TU ELECTRIC

Log # TXX-92466
File # 10010
909.5

September 24, 1992

William J. Cahill, Jr.
Group Vice President

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION (CPSES)
DOCKET NOS. 50-445 AND 50-446
CONFIRMATORY TESTING OF THERMO LAG
FIRE BARRIER SYSTEM AT CPSES

REF: 1) TU Electric letter logged TXX-92429 from William J. Cahill, Jr. to NRC dated September 8, 1992.

Gentlemen:

During a teleconference with your staff on September 22, 1992, TU Electric verbally provided details regarding the methodology of upcoming Thermo-Lag Barrier Fire Endurance Testing. During this teleconference your staff requested a description of subjects discussed, and clarification of information provided previously via reference 1 and/or verbal discussions. The teleconference subjects of discussion are briefly discussed below, with details for specific attributes enclosed for your review and approval.

A. Test Configuration

TU Electric will perform fire endurance tests on 6 raceway configurations (also referred to as test schemes) during the upcoming tests. These schemes are described below:

a) Scheme #9; consists of 3 conduits as follows:

(i) A 3/4 inch diameter conduit including the radial bend will be protected with a 1/2 inch (nominal) thick prefabricated Thermo-Lag section with 1/4 inch (nominal) thick prefabricated overlay sections of Thermo-Lag material. Material thickness will be increased on radial bends with stress skin and trowel grade material as specified in site specifications. At the lateral bend enclosure (LBD box) the Thermo-Lag joints are reinforced with stress skin and trowel grade material.

(ii) A 3 inch diameter conduit protected with 1/2 inch (nominal) thick prefabricated Thermo-Lag material. At the LBD box the joints are reinforced with stress skin and trowel grade material. On the

D029 1/1

radial bend the Thermo-Lag material has been increased with stress skin and trowel grade build up as specified in site specifications.

(iii) A 5 inch diameter conduit protected with 1/2 inch (nominal) thick prefabricated Thermo-Lag material. At the LBD box the Thermo-Lag joints are reinforced with stress skin and trowel grade Thermo-Lag material. On the radial bends the Thermo-Lag material will be increased using stress skin and trowel grade Thermo-Lag material as specified in site specifications.

b) Scheme #10; consists of two 3 inch diameter conduits, with two typical junction box configurations and LBD boxes.

(i) The conduit section are protected with 1/2 inch (nominal) thick sections of prefabricated Thermo-Lag material.

(ii) Joints at the LBD boxes and junction boxes have been reinforced with stress skin and trowel grade Thermo-Lag material.

(iii) The junction boxes are protected with two layers of 1/2 inch thick (nominal) board. The inside layer is a "flat" board and the outside layer is a "ribbed" board on top of the flat board.

c) Scheme #11; consists of a 24"x4" ladder back cable tray and three conduit sections with air drop configurations.

(i) Protection of the conduits is consistent with the methods described above in scheme #9 and scheme #10.

(ii) Cable air drop bundles are protected with Thermo-Lag 330-660 "Flexiblanket" material. Three layers of "Flexiblanket" will be applied for cable bundles less than or equal to 2 inch diameter; and two layers will be applied for cable bundles greater than 2 inch diameter.

(iii) The cable tray is protected with 1/2 inch (nominal) thick Thermo-Lag board sections with ribs. Vertical and bottom butt joints will be reinforced with tie wires and a layer of stress skin with trowel grade Thermo-Lag will be used for build up of the Thermo-Lag material. The longitudinal joints will be reinforced with stress skin and trowel grade Thermo-Lag material.

d) Scheme #12; consists of a 12"x4" ladder back tray with a tee configuration. Thermo-Lag for this configuration is consistent with the technique for cable tray described in scheme #11 above.

e) Scheme #13; consists of 12"x4" ladder back cable (straight run) tray with 90 degree bends. Thermo-Lag installation for this configuration is consistent with the techniques described in cable tray scheme #11.

f) Scheme #14; consists of a 30"x4" ladder back (straight run) with 90 degree bends. Thermo-Lag installation for this configuration is consistent with the techniques described in scheme #11 above.

All supports in the test schemes are protected with Thermo-Lag, for a distance of 9 inches from the raceway protective envelopes. The remainder of the support assemblies will be unprotected (exposed). Sketches for these configurations are provided as enclosure "A". A matrix of Unit 2 raceway commodities with corresponding qualification test is provided as enclosure "B".

B. Test Attributes

Thermo-Lag materials are cured for 30 days prior to the fire endurance test (previously described in reference 1).

a) A pre-test insulation resistance (megger) reading is taken for all cables in the test assembly. Details of the insulation resistance measurement is provided in enclosure "C" of this letter. Compliance with the acceptance criteria will be documented.

b) The fire endurance test will then be conducted. The test articles will be exposed to the standard time temperature curve of ASTM E-119 for 1 hour. Circuit continuity and cable temperature will be monitored and recorded during the test. The acceptance criteria includes circuit integrity and cable temperature. Circuit integrity will be monitored throughout the test. Details of circuit integrity were provided in reference 1. Cable temperatures are to be maintained below 325°F as measured by thermocouples installed on cables close to the inside of the protective envelope; at six inch intervals. Compliance with the acceptance criteria will be documented. The acceptance criteria is described in enclosure "D".

c) A hose spray test will be conducted, using the guidance of BTP CMEB 9.5.1 and IEEE Std. 634-1978 for penetration seals previously described in reference 1.

d) A post-test insulation resistance reading will be taken following the hose test for all cables as described in enclosure "C" and item B.a above.

e) A visual inspection of the Thermo-Lag material will be performed to identify any areas of burnback and burnthrough. Details of the criteria for this inspection are provided in enclosure "D". Refer to the decision flow chart in enclosure "E".

f) The test assemblies will then be disassembled and all cables will be visually inspected for abnormalities. Enclosure F describes the inspection/verification sub-attributes for visual assessment of cable.

These sub-attributes have been conservatively derived from CPSES installation/fabrication specifications and site approved procedures. Compliance with the acceptance criteria will be documented.

When a test configuration meets the acceptance criteria described above, the configuration is considered qualified as a 1 hour barrier at CPSES. If one or more of the criteria are not met, TU Electric will decide whether it is appropriate to retest or perform an engineering analysis to accept the unsatisfactory condition. If TU Electric accepts an unsatisfactory condition via an engineering analysis, they will obtain NRC review and concurrence of the engineering analysis prior to declaring the tested configuration acceptable. Refer to enclosure "E" for decision flow chart.

C. Transient Temperature Response

Additionally, your staff requested a calculation to be performed on transient temperature response. TU Electric performed a "for information only" calculation which is provided in enclosure "G".

Should you have any questions or require additional information please contact Obaid Bhatty at extension (817) 897-5839.

Sincerely,

William J. Cahill, Jr.

William J. Cahill, Jr.

By: Roger D. Walker

Roger D. Walker
Manager of Regulatory Affairs
for NEO

OB/tg

Enclosures

c - Mr. J. L. Milhoan, Region IV
Mr. B. E. Holian, NRR
Resident Inspectors, CPSES (2)

ENCLOSURES TO TXX-92466

ENCLOSURE A: TEST SCHEME SKETCHES

ENCLOSURE B: COMMODITY/CONFIGURATION MATRIX

ENCLOSURE C: TEST METHOD INSULATION RESISTANCE MEASUREMENT

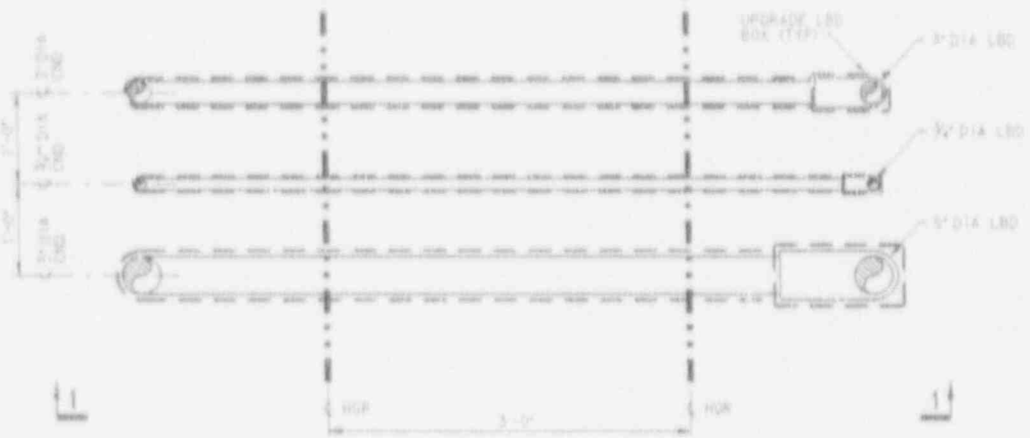
ENCLOSURE D: ACCEPTANCE CRITERIA

ENCLOSURE E: TEST ACCEPTANCE METHODOLOGY FLOW CHART

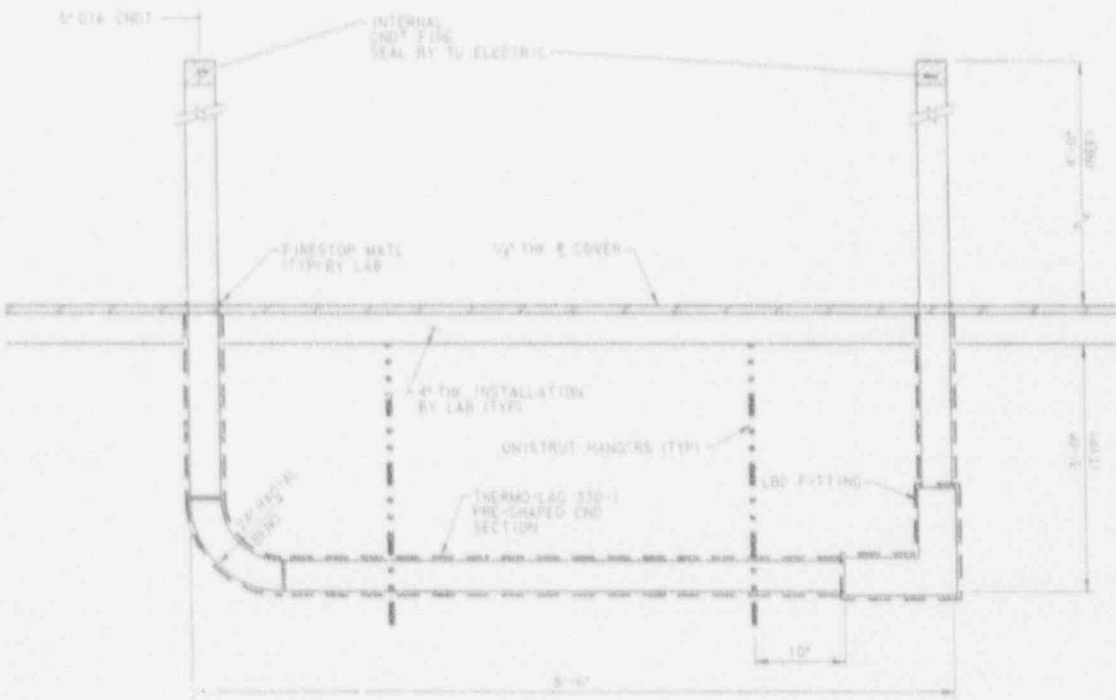
ENCLOSURE F: VISUAL ASSESSMENT OF CABLE

ENCLOSURE G: TRANSIENT TEMPERATURE RESPONSE CALC.

SCHEME #9
CONDUIT W/RAD BEND



PLAN VIEW



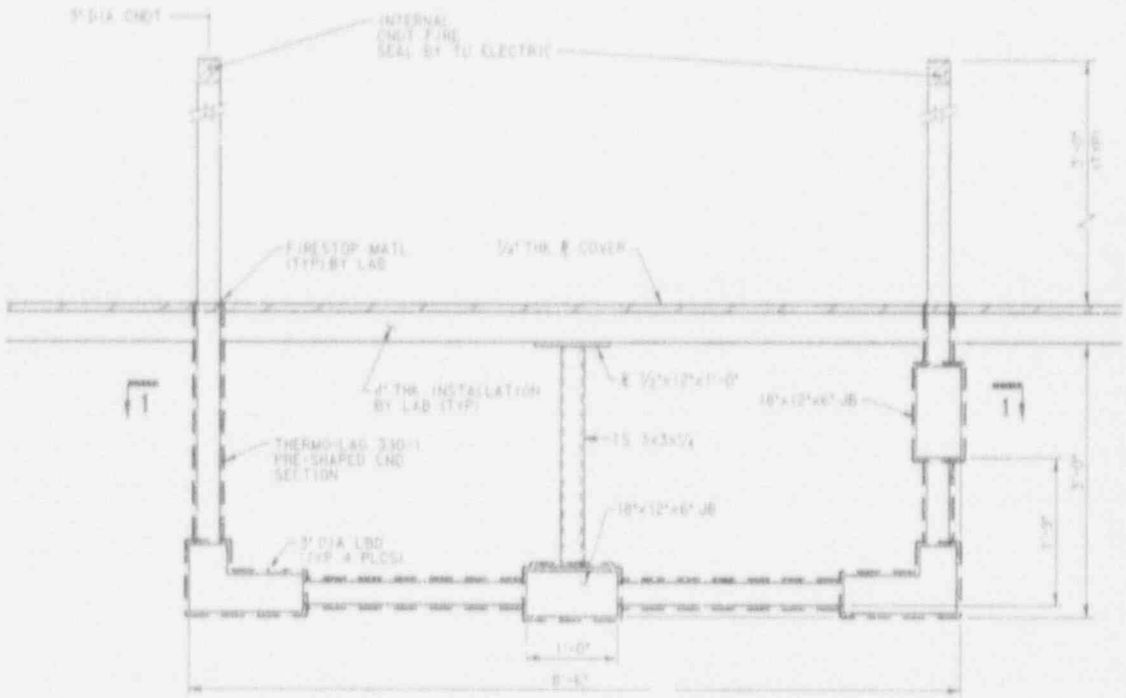
ELEVATION 1-1

TU ELECTRIC
CPSES
GLEN ROSE, TEXAS

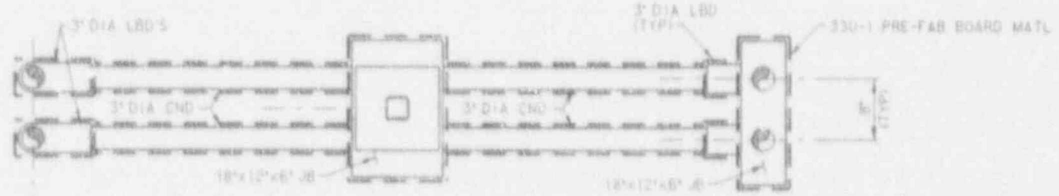
FIRE TEST ASSEMBLY

TLAS0005.DGN

SCHEME #10
3" CONDUIT W/JUNCTION BOX
(NTS)



ELEVATION

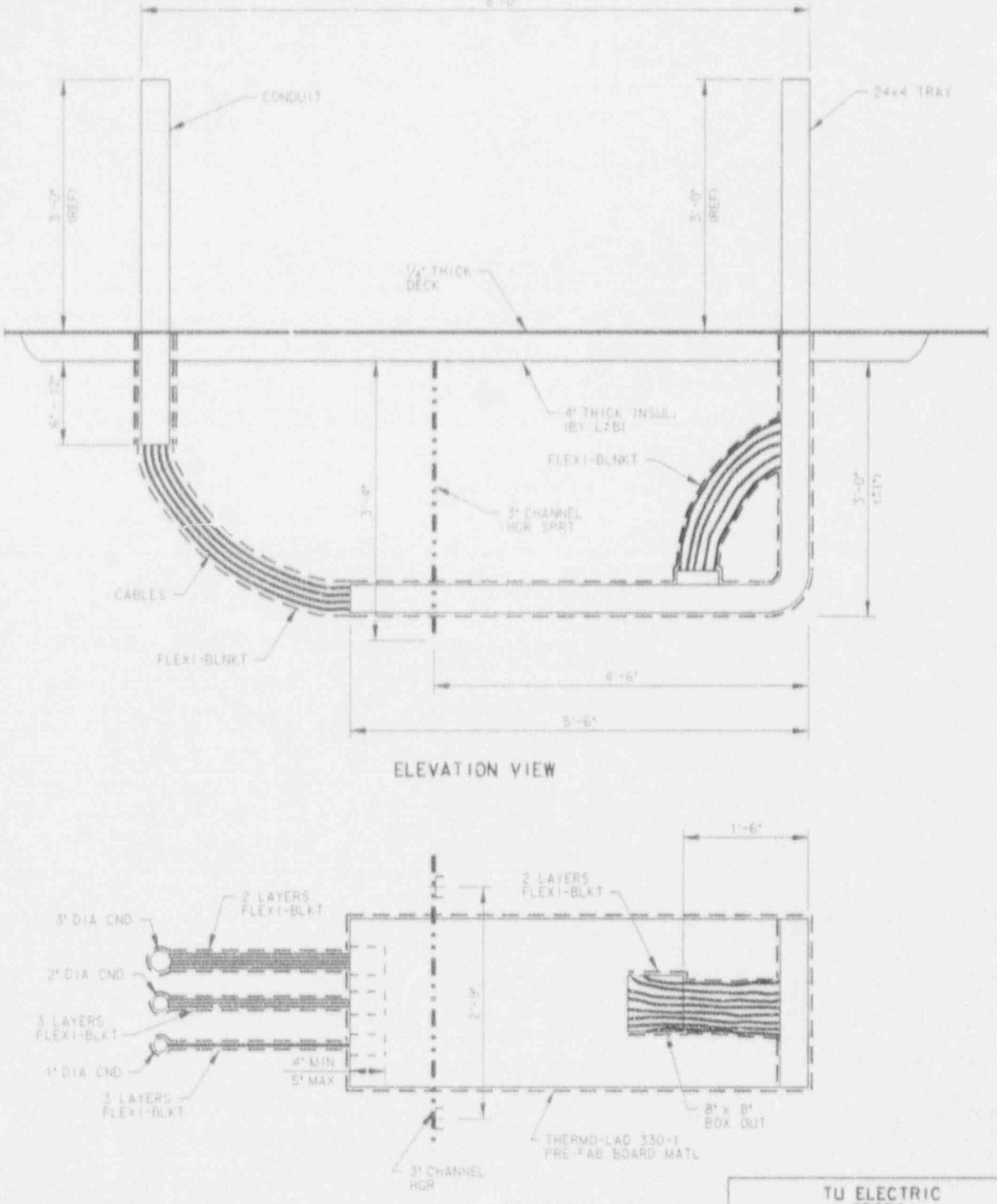


SECTION 1-1

TU ELECTRIC CPSES GLEN ROSE, TEXAS
FIRE TEST ASSEMBLY
DWG. NO. / SH. NO. / REV.

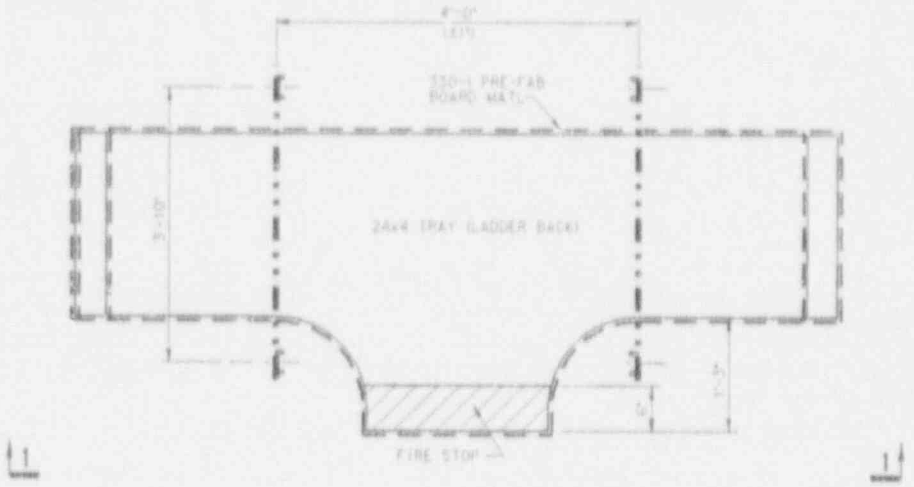
TLA00005.IDN

SCHEME #11 24" CABLE TRAY WITH AIR DROP CABLE

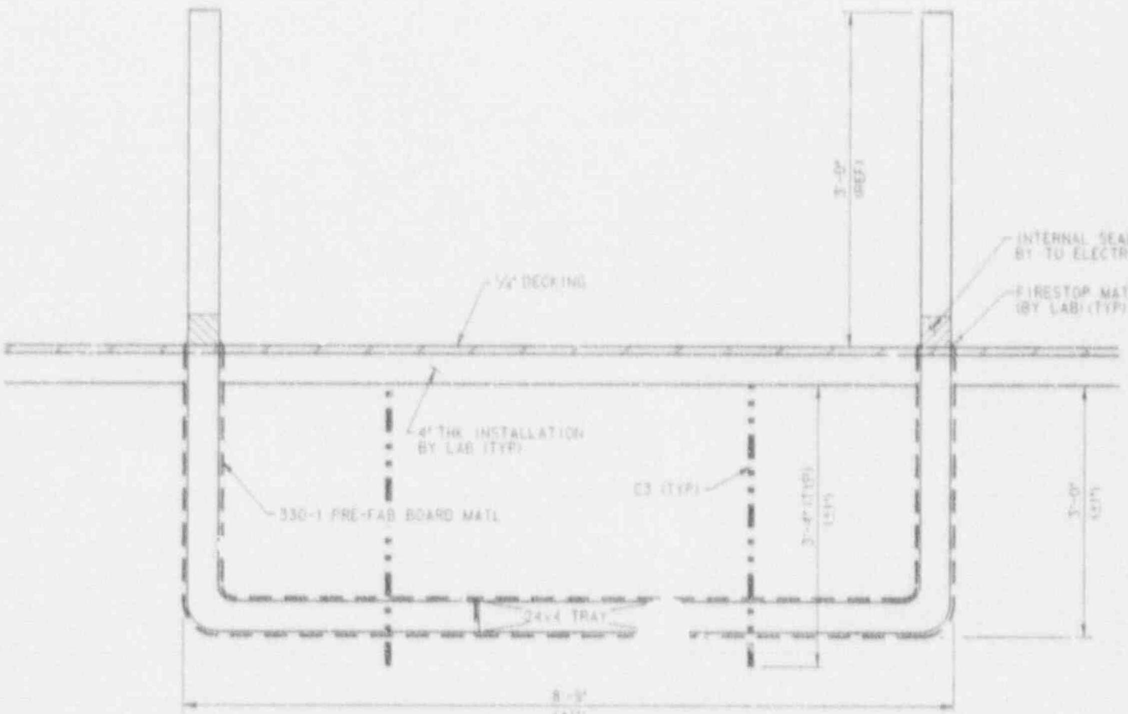


TU ELECTRIC CPSES GLEN ROSE, TEXAS
FIRE TEST ASSEMBLY

SCHEME *12
CPSES 24" CABLE TRAY W/TEE
TEST SPECIMEN ASSEMBLY (NTS)



PLAN VIEW



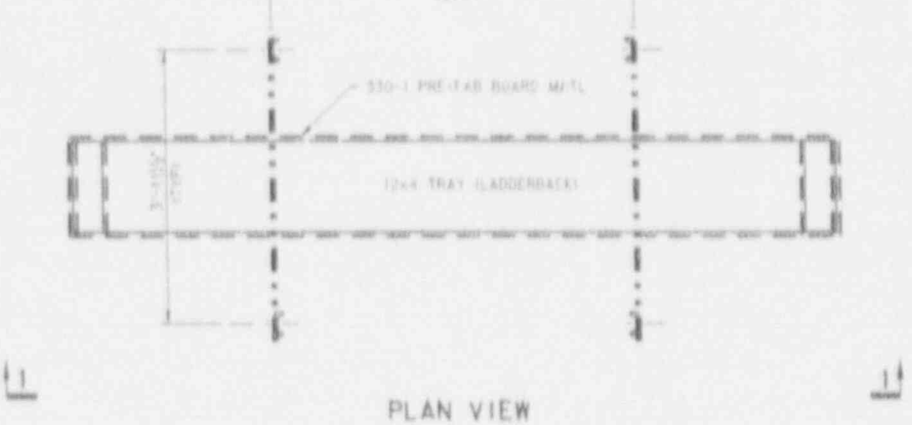
ELEVATION 1-1

TU ELECTRIC
CPSES
GLEN ROSE, TEXAS

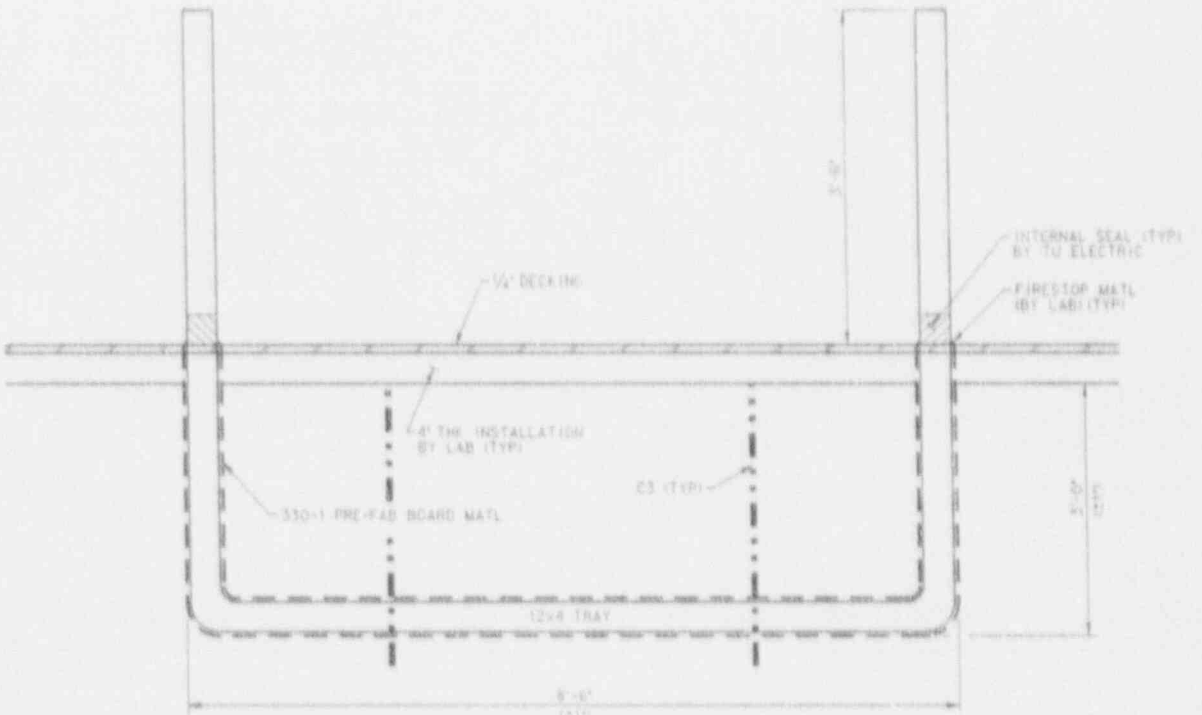
FIRE TEST ASSEMBLY

DWG. NO.	SH. NO.	REV.

SCHEME #13
CPSES 12" CABLE TRAY W/O TEE
TEST SPECIMEN ASSEMBLY (NTS)



PLAN VIEW



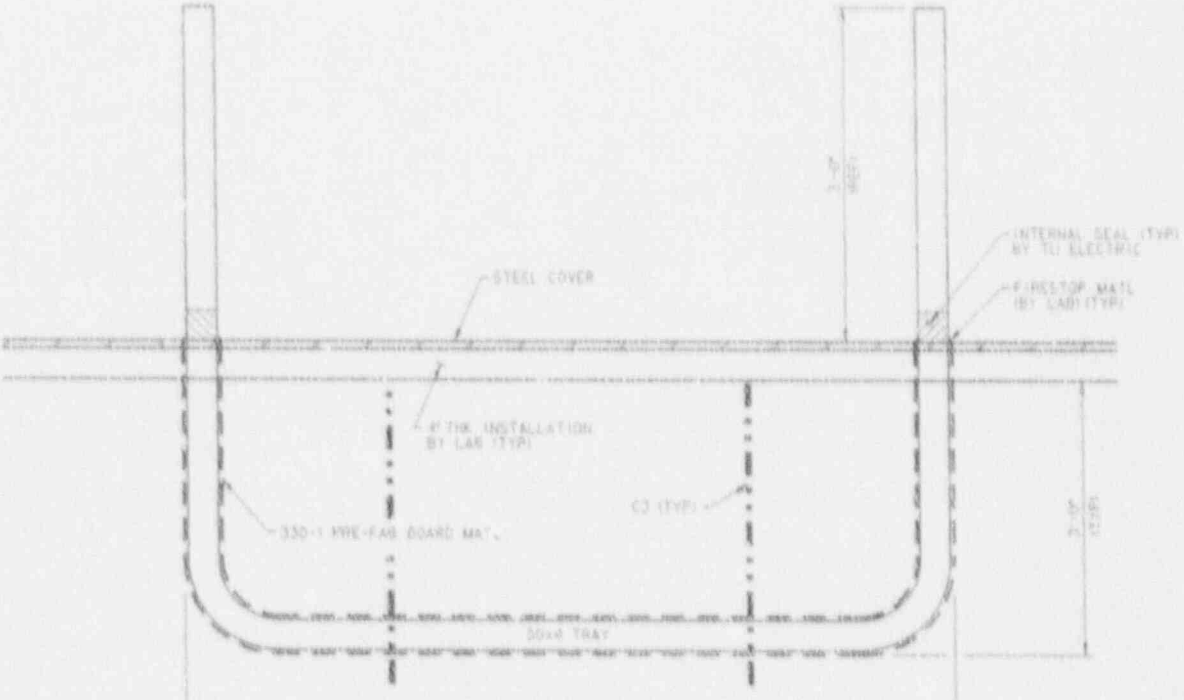
ELEVATION 1-1

TU ELECTRIC CPSES GLEN ROSE, TEXAS
FIRE TEST ASSEMBLY
DWG. NO. / SH. NO. / REV.

TLAG00005.40N

SCHEME #14
CPSES 30" CABLE TRAY W/O TEE
TEST SPECIMEN ASSEMBLY (NTS)

PLAN VIEW



ELEVATION 1-1

TU ELECTRIC CPSES GLEN ROSE, TEXAS
FIRE TEST ASSEMBLY

TLA00005.SCN

COMMODITY / CONFIGURATION / TEST SCHEME MATRIX

Commodity	Configuration	Tested (yes/No)	Qualifying Test Scheme No.	Thermolag Configuration	Notes:
Conduit	3/4" φ	Yes	9, (7) (See Note 7)	See Note (1)	(1). 1/2" φ (Nominal) Thick Sections with 1/4"(nominal) thick overlay sections •Joints Reinforced on Lateral Bend Enclosure (LB Boxes) •Material Thickness increased on Radial Bends using 1/2" (nominal) overlay sections •Material Thickness increased on Radial Bend with stress skin/trowel grade Buildup (2). 1/2" (Nominal) Thick Sections •Joints Reinforced on Lateral Bend Enclosures (LB Boxes) •Material Thickness increased on Radial Bend with stress skin/trowel grade Buildup (3). Bounded by 3/4" φ & 3" φ Qualifying Test (4). Bounded By 3" φ & 5" φ Qualifying Test (5). Bounded By Air Drop Qualifying Test (6). 2 Layers of 1/2" (nominal) Thick Board (inside Flat & outside Ribbed). •Joints Reinforced with stress skin & trowel grade buildup (7). Supportive Test Providing additional design information. (Indicated in parenthesis)
	1" φ	No (See Note 3)	9	See Note (1)	
	1 1/2" φ	No (See Note 3)	9	See Note (1)	
	2" φ	No (See Note 3)	9	See Note (1)	
	3" φ	Yes	10, 9, (7) (See Note 7)	See Note (2)	
	4" φ	No (See Note 4)	9	See Note (2)	
	5" φ	Yes	9, (2) (See Note 2 & 7)	See Note (2)	
Lateral Bend Fitting	"BOX" 3/4" φ - 5" φ	Yes	9, 10	Joints Reinforced with Stress Skin & Trowel Grade Buildup	
Radial Bend	3/4" φ - 5" φ	Yes	9	See Note (1 & 2)	
J-Boxes	All Sizes	Yes	10, (2) (See Note 7)	See Note (6)	
Structural Supports	All	Yes	9, 10, (7)	Unprotected Supports	
Air Drops	All Sizes	Yes	11	< 2" φ 3 Layers "Flexiblanket" > 2" φ 2 Layers "Flexiblanket"	
Flex Conduit	3/4" φ - 5" φ	No (See Note 5)	11	Same as Air Drop	

MATRIX-CONTINUED

Commodity	Configuration	Tested Yes/No	Qualifying Test Scheme No.	Thermolag Configuration	NOTES:
Cable Tray	12"	Yes	(1), 3, 13 See note (4)	See Note (1)	(1). 1/2" (Nominal) Board Sections with ribs • Tie Wire & Stress Skin with trowel grade buildup on bottom & vertical butt joints • Stress skin with trowel grade buildup on longitudinal joints. (2) Bounded by 12" & 24" Qualifying Test (3) Also Bounded by 24" & 36" Qualifying Test (4) Supporting Test Providing additional design information (indicated in parenthesis)
	18"	No	(1), 12, 13 (See Note 2 & 4)	See Note (1)	
	24"	Yes	(1), 12 (See Note 4)	See Note (1)	
	30"	Yes	(1), 12, 14 (See Note (3 & 4)	See Note (1)	
	36"	Yes	1	Butt Joints Reinforced With Tie wire, Longitudinal Joints Reinforced with stress skin & trowel Grade buildup	
Structural supports		Yes	(6) (8), 12, 13, 14 (See Note 4)	Unprotected supports	

TEST METHOD
INSULATION RESISTANCE MEASUREMENT

THERMO-LAG FIRE TEST

1. The insulation resistance of each conductor will be measured using a 500 V dc megohmeter. Each conductor will be measured in accordance with IEEE 690 as follows:

    a) For multiple conductor cables, each conductor insulation will be measured against all other conductors with the conductors connected to ground. The tray and conduit will also be connected to ground.

    b) For shielded cables, each conductor insulation will measured against all other conductors and the shield with the conductors and the shield grounded. The tray and conduit will also be connected to ground.

    c) For single conductor cable, the conductor insulation will be measured against the conduit/tray connected to ground.

2. All measurements will be expressed in ohms or M ohms. Test equipment will be furnished by CPSES and calibrated in accordance with site procedures. The equipment will be recalibrated after the test.

3. Insulation Resistance measurement will be made on the cable at the following times:

    a) After the cable has been installed in the raceway.

    b) Immediately after the hose stream portion of the fire test.

4. Acceptable Insulation Resistance is 100/L M ohms. Where L is the length of cable in the test with a nominal length of 20 feet, the acceptable megger length is 5 M ohms.

5. The Insulation Resistance acceptance value is based on the most sensitive circuits, which are instrument loops. Circuit requirements to avoid instrument errors is a minimum of 1 M ohms. This is an absolute value regardless of cable length. The maximum field cable engulfed in fire (and enclosed in thermo-lag) is taken as 100 ft.

CHECK LIST
CABLE INSULATION RESISTANCE MEASUREMENT

SPECIMEN NUMBER			
CABLE MARK NUMBER			
SPECIMEN LENGTH- L, FT[2]			
	READING M-OHMS	ACCEPTANCE M-OHMS	COMPLIANCE YES/NO
PRE-TEST IR VALUE:			
COND 1			
COND 2			
COND 3			
COND 4			
COND 5			
COND 6			
POST TEST IR VALUE:			
COND 1			
COND 2			
COND 3			
COND 4			
COND 5			
COND 6			
COND 7			

NOTES:

1. **ACCEPTANCE** = 100/L M ohms, The acceptance value is based on the most sensitive circuits, which are instrument loops; circuit requirements to avoid instrument errors is 1 M ohms (absolute); maximum field cable engulfed in fire is 100 ft.

2. L = length of specimen inside test enclosure only

ACCEPTANCE CRITERIA
TEMPERATURE

The thermocouples will be located as close as possible to the inside of the protective envelope. The acceptance criteria utilized shall be maintenance of cable temperatures below 325°F as measured by thermocouples installed on cables at six (6) inch intervals.

BURNBACK/BURNTHROUGH
VISUAL INSPECTION

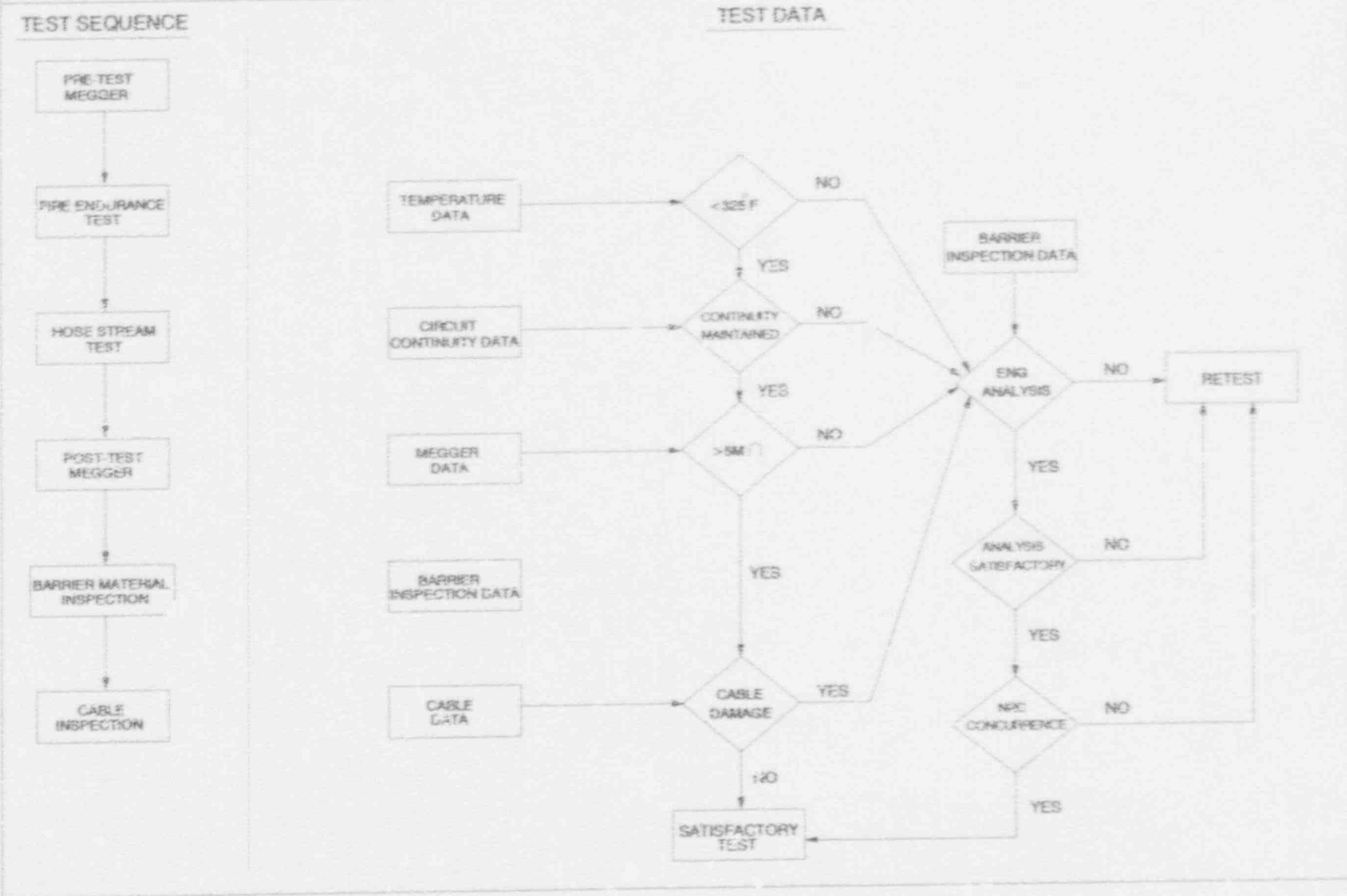
1. No burnback is defined as loss of the protective material the edges or corners in excess of the joint overlap.

   Burnback is caused by the sacrificial properties of the Thermo-Lag. At a corner or an edge, the inner layer of stress skin on the overlapping panel is exposed to the fire, and the Thermo-Lag may burn away from the stress skin. Since the Thermo-lag fire barrier is not penetrated, there is no passage of flame or hot gasses into the interior enclosure, and the cables are not affected.

2. No burnthrough is defined as no exposure of the innermost layer of stress skin greater than one-half square inch (no Thermo-lag 330-1 remains on the stress skin) or no line of sight opening into the envelope for Flexi-Blanket 660 greater than one-half square inch.

   Any hole smaller than one-half square inch would not allow the passage of flame or hot gasses into the interior enclosure because the sublimation of the surrounding Thermo-Lag causing a cooling effect. This cooling effect was exhibited even on large joint failures in recent tests and delayed the effects of the opening into the enclosure on the cables (the slow rise in cable temperature after the barrier was breached).

FIRE ENDURANCE TEST ACCEPTANCE METHODOLOGY



CHECK LIST
VISUAL ASSESSMENT OF CABLE
POST FIRE TEST

Attribute	Yes/No	Remarks
Speciman Number	NA	
Cable Mark Number	NA	
Jacket Swelling		
Jacket Splitting		
Jacket Discoloration		
Shield Exposed		
Jacket Hardening		

ACCEPTANCE CRITERIA IS THAT NONE OF THE ATTRIBUTES ABOVE ARE IDENTIFIED.

Comments:____
____
____
____

Figure 7.4

CALCULATION CONTINUATION SHEET

CALC. NUMBER:

REV. NUMBER:

PAGE NUMBER:

OBJECTIVE

1. DETERMINE TEMPERATURE RESPONSE AS A FUNCTION OF DISTANCE AT THE SURFACE OF A SEVEN CONDUCTOR 0.6 INCH DIAMETER CABLE WHEN EXPOSED TO A HEAT SOURCE OF 800°F OVER A 1 1/2 INCH CIRCUMFERENTIAL SPAN.

2. REVIEW THERMOLAG TEST FOR A CASE WHERE THERMOLAG DID NOT BREACH, IN ORDER TO OBSERVE HEAT TRANSFER PATTERNS AND PREDICT TEMPERATURE GRADIENTS.

3. THIS OBJECTIVE IS THE SAME AS OBJECTIVE 1 BUT WITH A 500°F HEAT SOURCE.

FOR INFORMATION ONLY

Figure 7.4

CALCULATION CONTINUATION SHEET

CALC. NUMBER:

REV. NUMBER:

PAGE NUMBER:

REFERENCES

1. HEAT TRANSFER THIRD EDITION ALAN J CHAPMAN

2. HEATING 6 (HEAT ENGINEERING AND TRANSFER IN NINE GEOMETRIES) COMPUTER PROGRAM. A MULTIDIMENSIONAL HEAT CONDUCTION ANALYSIS WITH THE FINITE DIFFERENCE FORMULATION. (Design Verified 9 7-89) OAK RIDGE NATIONAL LABORATORY

3. Fundamentals of Heat and Mass Transfer Second Edition F. P. INCROPERA, DAVID P. DEWITT

Figure 7.4

CALCULATION CONTINUATION SHEET

CALC. NUMBER ____________

REV. NUMBER ____________

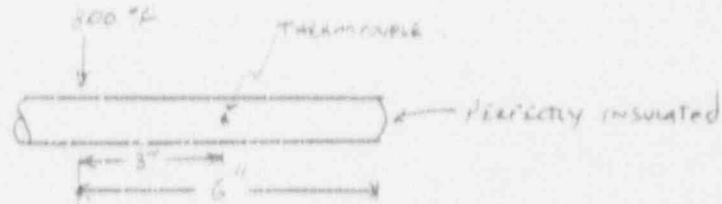
PAGE NUMBER ____________

OBJECTIVE No. 1

TRANSIENT TEMPERATURE RESPONSE

A 0.6 INCH DIAMETER CABLE CONTAINING SEVEN CONDUCTORS WAS MODELED USING THE HEATING 6 COMPUTER CODE Ref 2. THIS MODEL IS INTENDED TO SHOW THE TEMPERATURE RESPONSE OF THE SURFACE OF THE CABLE AS A FUNCTION OF DISTANCE FROM A HEAT SOURCE

THE FOLLOWING IS A SIMPLIFIED SKETCH



INITIAL TEMPERATURE 325°F

THE 800°F HEAT SOURCE IS ASSUMED TO OCCUR OVER A 1½" SPAN AROUND THE CIRCUMFERANCE OF THE CABLE.

THE 800°F IS ASSUMED TO HAVE OCCURRED DUE TO A BARRIER BREACH, ANY ADDITIONAL HEAT SOURCES DUE TO RADIATION OR THE HOT AIR SURROUNDING THE CABLE ARE IGNORED BY MAKING THE CABLE SURFACE Perfectly INSULATED. THIS IS VERY CONSERVATIVE SINCE CONDUCTION IS THE ONLY HEAT FLOWPATH ALLOWED

Figure 7.4

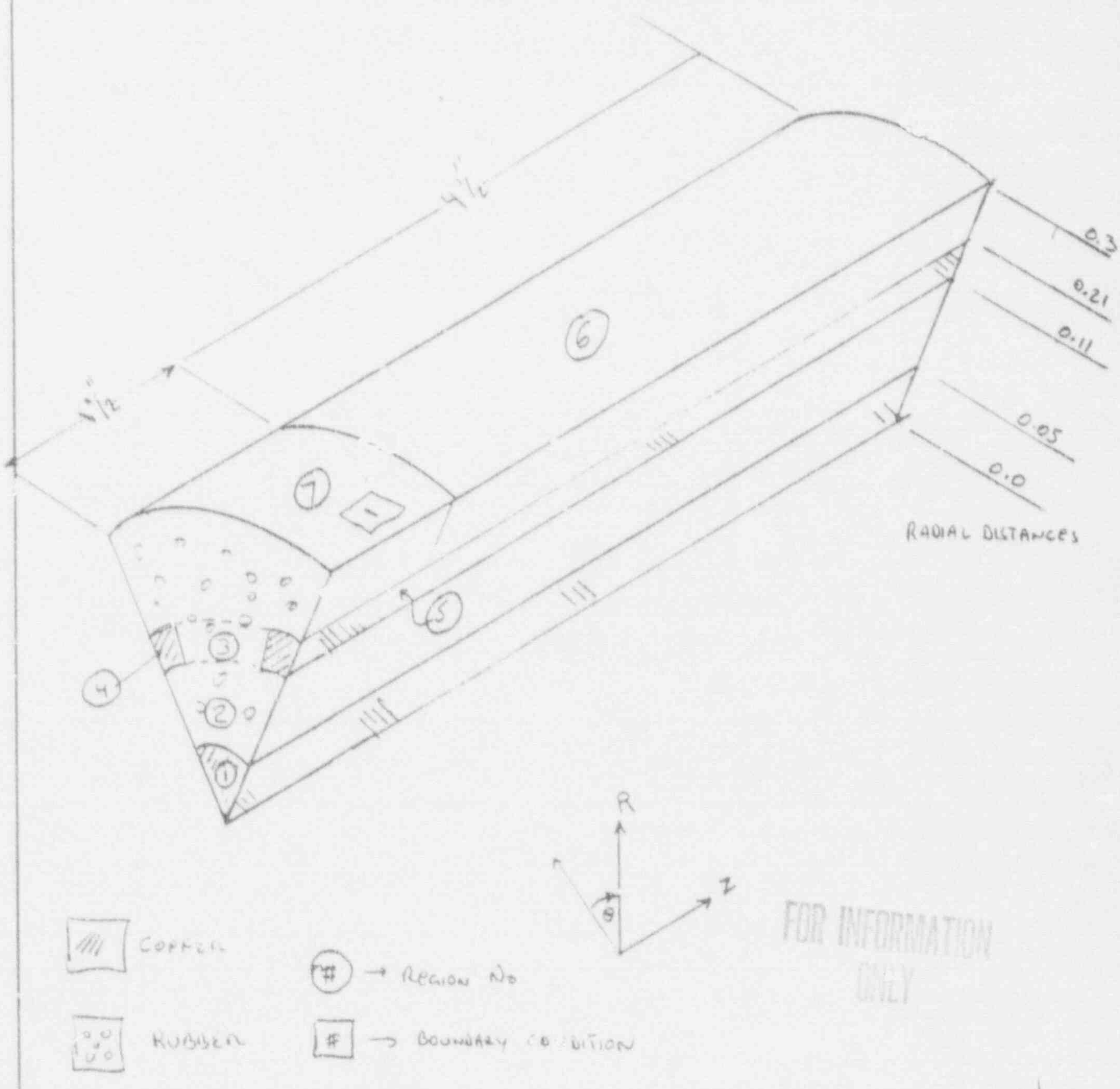
CALCULATION CONTINUATION SHEET

CALC. NUMBER: ______________________

REV. NUMBER: ______________________

PAGE NUMBER: ______________________

THE FOLLOWING IS A GRAPHICAL REPRESENTATION OF THE THREE DIMENSIONAL MODEL INDICATING THE REGION NUMBERS



ALL BOUNDARY CONDITIONS ARE ZERO except where noted

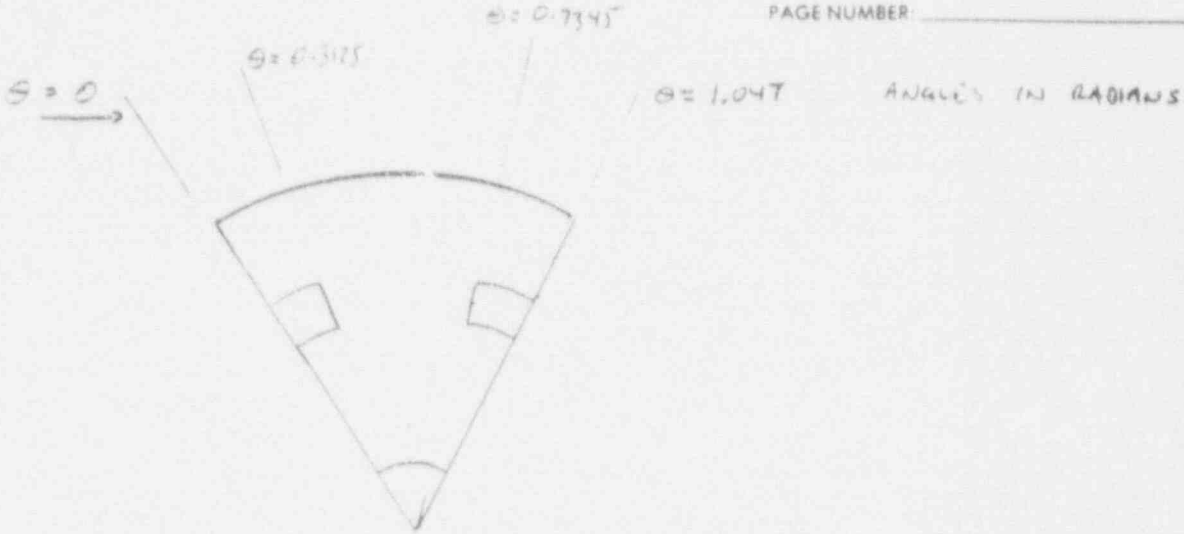
Figure 7.4

CALCULATION CONTINUATION SHEET

CALC. NUMBER: ______

REV. NUMBER: ______

PAGE NUMBER: ______



THE THERMAL PROPERTIES USED ARE:

RUBBER

THERMAL CONDUCTIVITY = 0.087 $\frac{BTU}{Hr\ ft\ ^\circ F}$ (BASED ON REF 1)

= 1.21×10^{-4} $\frac{BTU}{MIN-IN\ ^\circ F}$

DENSITY = 74.8 $\frac{lbm}{ft^3}$ = 0.043 $\frac{lbm}{IN^3}$ (BASED ON REF 1)

Specific Heat = 0.48 $\frac{BTU}{lbm\ ^\circ F}$ (BASED ON REF 3)

COPPER

THERMAL CONDUCTIVITY = 223 $\frac{BTU}{Hr\ ft\ ^\circ F}$ = 0.31 $\frac{BTU}{MIN-IN-^\circ F}$ (REF 1)

Density = 559 $\frac{lbm}{ft^3}$ = 0.323 $\frac{lbm}{IN^3}$ (REF 1)

Specific Heat = 0.0915 $\frac{BTU}{lbm\ ^\circ F}$ (REF 3)

FOR INFORMATION ONLY

Figure 7.4

CALCULATION CONTINUATION SHEET

CALC. NUMBER: ______

REV. NUMBER: ______

PAGE NUMBER: ______

THE FOLLOWING IS AN INPUT LISTING OF THE MODEL

```
PRINT INPUT CARD IMAGES W/CARD COLUMNS INDICATED EVERY 10TH CARD--

CARD
NO./COL. 1.......10........20........30........40........50........60........70........80
    1    TEMPERATURE PROFILE IN CABLE 1 HR 800 DEG F SOURCE
    2    10000 1 -1 0. 60. 0. 0 0 0
    3    0 0 0
    4    REGIONS
    5    1 2 0.0 0.05 0.0 1.047 0.0 6.0
    6    1 0 0 0 0 0 0 0
    7    2 1 0.05 0.11 0.0 1.047 0.0 6.0
    8    1 0 0 0 0 0 0 0
    9    3 1 0.11 0.21 0.3125 0.7345 0.0 6.0
   10    1 0 0 0 0 0 0 0
NO./COL. 1.......10........20........30........40........50........60........70........80
   11    4 2 0.11 0.21 0. 0.3125 0. 6.0
   12    1 0 0 0 0 0 0 0
   13    5 2 0.11 0.21 0.7345 1.047 0.0 6.0
   14    1 0 0 0 0 0 0 0
   15    6 1 0.21 0.3 0.0 1.047 1.5 6.0
   16    1 0 0 0 0 0 0 0
   17    7 1 0.21 0.3 0.0 1.047 0.0 1.5
   18    1 0 0 1 0 0 0 0
   19    MATERIALS
   20    1 RUBER 1.21E-4 0.043 0.48 0 0 0 0
NO./COL. 1.......10........20........30........40........50........60........70........80
   21    2 COPPER 0.31 0.323 0.0915
   22    INITIAL TEMPERATURES
   23    1 325.
   24    BOUNDARY CONDITIONS
   25    1 2 800. 0 0 0
   26
   27    XGRID
   28    0. 0.05 0.11 0.21 0.3
   29    2 2 2 2
   30    YGRID
NO./COL. 1.......10........20........30........40........50........60........70........80
   31    0.0 0.3125 0.7345 1.047
   32    2 2 2
   33    ZGRID
   34    0.0 1.50 6.0
   35    6 18
   36    PRINTOUT TIMES
   37    5.0 10.0 15.0 [illegible] 25.0 30.0 35.0 40.0 45.0 50.0 55.0 60.0
   38    TRANSIENT PARAM
   39    1.D-4 1. 1.D-4
   40    0.1 0 0.5 0 0 5.0
NO./COL. 1.......10........20........30........40........50........60........70........80
   41    %
```

FOR INFORMATION ONLY

Figure 7.4

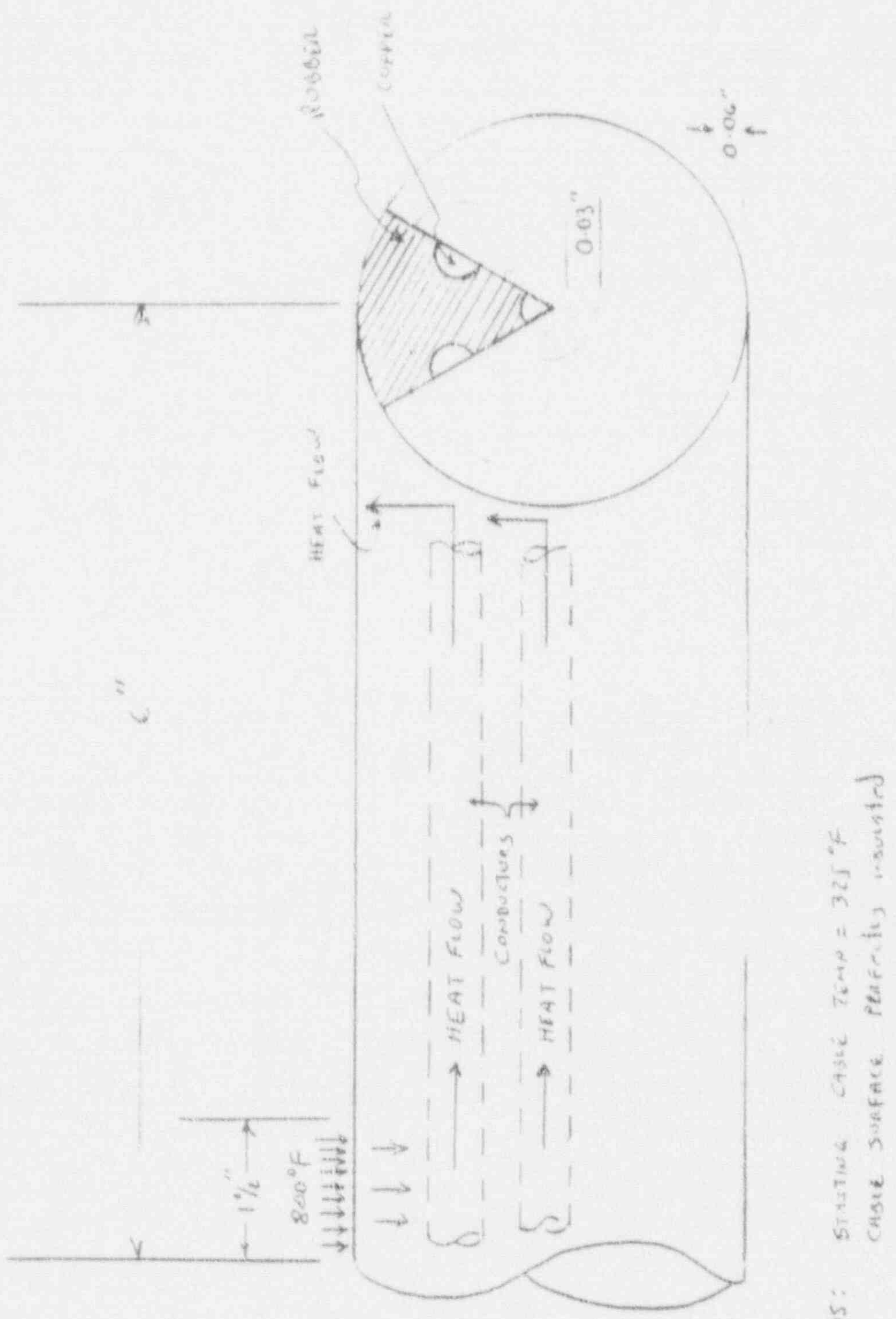
CALCULATION CONTINUATION SHEET

CALC. NUMBER:

REV. NUMBER:

PAGE NUMBER:

THE COMPUTER OUTPUT INDICATES THE FOLLOWING HEAT FLOW PATH



ASSUMPTIONS: STARTING CABLE TEMP = 325°F
CABLE SURFACE PERFECTLY INSULATED

TEMPERATURE RESPONSE vs DISTANCE

FROM HEAT SOURCE OF 0.6 INCH 7 CONDUCTOR CABLE

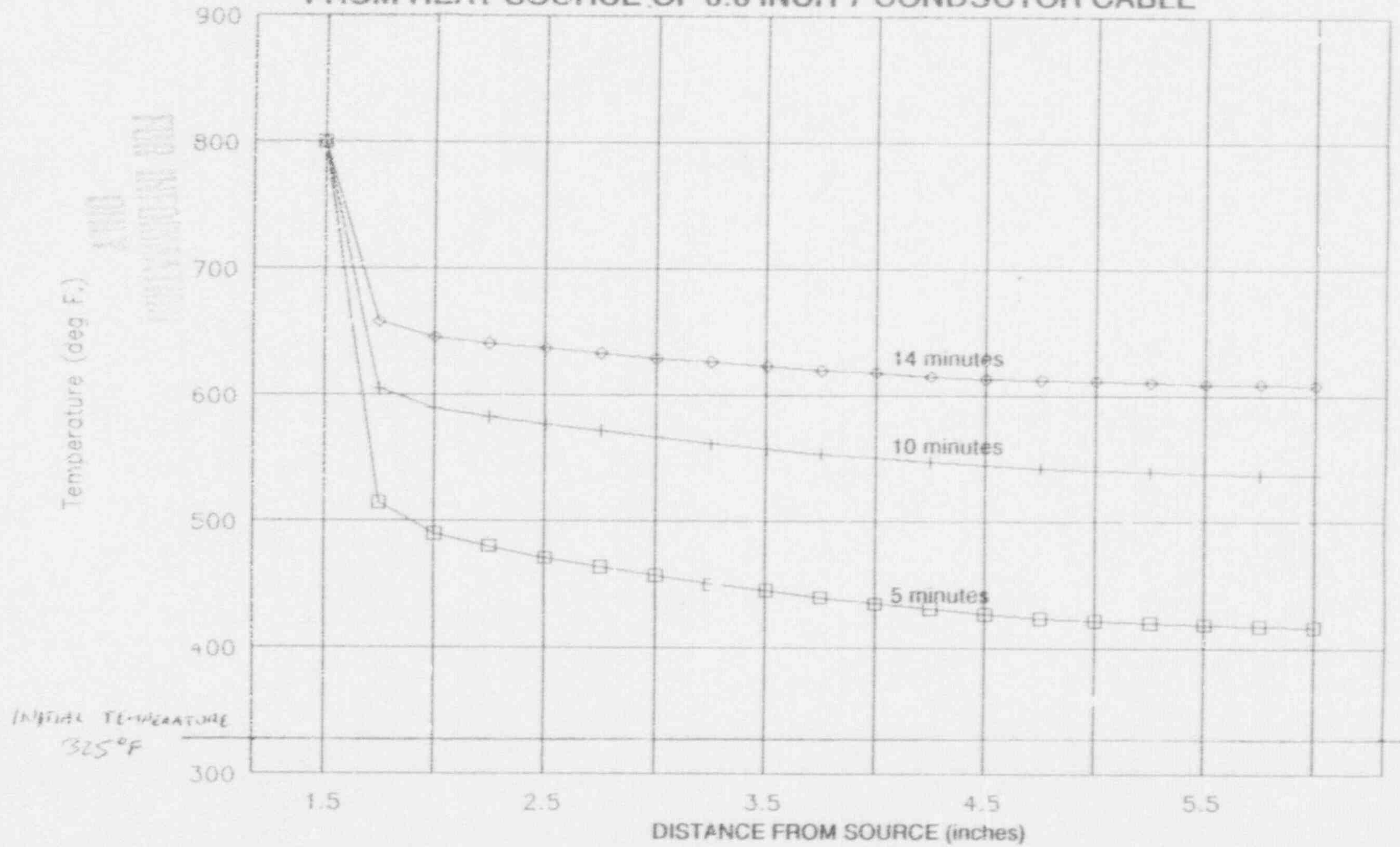


Figure 7.4

CALCULATION CONTINUATION-SHEET

CALC. NUMBER: ____________

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OBJECTIVE No 2

A REVIEW OF THE 5" CONDUIT ENTITLED "SCHEME 2" THERMO LAG TEST WAS performed. THERMO COUPLES 1 – 39 REPRESENTING 3 DIFFERENT SIZE CABLES ARE INCLUDED IN THIS REVIEW.

THE HIGHER TEMPERATURE READINGS FOR THIS TEST OCCURRED NEAR OR AT THE PROTRUDING MEMBERS AND THE JUNCTION BOX. THIS INCREASE IN TEMPERATURES ARE ATTRIBUTED IN PART TO THE CONDUCTIVE HEAT TRANSFER THAT THE PROTRUDING MEMBERS PROVIDE.

THE END TEMPERATURE PROFILES Demonstrating THE ABOVE IS SHOWN IN FIGURE 1

FIGURE 1 ALSO INDICATES THAT THE THINNER CABLE (#16) RAN THE HOTTEST.

BEING THAT THERMOCOUPLES were placed IN LINE WITH THE PROTRUDING MEMBER THERE IS ALSO A HIGH DEGREE OF CONFIDENCE That PEAK TEMPERATURES WERE OBSERVED AT THIS points

FIGURE No. 1

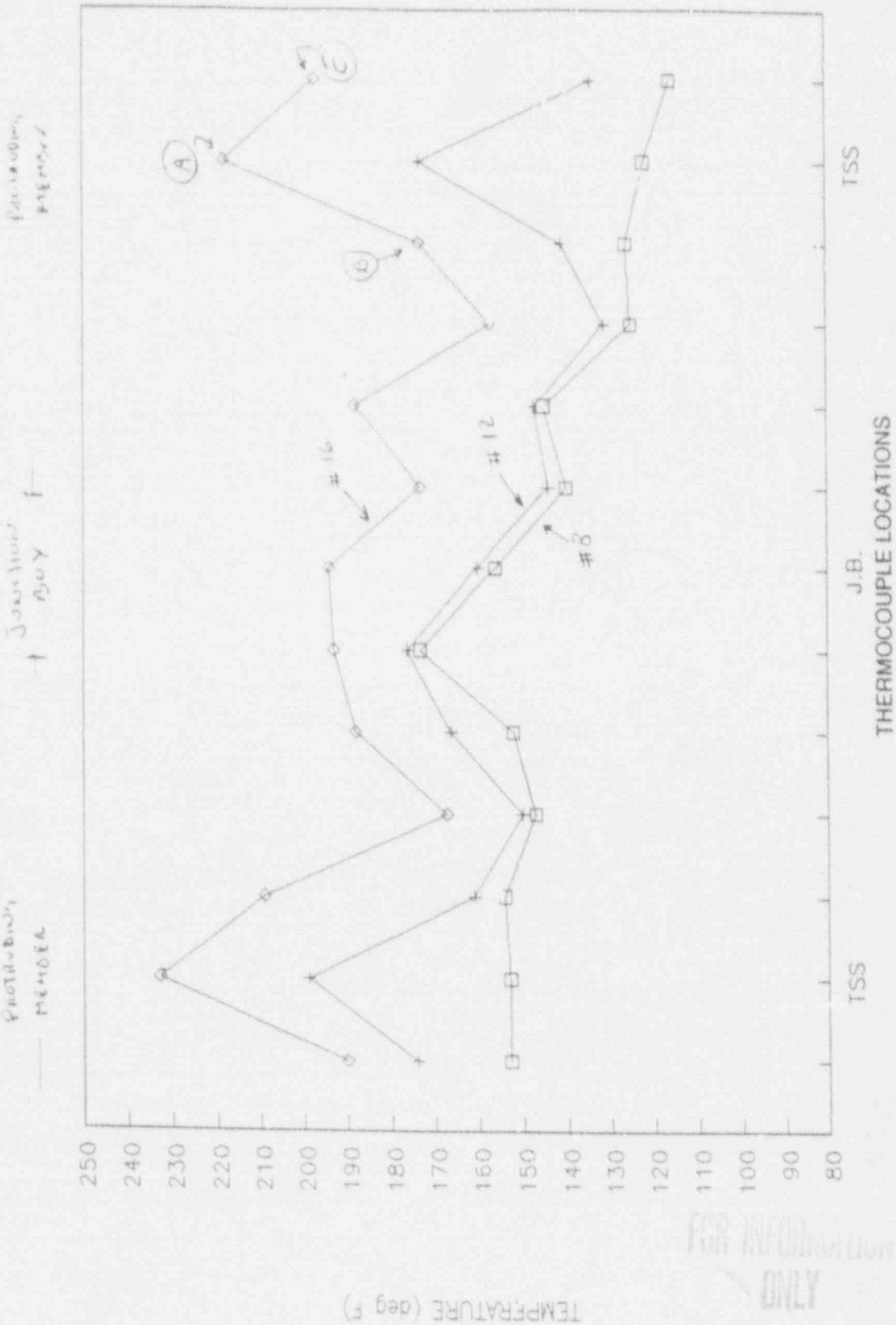

TEMPERATURE (deg F)
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
THERMOCOUPLE LOCATIONS
TSS
J.B.
TSS
#16
#12
#8
A
B
C

Figure 7.4

CALCULATION CONTINUATION SHEET

CALC. NUMBER:

REV. NUMBER:

PAGE NUMBER:

Selecting Two Thermocouples Adjacent To Each other experiencing A Large gradient See Figure 1. Points A + B and plotting these Thermocouples Response and their difference as a function of time, we obtain Figure 2.

It can be seen That The Temperature difference between These Two is becoming approximately constant. At about thirty minutes even though The Thermocouples continue To rise in Temperature. At this point it can be concluded That The Heat Transfer Rate between Thermocouples has become constant since

$$q = KA \frac{\partial T}{\partial x}$$ and K, A and ∂x are constants

It may also be determined That a Linearity has occurred between These points since an additional thirty minutes of The Transient did not contribute significantly To Their difference.

FOR INFORMATION ONLY

TEMPERATURE RESPONSE

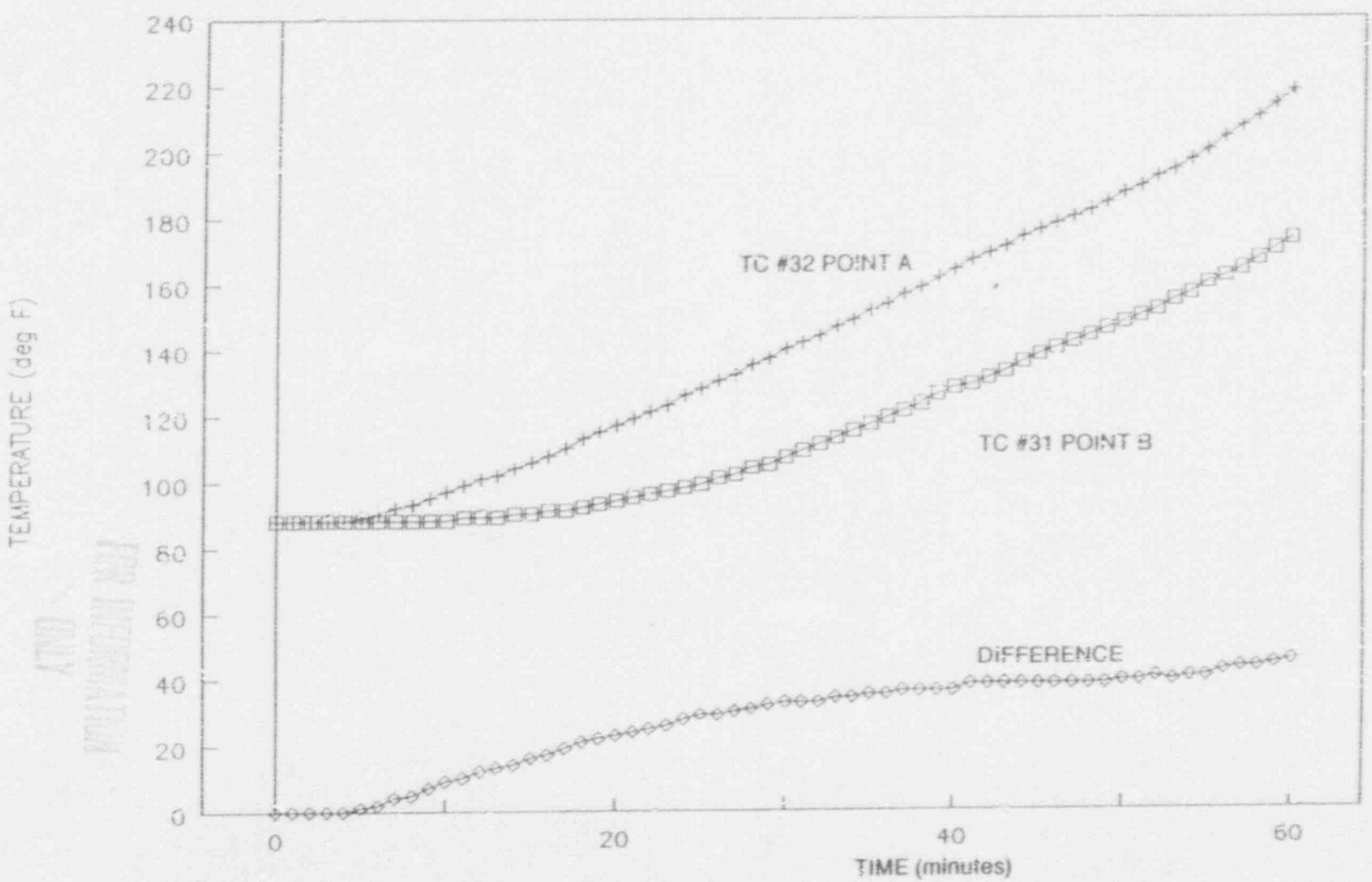


Figure No. 2

Figure 7.4

CALCULATION CONTINUATION SHEET

CALC. NUMBER: ______________

REV. NUMBER: ______________

PAGE NUMBER: ______________

THEREFORE, BASED ON THE ABOVE IF THERE EXISTED A HOT SPOT NOT DETECTED BY THE THERMOCOUPLES THIS SPOT MAY BE APPROXIMATED LINEARLY BY THE ADJACENT THERMOCOUPLES. TAKE FOR INSTANCE POINT A, B, C OF FIGURE 1

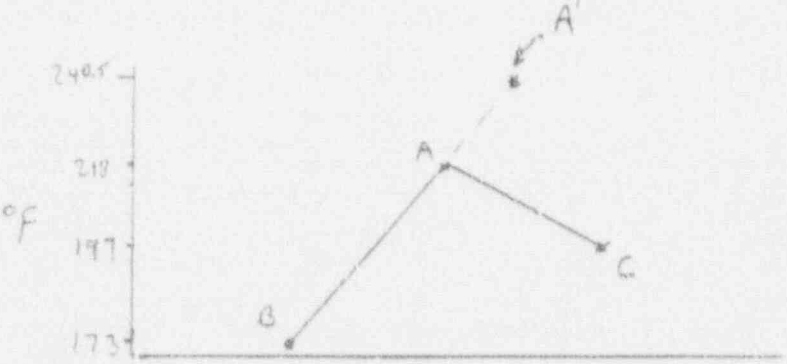
A' CAN BE APPROXIMATED BY:

$$A' = A + \frac{A - B}{2}$$

$$A' = 218 + \frac{218 - 173}{2}$$

$$A' = 218 + 22.5$$

$$A' = 240.5°F$$



IN SUMMARY, TESTS WHERE THERMOLAG BREACH IS NOT PRESENT, TO ACCOUNT FOR UNKNOWNS, IT CAN BE CONSERVATIVELY DETERMINED THAT THAT HIGHER TEMPERATURES CAN BE APPROXIMATED LINEARLY BY USING ADJACENT THERMOCOUPLES

FOR THIS PARTICULAR TEST TEMPERATURES SHOWN SHOULD BE WITHIN 23 °F OF ANY UNKNOWN PEAKS

CORRECTIVE No 3

FIGURE No 3