Appendix E
28 pages

Southern California Edison Company
San Onofre Nuclear Generating Station Units 2&3

Coaxial Cable LOCA Simulation
Test Procedure and Results for Monitoring Electrical Parameters

Second Test, March 25 through 30, 1996

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KT

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1.0 INTRODUCTION

This procedure establishes the requirements and instructions for measuring the performance of coaxial cable test specimens before, during, and after simulated LOCA environmental conditions. The simulated LOCA conditions are identified in the WYLE Laboratories Test Procedure 45145 (Reference 1).

Note that this procedure applies to the second LOCA test sequence performed on four test specimens, and one control penetration. The test specimens and control penetration are identified in Table 1.

2.0 SCOPE/PURPOSE

The scope of this test measuring procedure is limited to the Southern California Edison supplied coaxial cable test specimens as identified in Table 1.

The purpose of this procedure is to document the test specimen monitoring of "noise" affects occurring during simulated LOCA pressure, temperature and chemical spray conditions, and to determine what detector signal strength is required to overcome this noise.

2.1 Continuity and Static Insulation Resistance Verification

Continuity and insulation resistance (IR) between the test specimen center conductor and shield, and shield to ground, must be verified prior to, during, and following the LOCA simulation. Additional IR data may be taken as required.

This test will be performed using a megger with suitable test leads. Test data shall be recorded in the format shown in Table 2.

2.2 Dynamic Cable Performance

The purpose of this test is to identify and quantify any LOCA simulation induced "noise" on the individual coaxial cable test specimens. This cable noise may be from piezoelectric, triboelectric, or any other effects.

Figure 1 shows schematically the test specimen and measuring equipment configurations. The Keithly 261 will be used to simulate the "keep alive" source within the Sorrento Electronics (General Atomic) RD-23 detector. The Keithly 610 will be used to monitor the signal "noise" effects of LOCA conditions on the coaxial cable. Coaxial cable current levels during LOCA simulation will be monitored and recorded as described in Section 6.2.

3.0 TEST EQUIPMENT

All test measuring equipment used in this procedure is calibrated in accordance with the Wyle Laboratories Quality Assurance Program and is identified in the Wyle Test Report (Reference 2).

3.1 Static Insulation Resistance Test

(4) Four test specimens with BNC connectors on each end.

(1) Control Test Vessel Penetration

(1) Megger, 500V

3.2 Dynamic Cable Performance Test

(4) Four test specimens with BNC connectors on each end.

(1) Control Test Vessel Penetration

(5) Keithly 610C or 610CR Electrometers

(5) Keithly 261 Current Source

(1) Astromed MT95K2 Mainframe including the following subcomponents:

(2) AWP1 analog input card

(1) VOP1 video module

(1) SVGA compatible video monitor

(2) "D" submini with four BNC female connectors

(5) PL-259 connectors for 610C input

(5) Cables to go from Keithly 610C to Astromed recorder

(1) Pack of 400 sheet Z fold paper for Astromed

(1) Configuration disk for Astromed recorder

4.0 REFERENCES

4.1 WYLE Laboratories Test Procedure 45145, "Test Procedure for LOCA Simulation of Coaxial Cable for Southern California Edison" Dated December 8, 1995.

4.2 WYLE Laboratories Test Report 45145-1, "Test Report for LOCA Simulation of Coaxial Cable for Southern California Edison"

5.0 ACCEPTANCE CRITERIA

5.1 Continuity and Static Insulation Resistance Test

Pre, Mid and Post LOCA coaxial cable test specimens must maintain center conductor continuity. Conductor to shield and shield to ground resistance measurements are taken for information only.

5.2 Dynamic Cable Performance Test

As discussed in Section 2.1, the purpose of this test is to identify and quantify any noise induced on the test specimens by the simulated LOCA environmental conditions, and to determine what current is required to overcome this noise. This information will be used in some future, separate evaluation outside the scope of this test measuring procedure. Therefore, there is no specific acceptance criteria for the dynamic cable performance test.

6.0 PROCEDURE

6.1 **Pre LOCA Continuity and Static Insulation Resistance Test**

Prior to exposure to the simulated LOCA environmental conditions, the following steps shall be performed on each test specimen (and control penetration).

6.1.1 Connect the megger to the test specimen using the megger test lead.

6.1.2 Verify continuity. Apply megger voltage(500V)and derive conductor to shield and shield to ground insulation resistance. Record in the applicable Table.

6.1.3 Turn megger off and disconnect test specimen.

6.2 **Dynamic Cable Performance Test**

6.2.1 **Preliminary Checks**

6.2.1.1 Ensure test equipment is present as per Section 3.2.

6.2.1.2 Ensure test cables on the outside of chamber are wrapped with thermal insulating material.

6.2.2 **Setting up and configuring the Astromed recorder.**

6.2.2.1 Install connectors on analog module cards (AWP1).

6.2.2.2 Install cables from Keithly 610C into appropriate channels on AWP1 amplifier per Figure 2.

6.2.2.3 Connect Astromed recorder to a power source.

6.2.2.4 Turn Astromed to the ON position (1).

6.2.2.5 Set recorder internal date and time by performing the following.

6.2.2.5.1 Depress the front panel SYS key.

6.2.2.5.2 Depress the soft key above SYSTEM CLOCK.

6.2.2.5.3 Use selection arrows to select each component date and time.

6.2.2.5.4 Depress EXIT

6.2.2.6 Downloading of the configuration program.

6.2.2.6.1 Insert the disk labeled Wyle Labs Cable Testing Astromed setup in disk drive.

6.2.2.6.2 Press the MODE key

6.2.2.6.3 Press the soft key above FROM DISK

6.2.2.6.4 Use the encoder wheel to select file you want to download.

6.2.2.6.5 Press the soft key above RUN. This should download the entire recorder configuration and labels.

6.2.2.6.6 Depress SAVE.

6.2.2.6.7 Depress the soft key above ENTIRE MODE in the left display.

6.2.2.6.8 Use INC or DEC to select one of four soft keys into which the mode will be saved.

6.2.2.6.9 Use the keypad to type a label for the grid.

6.2.2.6.10 Press the soft key above ACCEPT to store the chart into the selected soft key. This will be displayed whenever the MODE key is depressed.

NOTE: If any labels need to be changes depress EDIT and edit buffers 1-9 as required.

6.2.3 **To activate recorder to begin recording**

6.2.3.1 Ensure that inputs are approximately in the middle of each chart. If not, the zero suppression may need to be used to center the channel.

6.2.3.2 Ensure there is enough paper in the recorder to last the duration of the test to be performed. This can be done by checking the printed number on the paper. The paper goes from 400 downward to 1. The lower the number, the less paper you have.

6.2.3.3 Verify chart speed is correct for application.

6.2.3.4 Start recording by depressing the RUN/HALT button.

6.2.4 **Stopping the recorder.**

6.2.4.1 Depress the RUN/HALT button

6.2.4.2 Remove, label and store the trace.

6.2.5 **Setting up and configuring the Keithly 610C Electrometer (set up and checkouts).**

6.2.5.1 Set METER SWITCH to POWER OFF

6.2.5.2 Lock ZERO CHECK

6.2.5.3 Set RANGE SWITCH to VOLTS and MULTIPLIER SWITCH to 1.0

6.2.5.4 Turn METER SWITCH to CENTER ZERO. Meter should read the center zero. If not, adjust as required.

6.2.5.5 Set FEEDBACK switch to FAST

6.2.6 **Setting up and configuring the Keithly 261 Pico Ammeter (set up and checkouts).**

6.2.6.1 Connect test specimen input cable to front input connection.

6.2.6.2 Set POLARITY SWITCH to "OFF." Warm up 15 minutes.

6.2.6.3 Set mantissa to 1E-11.

6.2.6.4 Set polarity to "+."

6.2.6.5 Ensure that both Astromed and Keithly 610 respond to input signals. Run through the listed range of -5E-11 to +5E-11 amps.

6.2.7 **Testing procedure checklist.**

6.2.7.1 Ensure all cables are connected to test equipment. This includes verifying that cables are installed per Figure 1.

6.2.7.1.1 Test specimen to Keithly 610.

6.2.7.1.2 Keithly 610 recorder output to Astromed.

6.2.7.1.3 Keithly 261 output to test specimen.

6.2.7.2 Ensure all test equipment is powered up, functional and on the correct range.

6.2.7.2.1 Astromed

6.2.7.2.2 Keithly 610C

6.2.7.2.3 Keithly 261

6.2.7.3 Ensure the Astromed recorder is selected to desired chart speed for testing. For the first 60 seconds or so, set recorder speed to 5 mm/sec.

6.2.7.4 Start the Astromed recorder.

6.2.7.5 Start steam testing.

6.2.7.6 Adjust Keithly 610 range as necessary to avoid bottoming out on Astromed recorder. Annotate recorder trace with any range changes.

6.2.7.7 Adjust Keithly 261 range as necessary to avoid bottoming out on Astromed recorder. Annotate recorder trace with any range changes.

6.2.7.8 After readings stabilize somewhat, reduce chart speed to 1 mm/sec for balance of test.

6.3 **Mid LOCA Continuity and Static Insulation Resistance Test**

At some time during exposure to the simulated LOCA environmental conditions, the following steps shall be performed on each test specimen.

6.3.1 Connect the megger to the test specimen using the megger test lead.

6.3.2 Verify continuity

6.3.3 Apply megger voltage (500VDC) and derive conductor to shield and shield to ground insulation resistance. Recorded in the appropriate Table.

6.3.4 Turn megger off and disconnect test specimen.

6.4 **Post LOCA Continuity and Static Insulation Resistance Test**

Following exposure to the simulated LOCA environmental conditions, the following steps shall be performed on each test specimen.

6.4.1 Connect the megger to the test specimen using the megger test lead.

6.4.2 Verify continuity

6.4.3 Apply megger voltage (500VDC) and derive conductor to shield and shield to ground insulation resistance. Recorded in the appropriate Table.

6.4.4 Turn megger off and disconnect test specimen.

6.5 **Use Attachment 2 "IN CONTAINMENT CABLE TEST PROCEDURE" to document procedure execution.**

TABLE 1

TEST SPECIMEN DESCRIPTIONS

SPECIMEN NUMBER	DESCRIPTION
1	250' Rockbestos RSS-6-105/LE (100% in conduit)
2	250' Rockbestos RSS-6-105/LE (50% in conduit)
3	250' Rockbestos RSS-6-104/LE (100% in conduit)
4	250' Rockbestos RSS-6-104/LE (50% in conduit)
5	Control Penetration (18" Loop of RSS-6-104/LE)

TAPLE 2

PRE-LOCA TEST

CONTINUITY AND STATIC INSULATION RESISTANCE TEST

Time/Date: 0826 3/29/96

Specimen Number	Continuity (Y/N)	Conductor to Shield Resistance @500 VDC	Shield to Ground Resistance @500 VDC
1	Y	5.5E12	2E9
2	Y	2E13	2E9
3	Y	1.8E12	1.8E9
4	Y	1.5E12	1.5E9
5	Y	8.2E12	1.7E9

Notes:

TABLE 3

MID-LOCA TEST

CONTINUITY AND STATIC INSULATION RESISTANCE TEST

Time/Date: 1554 3/29/96

Specimen Number	Continuity (Y/N)	Conductor to Shield Resistance @500 VDC	Shield to Ground Resistance @500 VDC
1	Y	60K (Note 1)	1.8E8
2	Y	30K (Note 1)	8E7
3	Y	690K (Note 1)	2E8
4	Y	1M (Note 1)	1.4E8
5	Y	3E11	5.8E8

Notes:

1. Shorted at 500 and 10 VDC. Reading taken with hand held multi meter.

TABLE 4

POST-LOCA TEST

CONTINUITY AND STATIC INSULATION RESISTANCE TEST

Time/Date: 0800 3/30/96

Specimen Number	Continuity (Y/N)	Conductor to Shield Resistance @500 VDC	Shield to Ground Resistance @500 VDC
1	Note 1	Shorted (Note 3)	8E11
2	Note 1	1.8M (Notes 2 and 4)	1E12
3	Note 1	2.2E5 @ 10VDC	Shorted
4	Note 1	0.7M (Notes 2 and 5)	1E12
5	Note 1	Note 1	Note 1

Notes:

1. Not recorded.
2. Shorted at 500 and 10 VDC. Reading taken with hand held multi meter.
3. 150 mV battery effect measured by hand held multi meter.
4. 250 mV battery effect measured by hand held multi meter.
5. 85 mV battery effect measured by hand held multi meter.

TABLE 5

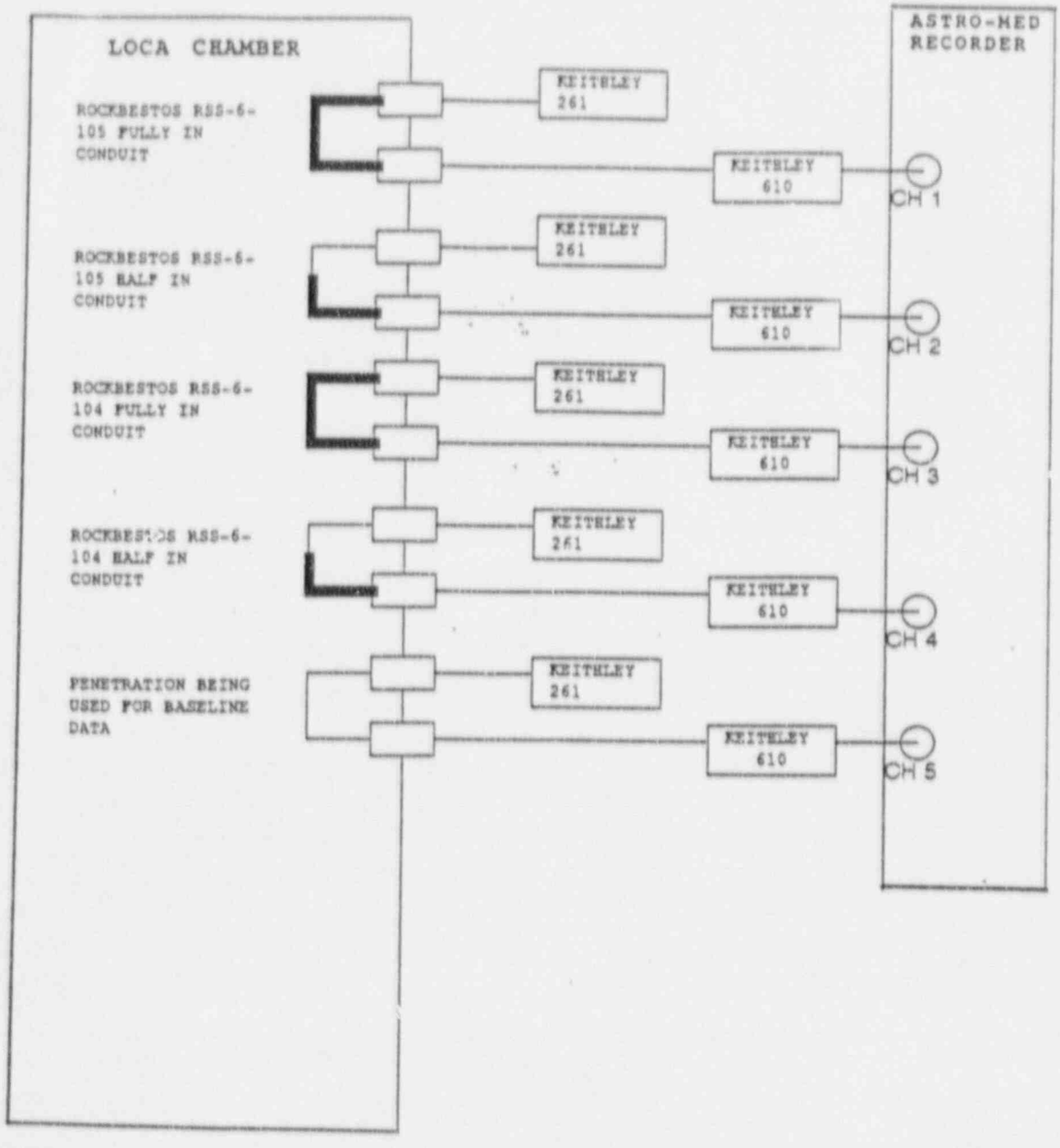
POST LOCA PENETRATION AND SPECIMEN IR DATA

Specimens Only @500 VDC Post LOCA IR Data, 3/30/96, 8:30AM		
Specimen	Conductor to Shield	Shield to Ground
1 (105 full)	3.0E11	2.5E11
2 (105 half)	1.0E12	1.0E11
3 (104 full)	2.2E12	2.0E11
4 (104 half)	7.5E9	5.0E11

Full Conduit Penetration Only Post LOCA IR Data, 3/30/96, 8:45AM		
Specimen	Conductor to Shield	Shield to Ground
1a (105 full)	9.0E5 @10VDC	1.3E13
1b (105 full)	2.0E9 @500VDC	1.2E13
3a (104 full)	1.0E8 @500VDC	3.0E12
3b (104 full)	1.0E9 @500VDC	1.2E13

Half Conduit Penetration Only Post LOCA IR Data, 3/30/96, 8:50AM		
Specimen	Conductor to Shield	Shield to Ground
2a (105 half)	3.0E12 @500VDC	4E12 @500VDC
2b (105 half)	9.0E4 @10VDC	3.5E12 @500VDC
4a (104 half)	4.5E7 @500VDC	5.0E12 @500VDC
4b (104 half)	1.5E12 @500VDC	4.5E12 @500VDC

FIGURE 1
ELECTRICAL TEST SCHEMATIC



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Here is the As-Found data for each of the cable samples after they have been cut to length and had connectors added to each end.

Sample #1
250' of RSS-6-105/LE
Insulation Resistance @ 500VDC: 300E12 Ohms Center to Center conductor resistance: 3.83 Ohms Shield to Shield conductor resistance: 1.93 Ohms

RSO-0314-96
Taken from Rockbestos Reel #93A1772G, 748', PO 6J236003 Cable is marked on outer jacket as:
"ROCKBESTOS (R) RSS-6-105/LE 1993 1/C 22AWG TCU XLPE 2300V 90 DEG C D86-01 3E-29 06114 FEET"

Sample #2
250' of RSS-6-105/LE
Insulation Resistance @ 500VDC: 300E12 Ohms Center to Center conductor resistance: 3.79 Ohms Shield to Shield conductor resistance: 1.89 Ohms

No RSO associated with this sample. The following data was taken from the metal tag affixed to the cable reel:
PRODUCT CODE H440105
DESCRIPTION RSS-6-105/LE BK
SHOP ORDER # 100476
CUST ORDER # 000000
REEL # 95K0875G
FOOTAGE 750

Cable is marked on outer jacket as:
"ROCKBESTOS (R) RSS-6-105/LE 1994"

Sample #3 and Sample #4
250' of Rockbestos RSS-6-104/LE
Insulation Resistance @ 500VDC: 300E12 Ohms Center to Center conductor resistance: 3.83 Ohms Shield to Shield conductor resistance: 1.88 Ohms

RSO-0322-96
Taken from reel# 94D0286G
PO# 6J236005
RSS-6-104/LE BK 600V
SCE MATL CODE: 027-75377
H44-0104
SPEC# RSS-6-104/LE

Spare #1
250' of RSS-6-105/LE
Insulation Resistance @ 500VDC: >300E12 Ohms Center to Center conductor resistance: 3.85 Ohms Shield to Shield conductor resistance: 1.94 Ohms

Same pedigree as Sample #1

Spare #2
120' of RSS-6-104/LE
Insulation Resistance @ 500VDC: >300E12 Ohms Center to Center conductor resistance: 1.88 Ohms Shield to Shield conductor resistance: 0.93 Ohms

Same pedigree as Samples #3 and #4

Insulation resistances measured with General Radio Megohm Bridge Model 1644A, SONGS M&TE ID I1-6044, recal date 5-14-96

Conductor resistances measured with Fluke 8050A DMM, SONGS M&TE ID I2-6697, recal date 4-5-96

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ATTACHMENT 1
Test Specimen Traceability Information (one page)

IN CONTAINMENT CABLE
TEST PROCEDURE

ATTACHMENT 2
TEST Procedure Checklist

E17/23

Main Procedure for Wyle Cable Testing

Pre Test

- [M] Perform Instrument and test equipment inspection per Attachment 1
- [M] Perform Configuration of Astro-Med Recorder by performing Attachment 2, "Installation and Clock set"
- [M] Download Wyle test program from the disk labeled WYLE LAB CABLE TEST using Attachment 3.
- [M] Configure Keithley 610 by performing Attachment 4
- [M] Configure Keithley 261 by performing Attachment 5
- [M] Perform Pre Test Continuity and Megger check for each sample of cable and record on attachment 6.
- [M] Perform Pre Test Checklist per attachment 7.

LOCA TESTING

- [M] Start the Astro-med recorder with chart speed set to 5 mm/sec.
- [M] Start LOCA testing
- [M] Adjust Keithley 610 as required to keep trace on chart
- [M] Reduce Astro-med chart speed to 1 mm/sec when required
- [M] Perform Mid test cable meggering and continuity testing. Record results on Attachment 6.
- [M] At the end of LOCA testing, perform post LOCA megger and continuity checks recording values on Attachment 6

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Main Procedure for Wyle Cable Testing

POST LOCA

[✓] Disconnect all cable samples from test equipment

[✓] Power down all test equipment

[✓] Store test equipment and make provisions for shipping back to SCE.

[✓] Remove video tape from video camera and make provisions for sending to SCE

[✓] Remove recorder traces from astro-med recorder and make provisions to take to SCE.

[✓] Make provisions for sending cables, penetrations and anything else deemed required to SCE.

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Wyle Lab Cable Test

Preliminary Checks

A) ✓ Ensure test cables are properly wrapped with no strain on the cable specimens

B) Perform Inspection of test equipment

✓1) 5 Keithley 610C electrometers

✓2) Astro-med MT95K2 Mainframe Recorder (with proper card configuration)

✓3) 5 Keithley 261 Current sources

✓4) "D" submini with BNC females connectors

✓5) PL259 (RCA) connectors for 610 Inputs

✓6) 5 cables that go from keithley 610 to astro-med

✓7) 2 packs of Z fold paper for astro-med recorder

✓8) Configuration disk for the astro-med recorder

ATTACHMENT 1

E20/28

Astro-med recorder Configuration

Installation and Clock Set

1. Ensure all input cards are installed and in the required position

2. Ensure connectors are installed on AWP 1 card.

3. Install cables from Keithley 610 to proper channel of the astro-med recorder.

4. Tape the connectors with scotch 33 electrical tape.

5. Connect astro-med to power source

6. Turn the astro-med to the "**ON**" position

7. Set the recorder's internal **date and clock** by performing the following:

   A) Depress the front panel **SYS** key

   B) Depress the soft key above "**SYSTEM CLOCK**"

   C) Use the selection arrows to select each component of the date and time.

   D) Use the encoder wheel to set each desired value.

   E) Depress **EXIT**.

ATTACHMENT 2

E21/28

Astro-med recorder Configuration
Downloading of Disk

1. Insert disk labeled WYLE LAB CABLE TEST into disk drive on the front of the astro-med recorder
2. Press the **MODE** key
3. Press the soft key above "**FROM DISK**"
4. Use the encoder wheel as required to select the file that you want to download.
5. Depress the soft key above **RUN.**
6. Depress **SAVE**
7. Press the soft key above "**ENTIRE MODE**" in the left display.
8. Use **INC** or **DEC** to select one of the four soft keys into which the program will be saved.
9. As required, use the keypad to type a label for the grid.
10. Check the scaling of the recorder channels and ensure that the program has been downloaded properly. Ensure that the inputs are approximately in the center of the chart's input.
11. Press the soft key above **ACCEPT** to store the chart into the selected soft key. The label will appear under the assigned key. This will be displayed whenever the MODE key is depressed.

ATTACHMENT 3

Configuration of Keithley 610 Electrometer

1. Set meter switch to power off position.
2. Lock zero check
3. On the back of the Keithley 610, ensure that the selector switch is set to the 3 volt position.
4. Set range switch to Volts and the multiplier switch to 1.0
5. Turn meter switch to Center Zero. Meter should read zero. If not, adjust as required.
6. Return meter switch to the power off position.
7. Set range switch to E-10 and multiplier to 1.
8. Unlock zero check
9. Ensure feedback is in FAST.

ATTACHMENT 4

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CONFIGURATION AND SETUP OF KEITHLEY 261

- [M] Connect test cable to input
- [M] select current output to 1E-11 A
- [M] Place ~~power~~ POLARITY switch to "+"
- [M] Let Keithley warm up for 15 minutes

ATTACHMENT 5

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Conter to Shield (Megger set to 500 Volts)

Sample	Date	Pre	Mid	Post
#1	03/29/96	5.5E12	60K *	2.205 @ 10VDC
#2	03/29/96	2E13	30K*	Shorted 150mV battery effect
#3	03/29/96	1.8E12	690K*	1.8 M *
#4	03/29/96	1.5E12	1MEG*	Shorted @ source 0.7M *
#5	03/29/96	8.2E12	3E11 *	Not recorded
	@TIME	0826	1554	3/30/96 8Am

* HANDHELD METER USED

Shield to Ground (Megger set to 500 Volts)

Sample	Date	Pre	Mid	Post
#1	03/29/96	2E9	1.8E8	Shorted
#2	03/29/96	2E9	8E7	8E11
#3	03/29/96	1.8E9	2E8	1E12
#4	03/29/96	1.5E9	1.4E8	1E12
#5	03/29/96	1.7E9	5.8E8	Not recorded
	TIME	0826	1554	3/30/96 8Am

Continuity (Good / Bad) (center/center, shield/Shield)

Sample	Date	Pre	Mid	Post
#1	03/29/96	G	G	G**
#2	03/29/96	G	G	G**
#3	03/29/96	G	G	G**
#4	03/29/96	G	G	G**
#5	03/29/96	G	G	G**
	TIME	0826	1554	3/30/96 8Am

** = not recorded

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Pre Test Checklist

1. Ensure all cables are installed properly per loop diagram.

   [✓] Test cable to Keithley 610

   [✓] Keithley 610 cable to Astro-med recorder

   [✓] Keithley 261 to test cable input

2. Ensure all test equipment is powered up and functional

   A) Keithley 610

   [✓] Powered Up

   [✓] Selected to 3 volt range, Mult set to 1 and mantissa set to E-10.

   [✓] Zero Lock has been removed

   B) Astro-med recorder

   [✓] Powered Up

   [✓] Inputs functional

   [✓] Chart drive speed is set to desired value

   [✓] Plenty of chart paper to last the duration of the test.

   [✓] Scaling is correct

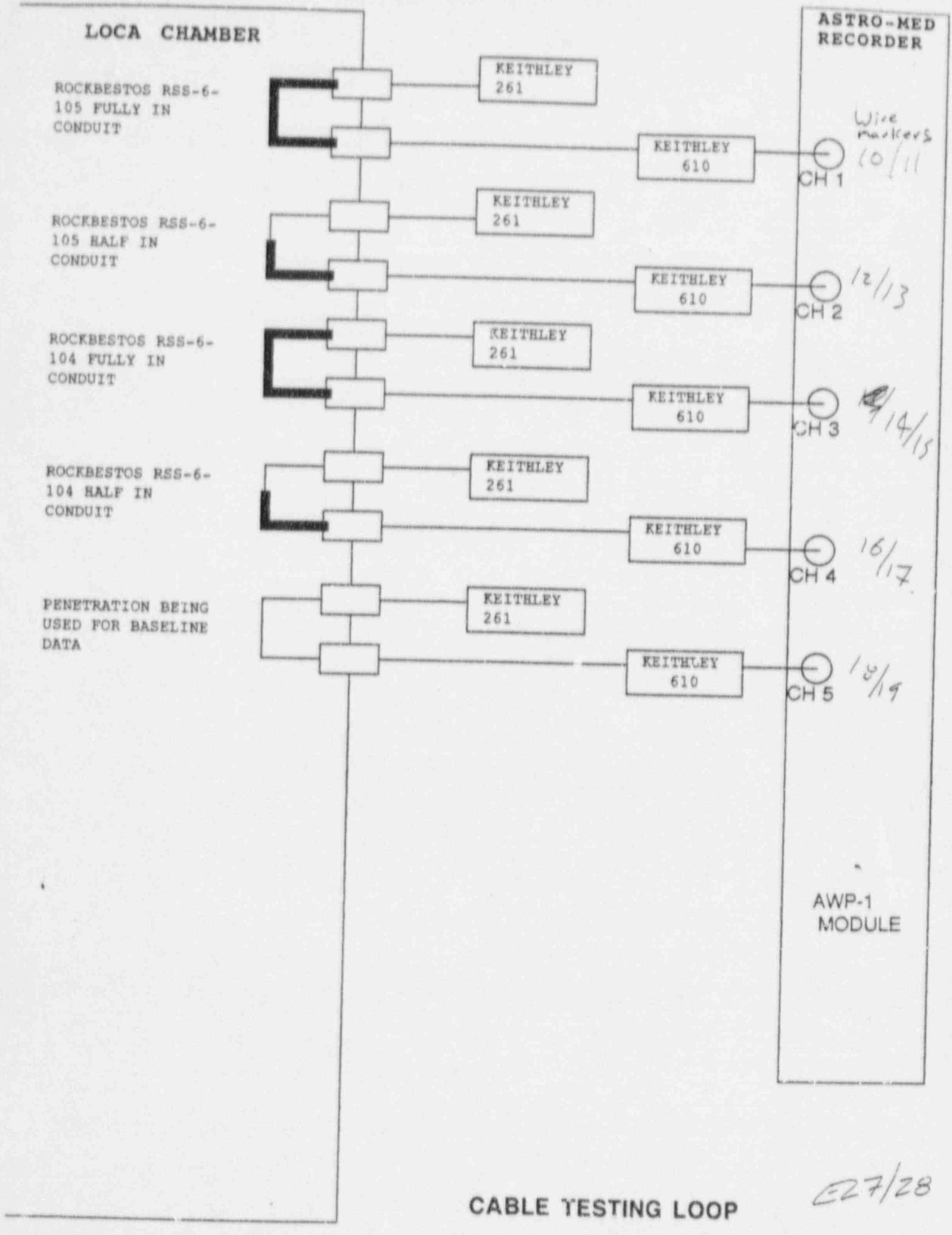
   C) Keithley 261

   [✓] Powered up

   [✓] Instrument set to 1.00E-11 A.

ATTACHMENT 7

E26/29


LOCA CHAMBER
ASTRO-MED RECORDER
ROCKBESTOS RSS-6-105 FULLY IN CONDUIT
ROCKBESTOS RSS-6-105 HALF IN CONDUIT
ROCKBESTOS RSS-6-104 FULLY IN CONDUIT
ROCKBESTOS RSS-6-104 HALF IN CONDUIT
PENETRATION BEING USED FOR BASELINE DATA
KEITHLEY 261
KEITHLEY 610
CH 1
CH 2
CH 3
CH 4
CH 5
Wire markers
10/11
12/13
14/15
16/17
18/19
AWP-1 MODULE
CABLE TESTING LOOP
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Checkout of System

1. Continuity Checks
   (Center and shield shorted)

2. Megger checks (Megger set to 500 volts)
   (Center / shield and Shield / Ground)

3. Install Keithley 261 to the test cable input.
   Set Keithley to 1.00E-11 A.

4. Input test current through the test cable and ensure that Keithley 610 indicates current and astro-med all reflects the current. Also ensure that the proper channel responds.

5. Repeat this for each test cable.

Wyle Test Results-March 29/96

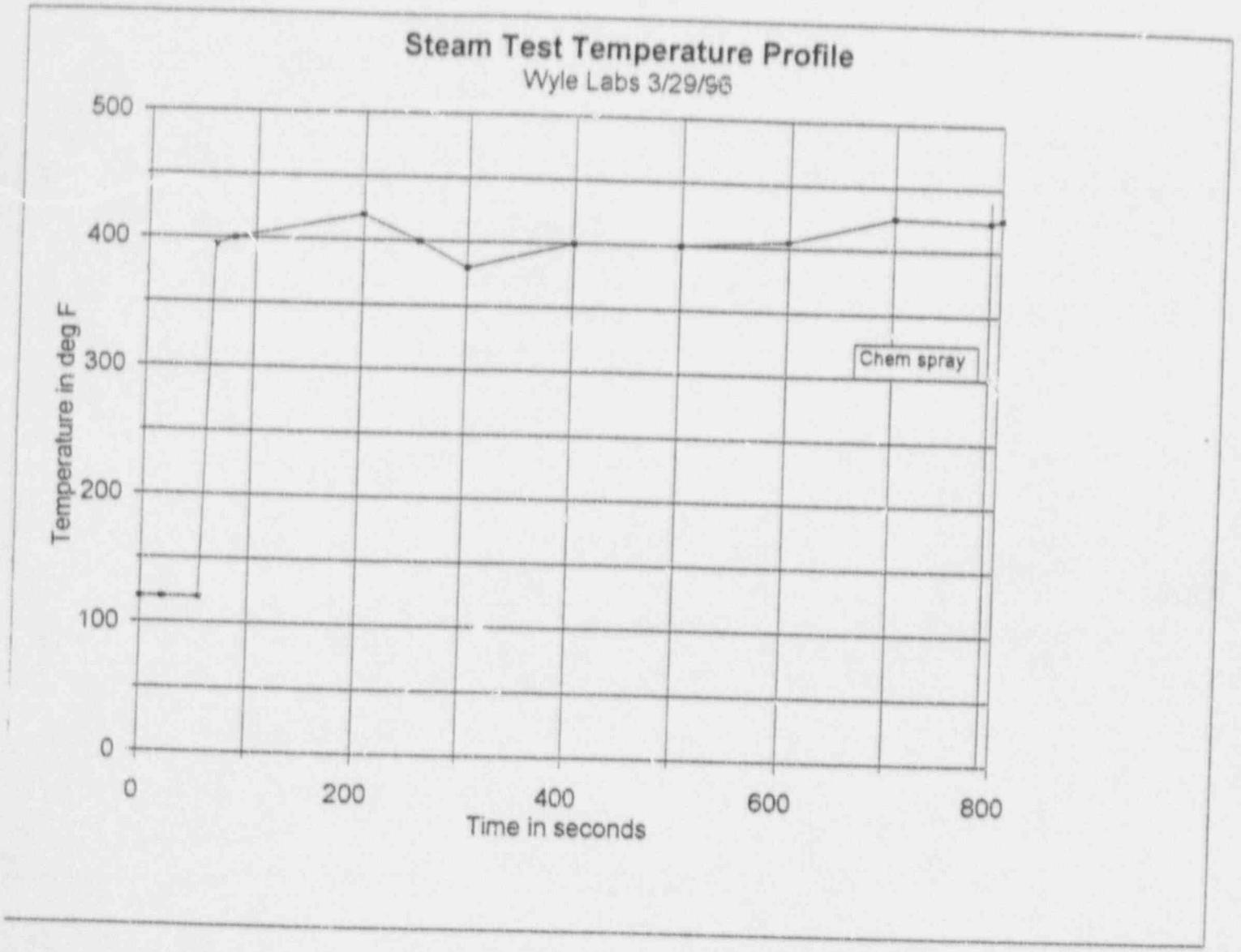
High temperature steam testing of Rockbestos cables was conducted at Wyle Labs, Huntsville, AL on March 29 1996. Rockbestos cable types RSS-104 & RSS-105 were tested, mounted completely within a conduit housing. Two other sets of cables, using 104 & 105 types were tested with one half the cable in a conduit housing and the other half laying in an open cable tray.

After initially heat soaking the cable test set ups for 2.5 hours at 120 F, the steam was introduced to raise the temperature in the autoclave up to 420 F. This temperature was maintained for more than 800 seconds. At 790 seconds into the test, chemical spray was introduced into the chamber.

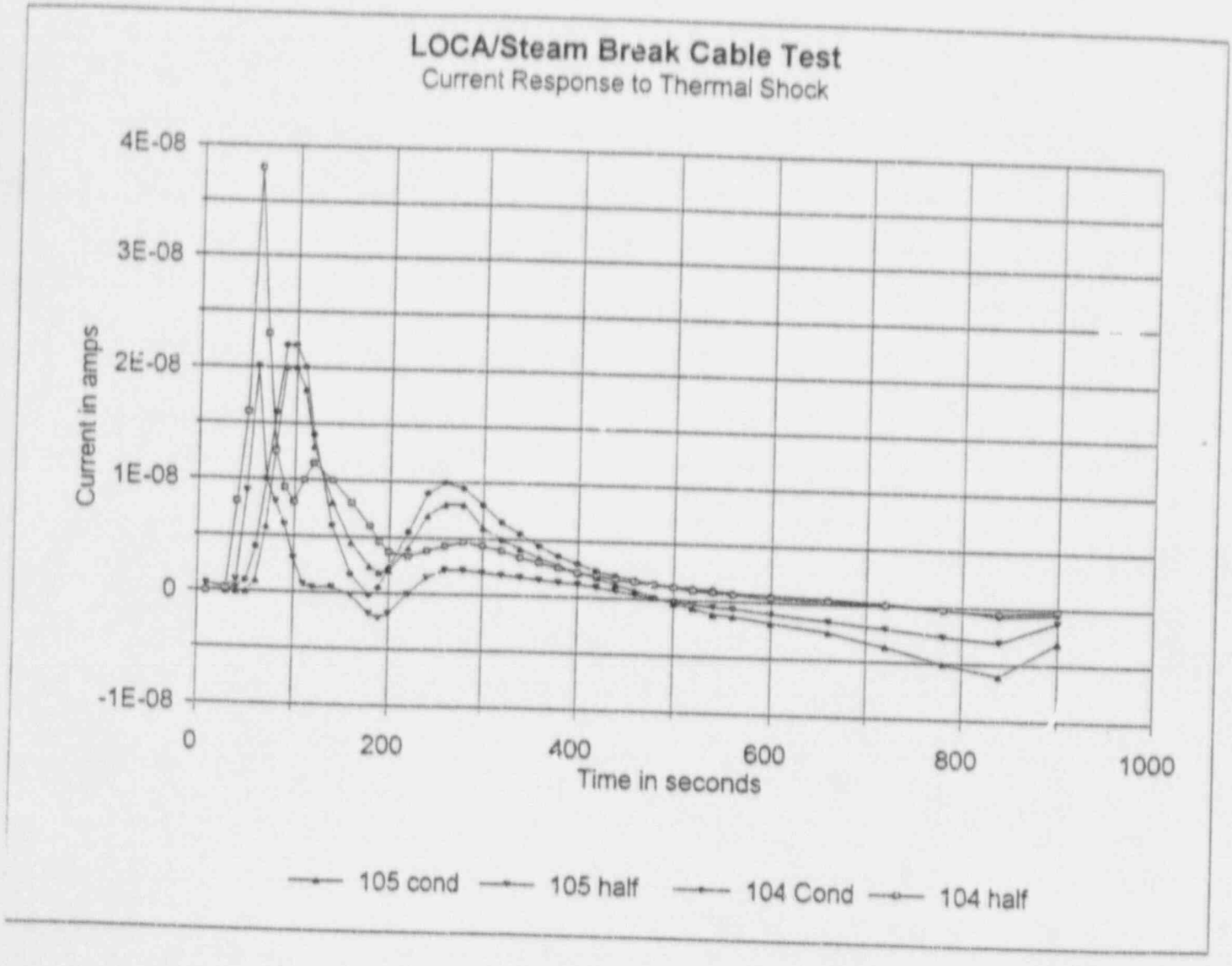
A review of the thermally induced currents produced within the cables showed the following:

1. The completely conduited cables did not substantially reduce the peak induced values of current.
2. The induced current within the fully conduited cabled test set ups, showed a time delay of 60 seconds in reaching a peak induced current.
3. The maximum equivalent dose values were, as expected, in the 2,000 R/hr range. The half conduited, 104 cable was higher at 3800 R/hr.
4. A secondary induced peak reached a maximum at about 280 seconds after the application of steam. The magnitude of the secondary peak in the conduited set ups produced a peak about 50% of the main peak. In the half conduited set ups, this secondary peak only produced a peak of about a 10% of the main peak. (Stored energy effect?)
5. At about 500 seconds, the 105 cables swung negatively (Max. 6×10^{-9} amps), similar to previous testing. The 104 cables eventually went negative but later, at 800 seconds and at much lower levels of current (max. 10^{-11} range).
6. At about 900 seconds into the test, noise/oscillations appear as the current reduces into the lower current levels. Excess noise and/or oscillations, in the past, has indicated moisture leakage into the cable. At the end of the test (~2 hrs) low IR readings were obtained. The control cable/penetration change in reading after disconnecting the connector, removing a water droplet and then after re-connection the readings were back to normal levels supports the contention that only a small amount of water inside the cable can greatly impact the IR readings.
7. Based on the IR values taken after completion of the test, it seems that all cable suffered some form of moisture migration into the cabling.

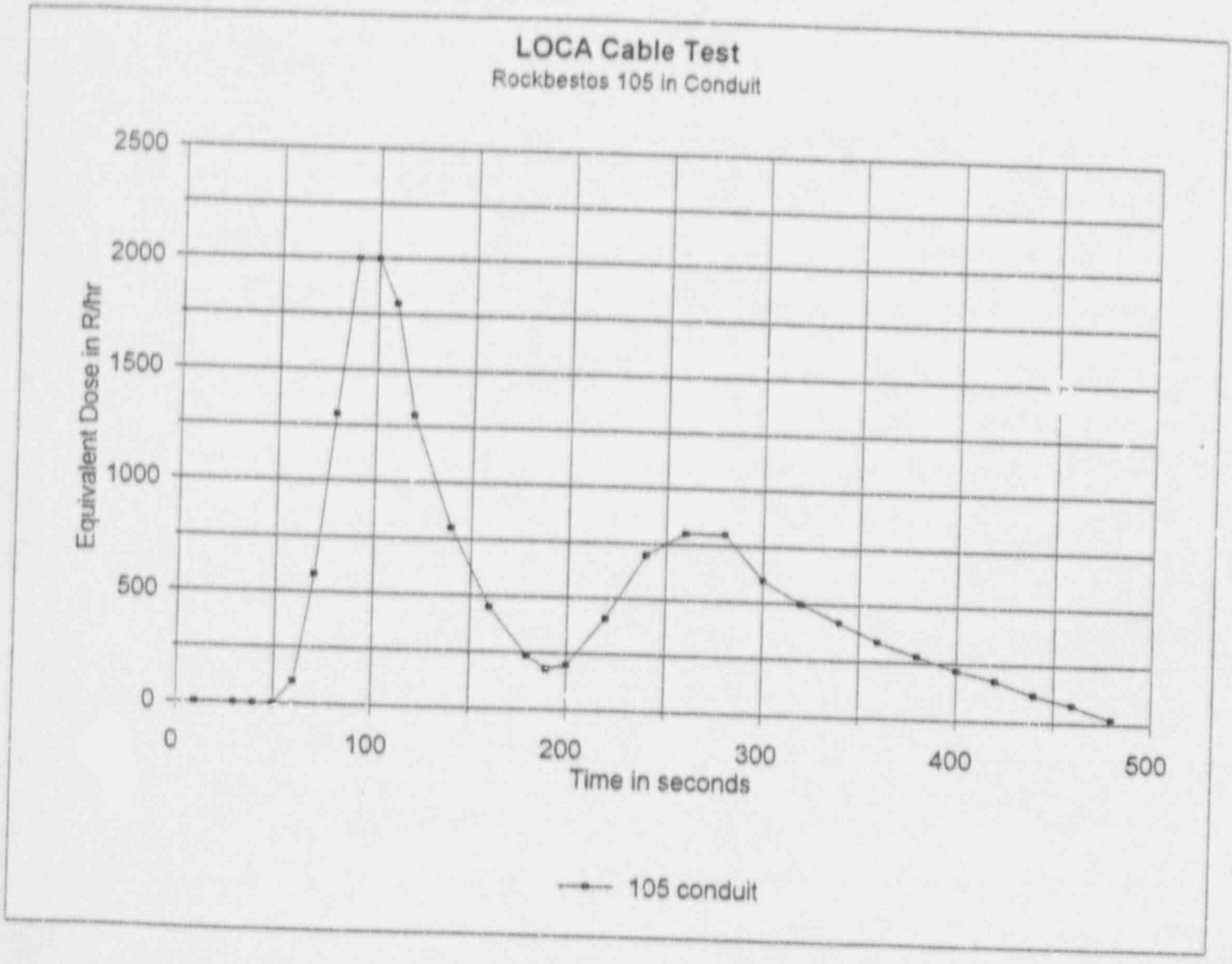
Prepared by: A.T. Hyde 4/2/96 filename: 7820data\note4296

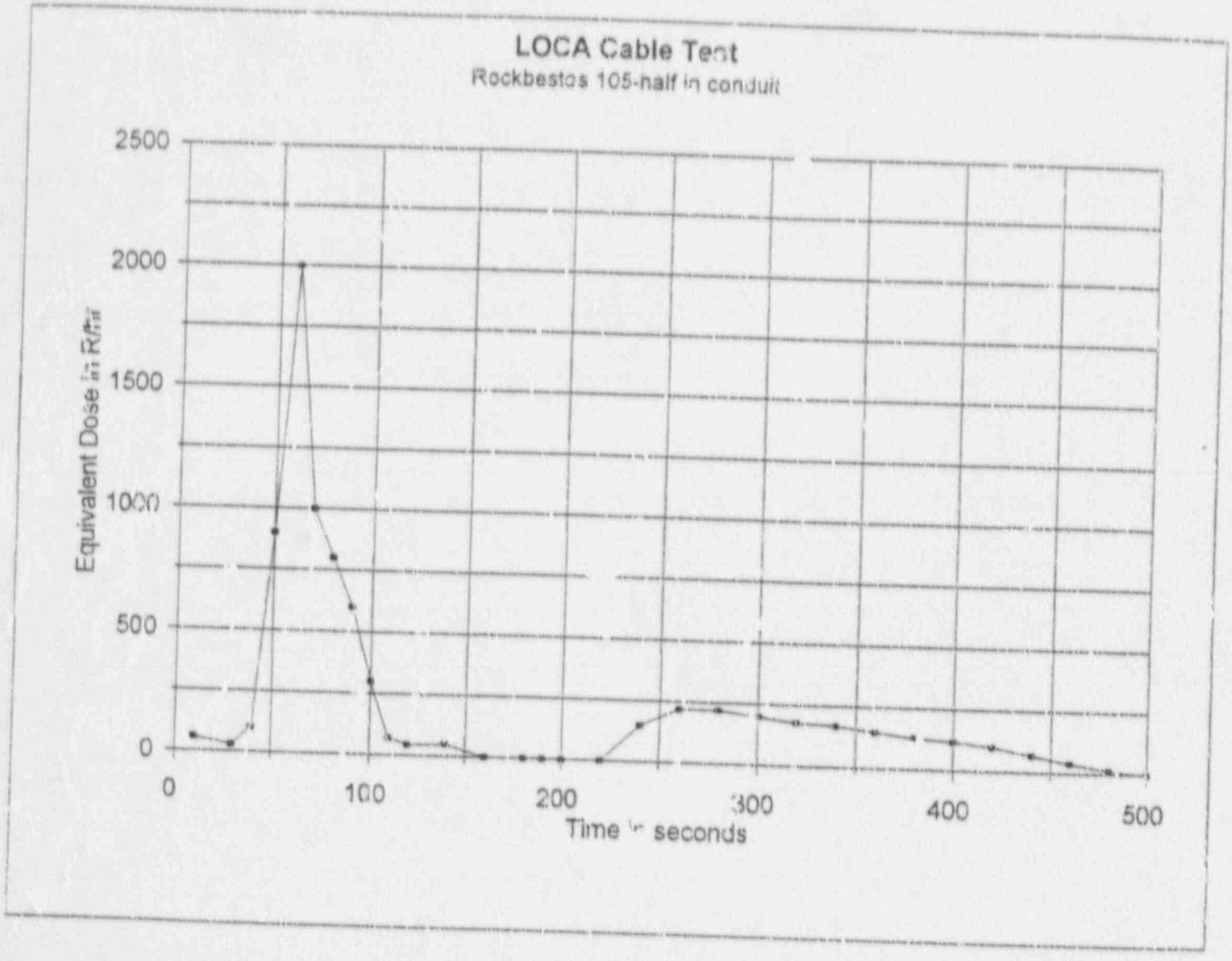

Steam Test Temperature Profile
Wyle Labs 3/29/96
Temperature in deg F
500
400
300
200
100
0
0
200
400
600
800
Time in seconds
Chem spray

Exp. F f 3/2

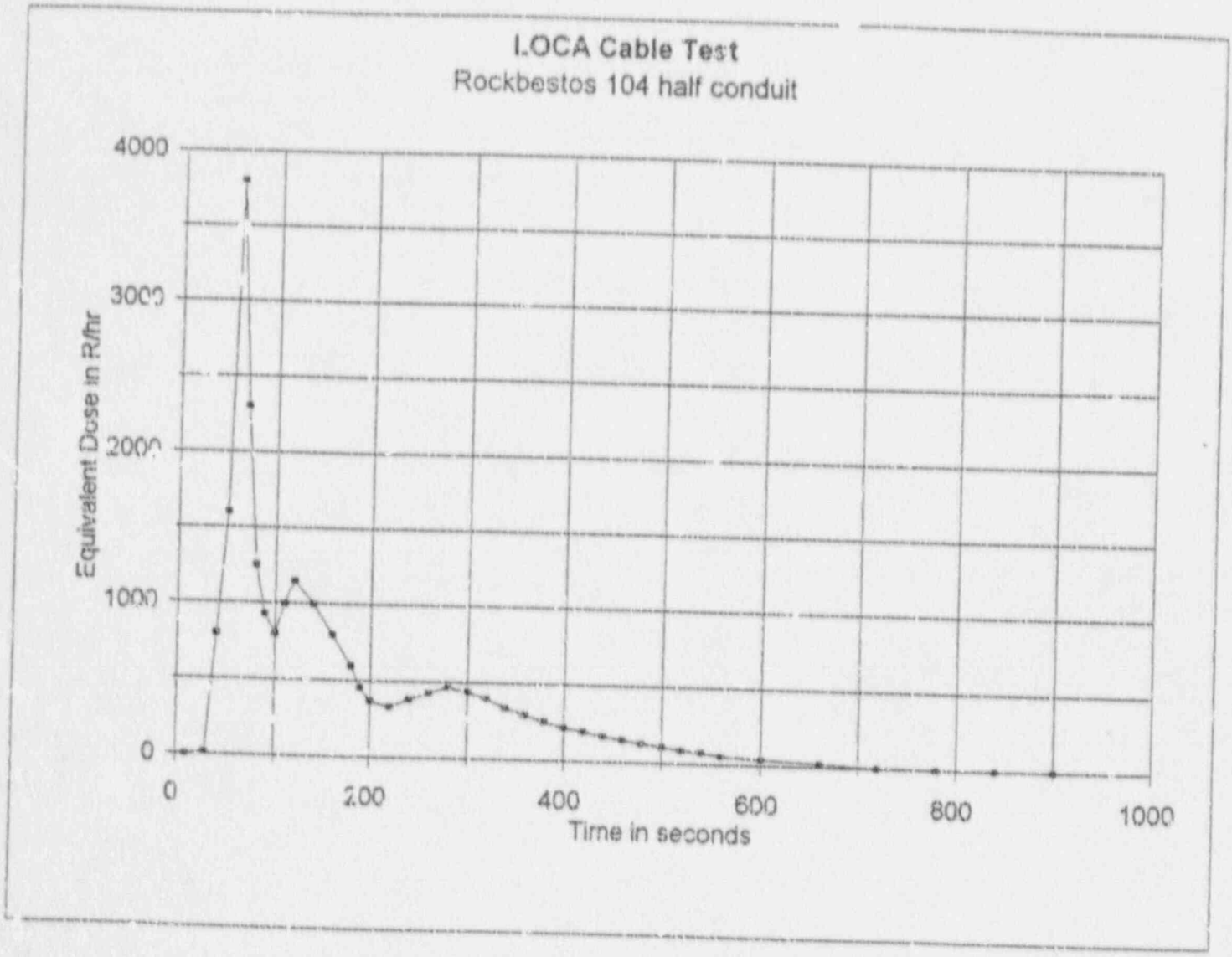

LOCA/Steam Break Cable Test
Current Response to Thermal Shock
4E-08
3E-08
2E-08
1E-08
0
-1E-08
Current in amps
0
200
400
600
800
1000
Time in seconds
105 cond
105 half
104 Cond
104 half

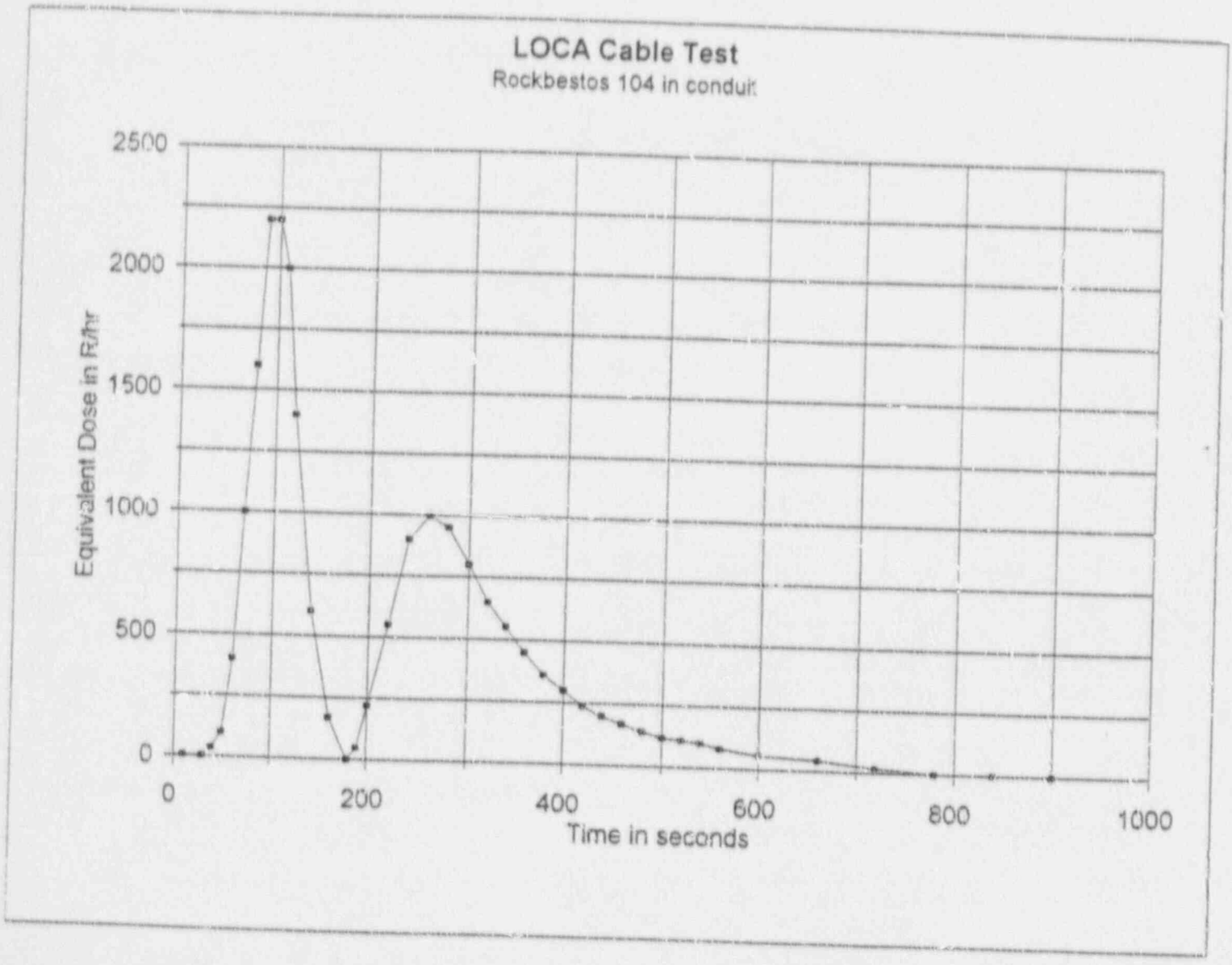
Att. F p. 4/8

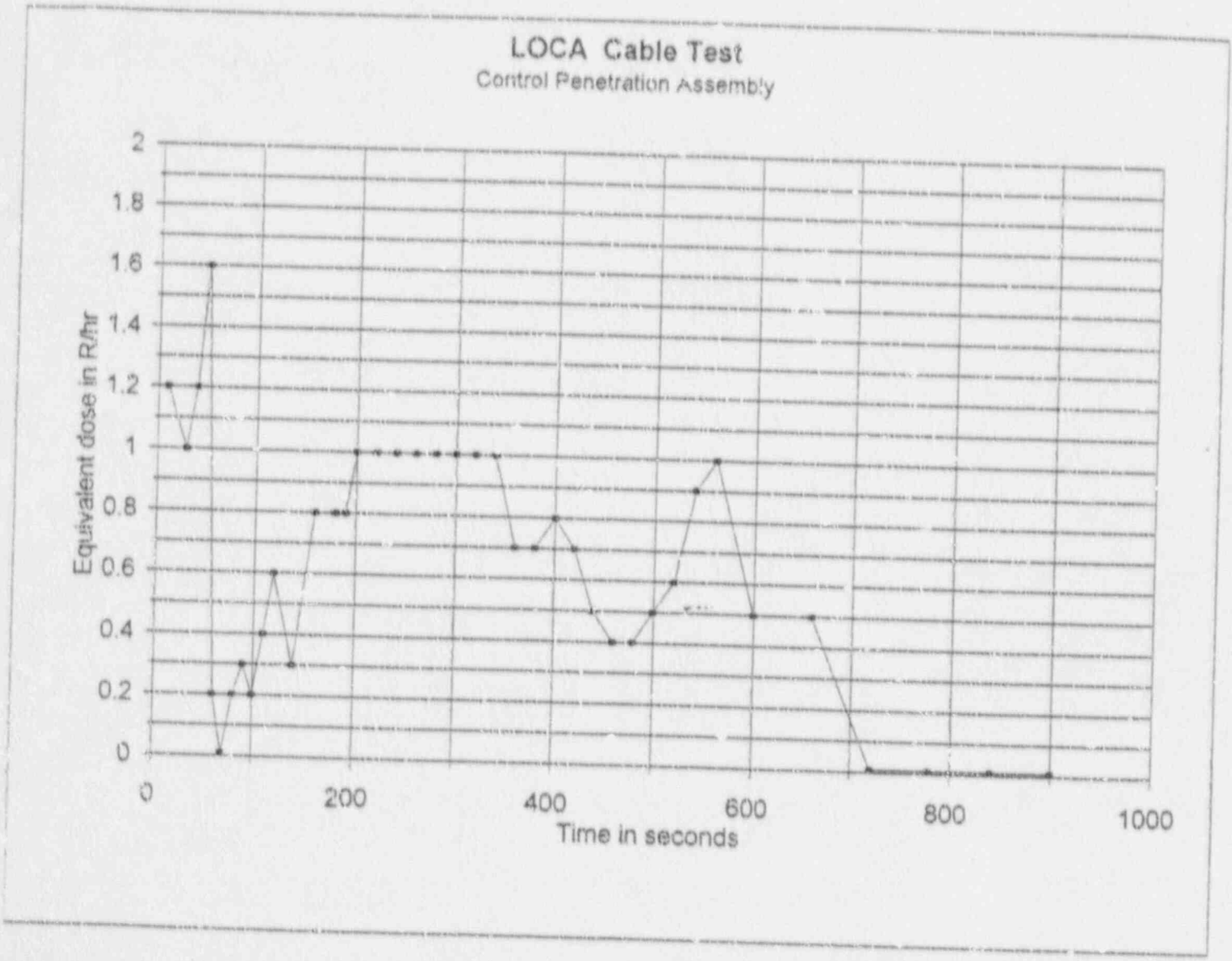

LOCA Cable Test
Rockbestos 105 in Conduit
Equivalent Dose in R/hr
2500
2000
1500
1000
500
0
0
100
200
300
400
500
Time in seconds
105 conduit


LOCA Cable Test
Rockbestos 105-half in conduit
Equivalent Dose in R/hr
2500
2000
1500
1000
500
0
0
100
200
300
400
500
Time in seconds

App. F p 5/8


LOCA Cable Test
Rockbestos 104 half conduit
Equivalent Dose in R/hr
4000
3000
2000
1000
0
0
200
400
600
800
1000
Time in seconds


LOCA Cable Test
Rockbestos 104 in conduit
Equivalent Dose in R/hr
2500
2000
1500
1000
500
0
0
200
400
600
800
1000
Time in seconds


LOCA Cable Test
Control Penetration Assembly
Equivalent dose in R/hr
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
200
400
600
800
1000
Time in seconds

Appendix G p 1/2

Notes on Thermally Stimulated Depolarization Currents

Ref. R. Chen, Y. Kirsh; Analysis of Thermally Stimulated Processes; 1981, Pergamon Press

This text identifies many mechanisms where current can be released from a dielectric as a result of raising the temperature. The manner in which polarization can occur within a dielectric is by charges creating dipoles at impurity molecule sites within the dielectric. These dipoles require an electric field to initiate the dipole.

The release of the dipole charge requires a certain amount of activation energy (eV). As the temperature of the dielectric rises, the activation energy level is reached and the charge is released. The time constant or relaxation time for this release can be expressed as:

$$\tau(T) = \tau_0 \exp(\frac{E}{kT})$$

where $\tau(T)$ is the relaxation time, τ_0 is a time factor independent of temperature, E is the activation energy in eV, k is Boltzmann's constant in eV/°K, T is temperature in °K.

The saturation polarization in coulombs/unit volume can be expressed as:

$$P_0 = \frac{\mu^2 E_p N \alpha}{k T_p}$$

Where P_0 is the saturation polarization, μ is the dipole moment, E_p is the applied electric field at temperature T_p, N is the concentration of dipoles in dipoles/unit volume, α is factor that depends on the dielectric lattice/crystal structure. This equation assumes that just one impurity type exists. For an array of impurities, similar equations exist.

Using a Bucci model, the current density of the released current is proportional to the number of remaining dipoles in the dielectric.

$$j(T) = -\frac{dP}{dt} = \frac{P}{\tau(T)} = \frac{P}{\tau_0} \exp(\frac{-E}{k T})$$

Where j(T) is the density of released current

If the heating rate is linear, i.e. $dT/dt = \beta$ or $dt = dT/\beta$ then the current density can be described as:

$$J(T) = \frac{N\mu^2\alpha E_p}{kT_pT_0} \exp(\frac{-E}{kT}) \exp[(-\frac{1}{\beta T_0}) \int_{T_0}^{T} \exp(\frac{-E}{kT'})dT']$$

It follows that if this model is representive of the current releases observed in our cable tests, then the released current is dependent on the length of the cable. It is also dependent on the polarizing E-field, the number of impurity sites in the dielectric, the dipole activation energy and the rate of temperature change during the heating.

Some possible solutions to reducing this depolarization current are to preheat/temperature soak the cable prior to installation in order to release the dipole currents. Dielectric tests would have to be minimized and greatly reduced in magnitude, Say <<10 volts rather than >500 volts.

Prepared by A.T Hyde 5/9/96