24. EVALUATION OF RADIANT ENERGY SHIELDS
NORTH ANNA POWER STATION

Description of Evaluation

This evaluation assesses the adequacy of Thermo-Lag 330 fire barrier material to perform as a radiant energy shield in Containment.

Area Description

Fire Areas 1-1 and 1-2 are the Primary Containments for Units 1 and 2 respectively. Each primary containment is a multi-level structure with floor elevations of 216 ft.-11 in., 241 ft.-0 in., 262 ft.-10 in., and 291 ft.-10 in. The outer shell of containment is constructed of reinforced concrete with a fire rating in excess of three hours. The primary components inside containment are located within concrete cubicles. The walkways and stairways in the containment are mostly steel grating. Access into containment is through a personnel access lock on the 291 ft.-10 in. elevation and through an equipment hatch that opens into the yard area.

Electrical penetrations exist at two locations within containment. The primary electrical penetrations are located at approximately 259 ft. elevation. This penetration area goes into the respective unit's Cable Vault/Tunnel (CV/T) penetration areas. The second penetration area is into the Fuel Building above the 291 ft. elevation.

Radiant energy shields in the form of either panels (flat sheets) or conduit wrap (conduit protective envelopes) have been provided to separate primary and alternate instrumentation or components which are less than 20 ft. apart (See

Table 24-1). These shields are constructed of 1/2" thick Thermo-Lag 330 fire barrier material in preformed conduit and panel shapes. The conduit wrap is provided until a distance of 20 ft. of horizontal separation is achieved or until a rated fire barrier (such as a concrete cubicle wall) is encountered. The panels are used to form free standing shields and box enclosures to separate redundant components that are not separated by 20 ft. These shields are designed to prevent a single fire from disabling both trains of instrumentation or components.

Fire Protection Systems

The primary containment has fire extinguishers located just outside the containment at the personnel access hatch. There are dry hose stations located on the top two floors in containment. Adequate hose lengths are maintained outside containment to reach all areas inside containment. If additional fire fighting equipment is needed, it is available at the point where the fire brigade will enter containment.

There are heat and smoke detectors installed within containment. Specifically, smoke and heat detectors are installed at the CV/T electrical penetration area and smoke detectors are installed in the main recirculation ducts. Heat detectors are installed at the reactor coolant pumps. These detectors annunciate to the continuously manned Control Room.

System Descriptions

The primary containments contain the instruments and cabling for the primary plant instrumentation required for safe shutdown. The ability of these systems to meet Appendix R separation requirements is discussed in Exemption Request 27. Also located in containment is the Residual Heat Removal (RHR) System, which is required for cold shutdown.

A radiant energy shield in the form of free standing panels or conduit wrap has been provided to separate primary and alternate components where there is less than 20 ft. separation. A listing of the instrumentation and components that are protected by the radiant energy shields can be found in Table 24-1. Exemption Request 27 also contains a number of Figures that show the location and routing of the radiant energy shields.

Evaluation

The fire hazard analysis is divided into four sections. The first section discusses the combustibility of the radiant energy shield material. The next three sections describe Thermo-Lag fire endurance tests, discuss Thermo-Lag installation procedures, and provide a description of the combustibles in containment.

1. Combustibility

Thermo-Lag 330-1 fire barrier material is a water-based material, which provides protection from a fire through a subliming process. The key components of Thermo-Lag 330-1 are: subliming powder, resin, and chopped fiber (partially composed of fiberglass). When the minimum heat flux of 750 BTUs per pound or greater is directed towards the barrier, the subliming material boils off as the Thermo-Lag begins to change state. An endothermic process pyrolizes the resin (which holds the powder together) into a final state, known as the "char layer." The chopped fibers are an integral part of the char layer matrix.

The National Institute of Standards and Technology (NIST), Test FR 3989, tested Thermo-Lag 330-1 fire barrier material to ASTM E-136 and ASTM E-1354. These tests revealed that Thermo-Lag 330-1 material is combustible. The NRC does not define a specific test (such as ASTM E-136 or ASTM E-1354) in its regulations or implementing documents as a determinant of combustibility. Underwriters Laboratories (UL), File No. R6076, Project No. 81NK3238, tested Thermo-Lag 330-1 to ASTM E-84 to determine surface burning properties. This test revealed Thermo-Lag 330-1 has a Flame Spread value of 5, a Smoke Developed value of 15, and a Fuel Contributed value of 0.

Section III.G.2.f of Appendix R to 10 CFR 50 requires separation of cables, equipment, and associated non-safety circuits of redundant trains inside noninerted containments by a noncombustible radiant energy shield. Appendix R does not provide specific requirements for radiant energy shields. The guidelines (not a requirement for North Anna) in BTP APCSB 9.5-1, Section C.7.a(1)b., indicate that radiant energy shields should have a "fire barrier" fire resistance rating of 1/2 hour. In Section 3.7.1 of GL 86-10, the NRC has stated any material with a 1/2 hour fire rating should be capable of performing the function of a radiant energy shield. This section goes on to state that non-fire-rated energy shields would also be acceptable if they have been demonstrated by a fire hazards analysis to provide protection against the anticipated hazard within the containment.

The NRC has noted that "fire barriers" are rated for fire resistance by being exposed to the standard test fire defined by ASTM E119, "Standard for Fire Resistance of Building Materials." BTP APCSB 9.5-1 and Appendix A to BTP APCSB 9.5-1 reference NFPA Standard 251, "Standard Methods of Fire Tests of Building Construction and Materials", which is identical to ASTM E-119, and define fire rating as: "the endurance period of a fire barrier or structure; it defines the period of resistance to a standard fire exposure before the first critical point in behavior is observed."

The NRC applies the ASTM E-119 or NFPA 251 acceptance criteria for non-bearing fire barriers to electrical raceway fire barriers (raceway protective envelopes). These criteria specify that the transmission of heat through the barrier "shall not have been such as to raise the temperature on its unexposed surface more than 250 °F above its initial temperature." It is generally recognized that the ambient air temperature is 75 °F at the beginning of a fire test. The resulting 325 °F cold side temperature criterion is used because the fire barrier function is to preserve the integrity of the cables and keep them free of fire damage.

It is clear from the testing performed to date by the NRC, UL, and industry that Thermo-Lag 330-1 material does exhibit some combustible behavior at temperatures in excess of 1000 °F or in the presence of large heat fluxes. It is not however a highly combustible material. Thermo-Lag installations in containment are such that there are negligible amounts of combustible material within 5 ft. of the radiant energy shields. Containment being a multi-level structure would direct heat and hot gasses from a fire upward and away from the radiant energy shields. Therefore the radiant energy shields are not expected to see temperatures in excess of 1000 °F or be exposed to large heat fluxes.

2. Fire Endurance Tests

Texas Utilities (TU) instituted a fire endurance testing program to qualify its Thermo-Lag 330 electrical fire barrier systems (raceway protective envelopes) during the weeks of June 15, 1992 and June 22, 1992. Tests were witnessed by the NRC with the results described in NRC Bulletin 92-01. TU Electric's test program consisted of a series of 1 hour fire endurance tests (using ASTM E-119 Standard) on a variety of cable tray and conduit configurations.

The fire barrier installation on the conduit test configuration was performed in accordance with Thermo-Lag installation procedures and certified installers. On June 17, 1992, the first test was conducted. This test consisted of a junction box with a 3/4", 1", and 5" conduit entering and exiting the conduit box. The tested configuration used pre-formed 1/2" thick Thermo-Lag 330 conduit shapes to provide a 1 hour fire rating. Throughout the test, the cable inside the conduit was monitored for low voltage circuit integrity, continuity, and temperature. Throughout the test, none of the cables experienced a failure in circuit integrity. At 60 minutes, the temperature on the inside cover of the junction box and inside the 3/4" and 1" conduits exceeded the 325 °F cold side temperature criteria.

As a follow up to Bulletin 92-01, the test results were discussed with Mr. C. E. Beckett and Mr. T. Wright, TU Comanche Peak Station, by telephone on 7/06/92. They indicated that at 30 minutes into the test the temperatures inside the junction box and inside the 3/4" and 1" conduits was below 325 °F (see Attachment 24-1). Based on this information, the Thermo-Lag would be expected to satisfy the fire barrier criteria for a 1/2 hour fire rating since the cold side temperature did not exceed 325 °F at 30 minutes into the test.

On July 15, 1992 the National Institute of Standards and Technology (NIST) conducted small scale 1 and 3 hour fire endurance tests to determine the fire resistive properties of 1/2 and 1 inch thick Thermo-lag pre-formed panels. The fire tests conducted by NIST were classified as small scale tests. The small scale tests are not considered definitive in that the tests were not full scale, and therefore the results are not used to qualify the fire rating of a material. The results of those tests were presented in NRC IN 92-55, Current Fire Endurance Test Results for Thermo-Lag Fire Barrier Material. The tests consisted of a 31.5 inch square Thermo-Lag panel placed horizontally in a frame above a gas-fired furnace. The 1 hour test (1/2" thick panel) resulted in an average thermocouple reading on the unexposed side in excess of 325 °F in approximately 22 minutes. The unexposed surface of the material reached an average temperature of 1206 °F at 45 minutes. During the test, the panel burned through in 45 minutes. At the end of test, approximately 85% of the unexposed surface was blackened.

On August 6, 1992, the NRC sponsored a second 1 hour fire endurance test on a Thermo-Lag 330 1 hour panel, which had stress skin on one side only. This panel was placed on the furnace with the stress skin towards the fire. The stress skin was restrained by the furnace specimen support lip. The average unexposed surface temperature of the specimen exceeded 325 °F in 34 minutes. At 1 hour, the maximum temperature of the unexposed surface was 458 °F. However the specimen was not burned through. The performance of the specimen in this test was superior to the specimen tested on July 15, 1992, at which the stress skin faced the unexposed side, as recommended by the vendor.

3. Installation Procedure

A review of the Design Change Packages (DCPs) that installed Thermo-Lag 330 fire barrier material at both stations was conducted. The review of the DCPs has indicated that 1/2" thick preshaped conduit and panel sections were installed in accordance with the manufacturers installation manual. The installation was performed by trained installers and the installations were verified by station QC personnel.

4. <u>Combustible Loading</u>

The combustible loading analysis found in Chapter 8, Table 3, of the Appendix R report provides a calculation of Equivalent Fire Severities (EFS) for the Fire Area being analyzed. The EFS provides a method by which an area's combustible contents are related to the standard time-temperature curve. Fire Areas 1-1 (Unit 1 containment) and 1-2 (Unit 2 containment) have a EFS of 11 and 13 minutes respectively. The fixed combustibles contributing to the combustible loading for containment are comprised of cable insulation (≈59%), lube oil (≈34%), and charcoal (≈7%). The contribution from Thermo-Lag is considered to be negligible since it is less than 1%.

Intervening combustibles of concern are cable trays. In order to mitigate the potential of fire spread along the trays, vertical and horizontal fire stops (Marinite Board and Silicone foam) have been installed where the cable trays constitute a potential intervening combustible threat. Cable tray top covers have been installed on the cable trays in the vicinity of the Cable Vault/Tunnel penetration area in both unit's containment. In addition, a cable tray bottom cover has been installed in the lowest horizontal cable tray in this area. These cable tray covers provide protection to the trays from an exposure fire. However, these tray covers are not required to provide adequate separation or mitigate intervening combustibles between primary and alternate trains of instrumentation, which is accomplished by fire stops.

While a unit is at power, the only pumps in containment that are operating are the reactor coolant pumps. Each of these pumps has an oil collection system and is separated from the balance of the containment by a concrete open-top cubicle. Therefore, there is a minimum chance of a pressurized oil fire exposing the cables outside the cubicles while the unit is at power.

Station operating procedures limit access to containment while the unit is operating, thereby limiting transient combustibles as well. Transient combustibles during normal operations are essentially nonexistent.

Conclusion

The current configuration of radiant energy shields is expected to provide an equivalent level of protection as that required by Appendix R, Section III.G.2(f). The technical bases that justify this conclusion are summarized as follows:

1. The guidance provided by Appendix R and GL 86-10 indicates a 1/2 hour fire rated material or a non-fire-rated material justified by analysis are acceptable as radiant energy shields.

2. The 1/2 inch thick conduit sections (conduit protective envelopes) of Thermo-Lag will provide at least 30 minutes of fire resistance, based on fire endurance tests performed by TU.

3. The 1/2 inch thick panels of Thermo-Lag will provide at least 22 minutes of fire resistance, as indicated by small scale tests conducted by NIST. These tests are not considered definitive and are not used as a basis for determining the fire resistance rating of a material.

4. Based on containment design and the conditions in which Thermo-Lag is used in containment, radiant energy shields are not expected to see temperatures in excess of 1000 °F or be exposed to large heat fluxes.

5. The RHR pump motors are not expected to be damaged from an exposure fire due to the limited combustibles in containment and the heavy gauge metal construction of the pump motors.

6. Vertical and horizontal fire stops have been installed to prevent cable trays from being intervening combustibles.

7. Cable tray top covers are installed on all cable trays in the penetration area.

8. The bottom of the lowest horizontal cable tray on elevation 262 ft.-10 in. in the penetration area has been equipped with a cable tray cover.

9. Predominantly metal grate walkways in the cable tray areas eliminate the possibility for oil pool formation and subsequent pool fires.

10. Station operating procedures limit access to containment while the unit is operating, thereby limiting transient combustibles as well.

11. The only oil fire exposure in containment while the unit is operating is from the reactor coolant pumps. Each RCP has an oil collection system and is in a cubicle that will prevent exposure to the cable trays and penetration areas.

12. There are heat and smoke detectors in each containment in areas where there are concentrations of combustibles, which annunciate to the Control Room.

TABLE 24-1

RADIANT ENERGY SHIELD CONTAINMENT
THERMO-LAG 330 FIRE BARRIER MATERIAL
NORTH ANNA POWER STATION

ITEM	LOCATION	DESCRIPTION
1.	Units 1 and 2, RHR pump motors 1-RH-P-1A & 1B and 2-RH-P-1A & 1B, elev. 231'-6".	Radiant energy shield, 1/2" thick panels mounted to steel frame to form shield between pump motors.
2.	Units 1 and 2, the cable penetration to the Fuel Building, elev. 291'-0", column 5 (Unit 1) and column 13 (Unit 2).	Radiant energy shield, 1/2" thick panels mounted to a steel frame to form a 4 sided box around penetration.
3.	Unit 1, transmitters PT-RC-1000 & LT-RC-1000, elev. 262'-10", column 9.	Radiant energy shield, 1/2" thick panels mounted to a steel frame to form box around transmitters.
4.	Unit 2, transmitters LT-RC-2000 & LT-2461, elev. 262'-10", column 6.	Radiant energy shield, 1/2" thick panels mounted to steel frame to form shield between transmitters.
5.	Unit 1, conduit 1CX933NB (1.5") from PT-RC-1000 & LT-RC-1000 to Fuel Building penetration.	Radiant energy shield, 1/2" thick preformed sections attached to conduit.
6.	Unit 2, conduit 2CX906NV (1.5") from LT-RC-2000 for 20' to column 5 and from column 17 to Fuel Building penetration.	Radiant energy shield, 1/2" thick preformed sections attached to conduit.
7.	Unit 1, conduit (4") (wide and source range neutron flux indication) elev. 241'-6" between columns 4 & 6.	Radiant energy shield, 1/2" thick preformed sections attached to conduit.

TELECOPY COVER SHEET

COMANCHE PEAK STEAM ELECTRIC STATION
GLEN ROSE, TEXAS

TU ELECTRIC
DESIGN ENGINEERING

Telecopy To: TOM CARLISLE , 2211
Name Ext.

Telecopy Number: 804-273-2690

From: TIM WRIGHT , 6179
Name Ext.

No. of Pages (including Cover Sheet): 4

Comments: IF YOU HAVE ANY QUESTIONS, CALL ME @ 817-897-6179

TIM WRIGHT

Date: 7-15-92

Document To Be: ✓ Returned ____ Discarded

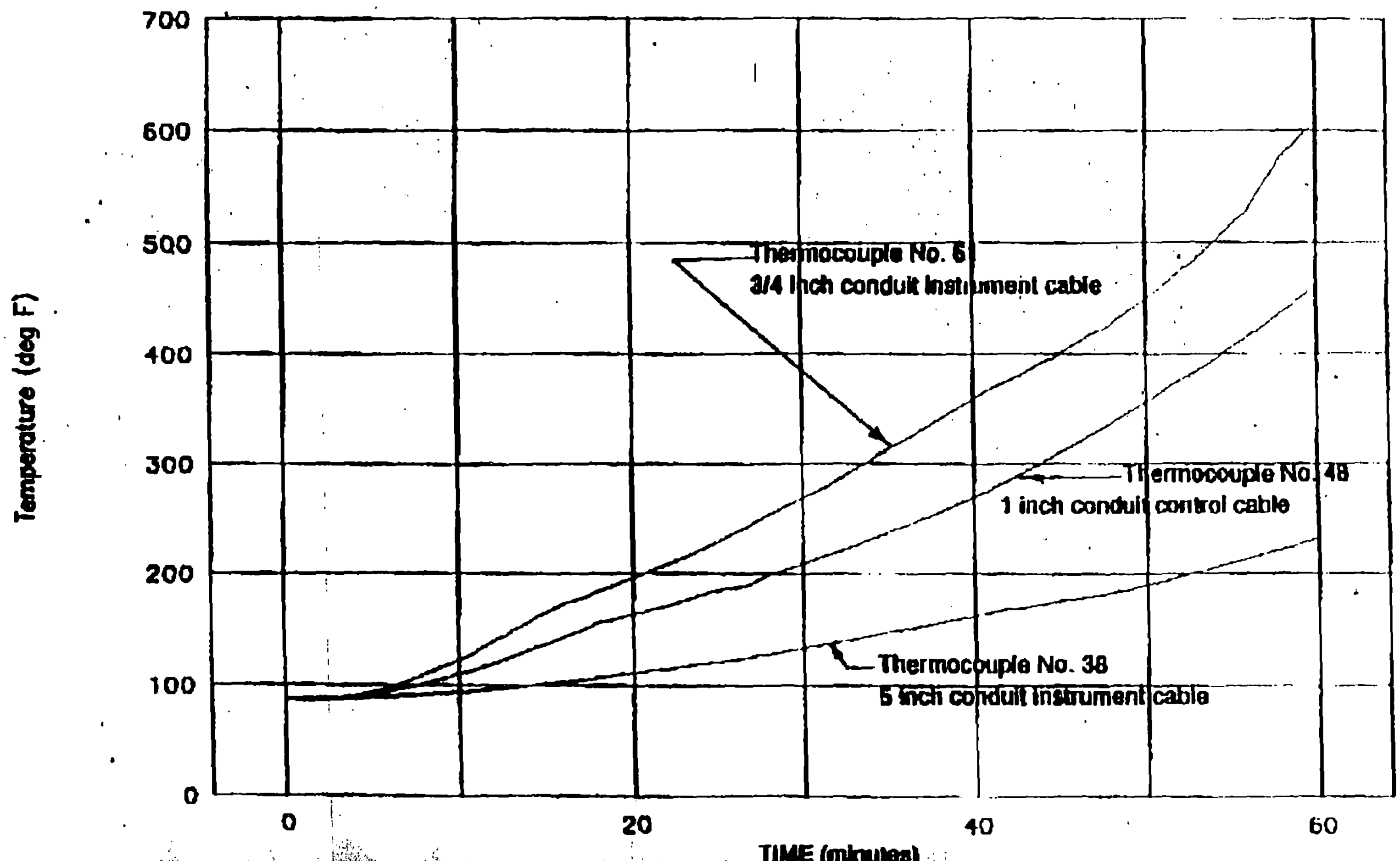
Fax Number: 817-[illegible]
Verification Number: 817-[illegible]

TEST PERFORMED 6-17-92

WORST CASE CABLE THERMOCOUPLE READINGS

(SCHEME 2)

FOR THERMOCOUPLES Nos. 38,48 & 61

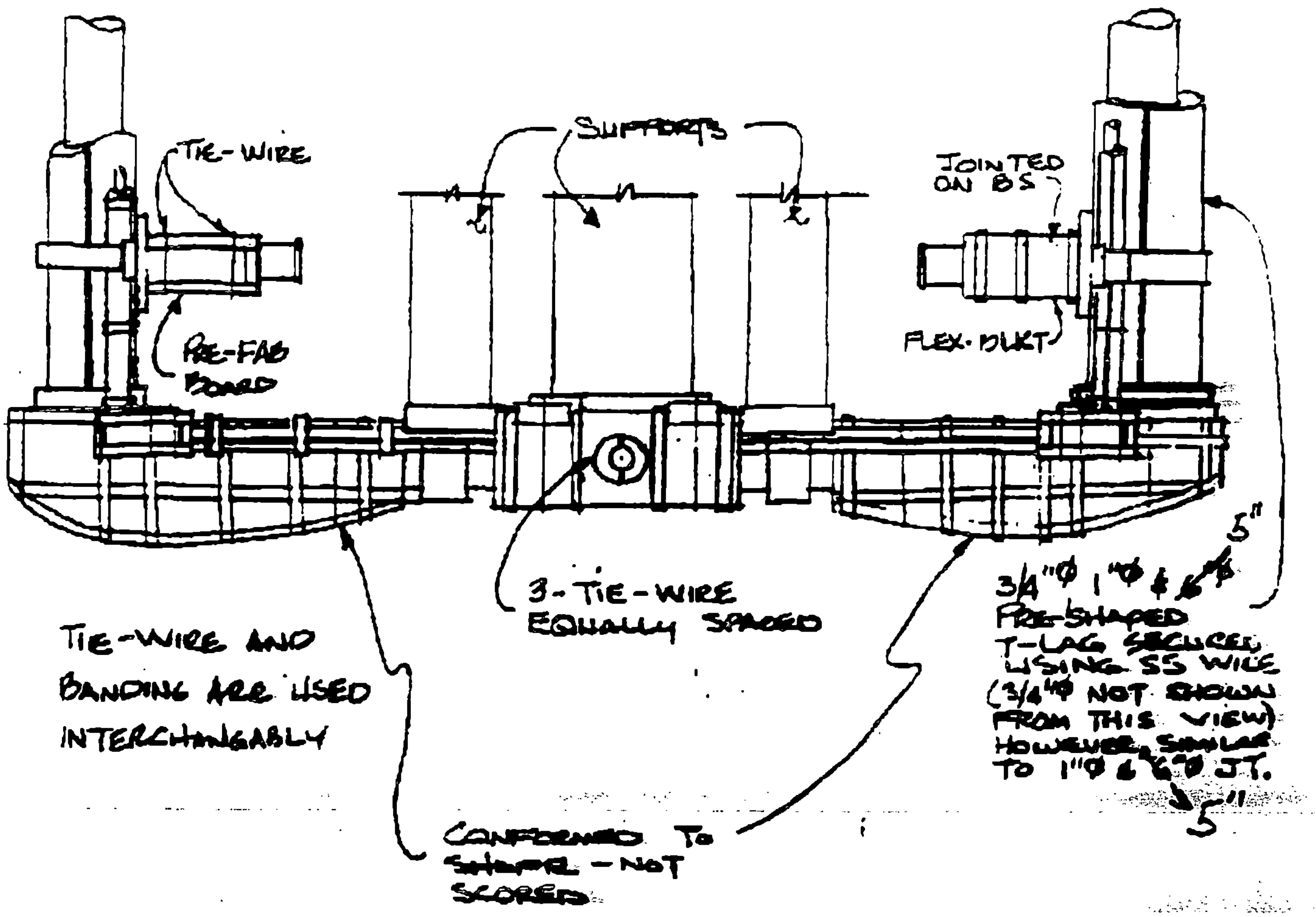


ID:8178970963 JUL 15 '92 14:46 No.030 P.02

TEST 6-17-92

A. (CONT)

- Thermo-Lag Details. (typical for both assemblies)



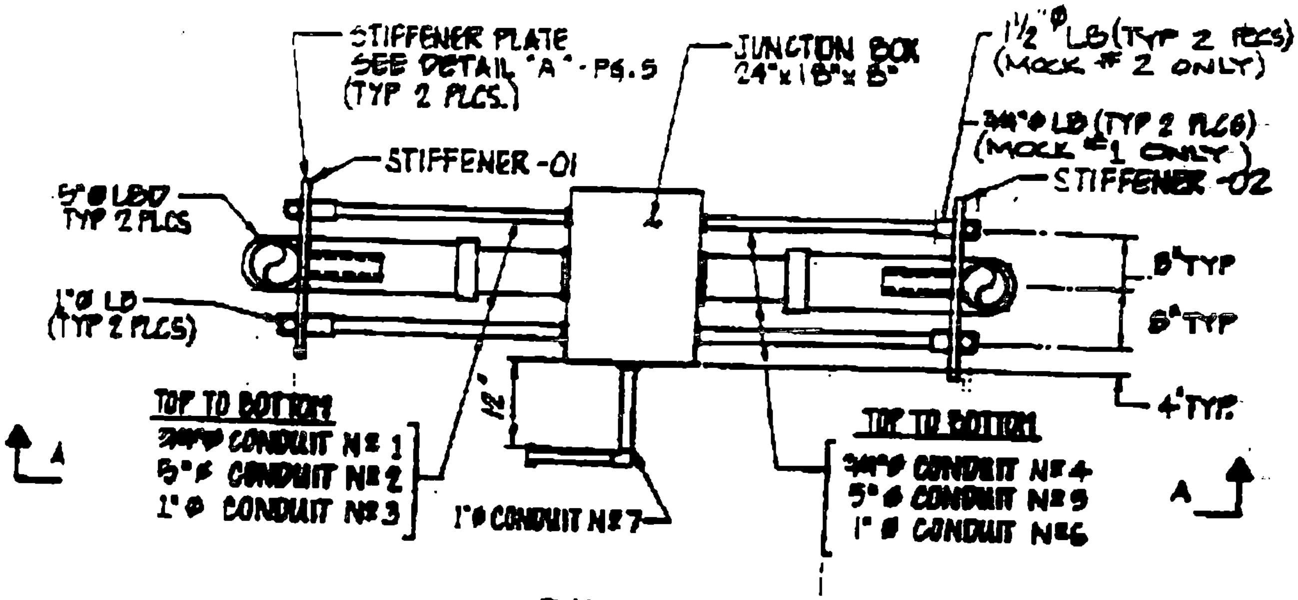
SECTION A-A

TEST 6-17-92

IV. CONDUIT AND J-BOX ASSEMBLY (SCHEME 2)

A. CONFIGURATION SKETCHES

- General configuration (typical for both assemblies)



PLAN VIEW
SUPPORTS NOT SHOWN FOR CLARITY