NES

# COMPARISON OF HEMYC SYSTEM FIRE TEST TO SANDIA 20-FT. SEPARATION TEST AND CMEB 9.5.1

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## 1. INTRODUCTION

On December 3, 1982, representatives of NES/INSULCO and several utilities met with the NRC in Washington DC to present the HEMYC Fire Protection System. The HEMYC System had been previously accepted by the ANI as a one-hour barrier for application to all U.S. cable types based on the E-119 fire test, hose stream, continuity and insulation resistance tests conducted in May 1982.

During the meeting, a concern about maximum cable temperatures achieved during the tests was discussed. In response to that concern, NES has prepared this paper, summarizing HEMYC test results and assessing other available data (Sandia 20-ft. separation report, CMEB 9.5.1) that were suggested to be pertinent during the meeting.

## 2. HEMYC SYSTEM TEST DESCRIPTION

Three tests were conducted for a variety of insulation wrapping and cable mix configurations for both cable trays and conduits exposed to the standard time-temperature curve defined by ASTM E-119. During each test, control cables were energized with low voltage (24V) and connected to a light detection system which indicated the occurrence of short circuits. Thermocouples were placed between cables in the trays and on the inner wall surfaces of the conduits. Subsequent to the test, the cables were subjected to a "megger" test (at 500V for a minimum of 30 seconds) to establish insulation resistance values, and a visual examination was conducted to evaluate any visible damage to the cable jackets.

1) Test No. 1

The layout for this test consisted of two 12-inch wide trays stacked vertically with 8 inches of vertical separation. The HEMYC system encapsulated both trays. The upper tray had 100% visual fill with PE/PVC cables; the lower tray featured a single layer of the same type of cable. The insulation material was placed around the trays with a 2-inch air gap.

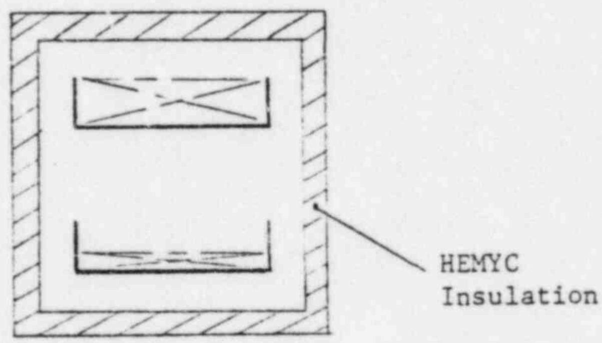
2) Test No. 2

In this test, a 12-inch tray with a single layer of PE/PVC cables was insulated with a 2-inch air gap. (In addition, two 4"-diameter conduits, 2 inches apart on the horizontal plane, were also insulated with a 2-inch air gap. The conduit direct wrap method evaluated in Test No. 3 achieved better results and is being offered as the preferred insulation approach for conduits.)

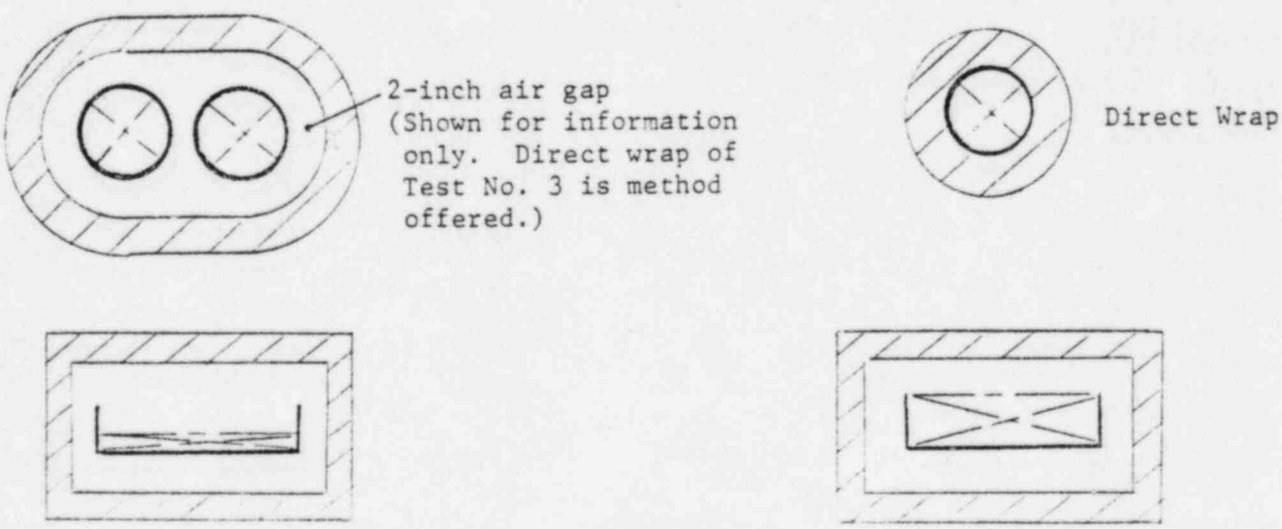
3) Test No. 3

In this test, a 12-inch tray with 100% visual fill of PE/PVC cables was insulated with a 2-inch air gap. In addition, a single 4"-diameter conduit was direct-wrapped.

Layouts of the configurations are shown below.




TEST NO. 1




TEST NO. 2

TEST NO. 3

# 3. RESULTS OF HEMYC TESTS

In all of the configurations described, it was observed that:

1) The cables had maintained circuit continuity at all times.
2) Insulation resistance "megger" tests resulted in minimum values of 600 to ∞ M Ω for direct wrap conduit cables and 150 to ∞ M Ω for the tray cables. (15 MΩ is considered to be adequate by industry standards.)
3) No functional damage to the cables had occurred.
4) Maximum thermocouple temperatures for all three tests never exceeded 180°C at the 50-minute mark of the one-hour test and only one recorded as high as 215°C in single-layered tray and 210°C for direct-wrap conduit at the 60-minute end point of the test.

Detailed results are presented in Table 1 below:

TABLE 1 HEMYC SYSTEM FIRE TEST RESULTS

| Test No. | Item | Maximum Ambient Temperatures @50 min. | Maximum Ambient Temperatures @60 min. | Circuit Integrity | Insulation Resistance | Functional Damage |
|---|---|---|---|---|---|---|
| 1 | Upper Tray | 60°C | 63°C | Yes | ∞ M Ω | No |
| | Lower Tray | 78°C | 81°C | Yes | ∞ M Ω | No |
| 2 | Tray (Single Layer) | 180°C | 215°C | Yes | 150- ∞ MΩ | No |
| 3 | Tray (100% fill) | 105°C | 110°C | Yes | ∞ M Ω | No |
| | Conduit (Direct wrap) | 180°C | 210°C | Yes | 600- ∞ MΩ | No |

It should be noted that the temperatures reported above are ambient air readings as the thermocouples were placed between cables in the trays and on the inner wall surfaces in conduits. Actual cable jacket temperatures are lower than those reported above.

# 4. ASSESSMENT OF SANDIA TESTS AND CMEB 9.5.1

## 4.1 Sandia Tests

An Underwriters Laboratory/SANDIA report, "Evaluation of Twenty-Foot Separation Distance, 10 CFR 50 Appendix R", has been referenced as having data on cable temperatures that may be pertinent to establishing the temperature levels at which cable insulation breakdown occurs. A review of the document indicates that the tests were performed to determine the effectiveness of the fire protection afforded by the separation of redundant safety-related cables by a horizontal distance of 20 feet with no intervening combustibles or hazards. In addition to preliminary fire experiments performed to provide exact configuration data and check out the instrumentation, six full-scale tests were performed for a variety of cable types and tray configurations to provide information with respect to circuit integrity and voltage withstand of cable insulation.

While the report is not specific enough to allow the development of direct correlations between the occurence of circuit shorts and corresponding temperatures (and thereby is of limited use for verifying HEMYC results), it does, nevertheless, present some data that confirm the margins of safety in the HEMYC system. Outlined on the following page are some of the salient features of the SANDIA tests that point to the conservative nature of the direct applicability of their results.

1) Cables were placed in the 18-inch wide trays in continuous loops to simulate 42 cable segments across the trays. This indicates that cable failure (loss of load carrying ability due to shorts) was observed at the cable U-bends with extremely tight radii. Because of high stresses in the tight bends, cable insulation failed in those areas at relatively low temperatures.

2) Cable jacket temperatures were recorded by thermocouples installed in five locations in the middle of the trays (3.5 feet from the bends) and, hence, are not directly indicative of temperatures at failure points at the bends at the time of observed shorts.

3) The test trays were subjected to open fire sources with potential exposure to direct flames and hot gases from the fire pans filled with heptane. Sporadic puffs of irregularly shaped flames deflecting along the ceiling were observed in all tests. Hence, there were local hot spots in the cable trays which could not occur in trays and conduits encapsulated by the HEMYC system.

4) Cables were secured to tray rungs with steel wire ties at the ends providing direct heat transfer paths which could contribute to cable failures at the bends.

Of the six tests conducted by SANDIA, Tests 1, 3 and 5 utilized non-qualified cables (3/C #12, PE/PVC) in layer loops in two

(upper and lower) trays. Tests 2, 4 and 6 were run with IEEE-383 qualified cables. Upon review, results of Test 1 were selected as being most directly applicable, albeit within the limitations discussed above, to the HEMYC system, inasmuch as Test 1 also features PE/PVC cables in open ladder types with no tray covers and plate insulation on cables (as in Tests 3 and 4), or no 1/8" thick cable coatings of thermoplastic resins, flame retardant chemicals, and inorganic fibers (as in Tests 5 and 6). Cable jacket temperatures were reported based on thermocouples embedded in cable jackets. Gas (ambient) temperatures measured nearest the trays were also reported and are the equivalent temperatures comparable to those measured as ambient air values by the HEMYC tests, which used thermocouples placed between cables (or on the inner walls of the conduits) rather than within the cable jackets. A summary of results is given in the table below:

TABLE 2 SANDIA FIRE SHORTING RESULTS

| | | Upper Tray | | Lower Tray | |
|---|---|---|---|---|---|
| Cable Type | Test No. | Time | Ambient Temp's | Time | Ambient Temp's |
| Non-qualified | 1 | 244 sec. | 500°C | 262 sec. | 460°C |
| NQ | 3 | PASSED | 340°C max. | *1043 sec. | *230°C* |
| NQ | 5 | 642 sec. | 380°C | 776 sec. | 330°C |
| Qualified | 2 | 775 sec. | 290°C | PASSED | 510°C max. |
| Q | 4 | PASSED | 350°C max. | PASSED | 350°C max. |
| Q | 6 | PASSED | 390°C max. | PASSED | 390°C max. |

*This data point is suspicious as it reports a cable short at unexpectedly low ambient gas temperature of 230°C, four minutes after a peak of 350°C was recorded. (The maximum cable jacket temperature at the time of the short was also recorded at an unlikely 70°C.)

Ambient gas temperatures reproduced in Table 2 are values measured at the time of the shorts for tests and trays where such shorts were observed. In cases where the cables passed the fire test with no failure, the peak ambient gas temperatures recorded in the entire test are reported.

Results indicate the the SANDIA non-qualified cables comparible to PE/PVC cables used in the HEMYC system were subjected to ambient gas temperatues of 330°C to 500°C before they shorted. Maximum cable jacket temperatures of 350°C were measured for Test 1 (the reference SANDIA test for comparison to HEMYC test) at the time of the short in lower tray (244 seconds). The corresponding values for the upper tray at 262 seconds was 400°C. Given that the HEMYC system is to be used on cables with under more conservative conditions (no tight radii, protected against direct flame and gases, etc.) and since the HEMYC tests resulted in no shorts and no functional damage up to ambient air temperatues of 215°C, it can be concluded that the HEMYC system exceeds the temperature requirements of a one hour fire barrier.

## 4.2 CMEB 9.5.1

An evaluation of the applicability of NRC Position CMEB 9.5.1 requirements to cable temperatures indicates that the 325°F (163°C) acceptance criterion stipulated therein was primarily established for fire stops and penetrations designed to prevent ignition of nearby combustibles, such as oil tanks, stored gas, hydrogen lines, etc., on the unexposed side. Accordingly, this criterion cannot be considered a realistic limit for tray and conduit insulation.

## 5. CONCLUSIONS

HEMYC tests resulted in no cable damage, no loss of continuity and insulation resistance, even for maximum temperatures of up to 215°C reached during the tests. In the SANDIA tests, temperatures of up to 330°C were shown not to compromise the ability of the cables to carry full load, cable insulation resistance remained acceptable and no functional damage was shown. In conclusion, the HEMYC system has adequately demonstrated its ability to protect cable safety channels following a one-hour (ASTM E-119) fire and subsequent hose stream test.

NES/INSULCO

INSULCO: - THERMAL INSULATION AND

- PENETRATION SEALS CONTRACTOR

NES: ENGINEERING, DESIGN, MANUFACTURING AND CONSTRUCTION SERVICE COMPANY.

JOINTLY, NES & INSULCO INTRODUCED THE HEMYC SYSTEM WHICH WAS TESTED TO MEET 10 CFR 50 APPENDIX-R ONE HOUR FIRE BARRIER REQUIREMENTS.

## SYSTEM TESTED

I) Trays

A. LIGHTWEIGHT METAL FRAMEWORK THAT:

- CLAMPS TO CABLE TRAY
- PROVIDES 2-IN. DEAD AIR SPACE
- RAILS WITH STUDS - 9" CENTER FOR BLANKET ATTACHMENT.

B. BLANKETS

- 1 1/2 CERAMIC FIBER
- ENVELOPED WITH FIREPROOF SILTEMP
- EXTERNAL STITCHING - QUARTZ THREAD
- CROSS STITCHING - COTTON OR NYLON THREAD
- SIZED FOR MINIMUM 2 INCHES OVERLAP, BEYOND STUDS

C. SILTEMP CLOTH

THE SILTEMP CLOTH SERVES TWO PRIMARY FUNCTIONS:

1. KEEPS THE CERAMIC BLANKET FIBER FROM BEING DISLODGED BEFORE, DURING OR AFTER A FIRE.
2. PROVIDES A WATER-REPELLANT FIRE BARRIER.

## SUMMARY OF TESTS

### FIRE TEST

PERFORMED TO THE ASTM E-119 SPECIFICATION.

### HOSE STREAM TEST

PERFORMED TO THE ANI INFORMATION BULLETIN 5(79), "ANI/MAERP STANDARD FIRE ENDURANCE TEST METHOD TO QUALIFY A PROTECTIVE ENVELOPE FOR CLASS 1E ELECTRICAL CIRCUITS, SECTION 3.4.2, TEST #1, (PREFERRED TEST)."

### WATER REPELLANT TEST

PERFORMED PER MANUFACTURER'S SPECIFICATION.

### TEST RESULTS

HEMYC SYSTEM SUCCESSFULLY PASSED ASTM E-119 FIRE TEST. RECEIVED ANI ACCEPTANCE AS A 1-HOUR FIRE BARRIER FOR APPLICATION TO CABLE TRAYS (SINGLE/MULTIPLE), CONDUITS, CABLE DROPS AND JUNCTION BOXES FOR ALL CABLE TYPES USED IN U.S. POWER PLANTS.

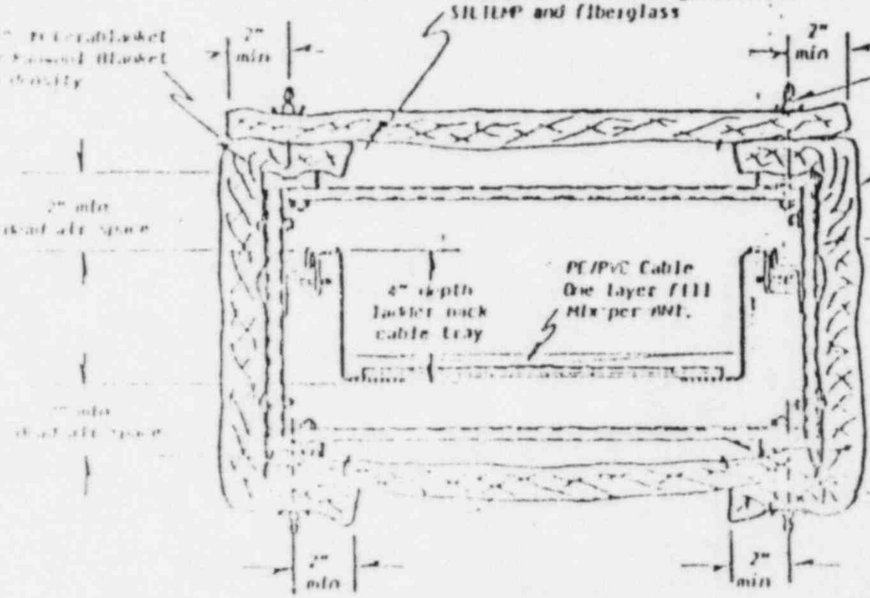
# HEMYC SYSTEM

## SALIENT FEATURES

- 1-HOUR FIRE BARRIER, APPLICATION TO:
  - CABLE TRAYS (SINGLE/MULTIPLE)
  - CONDUITS
  - JUNCTION BOXES, ENCLOSURES AND CABLE DROPS
- APPROVED FOR ALL U.S. CABLE TYPES.
- INSTALLED WITHOUT MODIFICATIONS TO THE CABLE TRAYS AND CONDUITS (I.E., NO DRILLING OR WELDING)
- PREFABRICATED SO AS TO MINIMIZE INFIELD APPLICATION LABOR AND ASSOCIATED QA/QC.
- PROVIDES EASY ACCESS INTO CABLE TRAYS, JUNCTION, BOXES, ETC.
- SYSTEM OPENED AND CLOSED WITHOUT NEW MATERIALS.
- NO RAD WASTE GENERATED
- ACTS ON CABLE TRAYS AND CONDUITS AS AN ADDED MASS EFFECT-ESSENTIALLY SIMILAR TO ADDING ADDITIONAL CABLES.
- LIGHTWEIGHT, MINIMIZES IMPACT ON CABLE TRAY/CONDUIT SYSTEM SUPPORTS.
- TREATED TO BE WATER-REPELLANT.
- DURABLE, 40-YEAR PLANT LIFE.

C7

**NOTE:**
Prefabricated blanket section dimensions determined by installers on a case by case basis. SILTEMP and fiberglass to be sewn with fire retardant Astroquartz or similar thread.



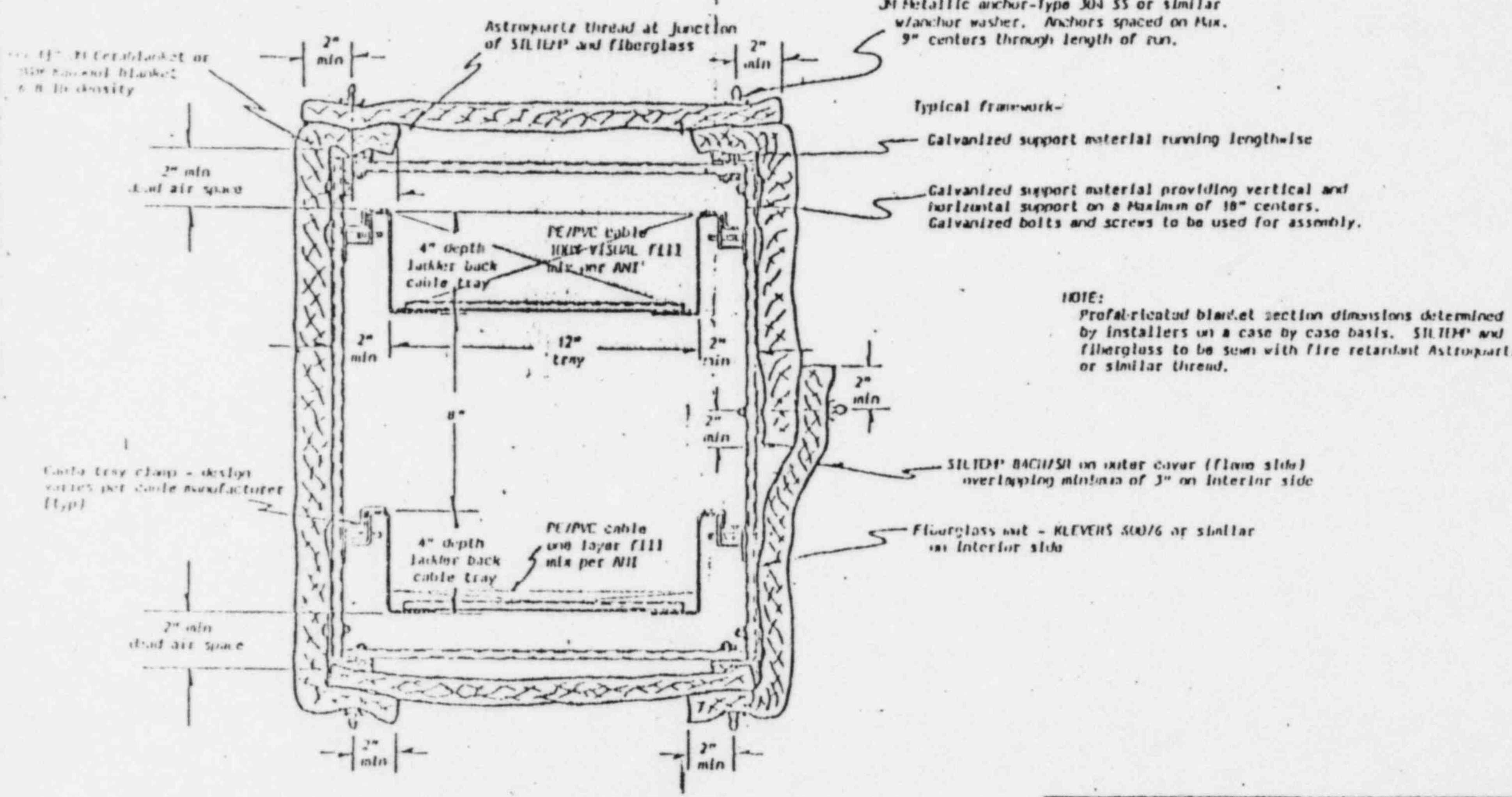

SECTION A-A

SINGLE CABLE TRAY
NON-VENTED
(TEST TWO)

| REVISIONS | | |
|---|---|---|
| NO | DATE | BY |
| | | |
| | | |
| | | |
| | | |
| | | |

HEMYC SYSTEM
SINGLE CABLE TRAY (NON VENTED)

| | | |
|---|---|---|
| LCS | nts | as noted |
| | 7/19/82 | |
| | | B - 222.9 |




SECTION A-A
MULTIPLE CABLE TRAY
(TEST ONE)

| REVISIONS | | | |
|---|---|---|---|
| NO | DATE | BY | Innovation, Inc. |
| 1 | | | HEMYC SYSTEM |
| 2 | | | MULTIPLE CABLE TRAY |
| 3 | | | DRAWN BY LCS — SCALE NTS — MATERIAL as noted |
| 4 | | | CHK'D — DATE — DRAWING NO |

## II. Conduits - DIRECT WRAP

### A. Strap

- CLAMPED TO CONDUIT
- PROVIDES CLIPS FOR ATTACHING BLANKET

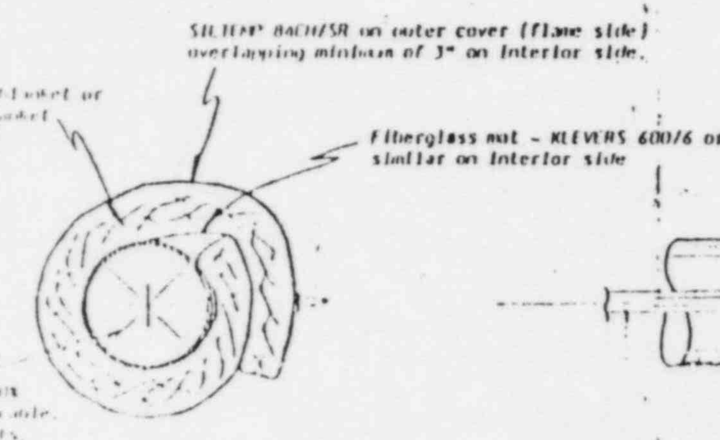
### B. Blankets

- SAME AS TRAY BLANKETS EXCEPT - 2" CERAMIC FIBER USED.

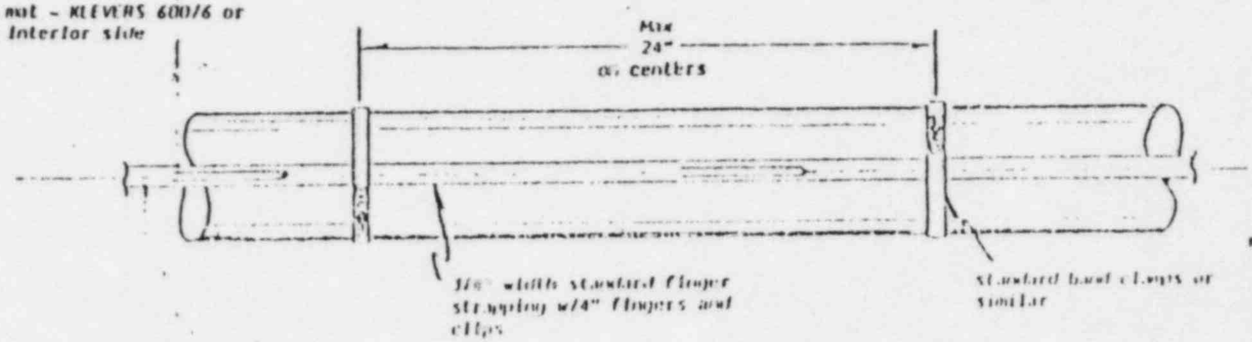
### C. Siltemp

SAME AS ON TRAYS.

NOTE:
Prefabricated blanket section dimensions determined by installers on a case by case basis. SILTEMP and fiberglass to be sewn with fire retardant Astroquartz or similar thread




SECTION B-B
SINGLE CONDUIT W/O AIR SPACE
(TEST THREE)




TYPICAL INSTALLATION
OF FINGERSTRAP

REVISIONS — NO. / DATE / BY

HEMYC SYSTEM
SINGLE CONDUIT W/O AIR SPACE

Drawn: FCS · Scale: nts · Material: as noted · Date: 7/19/82 · B - 222.13

## III. Conduits - stand-off

### A) Lightweight framework

- clamps around conduit(s)
- provides 2-in. dead air space
- rail has studs - 9" center for attaching blankets.

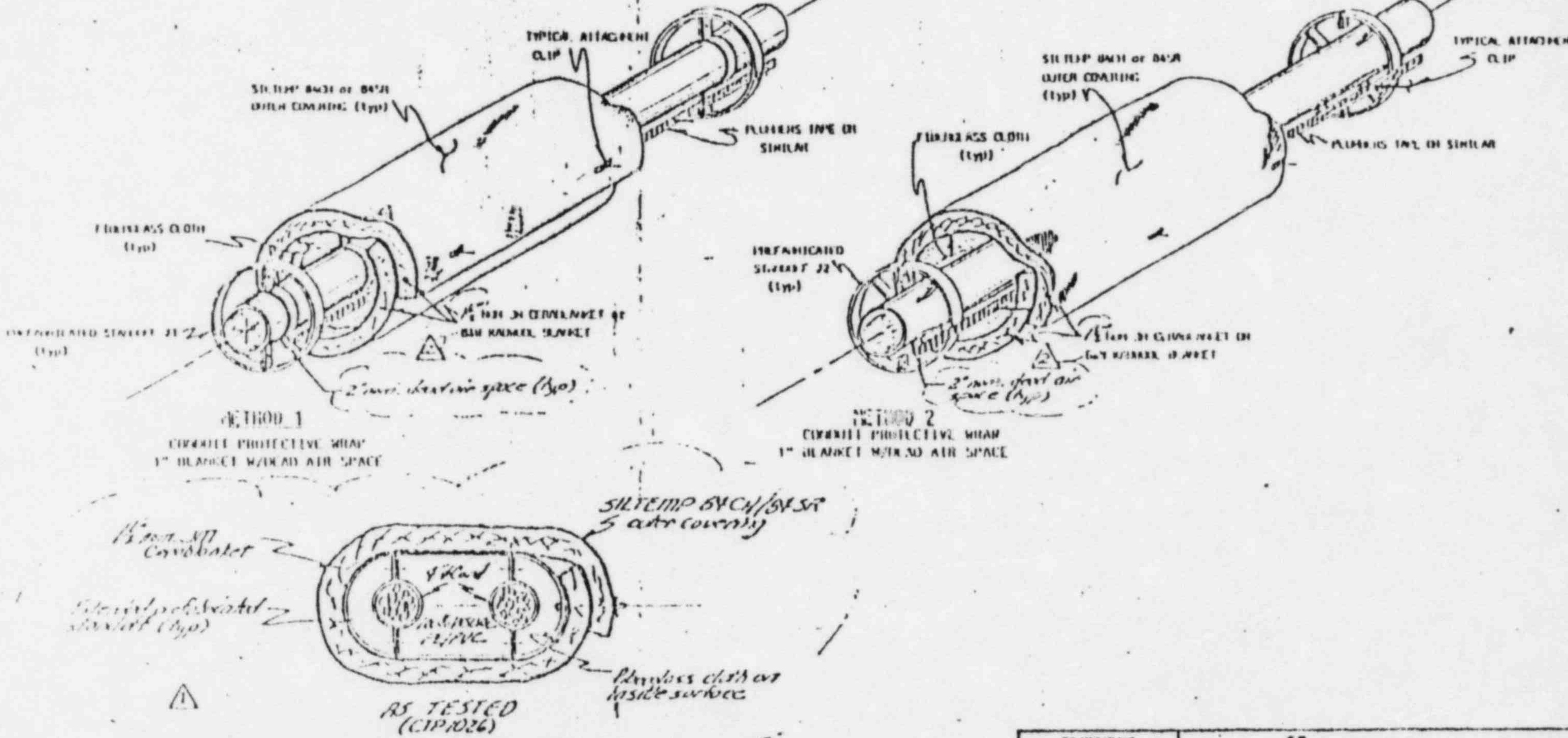
### B) Blankets

same as trays.

### C) Siltemp

same as trays.

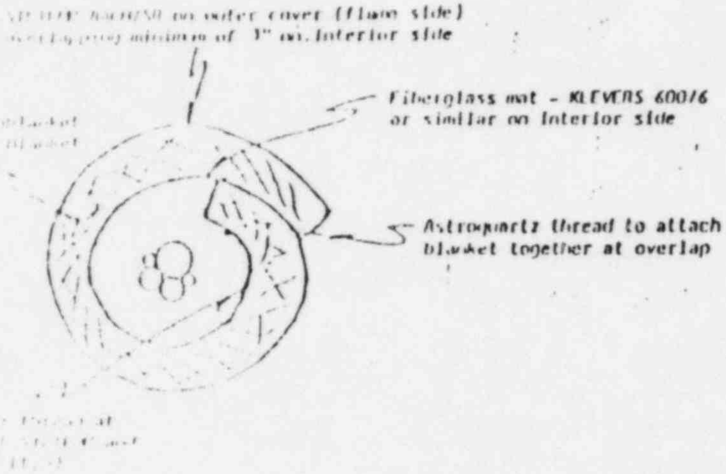
93



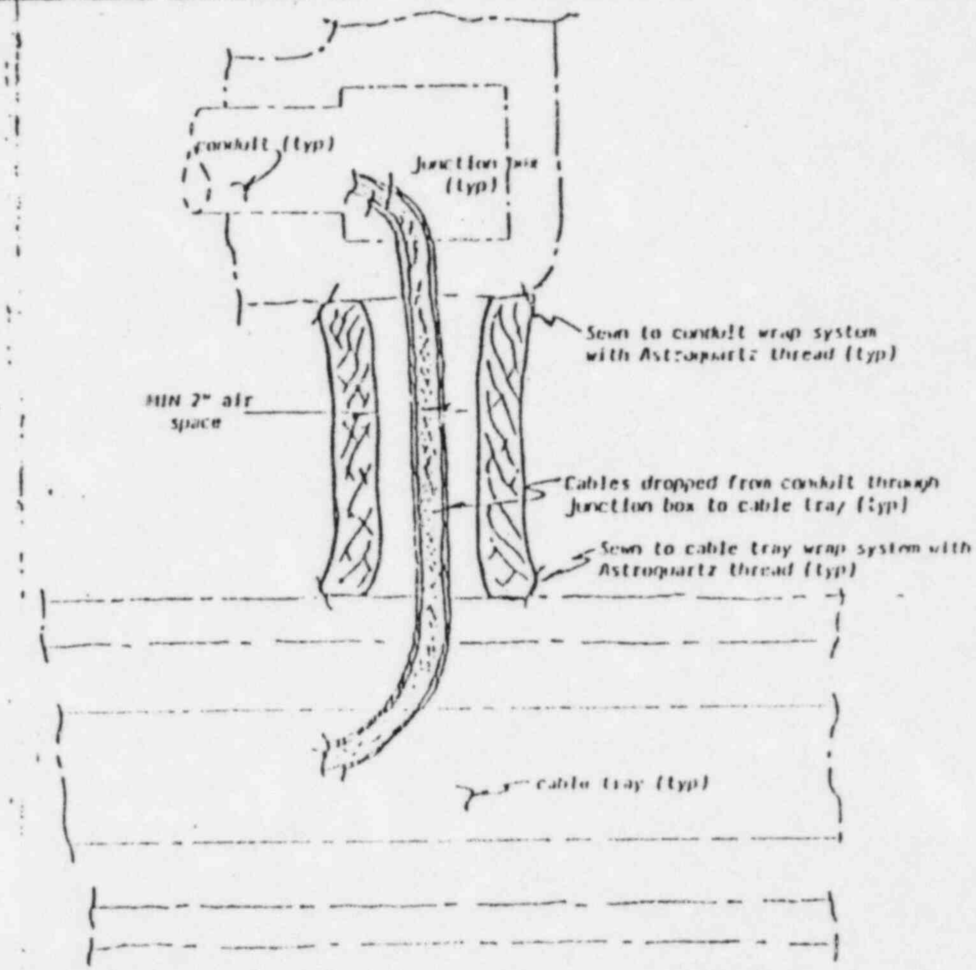

| REVISIONS | | | |
|---|---|---|---|
| NO | DATE | BY | |
| 1 | 7/01/82 | LCS | SEISMIC CONDUIT PROTECTIVE WRAP METHODS 1 & 2 |
| 2 | 9/21/82 | LCS | |

67

NOTE:
Prefabricated blanket section dimensions determined by installers on a case by case basis. SILTEMP and fiberglass to be sewn with fire retardant Astroquartz or similar thread.



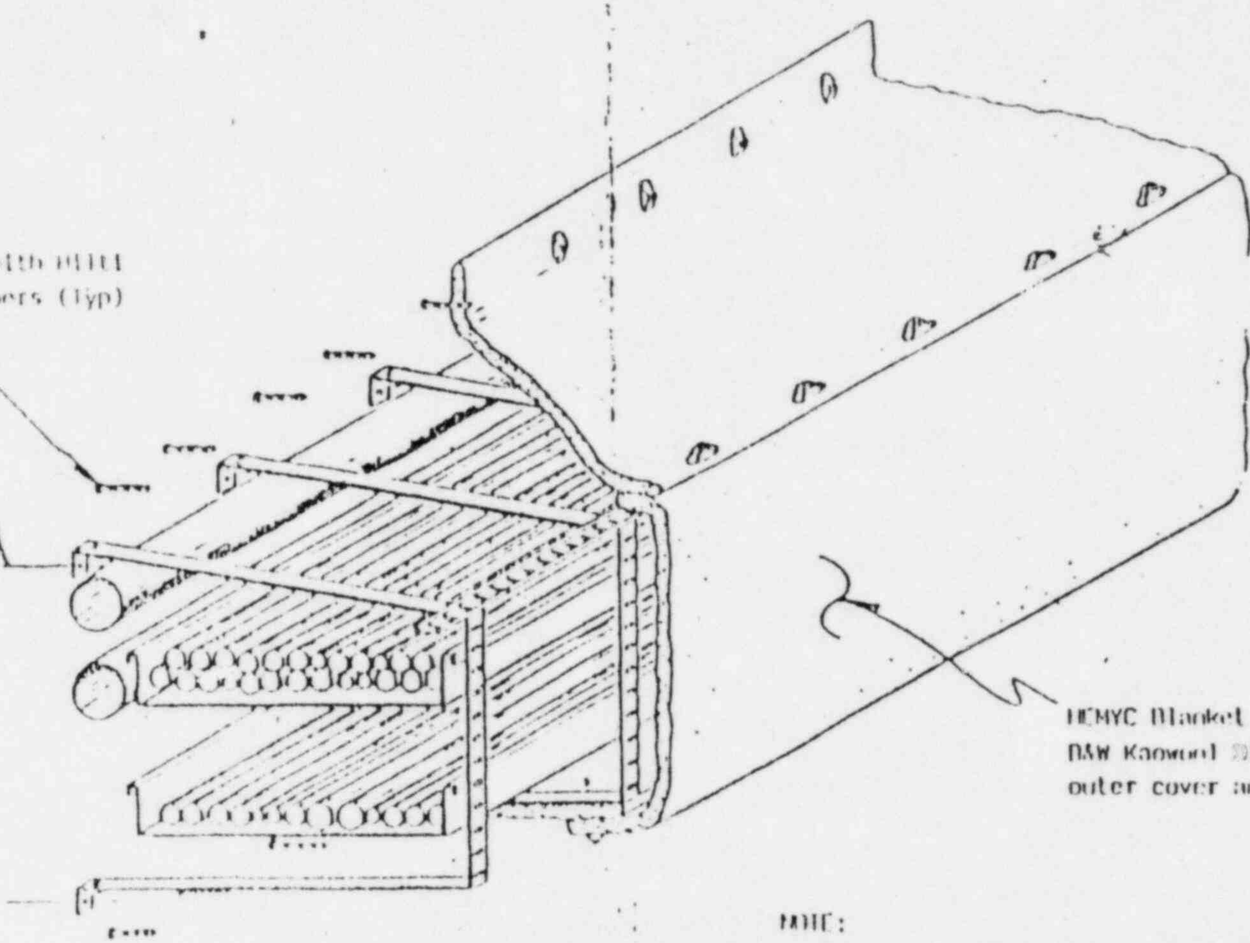

SECTION C-C
[illegible] W/ AIR SPACE
(TEST one)




TYPICAL INSTALLATION
OF CABLE DROP W/ AIR SPACE

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| NO | DATE | BY | Insulation, Inc. | | |
| | | | HEMYC SYSTEM | | |
| | | | CABLE DROP W/ AIR SPACE | | |
| | | | DRAWN BY ECS | SCALE nts | MATERIAL as noted |
| | | | CHKD | DATE 7/12/82 | DRAWING NO |
| | | | TRACED | | B - 272.11 |

C8




NOTE:
Overlap, spacing, air space, fastners, etc. shall be as referenced on cable tray wrap system drawings.

| REVISIONS | | | B&B INSULATION, INC. | | |
|---|---|---|---|---|---|
| NO. | DATE | BY | HEMYC SYSTEM<br>CLOSE PROXIMITY TO WALL/CEILING | | |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | DRAWN BY: LCS | SCALE: nts | MATERIAL: as noted |
| 4 | | | CHK'D: [illegible] | DATE: 08/10/82 | DRAWING NO: A 272.14 |
| 5 | | | TRACED: | APP'D: [illegible] | |

## INSTALLATION

- INSTALL FRAMEWORK TO PROVIDE A 2-INCH DEAD AIR SPACE.
- INSTALL BLANKETS WITH A 2-INCH OVERLAP (INDIVIDUAL BLANKET SECTIONS ARE SIZED TO ENSURE A MINIMUM OF 2 INCHES OF OVERLAP.)
- CUT BLANKET AS NECESSARY TO ENVELOPE STRUCTURAL MEMBERS
  - . CUTOUTS REPAIRED BY STUFFING ADDITIONAL CERAMIC FIBER (REPLACE ANY LOSS OF FIBER)
  - . PATCHED WITH SILTEMP CLOTH
  - . CLOTH COARSELY STITCHED IN PLACE
  - . SILTEMP PATCH IS PROVIDED TO KEEP THE CERAMIC FIBER FROM DISLODGING PRIOR TO AND AFTER THE FIRE.

## OVERLAPS

INDIVIDUAL BLANKETS ARE CONNECTED BY ATTACHING THEM TO A COMMON CONNECTOR (STUD) WITH A MINIMUM OF 2-IN. OVERLAP.

D1

# HEMYC SYSTEM
# FIRE TEST PROGRAM

- DEVELOPED TEST PROCEDURES USING PE/PVC CABLE TYPES.
- OBTAINED SERVICES OF AN ACCEPTABLE FURNACE.
- SUBMITTED TEST PROCEDURES AND FURNACE DESIGN DATA TO ANI.
- ANI APPROVAL TO CONDUCT FIRE TEST.
- ANI SELECTED BUREAU VERITAS AS CERTIFYING THIRD PARTY.
- TESTS
  - WITNESS BY B&B PRODUCTION AND QA/QC STAFF
  - BUREAU VERITAS STAFF - (MONITORED ALL PHASES OF TESTING AND CALIBRATION.)
  - HEMYC REPRESENTATIVES
  - F.E.C. TESTING AND QA/QC PERSONNEL
- TESTS RESULTS CERTIFIED BY BUREAU VERITAS.
- ANI ACCEPTANCE ISSUED 8/2/82

# ONE HOUR FIRE TEST

## TEST CRITERIA

. ASTM-E-119, ANI 5(79) BULLETIN

## TEST OBJECTIVE

MAINTAIN CIRCUIT INTEGRITY

- 1 HR. FIRE TEST
- 2 1/2 MINUTE HOSE STREAM TEST

## SUMMARY OF CONFIGURATION TESTED

- USING PE/PVC - (300MCM; 16/2; 12/7)
- CABLE LOADINGS AND TYPE PER ANI CRITERIA

SLAB-1

. MULTIPLE CABLE TRAY

. SYSTEM CONTINIOUS THROUGH WALL (PENETRATION SEAL APPLIED WITHIN HEMYC SYSTEM)

SLAB-2

. SINGLE TRAY

. MULTIPLE CONDUITS - WITH STAND-OFF

. CABLE DROPS (DIRECT WRAP)

. JUNCTION BOX (ENCLOSURE)

. SYSTEM FLARED TO WALL (CASE WITH EXISTING PENETRATION)

SLAB-3

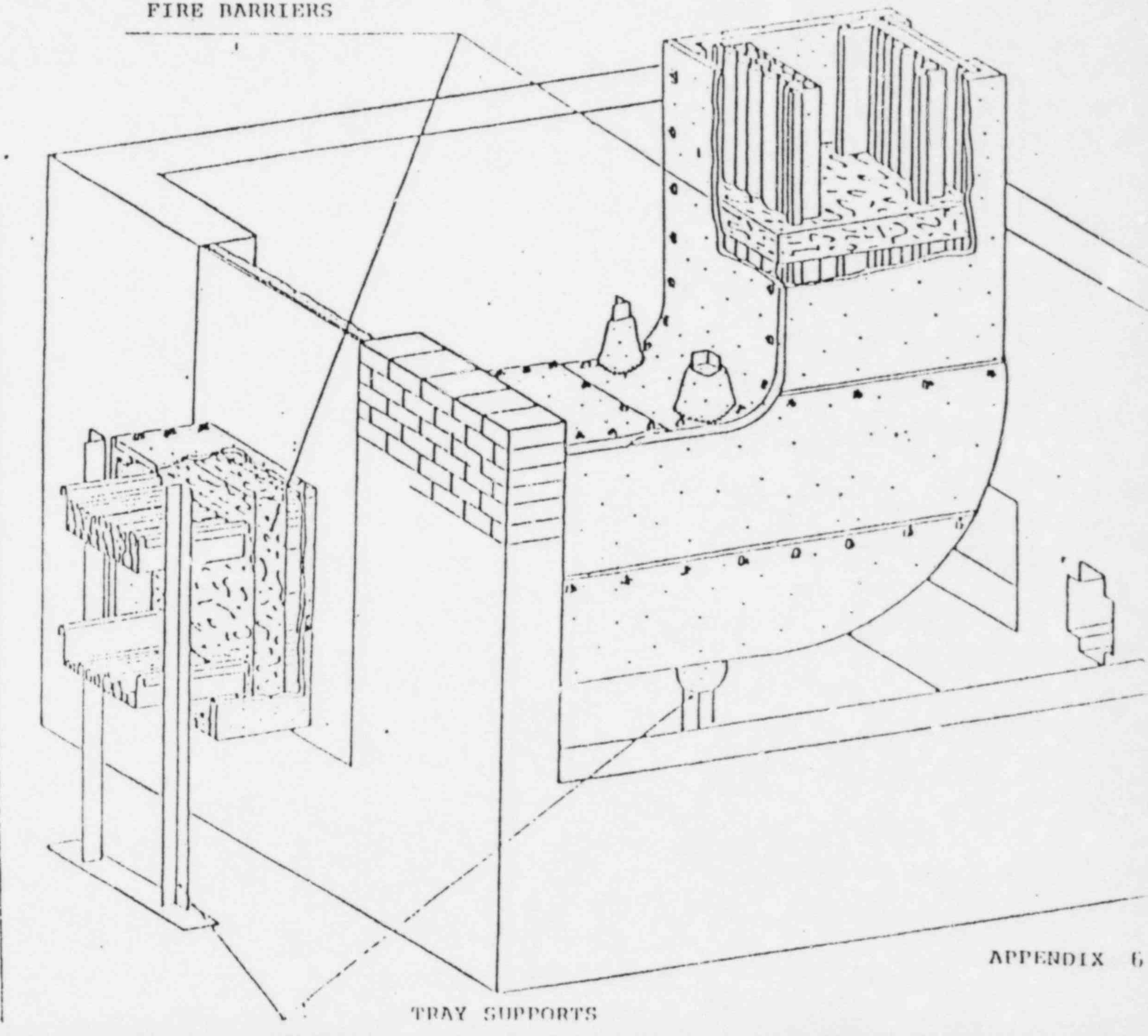
. SINGLE TRAY

. CONDUIT DIRECT WRAP

. CABLE DROP - WRAP ATTACHED TO BRACKET

D-1

TEST

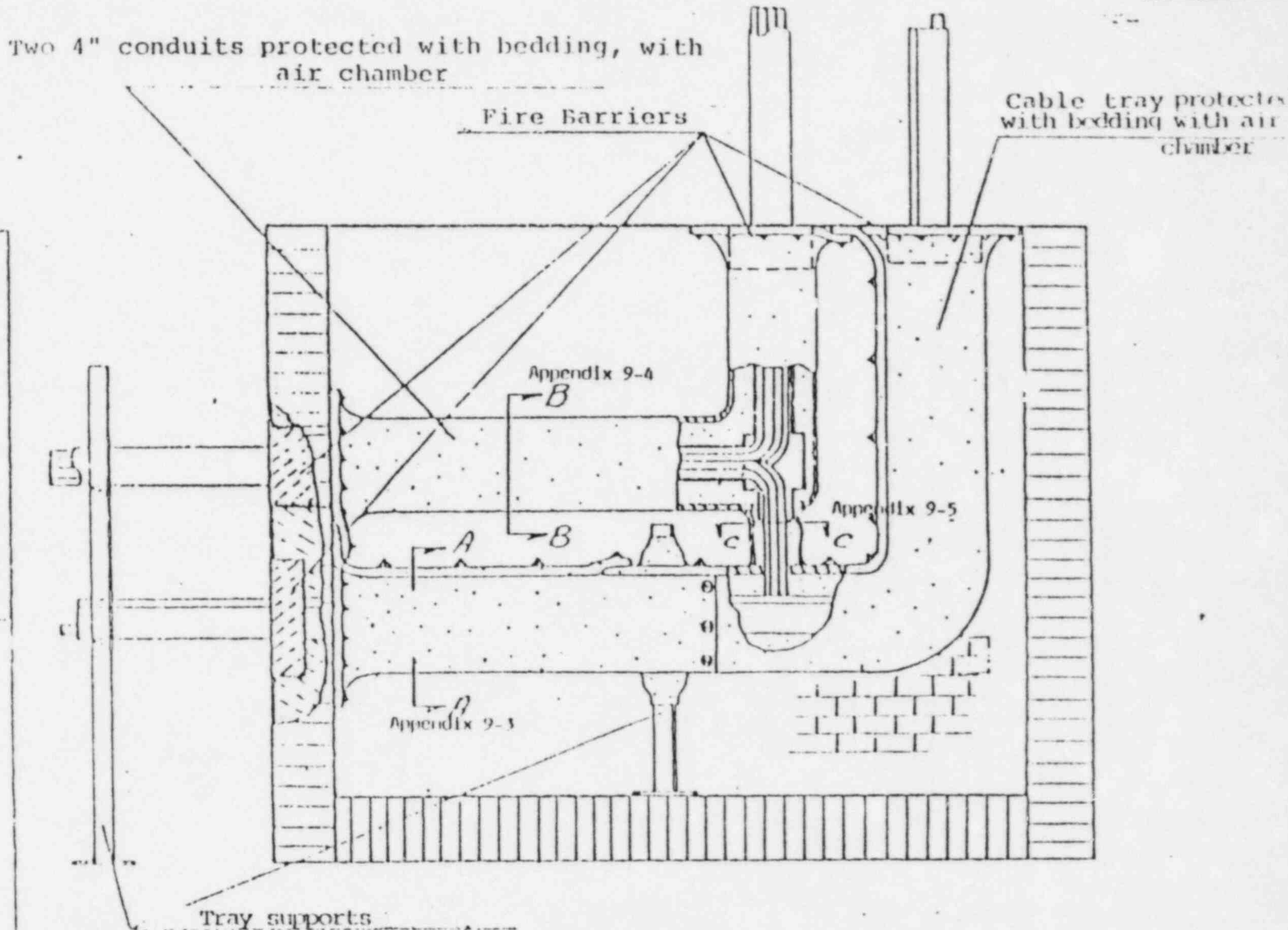



APPENDIX 6

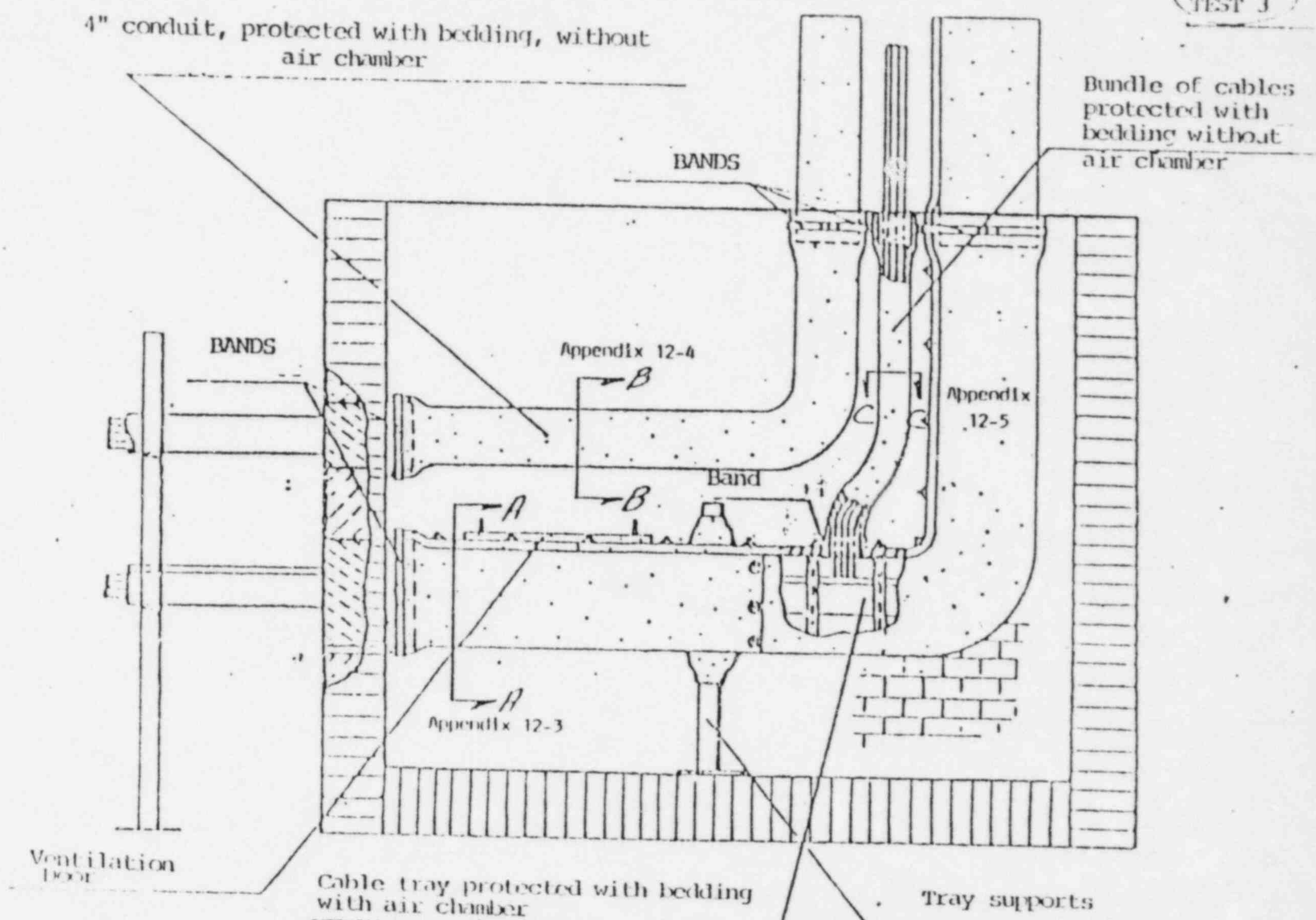
INSTALACIONES INDUSTRIALES

REVISION | FECHA

TEST 2




SIDE VIEW SECTION C-D




SIDE VIEW SECTION E-F