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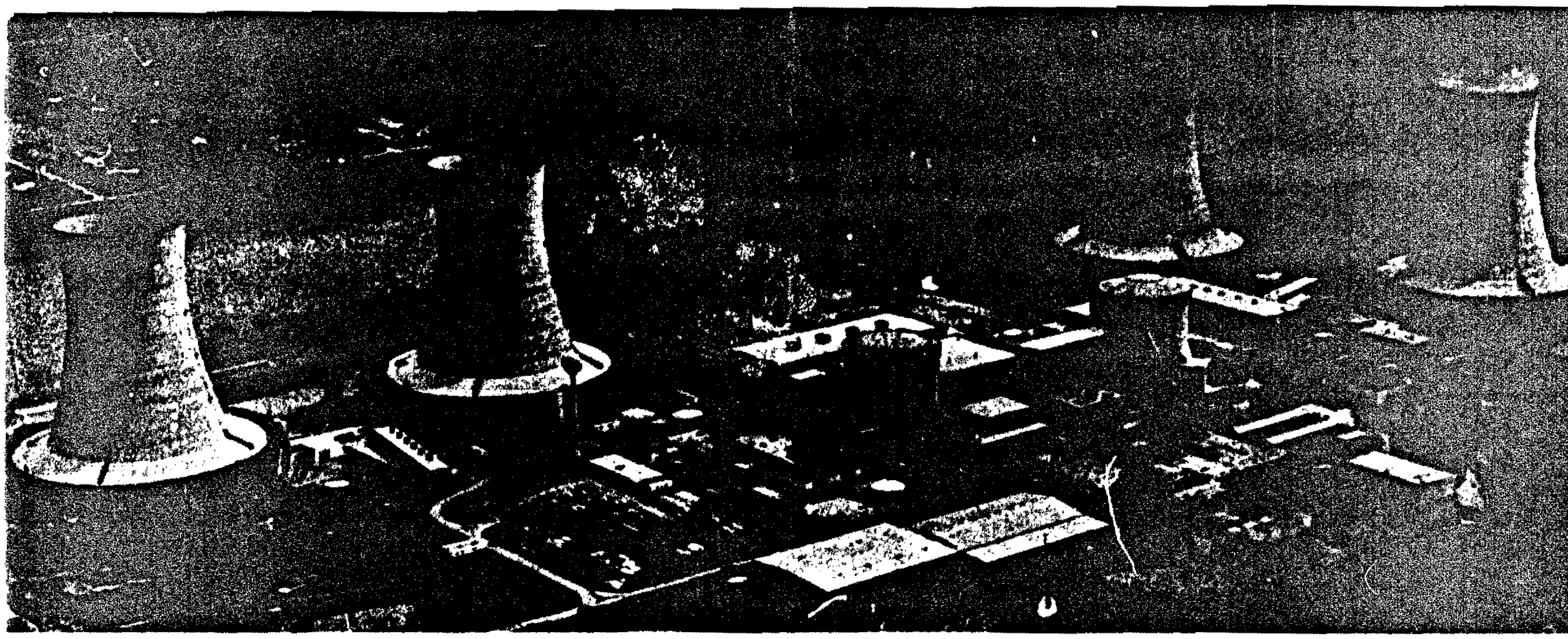

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FIELD MEASUREMENTS AND INTERPRETATION OF TMI-2 INSTRUMENTATION: HP-R-212

J. E. Jones
J. T. Smith
M. V. Mathis

Prepared for the
U.S. Department of Energy
Three Mile Island Operations Office
Under DOE Contract No. DE-AC07-76IDO1570

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Volume VIII

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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-212. This detector was located at 305 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 1200 feet of interconnecting cable. This instrument was believed to have failed due to a constant 45 mR/hr 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 junction 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,

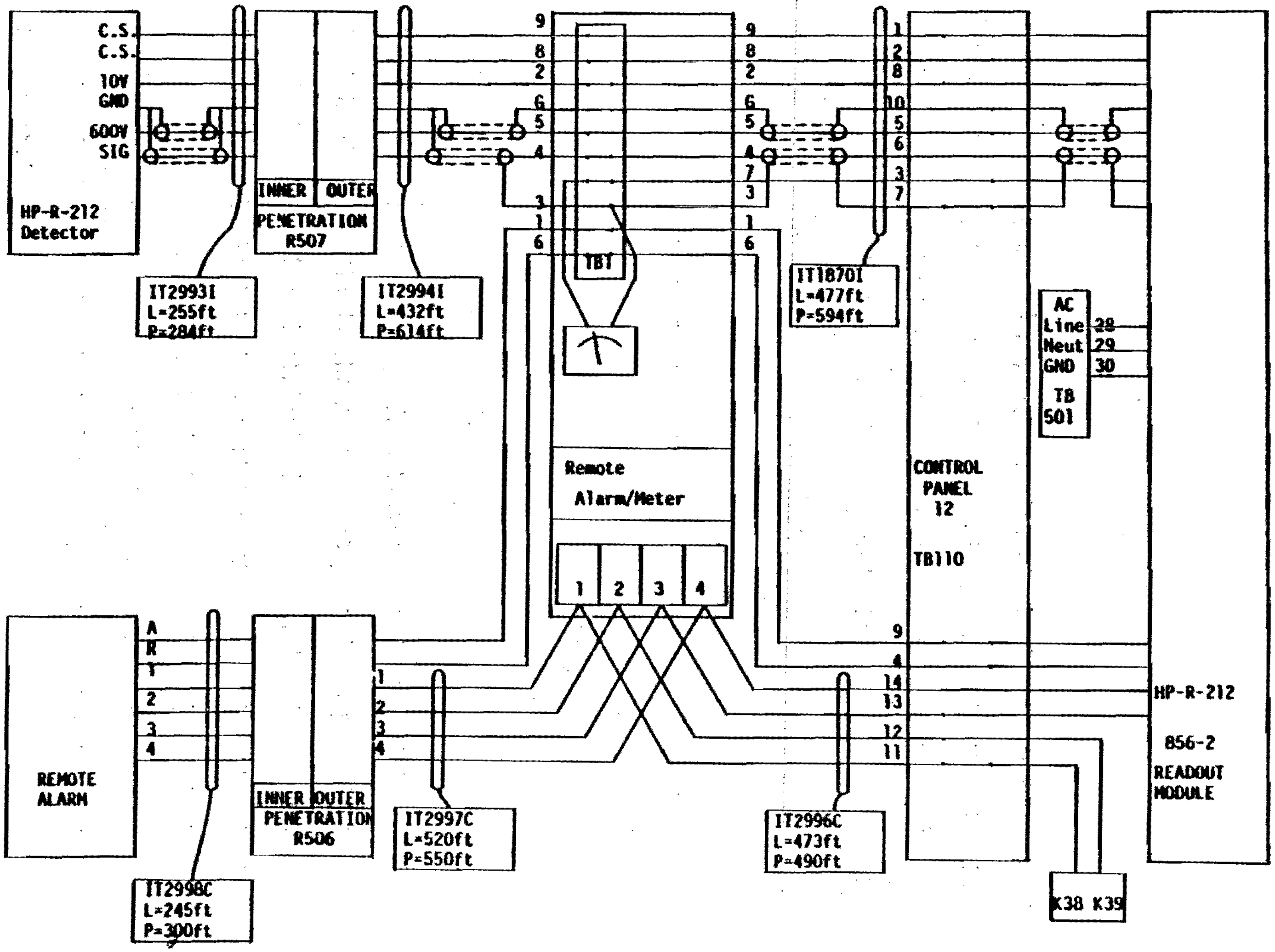


Figure 2-1. HP-R-212 Composite Electrical Diagram.

Table 2-1

TERMINATION POINTS FOR HP-R-212 MEASUREMENTS

Signal	Cabinet 12 Identification*
+10V Power Supply	TB110-8
+600V High Voltage	TB110-5
Signal In	TB110-6
Ground	TB110-10
CS**	TB110-1
CS**	TB110-2

*From cable IT1870I

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

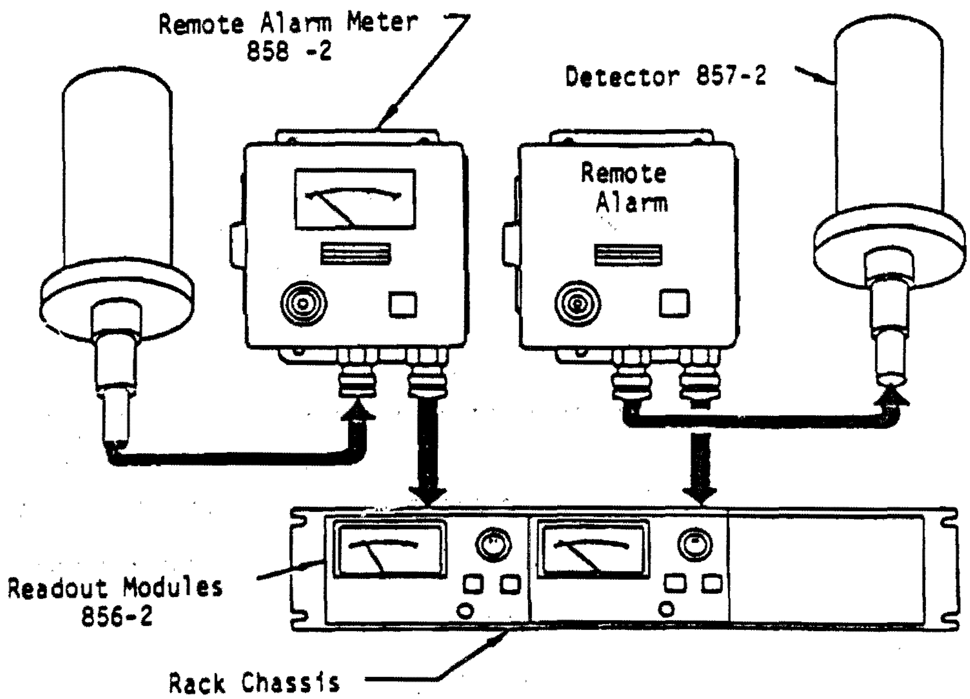


Figure 2-2. Sketch of Instrumentation for HP-R-212.

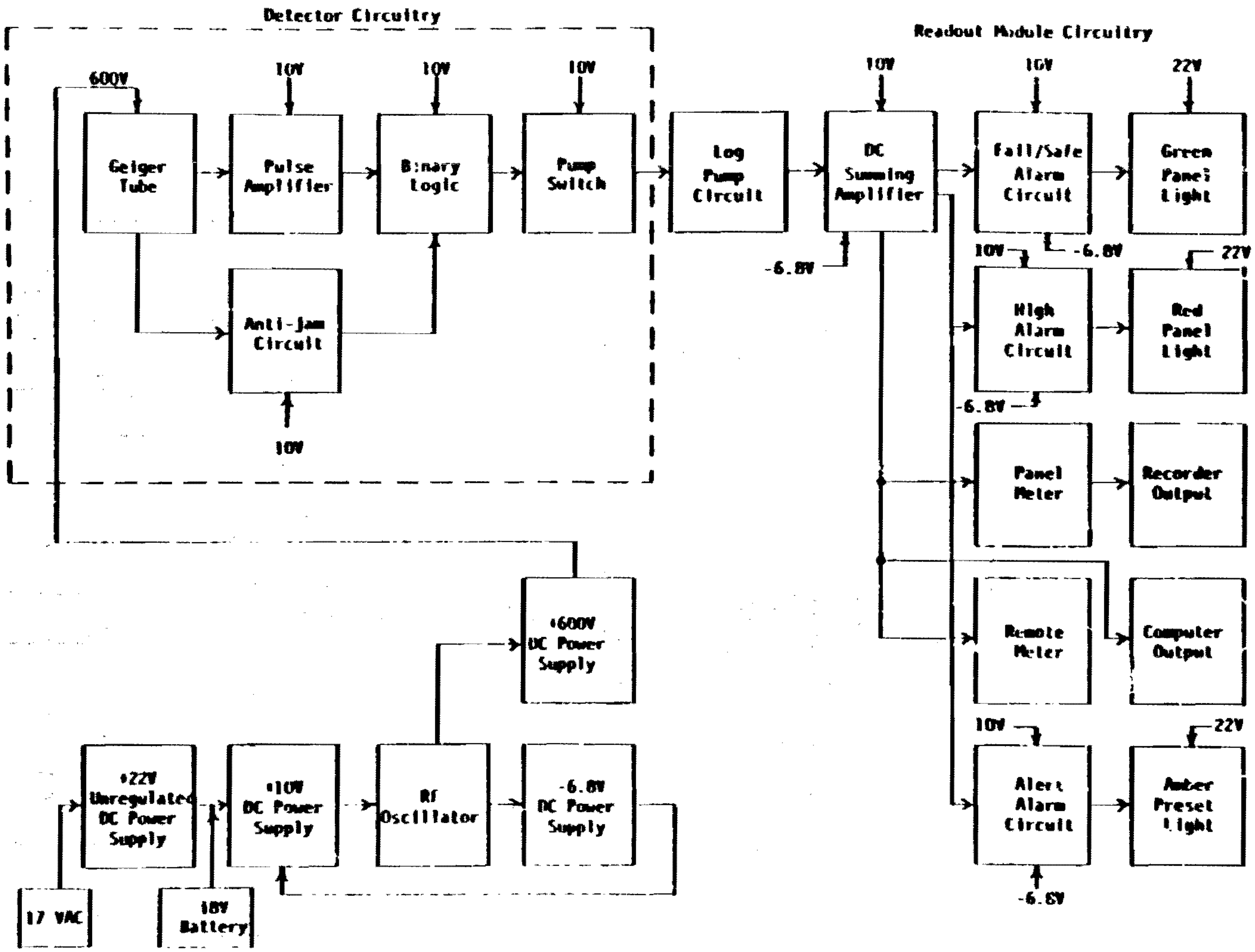


Figure 2-3 Functional Layout of Detector and Readout Module.

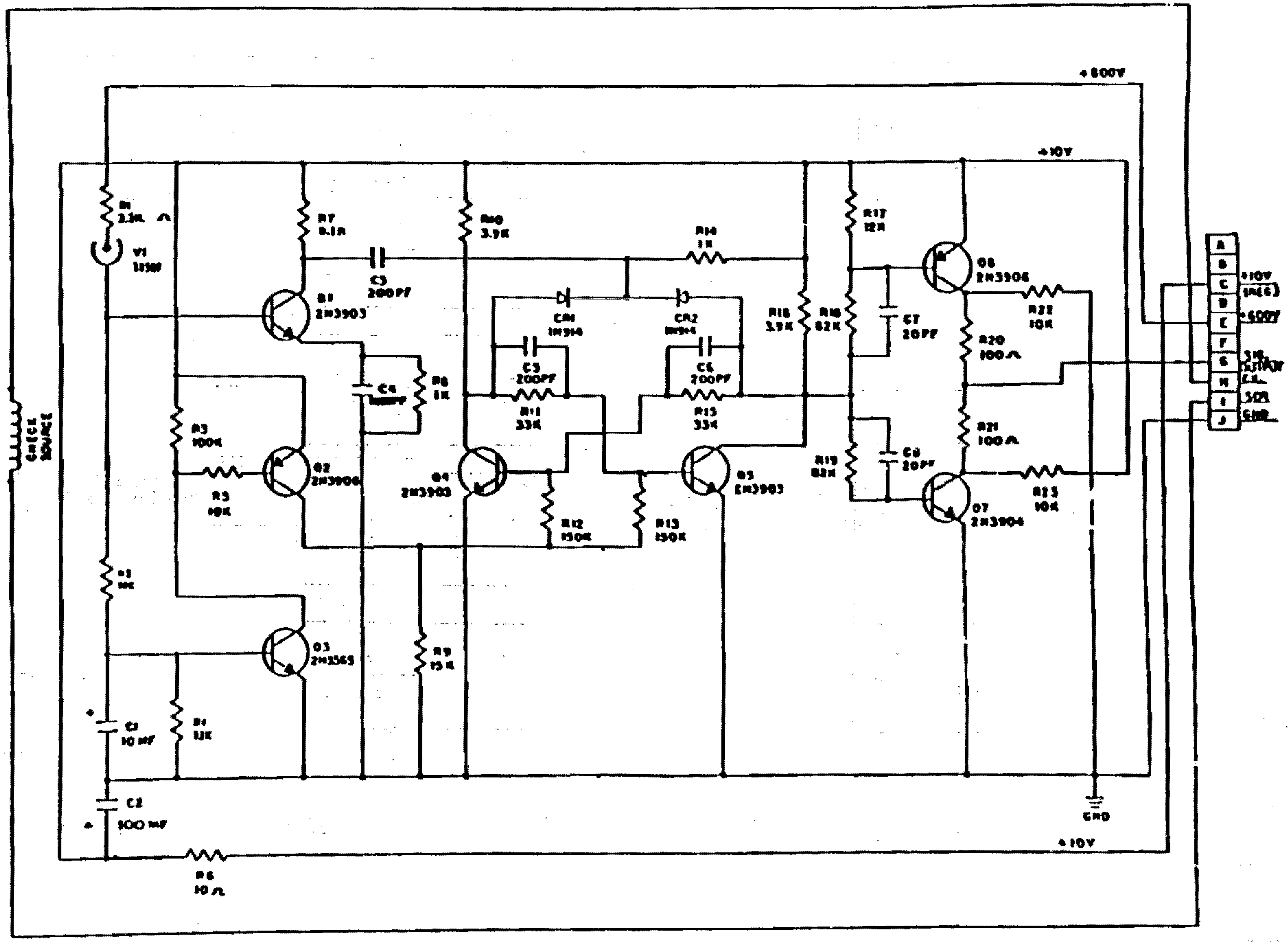


Figure 2-4 Electrical Circuit of Detector Card.

but was isolated from the signal line by the remote alarm/meter circuitry.) Similarly, the Model 356-2 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-212 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-212 indicated 45 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 @ 10.1 V

Signal Out @ 4.3 VDC

600 V Power Supply @ 469 VDC
@ 599 VDC (no load)

Checksource @ 13.8 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.

Following the frequency spectra measurements, electrical calibration was performed on the HP-R-212 readout module by a TMI technician. No significant adjustments were noted during this calibration. (See calibration

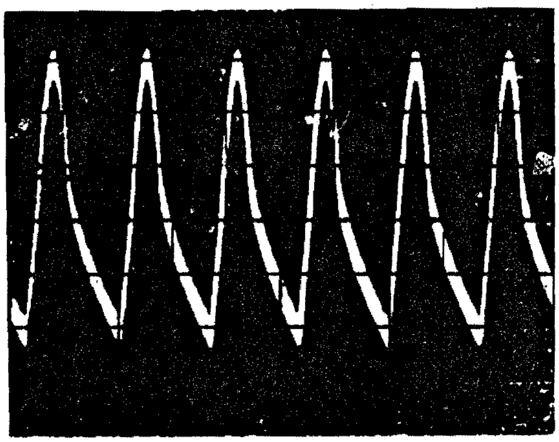


Photo # 102-1

Time - 5msec

Gain - 0.1V/div

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

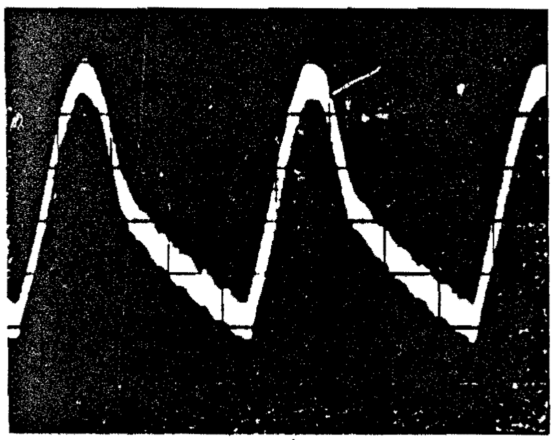


Photo #102-2

Time - 2msec

Gain - 0.1V/Div

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

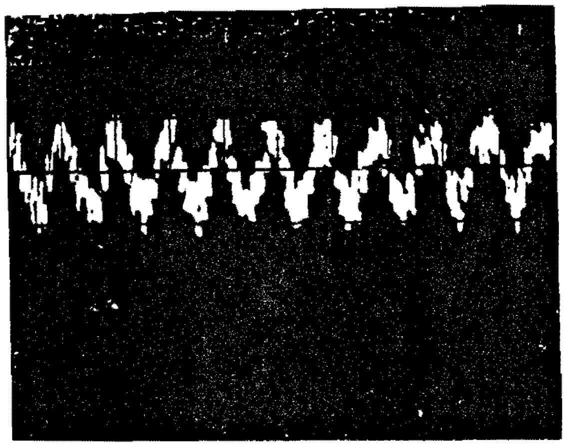


Photo #102-3

Time - 50µsec

Gain - 10mV/div

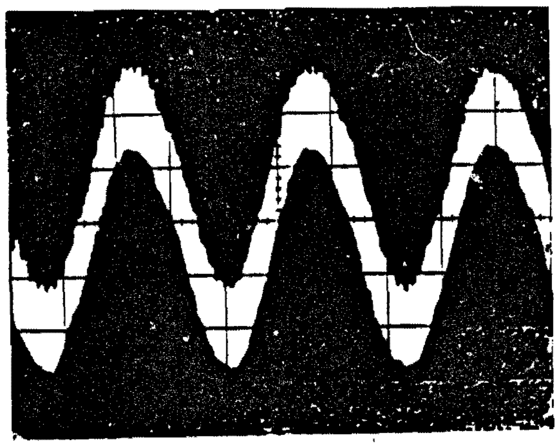


Photo #102-4

Time - 5msec

Gain - 10mV/div

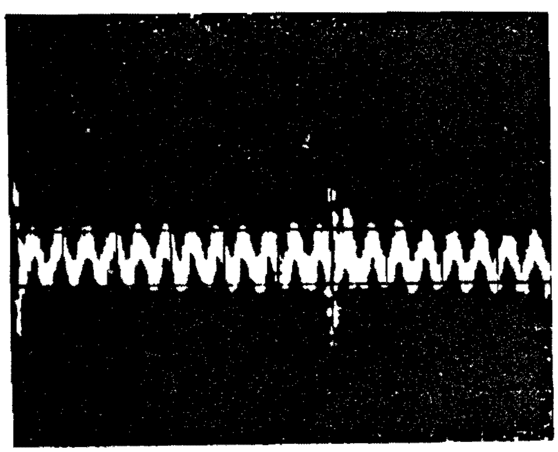


Photo #102-5

Time - 0.1msec

Gain - 20mV/div

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

Photo #102-6

Time - 5μsec

Gain - 2V/div

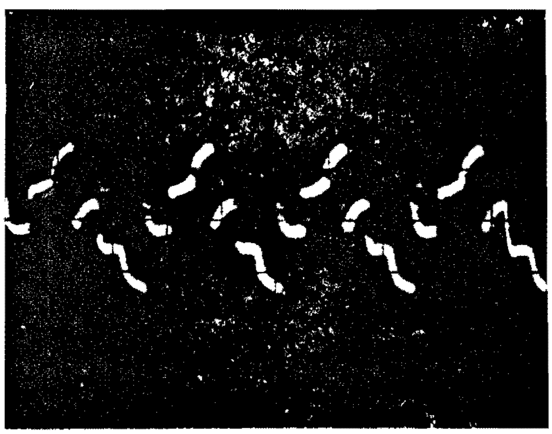


Photo #102-7

Time - 10μsec

Gain - 2V/div

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

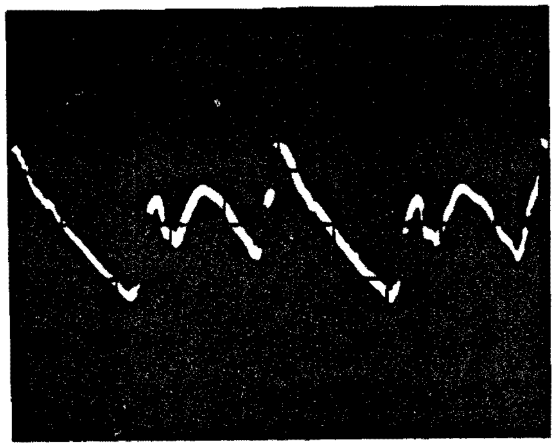


Photo #102-8

Time - 10μsec

Gain - 50mV/div

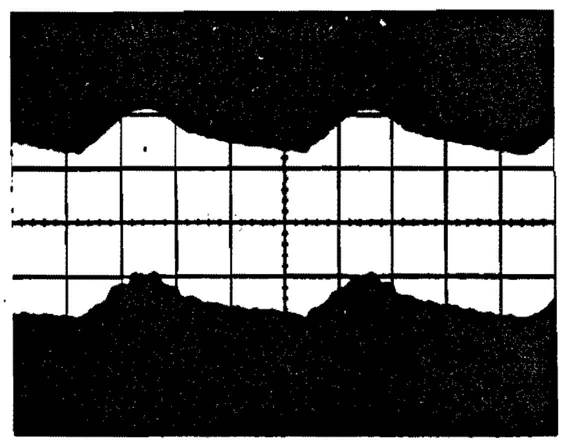


Photo #102-9

Time - 2msec

Gain - 50mV/div

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

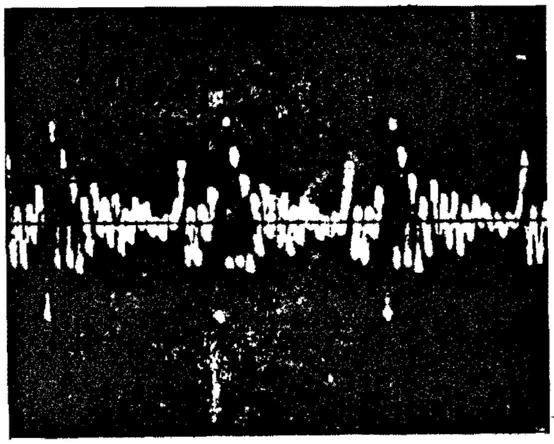


Photo #102-10

Time - 20μsec

Gain - 0.2V/div

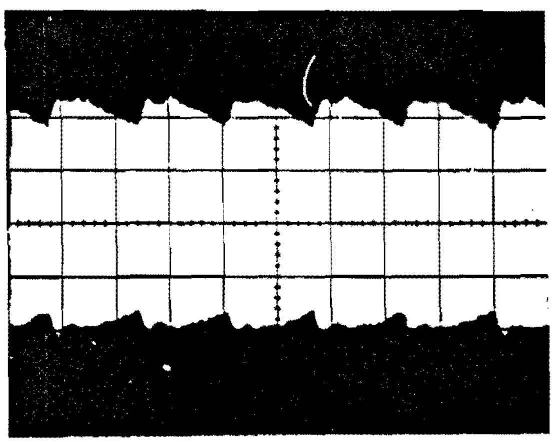


Photo #102-11

Time - 5msec

Gain - 0.2V/div

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

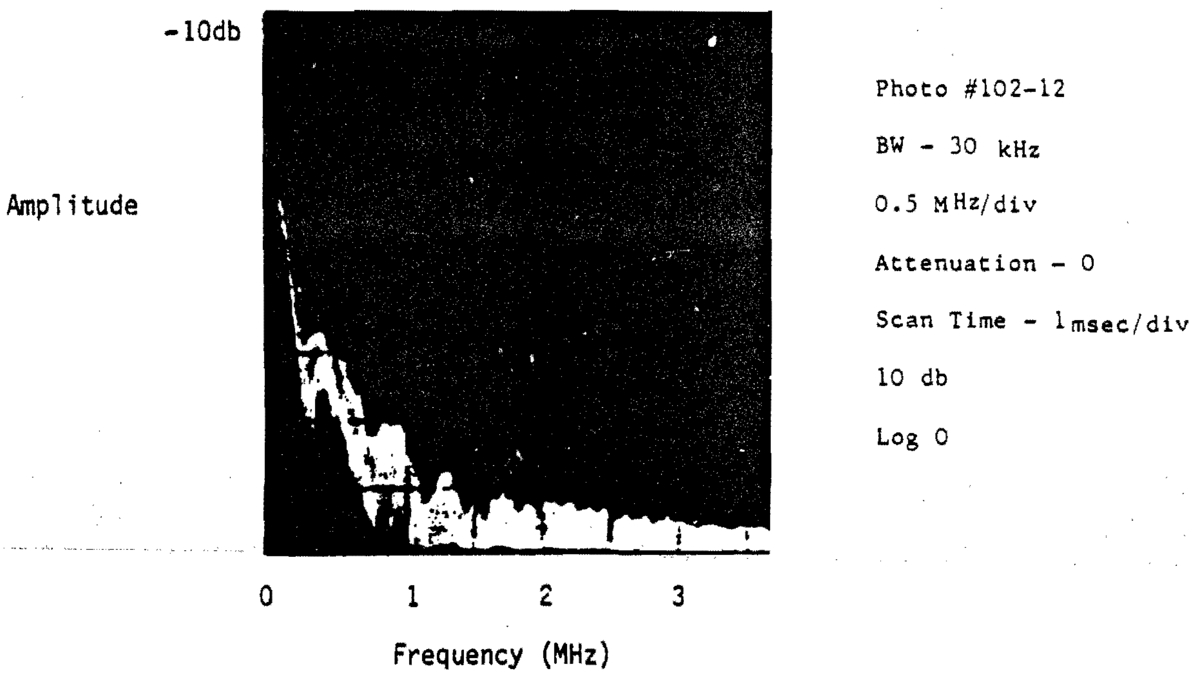


Figure 4-7. High Frequency Spectrum of 10V Power Supply.

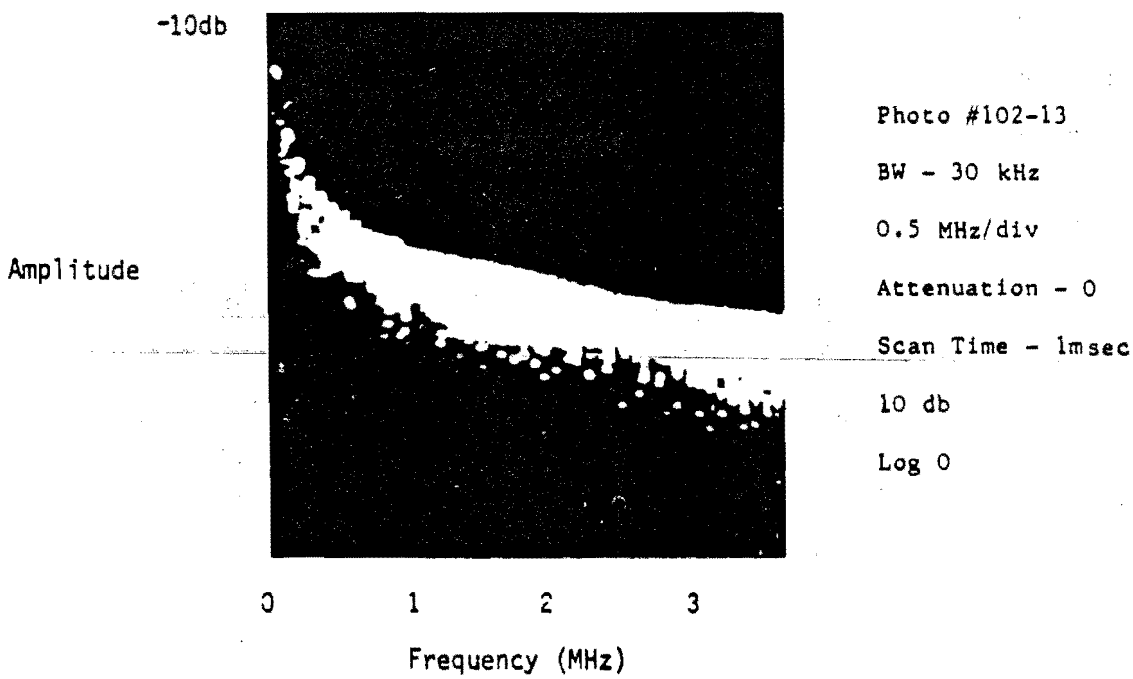


Figure 4-8. High Frequency Spectrum of Signal Output.

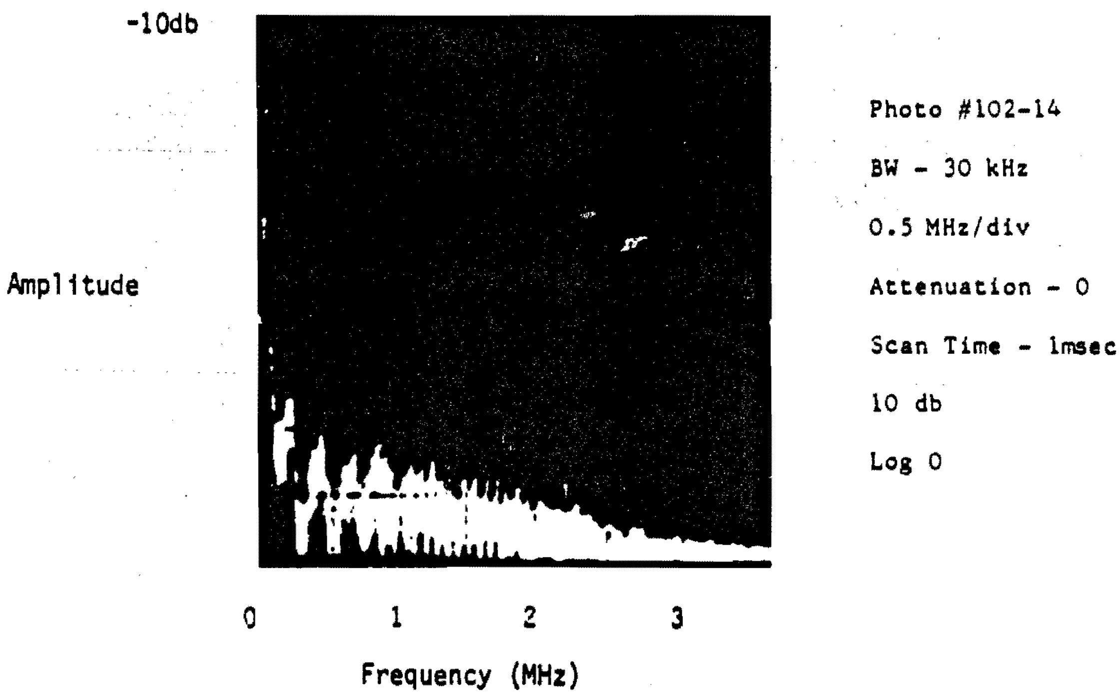


Figure 4-9. High Frequency Spectrum of 600V Power Supply.

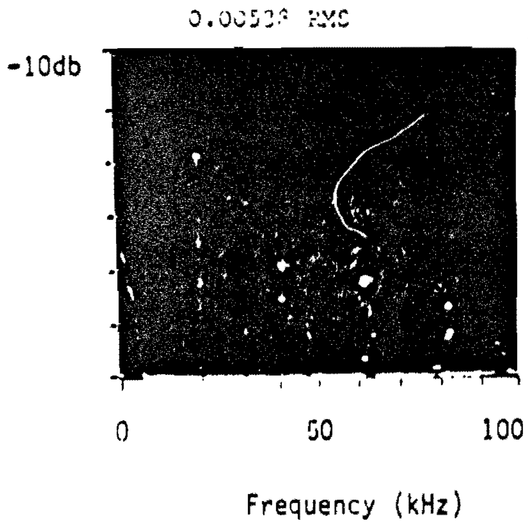


Photo #102-15

100 kHz F-MAX

+10db Reference

20 kHz harmonics illuminated

(16 kHz also present)

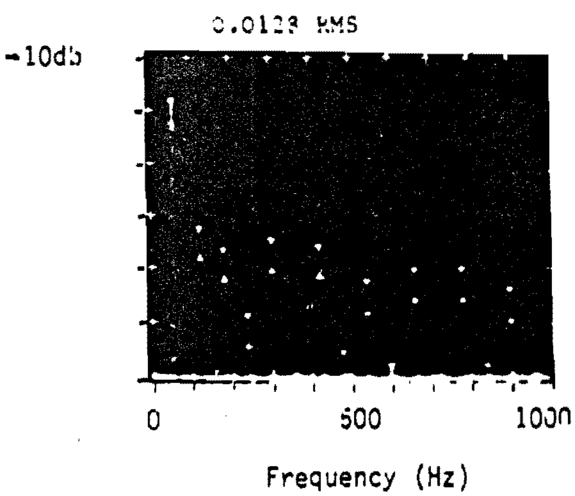


Photo #102-16

1 kHz F-MAX

+10db Reference

60 Hz harmonics illuminated

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

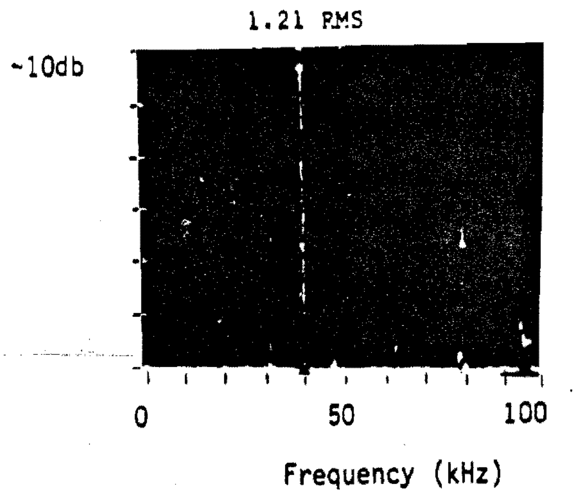


Photo #102-17

100 kHz F-MAX

+10db Reference

40 kHz harmonics illuminated

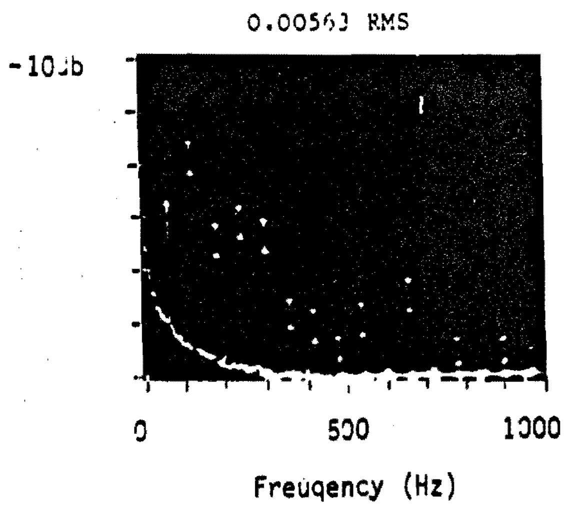


Photo #102-18

1 kHz F-MAX

+10db Reference

60 Hz harmonics illuminated

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

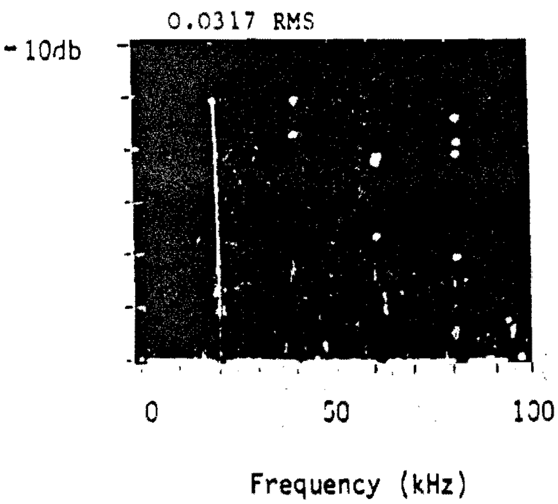


Photo #102-19

100 kHz F-MAX

+10db Reference

20 kHz harmonics illuminated

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

data sheet in the Appendix on page A-20.) After electrical calibration, power was removed from HP-R-212. The test fixture was removed and all signal lines from cable IT1870I 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 was 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 (-)	-9.84 μF	-5.44 μF	838	69.1	75.4	4.23	38 (40)
+600 V Ground	-400	22	-3.8 μF	VAR**	VAR	2.08	>2 M
Signal In Shield	VAR	30	-4 μF	4.9k	4.9k	1.88	9.94k (7.4k)
+10 V Ground	6 μF	4.6 μF	186	250	51	30	15.2k (7.7k)
Ground (field) Ground (cabinet)	VAR	-76 μF	43	1	4.4	39	--
Signal In +10 V	--	--	--	--	--	--	8.7k (7.1k)

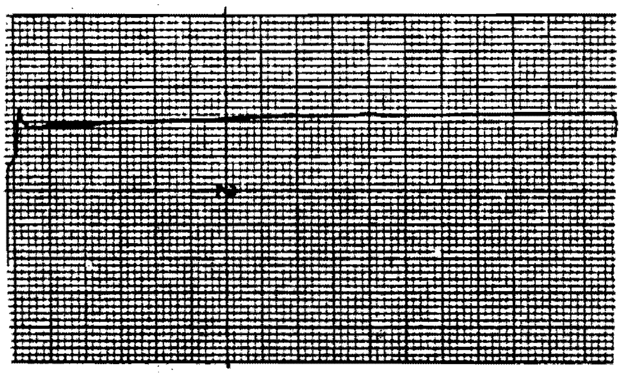
*Values in parentheses are reverse polarity values.

**Indicates variable response.

STRIP CHART 102-1

TB110: 1 to 2

Signal - Check Source



etting - 500mρ/div

Range - 52.6 ft/div

ensitivity - 0.5

15 hz filter

2nd plot begins @ 800 ft.

Cable dielectric - other

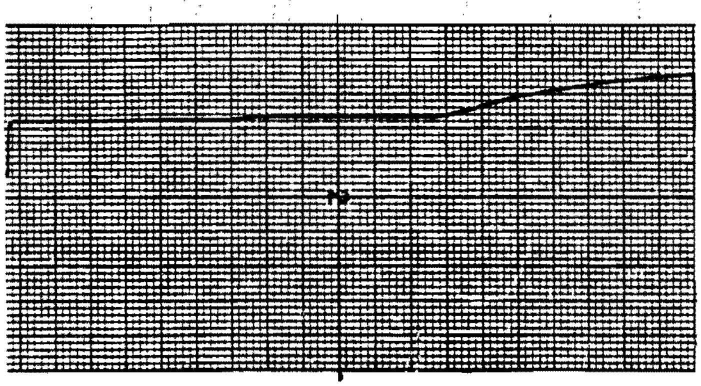
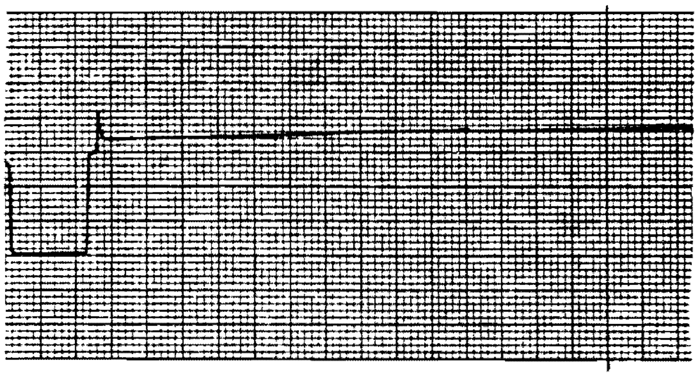


Figure 4-13. TDR Traces from the Checksource Lines.

STRIP CHART 102-2

TB110: 5 to 10

Signal - 600V



Setting - 500mp/div

Range - 52.6 ft/div

Sensitivity - 0.5

15 hz filter

2nd plot begins @ 800 ft.

Cable dielectric - other

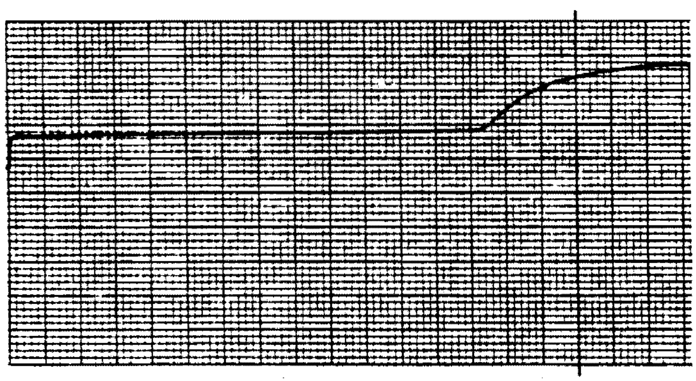
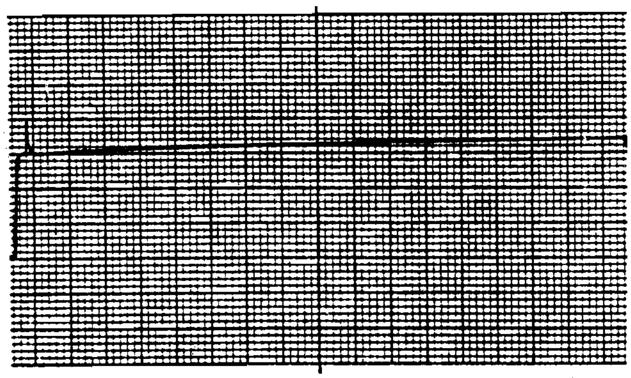


Figure 4-14. TDR Traces from the 600V Power Supply Cable.

STRIP CHART 102-3

TB110: 6 to 7

Signal - Signal In



Setting - 500mρ/div

Range - 52.6 ft/div

Sensitivity - 0.5

15 hz filter

2nd plot begins @ 800 ft.

Cable dielectric - poly

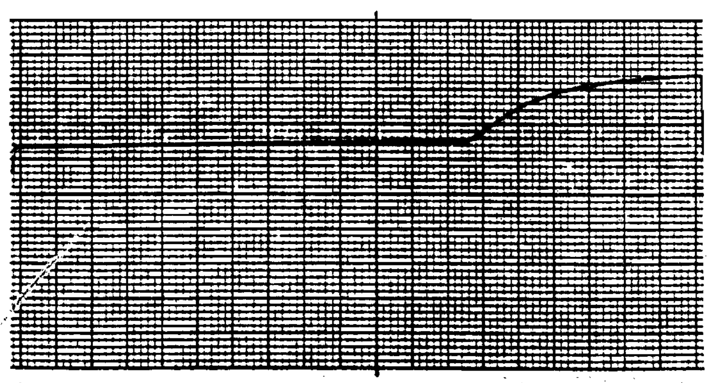
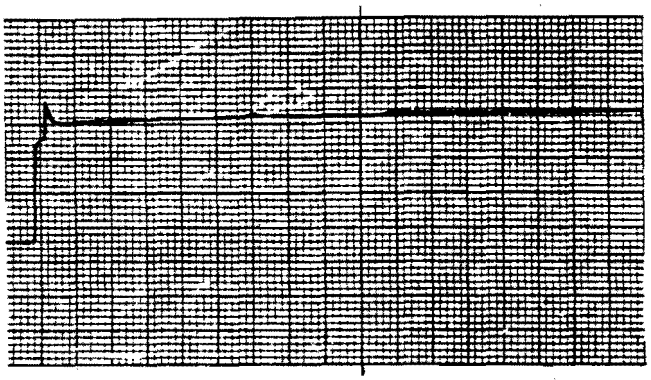


Figure 4-15. TDR Traces from the Signal-In Cable.

STRIP CHART 102-4

TB110: 8 to 10

Signal - +10V



Setting - 500mp/div

Range - 52.6 ft/div

Sensitivity - 0.5

15 hz filter

2nd plot begins @ 800 ft.

Cable dielectric - poly

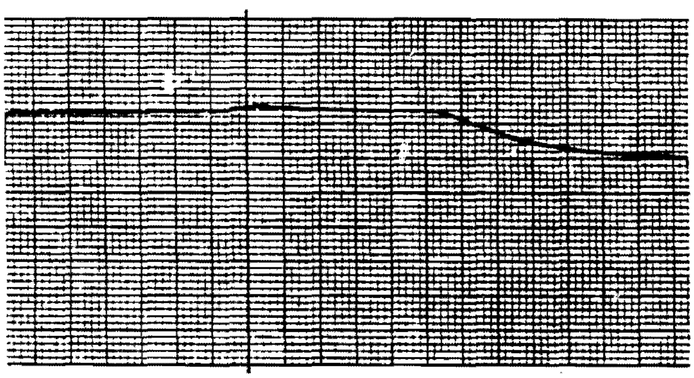


Figure 4-16. TDR Traces from the 10V Power Supply Lines.

5. SUMMARY AND INTERPRETATION OF MEASUREMENTS

This section presents a summary of the interpretation of the measurements taken on HP-R-212. 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 10.1 VDC output value, which is within the expected range. The 600 V power supply was measured at 469 VDC when connected to the detector assembly, but 599 VDC when the connecting cable to the assembly was removed. This indicates an excessive load on the high voltage due to some problem in the detector or cable, or a defective power supply. The Signal In measurement produced a 4.3 VDC reading, which is lower than the expected value of 5.0 VDC for a 0-10 V pulsing output. Measurements on the checksource produced a 13.8 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 only indication of a possible problem is from the relatively large 100 mV P-P 120 hertz ripple in the 10 V supply; however, this is not believed to be large enough to cause failure of the instrument.

Table 5-1

CHARACTERISTICS OF MAJOR SIGNAL LINES

Signal	Frequency	Amplitude
Signal Out	0 (DC)	4.3 V
	60 Hz and Harmonics	5.6 mV RMS
	40 kHz	1.1 V RMS
	Total Spectrum	6 V P-P (1.3 - 7.3 V)
600 V Supply	60 Hz	12.7 mV RMS
	16 kHz and Harmonics	<1 mV RMS
	20 kHz and Harmonics	4 mV RMS
	Total Spectrum	60 mV P-P
10 V Supply	120 Hz	100 mV P-P
	20 kHz and Harmonics	32 mV RMS
	Total Spectrum	200 mV P-P

The Signal In waveform would normally be 0-10 V pulses with a frequency proportional to the radiation present. The oscilloscope photograph of the Signal Out line (Figure 4-4) shows that the output is a periodic waveform of approximately 6 volt peak-peak variation (and a 4.3 volt offset). Frequency spectra show the frequency of the signal to be 40 kHz and nearly sinusoidal. Resistance data (Table 4-1) similarly indicate a problem among the Signal In, +10V, and Shield lines. Table 5-2 gives a comparison of resistance data from a new detector assembly to that from HP-R-212. All resistances are higher than for the new assembly, but only the Signal In-Shield (+) and the Shield-10 V (-) show a significant increase.

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 μF 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-212	
	Polarity +	Polarity -	Polarity +	Polarity +
Signal In Shield	8.78	7.25	9.94	7.40
Signal In +10 V	8.32	6.70	8.70	7.10
Shield +10 V	7.40	11.80	7.70	15.20

*Serial numbers 111 and 1405 composite data.

Notes: (a) All values are in ohms x 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 x 10^3 ohm scale.

Table 5-3

SUMMARY OF TDR MEASUREMENTS

Signal Lines	Distance (ft)*	Description**	Probable Cause
Checksource (+)	505	Point R Increase	Remote Meter
Checksource (-)	996	Point R Increase	Penetration R507
	1285	Continuous R Increase	HP-R-212 Detector
600 V Supply	515	Point R Increase	Remote Meter
Ground	1246	Continuous R Increase	HP-R-212 Detector
Signal	505	Point R Increase	Remote Meter
Shield	1320	Continuous R Increase	HP-R-212 Detector
10 V Supply	289	Point R Increase	(?)
Ground	474	Point R Increase	Remote Meter
	975	Point R Increase	Penetration R507
	1274	Continuous R Decrease	HP-R-212 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. The only unusual inflection occurred on the 10 V power supply line which indicated an interface resistance at approximately 289 feet from the control room. However, measurements did not indicate a resistance change on the 10 V line, and this was not considered to be a problem.

5.2 INTERPRETATION OF MEASUREMENTS

Based upon the observation of a periodic 40 kHz output on the Signal In line from the detector and the excessive loading on the 600 V power supply, it appears that the Geiger tube has failed. If the tube failed in an ionized condition (i.e., depletion of the quench gas), there would be an excessive current load on the 600 V power supply which could result in the observed drop in the supply voltage. Similarly, the detector assembly contains an "anti-jam" circuit which is designed to produce a periodic output upon saturation of the Geiger tube. This was designed to prevent loss of signal in the event of over-range radiation levels, but would also be triggered by a "shorted" tube.

In addition, the output of the detector should consist of 0-10 V pulses even if the "anti-jam" circuit is active. The observed output was nearly sinusoidal, ranging from approximately 1.3 V to 7.3 V, and resistance measurements indicated an increase in the expected values. A review of the detector circuit shows that this behavior could be explained by a failure of transistor Q7. The measurements indicate that

6. CONCLUSIONS

Based on the measurements, data reduction, and circuit analysis of HP-R-212, there is an indication of failure of the instrument. The observed output signals and resistance measurements suggest that the Geiger tube is in a continuously ionized state and that the output is being generated by the "anti-jam" circuit. Also, there is an indication that one of the output driver transistors, Q7, has failed. The result of these failures is a nearly sinusoidal 40 kHz output that spans approximately 6 volts peak-peak and is erroneously interpreted as a 45 mR/hr detector response by the readout module.

GENERATION CORRECTIVE MAINTENANCE SYSTEM
JOB TICKET FORM (WOR Page A-1 MILE ISLAND UNIT 2

COMPONENT DESIGNATION SYS	COMP. TYPE	COMP. ID.	LOCATION/UNIT	JOB TYPE	JOB TICKET NUMBER	REQUEST DATE MO DAY YR	RECOMMENDED PRIORITY
HP	R	0272	036002	CM	[redacted] C566	091680	2

DESCRIBE MALFUNCTION OR MODIFICATION DESIRED: Perform attached Procedure.

CAUSE OF MALFUNCTION (IF KNOWN):

ORIGINATOR'S EMP. NO. 06175 ORIGINATOR'S SIGNATURE J A Brun DATE 9/16/80

SUPERVISOR'S EMP. NO. 06175 SUPERVISOR'S SIGNATURE J A Brun DATE 9/16/80

X0001

WORK ORDER NUMBER LOCATION	SERIAL	GC CODE	ACCOUNT NUMBER	PLANT CONDITION SU	CP	HD	CD	RF	HS	LR	NPRD FAILURE YR MO DAY	START HR MIN
0360	00187T0		2872 6019	1	1	1	1	1	1	1		

CHANGE MOD REQ'D	PWP	NUC SAFETY	NP RD	REG AGENCY CODE	CHG/MOD NUMBER	ENV CODE	OUTAGE CAUSE CODE	STATUS HOLD CODE
0	0	0	0			X		

S/M APPROVAL COMMENCE WORK MO DAY YR	PRIORITY	RESP. LOCATION OR CONTRACTOR
091780	2	036N

Location: Control Room Panel 12, 331' elev.

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 1

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-212

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

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

   HP-R-212

4. References:

   Victoreen Manual

5. Special Tools, and Materials required.

   See attached

6. Detailed Procedure (attach additional pages as required)

   See attached

Supervisor of Maintenance recommends approval [signature] Date 9/16/80

Engineering Review [signature] Date 9/16/80

* 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.

TEC Technology for Energy Corporation	TITLE IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-212	NO. TP-102
		REV. 0
PROCEDURE	APPROVED [signature] M.V. Mathis, Director, Tech. Serv. Div.	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-212 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-212 is part of a redundant ARM system at elevation 305'. 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-212 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. AND RECONNECTIONS BE VERIFIED BY I/C PERS.

   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 integretary measurements on the appropriate instrumentation cables by inserting test signals on appropriate conductors of Cable IT1870I (terminations shall be removed and replaced on TB110 of Cabinet 12). Should these tests reveal cable integretary 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 concurrance prior to the performance of those measurements. ~~[illegible]~~

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).

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-211 & HP-R-212 (Sheet 5 of 11).
2. Instruction Manual for G-M Area Monitoring Systems, Model 855 Series Victoreen Part No. 855-10-1.
3. Burns & Roe Dwg. 3347, Sh. 6L and Sh. 6J.
4. Burns & Roe Dwg. 3043, Sh. 16D.
5. Burns & Roe Dwg. 3045, Sh. 34C.
6. Burns & Roe Dwg. 3045, Sh. 34A.
7. Instruction Manual, Tektronix model 1502 Time Domain Reflectometer.
8. Instruction Manual, Hewlett Packard Model 4274 Multifrequency LCR Meter.
9. Instruction Manual, Hewlett Packard Spectrum Analyzer (Model 141T, 8553B, 8552B Modules).
10. Instruction Manual, Nicolet Model 444A-26 Spectrum Analyzer.
11. Instruction Manual, Tektronix Model 335 Oscilloscope.
12. Instruction Manual, Lockheed Store-4 Recorder.
13. Instruction Manual, Tektronix SC502 Oscilloscope.
14. TEC Composite Electrical Connection Diagram, HP-R-212 (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-211 as follows:

TEC

TITLE IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-212

NO. TP-102

REV. 0

Signal	Cable IT2994I	Cabinet 12
+10V		TB110-8
600V		TB110-5
SIG		TB110-6
GND		TB110-10
CS		TB110-1
CS		TB110-2

STEPS

1. Notify Shift Supervisor/Shift Foreman of start of test on HP-R-212.

2. Verify power is applied to HP-R-212.

J. E. Ores (TEC) 9/17/80
Signature/Date

3. Record present signals and readings and indications on 856-2 Readout Module (Local & Remote). Record Signal-in at TB110-6/7 and record output for 30 minutes on FM Tape Recorder. Remove recorder when finished.

TEC | TITLE IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-212 | NO. TP-102 | REV. 0

Meter/Indicator/Switch	Local	Rmte
mR/hr Meter Reading	45	N/A
Off-Operate-Alarm Function Switch	OPERATE	N/A
Fail Safe Indicator	On___ Off ✓	N/A
High Alarm-Reset Indicator	On ✓ Off___	N/A

J.E. Jones (TEC)
Signature/Date 9/11/80

4. 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.

Note: GPU Fluke Differential Voltmeter
J.E. Jones

TEC

TITLE IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-212

NO. TP-102

REV. 0

SIGNAL	CABINET 12	TEST LEAD	READING
a.	TB110-8 TB110-10	(+) (-)	(10V) 10.1 V
b.	TB110-6 TB110-7	(+) (-)	(SIG IN) 4.3V CS OUT 4.3V CS IN
*c.	TB110-5 TB110-10	(+) (-)	(600V) 469 V
**d.	TB110-1 (open field side) TB110-1 (cabinet side)	(+) (-)	(≤500 mA est.) +13.8 ma Note: -1.8 ma in normal mode JEJ

Note: 599V when Detector Lead Removed. 9/18/80 JEJ

*Use electrostatic voltmeter
**Link closed after measurement

GPU Fluke Differential Voltmeter
JE Jones

JE Jones TEC 9/17/80
Signature/Date

TEC

TITLE IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-212

NO. TP-102

REV. 0

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

SIGNAL	CABINET 12	PARAMETER			
a.	TB110-1 TB110-10	CS	Photo 102-1 Time Base 5mS Vert Gain .1V	Photo ____ Time Base ____ Vert Gain ____	Photo ____ Time Base ____ Vert Gain ____
b.	TB110-2 TB110-10	CS	Photo 102-2 Time Base 2mS Vert Gain .1V	Photo ____ Time Base ____ Vert Gain ____	Photo ____ Time Base ____ Vert Gain ____
*c.	TB110-5 TB110-10	+600V	Photo 102-3 Time Base 50µS Vert Gain 10mV	Photo 102-4 Time Base 5mS Vert Gain 10mV	Photo 102-5 Time Base .1mS Vert Gain ~~1V~~ 20mV
d.	TB110-6 TB110-7	SIG	Photo 102-6 Time Base 5µS Vert Gain 2V	Photo 102-7 Time Base 10µS Vert Gain 2V	Photo ____ Time Base ____ Vert Gain ____
e.	TB110-8 TB110-10	+10V	Photo 102-8 Time Base 10µS Vert Gain 50mV	Photo 102-9 Time Base 2mS Vert Gain 50mV	Photo ____ Time Base ____ Vert Gain ____
f.	TB110-10 TB501-30	GND ACGND	Photo 102-10 Time Base 20µS Vert Gain .2V	Photo 102-11 Time Base 5mS Vert Gain .2V	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. E. [signature] (TEC) 9/17/80
Signature/Date

TEC

TITLE IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-212

NO. TP-102

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.	TB110-8 TB110-10	+10V GND	102-12	BW: 3ckHz, 500kHz/Div Atten: 0dB, 1 mSec/Div Sec. 10dB log, Ref 0dB
b.	TB110-6 TB110-7	SIG IN GND	102-13	"
*c.	TB110-5 TB110-10	+600V GND	102-14	"

*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

J E Jones (TEC) 9/17/80
Signature/Date

TEC

TITLE IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-212

NO. TP-102

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.	TB110-5 TB110-10	+600V GND	102-15 102-16	0-100kHz 0-1kHz
b.	TB110-6 TB110-7	SIG IN GND	102-17 102-18	0-100kHz 0-1 kHz
c.	TB110-8 TB110-10	+10V GND	102-19	0-100kHz

*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.

J E Jones (TEC) 9/17/80
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-212

NO. TP-102

REV. 0

Procedure Step	Remarks
	See attached sheet
See attached instrument shop procedure data sheet.	

Instrument Shop Procedure No. ________

________ Signature/Date

9. Remove all power from HP-R-212 (Tag Open TB501 links 28, 29, and 30 per procedure AP 1002).

(TEC) 9/18/80 Signature/Date

10. Open links for all field wires from Cable IT18701 at TB110 (Cabinet 12).

TEC

TITLE IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-212

NO. TP-102

REV. 0

TERMINAL (CABINET 12)	SIGNAL IDENT.
TB110-1 (Blue)	C.S.
TB110-2 (Orange)	C.S.
TB110-3 (White)	Rem. Meter
TB110-4 (Yellow) IT2996C	HI N.C.
TB110-5 (RG 59/U, 72 OHM)	600V
TB110-6 (RG 58/U, 50 OHM)	SIG IN
TB110-7 (RG 58/U, 50 OHM)	Shield (for signal)
TB110-8 (Red)	+10V
TB110-9 (Green) IT2996C	Alert N.C.
TB110-10 (Blk) (RG 59/U, 72 OHM)	GND Shield

(TEC) 9/18/80
Signature/Date

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

TEC

NO. TP-102

TITLE IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-212

REV. 0

TEST POINT	FROM* (RED)		TO* (Black)	
	CABLE	WIRE COLOR/TYPE	CABLE	WIRE COLOR/TYPE
a.	IT1870I	Blue (1)	IT1870I	Orange (2)
b.	IT1870I	RG 59/U Center (5)	IT1870I	RG 59/U Shield (10)
c.	IT1870I	RG 58/U Center (6)	IT1870I	RG 58/U Shield (7)
d.	IT1870I	Red (8)	IT1870I	Black (10)
e.	IT1870I	Black (10; Field Side)	IT1870I	TB109-10 (Cabinet Side)

*Numbers in parentheses refer to TB110 terminal numbers (field side).

Record the data required below:

Coil

Test Point*	Capacitance			Impedance		
Frequency	100 Hz	1 kHz	100 kHz	100 Hz	1 kHz	100 kHz
a. (1/2)	-9.84 μF	-5.44 μF	+838 nF	69.1 Ω	75.4 Ω	4.23 Ω
b. (5/10)	~~[illegible]~~ -400 nF	22 nF	-3.8 μF	4.7 kΩ	7.0 kΩ	2.08 Ω
c. (6/7)	~~[illegible]~~ ~ (NOISE)	30 nF	~~[illegible]~~ -4.0 μF	4.9 kΩ	4.9 kΩ	1.88 Ω
d. (8/10)	6 μF	4.6 μF	186 nF	250 Ω	51 Ω	30 Ω
e. (10/10)†	NOISE	-76 μF	43 nF	1 Ω	4.4 Ω	39 Ω.

VARIABLE

168° Phase

*Numbers in parentheses refer to TB110 FROM/TO terminal numbers on field side.

†Field side/Cabinet side across open link.

b.(5/10) with 10' RG58 test cable	NOISE	20 nF	195 nF	VAR 4→14 kΩ; PHASE VAR	VAR 5→7 kΩ; PHASE -10° VAR	15 Ω; 33°

[illegible] (TEC) 9/14/80

Signature/Date

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 Ampl Range Mult	Strip Chart Number
a. (1/2)			500mp 100ft/div 1	102-1
b. (5/10)			"	102-2
c. (6/7)			"	102-3
d. (8/10)			"	102-4
e. (10/10)†			"	102-5

*Numbers in parentheses refer to TB110 FROM/TO terminal numbers (field side).

†Field side/Cabinet side across open link.

J.E. Jones (TEC) 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-212

NO. TP-102

REV. 0

20 kΩ SCALE

TEST POINT	FROM LINK (field side) (CAB[illegible]	TO LINK (field side) [illegible] 12)	POLARITY From = +; To = - RESISTANCE	POLARITY From = -; To = + RESISTANCE
a.	TB110-1	TB110-2	38Ω	40Ω
b.	TB110-1	TB110-5	~	~
c.	TB110-1	TB110-6	~	~
d.	TB110-1	TB110-7	~	~
e.	TB110-1	TB110-8	~	~
f.	TB110-1	TB110-10	~	~
g.	TB110-2	TB110-5	~	~
h.	TB110-2	TB110-6	~	~
i.	TB110-2	TB110-7	~	~
j.	TB110-2	TB110-8	~	~
k.	TB110-2	TB110-10	~	~
l.	TB110-5	TB110-6	~	~
m.	TB110-5	TB110-7	~	~
n.	TB110-5	TB110-8	~	~
o.	TB110-5	TB110-10	~	~
p.	TB110-6	TB110-7	9.94 kΩ	7.4 kΩ
q.	TB110-6	TB110-8	8.7 kΩ	7.1 kΩ
r.	TB110-6	TB110-10	9.95 kΩ	7.4 kΩ
s.	TB110-7	TB110-8	7.7 kΩ	15.2 kΩ
t.	TB110-7	TB110-10	1 Ω	1Ω
u.	TB110-8	TB110-10	15.2kΩ	7.65kΩ

NOTE:
Close all links on TB110 (opened in Step 10) when finished with this step.

J E Jones (TEC) 9/18/8[illegible]
Signature/Date

TEC

TITLE IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-212

NO. TP-102

REV. 0

14. Notify Shift Supervisor/Shift Foreman of end of test on HP-R-212.

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 (TEC) 9/18/8
Signature/Date

Instrumentation T.P. 9/18/80
Signature/Date

JOB TICKET (WORK REQUEST) REVIEW – CLASSIFICATION – ROUTING CONTROL FORM

JOB TICKET NUMBER ____________

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. ____________ Yes ____ 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).

____________ 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).

____________ 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.

NA
____________ 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.

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
HP	R	0212		036002	CM	C5662	09	10	80

TXN CD (1–4)	ACT	ECM NUMBER (47–51)
804	A	

TXN CD (1–4)	ACT	PRTY (66)	RESP. LOCATION OR CONTRACTOR (67–71)	PRTY	ASSISTING CONTRACTOR	PRTY	ASSISTING CONTRACTOR
805	A	2	036N				

TXN CD (1–4)	ACT	PURCHASE REQUISITION NUMBER (59–66)	PURCHASE ORDER NUMBER (67–73)
807	A		

TXN (1–4)	ACT	STATUS HOLD CODE (39–40)	START DATE (41–45)	RELEASE DATE (47–52)	% COMPL. (53–55)	S/M APPROVAL TO COMMENCE WORK MO DAY YR (56–61)	FIELD WORK COMPLETION DATE MO DAY YR (62–67)
810	A						

CODE	START DATE	RELEASE DATE	
01			OUTAGE HOLD
02			PART HOLD
03			QUALITY CONTROL PART HOLD
04			QUALITY CONTROL PROCEDURE HOLD
05			OPERATIONS HOLD
06			CHANGE MODIFICATION HOLD
07			ENGINEERING HOLD
08			PLANNING HOLD
50			MANPOWER NOT AVAILABLE
51			AT PORC
52			AT QUALITY CONTROL
53			AT UNIT SUPERINTENDENT
54			AT READING
55			POST MAINTENANCE TEST HOLD
56			AT ALARA

Area Monitor HP-R-212

DETECTER

Model
Serial

RATEMETER

Model
Serial

FCK Posit.	Desired Mr./Hr.	As Found	As Left	Toler.
Closed		N/A		
Iter.				
Open				

Check Source Rdg. ________ Mr/Hr

Fail Safe ________ Volts

Ratemeter

Mr/Hr	Desired Mv. Out	As Found	As Left	Toler.
10^4	1.00V	+.9992		.15V
10^3	.800V	+.7892		.15V
10^2	.600V	+.5958		.15V
10	.400V	+.4000		.15V
1	.200V	+.2081		.15V
.1	.000V	+.0174		.15V

Pwr. Supply	As Found	As Left	Toler.
-6.8V	-6.96		±.5V
10.0V	+10.08		±.1V
22.0V	+19.39		±3.0V

Alarm Set. Pt.	As Found	As Left	Toler.

EQUIP. Fluke 8800A SER.NO. 53034 LAST CAL. 7-25-80 DUE 1-25-81

EQUIP. Digitec 3110 SER.NO. 1200-6 LAST CAL. 8-19-80 DUE 2-19-81

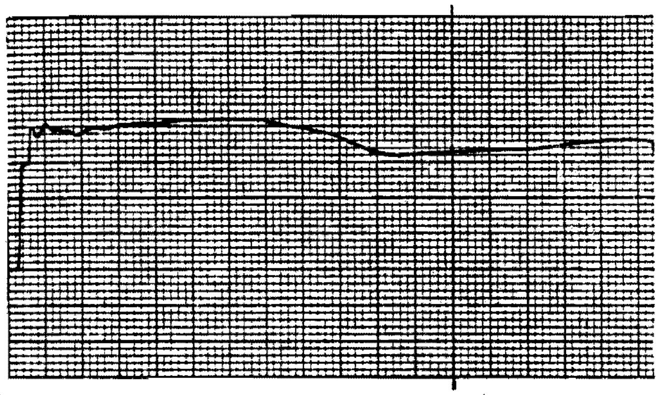
EQUIP. ________ SER.NO. ________ LAST CAL. ________ DUE ________

PERFORMED BY T.L. Gilbert DATE 9-16-80 APPROVED BY ________ DATE ________

STRIP CHART 102-5

TB110: 10 to 10

Signal - GND



Setting - 500mp/div

Range - 52.6 ft/div

Sensitivity - 0.5

15 hz filter

2nd plot begins @ 800 ft.

Cable dielectric - other