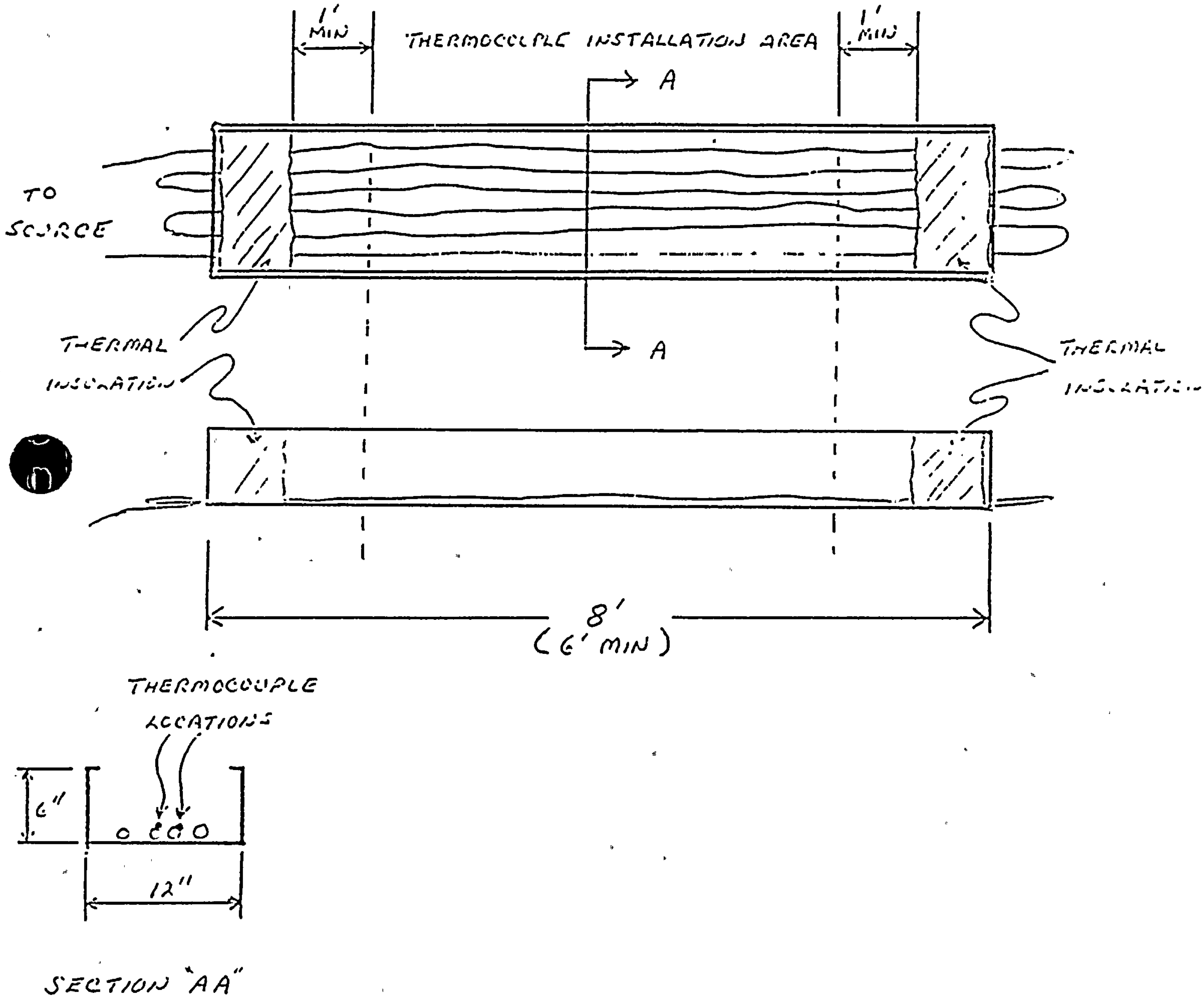
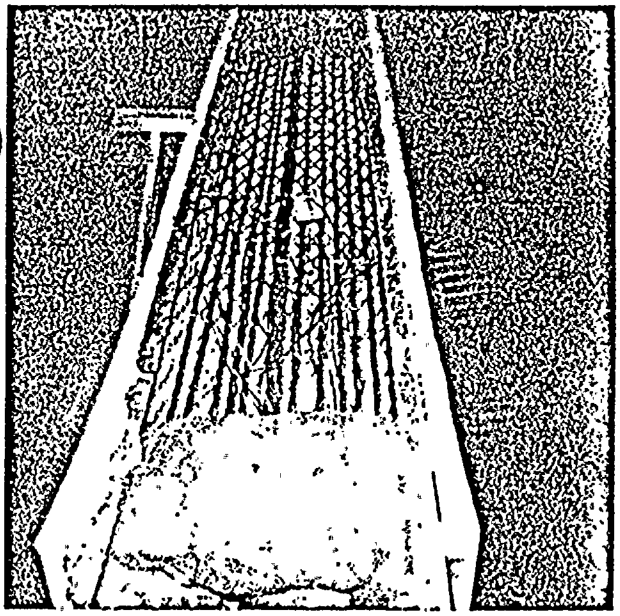
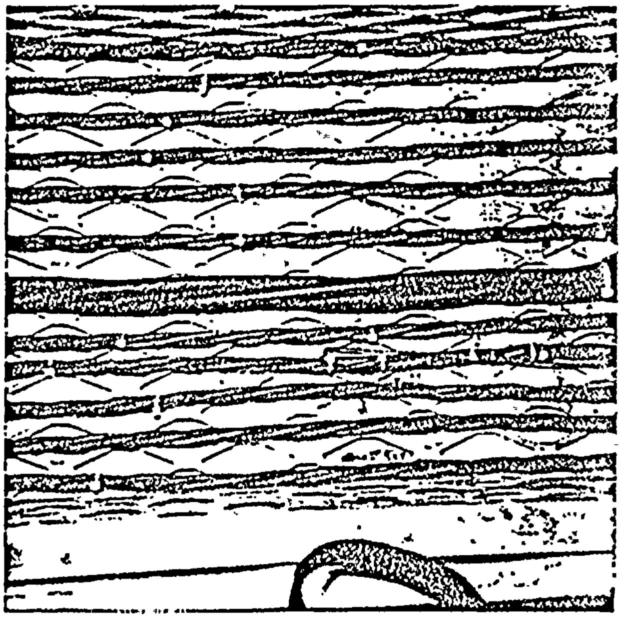


FIGURE 3

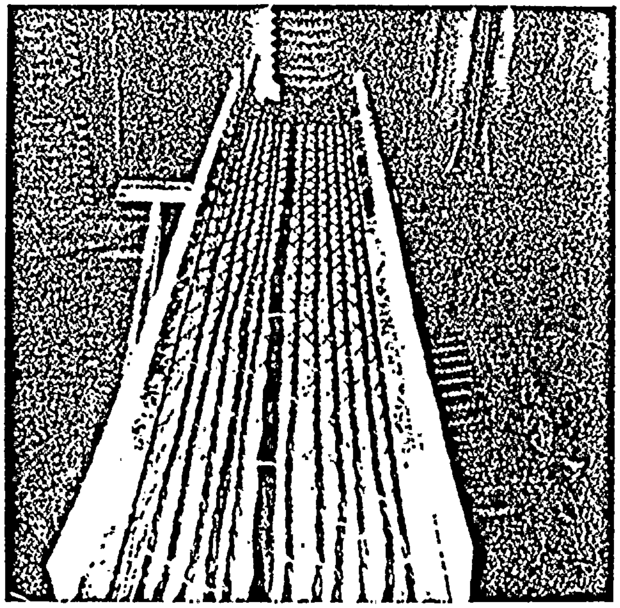
PS-CABLE-001
REV 0
ATTACHMENT 4
20 OF 23



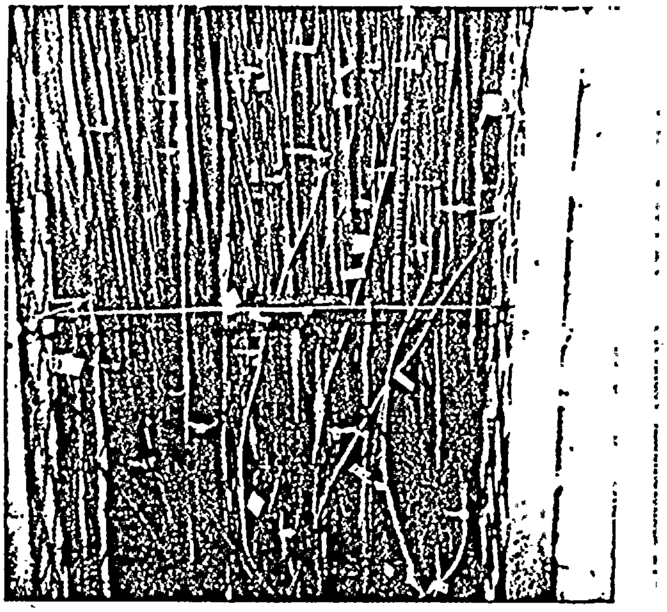
TRAY AIR SPACE



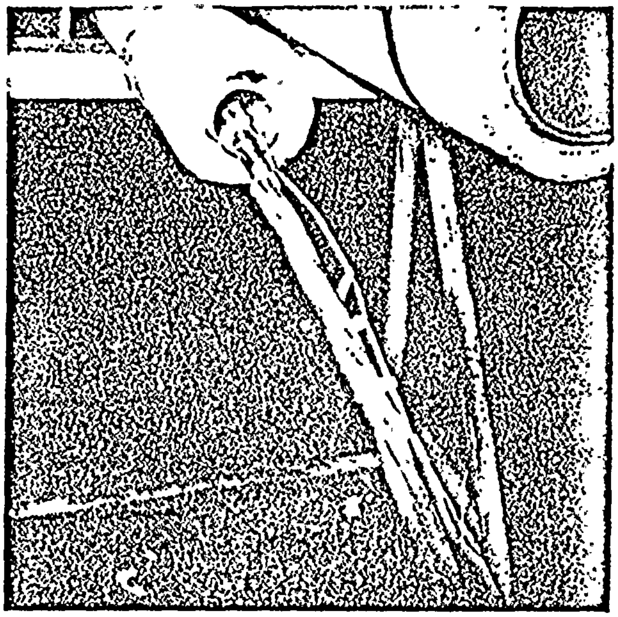
TEST #1



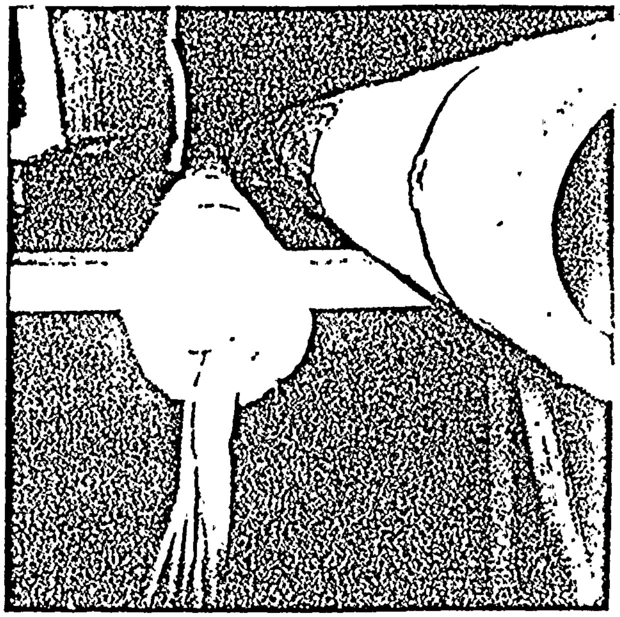
TEST #1



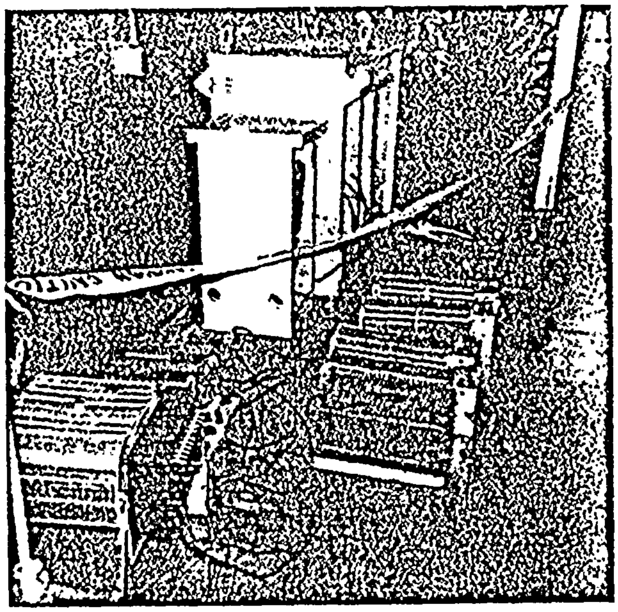
TEST #3



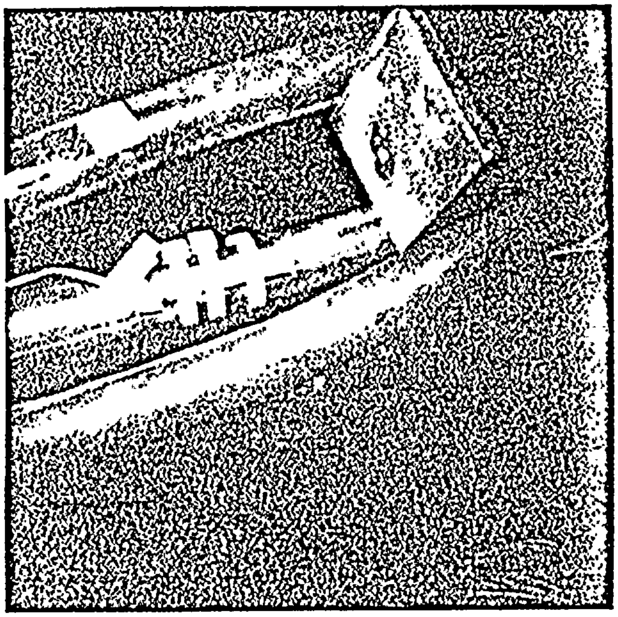
TEST #4



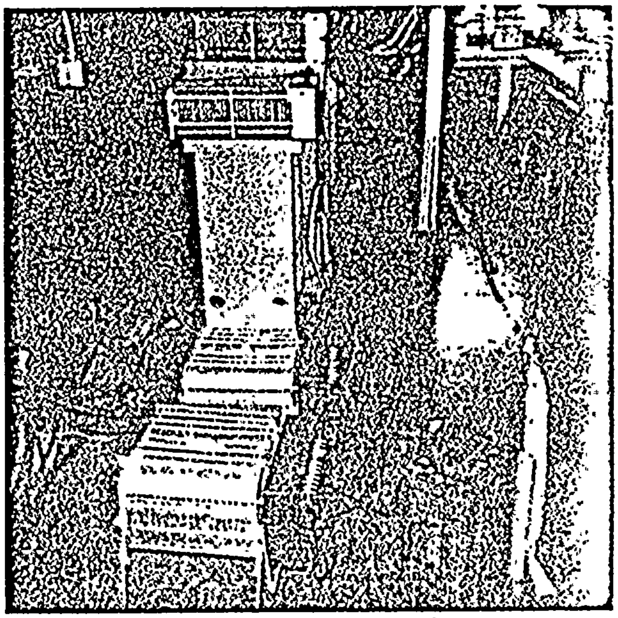
TEST #4



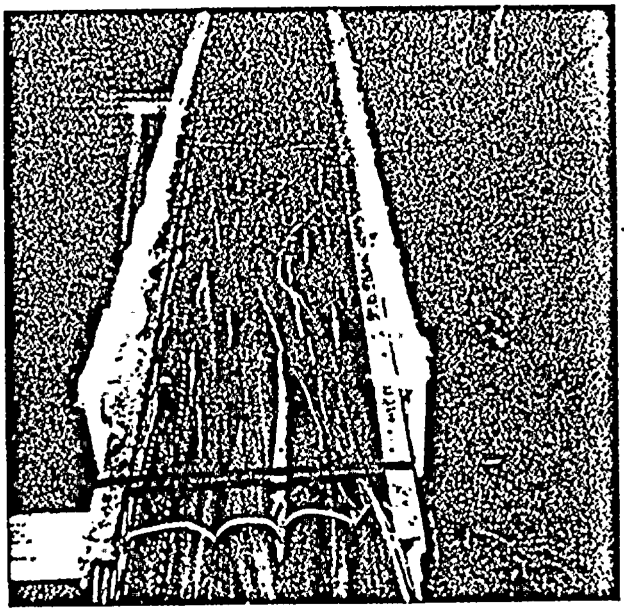
TEST #4
POWER SOURCES



TEST #5



TEST #5
POWER SOURCES



TEST #6

EN-015 (1/97)

DONALD C. COOK NUCLEAR PLANT

NEID Functional Area

VERIFICATION CHECKLIST - CALCULATIONS

Calculation Number PS-CABLE-001 Rev. 0

John Kutyo
Signature of Verifier

10/23/97
Date

1.0 Were the inputs/data sources correctly selected, incorporated and documented into the calculation? Yes ✓ N/A ___

Basis: THESE WERE IDENTIFIED IN BOTH REFERENCE + ATTACHMENT SECTIONS. THESE WERE REVIEWED BY THE VERIFIER TO CHECK THE INPUTS AND TO VERIFY THAT THE INPUTS/SOURCES WERE CORRECT AND ALSO TO COMPARE TO THE CALCULATION OUTPUTS.

2.0 Are assumptions necessary to perform the calculation adequately described and reasonable? Yes ✓ N/A ___

Basis: (PAGE 2) ONLY ONE ASSUMPTION "ALL CABLES ARE CARRYING THEIR RESPECTIVE RATED AMPACITY". IT IS ACCEPTABLE FOR THIS CALCULATION BUT ALSO SHOWN THAT IT IS CONSERVATIVE WITH RESPECT TO THE COOK PLANT CABLES.

3.0 Are the applicable codes, standards and regulatory requirements identified and requirements for design met? Yes ✓ N/A ___

Basis: PER REVIEW OF THE LISTED REFERENCES AND ATTACHMENTS IDENTIFIED IN THE CALCULATION.

4.0 Was an appropriate design method used? Yes ✓ N/A ___

Basis: WITH RESPECT TO THE MODEL, THIS WAS AN ACCEPTABLE METHOD TO GENERATE THE CORRECTION FACTORS FOR THE COOK PLANT TRAY CONFIGURATIONS. THE TU 32% IS A TEST RESULT MOST ACCEPTED BY THE INDUSTRY.

5.0 Is the output reasonable compared to input? Yes ✓ N/A ___

Basis: THIS IS BASED ON THE REVIEW OF THE CALCULATION AND "HAND" CALCULATING THE CORRECTION FACTORS. THE "HAND" CALCULATING IS DOCUMENTED IN THE ATTACHED SHEETS OF THIS VERIFICATION.

6.0 Are the results numerically correct? Yes ✓ N/A ___

Basis: BASED ON RANDOMLY "HAND" CALCULATING THE CORRECTION FACTORS. ALSO RANDOMLY CHECKED ALL ATTACHMENT TABLE COLUMNS.

ATTACHMENT 5
CAL. PS-CABLE-001 REV0
DES. VERIF. SH 1 OF 4

In addition to the verification checklist (Page 1), the following additional information documents the verification effort for calculation PS-CABLE-001, Revision 0.

For the identified cable trays at Cook Plant, it was necessary to predict correction factors for fills greater than those described in IPCEA-P-46-426 (up to 6 horizontal cables) so the appropriate conservative correction factor could be applied to the actual fill configuration. A mathematical model was developed which represents the correction factors identified in IPCEA-P-46-426. MATHCAD was used to calibrate this model with the results being equal to the correction factors in the IPCEA standard and to calculate the correction factors for fill quantities greater than the IPCEA standard maximum value of 6.

Per the calculation procedure 227200-STG-5400-02, if a computer program is used the requirements of 800000-LTG-7100-02 shall be met. Per review of section 2.2 of 800000-LTG-7100-02, software not identified for production purposes (e.g. one time calculation) is exempt from requirements in 800000-LTG-5400-08 and 800000-LTG-7100-02. Calculation PS-CABLE-001, Revision 0, documents the review of the ampacity derating for installed cables, for historical purposes, to closeout the Thermo-Lag issue. In the opinion of the independent verifier, this is a one time calculation which is exempt from procedure 800000-LTG-5400-08 and 800000-LTG-7100-02 as explained above.

The following minimum requirements, per 800000-LTG-7100-02, do apply to this software. Validation of the software shall be performed and independently reviewed. Also the program listing, verification and independent review shall be treated as a QA record. Validation of the software will be done by alternative hand calculation as shown in the following pages. The program listing , verification with review will be made a part of this calculation, which is a record. Quality Assurance (QA) was contacted and the use of this software for this calculation was discussed. QA concurred with this independent verifier's opinion to treat this use of software as a one time calculation.

The computer listing is a hard copy of the logic steps/commands of how the computer program operates (runs). The purpose of the program listing is to enable the computer program to be recreated and/or run at some future date. In the case of MATHCAD, there really is no official "program listing" because MATHCAD is a mathematical "number cruncher". Therefore , no computer listing is included in calculation PS-CABLE-001, Revision 0. However, attachment 2 is a copy of the input screen for MATHCAD. This input screen identifies the version of MATHCAD, mathematical model, and specific directions to replicate the correction factors as documented in the calculation.

The MATHCAD program was used to develop an equation to "prĕdict" correction factors for fills >6 cables horizontaly. The mathematical model was generated using the following data from IPCEA-P-46-426 table VII:

# CABLES	ADJACENT CABLES(t)	DERATING
1	0	1
2	1	0.93
3	2	0.87
4	3	0.84
5	4	0.83
6	5	0.82

The equation MATHCAD generated to "fit" these points is:

$$mf(t)= 0.8+0.129\ e^{(-t/1.974)}+ 0.073\ e^{(-t/1.991)}$$

Where t is a number of cables directly adjacent to the cable of concern.

The validation of MATHCAD was verified by plugging in any of the number pair above.

$$mf(2)= 0.8+0.129\ e^{(-2/1.974)}+ 0.073\ e^{(-2/1.991)}$$
$$= 0.8 + 0.047 + 0.027= 0.874$$

$$mf(3)= 0.8+0.129\ e^{(-3/1.974)}+ 0.073\ e^{(-3/1.991)}$$
$$= 0.8 + 0.028 + 0.016= 0.844$$

$$mf(5)= 0.8+0.129\ e^{(-5/1.974)}+ 0.073\ e^{(-5/1.991)}$$
$$= 0.8 + 0.010 + 0.006= 0.816$$

$$mf(12)= 0.8+0.129\ e^{(-12/1.974)}+ 0.073\ e^{(-12/1.991)}$$
$$= 0.8 + 0.000 + 0.000= 0.8$$

$$mf(20)= 0.8+0.129\ e^{(-20/1.974)}+ 0.073\ e^{(-20/1.991)}$$
$$= 0.8 + 0.000 + 0.000= 0.8$$

In section 4.0 of the calculation, the ampacity for 3TC # 6 Al cable is adjusted for 130°C (short time rating) in accordance with IPCEA-P-46-426 equation 5 as indicated below:

I'= I √ (Tc'-Ta)/ (Tc-Ta)*(228.1+Tc)/(228.1+Tc')

Where I'= Ampacity @ 130°C

I= Open Air Ampacity @ 90°C= 69 Amps

Tc'= Conductor Temperature @ 130°C

Tc = Conductor Temperature @ 90°C

I'=69 √ (130-40/ (90-40)*(228.1+90/(228.1+130)

I'=69 √ (90/ 50)*(318.1/(358.1)
=87.25 Amps.

In attachment 3, Table 3 through 8 the actual watts are calculated using following equation:

Actual watts = $\sum^n 3\ n\ I^2 R_{ac}$

Note : 3 is used for 3TC cable.