

DISCLAIMER

FIELD MEASUREMENTS AND INTERPRETATION OF TMI-2 INSTRUMENTATION: HP-R-213

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1. INTRODUCTION

During and following the TMI-2 accident, a number of instruments failed or were suspected of providing erroneous readings. Because of this problem, industry concerns were focused upon the behavior of instrumentation under adverse conditions. To better understand failure mechanisms, the Technical Integration Office (TIO) contracted Technology for Energy Corporation (TEC) to perform field measurements on a set of selected TMI-2 instruments to determine in-situ operating characteristics. For some instruments, these measurements were to be performed prior to removal (and replacement with new instruments) in order to have a cross reference with post-removal observations. For other instruments, an indication of the condition of the instrument (i.e., fully operational or failed) was desired.

This report provides the information gathered by TEC on the area radiation monitor HP-R-213. This detector was located at 347 feet elevation inside containment. This instrument consisted of a Victoreen Model 857-2 detector assembly connected to a Victoreen Model 856-2 panel alarm and approximately 330 feet of interconnecting cable. This instrument was believed to have failed due to a constant off-scale low radiation level indication and due to a lack of response to the manually activated checksource in the detector. As a result of this failure, the detector was a candidate for early replacement to provide long-term radiation monitoring capability inside containment.

2. INSTRUMENT LOCATION, CABLING, AND TERMINATIONS

A review of appropriate drawings from Victoreen and Burns & Roe (itemized in the Appendix in the measurement procedure, page A-5) resulted in the composite electrical diagram shown in Figure 2-1. From this information, Table 2-1 gives a list of the appropriate termination points for performing measurements in the Control Room in Cabinet 12. Also noted in Figure 2-1 are the cable lengths pulled during instrument installation (before final trimming) between each termination and/or function point.

The detector assembly is a Victoreen Model 857-2 which is shown in Figure 2-2 along with required interfacing connections to the readout module. Figure 2-3 shows the functional layout of the detector and associated readout module. This assembly is a "medium range" device with a range of 0.1 to 10^4 mR/hr. An electrical diagram of the detector circuit is shown in Figure 2-4. As shown in Figure 2-1, the circuit is somewhat complicated by the presence of a remote alarm/meter and a second remote alarm which are used as local indicators of the radiation levels.

Since measurements were being made in the control room, there was no way to remove the effect of the remote alarm/meter (attached to the signal line) from the observed instrument response. However, since the remote alarm/meter was located outside containment, it did not experience the severe operating environments and thus was not considered to present any measurement problems. (The remote alarm was located inside containment,

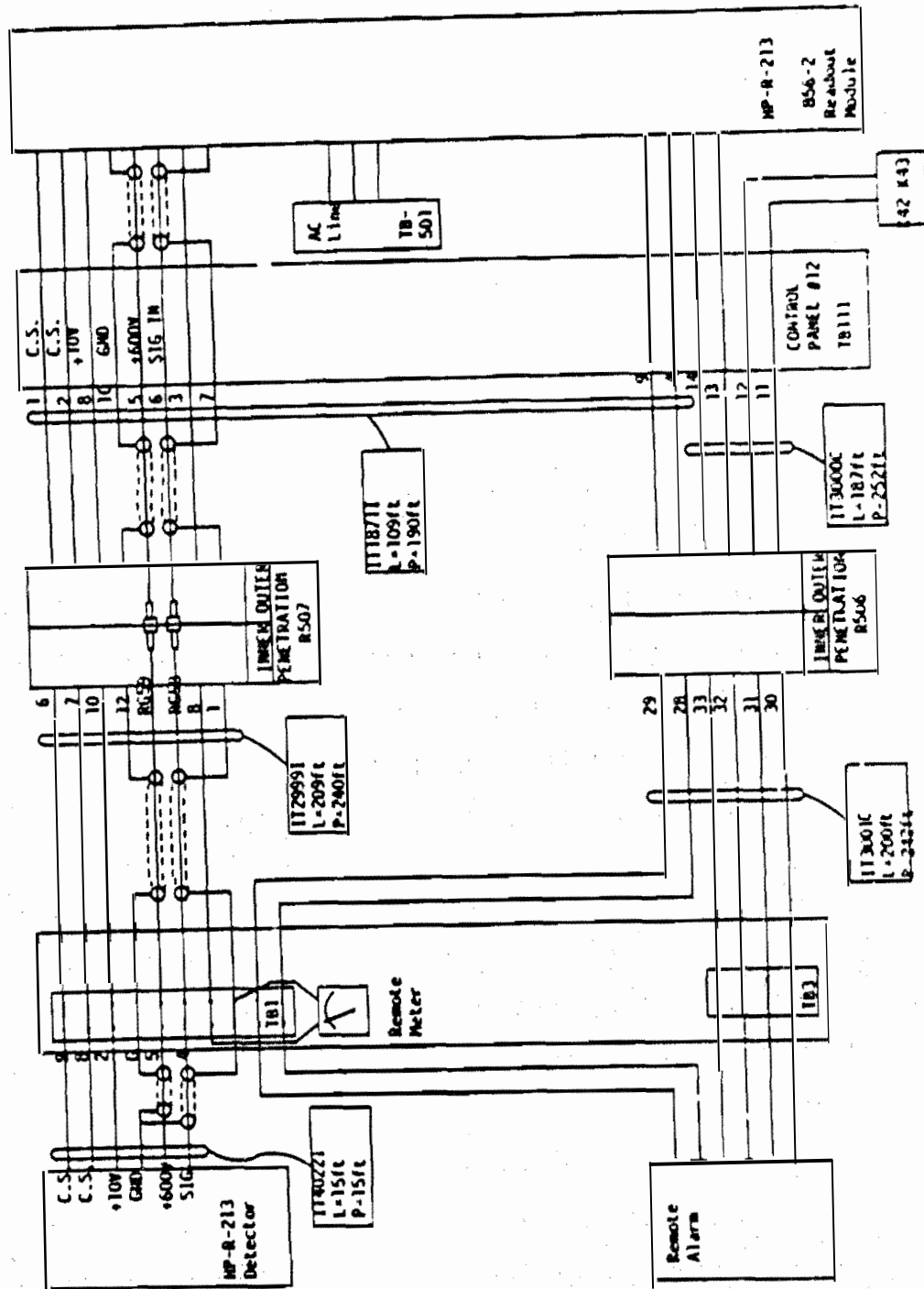


Figure 2-1. HP-R-213 Composite Electrical Diagram.

Table 2-1

TERMINATION POINTS FOR HP-R-213 MEASUREMENTS

Signal	Cabinet 12 Identification*
+10V Power Supply	TB111-8
+600V High Voltage	TB111-5
Signal In	TB111-6
Ground	TB111-10
CS**	TB111-1
CS**	TB111-2

*From cable IT18701

**CS = Checksource coil positive and return contacts (exact identification not necessary).

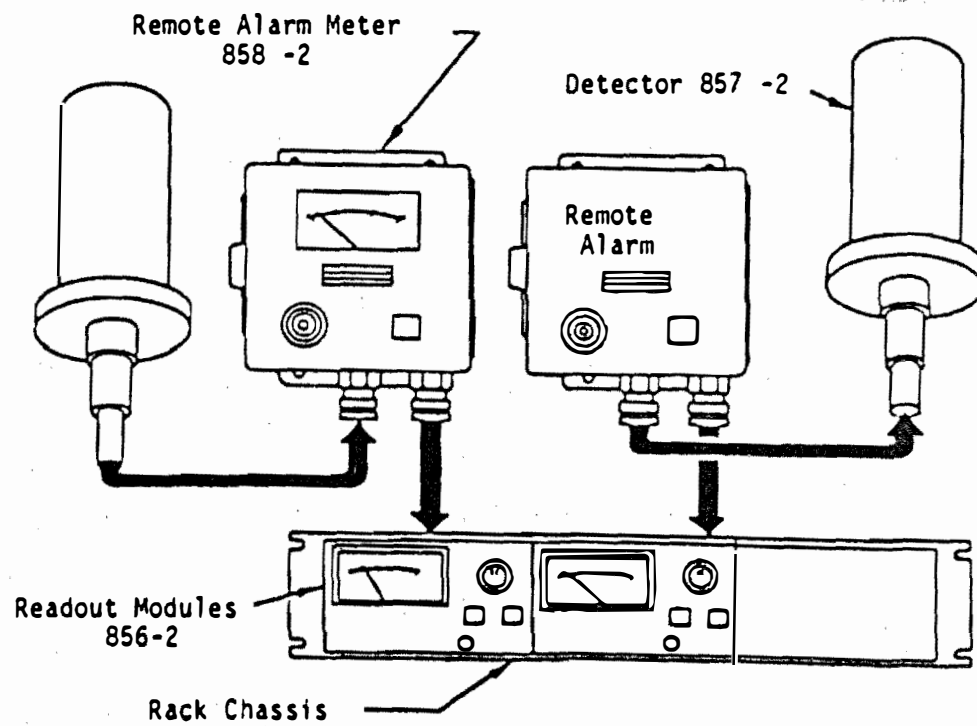


Figure 2-2. Sketch of Instrumentation for HP-R-213

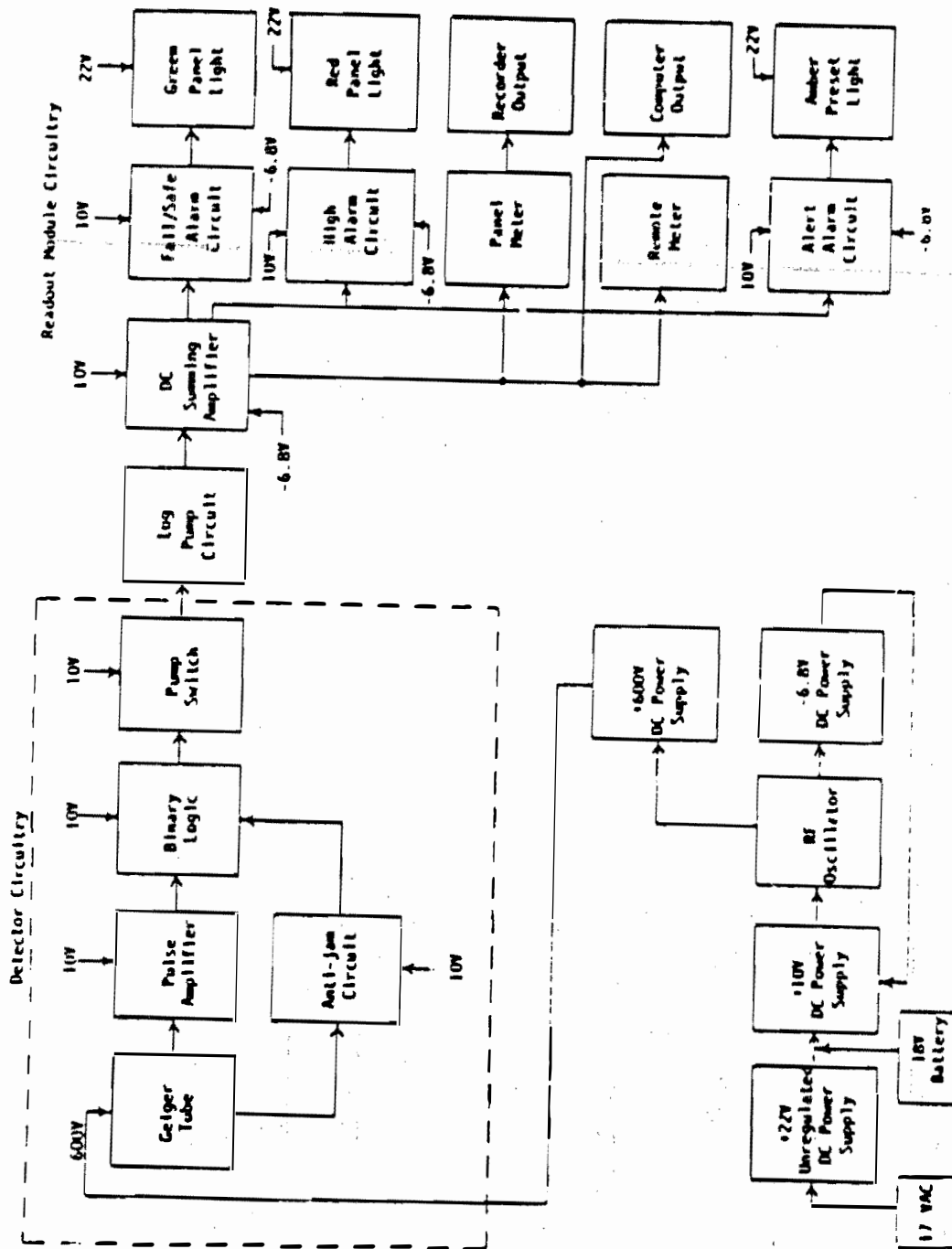


Figure 2-3 Functional Layout of Detector and Readout Module.

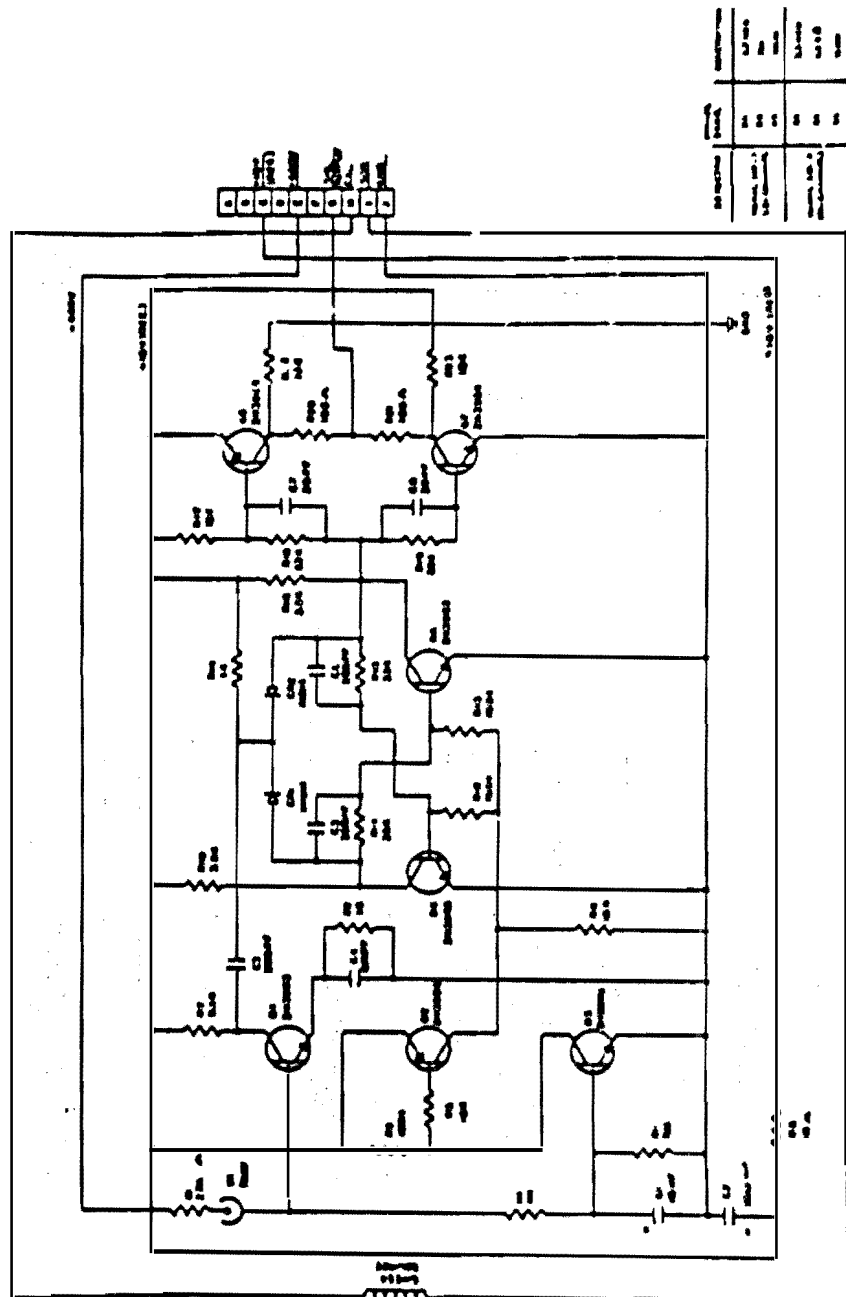


Figure 2-4. Electrical Circuit of Detector Card

but was isolated from the signal line by the remote alarm/meter circuitry.) Similarly, the Model 856-2 Readout Module, located in the control room, was not specifically considered to be a source of instrumentation problems except in its function of supplying power to the detector assembly.

3. PREPARATION OF MEASUREMENT PROCEDURES

As a result of generating the composite electrical diagram and from a review of the Victoreen Area Monitor Operation Manual, the major types of measurements to be performed were identified as:

1. Determine as-found condition of Readout Module and Remote Meter and record signal output
2. Perform passive measurements (i.e., passively monitor signals) on each electrical connection consisting of time domain waveforms, very-high frequency spectrum analysis (i.e., MHz region), and frequency spectra below 100 kHz
3. Perform resistance, capacitance, impedance, and Time Domain Reflectometry (TDR) active measurements (i.e., actively introducing a test signal).

These measurements were designed to verify the operation of the Readout Module (especially the power supplies), but the focus of the measurement was on the detector assembly, cabling, and terminations/connections to the assembly. The Appendix contains the detailed procedure which was followed during the measurement program, and a summary of measurements is presented in the next section.

4. MEASUREMENTS

Since the output of HP-R-213 was designed to cover the range of 0 to +10 volts, the signal could be directly measured without amplification. Before performing measurements, the readout of HP-R-213 indicated an off-scale low value of less than 0.1 mR/hr for the gamma dose inside containment. Activation of the checksource had no effect on the output reading. The Signal In was then recorded for approximately 10 minutes on an FM recorder and various outputs measured with a DVM. These measurements yielded the following results:

10 V power Supply @ 11.1 V

Signal IN @ 10.96 VDC

600 V Power Supply @ 599 VDC

Checksource @ 15.0 ma

The next measurements consisted of photographing the output waveforms of the checksource, Signal In, and power supplies from a storage oscilloscope. Figures 4-1 to 4-6 show the results of these time trace measurements. Along with the time traces, both high and low frequency spectra (frequency domain) were taken of the Signal In and power supplies. Figures 4-7 to 4-9 show the measured spectra over high frequency bandwidths (>1 MHz), while Figures 4-10 to 4-12 show spectra over bandwidths below 100 kHz.

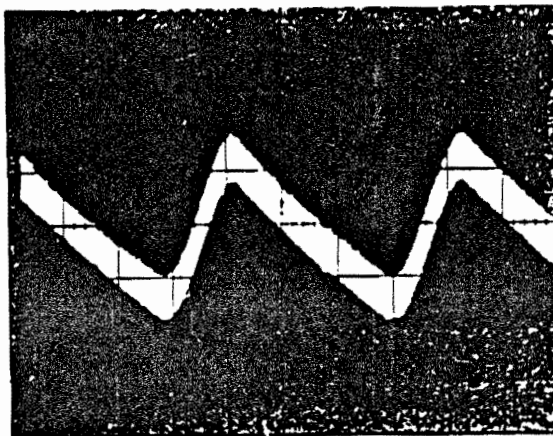


Photo #103-1

Time-2msec

Gain - 50 mV

TB111-1 to

TB111-10

Check Source

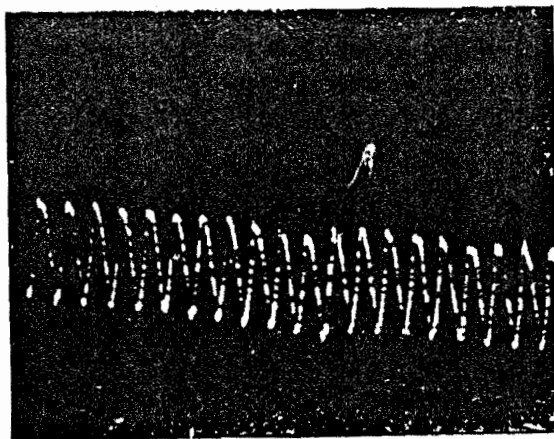


Photo #103-2

Time - 0.1 msec

Gain - 50 mV

TB111-1 to

TB111-10

Check Source

Figure 4-1. Typical Fluctuations Present on Checksource Line 1.

4-3

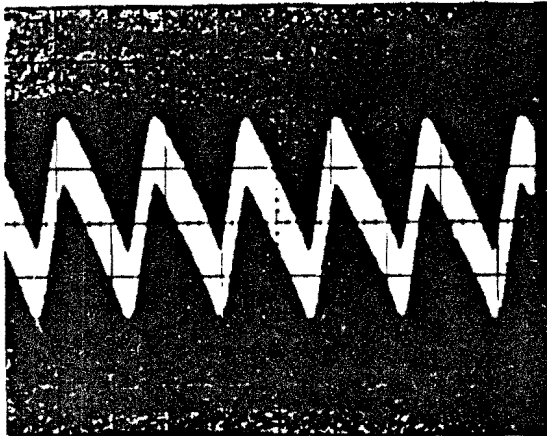


Photo #103-3

Time base - 2msec

Gain - 50 mV

TB111-2 to

TB111-10

Check Source

Figure 4-2. Typical Fluctuations Present on Checksource
Line 2.

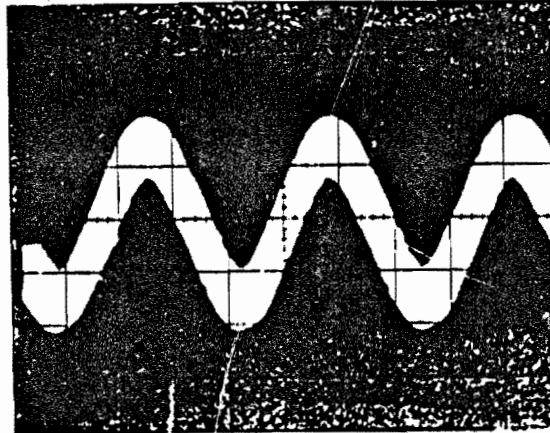


Photo #103-4

Time - 0.1 msec

Gain - 20mV

TB111-5 to

TB111-10

+600V

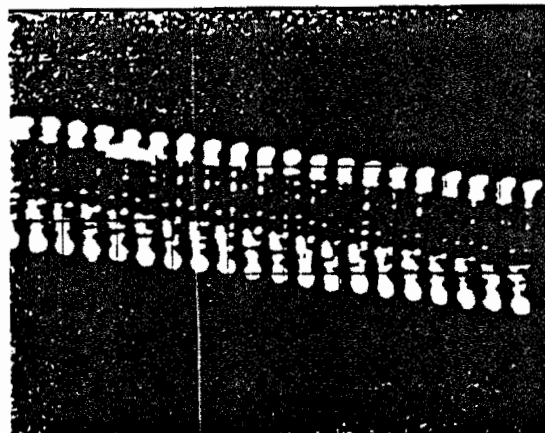


Photo #103-5

Time - 5 msec

Gain - 50mV

TB111-5 to

TB111-10

+600V

Figure 4-3. AC Variations on the 600V Power Supply.

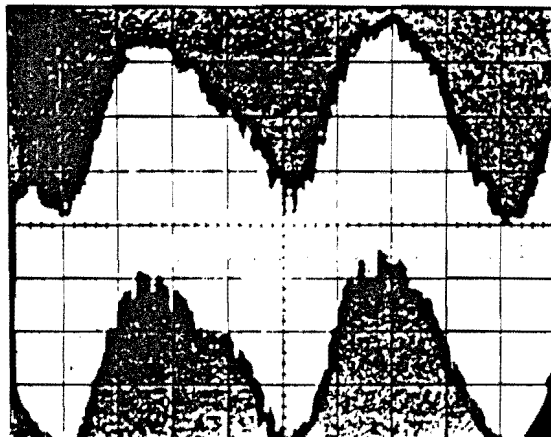


Photo #103-6

Time - 2msec

Gain - 2 mV

TB111-6 to

TB111-10

Signal

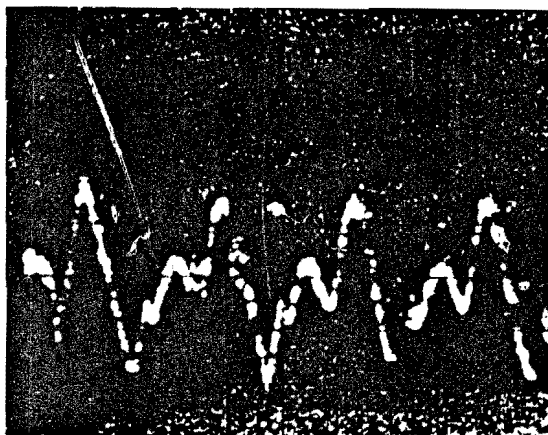


Photo #103-7

Time - 20μsec

Gain - 2 mV

TB111-6 to

TB111-10

Signal

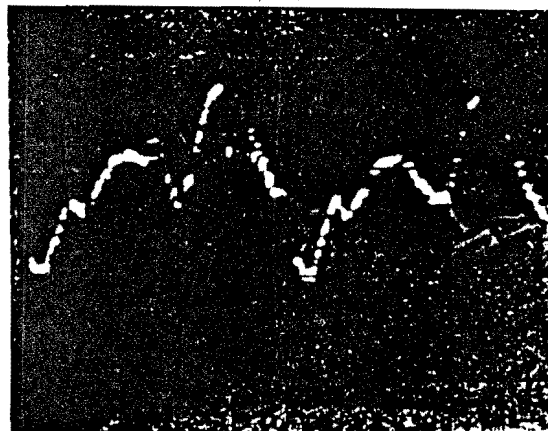


Photo #103-8

Time - 10μsec

Gain - 2 mV

TB111-6 to

TB111-10

Signal

Figure 4-4. AC Variations on the Signal Output.

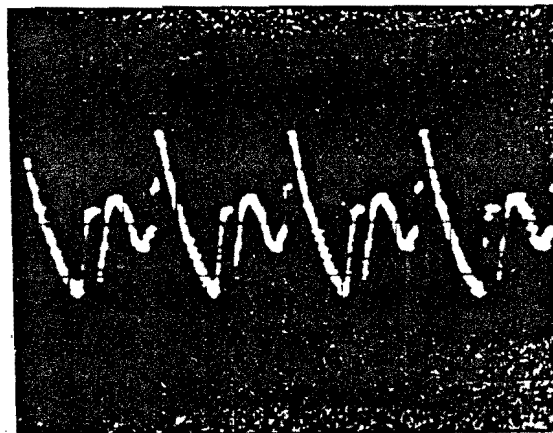


Photo #103-9
 Time - 20 μ sec
 Gain - 50 mV
 TB111-8 to
 TB111-10
 +10V

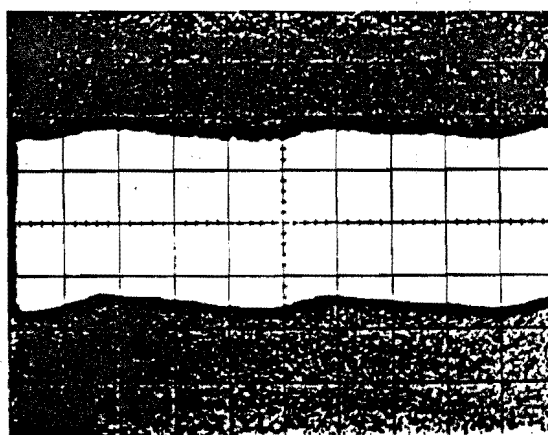


Photo #103-10
 Time - 2msec
 Gain - 50 mV
 TB111-8 to
 TB111-10
 +10V

Figure 4-5. AC Variations on the 10V Power Supply.

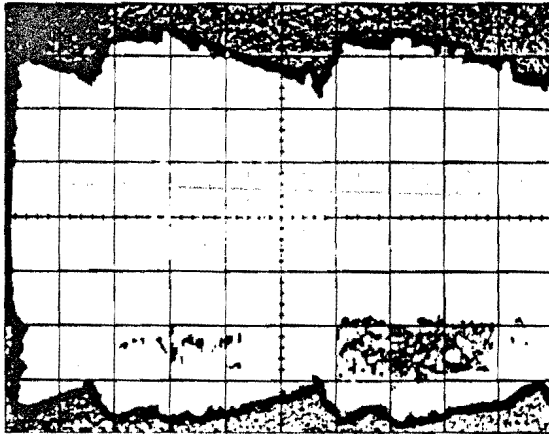


Photo #103-11

Time - 2msec

Gain - 0.1V

TB111-10 to

TB501-33

GND

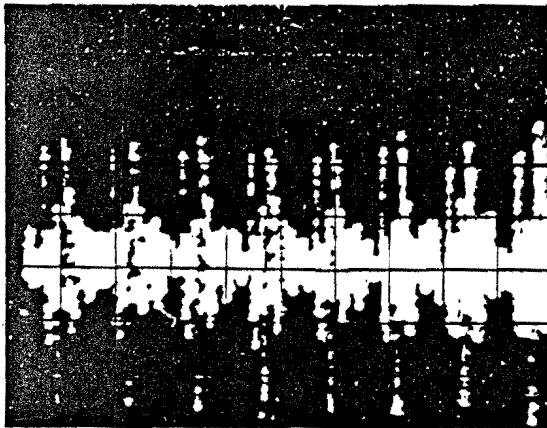


Photo #103-12

Time - 50μsec

Gain - 0.1V

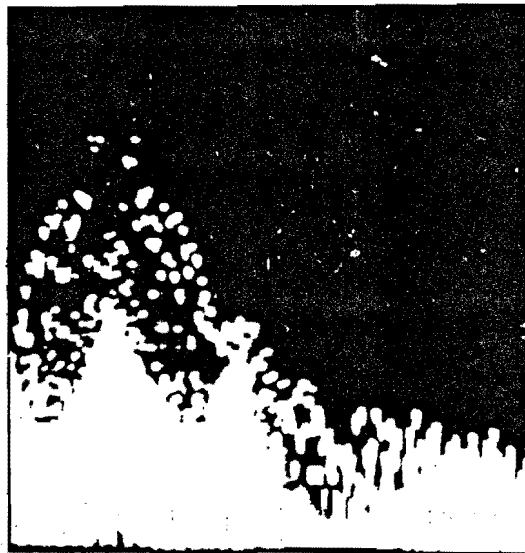
TB111-10 to

TB501-33

GND

Figure 4-6. Typical Fluctuations Present Between Ground-AC Ground.

- 20db



0 1 2 3

Frequency (MHz)

Photo #103-13

BW-1 kHz

Scan time - 1sec

Scan width - 0.5 MHz

Attn - 0

Log Ref --20db

TB111-8 to

TB111-10

+10V

Figure 4-7. High Frequency Spectrum of 10V Power Supply.

- 20db

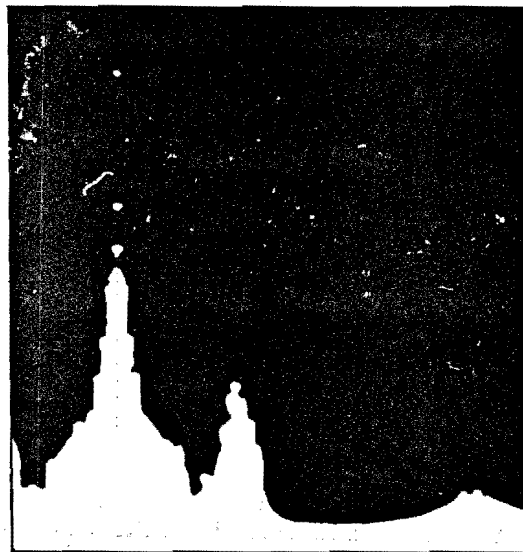


Photo #103-14

BW-1 kHz

Scan time - 1sec

Scan width - 0.5 MHz

Attn - 0

Log Ref - -20db

TB111-6 to

TB111-10

Signal In

Figure 4-8. High Frequency Spectrum of Signal Output.

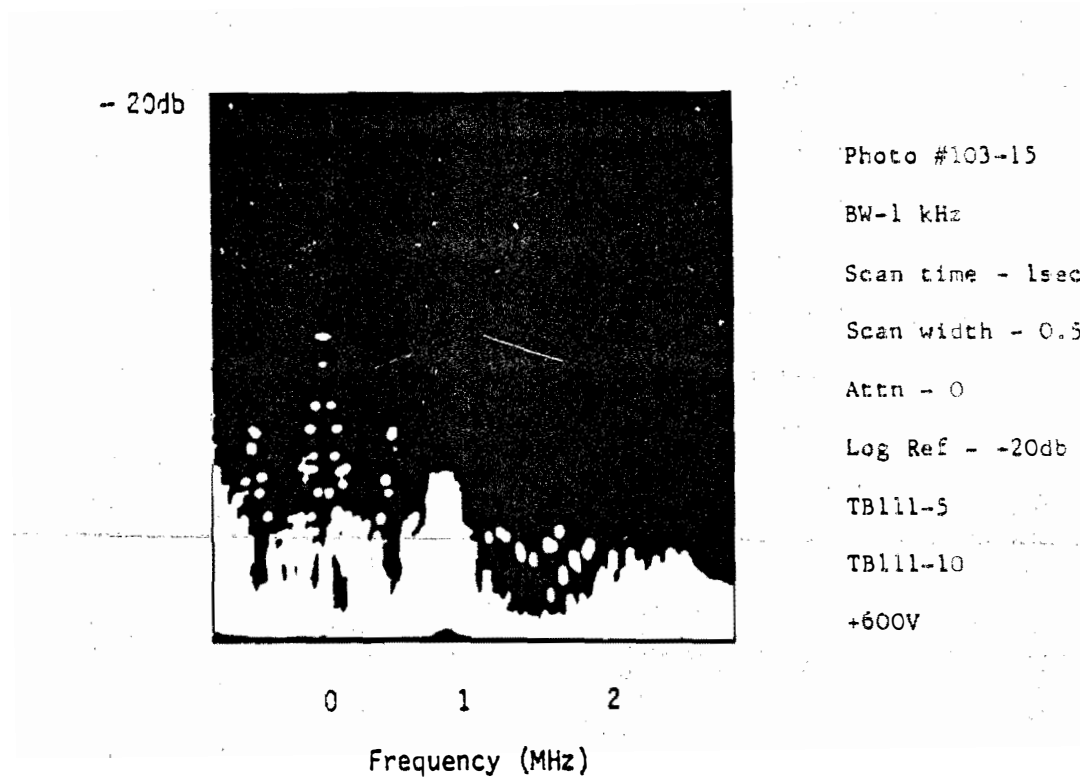


Figure 4-9. High Frequency Spectrum of 600V Power Supply.

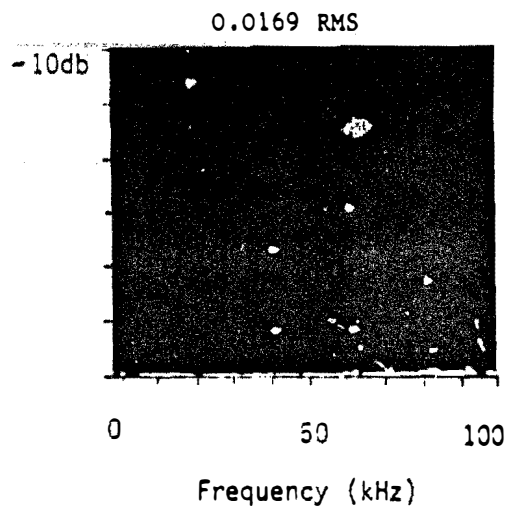


Photo #103-18

+600V

+10db Reference

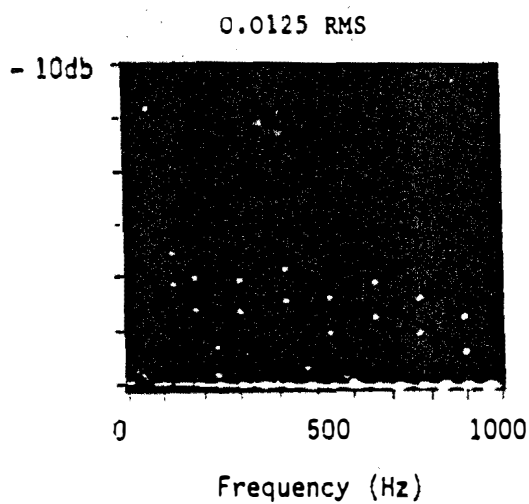


Photo #103-19

+600V

+10db Reference

Figure 4-10. Low Frequency Spectra of 600V Power Supply.

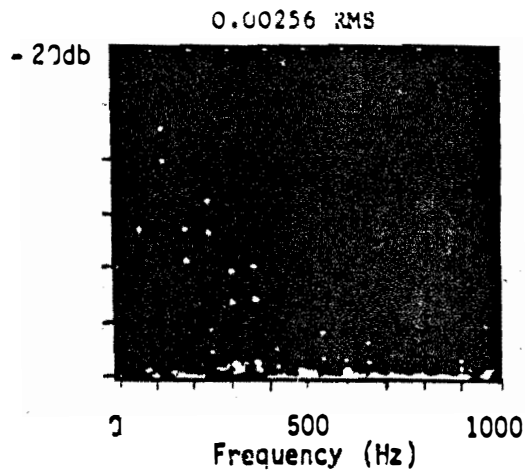


Photo #103-20

Signal In

+20db Reference

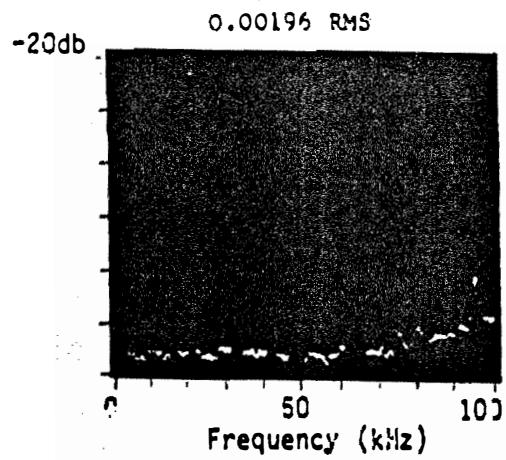


Photo #103-21

Signal In

+20db Reference

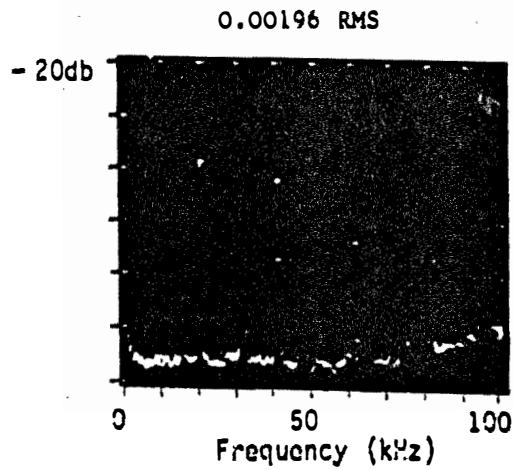


Photo #103-22

Signal :

+20db Reference

Figure 4-11. Low Frequency Spectra of Signal Output.

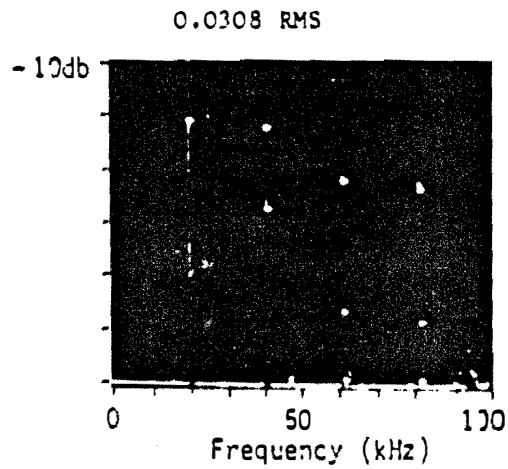


Photo #103-23

+10V

+10db Reference

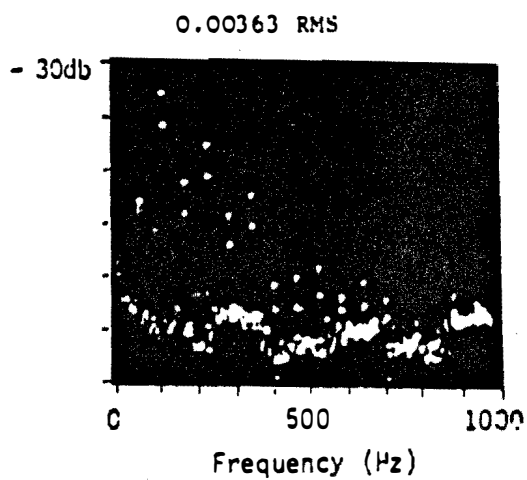


Photo #103-24

+10V

+30db Reference

Figure 4-12. Low Frequency Spectra of 10V Power Supply.

Following the frequency spectra measurements, electrical calibration was requested for the HP-R-213 readout module. During attempted calibration, a problem was identified in the readout module, but was not corrected due to other tasks requiring the attention of TMI technicians. Data from the instrument repair was then requested but not received. After attempting electrical calibration, power was removed from HP-R-213. The test fixture was removed and all signal lines from cable IT18711 to cabinet 12 were disconnected. A series of active measurements (i.e., actively introducing a test signal into the circuit) was then performed. Table 4-1 shows the results of capacitance, impedance, and DC resistance measurements on some of the field cable lines (see Appendix pages A-14 and A-16 for a complete set). A set of TDR measurements were taken on the signal lines to determine possible cable defects. These TDR traces are shown in Figures 4-13 to 4-16.

Table 4-1

CAPACITANCE, IMPEDANCE, AND RESISTANCE MEASUREMENTS

Signal	Capacitance (nF)			Impedance (ohms)			Resistance (ohms)*
	100 Hz	1 kHz	100 kHz	100 Hz	1 kHz	100 kHz	
Checksource (+) Checksource (-)	-2.8 μ F	-5.8 μ F	3.5	40.0	4.88	4.48	41 (41)
+600 V Ground	VAR**	10	10.5	OF+	16K	152	>2 M
Signal In	VAR	7.9	6.9	OF	OF	229	9.2K (8.6k)
+10 V Ground	96 μ F	119 μ F	-47	22.5	14.7	38	12.5K (8.3K)
Ground (field) Ground (cabinet)	VAR	53 μ F	26.7	1.2K	960	70	--
Signal In +10 V	--	--	--	--	--	--	8.8K (7.2K)

*Values in parentheses are reverse polarity values.

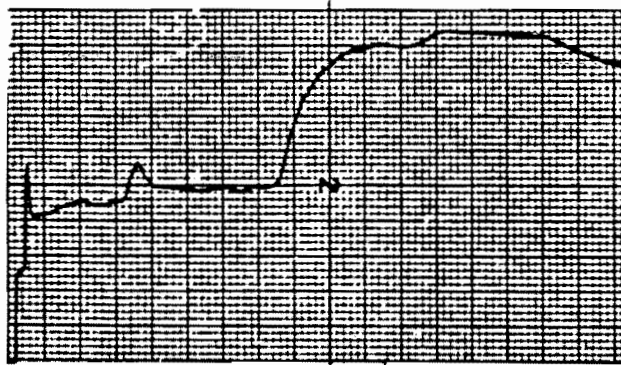
**Indicates variable response.

+ Indicates off-scale reading or excessive line noise.

STRIP CHART 103-1

TB111: 1 to 2

Signal - Check Source



Setting - 500mV/div

Range - 52.6 ft/div

15 hz filter

2nd plot begins @350 ft.

Cable dielectric - other

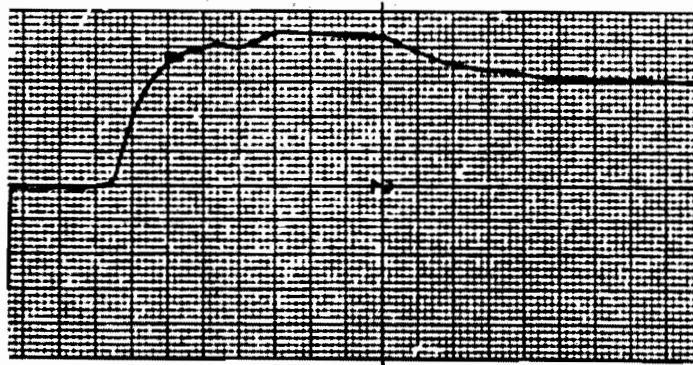
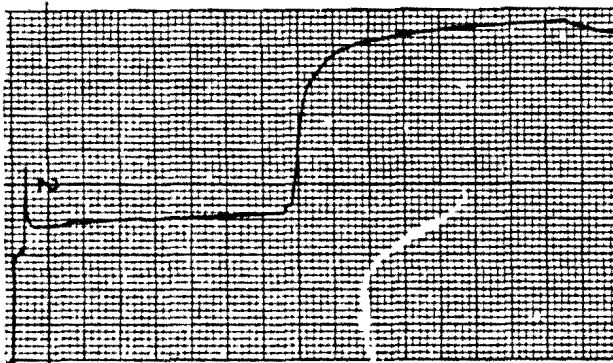


Figure 4-13. TDR Traces from the Checksource Lines.

STRIP CHART 103-2

TB111: 5 to 10

Signal - +600V



Setting - 500mp/div

Range - 52.6 ft/div

Sensitivity - 0.25

15 hz filter

2nd plot begins @350 ft.

Cable dielectric - poly

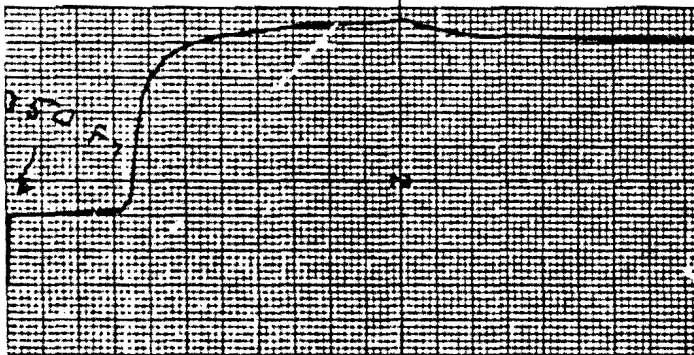
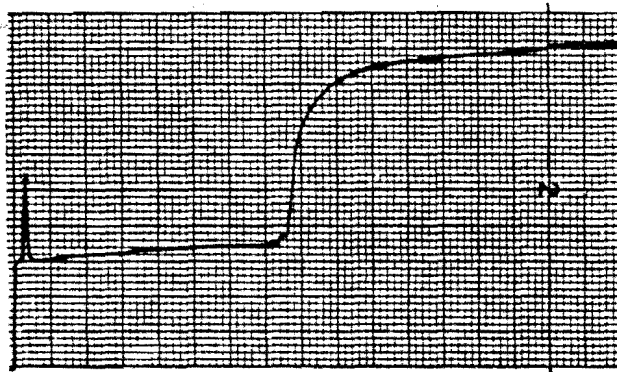


Figure 4-14. TDR Traces from the 600V Power Supply Cable.

STRIP CHART 103-3

TB111: 6 to 10

Signal: Signal In



Setting - 500mp/div

Range - 52.6 ft/div

Sensitivity - 0.25

15 hz filter

2nd plot begins @350 ft.

Cable dielectric - poly

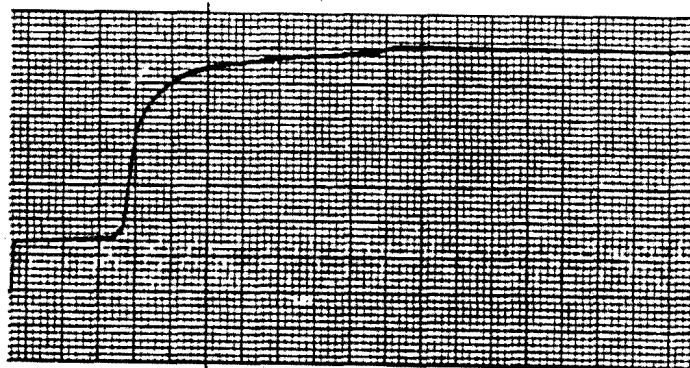
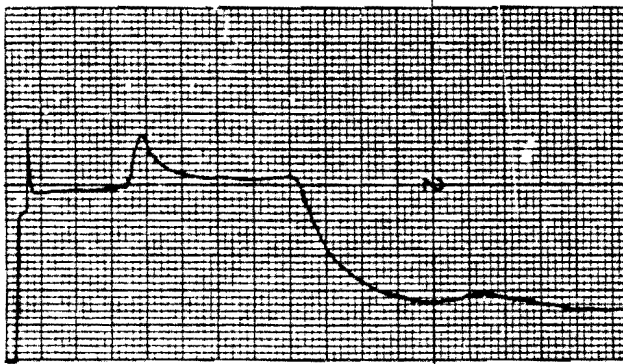


Figure 4-15. TDR Traces from the Signal-In Cable.

STRIP CHART 103-4

TB111: 8 to 10

Signal - +10V



Setting - 500mV/div

Range - 52.6 ft/div

Sensitivity - 0.25

15 hz filter

2nd plot begins @350 ft.

Cable dielectric - poly

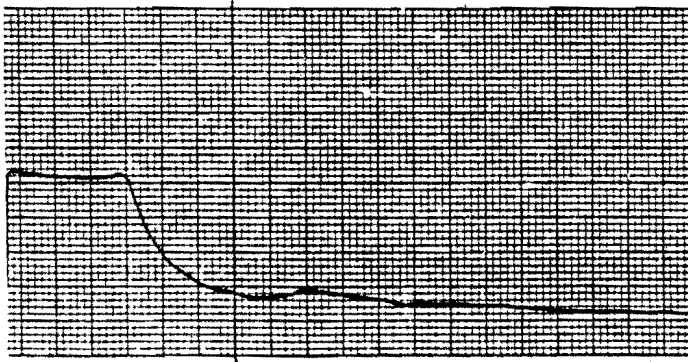


Figure 4-16. TDR Traces from the 10V Power Supply Lines.

5. SUMMARY AND INTERPRETATION OF MEASUREMENTS

This section presents a summary of the interpretation of the measurements taken on HP-R-213. This interpretation is intended to indicate the condition of the device based on observed data.

5.1 SUMMARY OF MEASUREMENTS

The 10 V power supply measurements indicated a 11.1 VDC output value, which is outside the normal variation, but probably not high enough to damage the circuitry. The 600 V power supply was measured at 599 VDC when connected to the detector assembly, which indicates this supply was working properly. The Signal In measurement produced a 10.96 VDC reading, which indicates the output is constant at very nearly the power supply level. Measurements on the checksource produced a 15 ma current load, which indicates the electrical path through the checksource coil is intact.

The time traces and frequency spectra were used to summarize the major characteristics of the measured waveforms. Results of this summary are presented in Table 5-1. Both the power supplies exhibit normal characteristics when compared to other TMI-2 measurements.

The Signal In waveform would normally be 0-10 V pulses with a frequency proportional to the radiation present. The oscilloscope photograph of

Table 5-1

CHARACTERISTICS OF MAJOR SIGNAL LINES

Signal	Frequency	Amplitude
Signal Out	0 (DC)	10.96 V
	60 Hz and Harmonics	2.5
	20 kHz and Harmonics	1.96 mV RMS
	Total Spectrum	16 mV P-P
600 V Supply	60 Hz	12.5 mV RMS
	16 kHz and Harmonics	<1 mV RMS
	20 kHz and Harmonics	16.8 mV RMS
	Total Spectrum	200 mV P-P
10 V Supply	120 Hz	3.6 mV P-P
	20 kHz and Harmonics	31 mV RMS
	Total Spectrum	150 mV P-P

the Signal In line (Figure 4-4) shows that the output has only a small AC variation from the 10.96 VDC level. These variations are mainly due to 60Hz and 20kHz low-level noise that was observed on other TMI instrument outputs. Resistance data (Table 4-1) shows a small increase in resistance among the Signal In, +10V, and Shield lines. Table 5-2 gives a comparison of the resistance data from a new detector assembly to that measured from HP-R-213. This overall increase in resistance is probably not significant since the observed changes could simply be the result of exposure to radiation and high temperatures. However, it could be the result of a degradation (but not total failure) of one of the output driver transistors (Q6 or Q7).

The capacitance and impedance data given in Table 4-1 is difficult to quantitatively interpret due to active components in the circuitry, but qualitative results are possible. Very low effective capacitance values would be expected from most signal lines except for the +10 V to ground, which has a 100 μ F capacitor present. The checksource lines indicate the presence of the coil inductance (negative capacitance) which is also expected. Impedance data is reasonable and exhibits major trends expected from the circuitry such as reducing values at higher frequency for the Signal In.

The results of TDR measurements performed on the cable (shown in Figures 4-13 to 4-16) are summarized in Table 5-3. Note that the lengths identified in the table are only approximate, since no calibration of the cable resistance and material composition was performed on the TDR instrument. Some junction points were not identified by these

Table 5-2

COMPARISON OF MEASURED DETECTOR RESISTANCE

Measurement Point	New Detector*		HP-R-213	
	Polarity +	Polarity -	Polarity +	Polarity +
Signal In Shield	8.78	7.25	9.20	8.60
Signal In +10 V	8.32	6.70	8.80	7.20
Shield +10 V	7.40	11.80	8.30	12.50

*Serial numbers 111 and 1405 composite data.

Notes: (a) All values are in ohms $\times 10^3$ unless otherwise indicated.

(b) First signal to positive terminal, second signal to negative terminal is considered Polarity +.

(c) All measurements made with a Keithley 177 DVM or 20×10^3 ohm scale.

Table 5-3

SUMMARY OF TDR MEASUREMENTS

Signal Lines	Distance (ft)*	Description**	Probable Cause
Checksource (+)	128	Point R Increase	Penetration R507
Checksource (-)	345	Continuous R Increase	HP-R-213 Detector
600 V Supply	144	Point R Increase	Penetration R507
Ground	360	Point R Increase	Remote Meter
	371	Continuous R Increase	HP-R-213
Signal	139	Point R Increase	Penetration R507
Shield	350	Point R Increase	Remote Meter
	361	Continuous R Increase	HP-R-213 Detector
10 V Supply	134	Point R Increase	Penetration R507
Ground	376	Continuous R Increase	HP-R-213 Detector

Note: Distances are not calibrated due to lack of prior information on the cable type which prevented calibration tests.

*TDR to terminal block test cable (15 ft) not included in distance.

**R is the abbreviation for resistance.

measurements, but this is not unusual due to the cable lengths involved and the small resistance changes that would occur at terminal block junctions.

5.2 INTERPRETATION OF MEASUREMENTS

Based upon the observation that the Signal In is at a constant level of 10.96 VDC and there are no significant resistance changes, it appears that either the Geiger tube has failed open or that several internal transistors (Q1, Q2, Q3) have failed. The result of the failure is that the output driver transistors (Q6 and Q7) are continuously asserting a high output level. It is believed that the 11.1 V level of the 10 V supply did not contribute to the failure.

6. CONCLUSIONS

Based on the measurements, data reduction, and circuit analysis of HP-R-213, there is an indication of failure of the instrument. The observed output signals and resistance measurements suggest that the Geiger tube has failed open, and that the output is constant at the power supply level. This would result in an effective "zero" input to the readout module due to an AC coupling in the receiver and would cause the readout to be off-scale low.

It is not believed that the high voltage level of the 10 V power supply contributed to the detector assembly failure.

APPENDIX
ORIGINAL FIELD PROCEDURES AND
DATA SHEETS FOR HP-R-213

GENERATION CORRECTIVE MAINTENANCE SYSTEM
JOB TICKET FORM (WC Page A-1 IEE MILE ISLAND

UNIT 2

COMPONENT DESIGNATION				LOCATION/UNIT	JOB TYPE	JOB TICKET NUMBER	REQUEST DATE			RECOMMENDED PRIORITY
SYS	COMP TYPE	COMP ID	MC				DAY	HR		
HP	R	0213		036002	CM	C5663	09	17	00	2

RECOMMENDED PRIORITY

DESCRIBE MALFUNCTION OR MODIFICATION DESIRED

CAUSE OF MALFUNCTION (IF KNOWN)

Perform attached procedure.

ORIGINATOR'S EMP NO.
06175

ORIGINATOR'S SIGNATURE

DATE

SUPERVISOR'S EMP NO.
06175

SUPERVISOR'S SIGNATURE

DATE

WORK ORDER NUMBER		GC CODE	ACCOUNT NUMBER	PLANT CONDITION								NPRD FAILURE			START	
LOCATION	SERIAL			SU	OP	MO	CO	RF	WS	LR	YR	MO	DAY	HR	MIN	
036000	18770		7876019	1	1	1	1	1	1							

REG AGENCY CODE	CHG/MOD NUMBER
0000	

ENV CODE	OUTAGE CAUSE CODE
X	

STATUS MOLO CODE

COMMENCE DATE
09/17/80

RECEIVED DATE
203614

Limits and Precautions:

a) Personnel

b) Equipment

c) Environment

d) Nuclear

Post Maintenance Testing required and Acceptance Criteria.

ORIGINATOR—SUPERVISOR—SUPERVISOR OF MAINTENANCE—MAINTENANCE FOREMAN—
JOB PERFORMER—MAINTENANCE FOREMAN—SUPERVISOR OF MAINTENANCE

COPY

Page A-2
WORK REQUEST PROCEDURE
TMI Nuclear Station
Maintenance Procedure Format and Approval

Unit No. 2

This form outlines the format and acts as a cover sheet for a maintenance procedure. Due to the limited size of the form, additional pages may be attached as required. Work Request procedure AP 1016 Section 6 should be used as a guide in preparing the maintenance procedure.

1. Procedure Title & No.:

Cable & Detector Performance Check for HP-R-213

2. Purpose: *To determine if improper reading due to cable or detector problem.*

3. Description of system or component to be worked on.

HP-R-213

4. References:

Victor Manual

5. Special Tools, and Materials required.

See attached

6. Detailed Procedure (attach additional pages as required)

See attached

Supervisor of Maintenance recommends approval

Date

9/12/80

• PORC RECOMMENDS APPROVAL

Unit No. 1 Chairman

Date

Unit No. 2 Chairman

Date

• UNIT SUPERINTENDENT APPROVAL

Unit No. 1

Date

Unit No. 2


Date

• Standing Procedure

Supervisor of QC

Date

*Note: These approvals required only on Nuclear Safety Related/Radiation work permit jobs.

	TITLE IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-213	NO. TP-103
	APPROVED M.V. Mathis, Director, Tech. Serv. Div.	REV. 0
Technology for Energy Corporation PROCEDURE	DATE 9-12-80	

PURPOSE: The purpose of these measurements is to gather baseline data and information in preparation for possible removal and replacement of Area Radiation Monitor HP-R-213 from the reactor building TMI Unit 2. The tests specified in this procedure are designed to assess the condition of the in-containment instrument module (gamma detector), associated cabling, and readout devices. This assessment will require the use of Time Domain Reflectometry (TDR), Impedance (Z), Spectral Analysis (frequency domain), special calibration measurements, and general oscilloscope observations (with recording) of waveforms from/to the unit under test (UUT).

PROCEDURE (ADMINISTRATIVE):

A. Limitations and Precautions

1. Nuclear Safety. Area radiation monitor HP-R-213 is part of a redundant ARM system at elevation 347'. The unit is not considered part of the engineered reactor safeguards system thus has no nuclear safety relevance.
2. Environmental Safety. Area radiation monitor HP-R-213 can be taken out-of and restored to service without producing a hazard to the environment.
3. Personnel Safety. The test described herein produces no additional personnel safety hazards other than normally associated with performing instrument calibrations and tests.
4. Equipment Protection. In the performance of each test described herein, care will be taken to insure adequate equipment protection as follows:
 - a. In all cases actual test hookups to the Unit-2 instrumentation shall be made and verified by Instrumentation Personnel.
 - b. All passive measurements (Spectral Analysis and Oscilloscope observations) of waveforms and signals from powered instruments shall be performed using high input impedance probes or inputs ($Z = \geq 1$ Meg ohm) to prevent loading of signals.
 - c. In all Time Domain Reflectometry and Impedance measurements, power will be removed from the unit under test and low level test signals prescribed in Table 4-1 shall be utilized to perform cable

TEC**TITLE****IN-SITU MEASUREMENTS OF CABLES AND SIGNALS
FROM AREA RADIATION MONITOR HP-R-213****NO. TP-103****REV. 0**

integratory measurements on the appropriate instrumentation cables by inserting test signals on appropriate conductors of Cable IT18711 (terminations shall be removed and replaced on TB111 of Cabinet 12). Should these tests reveal cable integratory problems further verification measurements will be made at TB1 of the appropriate Remote Alarm/Meter (Victoreen Model 858-3) located in the anteroom.

Table 4-1 Active Measurements

Active Signal Parameter	Time Domain Reflectometry	Impedance
Voltage	225 mV nominal (into 50 ohm base)	$\leq 5V_{rms}$
Frequency	---	100Hz, 1kHz, 10kHz, 100kHz
Current	$\leq 10mA$	$\leq 100mA$
Other	225mV, 110 picosecond pulses	---

- d. In the calibration verification measurements section, baseline data on the as-found condition will be recorded prior to the performance of any adjustments or electronic calibrations.

B. Prerequisites

1. The Shift Supervisor/Shift Foreman shall be notified for concurrence prior to the performance of those measurements.
2. Instrumentation personnel shall be assigned to assist in the performance of these measurements.
3. All measurements and test instrumentation shall be in current calibration (traceable to NBS).

TEC	TITLE	IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-213	NO. TP-103
			REV. 0

4. The Shift Supervisor/Shift Foreman shall be notified prior to starting and upon completion of the measurements.

C. Procedure for Performing Measurements

References:

1. Victoreen Dwg. No. 904550, Wiring Diagram Area Monitors Channels HP-R-213 & HP-R-214 (Sheet 6 of 11).
 2. Instruction Manual for G-M Area Monitoring Systems, Model 855 Series Victoreen Part No. 855-10-1.
 3. Burns & Roe Dwg. 3024, Sh. 304.
 4. Burns & Roe Dwg. 3347, Sh. 6K.
 5. Burns & Roe Dwg. 3043, Sh. 16D.
 6. Burns & Roe Dwg. 3045, Sh. 26B.
 7. Burns & Roe Dwg. 3045, Sh. 34.
 8. Burns & Roe Dwg. 3045, Sh. 26F.
 9. Burns & Roe Dwg. 3034, Sh. 34B.
 10. Instruction Manual, Tektronix model 1502 Time Domain Reflectometer.
 11. Instruction Manual, Hewlett Packard Model 4274 Multifrequency LCR Meter.
 12. Instruction Manual, Hewlett Packard Spectrum Analyzer (Model 141T, 85538, 85528 Modules).
 13. Instruction Manual, Nicolet Model 444A-26 Spectrum Analyzer.
 14. Instruction Manual, Tektronix Model 335 Oscilloscope.
 15. Instruction Manual, Lockheed Store-4 Recorder.
 16. Instruction Manual, Tektronix SC502 Oscilloscope.
 17. TEC Composite Electrical Connection Diagram, HP-R-213 (see attached).
- Victoreen Instrument Company Dwg. 904550 (Ref. 1) and B&R Drawings 3024 (Ref. 3) show the appropriate termination points for passive measurements of signals from HP-R-213 as follows:

TEC

TITLE

IN-SITU MEASUREMENTS OF CABLES AND SIGNALS
FROM AREA RADIATION MONITOR HP-R-213

NO. TP-103

REV. 0

Signal	Cable IT18711	Cabinet 12
+10V		TB111-8
600V		TB111-5
SIG		TB111-6
GND		TB111-10
CS		TB111-1
CS		TB111-2

NOTE

Selected steps will be completed on an identical Victoreen Area Radiation Monitor Detector with attached interface connector and terminal block to characterize signals and gather baseline data before the performance of this measurement.

STEPS

1. Notify Shift Supervisor/Shift Foreman of start of test on HP-R-213.
2. Verify power is applied to HP-R-213.

J. E. Jones 9/18/80
Signature/Date

3. Record present signals and readings and indications on 856-2 Readout Module (Local). Record Signal-in at TB111-6 and record output for 30 minutes on FM Tape Recorder. Remove recorder when finished.

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1 EL	TITLE	IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-213	NO. TP-103
			REV. 0

<u>Meter/Indicator/Switch</u>	<u>Local</u>
mR/hr Meter Reading	<u>< 0</u>
Off-Operate-Alarm Function Switch	<u>OPERATE</u>
Fail Safe Indicator	On ___ Off <input checked="" type="checkbox"/>
High Alarm-Reset Indicator	On ___ Off <input checked="" type="checkbox"/>

J. E. Jones 9/18/80
Signature Date

1. Using a Keithley Model 177 DMM (or equivalent) and an electrostatic voltmeter ($Z_i \geq 10^{12}$ OHMS, Range 0-2000 V, Precision = $\pm 1\%$) measure the DC voltage or current at the following test points.

NOTE: For signal d. it will be necessary to depress Fail-Safe Check Source push button during the measurement.

TEC

TITLE

IN-SITU MEASUREMENTS OF CABLES AND SIGNALS
FROM AREA RADIATION MONITOR HP-R-213

NO. TP-103

REV. 0

<u>SIGNAL</u>	<u>CABINET 12</u>	<u>TEST LEAD</u>	<u>READING</u>
a.	TB111-8 TB111-10	(+) (-)	(10V) <u>11.1 V</u>
b.	TB111-6 TB111- 7 10	(+) (-)	(SIG IN) <u>10.96</u> <u>10.95</u> CS OUT CS IN
*c.	TB111-5 TB111-10	(+) (-)	(600V) <u>599 V</u>
**d.	TB111-1 (open field side) TB111-1 (cabinet side)	(+) (-)	(<u>≤500 mA est.</u>) <u>15.02 ma</u> {-1.95 ma reference

*Use electrostatic voltmeter
**Link closed after measurement

 9/18/80
Signature/Date

TEC

TITLE

REV. 0

5. Using a Tektronix Model SC502 (or equivalent) oscilloscope observe the waveform at the following test points:

SIGNAL	CABINET 12	PARAMETER			
a.	TB111-1 TB111-10	CS	Photo <u>103-1</u> Time Base <u>2ms</u> Vert Gain <u>50mV</u>	Photo <u>103-2</u> Time Base <u>0.1ms</u> Vert Gain <u>20mV</u>	Photo _____ Time Base _____ Vert Gain _____
b.	TB111-2 TB111-10	CS	Photo <u>103-3</u> Time Base <u>5ms</u> Vert Gain <u>50mV</u>	Photo _____ Time Base _____ Vert Gain _____	Photo _____ Time Base _____ Vert Gain _____
*c.	TB111-5 TB111-10	+600V	Photo <u>103-4</u> Time Base <u>0.1ms</u> Vert Gain _____	Photo <u>103-5</u> Time Base <u>5ms</u> Vert Gain <u>50mV</u>	Photo _____ Time Base _____ Vert Gain _____
d.	TB111-6 TB111-710	SIG	Photo <u>103-6</u> Time Base <u>2ms</u> Vert Gain <u>2mV</u>	Photo <u>103-7</u> Time Base <u>20ms</u> Vert Gain <u>2mV</u>	Photo <u>103-8</u> Time Base <u>10ms</u> Vert Gain <u>2mV</u>
e.	TB111-8 TB111-10	+10V	Photo <u>103-9</u> Time Base <u>20ms</u> Vert Gain <u>50mV</u>	Photo <u>103-10</u> Time Base <u>2ms</u> Vert Gain <u>50mV</u>	Photo _____ Time Base _____ Vert Gain _____
f.	TB111-10 TB501-33	GND ACGND	Photo <u>103-11</u> Time Base <u>2ms</u> Vert Gain <u>1V</u>	Photo <u>103-12</u> Time Base <u>50ms</u> Vert Gain <u>1V</u>	Photo _____ Time Base _____ Vert Gain _____

*Decouple DC Voltage.

Sync the oscilloscope and photograph the waveform using up to three time base and vertical gain settings. (The necessity of 3 photographs will be determined by visual analysis by the field engineer.) Mark the back of the photographs with the instrument tag number and parameter measured.

J. T. S. H. 9/10/80
Signature/Date

TEC

TITLE

IN-SITU MEASUREMENTS OF CABLES AND SIGNALS
FROM AREA RADIATION MONITOR HP-R-213

NO. TP-103

REV. 0

6. Using a Hewlett-Packard Spectrum Analyzer (Models 141T, 8553B, and 8552, or equivalent) perform an analysis of the following signals for spectral content:

SIGNAL	CABINET 12	PARAMETER	PHOTO #
a.	TB111-8 TB111-10	+10V GND	<u>103-13</u>
b.	TB111-6 TB111-10	SIG IN GND	<u>103-14</u>
*c.	TB111-5 TB111-10	+600V GND	<u>103-15</u>

103-17 **

103-16 **

*Decouple DC voltage max input to Spectrum Analyzer
(50VDC)

Before photographing each scope display adjust analyzer for best spectral resolution. Record critical analyzer parameters e.g., RF bandwidth, RF bandwidth and sweep speed on rear of photograph as well as parameter analyzed.

	SPECTRUM IDENT	FREQUENCY	AMPLITUDE	REMARKS	
BANDWIDTH	SCAN WIDTH	INPUT ATTEN	SCAN TIME	LOG REF 10dB LOG	LINEAR SENS
* 1 KHz	.5 MHz / DIV	0	1 SEC	-20	0
** 1 KHz	.2 MHz / DIV	0	1 SEC	-20	0

J. T. S. 9/18/80
Signature/Date

TEC

TITLE

IN-SITU MEASUREMENTS OF CABLES AND SIGNALS
FROM AREA RADIATION MONITOR HP-R-213

NO. TP-103

REV. 0

7. Using the Nicolet Model 444 FFT Analyzer (or equivalent) perform FFT analysis of signals from the following test points:

SIGNAL	CABINET 12	PARAMETER	PHOTO #
*a.	TB111-5 TB111-10	+600V GND	103-18
b.	TB111-6 TB111- 7 10	SIG IN GND	103-20
c.	TB111-8 TB111-10	+10V GND	103-23

103-19

103-21, 103-22

103-2A

*Decouple DC voltage input to Spectrum Analyzer
(50VDC Max input)

If PSD plots from any one of the three signals show high or unusual amplitudes, utilize the zoom feature to provide finer resolution and obtain PSD data in the frequency band of interest.

Q-T S.H. 9/18/80
Signature/Date

8. Inside Cabinet 12 perform usual electronic calibrations using applicable instrument shop procedures. Attach a copy of the instrument shop calibration data sheet and identify any significant adjustments in the space below:

TEC

TITLE

IN-SITU MEASUREMENTS OF CABLES AND SIGNALS
FROM AREA RADIATION MONITOR HP-R-213

NO. TP-103

REV. 0

<u>Procedure Step</u>	<u>Remarks</u>
See attached instrument shop procedure data sheet.	

Instrument Shop Procedure No. _____

Signature/Date

9. Remove all power from HP-R-213 (Tag Open TB501 links 31, 32, and 33 per procedure AP 1002).

J. T. S. A 9/18/80

Signature/Date

10. Open links for all field wires from Cable IT1871I at TB111 (Cabinet 12).

IN-SITU MEASUREMENTS OF CABLES AND SIGNALS
FROM AREA RADIATION MONITOR HP-R-213

NO. TP-103

TEC

TITLE

REV. 0

<u>TERMINAL</u>	<u>SIGNAL IDENT.</u>
TB111-1 (Blue)	C.S.
TB111-2 (Orange)	C.S.
TB111-3 (White)	Rem. Meter
TB111-4 (Yellow) IT3000C	HI N.C.
TB111-5 (RG 59/U, 72 OHM)	600V
TB111-6 (RG 58/U, 50 OHM)	SIG IN
TB111-7 (RG 58/U, 50 OHM)	Shield (for signal)
TB111-8 (Red)	+10V
TB111-9 (Green) IT3000C	Alert N.C.
TB111-10 (Blk) (RG 59/U, 72 OHM)	GND Shield

Q. T. S. N. 9/14/80
Signature/Date

11. Using the Hewlett-Packard Model 4274 (or equivalent) Impedance Bridge measure the capacitance and impedance of the following test points:

IN-SITU MEASUREMENTS OF CABLES AND SIGNALS
FROM AREA RADIATION MONITOR HP-R-213

NO. TP-103

TEC

TITLE

REV. 0

TEST POINT	FROM*		TO*	
	CABLE	WIRE COLOR/TYPE [TB111-X]	CABLE	WIRE COLOR/TYPE [TB111-X]
a.	IT1871I	Blue (1)	IT1871I	Orange (-2)
b.	IT1871I	RG 59/U Center(-5)	IT1871I	RG 59/U Shield (-10)
c.	IT1871I	RG 58/U Center(-6)	IT1871I	RG 58/U Shield (-7)
d.	IT1871I	Red (-8)	IT1871I	Black (-10)
e.	IT1871I	Black (-10)(Field Side)	IT1871I	TB111-10 (Cabinet)

*Numbers in parentheses refer to TB111 terminal numbers (field side).

Record the data required below:

Test Point*	Capacitance			Impedance		
Frequency	100 Hz	1 kHz	100 kHz	100 Hz	1 kHz	100 kHz
a. TB111-(1/2)	2.8 nF	5.8 nF	3.5 nF	40 Ω / 40	40.8 Ω / 34	440 Ω / 10
b. TB111-(5/10)	27.36 nF	10 nF	10.5 nF	OF	16 K / -90	152 Ω / -85
c. TB111-(6/7)	57012 pF	7.9 pF	6.9 pF	OF	OF	229 K / -91
d. TB111-(8/10)	96 nF	119 nF	47 nF	22.5 Ω / -49	14.7 Ω / 5	38 Ω / 60
e. TB111-(10/10)	2706 nF	53 nF	26.7 nF	1.2 K / -84	960 Ω / -77	70 Ω / -58

**

BAD
DATA

*Numbers in parentheses refer to TB111 FROM/TO terminal numbers on field side.

†Field side/Cabinet side across open link.

**

RUN

TB111-6/10

-12 nF / 12.5 nF / 13 nF

4.8 K / 15° 4.4 K / 20° 121 Ω / -86°

Signature/Date

TEC

TITLE

IN-SITU MEASUREMENTS OF CABLES AND SIGNALS
FROM AREA RADIATION MONITOR HP-R-213

NO. TP-103

REV. 0

12. Using the Tektronix Model 1502 (or equivalent) TDR unit perform TDR measurements on the five test points given in Step 11. Record data below:

Test Point	High R @ N ft.	Low R @ N ft.	Instrument Settings	Strip Chart Number
			Ampl Range Mult	
a. TB112-(1/2) ^{1 2}				103-1
b. TB112-(5/10) ^{5/10}				103-2
c. TB112-(6/8) ^{6/8}	10			103-3
d. TB112-(8/10) ^{8/10}				103-4
e. TB112-(10/10) ^{10/10}				103-5

* TB111 TERMINAL #7 MISSING, CABLE FIELD SIDE
FOUND TERMINAL #17 CABLE IS CONNECTED TO TB111 TERM #10

[Signature] 9/18/80
Signature/Date

13. Using the Keithley Model 144 (or equivalent DMM) perform resistance measurements on the Test Points specified and record value in space provided.

TEC

TITLE

IN-SITU MEASUREMENTS OF CABLES AND SIGNALS
FROM AREA RADIATION MONITOR HP-R-213

NO. TP-103

REV. 0

ALL READINGS 20K SCALE.

TEST POINT	FROM LINK (field side)	TO LINK (field side)	POLARITY From = +; To = -	POLARITY From = -; To = +
			RESISTANCE	RESISTANCE
a.	TB111-1	TB111-2	41 Ω	41 Ω
b.	TB111-1	TB111-5	\sim	\sim
c.	TB111-1	TB111-6	\sim	\sim
d.	TB111-1	TB111- 5 10	\sim	\sim
e.	TB111-1	TB111-8	\sim	\sim
f.	TB111-1	TB111-10	\sim	\sim
g.	TB111-2	TB111-5	\sim	\sim
h.	TB111-2	TB111-6	\sim	\sim
i.	TB111-2	TB111- 5 10	\sim	\sim
j.	TB111-2	TB111-8	\sim	\sim
k.	TB111-2	TB111-10	\sim	\sim
l.	TB111-5	TB111-6	\sim	\sim
m.	TB111-5	TB111- 5 10	\sim	\sim
n.	TB111-5	TB111-8	\sim	\sim
o.	TB111-5	TB111-10	\sim	\sim
p.	TB111-6	TB111- 5 10	9.2 K	8.6 K
q.	TB111-6	TB111-8	8.9 K	7.2 K
r.	TB111-6	TB111-10	9.2 K	8.6 K
s.	TB111- 5 10	TB111-8	8.3 K	12.5 K
t.	TB111- 5 10	TB111-10		
u.	TB111-8	TB111-10		

NOTE:

Close all links on TB111 (opened in Step 10) when finished with this step.

JTS 9/18/80
Signature/Date

TEC	TITLE	IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-213	NO. TP-103
			REV. 0

15. Notify Shift Supervisor/Shift Foreman of end of test on HP-R-213.

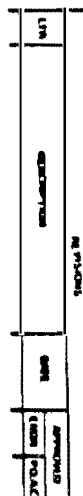
I hereby certify that this Test Procedure has been completed as written and that all data has been correctly entered and filed as requested.

TEC Representative

Q. T. Smith 9/18/80
Signature/Date

Instrumentation

David A. Burns 9/18/80
Signature/Date

[illegible][illegible]

JOB TICKET (WORK REQUEST) **REVIEW - CLASSIFICATION - ROUTING CONTROL FORM**

JOB TICKET NUMBER C5663

1. Does work represent a change or modification to an existing system or component? If yes, an approved change modification is required per AP 1021.

C/M No. N/AYes ☐ No ☒

- 2a. Does work requires an RWP?

Yes ☐ No ☒

- 2b. Is an approved procedure required to minimize personnel exposure?

Yes ☐ No ☒

- 3a. Is work on a QC component as defined in GP 1008?

Yes ☐ No ☒

- 3b. If 3a is yes does work have an effect on Nuclear Safety? If 3b is yes, PORC reviewed Superintendent approved procedure must be used.

Yes ☐ No ☒

4. Agreement that a PORC reviewed, Superintendent approved procedure is not required for this work because it has no effect on nuclear safety. (Applies only if 3a is Yes and 3b is No).

N/A
 UNIT SUPERINTENDENT

DATE

- 5a. Is the system on the Environmental Impact list in AP 1026?

Yes ☐ No ☒

- 5b. If 5a is YES, is an approved procedure required to limit environmental impact?

Yes ☐ No ☐

6. Agreement that 5b is No. (Required only if 5a is Yes).

N/A
 UNIT SUPT/SUPV OF OPERATIONS

DATE

7. Plant status or prerequisite conditions required for work. (Operating and/or shutdown)

8. QC Dept. review, if required in item No. 3.

N/A
 QC SUPERVISOR

DATE

9. Does work require code inspector to be notified?

Yes ☐ No ☐

10. Supervisor of Maintenance approval to commence work:

[Signature] Date 9/17/80

11. Maintenance Foreman Assigned:

12. Code Inspector Notified. Name:

Date

13. Shift Foreman's approval to commence work:

[Signature]

Date 9/17/80

Initial if Shift Foreman signature is not required.

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GENERATION CORRECTIVE MAINTENANCE SYSTEM
CM STATUS ACTIVITY FORM

COMPONENT DESIGNATOR				LOCATION UNIT	JOB TYPE	WORK AUTHORIZATION NUMBER	REQUEST DATE		
SYS	COMP. TYPE	COMP. ID.	LOOP				MO	DAY	YR
5	8	12	16 17	22 23 24 28	32 33	38			
H P	R	0213	036002	CM					

TXN CD	ACT
1	4
8 0 4	A

ECM NUMBER
47 51

TXN CD	ACT
1	4
8 0 5	A

P R T Y	RESP. LOCATION OR CONTRACTOR	P R T Y	ASSISTING CONTRACTOR	P R T Y	ASSISTING CONTRACTOR
66 67	71				
	2036N				

TXN CD	ACT
1	4
8 0 7	A

PURCHASE REQUISITION NUMBER	PURCHASE ORDER NUMBER
59	66 67 73

TXN	ACT
1	4
8 1 0	A

STATUS HOLD										% COMPL	S/M APPROVAL TO COMMENCE WORK			FIELD WORK COMPLETION DATE		
CODE	START DATE			RELEASE DATE			MO	DAY	YR		MO	DAY	YR			
39 40 41				45 47			52 53	55 56			61 62			67		

0 1															OUTAGE HOLD
0 2															PART HOLD
0 3															QUALITY CONTROL PART HOLD
0 4															QUALITY CONTROL PROCEDURE HOLD
0 5															OPERATIONS HOLD
0 6															CHANGE MODIFICATION HOLD
0 7															ENGINEERING HOLD
0 8															PLANNING HOLD
5 0															MANPOWER NOT AVAILABLE
5 1															AT PORC
5 2															AT QUALITY CONTROL
5 3															AT UNIT SUPERINTENDENT
5 4															AT READING
5 5															POST MAINTENANCE TEST HOLD
5 6															AT ALARA

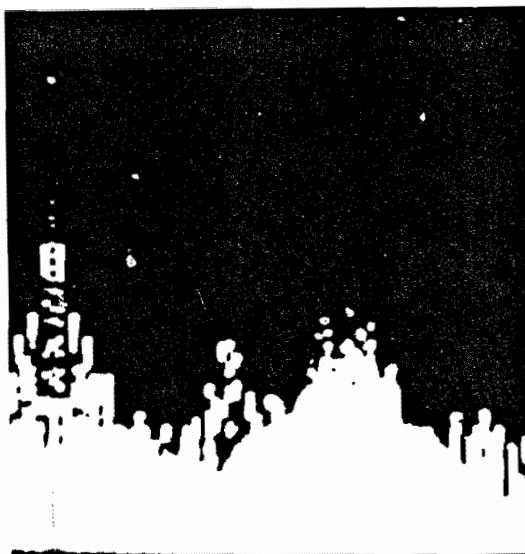


Photo #103-16

BW-1 kHz

Scan time - 1sec

Scan width - 0.2 MHz

Attn - 0

Log Ref - -20db

TB111-5 co

TB111-10

+600V

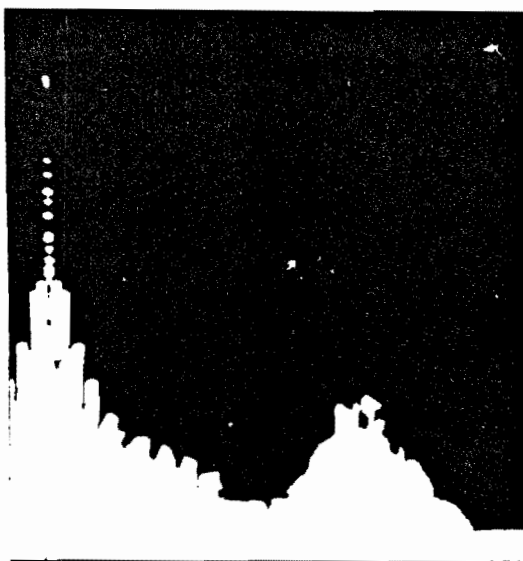


Photo #103-17

BW-1 kHz

Scan time - 1sec

Scan width - 0.2 MHz/div

Attn - 0

Log Ref - -20db

TB111-6 to

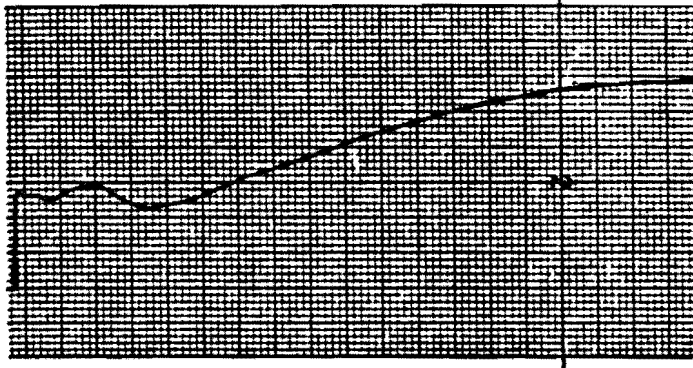
TB111-10

Signal In

STRIP CHART 103-5

TB111: 10 to 10

Signal - GND



Setting - 500mV/div

Range - 52.6 ft/div

Sensitivity - 0.25

15 hz filter

2nd plot begins @350 ft.

Cable dielectric - other

