Docket

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

October 16, 1992

Docket No. 50-390

APPLICANT: Tennessee Valley Authority (TVA)

FACILITY: Watts Bar Nuclear Plant, Units 1

SUBJECT: MEETING SUMMARY - OCTOBER 7, 1992, MEETING ON TESTS AND MODIFICATIONS TO BE APPLIED TO THERMO-LAG FIRE RETARDANT MATERIALS (TAC M63648)

REFERENCE: Meeting notice by P. S. Tam, September 28, 1992

On October 7, 1992, NRC and TVA representatives met at NRC headquarters in Rockville, MD, to discuss proposed tests and modifications that TVA plans to apply to Thermo-Lag fire retardant materials at Watts Bar. Enclosure 1 is the list of attendees.

TVA requested the meeting to seek the staff's approval of TVA's proposed tests and modifications, so that construction can proceed without any impact on the fuel loading schedule (January 1994). At Watts Bar Unit 1, TVA plans to cover approximately 3000' of conduit and 800' of 18-inch and 24-inch cable tray with Thermo-Lag materials. Approximately 600' of Thermo-Lag materials have already been installed.

The staff stated that draft acceptance criteria, which will be applicable to the entire industry, are undergoing NRC management review. Hence the staff could not state during the meeting whether TVA's proposed tests and modifications are acceptable. TVA stated that installation of Thermo-Lag materials will commence in the next few days. TVA recognizes that such work will be done "at risk", pending issuance of the staff's position concerning tests and modifications.

TVA's proposal is outlined in a white paper (Enclosure 2) and viewgraphs (Enclosure 3).

Memo

DF01

The staff stated that TVA should submit the detailed test plan and other information to augment Enclosures 2 and 3. TVA agreed to do so by October 26, 1992. The staff may request to meet again with TVA during its review.

Original signed by

Peter S. Tam, Senior Project Manager
Project Directorate II-4
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Enclosures:
1. Participant list
2. TVA white paper on Thermo-Lag
3. TVA viewgraphs

cc: w/enclosures
See next page

Distribution

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*SEE PREVIOUS CONCURRENCE

ORG	PDII-4/LA	PDII-4/PM	SPLB/BC*	PDII-4/D	
NAME	MSanders	PTam:dw	CMcCracken	FHebdon	
DATE	10/15/92	10/15/92	10/14/92	10/16/92	

The staff stated that TVA should submit the detailed test plan and other information to augment Enclosures 2 and 3. TVA agreed to do so by October 26, 1992. The staff may request to meet again with TVA during its review.

Peter S. Tam, Senior Project Manager
Project Directorate II-4
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Enclosures:
1. Participant list
2. TVA white paper on Thermo-Lag
3. TVA viewgraphs

cc: w/enclosures
See next page

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ENCLOSURE 1

LIST OF PARTICIPANTS

MEETING ON WATTS BAR THERMOLAG ISSUES

OCTOBER 7, 1992

Name	Affiliation
John E. Allen	TVA
Ralph Architzel	NRC/NRR/SPLB
Ken Barr (part-time by phone)	NRC/Region II
Biff Bradley	NUMARC
Philip Brady	Pennsylvania Power and Light
Kent W. Brown	TVA
Frank Czysc	Pennsylvania Power and Light
Thomas R. Davis	TVA
R. Scott Egli	TVA
Hukam Garg	NRC/NRR/HICB
Yue Guan	Bechtel
Fred Hebdon	NRC/NRR/Project Directorate II-4
Gary Humphrey (part-time by phone)	NRC/Region II
Roger Huston	TVA
Ronaldo V. Jenkins	NRC/NRR/EELB
Frank A. Koontz, Jr.	TVA
James A Krieg	TVA
Patrick Madden	NRC/NRR/SPLB
Conrad McCracken	NRC/NRR/SPLB
Theresa Meisenheimer	Bechtel
Isabel Moghissi	NRC/NRR/SPLB
Kelly Myers	Miller & Chevalier
Jimmy J. Pierce	TVA
W. Tom Ryan	TVA
Mark Henry Salley	TVA
Robert Schaaf	NRC/NRR/PDIV-2
Peter Tam	NRC/NRR/Project Directorate II-4
Roger D. Walker	Texas Utilities Electric
Steven West	NRC/NRR/SPLB
Lloyd Zerr	STS

Enclosure 2

TENNESSEE VALLEY AUTHORITY
WATTS BAR NUCLEAR PLANT

POSITION ON FIRE TESTING CRITERIA
FOR FIRE BARRIER SYSTEMS USED TO
PROTECT ELECTRICAL CABLING REQUIRED
FOR 10 CFR 50 APPENDIX R COMPLIANCE

Background

There is considerable discussion between the NRC, nuclear utilities and manufacturers of fire barrier systems on the appropriate test method and acceptance criteria for electrical fire barrier systems. The NRC has based its methodology and criteria on National Fire Protection Association (NFPA) 251, "Standard Method of Fire Tests of Building Construction and Materials," Chapter 7, "Tests of Nonbearing Walls and Partitions."[1] Thermal Science, Inc. (TSI), the manufacturer of Thermo-Lag, and most nuclear utilities, have based their methodology and criteria on American Nuclear Insurers (ANI) "Standard Fire Endurance Test Method to Qualify a Protective Envelope for Class 1E Electrical Circuits."[2] Other manufacturers of fire barrier systems, such as 3M and Thermal Ceramics, Inc., have typically used Underwriters Laboratory (UL) test methods and acceptance criteria such as "UL Subject 1724, "Outline of Investigation for Fire Tests for Electrical Circuit Protective Systems."[3] The American Society for Testing and Materials (ASTM) has recognized the need to develop a unique test method and acceptance criteria for electrical fire barrier systems. They have been working for approximately the last five years on this issue but have not issued a standard.

Discussion

The Code of Federal Regulations (CFR), Title 10 Part 50 Domestic Licensing of Production and Utilization Facilities, Appendix R, Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979, paragraph III.G.2 provides the requirements for fire protection and safe shutdown capability. If redundant trains are located in the same fire area and a licensee does not provide alternative or dedicated shutdown systems for the redundant equipment in that fire area, the three acceptable methods of ensuring that one of the trains is free from fire damage are:

a. Separation of cables and equipment and associated non-safety circuits of redundant trains by a fire barrier having a 3-hour rating. Structural steel forming a part of or supporting such fire barriers shall be protected to provide fire resistance equivalent to that required of the barrier;

b. Separation of cables and equipment and associated non-safety circuits of redundant trains by a horizontal distance of more than 20 feet with no intervening combustible or fire hazards. In addition, fire detectors and an automatic fire suppression system shall be installed in the fire area; or

c. Enclosure of cable and equipment and associated non-safety circuits of one redundant train in a fire barrier having a 1-hour rating. In addition, fire detectors and an automatic fire suppression system shall be installed in the fire area.[4]

A fire wall design that has passed on appropriate test method (e.g., NFPA 251) is considered a "rated" barrier. Components which penetrate fire walls, such as mechanical and electrical penetrations, fire doors, and HVAC fire dampers, are "rated" under their own unique test method and acceptance criteria. There is presently no generally accepted test method and acceptance criteria specifically applicable to fire barrier enclosures applied to electrical cable systems. Existing methods intended for other purposes have been utilized to test such barrier systems, but none of these standards are fully appropriate to this unique application of fire barrier materials. In an attempt to define a test method for electrical circuit protection, American Nuclear Insurers (ANI) prepared "Guidelines for Fire Stop and Wrap Systems at Nuclear Facilities". However, this test method was intended to be used "for insurance purposes only".[2] The method and acceptance criteria in the ANI document are not definitive.

Position

The fire testing methodology and acceptance criteria for electrical cable systems should be unique to these systems. Underwriters Laboratory currently has an appropriate test method (Subject 1724), which addresses the uniqueness of electrical cable fire barrier systems. This test method was developed by UL specifically to address issues such as Appendix R electrical fire barrier rating requirements. The scope of the test method is:

- Measurement of temperature changes within the electrical circuit protective system caused by the heat transfer through the electrical circuit protective system to the electrical conductor or raceway, or both, during the external fire exposure test.

- Determination of the integrity of the electrical circuit protective system during the external fire exposure and water hose stream test.

- Determination of the ability of insulated electrical conductors to maintain electrical circuit integrity at the temperature conditions present within the electrical circuit protective system during the external fire exposure test and during the water hose stream test.[3]

Details such as thermocouple types and placements are discussed in this test method. The test follows the standard time-temperature curve specified in ASTM E-119, as used in other fire endurance tests (e.g., NFPA 251). The test allows the use of the actual installed cables or a No. 8 AWG ($3.38mm^2$) bare copper conductor to simulate the electrical circuits. With the bare conductor method the thermocouple measurements can be correlated to actual cable qualification tests as described in Appendix B of UL Subject 1724.

TVA considers that UL Subject 1724 is the most appropriate test method currently available for determining the fire resistance rating of electrical fire barrier systems. TVA will use UL Subject 1724 with the following clarifications to perform tests of Thermo-lag 330 electrical circuit protective systems intended for use at Watts Bar:

(1) The exterior surface temperature of the electrical raceway will be recorded (cold side of the barrier). If the average temperature recorded by the exterior thermocouples is less than 250°F (121°C) above their initial temperature and no individual thermocouple is in excess of 325°F (163°C) above its initial temperature, the fire barrier will be considered acceptable for use with any type cable.[5]

(2) Section 6, <u>Internal Fire Exposure Test</u>, will not be used. TVA considers that this portion of the testing is not necessary, since an internally generated cable tray fire would be extremely unlikely. Circuits are protected with a fuse or breaker that will actuate prior to the jacket of a faulted cable reaching its auto-ignition temperature (for existing designs) or reaching its insulation damage temperature (for new designs) for all credible low impedance and bolted faults.[6] No other ignition sources exist within the protective barrier.

(3) Section 5, <u>Hose Stream Test</u>. TVA will follow the criteria for hose stream testing described in NUREG-0800 using one and one-half inch fog nozzle set at a discharge angle of 15° with a nozzle pressure of 75 psig and a minimum discharge of 75 gpm.[7] TVA considers that this would accurately represent the mechanical impact, erosion and cooling effects that would exist in TVA's nuclear power plant environment. The hose stream test shall be performed within ten minutes of the completion of the fire test. The duration and application will follow the requirements of UL 1724 Table 5.1. The nozzle will be located a maximum of ten feet measured horizontally from the outside edge of the testing assembly. Acceptance shall be based on the fire barrier system remaining intact with minimal material flaking. (The alternative test called for by the UL document, involving a one and one-eighth inch solid bore National Standard Playpipe operating at 30 psig, is not a realistic simulation of the challenge to barrier systems as installed in a nuclear power plant).

REFERENCES

(1) National Fire Protection Association (NFPA) 251, "Standard Method of Fire Tests of Building Construction and Materials", 1990 Edition.

Note: For the purposes of this paper NFPA 251 (90) is considered equivalent to ASTM E119-88 "Standard Test Method for Fire Tests of Building Construction and Materials".

(2) American Nuclear Insurers/Mutual Atomic Energy Reinsurance Pool (ANI/MAERE) RA "Guidelines for Fire Stop and Wrap Systems at Nuclear Facilities" Revision 0, November 1987.

(3) Underwriters Laboratories, Inc. (UL) Subject 1724, "Outline of Investigation for Fire Tests for Electrical Circuit Protective Systems", Issue Number: 2, August 1991.

(4) Code of Federal Regulations, Title 10, Part 50, Energy, January 1, 1992.

(5) Based on a NFPA 251 (90) acceptance criteria for Nonbearing Walls and Partitions.

(6) Tennessee Valley Authority (TVA), "Watts Bar Design Criteria - WB-DC-30-13, 10 CFR 50 Appendix R Type I, II, and III Circuits". Revision 2, February 13, 1990.

(7) U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Standard Review Plan, NUREG 0800, Rev. 2, July 1981, Section 9.5.1 Fire Protection Program, page 9.5.1-29.

NRC – TVA/WBN THERMO-LAG
OCTOBER 7, 1992

AGENDA

- INTRODUCTION – JOHN E. ALLEN, CHIEF ENGINEER
- FIRE TESTING – MARK H. SALLEY
- CABLE INTEGRITY TESTING – KENT W. BROWN
- TEST SEQUENCE – MARK H. SALLEY

Enclosure 3

BACKGROUND

- BULLETIN 92-01 & SUPPLEMENT 1
- DRAFT GENERIC LETTER, 92-XX DATED FEB.11,1992
- INFORMATION NOTICES:
  - 91-47
  - 91-79
  - 92-46
  - 92-55
- RECENT TESTING

TVA STATUS

- BFN UNIT 2 – CONDUITS, JUNCTION BOXES

- SQN UNIT 1 & 2 – CONDUITS, JUNCTION BOXES, & ONE 18" CABLE TRAY

- WBN UNIT 1 – CONDUITS, JUNCTION BOXES, 18" & 24" CABLE TRAYS   Estimate: 3000 ft conduit
  1700 ft trays

- BFN UNIT 3 – CONDUITS, JUNCTION BOXES

FIRE TESTING CRITERIA FOR ELECTRICAL FIRE BARRIERS

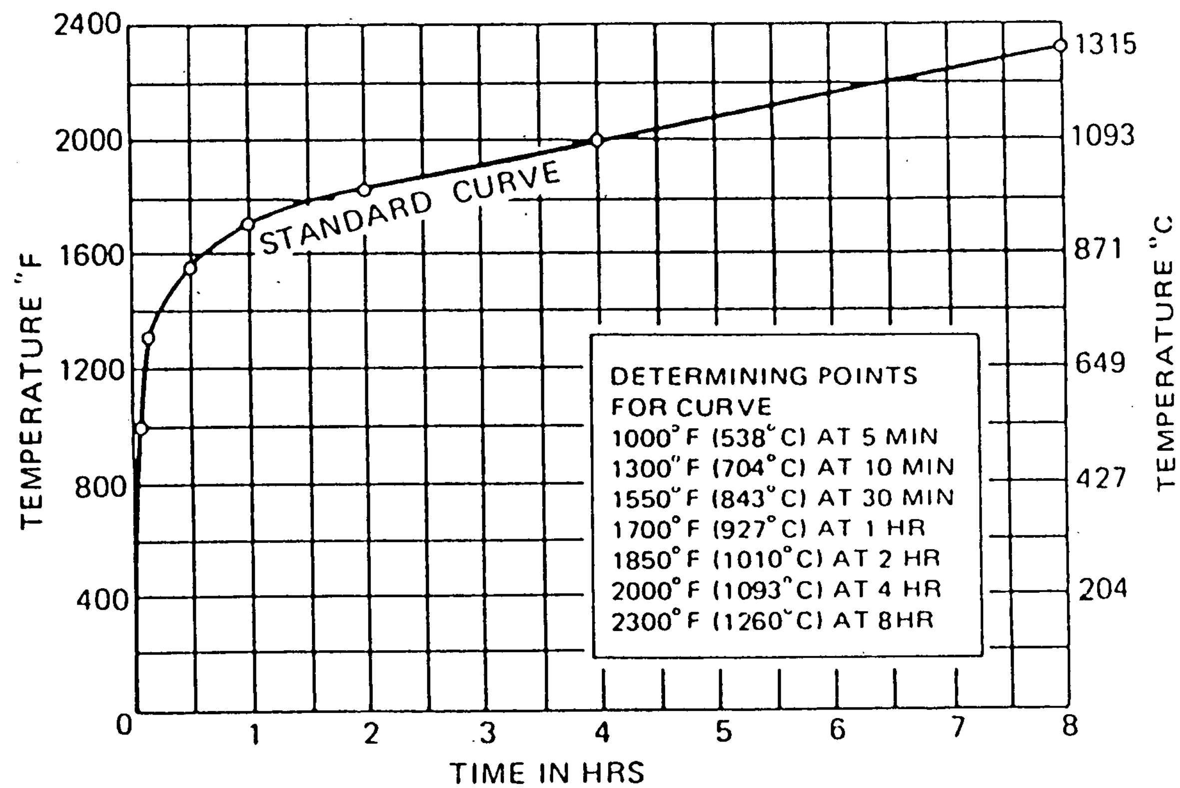
- FIRE TESTING STANDARDS AVAILABLE
  - NFPA 251 / ASTM E119
  - ASTM E814
  - ANI
  - UL 1724

UL 1724 MOST APPROPRIATE

UL 1724

- DEVELOPED FOR THIS SPECIFIC APPLICATION
- DEVELOPED BY A INDEPENDENT ORGANIZATION SPECIALIZING IN TESTING
- PROVIDES STANDARD METHODOLOGY
- STANDARD TIME / TEMPERATURE CURVE

STANDARD TIME / TEMPERATURE CURVE



ACCEPTANCE CRITERIA PARAMETERS

- THERMAL PERFORMANCE
  - I) RACEWAY EXTERNAL

    ΔT ave. $<$ 250°F
    AND
    ΔT max. $<$ 325°F

  - II) RACEWAY INTERNAL

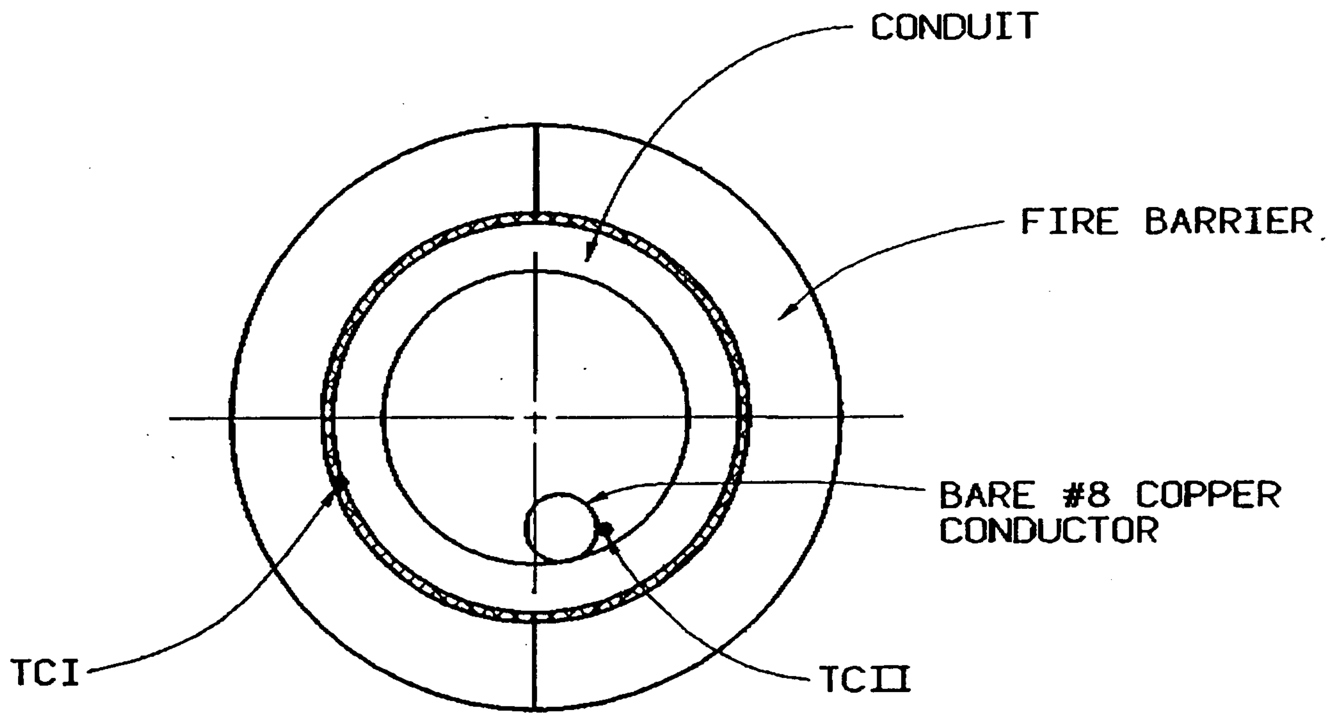
    ΔT max. INACCORDANCE WITH UL 1724 APPENDIX B

- INTERNAL GENERATED FIRES
  - NOT APPLICABLE
- HOSE STREAM TEST
  - FOG NOZZLE 15°, 75 GPM, 75 PSIG. (NUREG 0800)
  - PERFORMED AT THE END OF FIRE TEST

    OR

  - DUPLICATE ASSEMBLY AFTER 30 MINUTE FIRE TEST

THERMOCOUPLE LOCATION

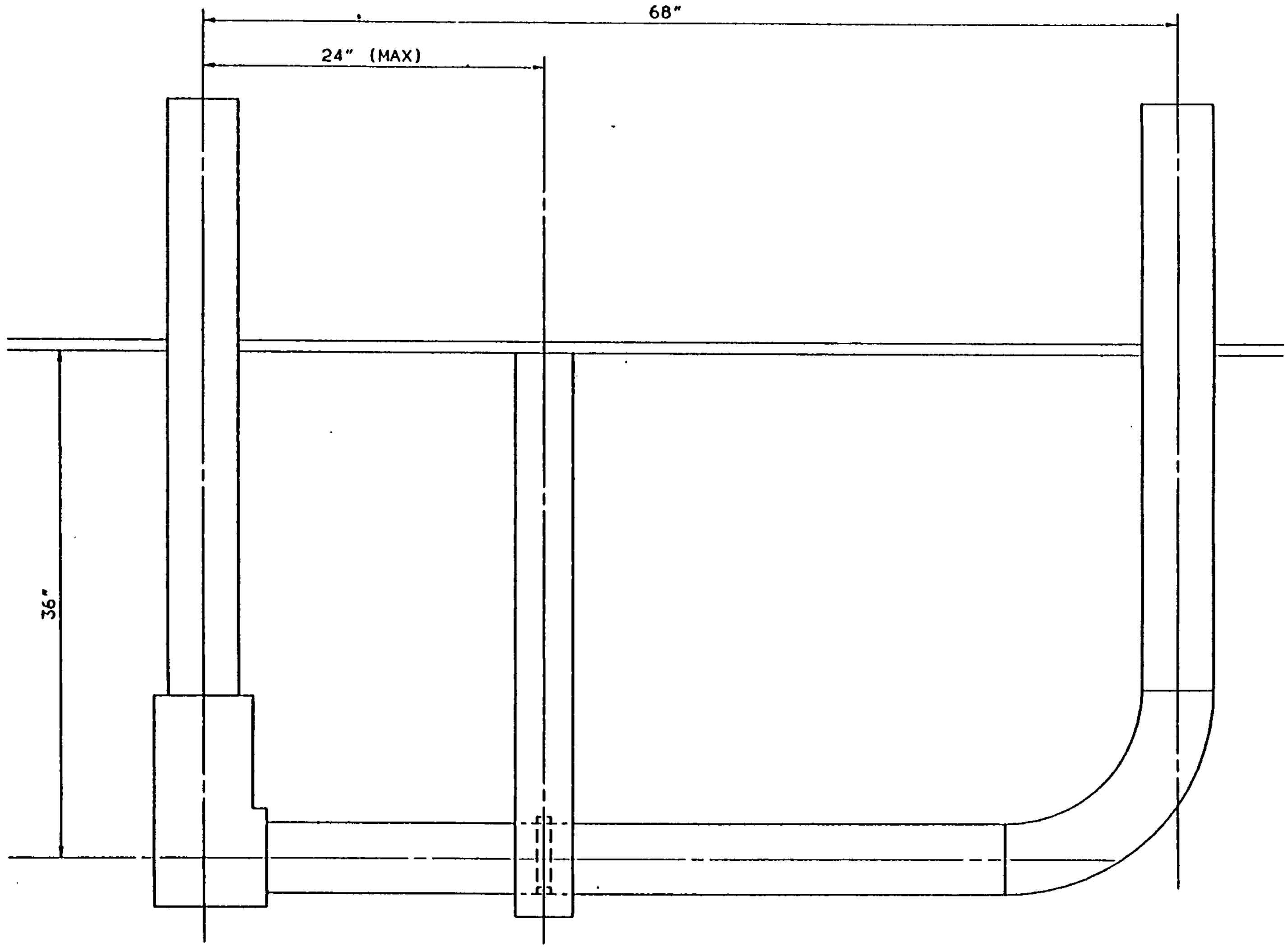


TCI -EXTERNAL RACEWAY TEMPERATURE
TCII -INTERNAL RACEWAY TEMPERATURE

TVA CONDUIT CONFIGURATION

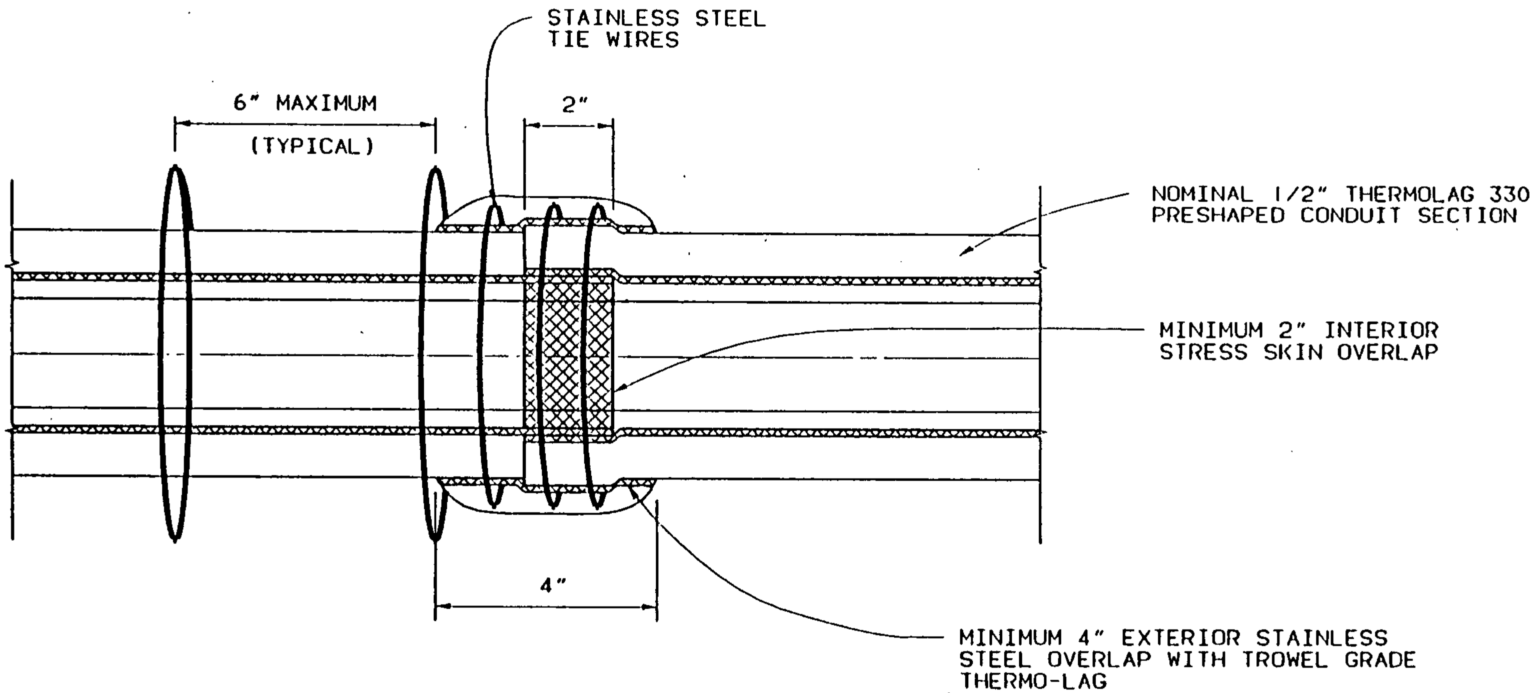
- ENGINEERED DESIGN
- EXTERNAL ENHANCEMENTS
- 1" TO 5" SIZES
- SIMILAR DESIGNS ARE BEING DEVELOPED FOR CABLE TRAYS & JUNCTION BOXES

TYPICAL CONDUIT TEST ASSEMBLY



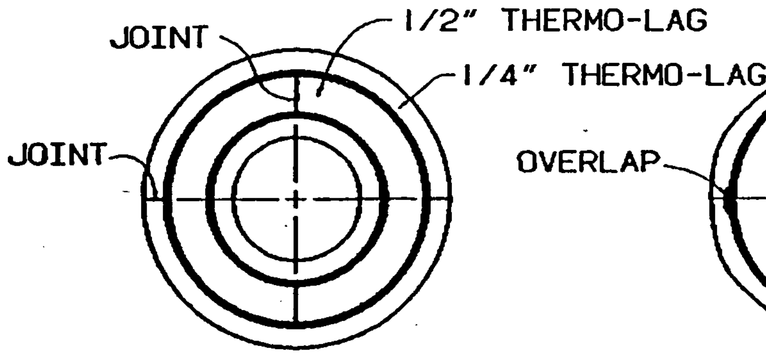
TVA ENGINEERED DESIGN

TYPICAL DETAIL

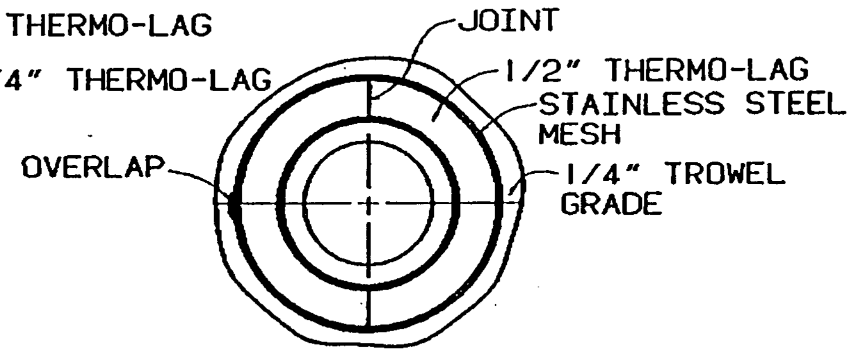


STRAIGHT JOINT

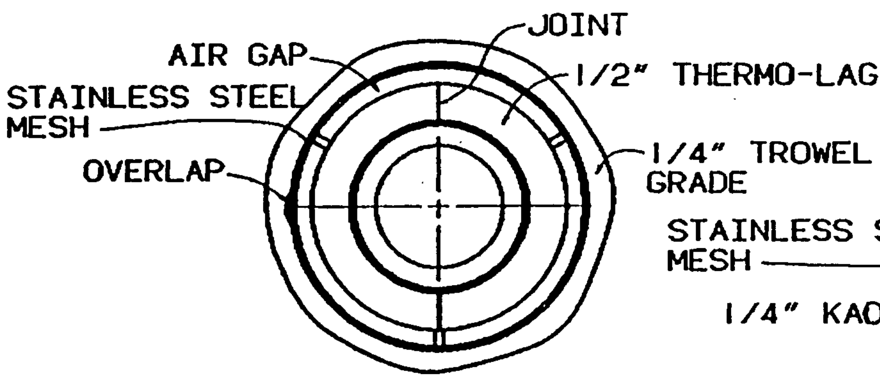
EXTERNAL CONDUIT DESIGNS



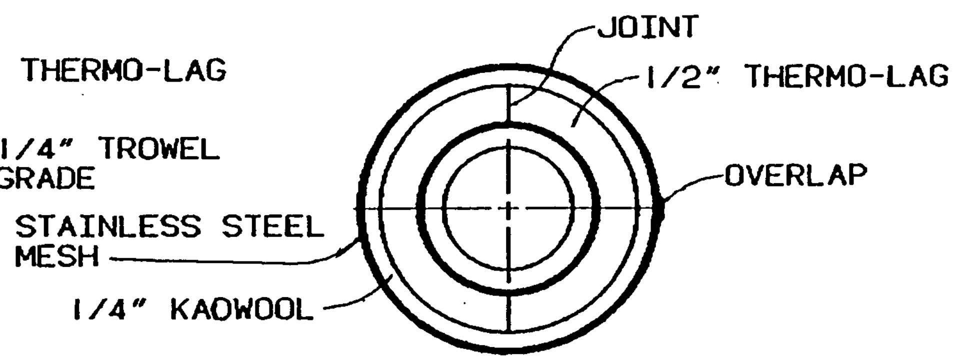
1/2" STANDARD THERMO-LAG WITH 1/4" UPGRADE



1/2" STANDARD THERMO-LAG WITH STAINLESS STEEL MESH AND 1/4" TROWEL



1/2" STANDARD THERMO-LAG WITH AIR GAP, STAINLESS STEEL MESH AND 1/4" TROWEL



1/2" STANDARD THERMO-LAG WITH 1/4" KAOWOOL, STAINLESS STEEL MESH

THERMO–LAG
CABLE ASSESSMENT

- MUST ESTABLISH CABLE INTEGRITY
  - LONG TERM (NORMAL OPERATION)
  - TRANSIENT (DURING APPENDIX R EVENT)

- APPENDIX R PERFORMANCE : HIGH TEMP ENDURANCE
  - ENHANCED UL COMPRESSIVE LOAD TEST

- LONG TERM EFFECTS OF BARRIER : AMPACITY DERATING
  - EXISTING DERATINGS QUESTIONABLE
  - TESTS FOR CONDUIT, AIR DROP AND TRAY

THERMO-LAG
UL 1724 APPENDIX B

- PERFORMED WHEN FURNACE TESTS USE BARE CONDUCTOR

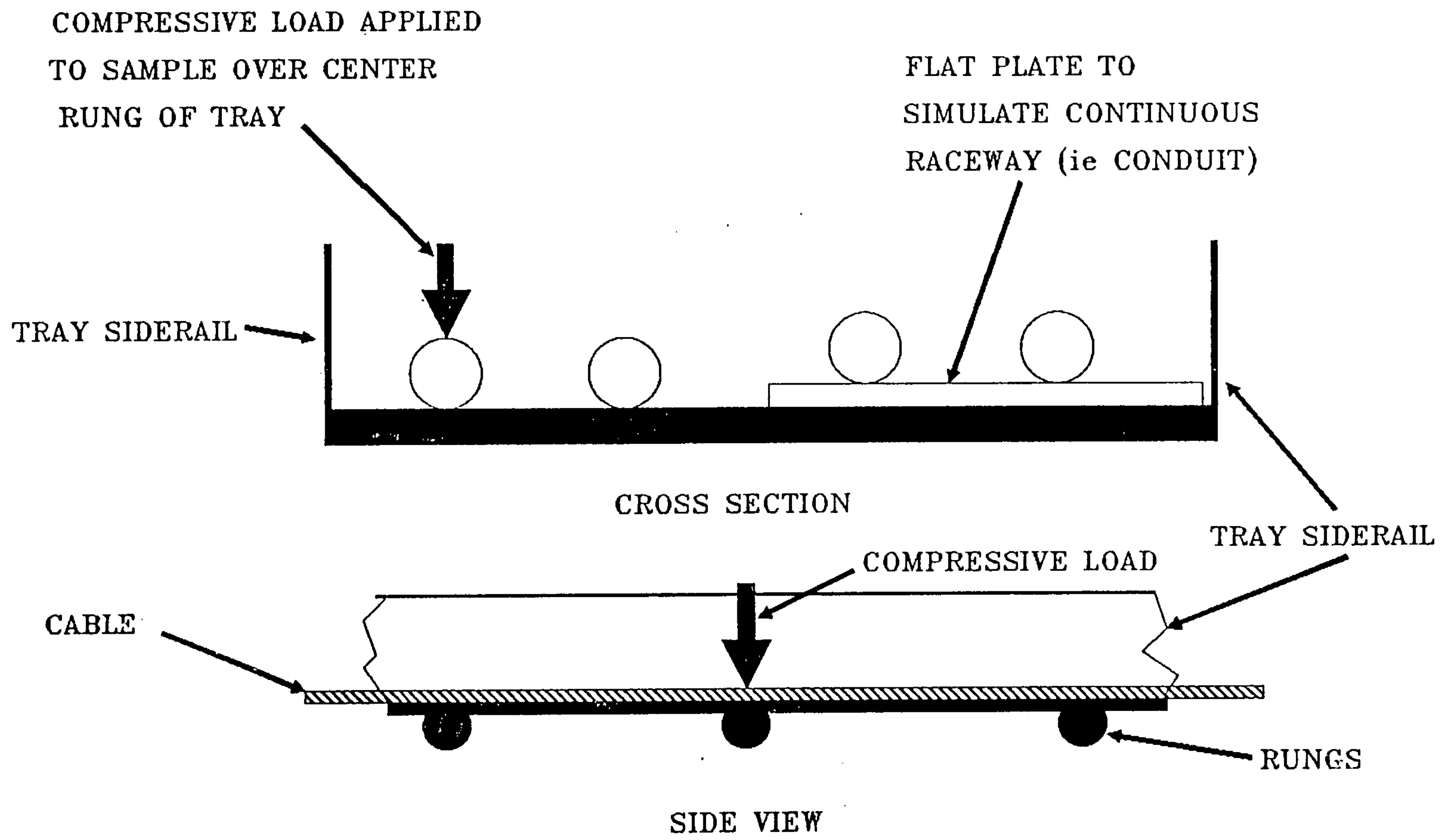
- COMPRESSIVE LOAD TEST
  - SIMULATES LOAD AT MAX FILL
  - ACCEPTANCE CRITERIA EXCEEDS UL RQMNTS
  - SPECIMENS REPRESENTATIVE OF EACH MAJOR FAMILY

- POWER CABLES
  - TEMP RISE FROM FIRE TEST PLUS CABLE RATING

- CONTROL/INSTRUMENTATION CABLES
  - TEMP RISE FROM FIRE TEST PLUS MAX AMBIENT

- IMPACT FORCE TEST NOT PERFORMED
  - SIMULATES HOSE STREAM EFFECT
  - WBN USES FOG NOZZLES
  - FOG NOZZLE IMPACT NEGLIGIBLE

THERMO-LAG
UL 1724 COMPRESSIVE LOAD TEST



THERMO-LAG
SPECIMEN SELECTION

- COMPRESSIVE LOAD TEST TO INCLUDE BASIC TVA TYPES
- SPECIMENS FOR EACH VENDOR/TYPE AS AVAILABLE

✓ PXJ/PXMJ	– 600V POWER/CONTROL TS INSULATION / TP JACKET	(*)
✓ CPJ/CPJJ	– 600V POWER/CONTROL TS INSULATION / TP JACKET	
✓ SROAJ	– 600V POWER/CONTROL TS INSULATION / ARAMID FIBER JACKET	
✓ MS	– 300V SIGNAL TS INSULATION / TP JACKET	(*)
✓ CPSJ	– 8KV POWER TS INSULATION / TP JACKET	
✓ EPSJ	– 8KV POWER TS INSULATION / TP JACKET	(*)

(*) FAMILY ALSO INCLUDES TS JACKET CONSTRUCTIONS

THERMO-LAG
COMPRESSIVE LOAD TEST

- CABLES ENERGIZED AT RATED VOLTAGE (UL IS ONLY 120 VDC)

- CABLES MONITORED FOR FAULT
  - CONDUCTOR-TO-CONDUCTOR (MC CABLES)
  - CONDUCTOR-TO-GROUND (ALL CABLES)

THERMO–LAG
CABLE ACCEPTANCE CRITERIA

- MUST HOLD RATED VOLTAGE (UL RQMNT)

- MUST PASS MODIFIED IEEE 690 TEST (EXCEEDS UL RQMNTS)

  – AT ROOM TEMPERATURE

  – IN WATER

  – MEGGER ACCEPTANCE CRITERIA : $\frac{(kV+1)*1000}{L}$ MOHMS

  – INSTRUMENTATION AND CONTROL : 500 V

  – LOW VOLTAGE POWER : 1500 V

  – MEDIUM VOLTAGE POWER :
    - MEGGER 2500 V
    - IEEE 400 (1980) MAINTENANCE HIPOT 20000 VDC

THERMO-LAG
FAILURE MODES VS ACCEPTANCE TESTS

- LIKELY DAMAGE MODES
  - CREEP : THERMOPLASTIC MTLS @ MODERATE-TO-HIGH TEMPS
    THERMOSET MTLS @ HIGH TEMPS W/ HIGH LOAD
  - CRACK : THERMOSET MTLS
- CONDUCTOR-TO-CONDUCTOR AND CONDUCTOR-TO-GROUND TEST
  - MONITORS CREEP PHENOMENON
- WET TEST
  - MONITORS CRACK PHENOMENON

THERMO-LAG
CABLE AMPACITY ASSESSMENT

- CONDUCTED PER IEEE P-848 DRAFT 11
  "PROCEDURE FOR THE DETERMINATION OF THE AMPACITY DERATING OF FIRE PROTECTED CABLES"

- PREPARED BY IEEE/ICC TASK GROUP 12-45

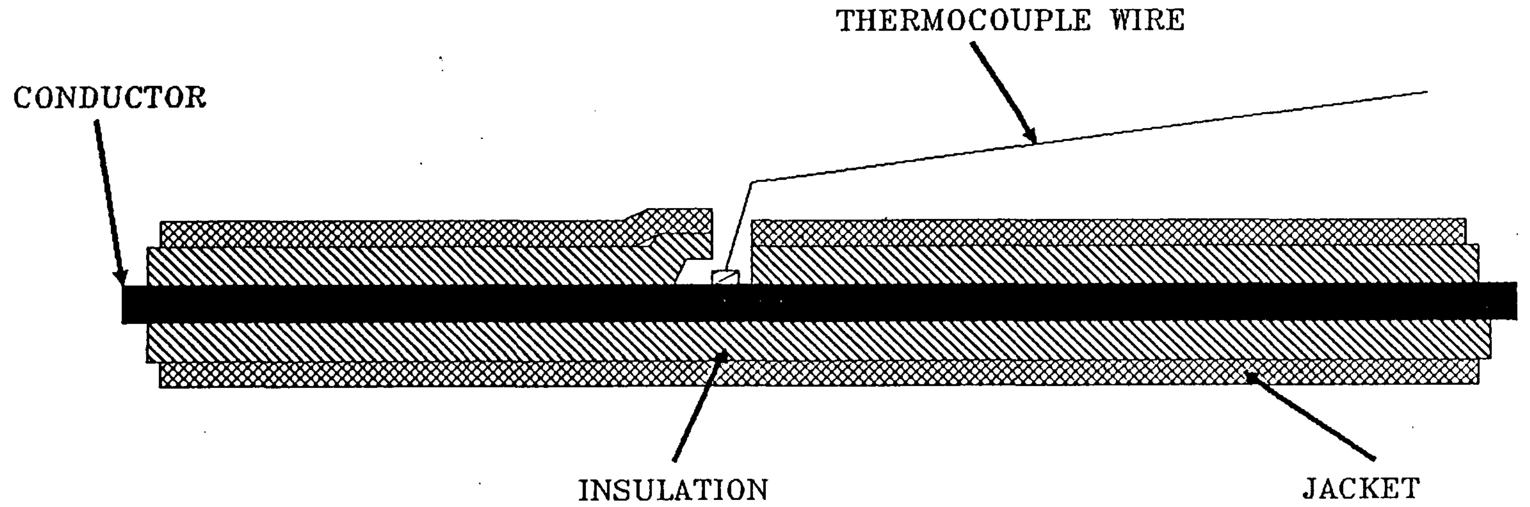
- IN FINAL SUBCOMMITTEE BALLOTING

THERMO–LAG
CABLE AMPACITY ASSESSMENT

- CONDUIT
  - TESTS REQUIRED FOR 1" AND 4"
  - 1" 1–3/C #6 AWG CABLE
  - 4" 1–3/C 750 Kcmil CABLE
  - CONDUIT THERMALLY ISOLATED FROM SUPPORT
  - THERMAL DAMS TO MINIMIZE END EFFECTS
  - THERMOCOUPLES IN 3 PLANES ALONG LENGTH
  - TESTS IN TEMPERATURE CONTROLLED ENCLOSURE
  - BASELINE (NON–WRAPPED) TESTS FOR EACH SIZE

THERMO-LAG
CABLE AMPACITY ASSESSMENT

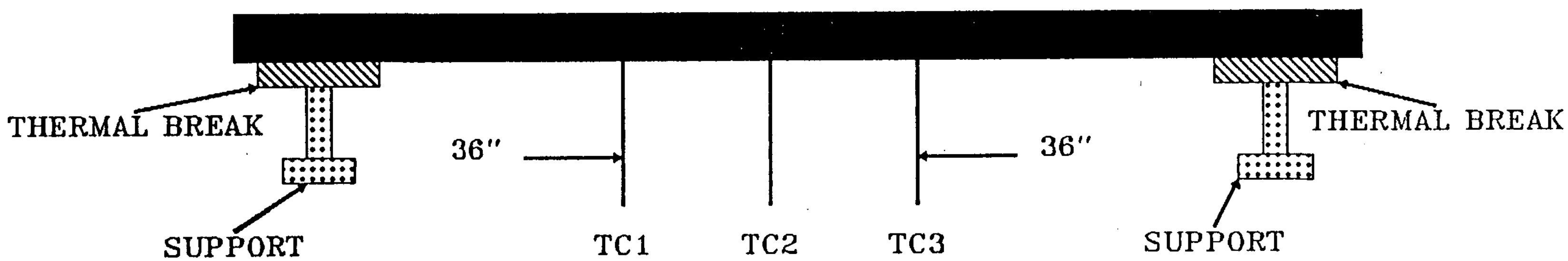
- THERMOCOUPLE PLACEMENT



TYPE K, 24 AWG CHROMEL-ALUMEL

THERMO–LAG
CABLE AMPACITY ASSESSMENT

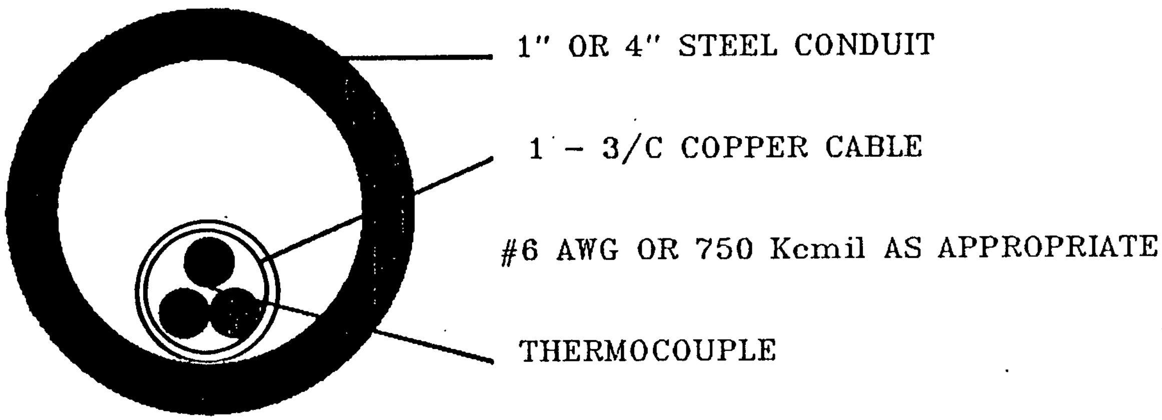
• THERMOCOUPLE PLACEMENT (SIDE VIEW)



1″ OR 4″ RIGID STEEL CONDUIT

THERMO-LAG
CABLE AMPACITY ASSESSMENT

- THERMOCOUPLE PLACEMENT (CROSS SECTION)



THERMO-LAG
CABLE AMPACITY ASSESSMENT

- DERATING FACTOR $= \frac{(Io - If)}{Io} \times 100$

Io = BASELINE AMPS (TEST OR ICEA STD)

If = AMPS @ 90C FOR CONDUIT/AIR DROP WITH TSI

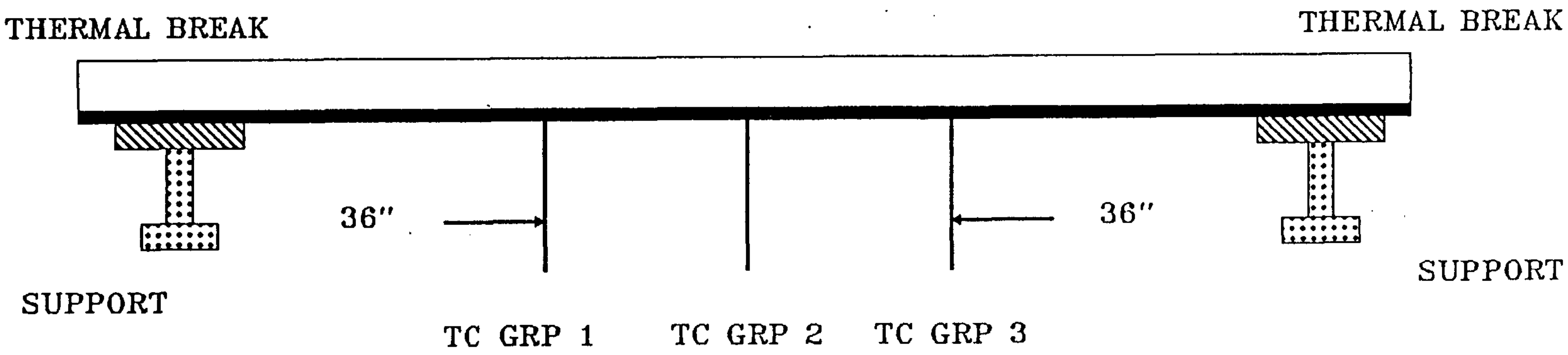
DETERMINED FOR : 1" AND 4" CONDUITS
: #6 AWG AND 750 Kcmil AIR DROP

THERMO-LAG
CABLE AMPACITY ASSESSMENT

- TRAY
  - 4" x 24" LADDER TRAY
  - 3/C #6 AWG CABLE
  - 40 PERCENT FILL
  - TRAY THERMALLY ISOLATED FROM SUPPORT
  - THERMAL DAMS TO MINIMIZE END EFFECTS
  - THERMOCOUPLES IN 3 PLANES ALONG LENGTH
  - TESTS IN TEMPERATURE CONTROLLED ENCLOSURE
  - BASELINE TEST ON OPEN TRAY

THERMO-LAG
CABLE AMPACITY ASSESSMENT

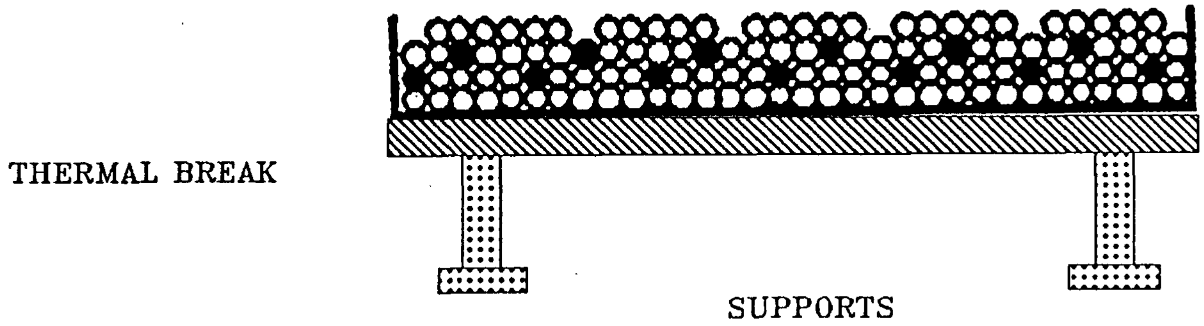
- THERMOCOUPLE PLACEMENT (SIDE VIEW)



4" x 24" LADDER TRAY

THERMO-LAG
CABLE AMPACITY ASSESSMENT

- THERMOCOUPLE PLACEMENT (CROSS SECTION)
- BLACK CIRCLES REPRESENT T/C LOCATIONS



122 3/C #6 AWG IN 4" x 24" TRAY

THERMO-LAG

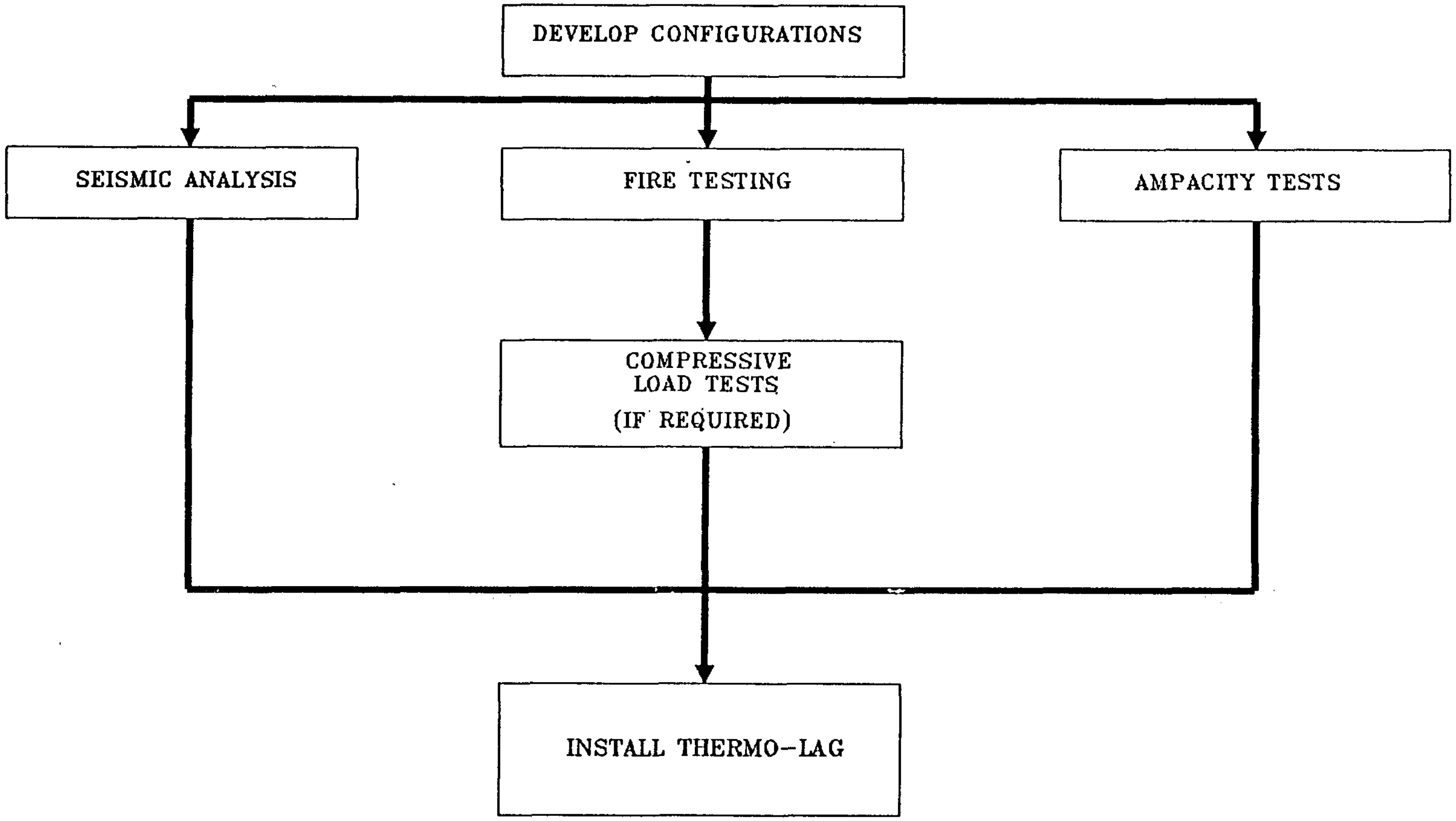
CABLE AMPACITY ASSESSMENT

- DERATING FACTOR $= \dfrac{(Io - If)}{Io} \times 100$

Io = BASELINE AMPS (LESSER OF TEST OR ICEA STD)

If = AMPS @ 90C FOR THE TRAY WITH TSI

THERMO-LAG TEST SEQUENCE



FIRE TESTING SCHEDULE

- CONDUITS / AIR DROPS - MID/LATE NOVEMBER 92

- CABLE TRAYS - MID DECEMBER 92

- JUNCTION BOXES /AIR DROPS - MID FEBRUARY 93