TMI DOCUMENTS

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POOR ORIGINAL

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RADIOLOGICAL REF. # 92

This Radiological Reference changed to # 44

Investigator's Name: Collins

Source for this Radiological Reference:

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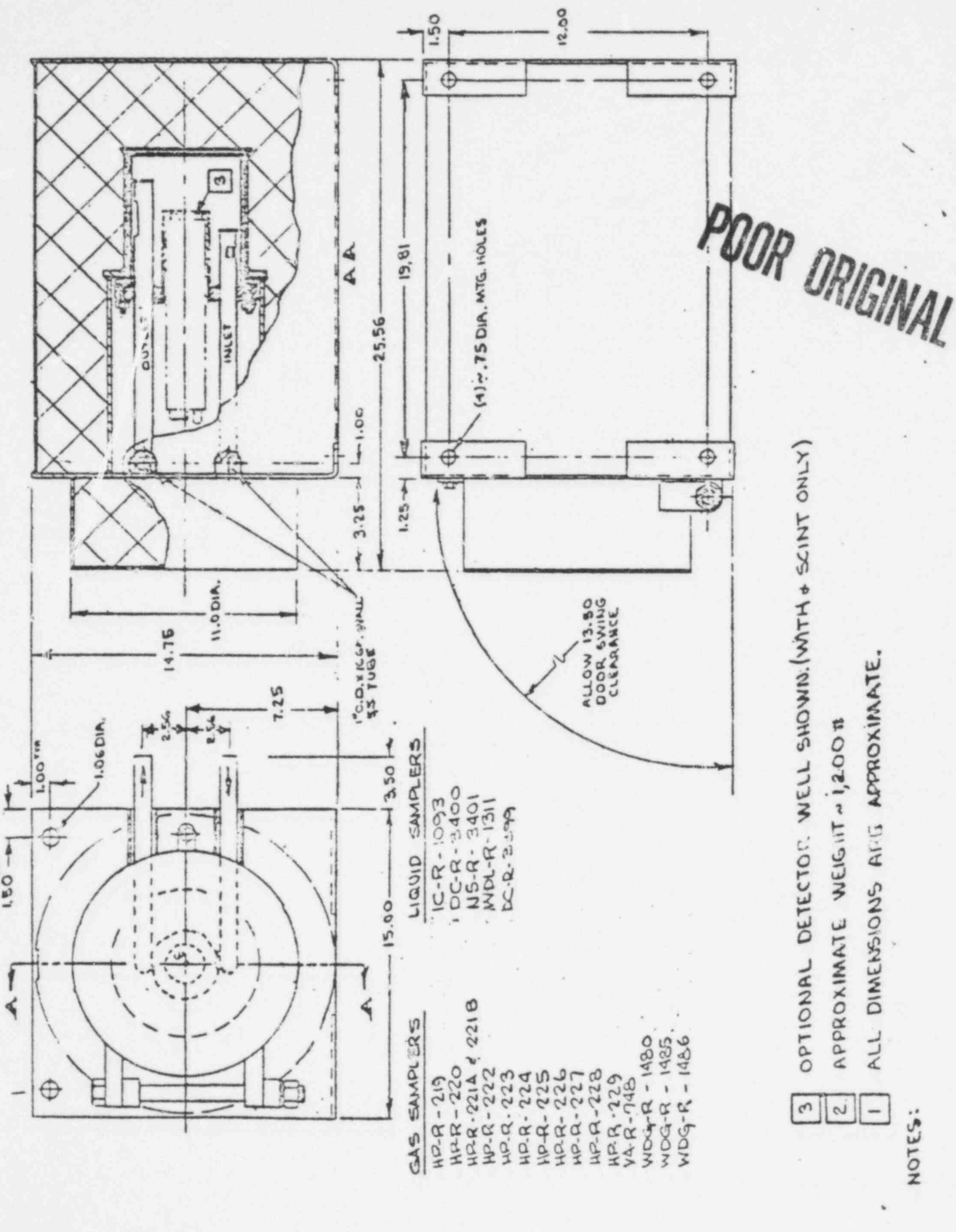
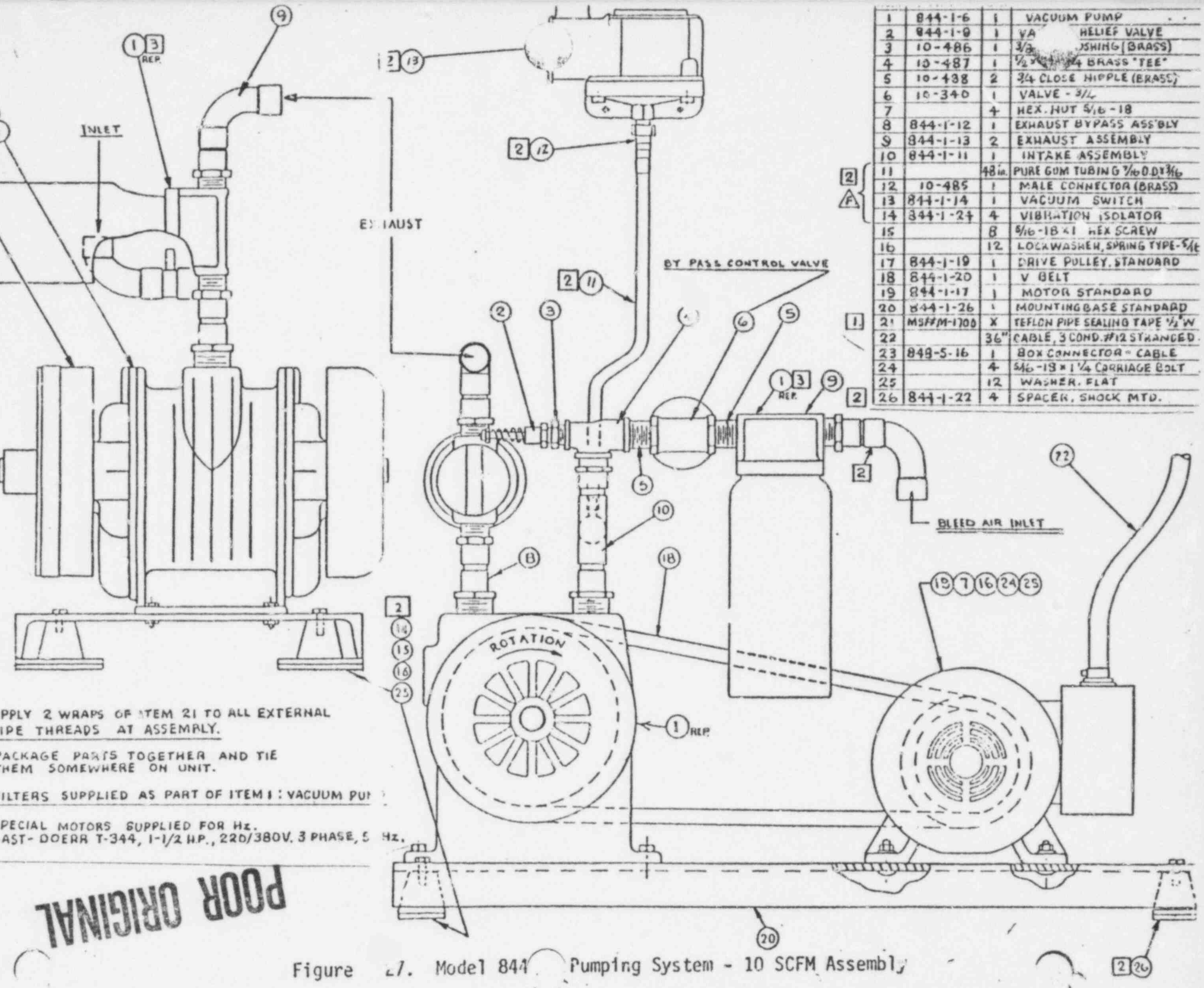


POOR ORIGINAL

Figure 3-26. 4 π Shield, Dimensional Outline

	1	844-1-6	1	VACUUM PUMP
	2	844-1-8	1	VA RELIEF VALVE
	3	10-486	1	3/4 USHING (BRASS)
	4	10-487	1	1/2 4 BRASS "TEE"
	5	10-438	2	3/4 CLOSE NIPPLE (BRASS)
	6	10-340	1	VALVE - 3/4
	7		4	HEX. NUT 5/16 - 18
	8	844-1-12	1	EXHAUST BYPASS ASS'BLY
	9	844-1-13	2	EXHAUST ASSEMBLY
	10	844-1-11	1	INTAKE ASSEMBLY
[2] △F	11		48 in.	PURE GUM TUBING 7/16 O.D. × 3/16
	12	10-485	1	MALE CONNECTOR (BRASS)
	13	844-1-14	1	VACUUM SWITCH
	14	844-1-24	4	VIBRATION ISOLATOR
	15		8	5/16-18 × 1 HEX SCREW
	16		12	LOCKWASHER, SPRING TYPE-5/16
	17	844-1-19	1	DRIVE PULLEY, STANDARD
	18	844-1-20	1	V BELT
	19	844-1-17	1	MOTOR STANDARD
	20	844-1-26	1	MOUNTING BASE STANDARD
[1]	21	MS##M-1700	X	TEFLON PIPE SEALING TAPE 1/2" W
	22		36"	CABLE, 3 COND. #12 STRANDED.
	23	848-5-16	1	BOX CONNECTOR - CABLE
	24		4	5/16-18 × 1 1/4 CARRIAGE BOLT
	25		12	WASHER, FLAT
[2]	26	844-1-22	4	SPACER, SHOCK MTD.



NOTES.

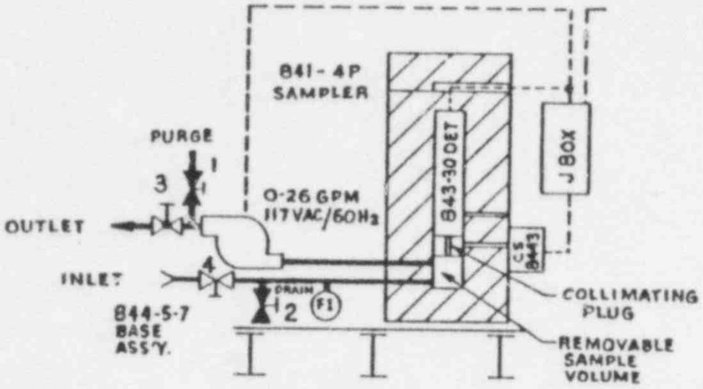
[1] APPLY 2 WRAPS OF ITEM 21 TO ALL EXTERNAL PIPE THREADS AT ASSEMBLY.

[2] PACKAGE PARTS TOGETHER AND TIE THEM SOMEWHERE ON UNIT.

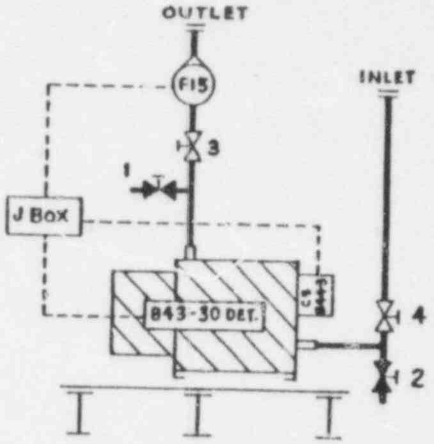
[3] FILTERS SUPPLIED AS PART OF ITEM 1 : VACUUM PU

[4] SPECIAL MOTORS SUPPLIED FOR Hz.
GAST-DOERR T-344, 1-1/2 HP., 220/380V. 3 PHASE, 5 Hz.

Figure 27. Model 844 Pumping System - 10 SCFM Assembly



PRIMARY COOLANT LETDOWN
MO-R-720 (LI &L2)



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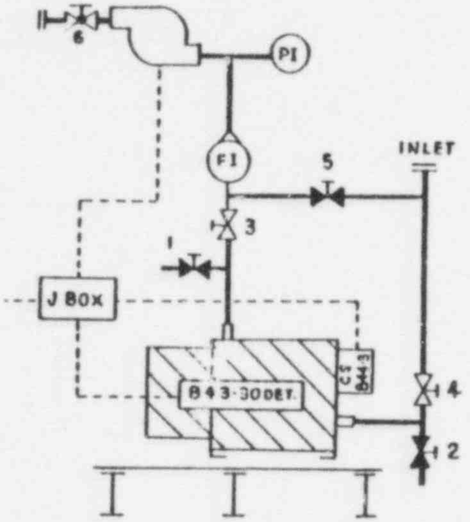


	Valve #1		Valve #2		Valve #3		Valve #4		Valve #5		Valve #6	
	Open	Closed	Open	Closed	Open	Closed	Open	Closed	Open	Closed	Open	Closed
Operate		X		X	0		0			X	0	
Isolate		X		X		X		X	0		0	
Purge	0		0	X		X		X	0		0	
Decontaminate Solution	0		0	X		X		X	0		0	
Remove Volume		X		X		X		X		X		X
Drain	0		0			X		X		X		X
Flushing	0		0			X		X		X		X
Return To Service				X	0		0			X	0	
By-Pass Sampler		X		X		X		X	0		0	

Figure 3-28. Liquid Monitor Valve Sequence Table

3.2.5.2.4 Disassembly.

To replace the carbon vanes or inspect the pump interior only the dead end plate opposite the drive shaft end should be removed. Remove the end cap screws, end cap and rotor spacers. In models 1550 and 3040, the dowel pins may be driven through with a punch.

The bearing and bearing shim will come off with the end plate, but before removing the bearing from the end plate mark the face of the bearing, DO NOT use a sharp instrument, so it can be replaced exactly as removed. Take care not to damage the felt seal washer when removing it. The end plate should be removed with an end plate puller to avoid damage to the end plate or body surfaces. Contact the Gast factory for additional puller information.

With the pump interior accessible, remove the old vanes and insert the new ones with the beveled edge fitting the bore. Also inspect the interior for obvious signs of damage.

3.2.5.2.5 Assembly.

Loosen the end cap screws on the drive end before replacing the dead end plate. Turn the pump to a vertical position, drive end down to permit the rotor to rest flush on the drive end plate. If necessary, apply pressure on the dead end of the rotor shaft to help contact the drive end. Replace the dead end plate and bolts. Tighten every third or fourth bolt around the circumference.

Insert the seal washer in the undercut and push the bearing shim and bearing squarely down to the shaft shoulder with a pusher tool and arbor press. Replace the spacers and end cap insuring all paint, dirt, burrs, etc. are removed from the end cap and surface of the end plate. Insert and tighten the end cap screws.

Return the pump to a horizontal position and tighten the end cap screws on the drive end bringing the rotor back to the original position. Check by hand for free rotor movement. If the rotor binds recheck the assembly procedure to insure proper sequence of parts installation.

3.2.5.3 Other Mechanical and Electrical Components.

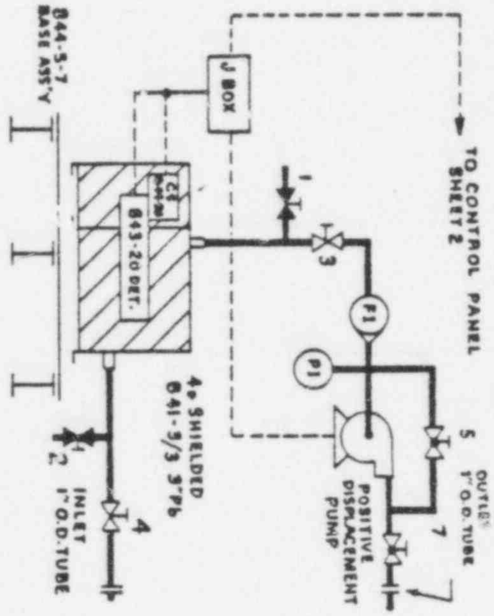
The remaining gas monitor components should rarely require maintenance. With the exception of the motor starter contact set. Other mechanical and electrical components should be replaced rather than attempting repairs unless unforeseen conditions dictate otherwise. Refer to Section IV for recommended spare parts list.

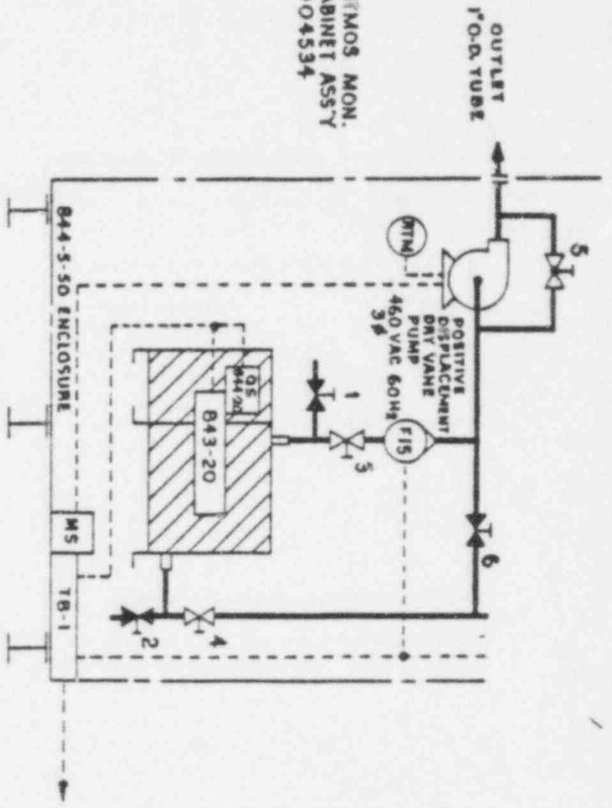
3.2.6 Atmospheric Monitors

Routine maintenance to be performed on atmospheric monitor systems consists mainly of changing filters. Frequency of change will depend on usage (paper speed, continuous operation, etc.).

3.2.6.1 841-1 Continuous Filter Air Sampler. See Figures 3-27, 3-30, and 3-34.

The continuous filter air sampler will require filter changes on approximately a monthly basis. The exact interval will depend upon the filter advance cycle selected and the number of fast advances performed.





POOR ORIGINAL

	Valve #1		Valve #2		Valve #3		Valve #4		Valve #5		Valve		Valve	
							ed Ope		en C					
Operate		X		X	0		0			X	0			
Isolate		X		X		X		X		X		X		X
Purge		X	0		0			X	0			X	0	
Decontaminate Solution	0		0			X		X	0			X	0	
Remove Volume		X		X		X		X		X		X		X
Drain	0		0			X		X	0			X	0	
By-Pass Sampler		X		X		X		X	0		0		0	
Return To Sampler		X		X	0		0		0			X	0	

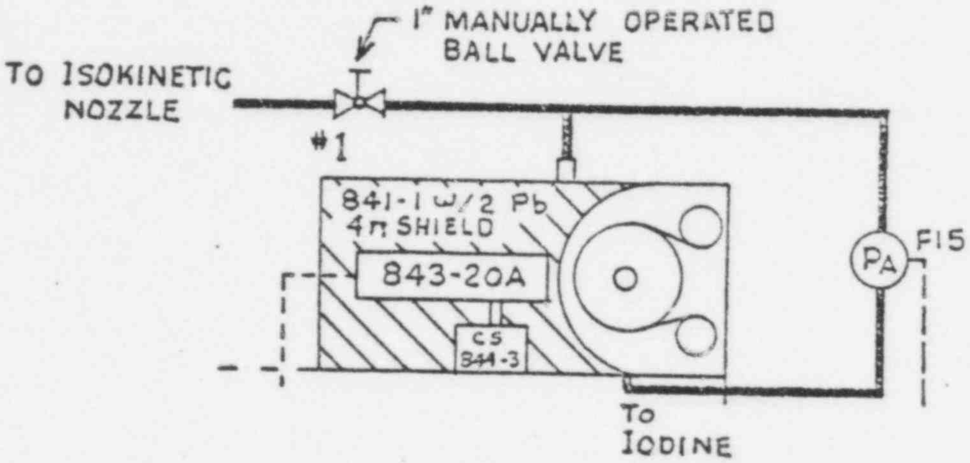
Figure 3-29. Gas Monitor Valve Sequence Table

CAUTION

The spent filter may contain radioactive material and should be checked by health physicist prior to removal.

3.2.6.1.1 Filter Change.

1. Turn off the sample pumping system, isolate the monitor per the valve sequence table of Figure 3-30, and remove the sampler lid by releasing the spring catches. Do not attempt to remove the sampler lid from the system with an operating vacuum pump.



	Valve #1	
	Open	Closed
Operate	0	
Isolate		X
Replace Filter		X
Return To Sampler	0	

Figure 3-30. Air Sampler Valve Sequence Table

2. Remove the takeup spool retaining nut and plate.

3. Remove the filter and place it in a suitable container.

4. Remove the lead shielding block from the top of the capstan drum by lifting straight up.

5. Remove the retaining nut and washer from the supply spool.

6. Move the filter roll hub from the supply spool to the takeup spool ensuring that it is properly seated in the notch.

7. Place the fresh filter on the supply spool and thread per Figure 3-32. Insure the filter gauze backing side is toward the capstan before threading.

8. Insure the filter is properly fixed to the takeup spindle or the spent filter will not be properly wound during operation.

9. Replace the takeup plate, retaining nut, and lead shielding block, being careful to properly position the lead shielding block with respect to the alignment pins, the supply washer, and retaining nut.

10. Operate the fast advance controls until satisfactory filter motion is observed.

11. Replace the sampler lid, return the valves to the operate position, and restart the pump.

POOR ORIGINAL

3.2.6.1.3 Decontamination.

It is possible during filter change and from normal use for a small amount of radioactive material to build up on various parts near the sample inlet and filter paper. Periodically health physics personnel should survey the interior of the sampler with the filter removed. If decontamination is required, it should be performed by persons cognizant of decontamination procedures and methods. The unit should not be disassembled unless absolutely necessary for successful decontamination and even then, remove as few parts as possible to complete decontamination.

3.2.6.2 841-2 Iodine Sampler.

The iodine filter should be changed as required by the iodine ratemeter reading or standard plant operating procedures.

3.2.6.2.1 Filter Change

1. Shut down the pumping system and/or isolate and by-pass the iodine sampler by sequencing the valves as shown in Figure 3-31.

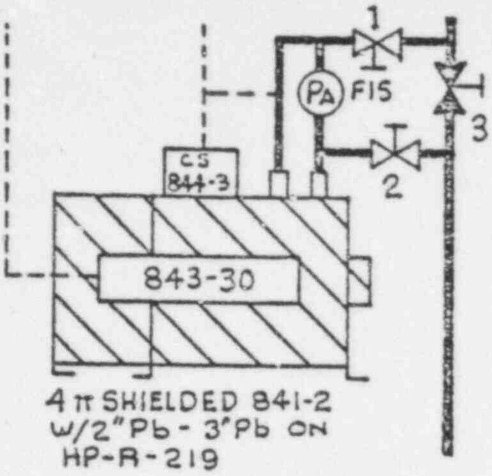
2. Loosen the 2 bolts fixing the filter holder to the sampler. See Figure 3-33 and remove the holder by turning to the left and pulling straight out of the shield.

3. Unscrew the top portion of the filter holder and remove the iodine filter cartridge.

4. Replace the spent cartridge with a fresh one and reverse the above procedure to return the unit to service.

3.2.6.2.2 Decontamination.

Contamination of the iodine sampler is very unlikely and if suspected should be surveyed by a health physicist. If decontamination is required, follow the steps 3.2.6.2.1 and decontaminate the unit while the filter is removed. Only persons cognizant of decontamination procedures and methods should attempt decontamination of the unit.



POOR ORIGINAL

	Valve #1		Valve #2		Valve #3	
	Open	Closed	Open	Closed	Open	Closed
Operate	0		0			X
Isolate		X		X	0	
Removed Connection		X		X	0	
Return To Service	0		0			X

Figure 3-31. Iodine Sampler Valve Sequence

3.2.6.3 841-33 Gas Sampler.

The gas sampler used in the atmospheric monitoring system carries the same sample volume as that of the liquid monitors. The only maintenance which may be necessary to the gas samplers would be air purge and/or decontamination of the sample volume. Air purge is initiated by appropriate valve sequencing. See Figure 3-29.

If decontamination of the sample volumes becomes necessary they must be processed per paragraphs 3.2.3.1.4 step 2 through 10, following shut down and isolation of the gas sampler per Figure 3-29.

3.2.6.4 844-1 Pumping System.

The pumping system is identical to that covered under paragraph 3.2.4.2 which should be referred to for maintenance details. Shut down the pumping system and isolate the atmospheric monitors per Figure 3-27 prior to performing any pump maintenance.

3.2.6.5 Local Control Panel.

Maintenance of the local control panel will be limited to indicator lamp replacement and relay replacement due to contact wear.

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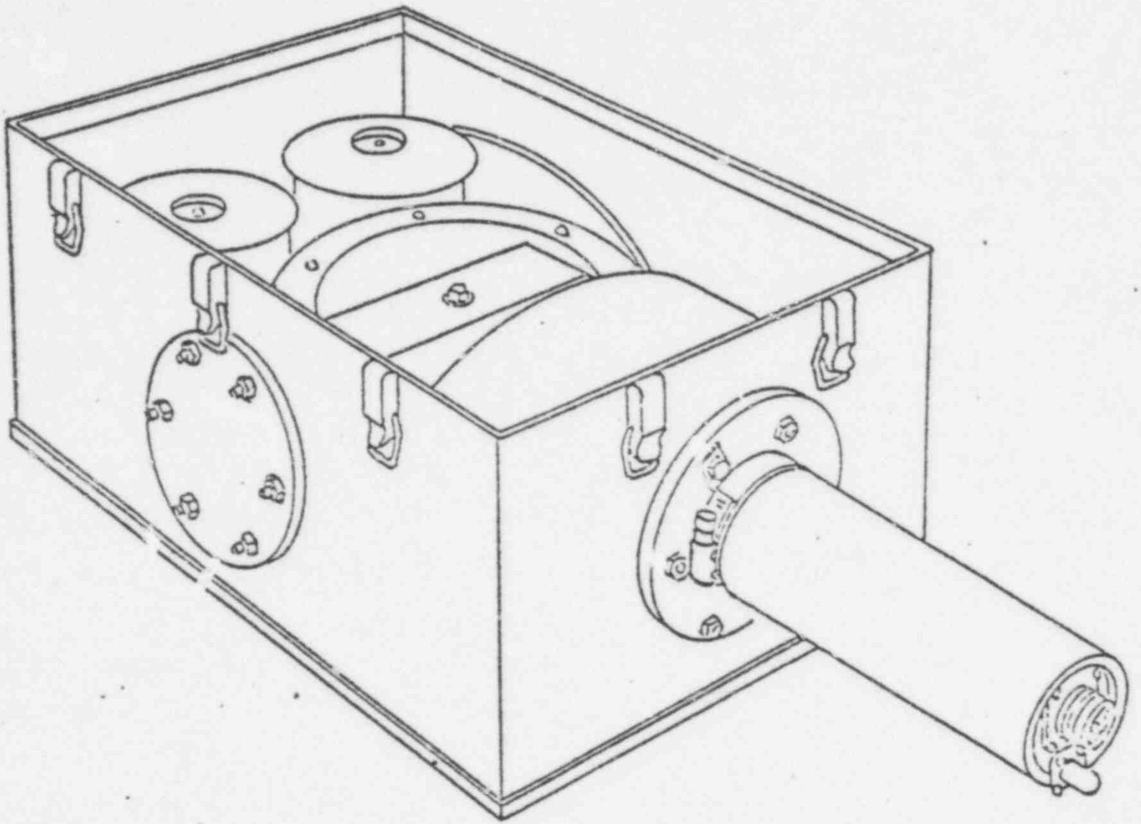


Figure 3-32. Continuous Air Sampler

3.2.6.6 Sample Flow Control System - Automatic Atmospheric Monitor.

The flow control devices used on the automatic isokinetic atmospheric monitor are covered in the manufacturers catalog section of this manual. Refer to the vendors manuals for maintenance details. Also refer to drawing 904549, sheets 1, 2, 3, and 4 and Figure 3-34.

Gas Flow Pump, #AF1-6KX - Hastings
Mass Flow Meter, #AHL-10C - Hastings
Basic Controller, #701 - Gelmac
Miniature Servo Recorder, #732 - Gelmac
Servo Amplifier, #A630 - Dahl
Motor Assembly, #SS-250 - Superior
dc Power Supply, #762 - Bailey
Signal Transmitter, #SC-1300 - Rochester
Signal Transmitter Isolator, #SC-1302 - Rochester
Differential Switch Catalog - Barksdale

3.2.6.6.1 Calibration.

Before turning on main power preset the 844-90 control panel as follows:

1. 844-90 auxiliary moving filter control panel; motor control HAND-OFF-AUTO switch to OFF.
2. Advance switch to OFF.
3. Local power switch to OFF.

3.2.6.6.2 844-90 Control Panel for HP-R-219 In Control Panel 12.

1. Program switch in NORMAL
2. Power switch to ON.

3.2.6.6.3 844-100 Control Panel - Iodine.

1. Turn motor control switch HAND-OFF-AUTO to the OFF position.
2. Turn power switch ON.

3.2.6.6.4 844-90 Auxiliary Moving Filter Control Panel.

1. Turn power switch ON. The automatic monitor is now on except for the pumping systems which will start after calibration.

3.2.6.6.5 Calibration - Cascade Input.

After unit is powered up calibrate the cascade input loop and the process variable loop in the following sequence:

1. Zero and calibrate the Hastings Gas Flow Probe as outlined in the manual listed in paragraph 3.2.6.6.

NOTE

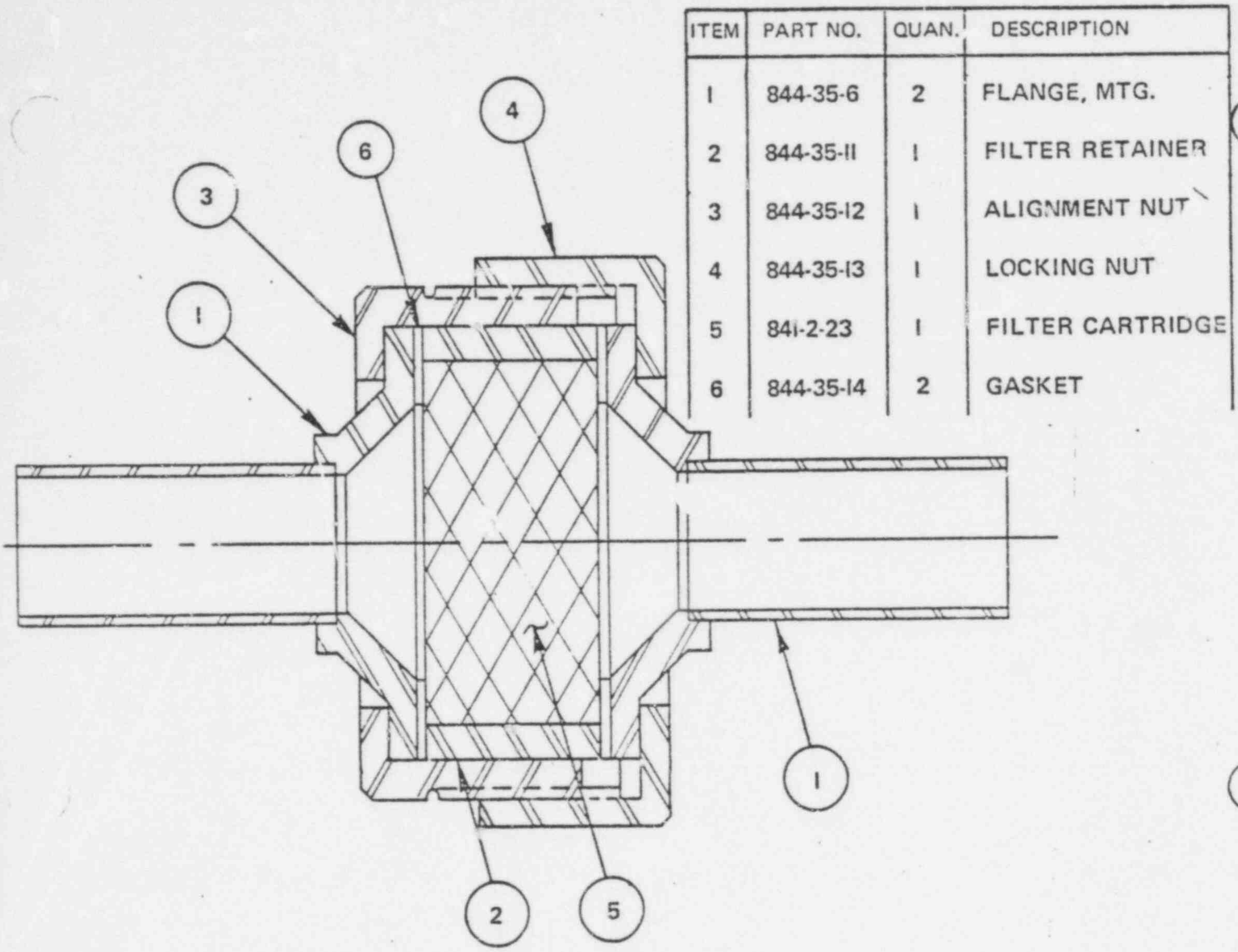
> In this system the purge system when the stack flow probe is not used. See Dwg. 904549, sheet 2 and Figure 3-34.

2. Remove the signal input and signal ground from the stack flow probe, TB1 #6 & 7, Figure 3-35 and calibrate using a dc power supply and a digital voltmeter-ammeter. Use the calibration sheets in Figure 3-36, schematic drawing 906148, Figure 3-37 and 3-38. After calibration install the signal input to TB1 #6 & 7.

NOTE

> This calibration is performed at 500 through 2500 fpm which is the range of the stack flow.

3. Remove the linearizer output leads from the linearizer TB1 #4 & 5 (10 - 50 ma). Figure 3-35, 3-37, and drawing 906148.



ITEM	PART NO.	QUAN.	DESCRIPTION
I	844-35-6	2	FLANGE, MTG.
2	844-35-II	I	FILTER RETAINER
3	844-35-I2	I	ALIGNMENT NUT
4	844-35-I3	I	LOCKING NUT
5	84I-2-23	I	FILTER CARTRIDGE
6	844-35-I4	2	GASKET

Figure 3-33. Inline Iodine Filter Assembly

Apply an input signal to the RIS SC-1302 Isolator and calibrate at zero and full scale. (10 - 50 ma). Refer to service manual.

4. After the isolator is calibrated, adjust the 2-pen recorder so that it tracks this same 10 - 50 ma signal applied to the isolator. Refer to service manual.

5. After the recorder is calibrated measure the voltage input of the cascade input on the controller terminal board (on guard rail) pin #6 (+) and pin #4 (common). 10 - 50 ma should correspond to 1 to 5V. After this cascade loop is calibrated go to the process variable side of the system.

3.2.6.6.6 Calibration Process Input.

1. Zero and check the Hastings Mass Flow Meter as outlined in the service manual, drawing 904549, sheet #2 and Figure 3-34.

2. Remove the 0 - 5V input signal from the mass flow meter on signal transmitter #3, a Rochester SC-1300, TB1 #1 (-) and TB1 #2 (+). Refer to service manual and drawing 904549, sheet #2 and Figure 3-37 and using a power supply, calibrate

the zero and full scale signal of the SC-1300 0 - 5V input = 10 - 50 ma output.

NOTE

Leave power supply attached for recorder and isolator calibrations.

3. After the signal transmitter #3 is calibrated (10 - 50 ma), adjust the recorder to track the signal transmitter 0V is = to 10 ma = 0 fpm. 5V is = 50 ma = 3300 fpm. Reference service manual, drawing 904549, sheet #2 and Figure 3-37.

4. After the recorder calibration 0 - 3300 fpm, adjust the signal isolator #2 so that zero and full scale are calibrated using the power supply. Refer to service manual, drawing 904549, sheet #2, and Figure 3-37. 0V = 10 ma transmitter = 10 ma isolator, 5V = 10 ma transmitter = 10 ma isolator.

5. After the recorder and isolator are calibrated, measure the voltage input of the process variable input on the controller terminal board (on guard rail) pin #5 (+) and pin #4 (common). 10 - 50 ma should correspond to 1 - 5V. After the process loop is calibrated, go to the controller output loop.

3.2.6.6.7 Calibration Output.

1. Place controller in the manual mode, drawing 904549, sheet #2. measure output of controller as follows:

a) Depress left button marked OPEN and move the panel meter until it reaches zero. This should be 4.0 ma measured on controller TB pin #8 (+) & #9 (-) or 1.0V across Dahl valve operator input. Set controller for 4.0 ma or 1.0V.

b) Depress right button marked CLOSED and move the panel meter until it reads 100% full scale, this should be 20 ma on output TB or 5V measured at input.

2. Servo amplifier calibration, refer to service manual. Dahl servo amplifier (located be [illegible] place remote switch in the AUTO position. Adjust the controller to 0% manually (4.0 ma output). Adjust electric valve for the CLOSED position. Adjust the controller to 100% manually (20 ma output). Adjust Diehl valve for the OPEN position.

3. Calibration is completed. Remove test leads.

3.2.6.6.8 Placing In Service.

1. Using the controller in the MANUAL mode adjust valve output to 50%.

2. Place continuous filter pump switch in the AUTO position.

3. Place iodine pump switch in the AUTO position.

4. Start pump from main control panel (panel 12).

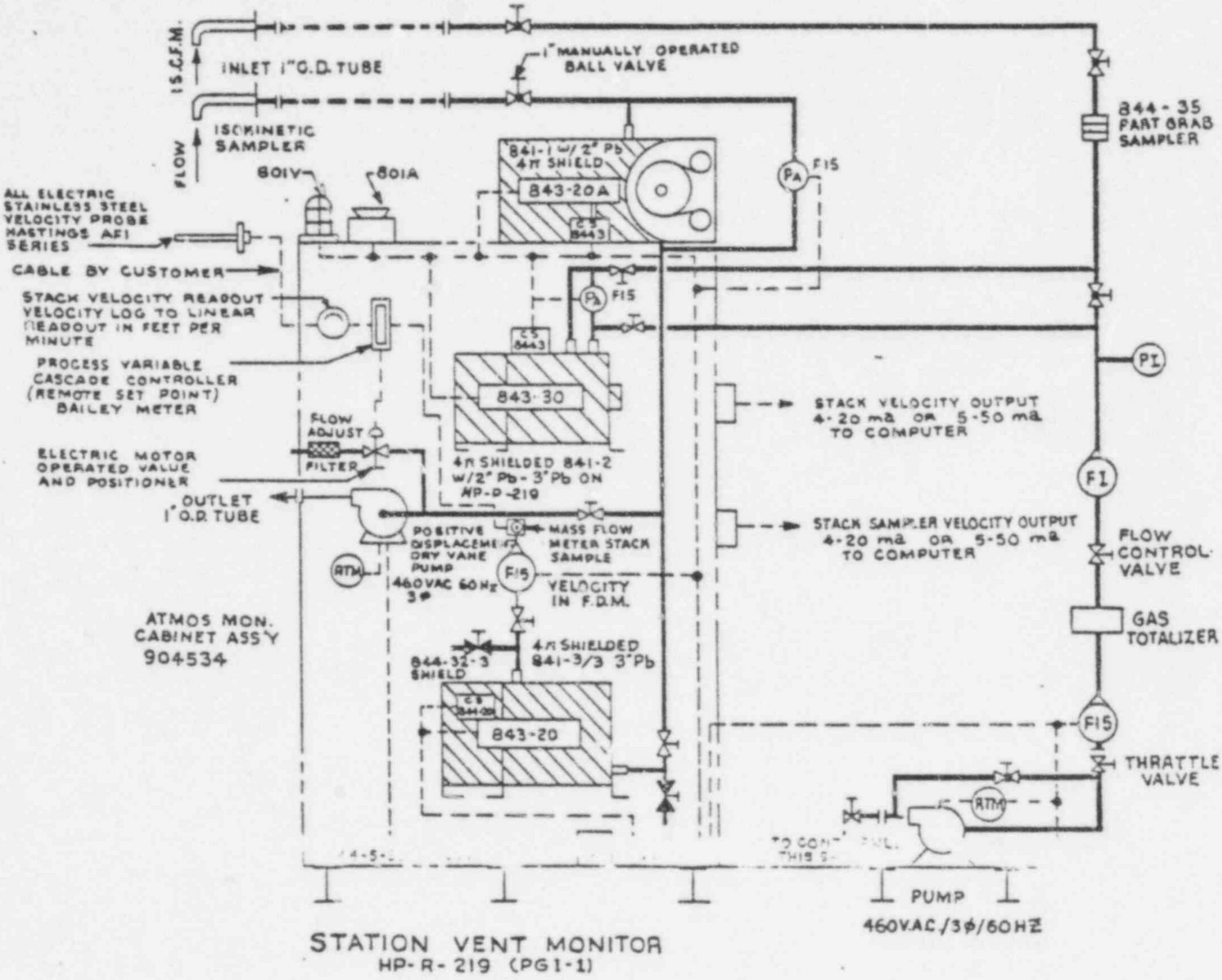
5. After both pumps are running note stack flow in cfm.

6. Note sample flow in cfm.

7. Transfer the controller from the MANUAL mode to the AUTOMATIC mode.

8. Sample flow should automatically self adjust to stack flow. Unit is now operating properly and will automatically compensate for variances in stack flow and filter build-up.

9. Refer to Barksdale catalog section for pressure switch adjustments on flow alarms.



ISOKINETIC NOZZLE, PARTICULATE GRAB SAMPLER. & PLANT IODINE MONITOR WITH CONSTANT 1.00 S.C.F.M. IODINE SAMPLE FROM SAMPLE LINE.

Figure 3-34. Station Vent Monitor HP-R 219 (PGI-1)

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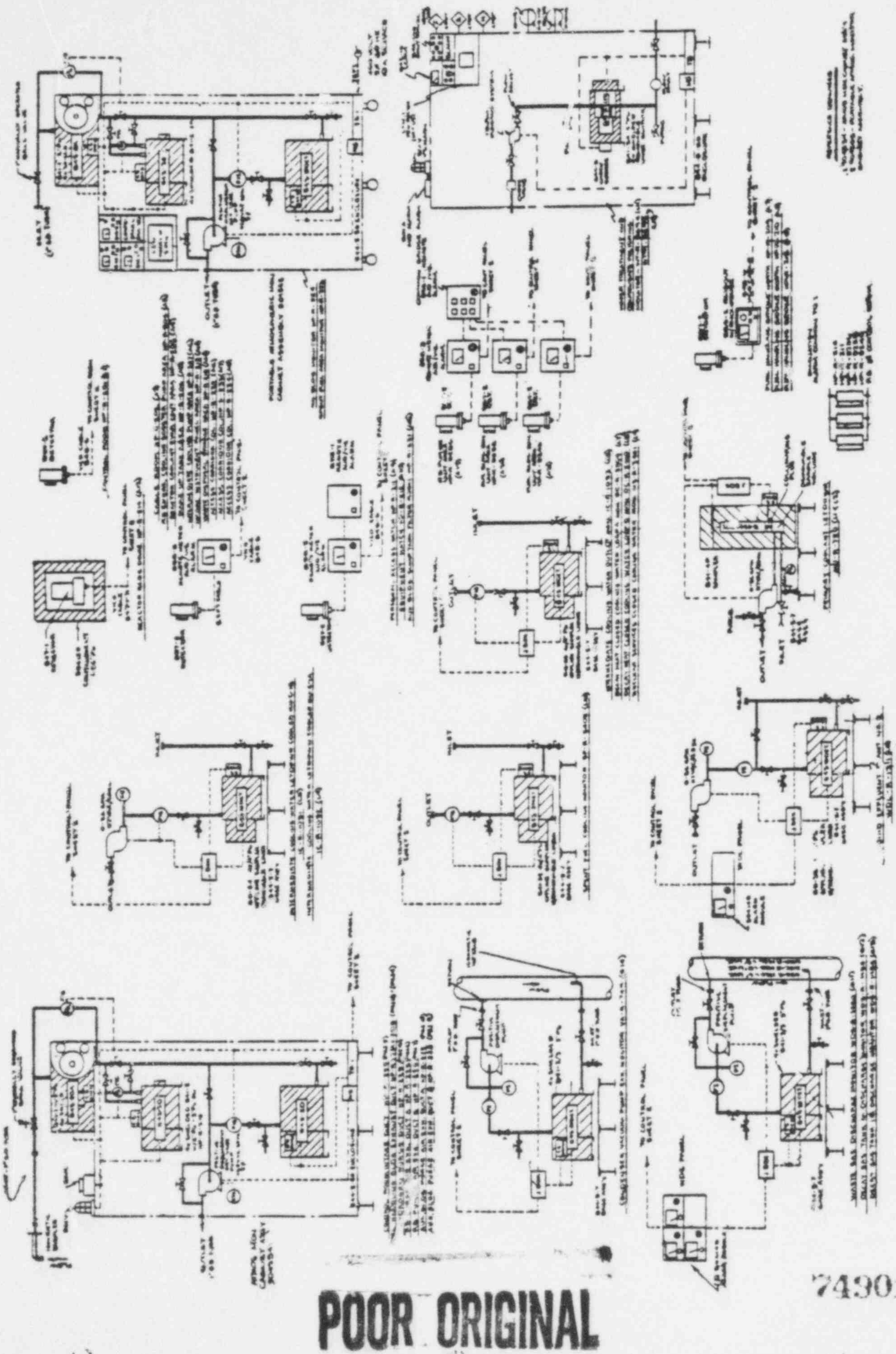

Figure 3-24. System Diagram, Drawing #904' 1, Sheet 1 of 2

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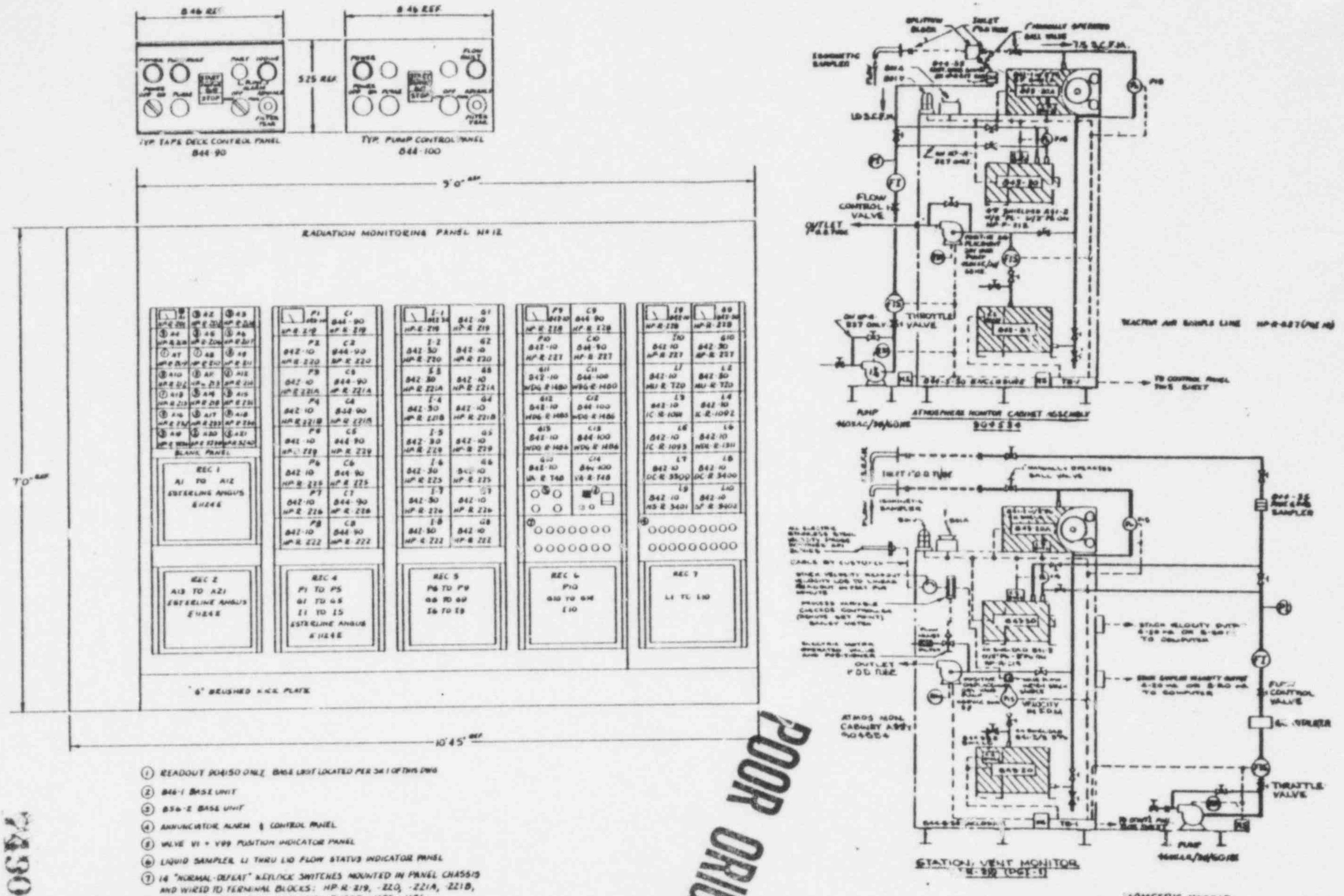

① READOUT 904150 ONLY. BASE UNIT LOCATED PER SH 1 OF THIS DWG

② 846-1 BASE UNIT

③ 856-2 BASE UNIT

④ ANNUNCIATOR ALARM & CONTROL PANEL

⑤ VALVE V1 + V99 POSITION INDICATOR PANEL

⑥ LIQUID SAMPLER L1 THRU L10 FLOW STATUS INDICATOR PANEL

⑦ 14 "NORMAL-DEFEAT" KEYLOCK SWITCHES MOUNTED IN PANEL CHASSIS AND WIRED TO TERMINAL BLOCKS: HP-R-219, -220, -221A, -221B, -222, 225, -226, 228, -229; WDG-R-1480, -1485, -1486; VA-R-748; WDL-R-1311.

ISOMETRIC NOZZLE, PARTICULATE GRAB SAMPLER, & PLANT IODINE MONITOR WITH CONSTANT 100 S.C.F.M. IODINE SAMPLE FROM SAMPLE LINE.

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Figure 3-25. Cabinet Outline. Drawing #904148. Sheet 2 of 2

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Description	Manufacturer, Model Number, Etc.	Victoreen Part No.	Qty.
Detector	Victoreen Instrument Div.		1
Check Source	"		1
Alarm Horn	Edwards		1
Alarm Light	Federal		1

4.2.6 Gas Monitor

Description	Manufacturer, Model Number, Etc.	Victoreen Part No.	Qty.
Motor Starter	GE, 200 line with "Hand, Off, Auto" Switch		1
Relay	Square D, KP12, 2PDT		2
H. V. Connector	Amphenol, MHV-Bulkhead		1
Terminal Board	States, 10-Position		3
3/4" Valve	Dynaquip, Full Port, Brass		3
Pumping System	Victoreen Instrument Div.	844-1	1
Lead Shield	"		1
Sample Volume	"		1
Detector	"		1
Check Source	"		1

4.2.7 Atmospheric Monitor

4.2.7.1 Atmospheric Monitor - Standard

Description	Manufacturer, Model Number, Etc.	Victoreen Part No.	Qty.
Elapsed Time Meter	Hayden		1
Differential Pressure Switch	Barksdale		2
Motor Starter	GE, CR206BO with 3-C2.68A O.L. Heaters		1
Relay	Square D, KP12, 2PDT		6
Terminal Board	States, 20-Position		1
Terminal Board	States, 10-Position		3
1" Valve	Dynaquip, Full Port, Stainless		2
1" Valve Inlet	Dynaquip, VFB25A1		1
3/4" Valve	Dynaquip, Full Port, Brass		3
Moving Filter Sampler w/C	Victoreen Instrument Div.	841-1	1
Gas Sampler w, CS	"	841-33	1
Iodine Sampler w/CS	"	841-2	1
Pumping System	"	844-1	1
Control Panel	" (Located in Panel #12)		1
Control Panel	" (Located on Local Enclosure)	844-90	1
Flow Control Panel	" (Modified for Elapsed Time Meter)		1
Alarm Horn	Edwards		1
Alarm Light	Federal		1

4.2.7.2 Atmospheric Monitor -Portable

Description	Manufacturer, Model Number, Etc.	Victoreen Part No.	Qty.
Relay	Square D, KP12, 2PDT		6

Description	Manufacturer, Model No., Etc.	Victoreen Part No.	Qty.
Relay	Agastat, GPI		9
Terminal Board	States, 24-Position		2
Terminal Board	States, 16-Position		2
Terminal Board	States, 10-Position		1
Pressure Switch	Barksdale		2
Elapsed Time Meter	Hayden		1
Recorder	Leeds & Northrup - 3 Pen		1
1" Valve	Dynaquip, Full Port, Stainless		2
3/4" Valve	Dynaquip, Full Port, Brass		5
Alarm Horn	Edwards		1
Alarm Light	Federal		1
Moving Filter Sampler	Victoreen Instrument Div.	841-1	1
Iodine Sampler	"	842-1	1
Gas Sampler	"	841-33	1
Ratemeter	"	842-10	3
Control Panel	"	844-90	1
Electrical Panel	"		
Flow Panel	"		

4.2.7.3 Atmospheric Monitor - Automatic

In addition to those parts under 4.2.7.1, the following are used to complete the automatic monitor.

Valve	Dahl, Electric w/controller		1
Signal Converter	Rochester Instrument Systems, SC1300, E/I Conv.		3
Terminal Board	States, 9-Position		5
Gas Flow Equipment	Hastings		1
Mass Flowmeter	Hastings (Probe located in stack)		1
Recorder	GE, 2-Pen		
Controller	GE		

4.2.8 Pumping System, Model 844-1

Vacuum Pump	Victoreen Instrument Div.	844-1-6	1
Vacuum Relief Valve	"	944-1-9	1
Bushing (Brass)	" (3/8 to 1/2 inch)	10-486	1
Brass Tee	"(1/2 x 3/4 x 3/4)	10-487	1
Close Nipple(Brass)	" (3/4 inch)	10-488	2
3/4" Valve	"	10-340	1
Exhaust By-Pass Assembly	"	844-1-12	1
Exhaust Assembly	"	844-1-13	2
Intake Assembly	"	844-1-11	1
Pure Gum Tubing	" (3/16 O.D. x 3/14 I.D.)		48 in.

Description	Manufacturer, Model No., Etc.	Victoreen Part No.	Qty.
Male Connector (Brass)	Victoreen Instrument Div.	10-485	1
Vacuum Switch	"	844-1-14	1
Vibration Isolator	"	844-1-24	1
Drive Pulley Std.	"	844-1-19	1
V Belt	"	844-1-20	1
Motor, Std.	"	844-1-17	1
Mtg. Base, Std.	"	844-1-16	1
Box Conn.- Cable	"	844-5-16	1
Spacer, Shcok Mtd.	"	844-1-22	4

4.2.9 Moving Filter Sampler- Model 841-1

Rectifier (Diode) 1N2071	"	52-43	2
Diode MDA 020A-7	"	52-124	2
Check Source Solenoid	"	716-50	1
Tear Switch Ass'y.	"	841-1-65	1
Solenoid	"	841-1-78	1
Take-Up Spool Motor	"	841-1-79	1
*Cycling Timer, Cont.	"	841-1-107	1
*Cycling Timer, Advance	"	841-1-106	1
*Time Switch	"	841-1-90	1

*Located on Electrical Control Panel

4.2.10 Iodine Sampler - Model 841-2

There are no replaceable parts to this unit other than the filter holder. Consult factory.

4.2.11 Gas/Liquid Sampler - Model 841-33

Volume Assembly	Victoreen Instrument Div.	841-33-28	1

4.2.12 Control Panel-Moving Filter Sampler, Model 844-90

Indicator Light Base	Victoreen Instrument Div.	20-48	1
Replacement Lamp	"	17-54	3
Fuse: 3AG, 3/4 Amp	"	19-2	1

4.2.13 Control Panel - Gas Sampler, Model 844-100

Indicator Light Base	Victoreen Instrument Div.	20-48	1
Replacement Lamp	"	17-54	3
Fuse; 3 AG, 3/4 Amp	"	19-2	1

905109

678

OCT 20 1976

ITEM	PART NO	QUAN	DESCRIPTION

	NOZZLE AND ACCESSORIES								DIMENSIONS IN INCHES										FLOWS IN SCFM			
CHANNEL NO.	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	SAMPLE FLOW RATE	DUCT FLOW RATE	DUCT SIZE	VICO PART NO.
HP-R-220	.946	4.75	.946	1.0	1.125	1.25	7.125	1.0	2.25	17	3	.25	9	9		6.25	6.25	10	8.5	15,620	54x24	905109-1
HP-R-222A	.946	4.75	.946	1.0	1.125	1.25	7.125	1.0	2.25	19	3	.25	9	9		6.25	6.25	10	8.5	13,725	38x30	905109-2
HP-R-222B	.826	4.25	.826	1.0	1.125	1.25	6.625	1.0	2.25	40	3	.25	9	9		6.25	6.25	10	8.5	50,715	100x32	905109-3
HP-R-222C	.925	4.75	.925	.75	1.125	1.25	5.75	1.0	2.25	17.5	3	.25	9	9		6.25	6.25	10	8.5	19,450	55x28	905109-4
HP-R-221A	.864	4.50	.864	.25	1.125	1.25	6.125	1.0	2.25	44	3	.25	9	9		6.25	6.25	10	8.5	56,450	100x36	905109-5
HP-R-221B	.796	4.0	.796	1.25	1.125	1.25	6.625	1.0	2.25	23	3	.25	9	9		6.25	6.25	10	8.5	56,450	66x50	905109-6
HP-R-225	.798	4.0	.796	1.25	1.125	1.25	6.625	1.0	2.25	13	3	.25	9	9		6.25	6.25	10	8.5	25,000	46x32	905109-7
HP-R-226	.798	4.0	.796	1.25	1.125	1.25	6.625	1.0	2.25	13	3	.25	9	9		6.25	6.25	10	8.5	25,000	46x32	905109-8
HP-R-228A	.706	3.75	.706	2.5	1.125	1.25	7.625	1.0	2.25	11	3	.25	9	9		6.25	6.25	10	8.5	83,890	92x42	905109-9
HP-R-228B	.706	3.75	.706	2.5	1.125	1.25	7.625	1.0	2.25	11	3	.25	9	9		6.25	6.25	10	8.5	83,890	92x42	905109-10
HP-R-219A	.742	4.0	.742	2.0	1.125	1.25	7.375	1.0	2.25	47	3	.25	9	9		6.25	6.25	10	7.5	177,206	114 D.	905109-11
												①	①	①		①	①					
HP-R-219B	.271	1.4	.271	8.75	1.125	1.25	11.525	1.0	2.25	47	3	.25	9	9		6.25	6.25	10	1.0	177,206	114 D	905109-12
												①	①	①		①	①					
② HP-R-222D	.500	2.50	.500	5.50	1.125	1.25	9.375	1.0	3	9	3.	.25	9	9	10.5	6.25	6.25	10	8.5	83,890	36x54	905109-13 ②

① MOUNTING PLATE MUST BE BENT TO FIT THE OUTER DIAMETER OF A 114" DIA PIPE. HOLES MUST BE ADDED TO PLATE FOLLOWING BENDING TO ASSURE ALIGNMENT.

② USE NOZZLE DESIGN ON SHEET #3 FOR 905109-13 ONLY.
USE SHEET #1 FOR NOZZLE DESIGN AND MOUNTING PLATE DESIGN.

B=5(A)
C=A
$D=\frac{(88-C)}{.06984}$ IF 88>C
$Q=\frac{(C-88)}{.06984}$ IF C>88
G=B+D+E+.25

NOTES: UNLESS OTHERWISE SPECIFIED

905109

REV. 3

REV LET	DESCRIPTION	DATE
A	ADDED HP-R-219 B.W.	11-20-74
B	HP-R-219A WAS HP-R-219. ADDED (LINE): HP-R-219B, & (FUTURE) 905109-13. R.J.C.	3-19-76
C	ADDED DATA FOR -13 NOZZLE (HP-R-222D) & NOTE ②. ADDED SH.3 FOR HP-R-222D.	3-22-76 R.J.C.

JERSEY CENTRAL POWER & LIGHT
THREE MILE ISLAND #2

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL DIMENSIONS ± .015
DECIMAL DIMENSIONS
XX ± .015 - XXX ± .005
ANGLES
ALL OTHER TOLERANCES PER VICTOREEN DWG NO. 901778

NEXT ASS'Y	USED ON
	E-07582
	E-28425

APPLICATION

VICTOREEN INSTRUMENT DIVISION
10101 WOODLAND AVE., CLEVELAND, OHIO 44104

NAME
ISOKINETIC NOZZLE DATA

MATERIAL	FINISH
∽	∽

DRAWN	DATE	CHECKED	DATE	APP'D	DATE
A.S.	5-10-74				

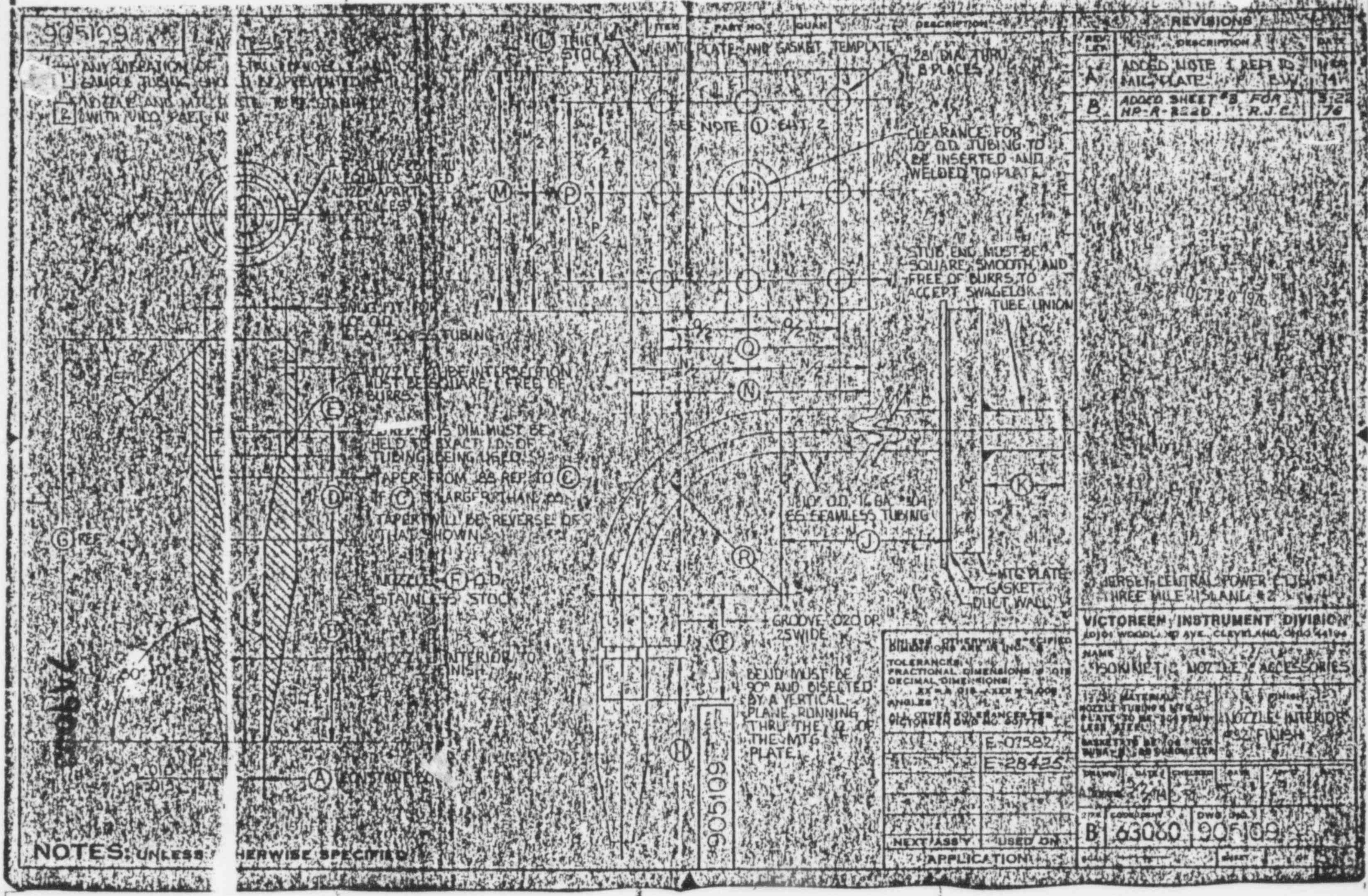
SIZE	CODE IDENT	DWG. NO.
B	63060	905109

SCALE ——— SHEET 2 OF 3

749022

POOR ORIGINAL

POOR ORIGINAL



① ANY ABRASION OF SAMPLE TUBING SHOULD BE PREVENTED

② NOZZLE AND MTG PLATE TO BE STAMPED WITH VICO PART NO.

NOTES: UNLESS OTHERWISE SPECIFIED

ITEM	PART NO.	QUAN	DESCRIPTION
			MTG PLATE AND GASKET TEMPLATE

REVISIONS

REV. LET.	DESCRIPTION	DATE
A	ADDED NOTE 1 REF TO MTG PLATE B.W.	11-69 / 74
B	ADDED SHEET #3 FOR HP-R-222D R.J.C.	3-22 / 76

OCT 20 1976

JERSEY CENTRAL POWER & LIGHT
THREE MILE ISLAND #2

VICTOREEN INSTRUMENT DIVISION
10101 WOODLAND AVE., CLEVELAND, OHIO 44104

NAME: ISOKINETIC NOZZLE & ACCESSORIES

MATERIAL: NOZZLE TUBING & MTG PLATE TO BE 304 STAINLESS STEEL
GASKET TO BE .06 THICK RUBBER
FINISH: NOZZLE INTERIOR #32 FINISH

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL DIMENSIONS ± .015
DECIMAL DIMENSIONS:
.XX ± .015 .XXX ± .005
ANGLES
ALL OTHER TOLERANCES PER VICTOREEN DWG NO. 901776

NEXT ASS'Y	USED ON
	E-07582
	E-28425

APPLICATION

DRAWN: A. [illegible] DATE: 3-2-74 CHECKED

SIZE: B CODE IDENT: 63060 DWG NO.: 905109

SHEET

749 023

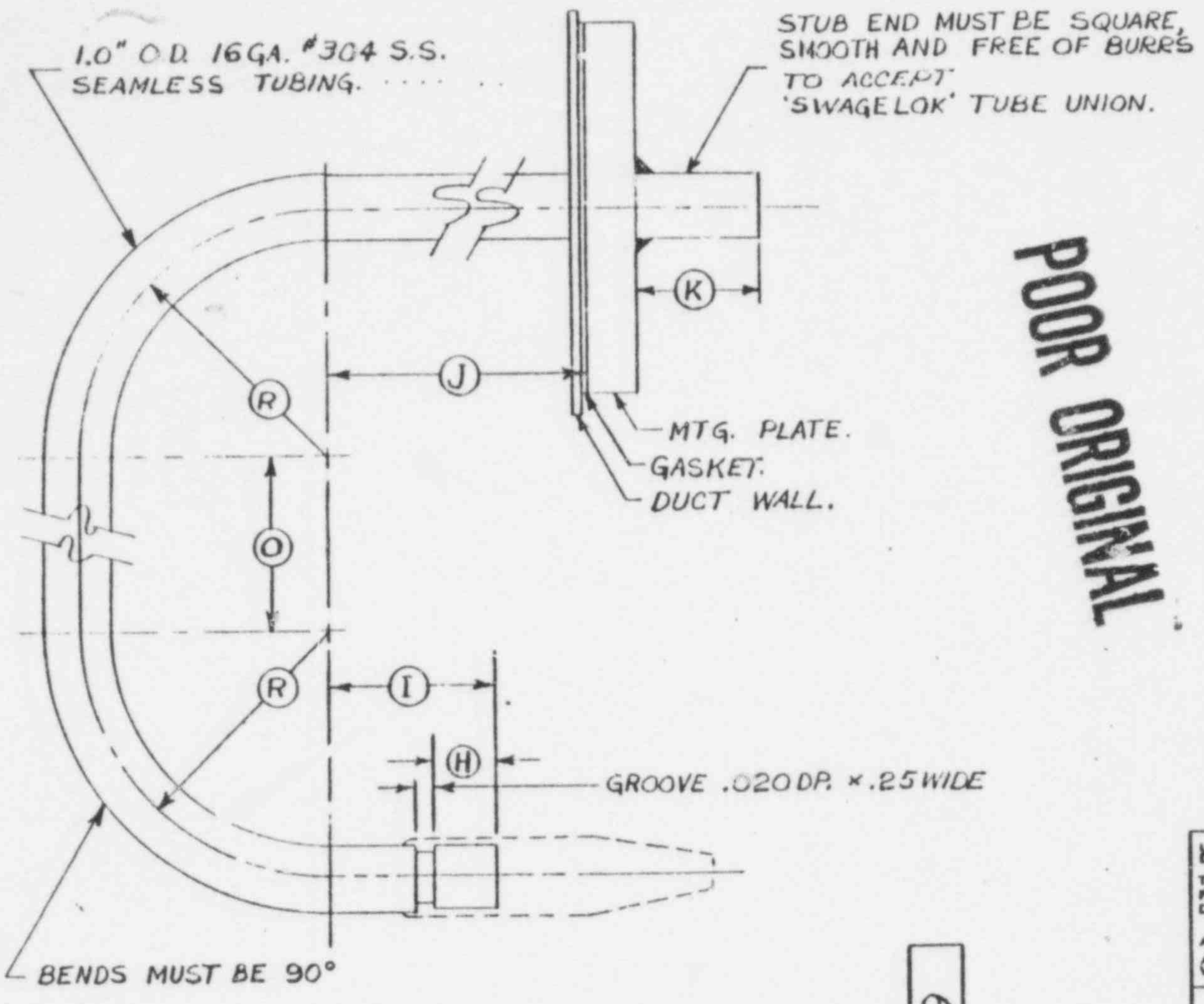
90510.

ITE	PART NO	QUAN	DESCRIPTION

REV LET	RE S DES K	DATE

OCT 20 1976

POOR ORIGINAL



749024

905109

1. USE NOZZLE DETAIL AND MOUNTING PLATE DETAIL ON SHEET #1.

NOTES: UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL DIMENSIONS ± .015
DECIMAL DIMENSIONS:
.XX = ± .015 - .XXX = ± .005
ANGLES
ALL OTHER TOLERANCES PER VICTOREEN DWG NO. 901778

E-28425

NEXT ASS'Y	USED ON
APPLICATION	

VICTOREEN INSTRUMENT DIVISION
10101 WOODLAND AVE., CLEVELAND, OHIO 44104

NAME ISOKINETIC NOZZLE & ACCESSORIES

MATERIAL	FINISH
~	~

DRAWN	DATE	CHECKED	DATE	APPD	DATE
R.J.C.	3-22-75	RJ	3/23/2		3-22-7

SIZE	CODE IDENT	DWG. NO.
B	63060	905109

SCALE ~ SHEET 3 OF 3

678

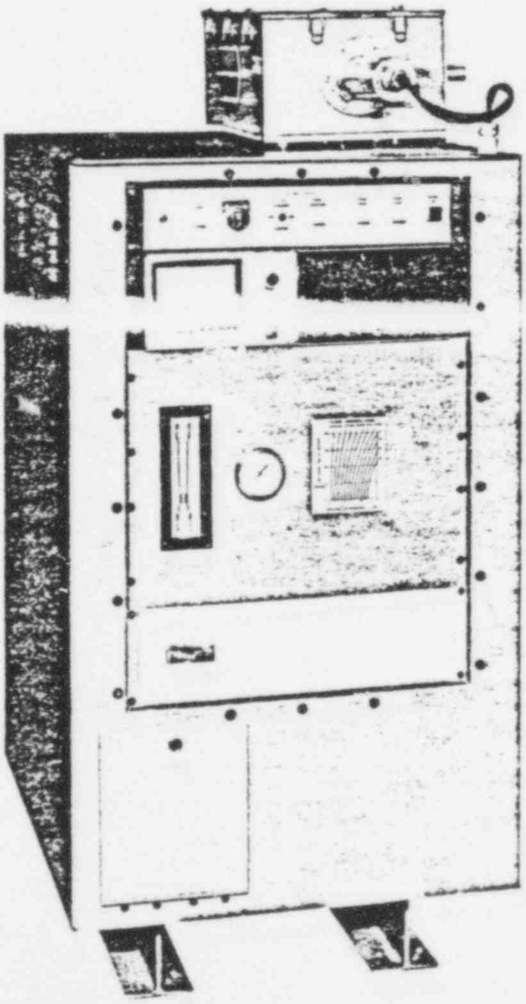
CONTINUOUS AIR MONITOR

840-1

- ☐ Motorless, Jam Proof, Filter Tape Transport Mechanism
- ☐ Choice of Filter Tape Speeds
- ☐ Capable of Either Continuous or Step Advance Operation
- ☐ Extra Heavy Duty Pumping System
- ☐ Modular Components Provide Maximum Versatility

MONITORING SYSTEMS

POOR ORIGINAL



Victoreen

749025

APPLICATIONS

The Model 840-1 Continuous Air Particulate Monitor fulfills the very definition of air particulate monitoring which is to provide an accurate determination of the concentration of airborne radioactivity. The Code of Federal Regulations is very specific in stating the permissible levels of radioactivity that can be released into the environment; this necessitates monitoring airborne effluents at the point of their release to the surroundings.

Besides the legal aspects of releasing activity into the environment, the essentials of industrial hygiene require continuous monitoring of any area where there is the slightest chance that the air may be contaminated. These areas include reactor facilities in general and especially in the containment and in auxiliary buildings, fuel loading eas, and certainly within the exhaust ducts or discharge stack. Accelerators also produce radioactive airborne particulates by induced activation and processing plants where nuclear materials are handled, machined or stored are also potential sources of airborne radioactivity and should be monitored. Dependence on air cleansing techniques such as scrubbers, absolute filters, etc., in itself is not sufficient, but continuously checking the integrity of these techniques with a Model 840-1 Air Particulate Monitoring System removes any doubt as to their adequacy.

SYSTEM DESCRIPTION

Typical components of a Model 840-1 are:

- Model 841-1 Continuous Air Sampler
- Model 843-20 Scintillation Detector Assembly
- Model 844-1 Pumping System
- Model 842-10 Ratemeter
- Model 844-4 Enclosure
- Model 844-9 Control Panel

The filter tape transport mechanism programs the movement of the paper tape and incorporates the popular rotating capstan technique with an added feature of dependable solenoid/ratchet operation instead of complicated gear train mechanisms. The transport tape mechanism is sealed against inhalation leakage during operation while allowing easy change of filter thro gh a quick opening cover. The unit is designed to operate on a continuous basis between filter changes (approximately 30 days based on 1 in./hr. operation).

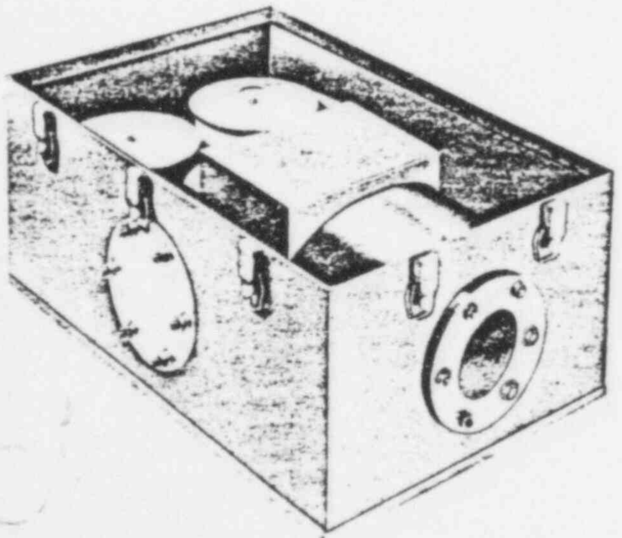
The Model 843-20 Scintillation Detector normally recommended for this type of application is equipped with a beta radiation sensitive plastic scintillator. Essentially all of the gamma emitting isotopes that are of usual interest also emit beta radiation. This permits the use of the thin beta sensitive plastic scintillator which reduces shielding requirements around the detector while providing excellent sensitivity and dynamic range.

The Model 844-1 Pumping System is a heavy duty dry vane system.

Data display for this type of monitoring usually demands a logarithmic readout such as provided by the Model 842-10 Log Ratemeter. A full scale log display of 10^6 cpm insures the reliability of unattended operation even during large fluctuations in activity levels.

The Model 844-4 is a rugged and attractive enclosure which comes equipped with either casters or skids. The removable standard 19 inch front panel permits easy access for servicing or the addition of recorders, ratemeters, etc.

The Model 844-3 solenoid operated check source, supplied as standard equipment, provides a quick positive means of assuring proper functioning of the system. Also included as standard is a high and low flow alarm and a filter failure alarm.



Model 841-1 Continuous Air Sampler

SPEC

Electrical Power Requirements: 20 amperes, 110 volts a.c., 60 Hz, single phase. (Others available on request).

Air Flow: 10 SCFM.

Air Sample Temperature Limits:
0°C to 50°C (32°F to 120°F) — Models 843-10 843-20 and 843-30 detectors.
—55°C to 75°C (-6_°F to 165°F) — Model 843-4 detector.

Air Inlet Connection: 1 in. O.D. tubing (2.54 cm).

Air Outlet Connection: 1 in. O.D. tubing (2.54 cm).

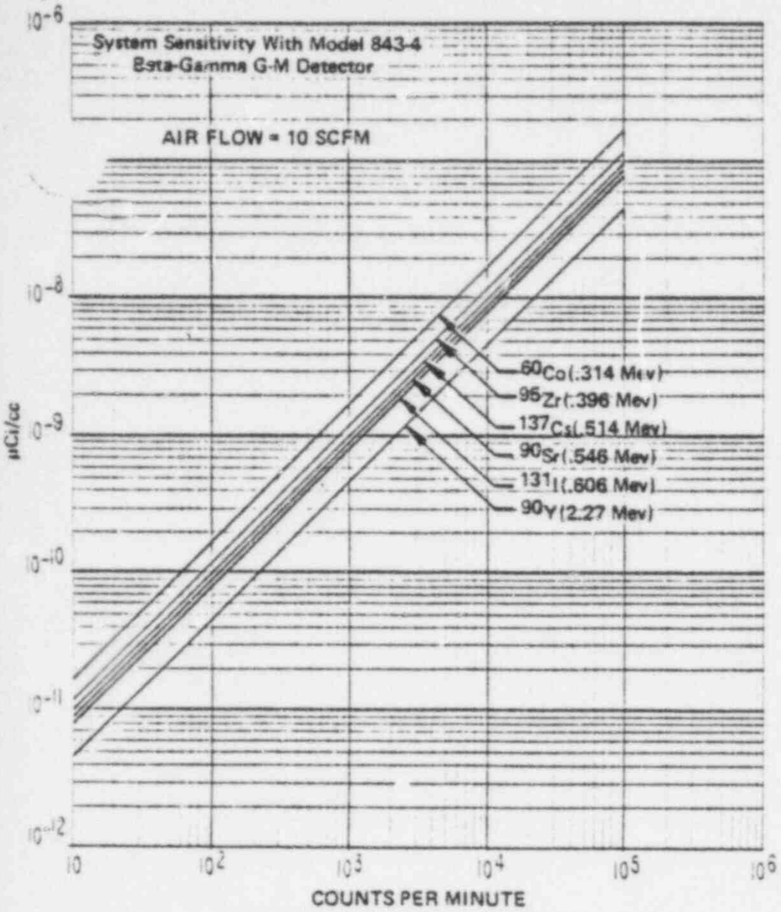
Shielding: 2 in. lead (5.10 cm), around sensitive end of the detector.

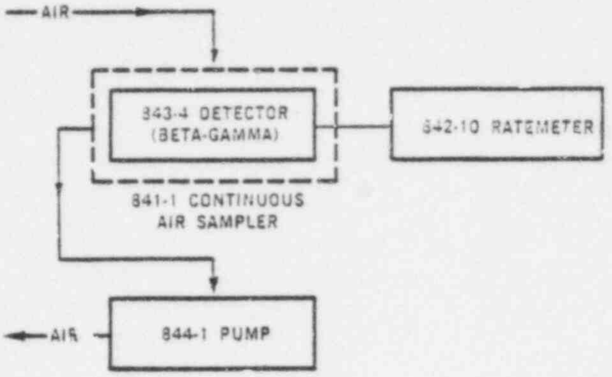
Filter Tape: 3 in. wide x 80 ft. long (7.65 cm, 2440 cm). Effective collection area — 3 square inches (19.4 cm^2).

Mounting: Skid mounts standard, casters optional.

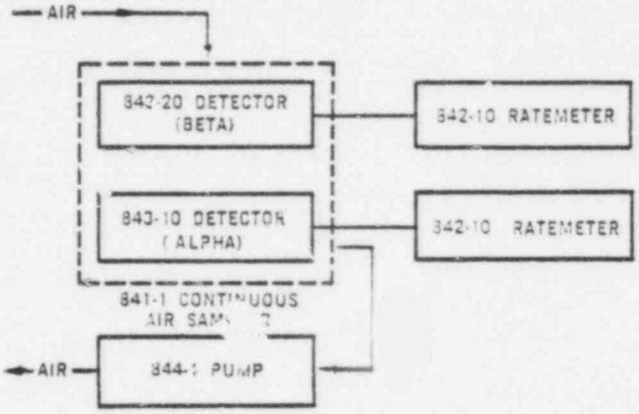
Dimensions: 54 in. high, 27½ in. wide, 33 in. deep (137.2 cm, 70 cm, 83.8 cm) excluding 841-1 Continuous Air Sampler. Add 9" for height with sampler.

Weight: Approximately 550 pounds (250 Kg).

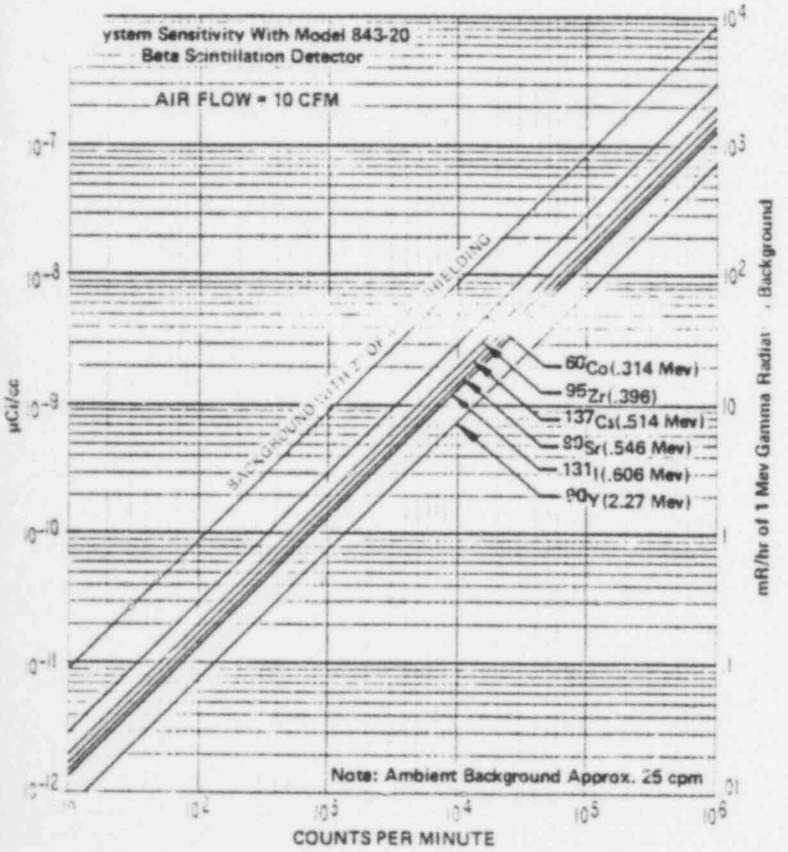




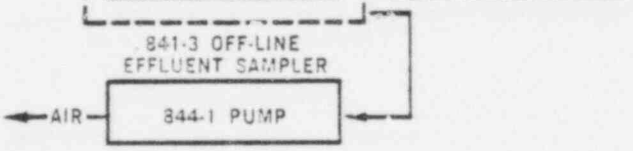
Gross Beta-Gamma Air Particulate System



Alpha and Beta Air Particulate System



POOR ORIGINAL



Combination Beta-Gamma Air Particulate
and Gamma Gaseous System

749027

VICTOREEN

VICTOREEN INSTRUMENT DIV. of VLN
10101 WOODLAND AVENUE • CLEVELAND, OHIO 44104
Phone: [216] 795-8200 • TWX [810] 421-8287

Form 3196C-11-70

Litho in U.S.A.

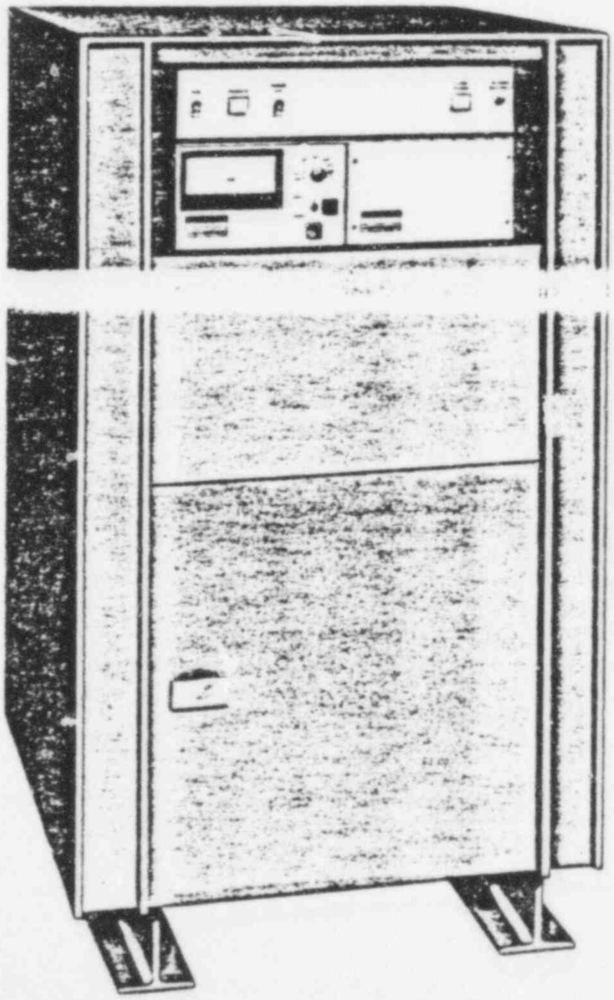
FIXED FILTER AIR/IODINE MONITOR

840-2

- Airborne Particulate Monitoring, Iodine Monitoring or Both Simultaneously
- Shielding Configuration Permits Choice of Detector
- Compact, Rugged, and Extremely Reliable
- Heavy Duty Pumping System
- Wide Dynamic Range Available In Log or Linear Display
- Single Channel Analyzer Capabilities for Iodine Monitoring

MONITORING SYSTEMS

POOR ORIGINAL



victoreen

749028

APPLICATIONS

The Model 840-2 Fixed Filter Monitor is recommended in applications where an air particulate monitor is not required to operate around the clock or where it is easily accessible for filter changes. The Model 840-2 Fixed Filter Monitor can be used in place of the Model 840-1 Continuous Air Monitor at some savings in cost, especially where regular work shifts make routine changing of filters feasible. The cleanliness of the air usually determines the frequency of filter changes. The Model 840-1 Continuous Air System would be recommended should the dust loadings become excessive and frequent filter changes become necessary. An essential requirement for air monitoring is maintenance of sufficient air flow through the filter to achieve the desired sensitivity.

The Model 840-2 when used as an Iodine Monitor provides the most efficient means commercially available for collection and measurement of field Iodine*. The charcoal cartridge provides a collection efficiency of better than 95% for field iodine. Iodine, being a fission product, is readily present in and about nuclear reactor facilities and is one of the more prominent isotopes requiring special surveillance, such as provided by the Model 840-2.

With the use of two VICTOREEN ratemeters, one equipped with a spectrometer, both the gross activity and the iodine concentration collected can be read out.

POOR ORIGINAL

SYSTEM DESCRIPTION

The heart of the Model 840-2 system is the lead shielded filter holder assembly. The unique design of this assembly causes effluent to first flow through the filter paper and then immediately through a charcoal cartridge. The detector is positioned to then monitor both the filter paper and the iodine cartridge simultaneously. The filter is readily changed by hand at desired intervals. The Model 843-30 Sodium Iodide Scintillation Detector in normally supplied for iodine and gross gamma monitoring. Additional detectors, such as, the Model 843-40 Thin-End Window Geiger Mueller Tube Detector, Model 843-20 Thin Plastic Beta Scintillation Detector or Model 843-10 Alpha Detector may be used interchangeably with this system.

A positive displacement dry vane pumping system is utilized to provide continuous duty. Excellent sensitivity is achieved in short time intervals with the use of up to eight cfm of air flow. The attractive system enclosure is of a rugged design to meet the most strenuous demands of heavy industrial use.

The extreme versatility of the system provides for mounting the ratemeter readout in the enclosure or remoting it to some central control console. For gross counting, either the Model 842-20 Linear Ratemeter or the Model 842-10 Log Ratemeter may be used. When monitoring for a specific isotope, such as iodine, either of the above ratemeters equipped with an analyzer is recommended.

Standard features for the system include alarms for alert, high radiation, failure, and flow rate to assure immediate notification of any abnormal condition. Another standard feature is the solenoid operated check source which provides an instant check out of the system functional status.

Victoreen process monitors will continue to operate with 1g seismic loads in the horizontal and vertical planes over the frequency range of 1-30 Hz.

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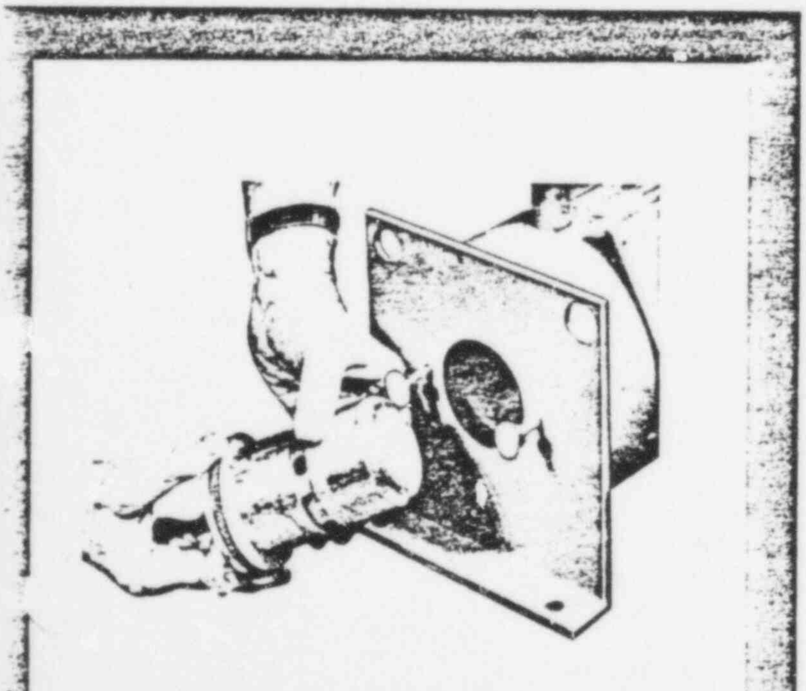
*Field iodine as defined by LASL Report LA-3363 is iodine released by nuclear reactors and hot cells.



Model 841-2 Fixed Filter Sampler

SPECIFICATIONS

Electrical [illegible] Requirements: 20 [illegible] volts a.c., 60 Hz, single phase. (Others available on request.

Air Flow: 8 cfm with clean filter.

Air Sample Temperature Limits:
0°C to 50°C (32°F to 120°F) — Models 843-10 843-20 and 843-30 detectors.
—55°C to 75°C (—65°F to 165°F) — Model 843-4 detector.

Air Inlet Connection. 1 in. O.D. tubing (2.54 cm).

Air Outlet Connection: 1 in. O.D. tubing (2.54 cm).

Shielding: 2 in. lead (5.10 cm). Around sensitive end of the detector. (4π Pb shielding available on request.)

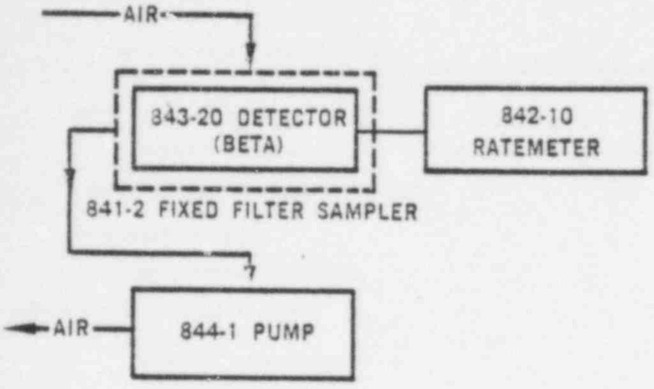
Filter Size: 2 in. diameter (5.10 cm).

Cartridge Size: 2 in. diameter, ¾ in. thick (5.10 cm, 1.91 cm).

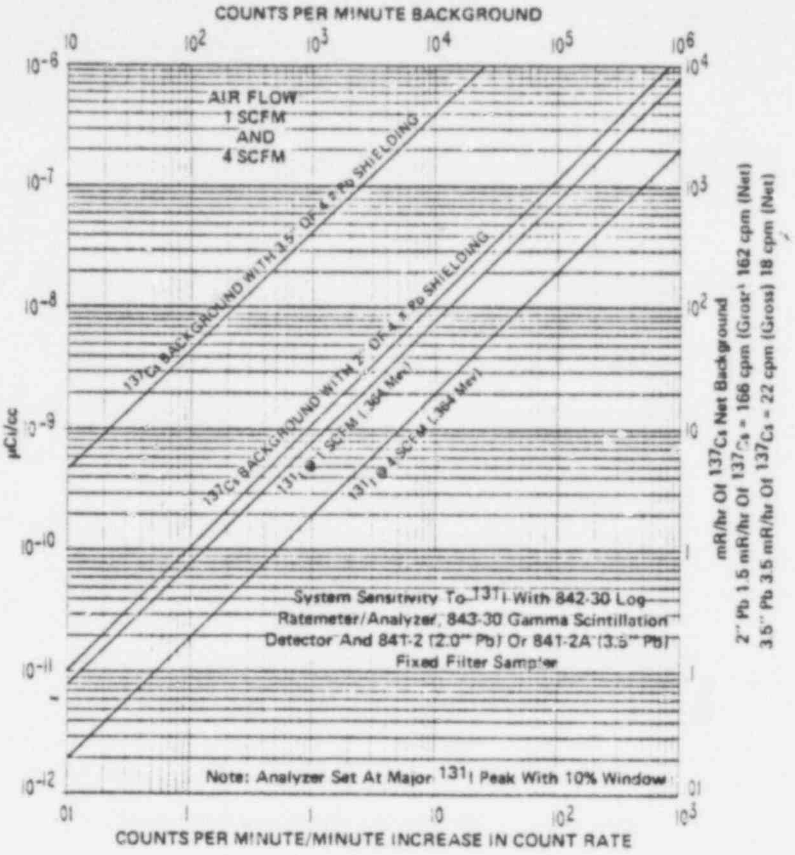
Mounting: Skid mounts standard, casters optional.

Dimensions: 54 in. high, 27½ in. wide, 33 in. deep (137.2 cm, 70 cm, 83.8 cm).

Weight. Approximately 500 pounds (227 Kg).

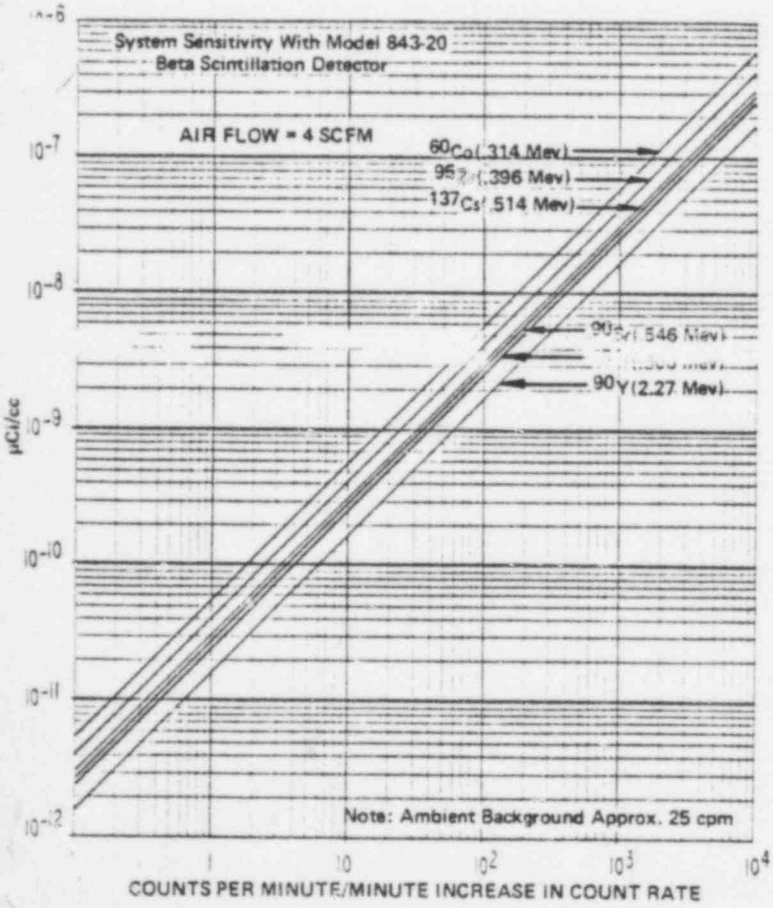


Fixed Filter Particulate System



System Sensitivity To ^{131}I With 842-30 Log Ratemeter/Analyzer, 843-30 Gamma Scintillation Detector And 841-2 (2.0" Pb) Or 841-2A (3.5" Pb) Fixed Filter Sampler

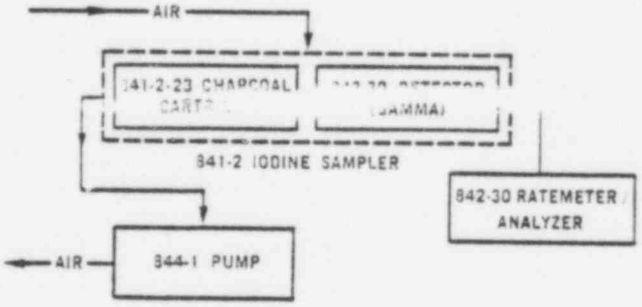
Note: Analyzer Set At Major ^{131}I Peak With 10% Window



System Sensitivity With Model 843-20 Beta Scintillation Detector

Note: Ambient Background Approx. 25 cpm

POOR ORIGINAL



Fixed Filter Iodine Particulate System

7490030

VICTOREEN

VICTOREEN INSTRUMENT DIV. of VLN
10101 WOODLAND AVENUE • CLEVELAND, OHIO 44104
Phone: [216] 795-8200 • TWX [810] 421-8287

Form 3197B-11-70

Litho in U.S.A.

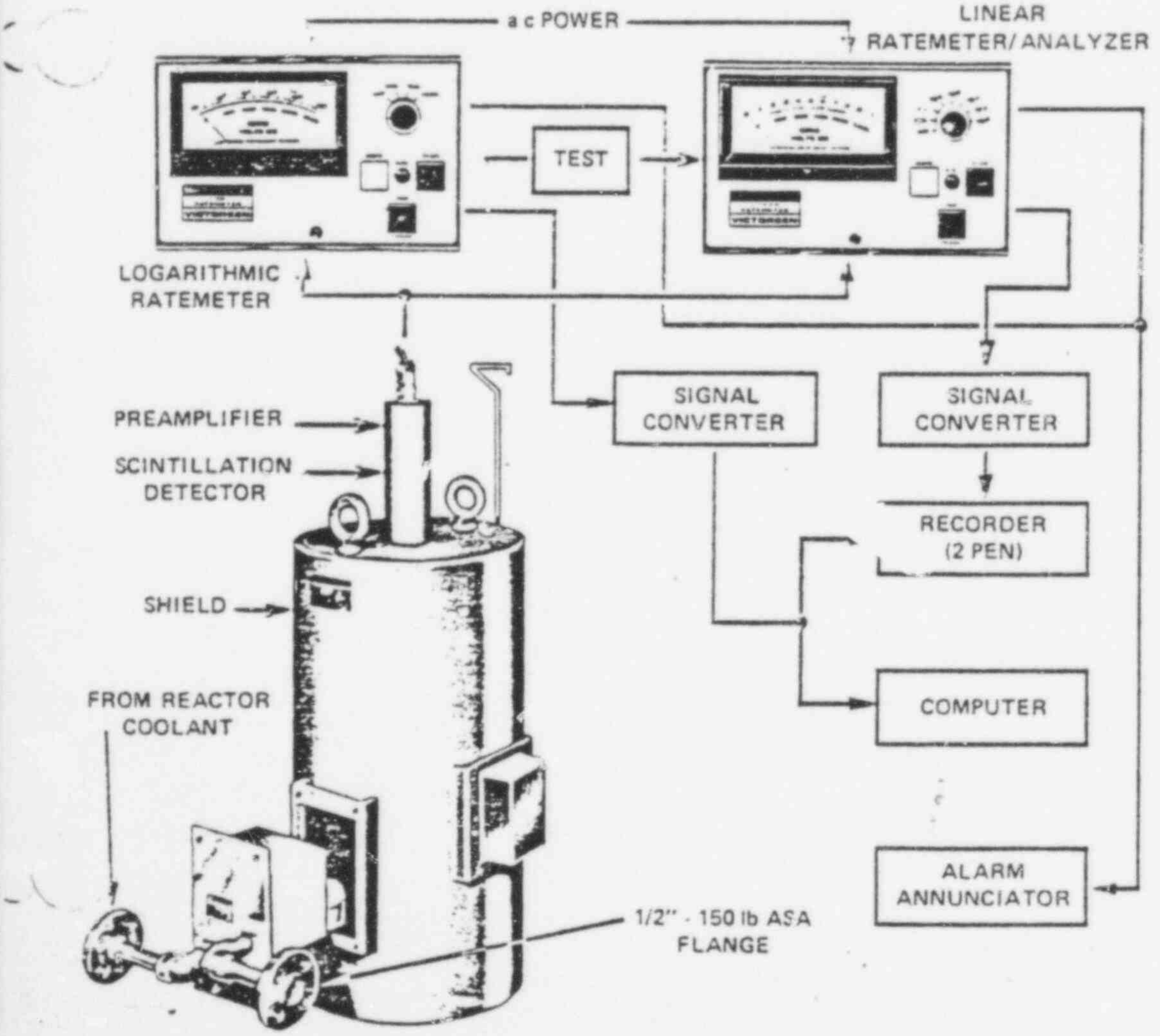
FAILED FUEL MONITOR

840-4F

- ☐ Measures Radiation Intensity in Primary Coolant Water by Gross Activity and Individual Isotope Concentrations •
- ☐ Detector Shielded in 4π Geometry by Five Inches of Lead to Reduce Background •
- Collimation Plug Provides 2½ Decades Compensation to Maintain Detector Sensitivity •
- ☐ Instant Direct Reading of Gamma Radiation Intensity in Primary Coolant •
- ☐ Removable Stainless Steel Liner for Easy Decontamination •
- ☐ Analyzer Window Settable Over Wide Spectrum With ΔE Potentiometer Control •

MONITORING SYSTEMS

POOR ORIGINAL



VICTOREEN

749031

INTRODUCTION

In commercial light water nuclear power reactors, monitoring the activities of the reactor coolant process on a continuous basis can provide extremely valuable information concerning fuel element cladding failure. Victoreen has designed, fabricated nd delivered radiation monitoring systems that continuously easure the gamma radiation in a continuously flowing sample tream of primary coolant. The purpose of this system is to detect the failure of one or more fuel element claddings by the gamma emissions of fission products released into the primary reactor coolant of a light water reactor.

The sampler is normally located so that the transient time between the primary coolant and the detector is approximately 2 minutes. This location is recommended so that the high level gamma radiation associated with ^{16}N has time to decay to an insignificant level. However, the sampler may be located so that the transient time is less than 30 seconds if required. The output of the integral preamplifier, associated with the detector, is sufficient to drive signals through approximately 1500 feet of interconnecting cable to the linear ratemeter/analyzer and the logarithmic ratemeter, which are both normally located in the reactor control room. By appropriate selection of the Delta "E" and the Delta "E" Scan pots, the linear ratemeter/analyzer will monitor specific fission product gamma activity. The logarithmic ratemeter measures the gross gamma activity associated with a fuel cladding failure. Optional dual pen recorder simultaneously displays the specific fission product activity and the gross activity of the primary coolant. In addition to providing comparative indication, the ratemeter and ratemeter/analyzer have alert and high radiation alarms and data logging outputs.

One advantage of this system, as compared to other contemporary schemes, is its location. The unit may be located outside of the reactor building for convenient field maintenance. is normally located across a demineralizer unit associated h the primary coolant system. This location allows a suffi- ent pressure drop so that a pumping system is not required. In addition, the gross gamma monitoring channel provides an extremely fast indication of cladding failure. Further, as the activity of the specific fission product being monitored by the ratemeter/analyzer increases, the user is provided with undeniable evidence of a cladding failure as opposed to radiation associated with tramp uranium. Also, extremely wide dynamic range is afforded by use of a collimating plug.

SAMPLE

The Model 841—4P Sampler is of the off-line type, with a removable sample volume, 5 inches of 4 π lead shielding around the radiation detector and an integral preamplifier. The sample cell is certified stainless steel, 2-1/2 inches in diameter and 1-3/4 inches high and is connected by two 1/2 inch, 150 pound, stainless steel flanges to the sample line. The welding is certified to comply with the nuclear piping code. Testing of this system includes a hydrostatic test of 300 psig and a dye penetrate test.

Provision is made for desensitizing the system by approximately two and one-half decades to compensate for permanent activity build-up resulting from long term normal operation. This is accomplished by insertion of a collimating plug between the sensitive end of the detector and the sample volume. Refer to the graphs for count rates versus activity and background contribution. Figure 1 shows a cross-sectional view of the sampler and detector arrangement.

TECTOR

e radiation detecting element is a gamma scintillation detector utilizing a 1-1/2 inch diameter by 1 inch thick sodium iodide crystal optically coupled to a ten-stage photomultiplier tube, housed in steel. The photomultiplier tube has a preamplifier with a dynamic range of 25 which is suitable for pulse height analysis over the energy ranges of 80 keV to 2 MeV.

CHECK SOURCE

Mounted on the outside of the shield assembly is a solenoid-operated, 8 μCi, ^{137}Cs, check source that checks the operational integrity of the system. Depressing a pushbutton switch on the ratemeter actuates the solenoid which moves the radioactive material into line with a beam port. Actually, two beam ports are provided, one to be used while the collimating plug is inserted in the shield, and the other without the collimating plug.

READOUT

The output from the detector preamplifier is −5V peak, which is simultaneously fed to two readout devices. One readout device is a five—decade log ratemeter with a dnyamic range of 10 to 10^6 counts per minute, the other is a linear ratemeter/analyzer. The log ratemeter monitors gross activity - all the output pulses of the scintillation detector. The ratemeter circuitry is completely solid state with a built-in variable power supply that has a range from 500 to 2500 volts and is normally used with this type of detector at approximately 1000 volts.

In addition to the check source control, that is located on the ratemeter, the unit also has two radiation alarm set points, one designed to operate as an alert alarm, the other as a high radiation alarm. These are pushbutton type lights on the front panel. The logic operates as follows. To check alarm set points, switch the Function Selector to the CAL.SIG. and depress either of the alarm pushbuttons for a meter indication of alarm set points.

To change the alarm set points, the ratemeter is partially withdrawn from the rack to provide access to the two miniature, 15-turn pots used for the alert and high radiation alarms. The high and alert alarms are adjustable anywhere on the meter scale. Normally, these alarms are used in a manual reset mode; that is, if an alarm condition occurs, the alarm light will remain on even though the radiation intensity causing condition has subsided. To reset the unit, a green reset button is provided on the front panel which, when depressed, will extinguish the alarm lights. In addition to the alarm lights on the front panel, relay contacts are provided on the back of the chassis to operate any external alarming or enunciating devices. The green reset light on the front panel also serves as a Fail/Safe indicator. This light is on at all times during normal operation if mode jumper is in "A" position, and off during normal operation if mode jumper is in "B" position (optional). On the back panel of the ratemeter is a 0 to 10 millivolt recorder output and a 0 to 50 millivolt computer output. The computer output can be changed by moving one end of the jumper for either 0—50 millivolts, 0—1 or 0—5 volts. The computer outputs are isolated from the recorder output. The time constants of the ratemeter vary from one minute at 10 counts per minute down to 0.2 seconds at 10^6 counts per minute.

The brochure cover shows a block diagram of the 840—4P system and options.

The linear ratemeter/analyzer fits side by side in a 19 inch panel with the log ratemeter. The analyzer board has provision for Delta "E" and Delta "E" Scan adjustments, both operating independently. This then provides a means of looking at the gross activity with the log ratemeter, while at the same time analyzing the same signal by means of a single channel analyzer with a 100 keV window, which is adjustable to observe the energy of interest. As used in this system, the recorder output of each of the ratemeters is fed to one pen of a two-pen optional recorder, thus giving a visual and permanent comparative display of the outputs.

SYSTEM CALIBRATION

The system was calibrated with an isotopic solution of ^{60}Co in water. Two different concentrations were used. The calibration also was done both with and without a collimating plug. Since the isotope of interest was ^{135}I rather than ^{60}Co, the data were corrected, taking into consideration the gamma branching ratios and energies, so that the resulting curve of microcuries per cubic centimeter was obtained. The background shown in the sensitivity curve was established by using a Cobalt source located at various points around the shield assembly.

The horizontal scale of the graphs registers the equivalent of a 5 decade log meter; that is, ranging from 10 counts per minute up to 10^6 counts per minute. To determine the background contribution, take the intersect between the horizontal lines from the background level with the background curve and read down. This gives the counts per minute versus the background reading in mR/h.

The microcuries per cubic centimeter of ^{135}I is interpreted in a similar manner. If the ratemeter, for example, is reading at 10,000 counts per minute, or 10^4, follow that vertical line until it intersects with the curve of interest. This will give, on the lefthand scale, the concentration equivalent in microcuries per cubic centimeter of ^{135}I.

CONCLUSIONS

The 840—4P system meets the measurement objectives because of the following considerations.

1. Gamma spectrometry allows isolated measurement of selected isotopes which are high on the fission yield curve, and whose presence in the reactor coolant is a sure sign of fission product activity in the coolant; e.g., ^{135}I. The physical properties of this isotope ensure its release under all known mechanisms associated with fuel element ruptures. Also, ^{135}I is not plated or absorbed into metal surfaces enclosing the reactor cooling system.
2. Gamma-ray spectrometry allows the use of instrumentation with minimum sensitivity on the order of 10^{-4}μCi/cc of ^{135}I in the coolant, yielding trend information on fission product activity well below a 1% gross failed element limit.
3. Gamma-ray spectrometry provides excellent discrimination against background gamma radiation. With the primary detection element properly shielded and located, power maneuvering background effects are negligible.
4. Provision for a logarithmic gross-activity measurement channel, in addition to a linear single-activity measurement channel, contributes to read-out diversity and gives trend information or the total gross fission product and non-fission product activities in the primary coolant.
5. The system response time is on the order of six minutes which is acceptable.
6. To guard against saturation, the system sensitivity can be decreased, with proper collimators, to approximately 100μCi/cc of ^{135}I which is typically in excess of 30 times higher than the expected activity level in the coolant at 1% fuel element failure.
7. The location of the scintillation detector abutting on the enlarged section of the line provides a better measurement geometry and an arrangement which can be more easily shielded than an installation on the surface of the pipe. The geometry and shielding factors are essential to the sensitivity of the device; better geometry and better shielding contribute to a more sensitive instrument.

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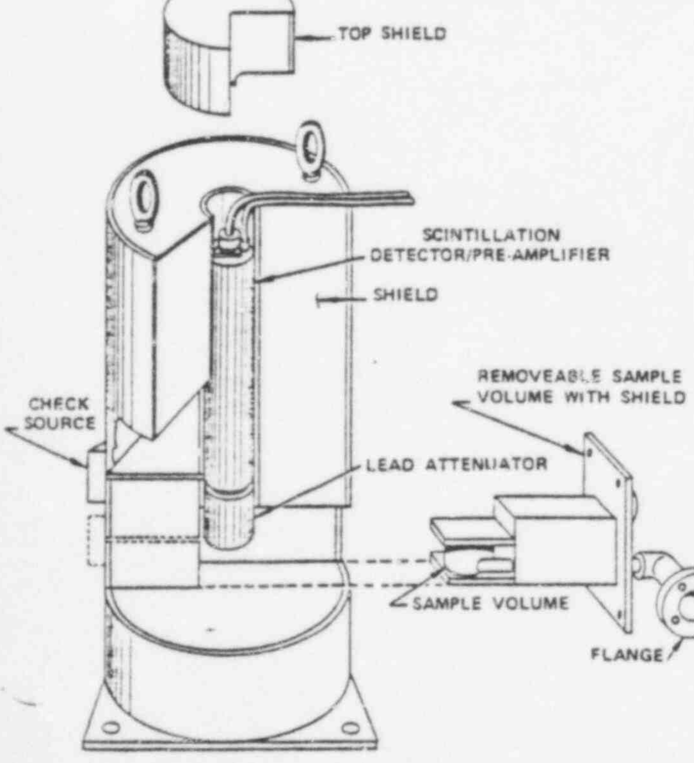
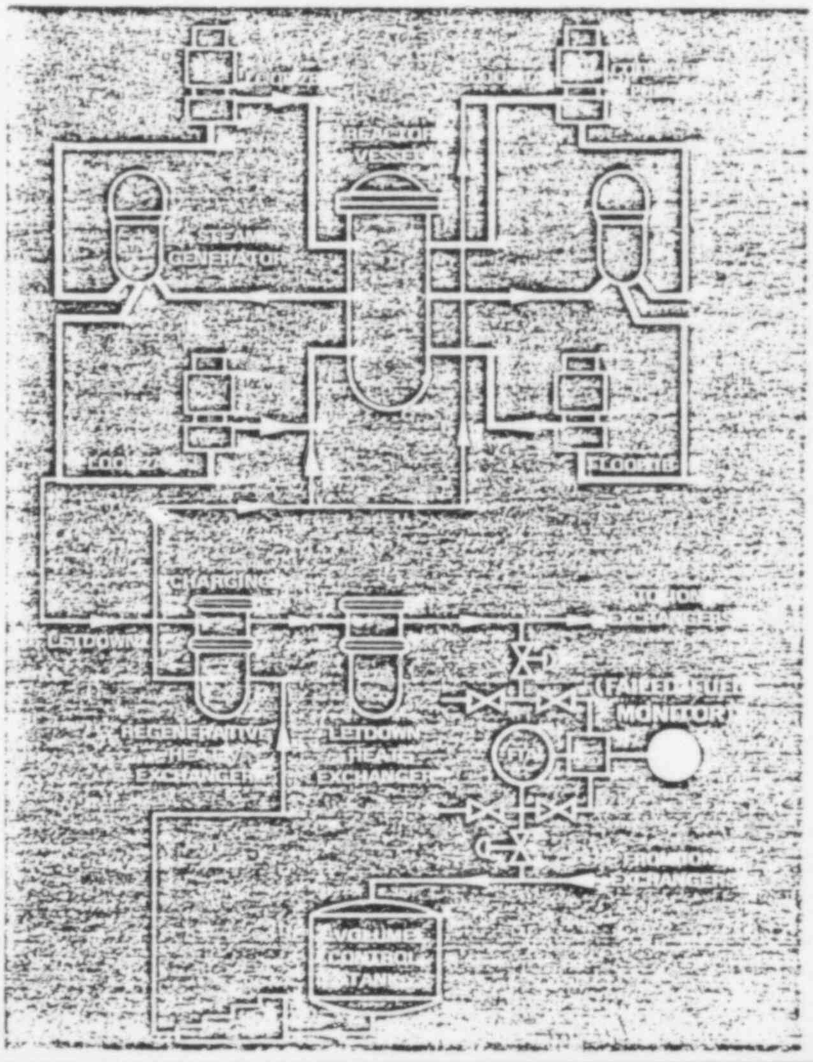
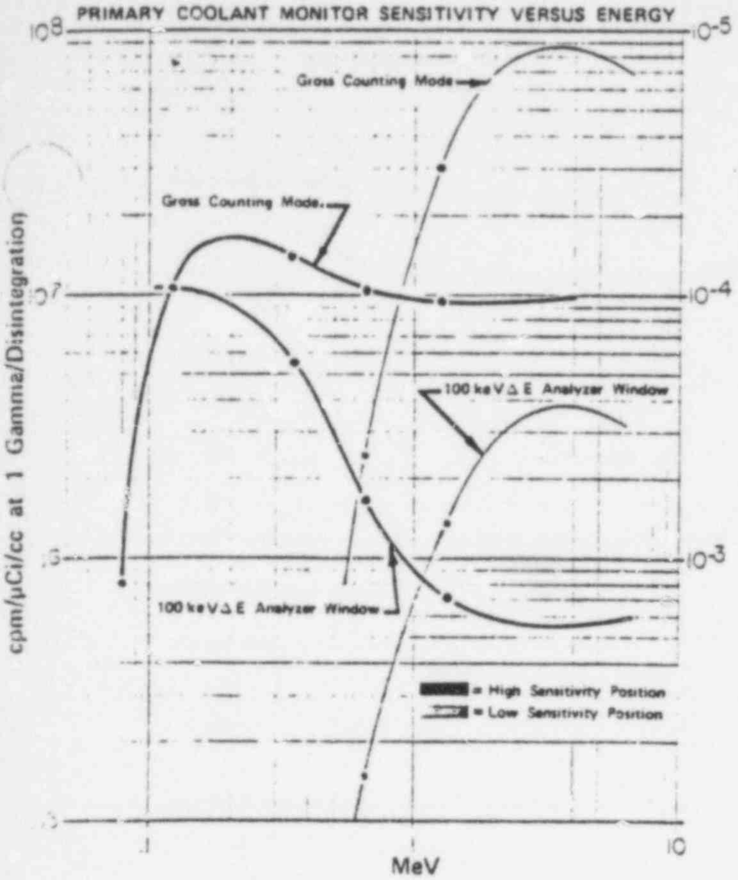


Model 841-P Sampler With Model 843-30 Detector In Place

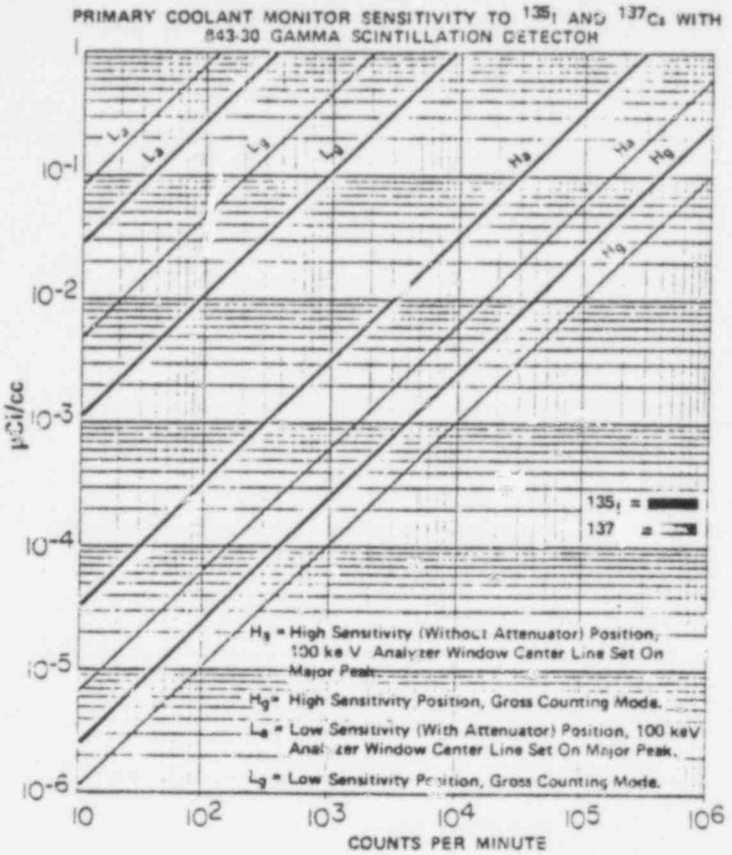
Process Radiation Monitor Installation



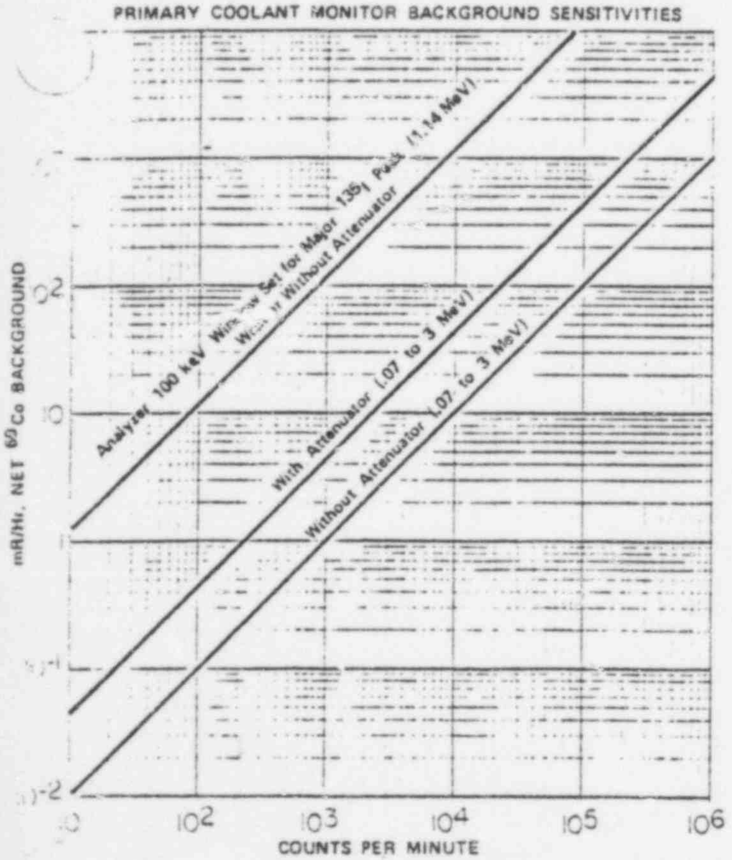
PRIMARY COOLANT MONITOR SENSITIVITY VERSUS ENERGY



PRIMARY COOLANT MONITOR SENSITIVITY TO ^{135}I AND ^{137}Cs WITH 843-30 GAMMA SCINTILLATION DETECTOR



PRIMARY COOLANT MONITOR BACKGROUND SENSITIVITIES



MODEL 840-4P PRIMARY COOLANT MONITOR EFFLUENT AND BACKGROUND SENSITIVITIES

MEASUREMENT PARAMETERS		cpm/µCi/cc ^{135}I	cpm/µCi/cc ^{137}Cs	cpm at 5mR/Hr NET ^{60}Co BACKGROUND*
WITHOUT ATTENUATOR	GROSS	3.6×10^6	9.05×10^6	4782
	ANALYZER WITH 100 keV WINDOW	3×10^5	1.45×10^6	~ 40
WITH ATTENUATOR	GROSS	8.7×10^3	2.11×10^3	1061
	ANALYZER WITH 100 keV WINDOW	3.6×10^2	1.28×10^2	~ 40

*ANALYZER WINDOW CENTER LINE SET AT ^{135}I PEAK (1.14 MeV)

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AREA MONITOR
845

- ☐ Seismic Tested and Proven Rugged
- ☐ Individual Power Supplies Allow Independent Operation of Every Channel
- ☐ Eight Decade Display Plus Choice of Any Three Consecutive Decades From 0.1 to 10^7 mR/hr
- ☐ Completely Interchangeable Detectors and Readouts
- ☐ Selection of Range After Installation
- ☐ Fixed Fast Response On All Ranges

MONITORING SYSTEMS

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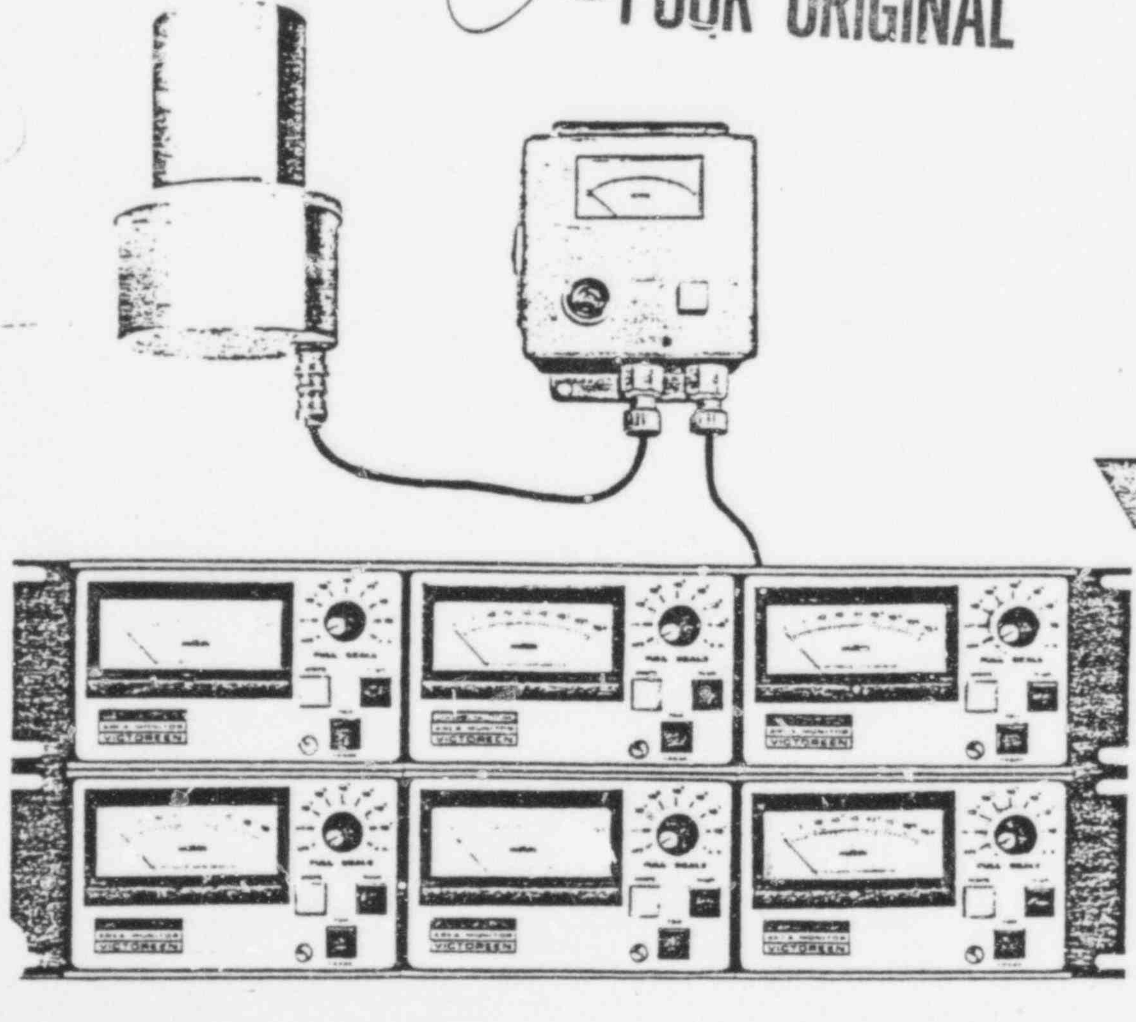

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APPLICATION

Area monitoring systems detect and measure ambient gamma or X-ray radiation. The VICTOREEN 845 Area Monitoring System achieves this in and around nuclear reactors, accelerators, hot cells, irradiators and other facilities where radiation emitting materials are handled or processed. The Code of Federal Regulations determines limits on radiation exposure. Part of Title 10 of the CFR specifically states that persons having in their possession fissionable materials must have an operating criticality alarm system. The VICTOREEN 845 Area Monitor provides these necessary criticality alarm capabilities.

Typically, an area monitoring system will utilize a detector in any location where personnel might possibly be exposed to an adverse amount of radiation. For reactor facilities, these areas consist of the following: inside and outside the containment, fuel storage and handling areas, reactor beam ports, hold-up tanks, coolant loops, normal working areas such as labs, hallways and control rooms.

Monitoring of pulsed beams and residual radiation is required around accelerator and irradiator facilities which means that the detector must respond properly to both pulsed and steady state radiation. The critical design parameters necessary for a detector to achieve this dual capability have been thoroughly considered in the 845 Area Monitor. Additional areas needing area monitoring are beam switching yards, target and control areas.

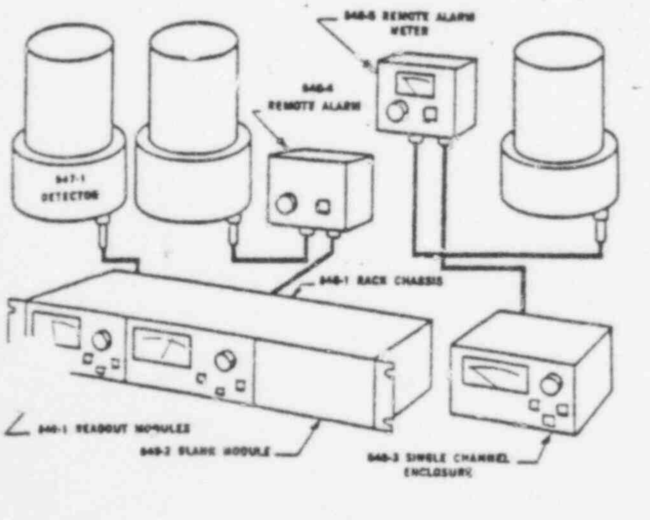
Radiochemistry labs should have at least one detector in each room of normal size and several strategically located in larger open areas. The readout console itself including the alarm set controls should be located in areas under supervisory control. In addition to issuing a warning of increasing and high radiation levels, the alarm trips can be used to actuate interlock devices or other safety features.

SYSTEM DESCRIPTION

The 845 Area Monitoring System consists of only two essential parts; the 846-1 Readout Module and 847-1 Detector.

The detector collects charge caused by incident radiation. This charge is then conditioned and transmitted via multi-conductor cable and displayed on the readout module meter. The meter has a dual scale. The upper scale covers an eight decade range of 0.1 to 10^7 mR/hr and the lower scale can indicate any three consecutive decades within the eight decade span. The choice of range to be displayed on the meter is selected or changed by rotating the switch to ALL for the full 8 decade display or to any position marked 10^2 to 10^7 for a 3 decade display with a full scale reading corresponding to the number selected. Recorder output continues to track eight full decades.

Two checking systems are provided to test the integrity of the overall system; one continuously and one on command. The continuous failure indicator will actuate if either ion chamber loses its collecting or supply voltage, or in case of a line failure. The on command checking system consists of a very small unlicensed isotopic source which pivots into place to direct ionizing radiation into the ion chambers, when the rotary switch on the readout module is in the C.S. position. This causes an up-scale reading verifying system integrity.



In addition to the failure alarm, an alert alarm to warn of increasing radiation and a high radiation or scram alarm are also included. Both the alert and high alarms are non-contacting and are adjustable. Each channel of a system has its own individual power supply.

The 846-1 readout module features printed circuit boards, meter readout, independent power supplies, and two adjustable non-contacting alarm trips. The compact module design allows for six channels of area monitoring in the space usually occupied by five channels while providing a wide 3½-inch meter. All alarm adustments are located behind the front panel to prevent tampering or accidental changing of alarm settings. The independent power supplies for each channel eliminate the possibility of losing other channels of monitoring due to a single power supply failure.

Eight full decade display or a choice of any three consecutive decades from 100 mR/hr full scale to 10^7 mR/hr full scale are switch selectable on the front panel. This feature is advantageous because it is no longer necessary to know the intensity levels at which the detector will be utilized. Thus, the range can be set or changed after installation without the need of buying new detectors or readout modules.

The 847-1 detector utilizes coaxial type ionization chambers, air filled to one atmosphere pressure, which eliminates the problem of detector malfunction due to leakage as experienced by gas filled or pressurized chambers. Unique VICTOREEN design, using all solid state circuitry, eliminates drift causing electrometer tubes. The rugged weatherproof detector housing comes equipped with extruded mounting brackets for easy installation.

Certified test data has shown that 845 Area Monitoring Systems will continue to operate with a seismic load of 1 G in the horizontal and vertical direction over the frequency range of 1 — 30 Hz.

THEORY OF OPERATION

The VICTOREEN 845 Area Monitoring System measures ion chamber currents by averaging or integrating them over a constant recycling time interval. It therefore operates on the principle of a recharging pulse, but instead of measuring pulse repetition rates of constant magnitude pulses, pulse magnitudes of constant repetition rates are measured. This is accomplished by means of a high impedance switch located between the chamber electrode and the preamplifier which closes three times per second for three milliseconds. During the open switch interval, ionization current charges the chamber capacitance. Upon switch closure this charge is almost instantaneously transferred to a capacitor connected in a feedback configuration with the preamplifier. The resultant pulse at the output of the preamplifier is a peak magnitude which is directly proportional to the ionization current. Thus by definition a measure of the pulse magnitude is also a measure of radiation intensity.

The pulses from the charge sensitive amplifier are gated and then amplified by cascaded pulse amplifiers which in turn, have clipped outputs.

These pulses are then summed as current pulses by a summing amplifier the output of which is a composite pulse whose peak value is related to the radiation intensity in a discontinuous-linear manner. A peak reading voltmeter reads out the radiation intensity independently for each pulse at 1 volt per decade with linear variation between decades. In addition, bias voltages have been incorporated into the meter reading system so that any three decades within the dynamic range can be presented on the lower scale.

ACCESSORIES

The 848-4 is a visual and audible alarm which can be mounted adjacent to the detector (847-1) or in any other convenient location. The 848-5 remote meter is basically the same as the 848-4 alarm but also provides a 3½-inch wide scale, 8 decade display of the radiation level. The 848-3 is a rugged, attractive enclosure in which to house the readout module when single channels are used. The enclosure can be used as a bench top unit or shelf mounted. The 848-1 chassis provides a convenient means for installing three 846-1 readout modules in a standard 19-inch relay rack. The 848-2 blank plug-in panel is used when less than three channels of readout are required.

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MODEL 848-8, FIELD CALIBRATION KIT

The 848-8 Field Calibration Kit provides a quick means of checking the calibration of the VICTOREEN 845 Area Monitoring System.

The 100 mc, ^{137}Cs source is encapsulated in welded stainless steel and secured inside a rotating shield. It has low and high range positions. The low range provides an incident flux field of about 500 mR/hr. while the high range provides about 5000 mR/hr.

Because of the short (less than one second) time constant of the 845 Area Monitoring System, a few seconds of source exposure are all that is needed to check calibration, and adjust if necessary.

A copy of your AEC license will be required before shipment.

Features . . .

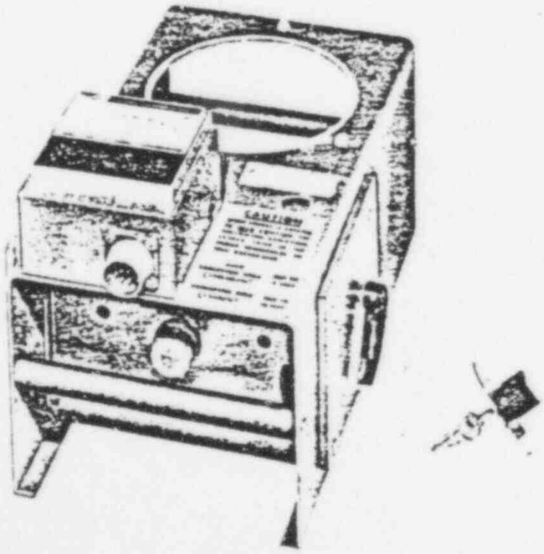
- **Precise, Accurate Calibrations.**
- **Safe, Quick Means of Checking System Integrity.**
- **High and Low Range Positions.**
- **Encapsulated ^{137}Cs Source and Highly Reproducible Geometry.**

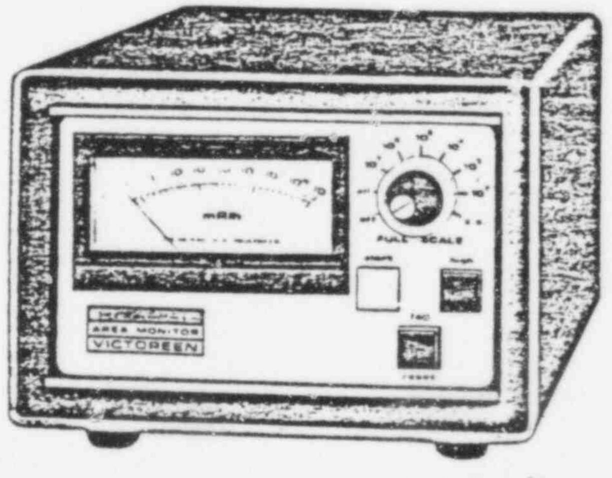
Specifications . . .

Source Activity: 100 mc, ^{137}Cesium.

Dimensions: 6⅝" high, 13¼" long, 8⅞" wide (16.8 cm, 33.6 cm, 22.5 cm) including mounting bracket.

Net Weight: 24 pounds (11 Kg).





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Single Channel Area Monitor

SPECIFICATIONS

DETECTOR 847

Radiation Detected: Gamma.

Type: Coaxial ionization chambers.

Fill: Air filled at atmospheric pressure.

Range: From 0.1 mR/hr to 10^7 mR/hr.

Energy Dependence: ±15% 80 Kev to 3 Mev.

Directional Dependence: Less than 10% from any direction, Co-60.

Circuitry: All solid state.

Temperature Limits: —20°C to 60°C (—4°F to 140°F).

Pressure Limits: 15 psig (special housings available for high pressure requirements).

Humidity Limits: 0 to 95% (weatherproof).

Electronic Exposure Life: 10^8R or 10 hours at full-scale.

Remote Capability: 500 ft. (approximately 150 meters). Up to 1000 ft. with optional cable (special).

Connector: AN 3102-18-1P.

Dimensions: 7¾ in. diameter, 11¾ in. high (19.7 cm, 29.9 cm).

Weight: 5 pounds (2.27 Kg).

READOUT MODULE 846-1

Meter: 3½ in. (8.90 cm) wide. Three (3) and eight (8) decade arcs.

Alarms: Failure/Reset: Green push-button light which remains "ON" while system is in normal operation and goes "OUT" if high voltage, signal or line voltage fails. Depress to reset ALERT and HIGH alarms. Fail alarm automatically resets when malfunction is corrected. Dustproof plug-in SPDT relay rated at 5 amperes, 115 volts is provided for operating external alarm.

Alert: Amber push-button light that goes "ON" when radiation exceeds preset level. The level is adjustable. Depressing the light causes meter needle to indicate where the alarm level is set. Alarm adjust is a 15-turn potentiometer located behind the front panel requiring partial withdrawal of the module to change the setting. Dustproof plug-in SPDT relay rated at 5 amperes, 115 volts is provided for operating external alarm.

High: Red push-button light that goes "ON" when radiation exceeds preset level. The level is adjustable. Depressing the light causes meter needle to indicate where the alarm level is set. Alarm adjust is a 15-turn potentiometer located behind the front panel requiring partial withdrawal of the module to change the setting. Dustproof plug-in SPDT relay rated at 5 amperes, 115 volts is provided for operating external alarm.

Sampling Rate: Ion chamber pulses are sampled every 0.3 seconds for 0.003 second.

Meter Response Time: 3 — 15 seconds depending upon signal level being read.

Recorder Output: 0 to 10 mV, ±0.14 mV. Optional outputs available upon request.

Computer Output: 0 to 50 mV, ±0.68 mV. Optional outputs available upon request.

Connectors: Terminal strip on rear apron for easy field hookup of detector cable, recorder, computer, external alarms and follow meters.

Power Supply: 14.0 volts, ±0.1%.

Input Power: 120/240 volts a.c., ±15%, 47 to 65 Hz.

Accuracy: ±10% of decade.

Circuitry: All solid state.

Dimensions: 3½ in. high, 5⅝ in. wide, 9 in. deep (8.90 cm, 14.4 cm, 22.9 cm).

Weight: 3 pounds (1.36 Kg).

REMOTE ALARM 848-4

Visual Alarm: Red light 1 in. square, ½ in. thick (2.54 cm, 1.27 cm).

Audible Alarm: Loud buzzer activates with alarm light.

Logic: Same as the "High Alarm" on the readout module.

Temperature Limits: —20°C to 60°C (—4°F to 140°F).

Pressure Limits: 15 psig.

Humidity Limits: 0 to 100% (weatherproof).

Mounting: Heavy duty industrial junction box with flanges for wall mounting.

Dimensions: 7 in. high, 7 in. wide, 4 in. deep (17.8 cm, 17.8 cm, 10.2 cm).

Weight: 4.65 pounds (2.11 Kg).

REMOTE ALARM METER 848-5

Visual Alarm: Red light, 1 in. square, ½ in. thick (2.54 cm, 1.27 cm).

Audible Alarm: Loud buzzer activates with alarm light.

Logic: Same as the "High Alarm" on the readout module.

Meter: 3½ in. wide with 8 decade display (8.90 cm).

Temperature Limits: —20°C to 60°C (—4°F to 140°F).

Pressure Limits: 15 psig.

Humidity Limits: 0 to 100% (weatherproof).

Mounting: Heavy duty industrial junction box with flanges for wall mounting.

Dimensions: 7 in. high, 7 in. wide, 4 in. deep (17.8 cm, 17.8 cm, 10.2 cm).

Weight: 5 pounds (2.27 Kg).

SINGLE CHANNEL
READOUT ENCLOSURE 848-3

Application: Single channel area monitoring readout module.

Construction: Wrap-around, welded steel case, with channel guide for module insertion.

Mounting: Rubber pads for bench or shelf mounting.

Dimensions: 4½ in. high, 6½ in. wide, 10¾ in. deep (11.4 cm, 16.5 cm, 27.4 cm).

Weight: 5½ pounds (2.49 Kg).

RACK CHASSIS 848-1

Application: Multi-channel area monitoring readout modules.

Construction: Sheet steel welded to angle steel brackets, with plastic guides for insertion of three readout modules.

Mounting: Drilled to fit in standard 19 in. relay rack (48.3 cm).

Dimensions: 3½ in. high, 19 in. wide, 11 in. deep (8.9 cm, 48.3 cm, 28.0 cm).

Weight: 7½ pounds (3.4 Kg).

BLANK READOUT MODULE PANEL 848-2

Application: Fill in black space(s) of the rack chassis.

Construction: Extruded aluminum frame with brushed aluminum finish.

Mounting: Simply slides into the rack chassis.

Dimensions: 3½ in. high, 5⅝ in. wide (8.90 cm, 14.4 cm).

Weight: ½ pound (0.23 Kg).

DETECTOR CABLE 848-7

Type: 6 Conductor, shielded; Outer insulation waterproof.

Outside Diameter: 0.35 in. (0.9 cm).

Temperature Limits: —40°C to 70°C (—40°F to 158°F).

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Phone: [216] 795-8200 • TWX [810] 421-8287

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AREA MONITOR
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- ☐ Seismic Tested and Proven Rugged
- ☐ Individual Power Supplies Allow Independent Operation of Every Channel
- ☐ Five Decades of True Log Readout
- ☐ Simple, Economic and Reliable Operation
- ☐ Interchangeable Detectors and Readouts

MONITORING SYSTEMS

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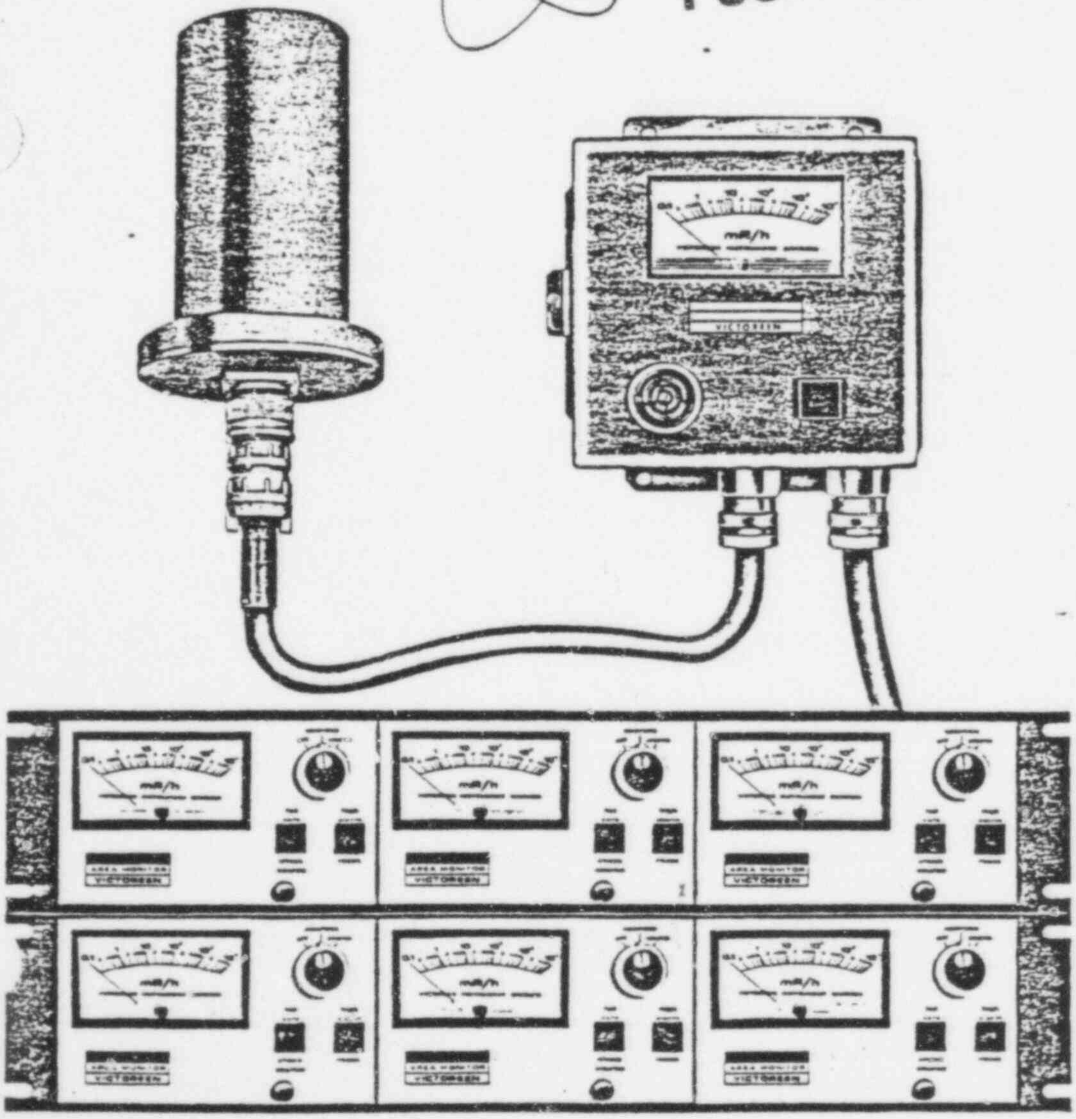

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Typically, an area monitoring system will utilize a detector in any location where personnel might possibly be exposed to an adverse amount of radiation. For reactor facilities, these areas consist of the following; inside and outside the containment, fuel storage and handling areas, reactor beam ports, hold-up tanks, coolant loops, normal working areas such as labs, hallways and control rooms.

Monitoring of residual radiation is required around accelerator and irradiator facilities. Additional areas needing area monitoring are beam switching yards, target and control areas.

Radiochemistry labs should have at least one detector in each room of normal size and several strategically located in larger open areas. The readout console, including the alarm set controls, should be located in areas under supervisory control. In addition to issuing a warning of high radiation levels, the alarm trip can be used to actuate interlock devices or other safety options.

SYSTEM DESCRIPTION

The 855 Area Monitoring System consists of two essential parts, the Readout Module and the Detector. The detector converts the incident gamma radiation into an electrical signal which is transmitted to the readout module with a multi-conductor cable. Two ranges are available 0.01 mR/hr to 10^3 mR/hr or 0.1 mR/hr to 10^4 mR/hr. Two checking systems are provided to test the integrity of the system; one continuous and one on-command.

A continuously lit green light on the front panel indicates the system is ON and will go out upon signal or power failure. The On-Command checking system consists of a minute amount of radioactivity that pivots into position impinging radiation onto the sensing element when the green light is depressed. This causes an upscale reading verifying system integrity.

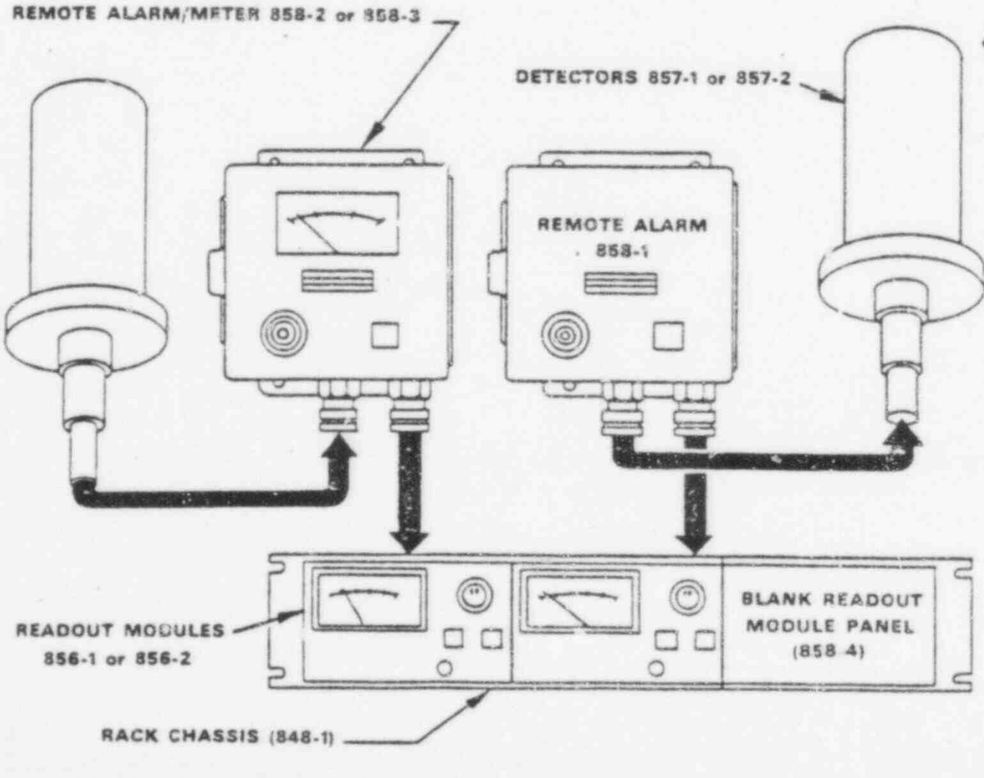
In addition to the failsafe alarm light, a red high radiation alarm light is included on the front panel.

This is a non-contacting adustable alarm. Rotating the front panel knob to the "Alarm Point" position causes the meter to indicate where the alarm point is set. Adustment of the alarm set point is accomplished by partially withdrawing the module from its housing and turning a 15-turn potentiometer. In addition to the red high alarm light indication on the front panel, outputs from a relay are located on the rear of the chassis to operate external alarms.

Each channel (detector/readout combination) has its own independent power supply eliminating possibility of losing many channels of instrumentation with the failure of one power supply.

The compact modular solid state design permits mounting three readout modules in a 19-inch wide relay rack chassis only 3½ inches high. The rugged weather-proof detector comes equipped with a mounting bracket for easy installation.

Certified test data has shown that 855 Area Monitoring Systems will continue to operate with a seismic load of 1 G in the horizontal and vertical direction over frequency range of 1 — 30 Hz.



THEORY OF OPERATION

VICTOREEN 855 Area Monitoring Systems consist essentially of a halogen quenched G-M tube whose pulses drive a multiple pump ratemeter circuit. The output from the pump circuit is a true log d.c. signal directly related to the radiation intensity.

The G-M tube is shielded with appropriate filter material to provide the necessary Energy Correction for conversation of cpm to Roentgen/hr.

A built-in anti-saturation circuit prevents the system readings from falling off full scale during over-range conditions.

Natural background and check source contribution holds the system in the non-failure condition. If for any reason, the system stops responding to radiation, a failure condition will be indicated on the readout module.

ACCESSORIES

The 858-1 Remote Alarm is a visual and audible alarm which can be mounted adjacent to the detector or any other convenient location. The 858-2 or 858-3 Remote Alarm/Meter is basically the same as the 858-1 Remote Alarm but also provides a 3½ inch wide meter scale, five decade visual display of the radiation level. The 848-3 Readout Enclosure provides a rugged, attractive enclosure in which to house the readout module when single channels are used. The enclosure can be used as a bench top unit or shelf mounted. The 848-1 chassis provides a convenient means for installing three readout modules in a standard 19-inch relay rack. The 858-4 blank plug-in panel is used when less than three channels of readout are required.

MODEL 858-5 FIELD CALIBRATION KIT

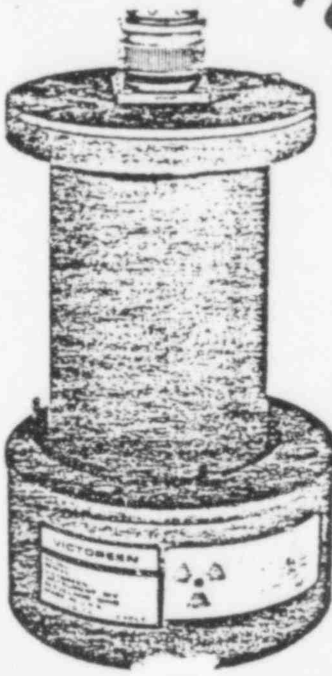
POOR ORIGINAL

The 858-5 Field Calibration Kit provides a quick means of checking the calibration of the VICTOREEN Model 855 Area Monitoring System.

A sealed radiation source, in conjunction with reproducible geometry, assures constant, accurate results.

The 0.1 mg Radium Source is encapsulated in a Platinum-Irridium capsule and secured inside a steel tube surrounded by a lead shield.

Radiation level one foot from any surface of the unit is less than 1 mR/hr.



Features . . .

Precise, Accurate Calibrations

Safe, Quick Means of Checking System Integrity

Encapsulated ^{226}Ra Source and Highly Reproducible Geometry

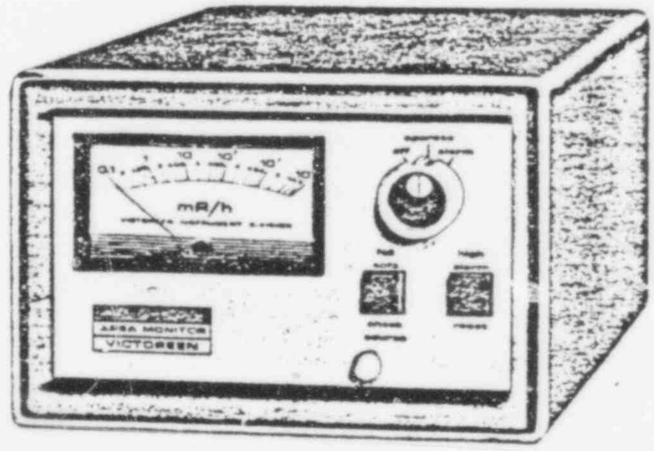
Scale Reading Approximately 30 mR/hr

Individual Calibration supplied with Each Calibrator

Specifications . . .

Source Activity: 0.1 mg Radium in a Platinum-Irridium Capsule.
Dimensions: 4¾" diameter x 2⅜" high.(12.1 cm, 6.04 cm).
Net Weight: 7½ lbs. (3.4 Kg.)
Phenolic Liner for precise positioning of detector.

An A.E.C. license is not required. However, purchasers in agreement states may be subject to licensing or registration requirements.



Single Channel Area Monitor 749041

SPECIFICATIONS

DETECTORS 857-1 or 857-2

Type: G-M tube.

Fill: Argon, halogen quenched.

Range: Model 857-1 Detector: 0.01 to 10^3 mR/hr. Model 857-2 Detector: 0.1 to 10^4 mR/hr.

Energy Dependence: ±15% from 100 Kev to 1.5 Mev.

Radiation Detected: Gamma.

Temperature Limits: —20°F to 140°F (—29°C to 60°C).

Pressure Limits: 30 psig.

Humidity Limits: 0 to 100%.

Connector: AN3102-18-1P.

Detector Element Life: Exceeds 1000 hours at full-scale or over.

Electronic Exposure Life: Approximately 10^8 Rads.

Dimensions: 3" diameter, 7⅛" high (7.63 cm, 18.1 cm).

Weight: Approximately 1 pound (0.45 Kg).

Mounting: Wall bracket.

Remote Capability: Up to 1000 feet.

READOUT MODULES 856-1 or 356-2

Meter Scale Size: 3½" (8.90 cm) taut band.

Alarms:

Fail Alarm; A green pushbutton light is provided on the front panel. This light is ON during operation and goes out if the signal or power fails. This circuit automatically resets when a malfunction is corrected. Depressing this pushbutton will activate the check source in the detector causing an upscale reading proving the channel integrity. The pushbutton is spring loaded and will return the channel to normal operation when released.

High Alarm; A red pushbutton light is provided on the front panel. This light will go ON when the radiation exceeds the preset level. Depressing this spring loaded button will reset the alarm when the radiation has subsided below the preset level. The alarm will not reset while the radiation level is above the alarm set point.

The High Alarm level trip point is adjusted by means of a 15-turn potentiometer, located on the printed circuit board.

Controls:

Rotary Function Switch; "OFF" position shuts off all power to the channel. "OPERATE" position puts channel into normal operation. In "ALARM POINT" position meter needle indicates where the alarm point is set. The alarm circuit is isolated to prevent the alarm from actuating and to prevent a recorder/computer from tracking the alarm point when switch is held in the "Alarm Point" position. This switch is spring loaded to return to the "OPERATE" position when released.

External Alarm Contacts; High and fail; 5 amperes, 120 volts; SPDT.

Recorder Output: 0 to 10 mv. Spans five decades (isolated from computer output).

Computer Output: 0 to 50 mv (isolated).

Connector: Terminal strip for hookup of detector cable, recorder, computer, external alarms and follow meters on back of printed circuit boards. Accessible from front with unit withdrawn from rack.

Temperature Limits: 32°F to 120°F (0°C to 49°C).

Humidity Limits: 0-95%.

Input Power Requirement: 117/234 volts ±15%, 50/60 Hz.

Power Supplied: +600 volts regulated, +22 volts unregulated, +10 volts regulated, —6.8 volts regulated.

Auxiliary Power: 15 to 18 volts d.c. battery (standby), 300 ma maximum.

Meter Response: (Approx.) 2.5 sec. for full-scale deflection.

Time Constant: 60, 6, .6 sec. @ .01, .1, 1 mR/hr respectively.

Dimensions: 5⅝" wide, 3½" high, 11⅛" deep (14.4 cm, 8.90 cm, 28.3 cm).

Weight: Approximately 3 pounds (1.36 Kg).

REMOTE ALARM 858-1

Visual Alarm: Red light, 1" square, ½" thick (2.54 cm, 1.27 cm).

Audible Alarm: Loud buzzer activates with alarm light.

Logic: Same as the "High Alarm" on the Readout Module.

Temperature Limits: —20°F to 140°F (—29°C to 60°C).

Humidity Limits: 0 to 95% (weatherproof).

Mounting: Heavy duty industrial junction box with flanges for wall mounting.

Dimensions: 7" high, 7" wide, 4" deep (17.8 cm, 17.8 cm, 10.2 cm).

Weight: 4¾ pounds (2.15 Kg).

REMOTE ALARM/METER 858-2 or 858-3

Range: Model 858-2; 0.01 to 10^3 mR/hr. Model 858-3; 0.1 to 10^4 mR/hr.

Visual Alarm: Same as Remote Alarm above.

Audible Alarm: Same as Remote Alarm above.

Logic: Same as Remote Alarm above.

Temperature Limits: Same as Remote Alarm above.

Humidity Limits: Same as Remote Alarm above.

Mounting: Same as Remote Alarm above.

Dimensions: Same as Remote Alarm above.

Weight: 5 pounds (2.26 Kg).

Meter: 3½" wide with 5 decade display (8.90 cm). Remote Alarm/Meter tracks readout module meter within ±2% of fullscale.

SINGLE CHANNEL

Application: Single Channel Area Monitoring Readout Module.

Construction: Wrap-around, welded steel case, with channel guide for module insertion.

Mounting: Rubber pads for bench or shelf mounting.

Dimensions: 4½" high, 6½" wide, 12" deep (11.4 cm, 16.5 cm, 30.4 cm).

Weight: 5¾ pounds (2.60 Kg).

RACK CHASSIS (848-1)

Application: Multi-channel Area Monitoring Readout Modules.

Construction: Sheet steel welded to angle steel brackets, with plastic guides for insertion of three readout modules.

Mounting: Designed to fit in standard 19 inch relay rack.

Dimensions: 3½" high, 19" wide, 11⅛" deep (8.90 cm, 48.3 cm, 28.3 cm).

Weight: 7¾ pounds (3.50 Kg).

BLANK READOUT MODULE PANEL (858-4)

Application: Fill in blank space(s) of the rack chassis.

Construction: Aluminum frame with black finish.

Mounting: Simply slides into the rack chassis.

Dimensions: 3½" high, 5⅝" wide (8.90 cm, 14.4 cm).

Weight: ½ pound (0.23 Kg).

DETECTOR CABLE (848-6)

Type: [illegible]ti-conductor; outer insulation waterproof.

Outside Diameter: ½" nominal (1.27 cm).

Temperature Limits: —40°F to 158°F (—40°C to 70°C).

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VICTOREEN

[illegible]

Litho in U.S.A.

POOR ORIGINAL

MODEL 841-1 CONTINUOUS FILTER AIR SAMPLER

Filter Tape: 3 in. wide by 960 in. long (7.62 cm, 2440 cm), H-V 70, gauze back is recommended.

Filter Movement:

Continuous Mode: 1 in./hr. with fast advance to clear filtering operation of used filter in less than 30 seconds.

Step-Advance Mode: Counting time on fixed position variable up to 24 hours. Automatic filter advance speed is 7½ in./min.

Drive Mechanism: Motorless, solenoid operated capstan.

Shielding: 2 in. (5.10 cm) lead around sensitive end of the detector.

Sampling Area: 3 in.^{2} (19.4 cm^2).

Capstan: 7⅝ in. (19.4 cm) diameter for flat detector face.

Inlet Connection: 1 in. (2.54 cm) O.D. tubing.

Outlet Connection: 1 in. (2.54 cm) O.D. tubing.

Dimensions: 7⅝ in. high, 11 in. wide, 17 in. deep (19.4 cm, 28.0 cm, 43.2 cm).

Weight: Approximately 110 pounds (50 Kg).

MODEL 841-2 FIXED FILTER/ IODINE SAMPLER

Filter:

Particulate: 2 in. diameter disc (5.10 cm).

Iodine: 2 in. diameter, ¾ in. thick charcoal cartridge (5.10 cm, 1.91 cm).

Shielding: 2 in lead (5.10 cm). (4 π Pb shielding available upon request).

Inlet Connection: 1 in. (2.54 cm) O.D. tubing.

Outlet Connection: 1 in. (2.54 cm) O.D. tubing.

Dimensions: 8 in. high, 8 in. wide, 15 in. deep, (20.3 cm, 20.3 cm, 38.1 cm).

Weight: Approximately 150 pounds (68.0 Kg).

MODEL 841-3 OFF-LINE EFFLUENT SAMPLER

Sensitive Volume: 191 cu. in. (3130 cc) with well installed. 215 cu. in. (3520 cc) with 843-5 detector installed.

Shielding: 3 in. lead (7.62 cm).

Inlet Connection: 1 in. (2.54 cm) O.D. tubing.

Outlet Connection: 1 in. (2.54 cm) O.D. tubing.

Sampler Liner: Stainless Steel, removable for easy decontamination. Designed to accept 843-30 Gamma Scintillation Detector. Detector Well is not installed when 843-5 Thin Wall Beta-Gamma Detector is used.

Internal Walls: Stainless steel.

Pressure Limits: 150 psig with well installed. 15 psig with 843-5 detector installed.

Dimensions: 14¾ in. high, 15 in. wide, 25½ in. deep (37.5 cm, 38.1 cm, 63.5 cm).

Weight: 555 pounds (252) Kg.

MODEL 841-4 IN-LINE EFFLUENT SAMPLER

Sensitive Volume: 218 cu. in. (3570 cc).

Shielding: 2 in lead (5.10 cm).

Mounting: Fits between standard 4 in. (10.2 cm) pipe flanges. Adapters available for other pipe sizes.

Detector Well: Stainless steel, removable for easy decontamination. Designed to accept 843-30 Gamma Scintillation Detector.

Internal Wall: Stainless steel.

Pressure Limit: 150 psig.

Dimensions: 22¼ in. high, 10¾ in. wide, 19 in. deep (56.7 cm, 27.3 cm, 48.3 cm).

Weight: Approximately 150 pounds (68.0 Kg).

MODEL 844-1 10 CFM PUMPING SYSTEM

Capacity: 10 cfm normal operation at 1325 rpm, 5-10 scfm range.

Type: Features a 1½ HP, 1800 rpm motor, an oil-less/constant displacement/carbon vane vacuum pump with a vacuum relief valve; a by-pass valve and a vacuum switch.

Inlet Connection: ⅞ in. (2.22 cm) O.D. tubing.

Outlet Connection: ⅞ in. (2.22 cm) O.D. tubing.

Motor: 1.5 H.P., 60 Hz, 115V a.c.

Controls: On-Off switch provided on enclosure or remote panel. Flow control valve at the inlet of pumping system.

Dimensions: 15 in. high, 12.5 in. wide, 28 in. deep (38.0 cm, 31.8 cm, 71.1 cm).

Weight: 140 pounds (63.5 Kg).

MODEL 844-2 4 CFM PUMPING SYSTEM

Capacity: 4 cfm maximum at continuous duty.

Type: Features an integral ½ HP, 1725 rpm motor and oil-less/constant displacement/carbon vane vacuum pump with a vacuum relief valve; a by-pass valve and a vacuum switch.

Inlet Connection: ⅞ in. (2.22 cm) O.D. tubing.

Outlet Connection: ⅜ in. NPT.

Motor: 0.5 H.P., 60 Hz, 115V a.c.

Controls: On-Off switch provided on enclosure or remote panel. If remote operation, a motor starter should be specified. Flow control valve at the inlet of pumping system.

Dimensions: 9 in. high, 7.5 in. wide, 18 in. deep (22.8 cm, 19.0 cm, 45.8 cm).

Weight: 50 pounds (22.7 Kg).

MODEL 844-3 CHECK SOURCE

Type: Solenoid operated.

Controls: Pushbutton on the ratemeter.

Source: 137 Cs less than 10 μc (AEC exempt quantity).

MODEL 844-4 ENCLOSURE (SMALL)

Application: Fixed filter system, Iodine system, Continuous filter system or Off-Line Effluent Monitor.

Mounting: Skid mount, standard, casters optional.

Construction: Heavy duty steel platform. Welded cabinet with removable front panel.

Dimensions: 54 in. high, 27½ in. wide, 33 in. deep (137.2 cm, 70 cm, 83.8 cm).

Weight: 325 pounds (147 Kg).

MODEL 844-5 ENCLOSURE (LARGE)

Application: Combination systems.

Mounting: Skid mount, standard, casters optional.

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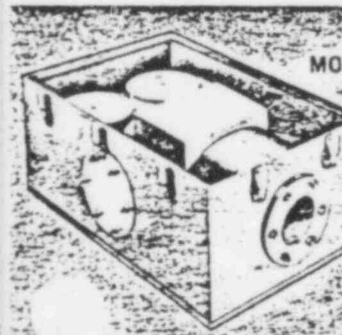
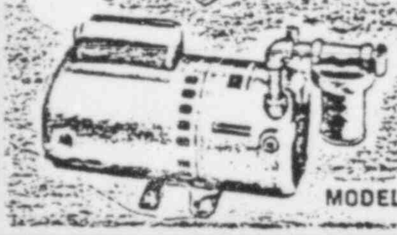
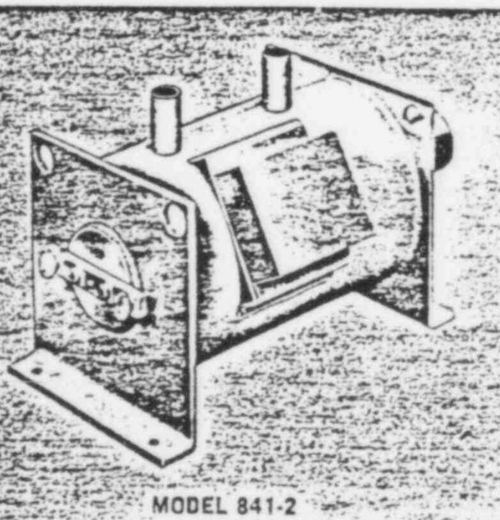


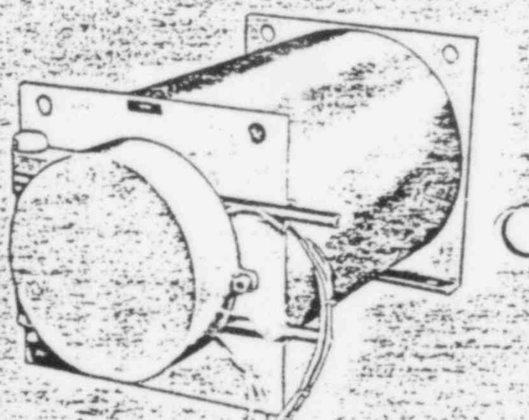
MODEL 841-1



MODEL 844-2

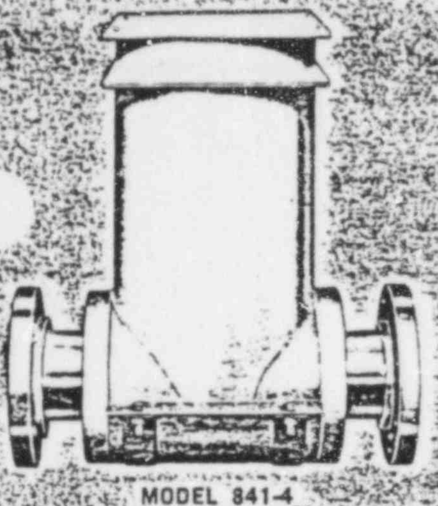


MODEL 841-2
(With 4 π Pb Shielding)

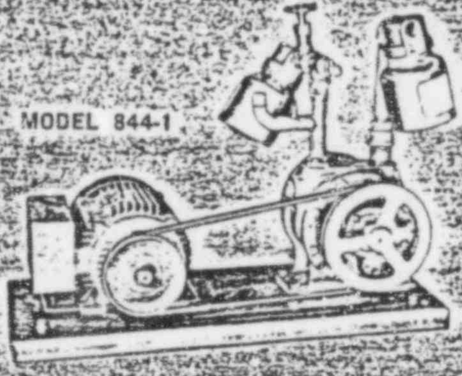


MODEL 841-3
(With 4 π Pb Shielding)

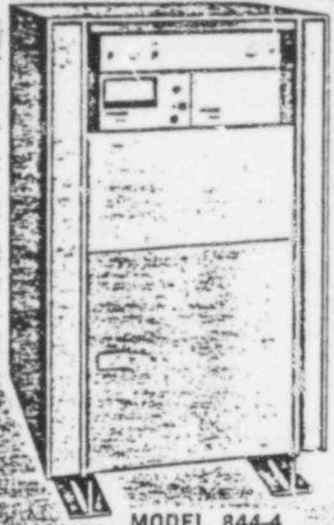
POOR ORIGINAL



MODEL 841-4
(With 4 π Pb Shielding)



MODEL 844-1



MODEL 844-4

Construction: Heavy duty steel platform. Welded cabinet with removable front panel.

Dimensions: 54 in. high, 43 in. wide, 33 in. deep (137.2 cm, 109.7 cm, 83.8 cm).

Weight: 450 pounds (220 Kg).

MODEL 844-6 GAS MONITOR FILTER

Type: Crud filter to prevent large contaminated particles from entering the sampler.

Efficiency: 50% for 5 micron particles.

Inlet Connection: ¾ in. NPT, female.

Outlet Connection: ¾ in. NPT, female.

Dimensions: 5 in. diameter, 12 in. long 12.7 cm, 30.5 cm).

Weight: Approximately 10 pounds (4.55 Kg).

MODEL 844-7 RATEMETER RACK CHASSIS

Application: Mounting the 842-10 thru 842-40 ratemeters in a relay rack. Accommodates two side by side.

Construction: Sheet steel, reinforced with heavy gauge brackets.

Dimensions: 5¼ in. high, 19 in. wide, 13.5 in. deep (13.3 cm, 48.3 cm, 34.4 cm).

Weight: 14 pounds (6.35 Kg).

MODEL 844-8 BLANK RATEMETER PANEL

Application: Filling up the 844-7 rack chassis when only one ratemeter is used.

Dimensions: 5¼ in. high, 8¼ in. wide, 0.5 in. deep (13.3 cm, 21.0 cm, 1.27 cm).

MODEL 841-2-64 FILTER (CONTINUOUS ROLL)

Type: Hollingsworth-Vose 70, gauze backed.

Efficiency: 99% for less than 0.3 micron particles.

Dimensions: 3 in. wide, 80 ft. long (7.65 cm, 2440 cm).

MODEL 841-2-22 FILTER (DISC)

Type: Hollingsworth-Vose 70, gauze backed.

Efficiency: 99% for less than 0.3 micron particles.

Dimensions: 2 in. diameter (5.10 cm).

MODEL 841-2-23 CARTRIDGE (IODINE)

Type: Activated charcoal, Potassium Iodide (KI), impregnated charcoal optionally available for Methol Iodide (CH_3I) detection.

Efficiency: Greater than 95% for field iodine.

Dimensions: 2 in. diameter, ¾ in. thick (5.10 cm, 1.91 cm).

MODEL 844-17 REMOTE ALARM

Type: The 844-17 features audible-visual alarms and the 115V a.c. remote alarm input is obtained through interconnecting with 842 Series Ratemeters.

Visual Alarm: Red light 1 in. square, ½ in. thick (2.54 cm, 1.27 cm).

Audible Alarm: Loud buzzer activates with alarm light.

Logic: Same as the "High Alarm" on the 842-10 or 842-20 Ratemeter.

Temperature Limits: —20°C to 60°C (4°F to 140°F).

Pressure Limits: 15 psig.

Humidity Limits: 0 to 100% (weatherproof).

Mounting: Heavy duty industrial junction box with flanges for wall mounting.

Dimensions: 12¼ in. high, 9¼ in. wide, 5 in. deep (31.1 cm, 23.5 cm, 12.7 cm).

Weight: 10½ pounds (4.76 Kg).

MODEL 844-18 REMOTE ALARM/INDICATOR

Type: 844-18 features audible-visual alarms and the 115V a.c. remote alarm and remote meter inputs are obtained through interconnecting with 842 Series Ratemeters.

Visual Alarm: Red light, 1 in. square, ½ in. thick (2.54 cm, 1.27 cm).

Audible Alarm: Loud buzzer activates with alarm light.

Logic: Same as the "High Alarm" on the 842-10 or 842-20 Ratemeter.

Meter: 3½ in. wide with 8 decade display (8.90 cm).

Temperature Limits: —20°C to 60°C (—4°F to 140°F).

Pressure Limits: 15 psig.

Humidity Limits: 0 to 100% (weatherproof).

Mounting: Heavy duty industrial junction box with flanges for wall mounting.

Dimensions: 12¼ in. high, 9¼ in. wide, 5 in. deep (31.1 cm, 23.5 cm, 12.7 cm).

Weight: Approximately 11 pounds (5 Kg).

MODEL 844-9 CONTROL PANEL

The 844-9 Control Panel has been designed for use with Continuous Air Monitoring Systems and features provisions for control and visual monitoring of the 115 volt, a.c., 60 Hz. input; pumping system control, normal or fixed program selection of filter tape transport mechanism with manual filter tape advance override as well as a filter fault light to indicate end of tape or torn tape; flow fault light to indicate loss of flow, too low or too high flow. The panel is designed to be mounted in standard 19-inch wide rack opening and is 5¼ inches high and 8½ inches wide.

MODEL 844-10 CONTROL PANEL

The 844-10 Control Panel has been designed for use with Fixed Filter Air/Iodine and/or Off-Line Effluent Monitoring Systems and features provisions for control and visual monitoring of the 115 volt, a.c., 60 Hz, input; pumping system control; flow fault light to indicate loss of flow, too low or too high flow. The panel is designed to be mounted in standard 19-inch wide rack opening and is 5¼ inches high by 8½ inches wide.

MODEL 844-14 SINGLE CHANNEL RATEMETER ENCLOSURE

Application. Single channel ratemeter module.

Construction: Wrap-around, welded steel case with channel guide for module insertion.

Mounting: Rubber pads for bench or shelf mounting.

Dimensions: 6¼ in. high, 9½ in. wide, 15 in. deep (15.5 cm, 24.1 cm, 38.1 cm).

Weight: Approximately 10 pounds (4.55 Kg).

749044

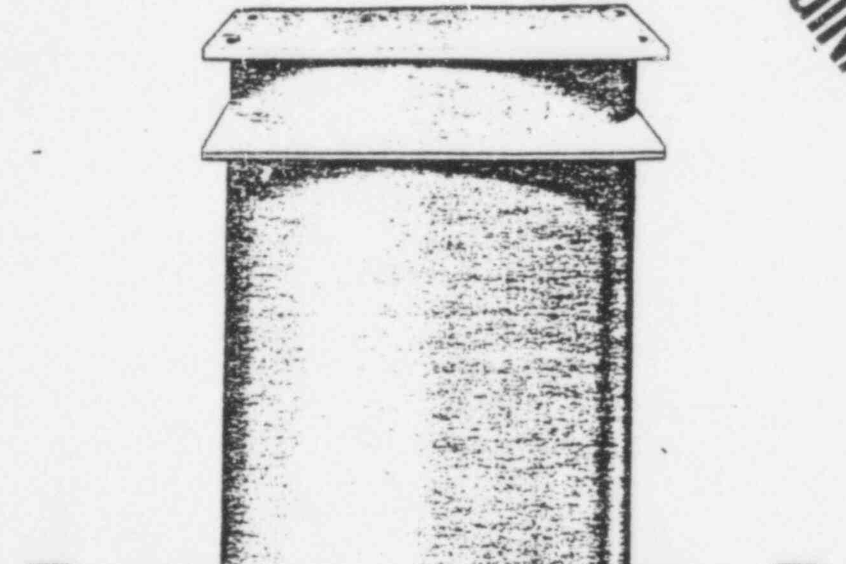
IN-LINE EFFLUENT MONITOR

840-4

- ☐ System Versatility Through Use of Modular Components
- ☐ Removable Detector Well for Easy Gamma Decontamination
- ☐ Dynamic Range to 10^6 CPM in Either Linear or Log Display
- ☐ Ease of Maintenance Through Use of Plug-In Printed Circuit Boards

MONITORING SYSTEMS

POOR ORIGINAL



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APPLICATIONS

The purpose of an In-Line Monitor is essentially the same as that of an Off-Line Monitor, which is to provide sufficient verification that the effluent material passing through a system is within the maximum permissible concentration (mpc) as stated in the Federal Code of Regulations. The Model 840-4 can be used for either liquid or gaseous effluents as long as the temperature and pressure remain within specifications. Non-corrosive material for all wetted surfaces combined with the removable detector well minimizes contamination problems.

Typically, secondary coolant loops, heat exchangers, and laboratory drain lines are monitored with in-line systems such as the Model 840-4. The Code of Federal Regulations requires licensees using radioisotopes to record data on radioactive effluents at the point where control is relinquished. The maximum concentrations that can legally be tolerated are listed in the accompanying table. Although, normally used for gross gamma monitoring, the Model 843-30 Scintillation Detector Assembly can be utilized with either the Model 842-40 or 842-30 Ratemeter/Analyzer for single channel analyzing of specific isotopes.

SYSTEM DESCRIPTION

The In-Line Effluent Monitoring System is the simplest of all VICTOREEN monitoring systèms. The basic parts of a typical system are the 841-4 Sampler, the Model 843-30 Scintillation Detector Assembly and a Model 842-10 Log Ratemeter. The Model 840-4 is designed to fit directly into a 4 inch diameter pipe through the use of standard 4 inch pipe flanges. Adapter flanges are available for coupling the In-Line Effluent Monitor to smaller size pipes. Also included is a solenoid operated check source - (Model 844-3) with which to check system integrity by means of a pushbutton on the ratemeter module. The ratemeter provides high radiation, alert, and failure alarms as standard features. The ratemeter can be remoted to a control console located at any distance desirable from the sampling point.

Certified test data has shown that VICTOREEN Process Monitoring Systems will continue to operate with a seismic load of 1 G in the horizontal and vertical direction over the frequency range 1 — 30 Hz.

POOR ORIGINAL

Sampler
(With 4 π Pb Shielding)

SPECIFICATIONS

Effluent Sample Temperature Limits: Model 843-30 detector; 0°C to 50°C (32°F to 120°F).

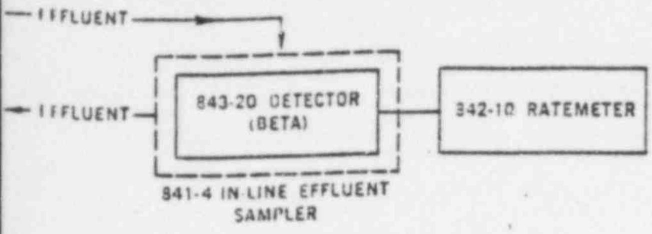
Pressure Limit: 150 psig.

Shielding: 2 in. lead (5.10 cm) standard. Optional 4π Pb shielding available on request.

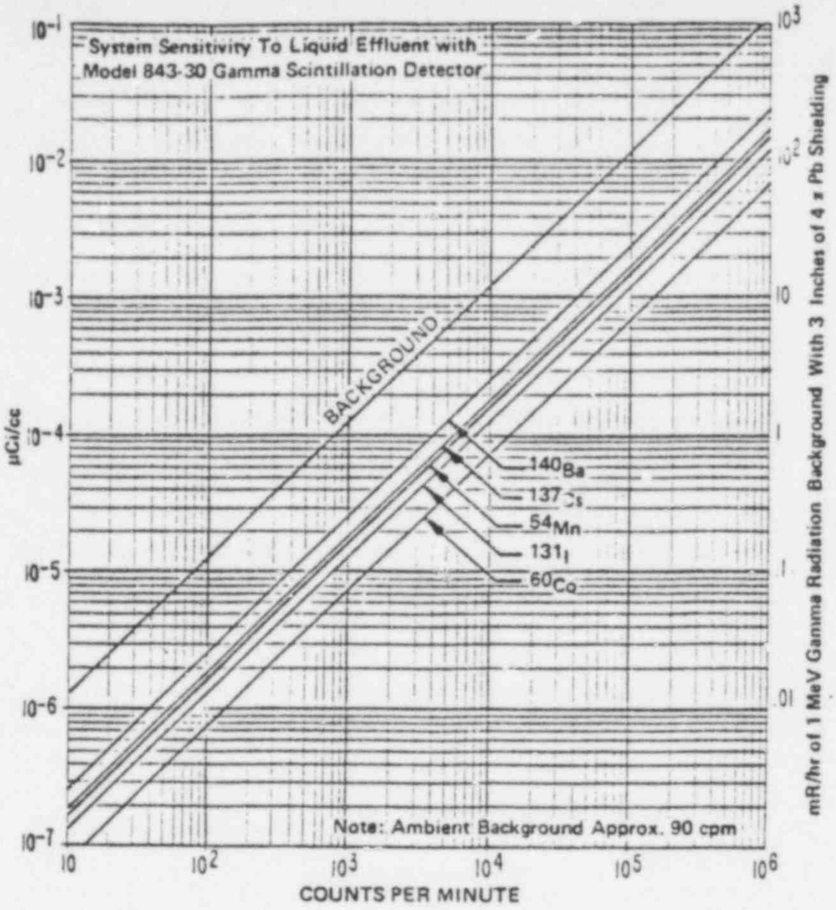
Detector Well: Stainless steel, removable for easy decontamination. Designed to accept 843-30 Gamma Scintillation Detector.

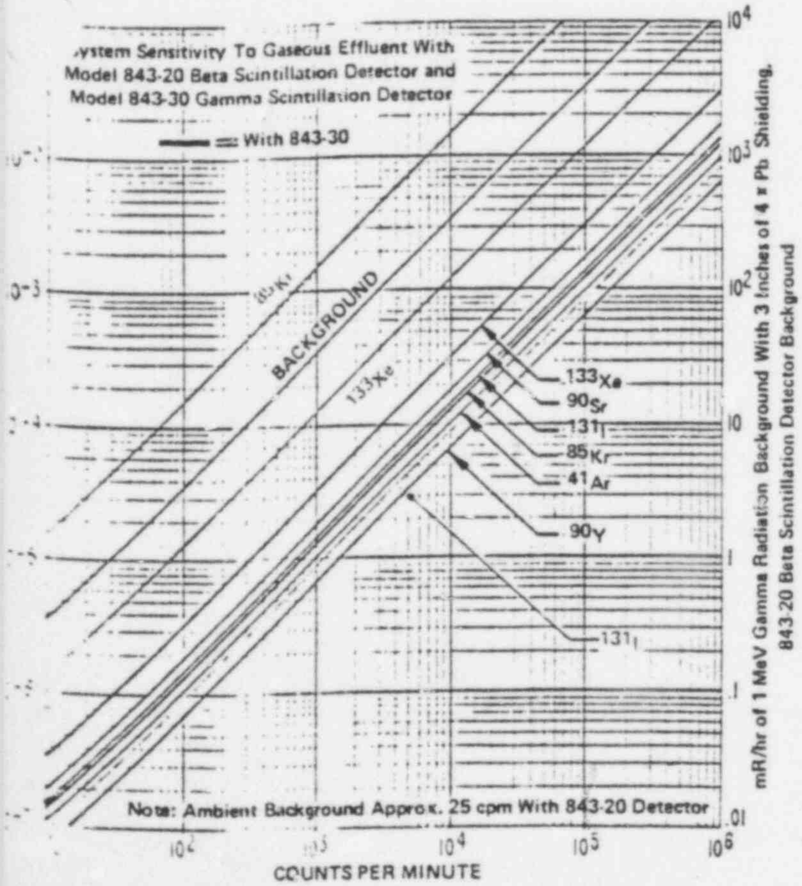
Dimensions: Mounts between two standard 4 in. pipe flanges (10.2 cm). Length 18⅞ in. between flange faces (48.0 cm).

Weight: Approximately 150 pounds (68 Kg) for standard 2 in. Pb shielding.

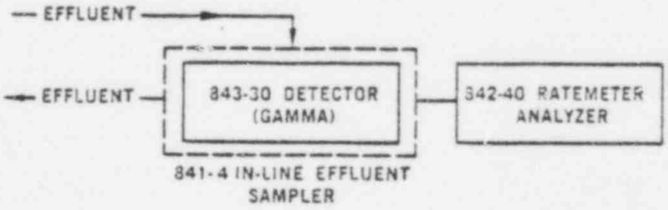


Beta Effluent System





POOR ORIGINAL



Specific Isotope Effluent System

749047

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VICTOREEN

TABLE 1-1. A MONITORS

Channel	Vico Ref.	Description	Local Alarm	Readout	Detector	El. Dwg. No.	Remarks
HP-R-201	A1	Control Room	None	856-2	857-2	Sheet 1 904550	
HP-R-202	A2	Cable Room	858-3 Mod.	856-2	857-2	Sheet 1 904550	
HP-R-204	A3	Reactor Bldg. Emer. Cooling Booster Pump Area	858-3 Mod.	856-2	857-2	Sheet 2 904550	
HP-R-205	A4	Reactor Coolant Evaporator Control Panel Area	858-3 Mod.	856-2	857-2	Sheet 2 904550	
HP-R-206	A5	Make-Up Tank Area	858-3 Mod.	856-2	857-2	Sheet 3 904550	
HP-R-207	A6	Intermediate Cooling Pump Area	858-3 Mod.	856-2	857-2	Sheet 3 904550	
HP-R-209	A7	904150 At 12 Fuel Handling Bridge-North	RB Evac.	856-2 Local	857-2	Sheet 4 904550	Readout Unit Is Local Common To Evac. Alarm
HP-R-210	A8	904150 At 12 Fuel Handling Bridge-South	RB Evac.	856-2 Local	857-2	Sheet 4 904550	Readout Unit Is Local Common To Evac. Alarm
HP-R-211	A9	Personnel Access Hatch	858-3 Mod. 858-1 Mod.	856-2	857-2	Sheet 5 904550	Common To Evac. Alarm
HP-R-212	A10	Equipment Hatch	858-3 Mod. 858-1 Mod.	856-2	857-2	Sheet 5 904550	Common To Evac. Alarm
HP-R-213	A11	In-Core Instrument Panel Area	858-3 Mod.	---	---	Sheet 6 904550	Common To Evac. Alarm
HP-R-214	A12	Reactor Building Dome	RB Evac.	846-1	847-1 In 904120 Containment	Sheet 6 904550	Common To Evac. Alarm
HP-R-215	A13	Fuel Handling Bridge	None	856-2 Local	857-2	Sheet 7 904550	Readout Unit Is Local

HP-R-218	A14	Waste Disposal Storage Area	858-3 Mod.	856-2	857-2	Sheet 7 904550	
HP-R-231	A15	Aux. Bldg. Sump Tank Filter Room	858-3 Mod. 858-1 Mod.	856-2	857-2	Sheet 8 904550	
HP-R-232	A16	Access Corridor Column AT/A61	858-3 Mod.	856-2	857-2	Sheet 8 904550	
HP-R-233	A17	Access Corridor Column AN/A63	858-3 Mod.	856-2	857-2	Sheet 9 904550	
HP-R-234	A18	Access Corridor Column CE/C50A	858-3 Mod.	856-2	857-2	Sheet 9 904550	
HP-R-3236	A19	Reactor Bldg. Purge Unit Area	858-1 Mod. 858-3 Mod.	856-2	857-2	Sheet 10 904550	Common Bridge A2
HP-R-3238	A20	Aux. Bldg. Exchange Unit Area	858-1 Mod. 858-3 Mod.	856-2	857-2	Sheet 10 904550	Common Bridge A2
HP-R-3240	A21	Fuel Handling Exchange Unit Area	858-1 Mod. 858-3 Mod.	856-2	857-2	Sheet 11 904550	Common Bridge A2

1.3 PROCESS MONITORS.

1.3.1 Unpackaging

1.3.1.1 842 Series Ratemeters. See Figure 1-11.

842 Series Ratemeter, when purchased as part of a monitoring system, are shipped in Model 844-7 standard 19-inch rack mount chassis mounted in the cabinet in which they will be used. The majority of the ratemeters will be installed in panel 12. Three ratemeters each will be found in the HPR-223 and 224 portable atmospheric monitoring cabinets. One ratemeter each will be found in the WTR-3894 and 3895 liquid monitoring cabinets. In each case the ratemeters should be partially withdrawn from their rack chassis and given a thorough visual inspection to assure no obvious damage has occurred.

1.3.1.2 843 Series Detectors.

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1.3.1.2.1 843-20 Beta Detectors.

The 843-20 Beta Detectors will be shipped in operating position and will require no further unpacking.

1.3.1.2.2 843-30 Gamma Detectors.

The 843-30 Gamma Detectors will be shipped loose. There is very little probability that the detectors will incur shipping damage and it is not advisable to inspect the internals. If the outer case of a detector shows obvious signs of distress contact the factory for further instructions.

1.3.1.3 Atmospheric Monitors. See Figures 1-12, 1-13, 1-14 and 1-15.

Each atmospheric monitor has been factory assembled on a steel baseplate mounted on a steel skid. A protective steel enclosure also mounted to the baseplate covers should be inspected both inside and out for obvious damage. It is not advisable to disassemble these units to inspect for damage.

1.3.1.4 Isokinetic Nozzles

With the exception of the two portable atmospheric monitors there is an isokinetic nozzle and mounting plate associated with each atmospheric monitor.

Give the nozzles and pipes a good visual inspection. Ensure that the pipes are free from sharp bends and kinks and that they are not out of alignment. The nozzles should be inspected particularly for nicks on the sharp sample inlet edge. The nozzles should be kept in shock absorbent material until installation.

The automatic isokinetic sampler-channel HPR-219 has in addition to the isokinetic nozzle, a mass flowmeter probe which must also be installed in the plant vent stack. The probe tip should be approximately 5 feet above the isokinetic nozzle on the same vertical centerline.

TABLE 1-2 ROCESS MONITORS

Channel	Vico Ref.	Descri ion	Local Alarm	Sampler	Readout-Serial #	Detector -Serial #	El. Dwg. No.	Remarks
HP-R-219	Part. 1	Station Vent M itor	801A & V On Encl.	4π 841-1	842-10 762	843-20A 144	904549	Automatic
	Iodine 1			4π 841-2	842-30 720	843-30 148		Isokinetic
	Gas 1			4π 841-33	842-10 743	843-20 140		Sampling
HP-R-220	Part. 2	Control Room take Duct	801A & V On Encl.	4π 841-1	842-10 747	843-20A 181	904549	
	Iodine 2			4π 841-2	842-30 732	843-30 266		
	Gas 2			4π 841-33	842-10 759	843-20 166		
HP-R-221A	Part. 3	Fuel Handling ldg. Exh. Duct - Upstre	801A & V On Encl.	4π 841-1	842-10 738	843-20A 195	904549	
	Iodine 3			4π 841-2	842-30 744	843-30 222		
	Gas 3			4π 841-33	842-10 669	843-20 177		
HP-R-221B	Part. 4	Fuel Handling ldg. Exh. Duct - Downst am	801A & V On Encl.	4π 841-1	842-10 671	843-20A 276	904549	
	Iodine 4			4π 841-2	842-30 748	843-30 186		
	Gas 4			4π 841-33	842-10 662	843-20 225		

HP-R-229	Part. 5	Hydrogen Purge Duct	801A & V On Encl.	4π 841-1	842-10 756	843-20A 187	904549	
	Iodine 5			4π 841-2	842-30 761	843-30 254		
	Gas 5			4π 841-33	842-10 670	843-20 163		
HP-R-225	Part. 6	RB Purge Air Exhaust Duct A	801A & V On Encl.	4π 841-1	842-10 668	843-20A 180	904549	
	Iodine 6			4π 841-2	842-30 734	843-30 157		
	Gas 6			4π 841-33	842-10 755	843-20 127		
HP-R-226	Part. 7	RB Purge Air Exhast Duct B	801A & V On Encl.	4π 841-1	842-10 673	843-20A 123	904549	
	Iodine 7			4π 841-2	842-30 764	843-30 245		
	Gas 7			4π 841-33	842-10 676	843-20 215		
HP-R-222	Part. 8	Aux. Bldg. Purge Air Exhaust - Upstream	801A & V On Encl.	4π 841-1	842-10 741	843-20A 138	904549	
	Iodine 8			4π 841-2	842-30 784	843-30 251		
	Gas 8			4π 841-33	842-10 760	843-20 178		
HP-R-228	Part. 9	Aux. Bldg. Purge Air Exhaust - Downstream	801A & V On Encl.	4π 841-1	842-10 757	843-20A 168	904549	
	Iodine 9			4π 841-2	842-30 743	843-30 263		
	Gas 9			4π 841-33	842-10 658	843-30 136		

TABLE 1-2. PROC MONITORS (CONT'D.)

Channel	Vico Ref.	Description	Local Alarm	Sampler	Readout-Serial #	Detector-Serial #	El. Dwg. No.	Remarks
HP-R-227	Part. 10	Reactor Air Sampler Line	801A & V On Encl.	4π 841-1	842-10 743	843-20A 182	904549	
	Iodine 10			4π 841-2	842-30 685	843-30 191		
	Gas 10			4π 841-34	842-10 660	843-20 123		
HP-R-223	Part.	Movable Monitor - Spent Fuel Area	801A & V On Encl.	4π 841-1	Local 842-10 682	843-20A 201	904567	Portable Monitor
	Iodine			4π 841-2	Local 842-30 677	843-30 288		
	Gas			4π 841-33	Local 842-10 682	843-20 176		
HP-R-224	Part.	Movable Monitor - Aux. Building	801A & V On Encl.	4π 841-1	Local 842-10 754	843-20A 158	904567	Portable Monitor
	Iodine			4π 841-2	Local 842-30 727	843-30 279		
	Gas			4π 841-33	Local 842-10 664	843-20 185		
MU-R-720	Liquid-1	Primary Coolant Let-down - Gross	None	4π 841-4P/5	842-10 646	843-30 280	904889	
	Liquid-2	Primary Coolant Let-down - Iodine			842-30 766			

IC-R-1091	Liquid-3	Intermediate ool. H_2O Ltdwn. Clr. U-C-1B	None	4π 841-34	842-10 663	843-30 178	904889	
IC-R-1092	Liquid-4	Intermediate ool. H_2O Ltdwn. Clr. U-C-1A	None	4π 841-34	842-10 751	843-30 173	904889	
IC-R-1093	Liquid-5	Intermediate ool. H_2O Cooler Outle	None	4π 841-33	842-10 683	843-30 180	904889	
WDL-R-1311	Liquid-6	Liquid Efflu - Plant #2	904149 Al. Mod. On WDL Panel	4π 841-33	842-10 675	843-30 199	904889	
DC-R-3399	Liquid-7	Decay Heat (sed Cool-ing Water - op A	None	4π 841-33	842-10 678	843-30 187	904889	
DC-R-3400	Liquid-8	Decay Heat (sed Cool-ing Water - op B	None	4π 841-33	842-10 739	843-30 198	904889	
NS-R-3401	Liquid-9	Nuclear Serv es Closed Cooling Wat	None	4π 841-33	842-10 722	843-30 195	904889	
SF-R-3402	Liquid-10	Spent Fuel C ling	None	4π 841-34	842-10 753	906015 N/A	904889	Detector well added
WT-R-3894	Liquid-11	Water Treat nt and Con-densate Poli ng	801A & V On Encl.	4π 841-34	Local 842-10 673	843-30 151	905222	
WT-R-3895	Liquid-12	Water Treat nt and Con-densate Poli ng	801A & V On Encl.	4π 841-34	Local 842-10 750	843-30 290	905222	
WDG-R-1480	Gas-11	Waste Gas I harge	904149 Al. Mod. On WDG Panel	4π 841-33	842-10 733	843-20 269	904863	

TABLE 1-2. P ESS MONITORS (CONT'D.)

Channel	Vico Ref.	Description	Local Alarm	Sampler	Readout-Serial #	Detector-Serial #	El. Dwg. No.	Remarks
WDG-R-1485	Gas-12	Decay Gas Tank 1A Discharge	904149 Al. Mod. On WDG Panel	4π 841-33	842-10 752	843-20 265	904863	
WDG-R-1486	Gas-13	Decay Gas Tank 1B Discharge	904149 Al. Mod. On WDG Panel	4π 841-33	842-10 723	843-20 161	904863	
VA-R-748	Gas-14	Condenser Vacuum Pump Exhaust	None	4π 841-33	842-10 667	843-20 146	904863	

1.3.1.5 Liquid Monitors. See Figures 1-16, 1-17, 1-18, 1-19, 1-20 and 1-21.

The liquid monitor components have been factory assembled on a steel baseplate mounted on a steel skid. No actual unpackaging will be required, however, each unit should be inspected for obvious shipping damage. It is not advisable to disassemble these units to inspect for damage. A protective steel enclosure has been furnished with two liquid units. Interior inspection of these units should be complete.

1.3.1.6 Gas Monitors. See Figures 1-22 and 1-23.

The gas monitor components have been factory assembled on a steel baseplate mounted on a steel skid. No actual unpackaging will be required; however, each unit should be inspected for obvious shipping damage. It is not advisable to disassemble these units to inspect for damage.

1.3.2 Power Requirements.

1.3.2.1 842 Series Ratemeters.

The 842 Series Ratemeters have been factory wired to operate on 120 volts 1 phase, 60 Hz power. Since the majority of the equipment has been factory installed in panel 12, it will not be necessary to individually connect power to each piece of equipment. The ratemeters shipped as part of an atmospheric monitor or liquid monitor will be covered under the appropriate section of this manual.

1.3.2.2 843 Series Detectors.

The 843 Series Detectors are powered from the associated ratemeter and require no separate power connections.

1.3.2.3. Atmospheric Monitors (drawing 904549) and Portable Monitors (drawing 904567

Each atmospheric monitor or portable monitor will require 480 volts, 3 phase, 60 Hz power. Refer to the drawings for individual enclosure details. Each enclosure will be supplied with 120 volts, 1 phase, 60 Hz power from panel 12 via field wiring.

1.3.2.4 Liquid Monitors.

[illegible] monitor will require [illegible] volts, [illegible] phase, 60 Hz power. Refer to drawings 904889 and 905222 for individual unit details.

1.3.2.5 Gas Monitors.

Each gas monitor will require 120 volts, 1 phase, 60 Hz power. Refer to drawing 904863 for individual unit details.

1.3.3 Installation

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1.3.3.1 842 Series Ratemeters - Panel 12.

All wiring connections external to each ratemeter have been made at the factory from two terminal strips (TB1 and TB2) on the rear panel of each ratemeter. The ratemeters are mounted in a 19-inch rack chassis (Model 844-7) which are in turn mounted in panel 12. Blank panels (Model 844-8) have been installed in the 844-7 rack chassis to cover any portions not being used. With the exception of completing field wiring to panel 12 the ratemeters will need no further installation.

1.3.3.2 842 Series Ratemeters - Monitor Enclosure Mounted.

All wiring connections to each enclosed mounted ratemeter have been made at the factory from two terminal strips (TB1 and TB2) on the rear panel of each ratemeter to the appropriate points within the monitor. Customer connections, if any, are brought out to customer interface terminal strips in the enclosure. These connections will be covered under the installation section for the enclosure.

1.3.3.3 843 Series Detectors.

843 Series Detectors are conpatible with 842 Series Ratemeters. Each detector has been factory calibrated to operate with a specific readout module. Ratemeter/detector pairs may be determined by consulting Table 1-2.

1.3.3.3.1 843-20 Beta Detectors.

Normally all beta detectors will be shipped in operating position. All cable connections will have been completed at the factory from the detectors to the customer interface terminal strips. With exception of wiring between individual monitors and the 842 ratemeters covered in the appropriate section of this manual, the 843-20 detectors will need no further installation.

1.3.3.3.2 843-30 Gamma Detectors. See Figure 1-34.

Gamma scintillation crystals are fragile and susceptible to shock - be careful.

Gamma detectors will normally be shipped separately and will require installation in the proper sampler. Consult Table 1-2 for the proper serial numbers of detector/ratemeter/sampler combinations.

Gamma detectors are easily installed in the corresponding sampler by removing any shielding from the detector area of the sampler. Some samplers simply require opening of the shielding door rather than disassembly. Loosen the hose clamp fastened to the mounting flange and insert the detector into the well. Ensure that the connector end of the detector remains outside the well and that the detector is inserted far enough to seat.

[illegible] necessary to torque the bolts so tight that future removal will be a chore. Complete the electrical connections by attaching each of the two connectors on the cable to its mate on the detector. Replace any shielding previously removed.

Detector wiring will now be complete to the customer interface terminal strips. With the exception of wiring between individual monitors and the 842 ratemeters covered in the appropriate section of this manual, the 843-30 detectors will need no further installation.

1.3.3.4 Atmospheric Monitors.

1.3.3.4.1 Standard Atmospheric Monitors. See Figures 1-12, 1-13, 1-14 and 1-15.

The standard atmospheric monitors are installed by selecting a convenient location and placing the enclosure in that location. Normally, monitors are bolted in place. Selection of bolts and mounting hole locations are left to installation supervision as requirements will vary with locations.

Following physical placement of the enclosure the sample inlet and outlet lines should be connected. Follow the recommendations for isokinetic sample lines noted in ANSI Standard 13.1 - 1969 for all sample inlets. Sample outlets may be connected in the most convenient workman-like manner as the configurations are not critical. At this time all additional connections, such as flushing inlets or drain lines, should either be completed or plugged to preclude inadvertent operation.

The wiring to each enclosure should be completed per the appropriate drawing. See Table 1-2.

1.3.3.4.2 Automatic Atmospheric Monitor. See Figures 1-16, 1-17, 1-18 and 1-19.

The primary difference between the automatic and standard atmospheric monitor lies in the ability of the automatic unit to sense the velocity of effluent in the plant vent stack and to adjust the sample flow rate to maintain isokinetic sampling under varying flow conditions. All installation requirements are similar to those noted under section 1.3.3.4.1.

1.3.3.4.3 Portable Atmospheric Monitors. See Figures 1-20, 1-21, 1-22 and 1-23.

These units require only physical placement in the areas of use and attachment of an electrical plug compatible with 480 volts, 3 phase, 60 Hz outlets in the area to the supplied cable. The plug is not supplied. Other than electrical power, the portable units are self-contained.

1.3.3.4.4 Isokinetic Nozzles. See Figure 1-35.

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Table 1-2 will give channel/nozzle number cross-reference so the proper nozzle can be installed at each sample point. Each nozzle and mounting plate is stamped with the nozzle number. See also drawing 905109 for nozzle details.

Nozzles must be mounted within the duct or stack to be sampled with the sharp edge facing the duct flow. Installation should be such that the sample piping and nozzle do not vibrate during normal duct flow conditions. Nozzle/piping installation should be in accordance with ANSI Standard 13.1 - 1969.

[illegible] supervision for additional nozzle/piping [illegible] details.

1.3.3.5 Liquid Monitors. See Figures 1-24, 1-25, 1-26, 1-27, 1-28, 1-29, 1-30 and 1-31.

The liquid monitors are installed by selecting a convenient location and placing the baseplate or enclosure in that location. Normally, monitors are bolted in place. Selection of bolts and mounting hole locations are left to installation supervision as requirements will vary with locations.

Following the physical placement of the monitor, the sample inlet and outlet lines should be connected. Additional connections such as flushing inlets and drain lines should either be completed at this time or the connection points should be plugged to preclude inadvertent entrance of foreign material.

The wiring to each monitor should be completed in accordance to drawing 904889 or 905222. Refer to Table 1-2.

1.3.3.6 Gas Monitors. See Figures 1-32 and 1-33.

The gas monitors are installed by selecting a convenient location and placing the baseplate in that location. Normally, monitors are bolted in place. Selection of bolts and mounting hole locations are left to installation supervision as requirements will vary with locations.

Following the physical placement of the monitor the sample inlet and outlet lines should be connected. Additional connections such as flushing inlets and drain lines should either be completed at this time or the connection points should be plugged to preclude inadvertent entrance of foreign material.

The wiring to each monitor should be completed in accordance to drawing 904863. Refer to Table 1-2.

1.4 CONTROL PANEL 12. See Figures 1-36, 1-37, 1-38 and 1-39.

1.4.1 Unpackaging.

Control Panel 12 will require removal from the wooden shipping skid to complete unpackaging. Inspect the internals of the panel to ensure all relays are in place and properly seated. Also check the recorders for obvious damage.

1.4.2 Power Requirements.

Refer to drawing 905031 for power requirements.

1.4.3 Installation.

Panel 12 will require bolting to the floor per drawing 904469. Assuming the foundation has been prepared it is only necessary to position panel 12 properly and bolt it down.

Electrical power connections should be made per drawing 905031. Grounding connections, in addition to power ground should be made per customer requirements to the copper ground buss supplied and installed in panel 12. See drawing 904924.

The following list indicates the equipment to be field connected and the electrical drawings covering those connections. See also drawing 904924 for terminal board layouts.

Equipment	Electrical Dwg. No.
1) Area Monitors	904550
2) Atmospheric Monitors	904549
3) Liquid Monitors	905222
4) Gas Monitors	904863
5) Annunciator Panel 211	905166

The annunciator panel interconnections will be by means of factory supplied cables with connectors on both ends. It will be necessary to ensure that each end of each cable is connected to the proper connector in both panel 12 and the annunciator panel. If the connections are not verified, damage to the annunciator logic could result upon powering up either or both cabinets.

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SECTION II

OPERATION

2.1 AREA MONITORS.

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2.1.1 855 Series Area Monitors.

2.1.1.1 General Description. See Table 2-1.

An 855 Series G-M Area Monitoring System includes a number of channels, each of which detects, indicates and initiates alarms in response to radiation.

The readout module/detector combination may be designed for HI, MED or LO ranges of activity The HI range covers 1 mR/hr to 10^5 mR; the MED range 0.1 mR/hr to 10^4 mR/hr; the LO range 0.01 mR/hr to 10^3 mR/hr. In each range the radiation indication is presented on a 5-decade log meter on the readout module front panel. Simultaneous meter readouts may be presented at one or more field units and computer outputs. The recorder outputs are 0 to 10 mV and the computer outputs may be connected for 0-50 mV, 0-1V or 0-5V. The computer outputs have been furnished connected for 0-50 mV output.

Each readout module incorporates two independently adjustable electronic comparator type radiation alarm trips. The alarm trips operate an audible annunciator system and a light on the readout module front panel. Each alarm may be connected to one or more remote field alarm boxes. Each radiation alarm trip causes a 4 PDT relay to energize, which, in addition to controlling the alarm annunciation system, has contacts available for customer use.

The readout module front panel controls and indicators consist of the following:

A. The Panel Meter.

B. Function Switch - This is the only rotary switch on the front panel. It turns the module on and off, selects the operating conditions and allows alarm set points to be indicated by the front panel meter.

C. Green Button/Indicator - Green (Fail) light off indicates power is not available to the module, the module is in the off state or a module or detector failure. Green light on indicates normal module/detector functioning. Pressing the green button activates the check source.

D. Amber Button/Indicator - Amber indicator on indicates alert radiation alarm trip. Amber indicator off indicates alert radiation alarm is de-energized. Amber button pressed while function switch is at ALARM, displays alert alarm set point on meter. Button pressed with function switch at OPER. resets the alert radiation alarm if the displayed radiation level on the meter is less than the alert alarm set point. The alarm reset function is not applicable if the alarm is being operated on the automatic reset mode.

E. Red Button/Indicator - Red indicator on indicates high radiation alarm trip. Red indicator off indicates high radiation alarm is de-energized. Red button pressed while function switch is at ALARM, displays high alarm set point on meter. Button pressed with function switch at OPER. resets the high radiation alarm if the displayed radiation level on the meter is less than the high alarm set point. The alarm reset function is not applicable if the alarm is being operated in the automatic reset mode.

2.1.1.2 Performance Specifications.

2.1.1.2.1 Detector/Readout Module.

Ranges: 5-decade; 10^{-2}mR/hr to 10^{3}mR/hr; 10^{-1}mR/hr to 10^{4}mR/hr; 1mR/hr to 10^{5}mR/hr
Accuracy: Each decade - within ±20% of reading
Circuitry: Solid state except G-M and HV regulator tubes
Response: Gamma radiation
Energy Dependence: ±15% from 100 keV to 2.5 MeV
Direction Dependence: Less than 30% from any direction
Detector Type: Geiger-Mueller (G-M) tube
Temperature Limits: Readout Module; 32°F (0°C) to 120°F (49°C). Detector; -20°F (-20°C) to 140°F (60°C)
Humidity: Readout Module; 0 to 95%. Detector; 0 to 100%
Radiation Alarms: Two (2) alarms, ALERT and HIGH, independently adjustable across the range of the readout module; reset is manual or automatic - jumper selected
Fail Alarm: Non-adjustable; automatic reset only
Internal Alarm Relay Contacts: DPDT, 5 ampere resistive at 120V ac
External Alarm Relay Contacts: 4 PDT, 10 amperes inductive at 120V ac, 1 ampere inductive at 125V dc
Recorder Output: 0 to 10mV, ±3%
Computer Output: 0 to 50mV, 0 to 1V, 0 to 5V, ±3%
Input Power: 120V, 1 phase, 60 Hz; ±15%
Internal Power Supplies: +600V dc regulated, ±16V; +22V dc unregulated, ±3V; +10V dc regulated, ±0.5V; -6.8V dc regulated, ±0.5V
Readout Module Terminations: Rear panel terminal strips
Detector Terminations: AN3102-18-1P connector or equivalent
Detector Dimensions: 3 in. (7.63cm) diameter; 6-1/2 in. (16.5cm) high
Detector Weight: 1 pound (0.45 kg)
Detector Mounting: Wall bracket
Readout Module Dimensions: 5-5/8 in. (14.4cm) wide, 3-1/2 in. (8.90cm) high, 11-1/8 in. (28.3cm) deep
Readout Module Weight: Approximately 3 pounds (1.36 kg)
Readout Module Mounting: 848-3 single channel enclosure or 848-1 rack chassis

2.1.1.2.2 Local Alarm, 858-1.

Visual Alarms: ALERT (amber light); HIGH (red light). Both lights are 1 inch (2.54cm) square and mimic readout module alarm lights
Audible Alarm: Horn which activates with either alarm light
Temperature Limits: -20°F (-29°C) to 140°F (60°C)
Humidity Limits: 0 to 95%
Enclosure: Heavy duty industrial junction box with wall mounting flange
Dimensions (not including horn): 7 in. (17.8cm) square; 4 in. (10.2cm) deep
Weight (not including horn): 4-3/4 pounds (2.15 kg)
Alarm Horn Dimensions: 4-1/2 in. (11.4cm) square; 3 in. (7.6cm) deep
Alarm Horn Weight: 1-1/2 pounds (0.68 kg)

2.1.1.2.3 Local Alarm/Indicator; 858-2 (LO Range), 858-3 (MED Range).

Visual Alarms: ALERT (amber light); HIGH (red light). Both lights are 1 in. (2.54cm) square and mimic readout module alarm lights
Audible Alarm: Horn which activates with either alarm light
Temperature Limits: -20°F (-29°C) to 140°F (60°C)
Humidity Limits: 0-95%
Enclosure: Heavy duty industrial junction box with wall mounting flange
Dimensions (not including horn): 7 in. (17.8cm) square; 4 in. (10.2cm) deep
Weight (not including horn): 5 pounds (2.27 kg)
Panel Meter: 3-1/2 in. (8.89cm) wide with 5-decade display
Alarm Horn Dimensions: 4-1/2 in. (11.4cm) square; 3 in. (7.6cm) deep
Alarm Horn Weight: 1-1/2 pounds (0.68 kg)

2.1.1.2.4 Single Channel Readout Enclosure, 848-3.

Application: Houses one area monitor readout module
Mounting: Rubber pads for sitting on bench or shelf
Dimensions: 4-1/2 in. (11.4cm) high, 6-1/2 in. (16.5cm) wide, 12-1/2 in. (31.6cm) deep
Weight (less readout module): 5-3/4 pounds (2.6 kg)

2.1.1.2.5 Rack Chassis, 848-1.

Application: Mounts in standard 19-inch relay rack and accepts up to three area monitor readout modules
Dimensions: 3-1/2 in. (8.4cm) high, 19 in. (48.3cm) wide, 12-1/2 in. (31.6cm) deep
Weight (empty): 7-3/4 pounds (3.5 kg)

2.1.1.2.6 Blank Readout Module Panel, 858-4.

Application: Cover blank rack chassis spaces
Dimensions: 3-1/2 in. (8.9cm) high, 5-5/8 in. (14.4cm) wide
Weight: 1/2 pound (0.23 kg)

2.1.1.2.7 Detector Cable, 848-6-5.

Type: Multiconductor, waterproof outer insulation
Conductors: Refer to engineering drawing 848-6-3
Outer Diameter: 1/2 in. (1.27cm)
Temperature Limits: -40°F (-40°C) to 158°F (70°C)

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2.1.1.3 Start-Up Procedure.

The start-up procedure assumes; the unit has been correctly installed including the detector and any field alarm boxes, cabling has been correctly terminated, correct power is available to the readout module.

A. Rotate the function switch to OPER. The green light should come on and the meter should begin giving upscale readings. It may be necessary to activate the check source momentarily by pressing the green button for the meter to begin indicating.

B. Allow the unit to operate for a few minutes and actuate the check source. See paragraph 2.1.1.5. After the check source reading has stabilized compare it with that noted in most recent calibration data sheet. It is normal for radiation indications on the module front panel meter including those from the check source to vary slightly around the actual reading. The meter variations should be averaged to approximate the correct reading.

C. The radiation alarm set points may be adjusted by the procedure in Section III. See Section III if set point changes are required.

2.1.1.4 Shutdown Procedure.

Rotate the function switch to off.

2.1.1.5 Design Data and Description.

2.1.1.5.1 Detector.

The 855 Series Area Monitors use Geiger-Mueller (G-M) tubes as radiation detectors. A G-M tube basically consists of a positive electrode (anode) surrounded by a negative electrode (cathode). The anode is usually a metal wire or rod running down the center of the tube. The cathode is usually a metal cylinder which actually forms the body of the tube. Within the tube is a mixture of rare gases and a quenching agent. For use with the 855, a potential of 600 volts dc is applied between the tube electrodes.

Beta radiation striking the tube will interact with the tube wall liberating ions, or will liberate ions from (ionize) the internal gas directly. Either interaction is called a primary event. The potential (600V dc) difference between the electrodes will cause the freed electrons (negative ions) produced by the primary event to be accelerated through the gas mixture toward the anode. Some of the accelerating electrons will strike gas molecules causing additional ionization called secondary ionization. The secondary ionization process continues creating more and more free electrons (gas amplification) which also accelerate toward the anode. The large number of electrons arriving at the anode is sometimes called an avalanch. The avalanch is a result of the tube gas amplification of the primary event electrons accelerating through the gas mixture. The avalanch of electrons arriving at the anode produce a current pulse at the tube electrodes. The number of current pulses produced per unit time is proportional to the radiation intensity (number of primary events per unit time) at the G-M tube. To accept additional primary events, the ionization within the tube must cease following each current pulse. This action called quenching is assisted by a gas mixture containing a quenching agent which serves to reform or heal the ionization paths of the accelerating electrons following passage through the gas mixture. The time required for a G-M tube to respond to a primary event and quench is called dead time. Additional primary events cannot be resolved since they will be masked by the activities already taking place within the tube.

It is possible for a G-M tube to be exposed to a number of primary events so great that the tube dead times overlap and the tube cannot recover from one event before another occurs. This results in continuous conduction of the tube called saturation (or jamming) and unless special anti-jam circuitry is employed, could cause a radiation reading of zero at the readout module while very high radiation levels existed at the detector. A zero reading would result because the indicator circuitry counts pulses and a G-M tube in continuous conduction produces a steady current rather than a series of pulses. The 855 series area monitor readout modules do incorporate anti-jam circuitry described in paragraph 2.1.1.5.2.

Gamma radiation acts on the G-M tube through Compton Scattering, Pair Production of Photoelectric Effect. Any of the preceding processes will cause affected atoms or molecules to give up one or more electrons. Since electrons are, by definition, beta particles, the tube reacts as described in the preceding paragraph.

The detector assembly includes a radium check source which may be actuated from the readout module to verify the ability of a channel to respond to radiation. Under normal conditions it is unreasonable to expect to see an increase in the readout module meter reading due to check source actuation if the meter reading prior to check source actuation is equal to or greater than 2 times the expected check source reading.

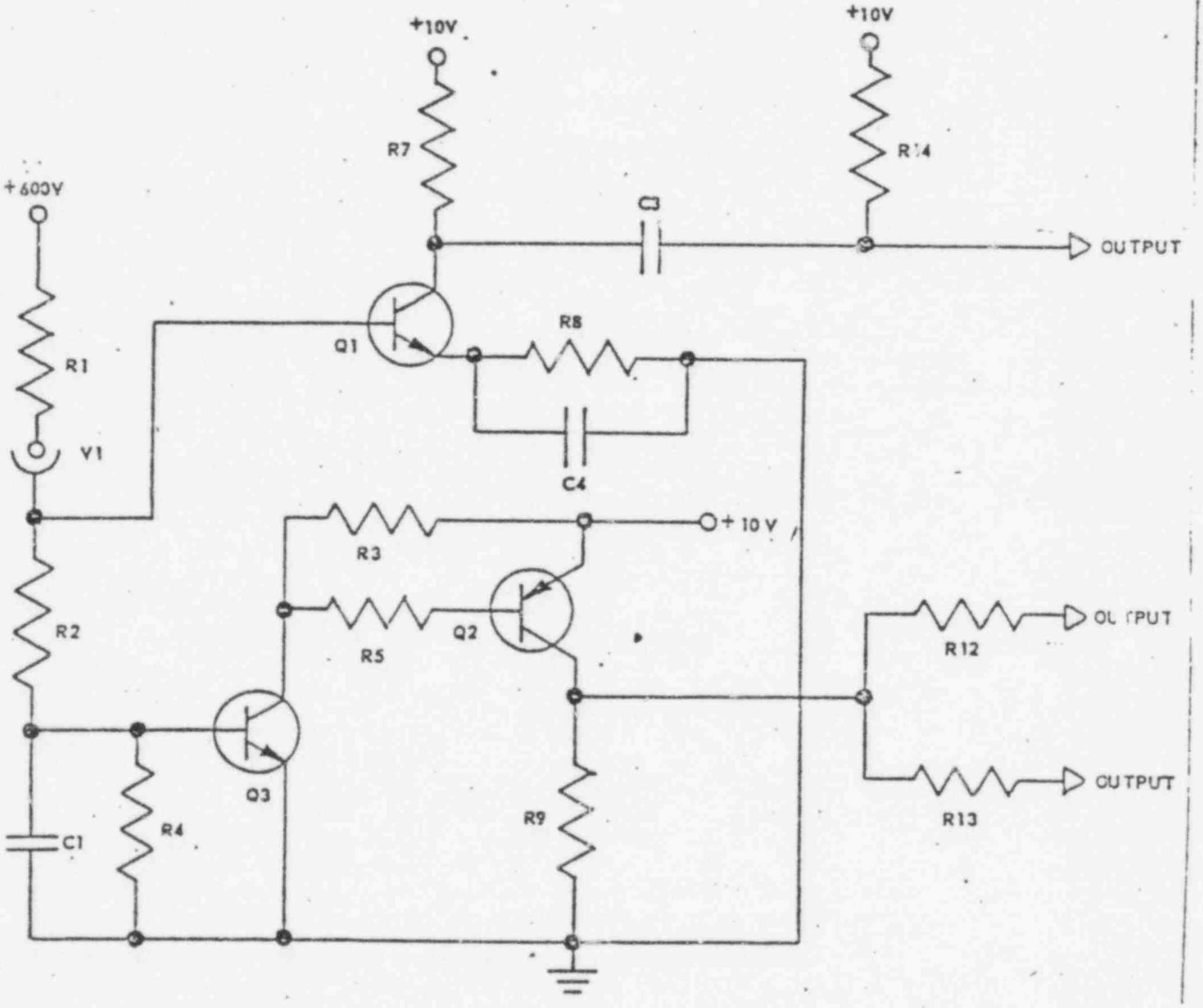

Figure 2-2. Detector-Pulse Schematic and Anti-Jam Circuitry

2.1.1.5.2 Detector Circuitry. See Figures 2-2, 2-3, 2-4, 2-5 and 2-6.

Pulses from the G-M tube are fed to the pulse amplifier and anti-jam circuit. The pulse amplifier Q1 is a transistor switch triggered from G-M tube V1. When

2.1.2 845 Series Area Monitor.

2.1.2.1 General Description. See Table 1-1.

The 845 Series Area Monitor is used to monitor gamma radiation levels in the actor building dome. The 847-1 detector is installed in a special 904120 housing with stainless steel walls and a 2-inch lead shield for extended radiation level response. The 846-1 readout module is located in panel 12. The radiation alarm system of the readout module is connected into the evacuation alarm system. See drawing 905474.

The radiation level is presented on the readout module panel meter and also as recorder and computer outputs from the unit. The recorder output is 0 - 10mV and the computer output is 0 - 50mV.

The readout incorporates two independently adjustable electronic comparator type radiation alarm trips. The alarm trips actuate the audible annunciator system and a light on the readout module front panel.

The readout module front panel controls and indicators consist of the following:

A. The Panel Meter.

B. Function Switch - This is the only rotary switch on the front panel. It turns the unit on and off, selects the ranges to be displayed and activates the check source.

C. Amber Button/Indicator - Light on indicates alert radiation alarm trip. Button pressed causes meter to indicate alert alarm trip set point.

D. Red Button/Indicator - Light on indicates high radiation alarm trip. Button essed causes meter to indicate high alarm trip set point.

E. Green Button/Indicator - Green light off indicates a power supply or collector supply voltage failure. Green light on indicates normal unit functioning. Green button pressed resets either or both radiation alarms.

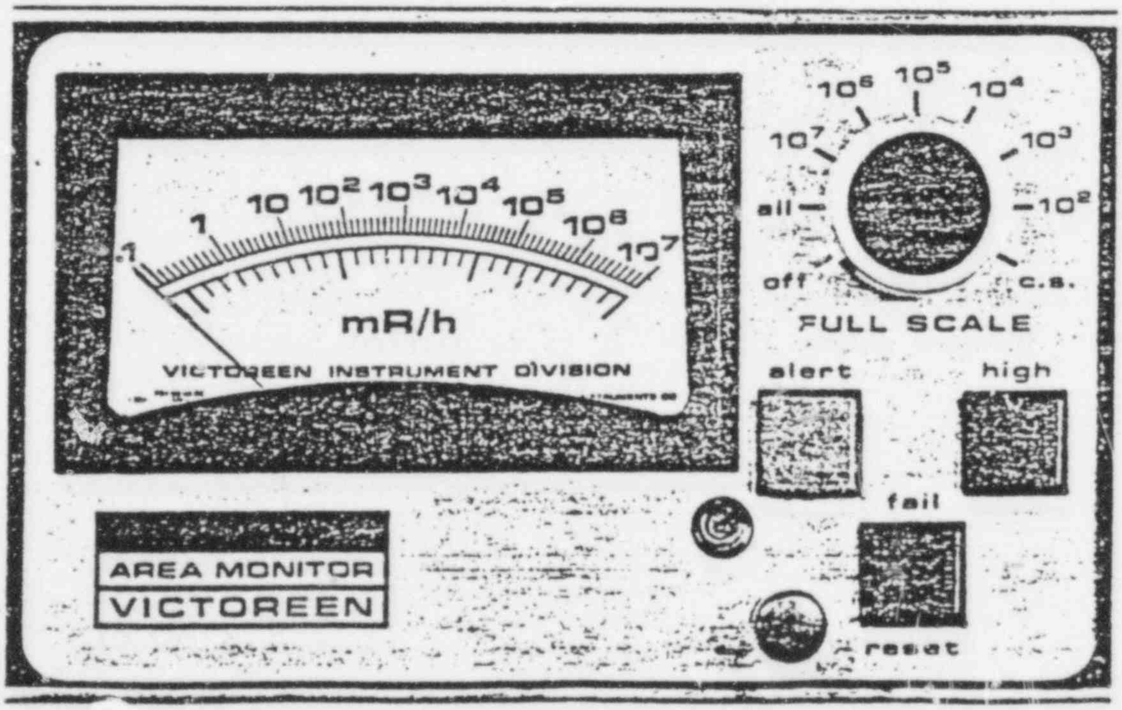

Figure 2-16. 845 Series - Model 846-1 Readout Module

2.1.2.2 Performance Specifications.

2.1.2.2.1 Detector/Readout Module.

Ranges: 8-decade: 0.1mR/hr to 10^7mR/hr; 3-decade: 0.1 to 10^2, 1 to 10^3, 10 to 10^4, 10^2 to 10^5, 10^3 to 10^6, 10^4 to 10^7mR/hr

Accuracy: Decade accuracy will be within ±10%

Circuitry: All solid state

Type of Radiation: Gamma or X-ray

Energy Dependence: ±10% from 80 keV to 3 MeV

Directional Dependence: Less than 10% from any direction with ^{60}Co

Type of Detector: Dual coaxial ionization chamber filled at atmospheric pressure

Pressure Limits: 15 psig, for both detector and readout module

Temperature Limits: Detector: -20°C to 60°C (-4°F to 140°F); Readout Module: 0°C to 60°C (32°F to 140°F)

Humidity: 0 to 95% for both readout module and detector

Alert Alarm: Adjustable trip level, indicated by meter deflection when alert light is pressed

High Alarm: Adjustable trip level, indicated by meter deflection when high light is pressed

Internal Alarm Contacts: One (1) set of Form C (SPDT) contacts rated at 115V dc, 5 amperes for each alarm: fail, alert, and high

Alarm Level Adjustment: Both the high and low level trip points are adjusted by means of a 15-turn potentiometer, located on the printed circuit board.

High and Alert Alarm Reset: There are two modes of reset available. The standard mode is a latching type alarm action with manual reset, reset for either alarm is by pressing the green (fail) light. The system can be converted to automatic reset by removing a jumper on the readout module printed circuit board. In this mode the alarms will automatically reset when the radiation levels drop below the trip level set points

Fail Indicator: Indicates a failure in the system power supply, the bias supply, the collector power supply, or loss of power. The indication is by means of the green light turning off

Always

Recorder Output: 0 to 10mV, ±0.14mV (Qlways indicating the full 8 decades)

Computer Output: 0 to 50mV, ±0.68mV (Always indicating the full 8 decades)

Power Supply: 14.0V, ±10mV

Input Power: 120/240V, ±15%, 47 to 65 Hz

Detector Connector: AN 3102-16-1P

Readout Module Connector: Rear terminal strip

Detector Dimensions: 7-3/4 in. (19.7cm) diameter, 11-3/4 in. (29.9cm) high

Detector Housing Dimensions: 14-3/8 in (36.43cm) high, 21.95 in. (55.73cm) high

Readout Module Dimensions: 3-1/2 in. (8.9cm) high, 5-5/8 in. (14.3cm) deep allowing 1 inch cable radius

Detector Weight: 5 pounds (2.27 kg)

Detector Housing Weight: 550 pounds (250.25 kg)

Detector Housing (904120) Mounting: By customer

Readout Module Weight: 3 pounds (1.36 kg)

2.1.2.2.2 Detector Cable 848-7.

Type: 6 conductor, shielded; outer insulation waterproof, Alpha 1254

Outside Diameter: 0.35 in. (0.9cm)

Temperature Limits: -40°C to 70°C (-40°F to 158°F)

2.1.2.3 Start-Up Procedure.

The start-up procedure assuming the unit has been correctly installed including the detector; cabling has been correctly terminated, correct power is available to the readout module.

A. Rotate the function switch to ALL. A nearly fullscale meter deflection will result which will require several minutes to fully decay. The initial deflection may cause the radiation alarms to trip. The alarms should be reset following meter decay. See paragraph 2.1.2.3.F.

B. The range is selected with the function switch. The ALL position selects the full 8-decade range which is displayed on the upper (red) arc of the meter. Positions 10^2 thru 10^7 select any one of six 3-decade expanded ranges. The 3-decade ranges are read on the lower (black) scale of the panel meter. The number opposite the function switch pointer indicates the fullscale value of the 3-decade range selected. Figure 2-17 shows the meter scale. If a function switch pointer indication of 10^5 is assumed the meter indication must be read on the lower black meter scale arc shown in Figure 2-17.

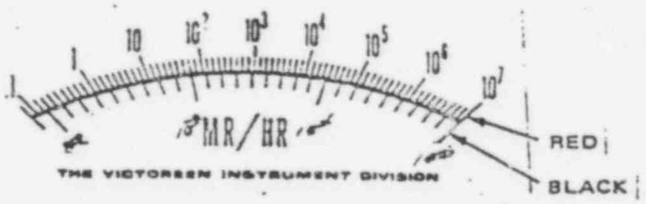

Figure 2-17. Meter Scale

C. The check source may be activated by rotating the function switch to the position labeled C.S. The meter deflection indicates the actual radiation intensity of the check source. Upon de-energizing the check source, the green pushbutton light should be depressed to avoid activating the alarm (if it is set below the reading of the check source). Since the check source is an actual response to external radiation, the recorder outputs will indicate the check source readings.

D. The amber alert alarm light will turn on when the radiation intensity exceeds the preset level. When the amber light is depressed, the meter pointer deflection will indicate the value of the preset level. This meter deflection can be read on any range and will not be indicated at the recorder outputs.

E. The red alarm light will turn on when the radiation intensity exceeds the preset level. The preset level will be indicated by the meter deflection when the red pushbutton light is depressed. This value can be read on any range and will not be indicated on the recorder output.

F. The manual alarm reset mode is the mode in which the alarms will lock after they exceed their preset levels. Depressing the green (fail light) pushbutton light will reset both alarms.

G. To switch either or both alarms to the automatic reset mode of operation, a per(s) located on the printed circuit board of the readout module must be removed. In this mode of operation the alarm(s) will trigger when the radiation exceeds the preset levels, and automatically reset when the radiation intensity falls below the preset level.

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2.1.2.4 Shut-Down Procedure

Rotate the function switch to OFF.

2.1.2.5 Design Data and Descriptions.

2.1.2.5.1 Detector.

An ion chamber detector was chosen because; 1) it has the ability to produce flat Roentgen response; 2) it has an excellent dynamic range and; 3) there is an absence of jamming at high radiation intensity levels. Next, a brief explanation will be given of how currents are formed within the chamber. These currents (by definition) reveal the radiation intensity in Roentgens per hour.

Figure 2-18 is a basic ion chamber circuit. The outer walls are connected to a high voltage source which is called the collecting voltage. The center electrode is referred to as the collecting electrode, and is supported from the walls by guarded insulators. The guarding serves to prevent any leakage currents (from the high voltage through the the insulators) from being read at the collecting electrode. These currents are intercepted by the guard ring which by-passes them to ground. Another function of the guard ring is to shape the electric field in the region around the collecting electrode.

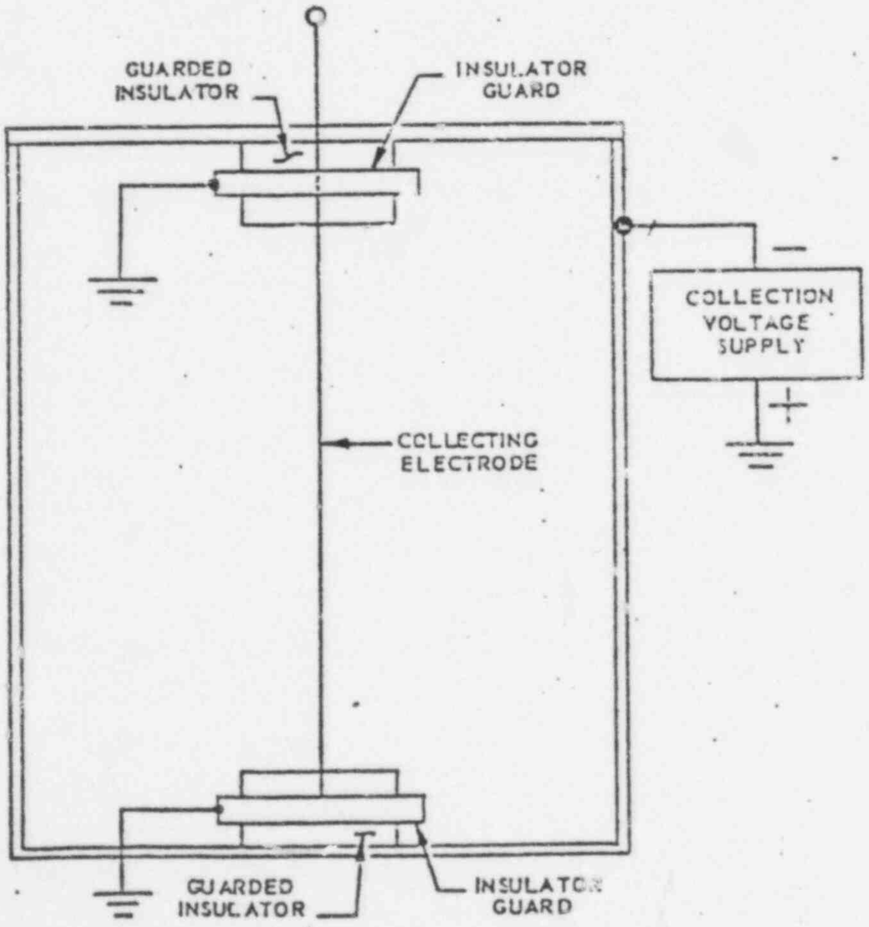

Figure 2-18. 847-1 Detector Ion Chamber Schematic

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When the chamber is exposed to radiation, one or more electrons are removed from a number the gas molecules within the chamber. The result is the formation of free electrons d positive charged ions. The behavior of these charged particles depends on the chamber, e tric field and type of gas within the chamber. The free electrons drift toward the si e electrode making many collisions with the gas molecules, the drift being in a rection away from the chamber wall. The positive ions drift in the opposite direction. e net result of these drifting charged particles is a current flow which can be measured tween the collecting electrode and ground. The amount of current depends on the amount charge collected per second, which in turn, depends on the radiation intensity.

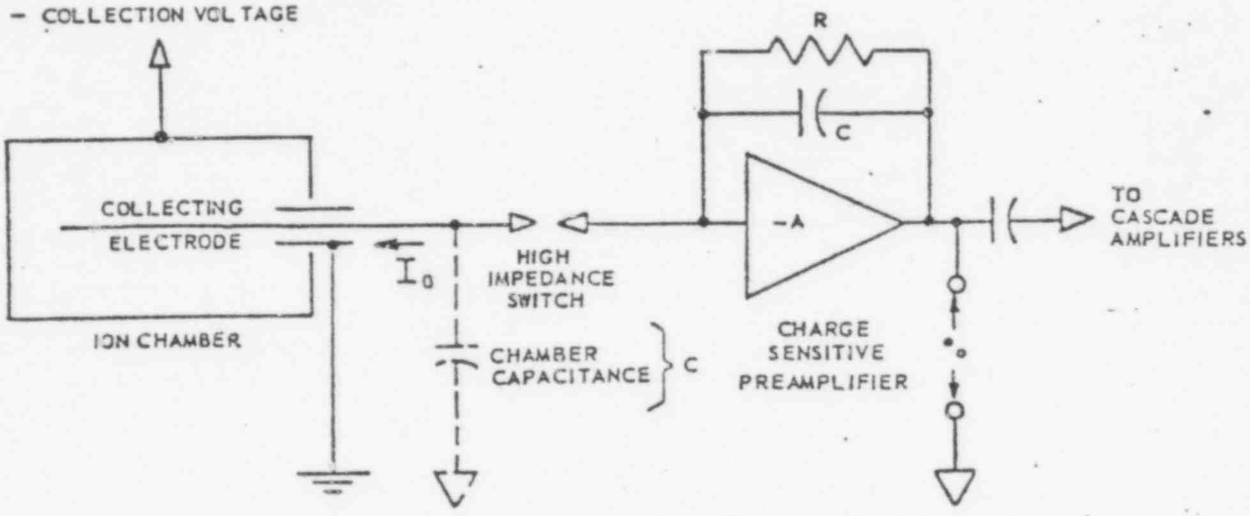

Figure 2-19. 847-1 Detector Schematic

The 845 system detector is a dual coaxial ion chamber with a high and low range ion rrent output. The high range covers the highest four decades while the low range covers ie lowest four decades. The chambers operate synchronously, each output is measured in like manner. The output ionization currents are measured by averaging or integrating iemm over a constant recycling time interval. Therefore, the magnitude of constant petition rate pulses are measured. The mechanism chosen to produce these pulses is scribed in next paragraph.

A high impedance switch is placed between the collecting electrode and a charge nsitive preamplifier. This switch is normally open, it closes for a duration of 4 lliseconds at a rate of 3 times per second, see Figure 2-19.

During the 1/3 of a second time interval, in which the switch is open, the ionization rrent I_0 charges the chamber capacitance to a value proportional to the radiation tensity. When the switch closes the charge is transferred to the charge sensitive plifier, resulting in a positive pulse at its output, with a decay determined by the me constant of R and C. The peak magnitude of that pulse is dependent on the collected arge and the value of feedback capacitor (C) in the charge sensitive amplifier. gure 2-20 shows all wave forms and illustrates how the output is derived.

If C and T are held constant, then the output pulse is directly proportional to the on ion current. Thus, by definition, a measurement of the pulse magnitude is a a nent of the radiation intensity. Figure 2-21 shows the block diagram of the mplete system. Remember that the two chambers operate synchronously, each with the me type of electronic measuring system. Only one chamber system will be discussed.

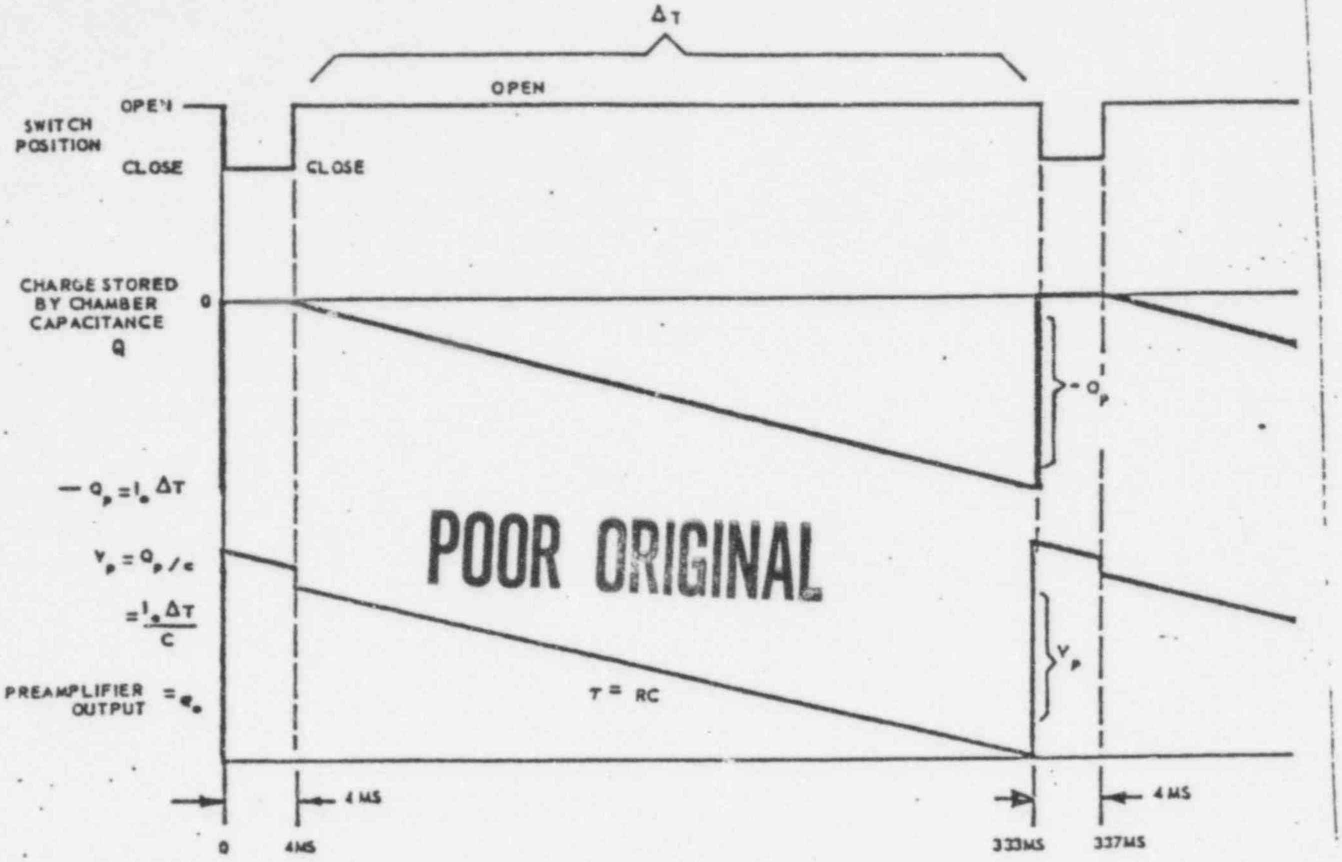

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Figure 2-20. 847-1 Detector Waveforms

The two guarded cylindrical chambers are arranged with chamber 2 in the center of chamber 1, the collecting electrode of chamber 1, being a cylinder surrounding the tube which holds the smaller chamber 2 in place.

The theory of how the pulses are formed by the high impedance switch, the ion chamber charged output capacity and the preamplifier has already been presented. The magnetic coupling and switch drive block will be described in paragraph 2.1.2.5.2.

The amplifier subsystem function can be detailed in another block diagram as shown in Figure 2-22. Pulses from the charge sensitive amplifier of the chamber are amplified by three cascaded pulse amplifiers having gains of nine, ten and ten respectively. Each of the cascade amplifiers has its output voltage limited or clipped by the diode CR, the clip voltage level being set at 9.0 volts. The output voltage pulses from each cascade amplifier are converted to current pulses by virtue of the series resistor R_0, the resulting current pulses are summed at the summing amplifier. It can be shown* that the output of the summing amplifier of this type of system is a composite pulse, whose peak value is related to the radiation intensity in a discontinuous-linear manner. The gain of the summing amplifier is adjusted to result in an output pulse magnitude of 1 volt per decade of radiation intensity.

*Reference: 1. Chapman, R.; Recorder Preamplifier for Displaying Three Decades On One Linear Scale. RSI 37: 12, 1966.

Fail indicator drive Q9 is just a switch which turns the indicator on when an input signal is present.

Regulated 14V supply consists of a series regulating element, Q11 with driver Q10, driver is fed from the differential amplifier Q12 and Q13. Q14 provides a constant current for Q13. The reference CR14 is temperature compensated by CR12 and CR13.

2.1.3 Evacuation Alarm System. See Drawing 904550, Sheet 11.

The evacuation alarm system consists of three Klaxton type alarm horns plus the actuating circuitry. The horns may be energized from a pushbutton in the control room or high radiation alarms from area monitor channels HP-R-209, HP-R-210, HP-R-211, HP-R-212, HP-R-213, and HP-R-214. The alarm, once actuated by any of the above means, can be silenced only from a pushbutton in the control room.

Victoreen has only supplied the alarm horns, pushbutton and drawing 905474 showing the suggested hook-up of the alarm components and therefore, cannot guarantee the proper installation or wiring of the evacuation alarm system.

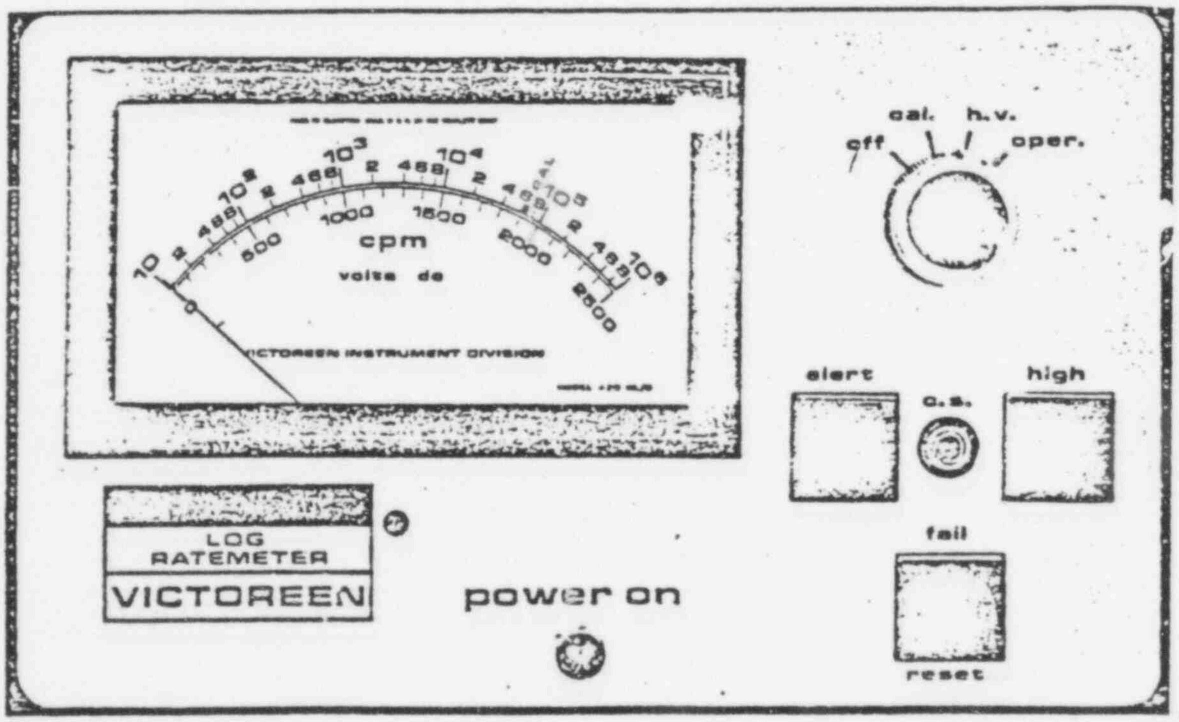

Figure 2-31. 842 Series Log Ratemeter

2.2 PROCESS MONITORS.

2.2.1 842 Series Ratemeter. See Figure 2-31.

2.2.1.1 General Description. See Table 1-2.

The 842 Series Ratemeters comprise a portion of the process monitoring system. The ratemeter is in most cases installed in panel 12 although a number of the ratemeters are field mounted in their respective sampler enclosures as noted in Table 1-2.

The ratemeters are available with either 5-decade (10cpm to 10^6cpm) log or linear readouts with or without single channel analyzer optional circuit boards installed. Simultaneous meter readouts may be presented at one or more field indication/alarm units.

The ratemeters will accept and process input signals from any of the 843 Series Radiation Detectors; alpha, beta or gamma scintillators; end-window or thin wall G-M tubes. Signals from the 843 series detectors are processed by the ratemeters to provide a front panel meter indication, a 0 to 10mV recorder output, a 0 - 50 mV computer output which may be altered for either a 0 to 1V or 0 to 5V output, two independently adjustable electronic comparator type radiation alarm trip circuits, and a fail alarm circuit which indicates channel malfunction.

The radiation alarm trips provide outputs to 4PDT relays which, in addition to controlling the alarm annunciation system including field alarms, have contacts available for customer use.

The fail alarm continuously monitors the performance of the channel (ratemeter/detector combination) and trips if any portion of the detector, pulse processing, power supply or analog output circuitry should malfunction. The fail alarm output is similar to that described above for the radiation alarms. Note that the fail alarm trip point is not user adjustable.

Each channel operates from its own integral high and low voltage power supplies. All controls which may adversely affect the ratemeter operation are located internally making access more difficult.

Two operational tests have been designed into the ratemeter. A calibration (CAL) oscillator provides pulses for an electronic calibration of the signal processing circuitry. The CAL frequency of approximately 6 x 10^4cpm, when routed to the ratemeter input, cause a 6 x 10^4cpm meter indication from a correctly functioning unit. A radioactive check source near the detector is actuated from the ratemeter front panel causing an upscale response from a correctly functioning channel.

The 500 to 2500V adjustable high voltage (HV) power supply provides the required voltage for operation of the 843 series radiation detectors. The actual HV setting is determined during factory calibration of each channel.

The recorder and computer output circuitry includes protective devices to preserve the integrity of the module alarm and indicator functions in the event of up to 120V ac or dc faults occuring on either or both the recorder and computer output.

Plug-in circuit boards have been provided for easy maintenance of the ratemeter. There are three plug-in boards; ratemeter circuit board, alarm circuit board and the optional analyzer circuit board in addition to the mother board which contains the power supply and signal routing components plus connectors for the three plug-in boards.

The mechanical configuration of the ratemeter allows side by side mounting of two ratemeters in a standard 19-inch relay rack with a rack chassis adapter. A single ratemeter enclosure is also available.

The ratemeter front panel controls and indicators consist of the following:

A. The Panel Meter - A 4-1/2 inch, 5-decade meter providing either a linear or logarithmic count rate (counts per minute) scale plus a 0 to 2500V HV scale. The count rate output scale also provides a CAL indication mark at 6 x 10^4cpm.

B. Function Switch - This is the only rotary switch on the front panel. It turns the ratemeter on and off, allows the high voltage reading to be displayed on the meter, allows the CAL signal frequency to be displayed on the meter and allows the radiation alarm set points to be displayed on the meter.

C. Check Source Button - Pressing will cause the channel detector to be exposed to the check source and an upscale meter reading will result from a properly functioning channel. Care should be taken that enough time is allowed with the button pressed for the channel to respond to the check source. A sharp upscale meter indication is not unusual when the button is pressed or released and is caused by inductive ringing in the check source circuitry.

D. Green Button/Indicator - Green (fail) light off indicates power is not available to the ratemeter, the function switch is off, a ratemeter or detector failure has occurred, or the green indicator lamp has failed. Green light on indicates normal ratemeter/detector functioning. Pressing the green button will reset the radiation alarms if the displayed radiation level is below the alarm set points and if manual alarm reset mode has been jumper selected on the alarm circuit board. The alarm reset function is not applicable if the alarms are being operated in the automatic reset mode.

E. Amber Button/Indicator - Amber indicator on indicates alert radiation alarm trip. Amber indicator off indicates alert radiation alarm is de-energized. Amber indicator off but alarm relay tripped indicates a failed amber indicator lamp. Amber button pressed while function switch is at CAL causes the alert alarm set point to be displayed on the module front panel meter. Note that the alarm set point is displayed only with the button pressed - CAL is indicated with the button released.

F. Red Button/Indicator - Red indicator on indicates high radiation alarm trip. Red indicator off indicates high radiation alarm is de-energized. Red indicator off but alarm relay tripped indicates a fail red indicator lamp. Red button pressed while function switch is at the CAL causes the high alarm set point to be displayed on the module front panel meter. Note that the alarm set point is displayed only with the button pressed - CAL is indicated with the button released.

2.2.1.2 Performance Specifications.

2.2.1.2.1 Ratemeter.

Voltage Requirements: 100-130/200-23CV ac, 50 - 60 Hz

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Power Consumption: 10 watts
Operating Temperature: 32°F (0°C) to 130°C (55°C)
Dimensions: 5-1/4 in. (13.3cm) high, 8-1/2 in. (21.6cm) wide, 13 in. (33.0cm) deep Two units can be mounted side by side in a Model 844-7 rack chassis, which in turn, mounts in a standard 19-in. (48.3cm) relay rack
Meter:
Scales: Black 10 - 10^6cpm, log or linear
Red 0 - 2500V dc
Accuracy: +2% of full scale
Size: 4-1/2 in. (11.4cm)
Front Panel Controls:
Function Switch: OFF, CAL, HV, OPER. positions
Check Source Button
ALERT Alarm Button/Indicator: amber lens
HIGH Alarm Button/Indicator: red lens
FAIL Alarm RESET Button/Indicator: green lens
Outputs:
Fail, Alert and High alarm trips, 1PDT relay contacts actuating 4PDT alarm transfer relays
Computer: 0 - 50mV, 0 - 1V, 0 - 5V
Recorder: 0 - 10mV
Power Supplies:
High Voltage: regulated, adjustable 500 to 2500V ac at 100uA
Low Voltage: -6.2V dc regulated, +16V dc regulated, +25V dc unregulated

2.2.1.2.1.1 Ratemeter Circuit Board.

Range: 10 - 10^6cpm
Sensitivity: 200mV
Input Pulse Polarity: Negative (-)
Input Impedance: 120 ohms at SIG. terminals
Discriminator Level: 0.2 - 5.5V adjustable
Calibration Oscillator:
Repetition Rate: 60,000cpm, nominal
Amplitude: negative (-) 6V

2.2.1.2.1.2 Analyzer Circuit Board.

Sensitivity: 100mV
Input Pulse Polarity: Negative (-)
Resolution: 10usec
Gain: 1 to 6, adjustable
Window Width: 50 mV to integral
Base Line Range: 0 - 5.5V

2.2.1.2.1.3 Alarm Circuit Board.

Accuracy: +5%
Contacts: (Pilot duty to activate alarm transfer relays. See paragraph 2.2.1.5.4.1. 5 amperes at 120V ac resistive

2.2.1.3 Start-Up Procedure.

The start-up procedure assumes; the channel has been properly installed including detectors, but with the detector high voltage lead properly disconnected, see 3.2.3,

2.2.2.1 General Description.

The 843-30 Gamma Scintillation Detector consists primarily of a sodium crystal (NaI) scintillation crystal optically coupled to a photomultiplier tube, a preamplifier and a metal housing. This detector is operated as part of a channel which also includes a companion 842 Series Ratemeter and a sampler which provides shielding and mounting for the detector.

2.2.2.2 843-20 and 843-20A Beta Scintillation Detectors. See Figure 2-52.

The 843-20 and 843-20A Beta Scintillation Detectors consist primarily of a beta sensitive plastic crystal optically coupled to a photomultiplier tube, a preamplifier and a metal housing. These detectors operate as a part of channels which also include a companion 842 Series Ratemeter and a sampler which provides shielding and mounting for the detector.

2.2.2.2.1 Performance Specifications.

The beta and gamma detector performance specifications are the same except for the scintillation crystal.

Housing: Weatherproof
Dimensions: 12 in. (30.5cm) long; 2.5 in. (6.35cm) outer diameter
Weight: 3 pounds (1.36 kg)
Photomultiplier Operating Voltage: 500 to 1400V (maximum)
Photomultiplier Operating Current: 100 microamperes (maximum)
Photomultiplier Resolving Time: 3 microseconds
Pgotomultiplier Output Pulse Polarity: Negative (-)
HV Connector: MHV Series UG 931/U
Signal Connector: AN3102E-16S-1P
Preamplifier:
  Operating Voltage: +16V dc
  Operating Current: 33 ma dc
  Input Impedance: 56 kohms
  Output Impedance: 9.3 ohms
  Input Pulse Polarity: Negative (-)
  Output Pulse Polarity: Negative (-)
  Signal Level: 0 - 5.5V-peak
  Gain: Approximately 25
Beta Detector Scintillation Crystal: NE 102; 2 in. (5.08cm) diameter by 0.1 in. (0.25cm) thick
  Temperature Limits: 32°F (0°C) to 120°F (50°C)
Gamma Detector Scintillation Crystal: NaI; 1.5 in. (3.81cm) diameter by 1 in. (2.54cm) thick
  Temperature Limits: 32°F (0°C) to 120°F (50°C) gradient must be less than 40°F (10°C) per hour

2.2.2.3 Start-Up Procedure.

There are no special procedures for the 843-30 gamma or 843-20, 843-20A beta detectors as they will be used as part of a channel with the companion 842 Series Ratemeters. Refer to paragraph 2.2.1.3 for start-up of the ratemeter.

2.2.2.4 Shut-Down Procedure.

Same as noted above in paragraph 2.2.2.3 except refer to paragraph 2.2.1.4 for emeter shut-down procedure.

2.2.2.5 Design Data and Description.

The primary differences between gamma and beta scintillation detectors are in the crystal structure and the mechanism by which the crystal interacts with various types of radiation to give off pulses of light.

2.2.2.5.1 Gamma Scintillator. See Figure 2-53.

Sodium iodide (NaI) crystals as used in the 843-30 gamma scintillation detector emit pulses (photons) of light when photons from radioisotopes entering the crystal interact with atoms of the crystal. The magnitude of the light pulse emitted by the crystal for a single radiation input event is dependent upon the characteristic gamma energy of the photon entering the crystal and which of the following conversion processes occurs.

1) Pair Production - an absorption process for X and gamma radiation in which the incident photon is annihilated in the vicinity of the nucleus of the absorbing atom, with subsequent production of an electron and positron pair. This reaction will only occur for incident photon energies exceeding 1.02 MeV. Energy greater than the 1.02 MeV required is imparted to the pair as kinetic energy which is presented to the crystal via ionization causing light to be emitted. The position will eventually combine with free electron (annihilation) and the energy of the two particles, in'uding rest energy, is converted into electromagnetic radiation called annihilation iation. This process is not very prevalent with photon energies less than 2 MeV.

2) Compton Scattering - an attenuation process observed for X and gamma radiation in which an incident photon interacts with an orbital electron of a crystal atom to produce a recoil electron and a scattered photon of energy less than the incident photon. The recoil electron causes low energy secondary ionization of the crystal atoms resulting in Compton Smear.

3) Photoelectric Process - a process by which an incident photon ejects an electron from an atom. All of the energy of the photon is absorbed and imparts kinetic energy to the electron. The ejected electron travels an ionization path within the crystal resulting in a light output proportional to the incident photon energy.

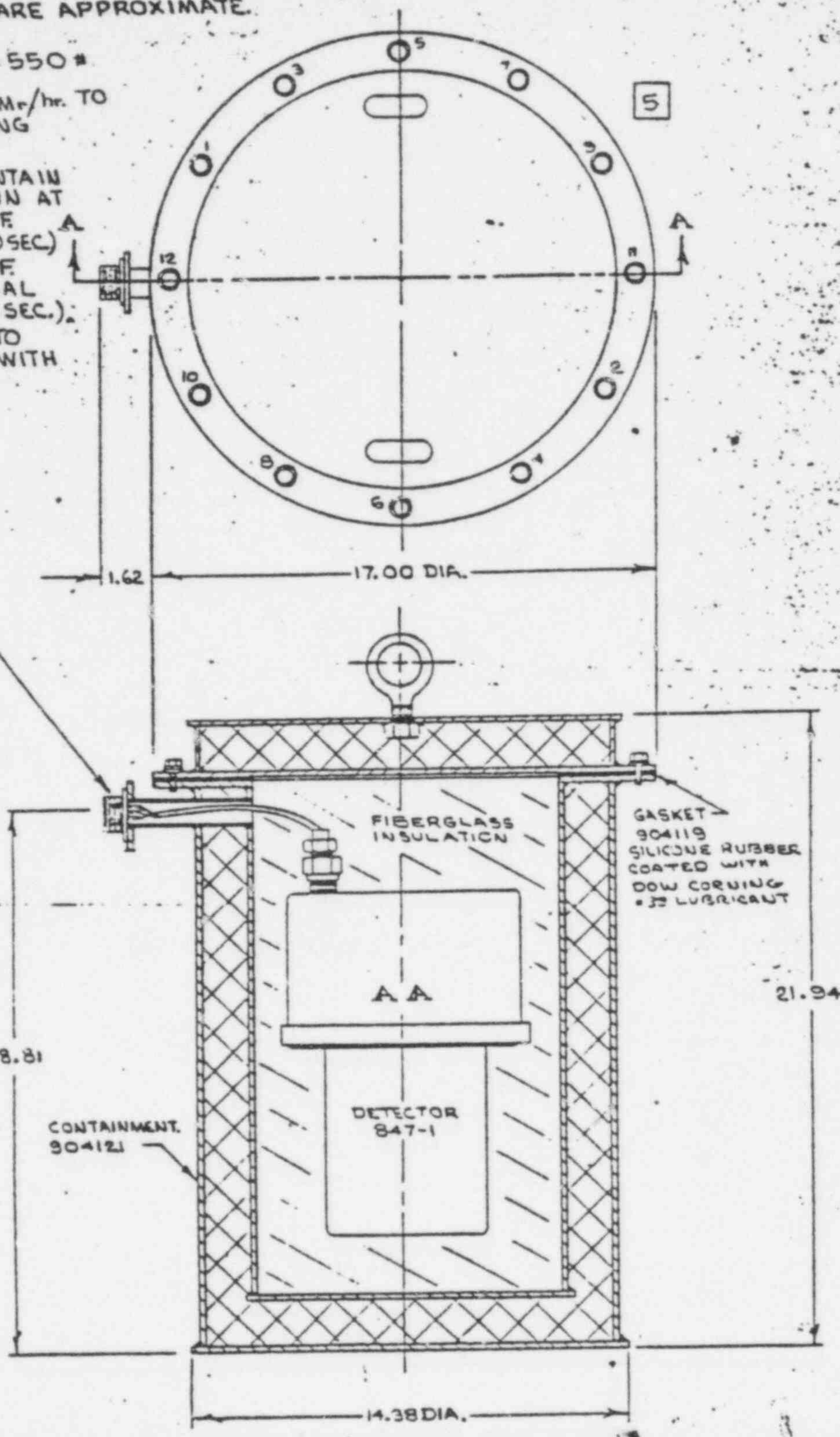
The photoelectric process is important because the proportional crystal light output for a given incident photon energy input allows qualitative determinations to be made of the isotope or isotopes near the sensitive portion of the detector. Since each radionuclide emits photons of characteristic energies, a device sensitive to the characteristics of those photon energies may form the basis of either a quantitative (gross or all energies) indicating system or a qualitative (analyzer or differential) indicating system. See also the ratemeter section of this manual, paragraph 2.2.1.

The scintillation crystal is coupled to the sensitive portion of the photomultiplier (PM) tube via a lucite light pipe and optical coupling grease. Photons of ht from the crystal travel through the light pipe and impinge upon the photohode of the PM tube where one or more electrons are ejected.

904120

NOTES:

1. ALL DIMENSIONS ARE APPROXIMATE.
2. APPROX. WEIGHT ~ 550 #
3. ATTENUATION 10^9 Mr/hr. TO 10^7 Mr/hr IN HOUSING
4. THIS UNIT WILL MAINTAIN NORMAL OPERATION AT 50.5 PSIG. @ 280°F FOR 50 MIN. (3000 SEC) AND 6 PSIG @ 160°F FOR AN ADDITIONAL 24 HOURS (86,400 SEC.)
5. TORQUE BOLTS TO 120 IN.-POUNDS WITH 1-12 PATTERN.



904120

REVISIONS

REV LET	DESCRIPTION	DATE
A	"AS BUILT" REVISIONS -76	5/4/76

MICROFILMED
ANY REVISION TO THIS DRAWING REQUIRES NEW DRAWING BE RE-MICROFILMED

POOR ORIGINAL

NOV 1 1976

749077

ITEM | PART NO. | QUAN | DESCRIPTION

UNLESS OTHERWISE SPECIFIED.
FRACTIONAL DIMENSIONS ± .018
DECIMAL DIMENSIONS: .XX = ± .018 · .XXX = ± .008
ALL OTHER TOLERANCES PER VICTOREEN INSTRUMENT DIV. DWG. NO. 801775

VICTOREEN INSTRUMENT DIVISION
10101 WOODLAND AVE. CLEVELAND, OHIO 44104

NAME AREA MONITOR CONTAINMENT ASS'Y.

MATERIAL S

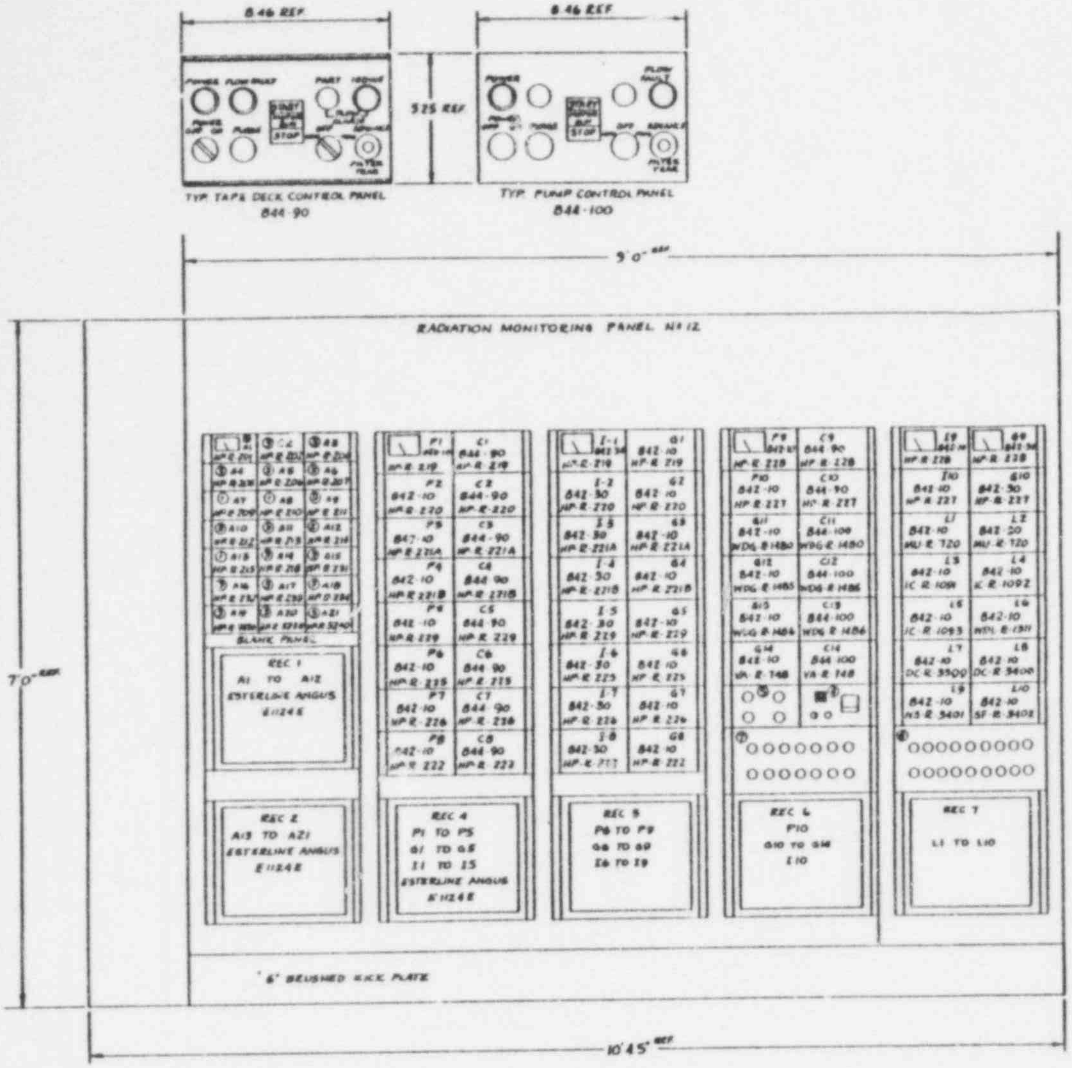
FINISH S

WHERE USED E-77120 RM-AB
MET. EDISON

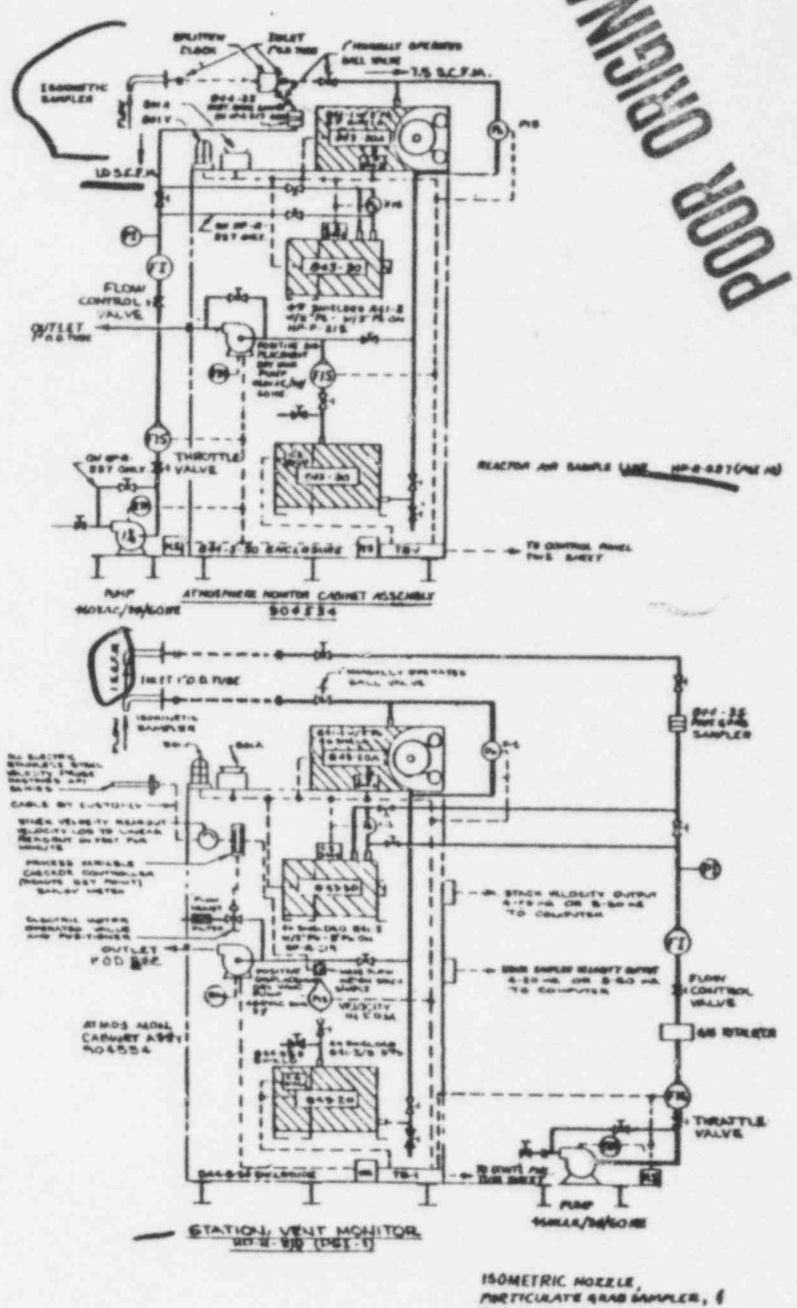
DR. WJN
CHKD
APPR
SCALE 1/4
DATE 10-18-71
DWG. NO. 904120

7439078

POOR ORIGINAL



① READOUT 904150 ONLY, BASE UNIT LOCATED PER SH 1 OF THIS DWG
② 846-1 BASE UNIT
③ 856-E BASE UNIT
④ ANNUNCIATOR ALARM & CONTROL PANEL
⑤ VALVE V1 + V9** POSITION INDICATOR PANEL
⑥ LIQUID SAMPLER L1 THRU L10 FLOW STATUS INDICATOR PANEL
⑦ 14 "NORMAL-DEFEAT" KEYLOCK SWITCHES MOUNTED IN PANEL CHASSIS AND WIRED TO TERMINAL BLOCKS: HP-R-219, -220, -221A, -221B, -222, -225, -226, -228, -229; WDG-R-1480, -1485, -1486; VA-R-148; WDL-R-1311.



ISOMETRIC NOZZLE, PARTICULATE GRAB SAMPLER, & PLANT IODINE MONITOR WITH CONSTANT 1.00 S.C.F.M. IODINE SAMPLE FROM SAMPLE LINE.

Figure 3-25. Cabinet Outline. Drawing #904148. .et 2 of 2

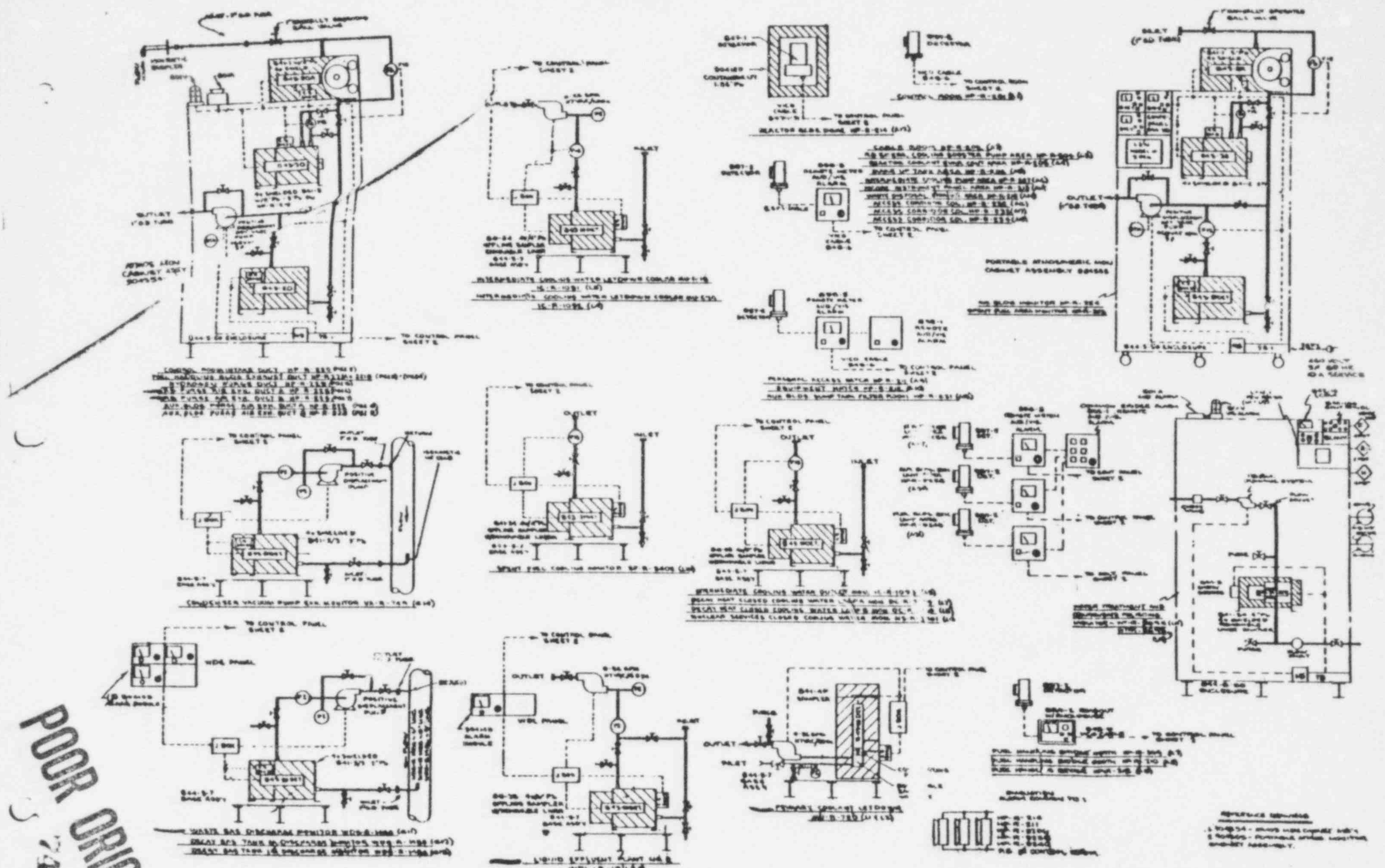


Figure 3-24. System Diagram, Drawing #904148, Sheet 1 of 2

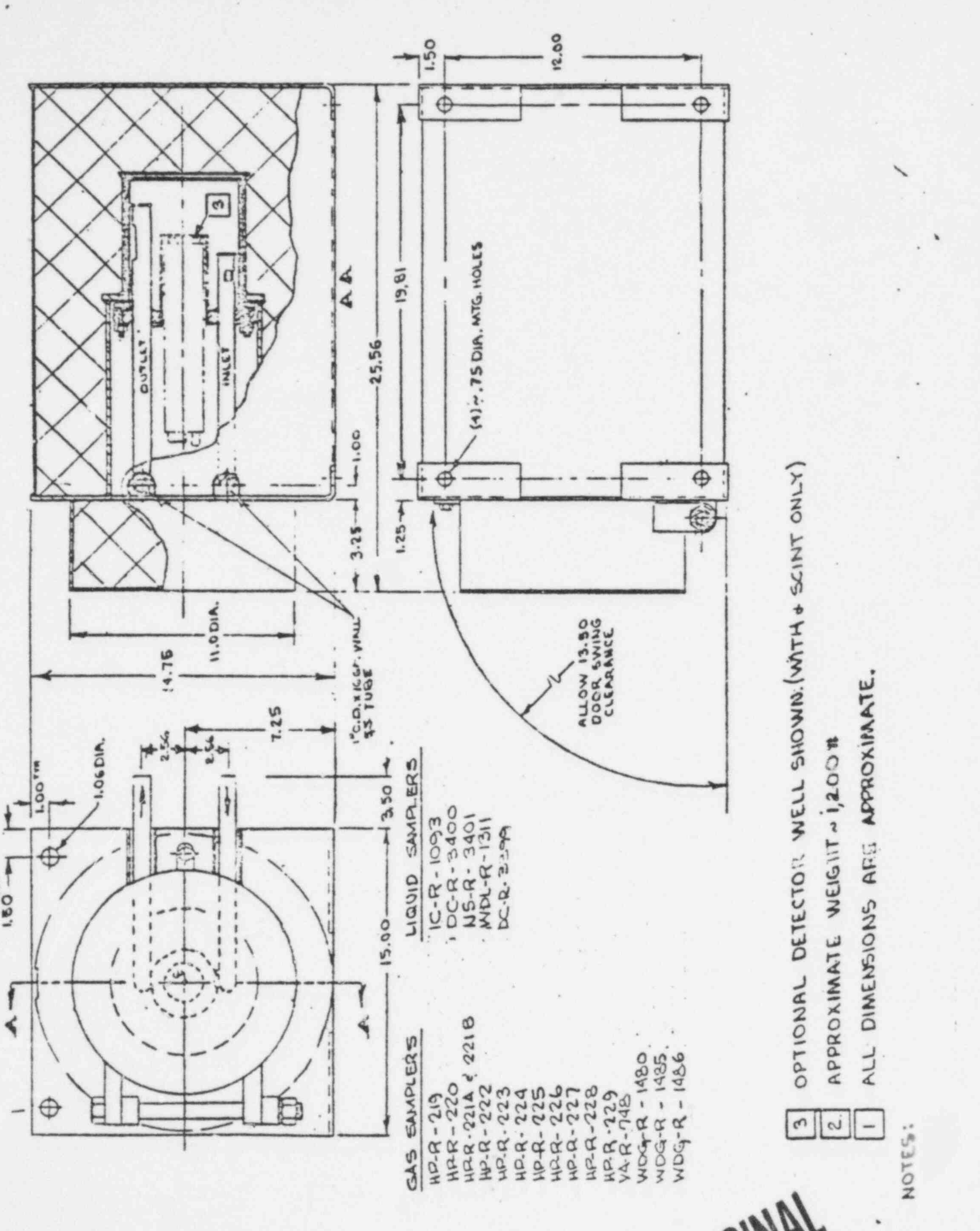


Figure 3-26. 4π Shield, Dimensional Outline

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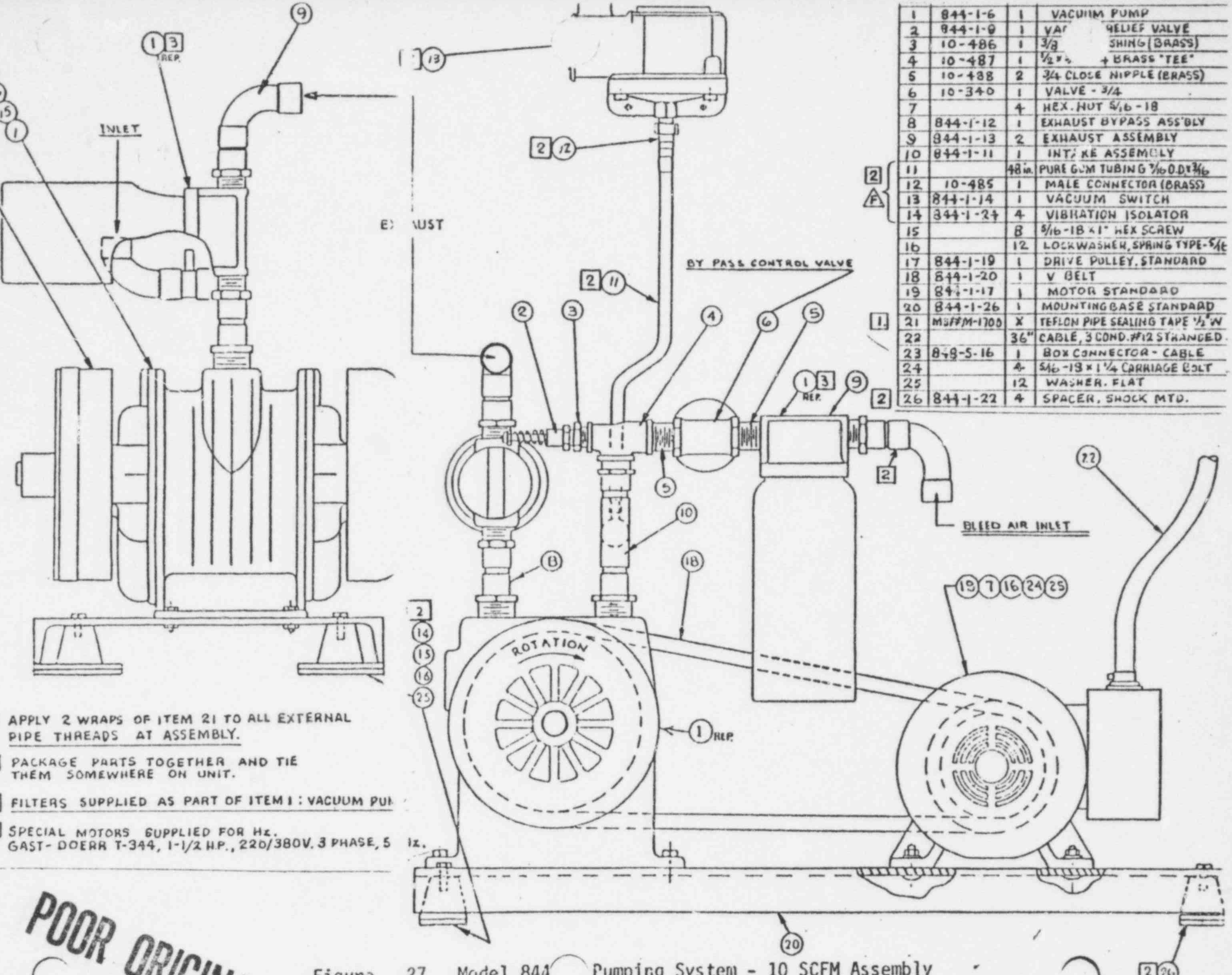
749080

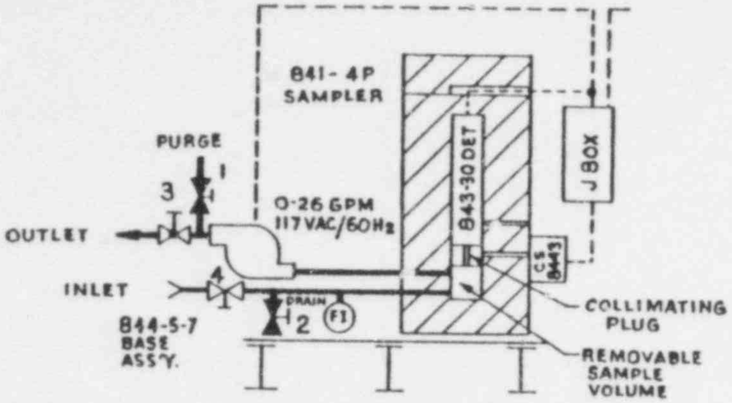
	1	844-1-6	1	VACUUM PUMP
	2	844-1-9	1	VA[illegible] RELIEF VALVE
	3	10-486	1	3/8 [illegible]SHING (BRASS)
	4	10-487	1	1/2 × [illegible] + BRASS "TEE"
	5	10-488	2	3/4 CLOSE NIPPLE (BRASS)
	6	10-340	1	VALVE - 3/4
	7		4	HEX. NUT 5/16 - 18
	8	844-1-12	1	EXHAUST BYPASS ASS'BLY
	9	844-1-13	2	EXHAUST ASSEMBLY
	10	844-1-11	1	INTAKE ASSEMBLY
2 F	11		48 in.	PURE GUM TUBING 7/16 O.D. × 3/16
	12	10-485	1	MALE CONNECTOR (BRASS)
	13	844-1-14	1	VACUUM SWITCH
	14	844-1-24	4	VIBRATION ISOLATOR
	15		8	5/16-18 × 1" HEX SCREW
	16		12	LOCKWASHER, SPRING TYPE-5/16
	17	844-1-19	1	DRIVE PULLEY, STANDARD
	18	844-1-20	1	V BELT
	19	844-1-17	1	MOTOR STANDARD
	20	844-1-26	1	MOUNTING BASE STANDARD
1.	21	MSFFM-1700	X	TEFLON PIPE SEALING TAPE 1/2" W
	22		36"	CABLE, 3 COND. #12 STRANDED.
	23	848-5-16	1	BOX CONNECTOR - CABLE
	24		4	5/16-18 × 1 1/4 CARRIAGE BOLT
	25		12	WASHER. FLAT
2	26	844-1-22	4	SPACER, SHOCK MTD.



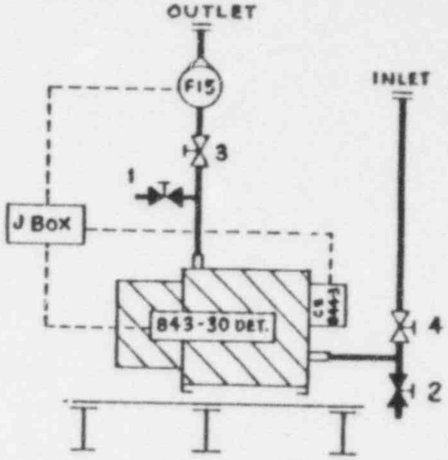
NOTES.

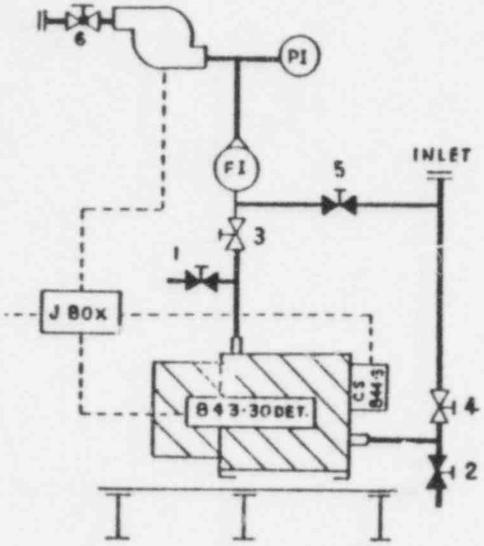
1. APPLY 2 WRAPS OF ITEM 21 TO ALL EXTERNAL PIPE THREADS AT ASSEMBLY.
2. PACKAGE PARTS TOGETHER AND TIE THEM SOMEWHERE ON UNIT.
3. FILTERS SUPPLIED AS PART OF ITEM 1 : VACUUM PU
4. SPECIAL MOTORS SUPPLIED FOR Hz. GAST-DOERR T-344, 1-1/2 HP., 220/380V. 3 PHASE, 5 Hz.

Figure 27. Model 844 Pumping System - 10 SCFM Assembly



PRIMARY COOLANT LETDOWN
MO-R-720 (LI &L2)





	Valve #1		Valve #2		Valve #3		Valve #4		Valve #5		Valve #6	
	Open	Closed	Open	Closed	Open	Closed	Open	Closed	Open	Closed	Open	Closed
Operate		X		X	0		0			X	0	
Isolate		X		X		X		X	0		0	
Purge	0		0	X		X		X	0		0	
Decontaminate Solution	0		0	X		X		X	0		0	
Remove Volume		X		X		X		X		X		X
Drain	0		0			X		X		X		X
Flushing	0		0			X		X		X		X
Return To Service		X		X	0		0			X	0	
By-Pass Sampler		X		X		X		X	0		0	

Figure 3-28. Liquid Monitor Valve Sequence Table

3.2.5.2.4 Disassembly.

To replace the carbon vanes or inspect the pump interior only the dead end plate opposite the drive shaft end should be removed. Remove the end cap screws, end cap and rotor spacers. In models 1550 and 3040, the dowel pins may be driven through with a punch.

The bearing and bearing shim will come off with the end plate, but before removing the bearing from the end plate mark the face of the bearing, DO NOT use a sharp instrument, so it can be replaced exactly as removed. Take care not to damage the felt seal washer when removing it. The end plate should be removed with an end plate puller to avoid damage to the end plate or body surfaces. Contact the Gast factory for additional puller information.

With the pump interior accessible, remove the old vanes and insert the new ones with the beveled edge fitting the bore. Also inspect the interior for obvious signs of damage.

3.2.5.2.5 Assembly.

Loosen the end cap screws on the drive end before replacing the dead end plate. Turn the pump to a vertical position, drive end down to permit the rotor to rest flush on the drive end plate. If necessary, apply pressure on the dead end of the rotor shaft to help contact the drive end. Replace the dead end plate and bolts. Tighten every third or fourth bolt around the circumference.

Insert the seal washer in the undercut and push the bearing shim and bearing squarely down to the shaft shoulder with a pusher tool and arbor press. Replace the spacers and end cap insuring all paint, dirt, burrs, etc. are removed from the end cap and surface of the end plate. Insert and tighten the end cap screws.

Return the pump to a horizontal position and tighten the end cap screws on the drive end bringing the rotor back to the original position. Check by hand for free rotor movement. If the rotor binds recheck the assembly procedure to insure proper sequence of parts installation.

3.2.5.3 Other Mechanical and Electrical Components.

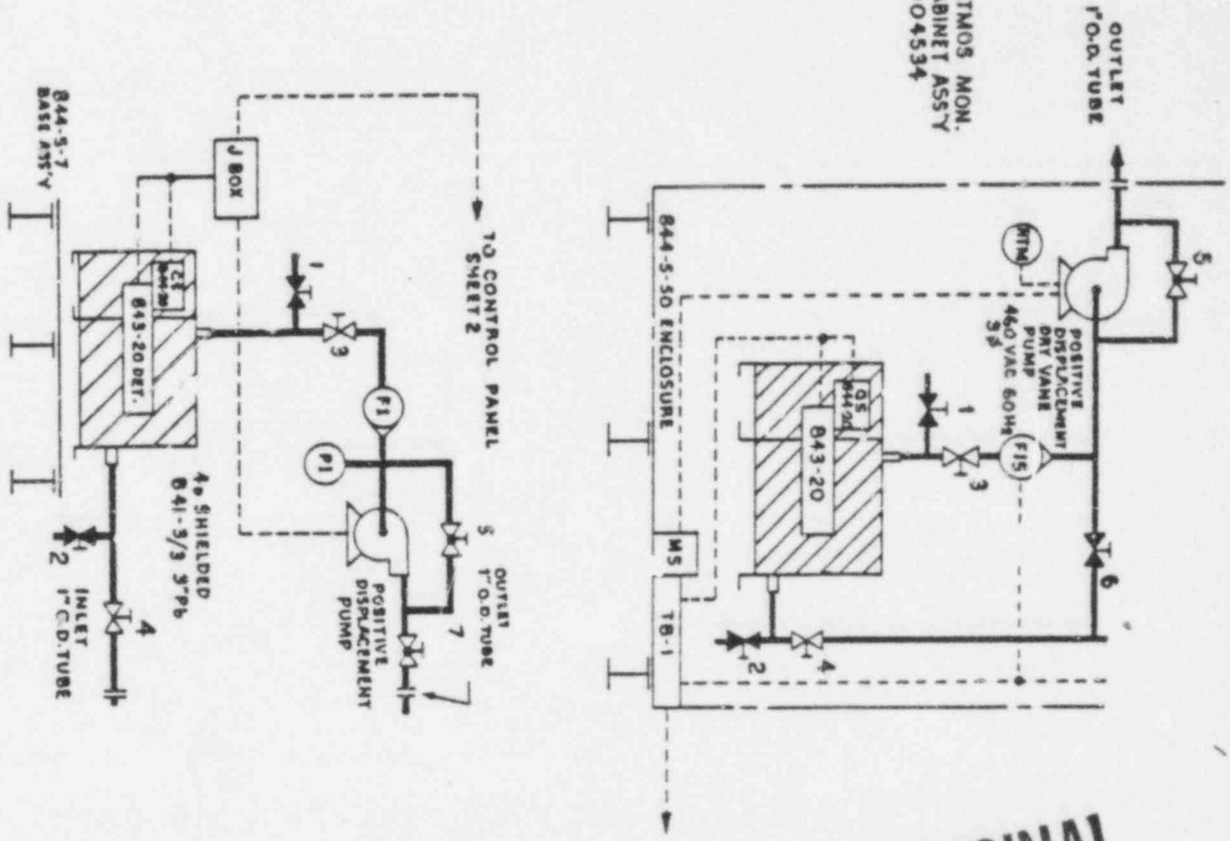
[illegible] Wi exception of the motor starter contact set. Other mechanical and electrical components should be replaced rather than attempting repairs unless unforeseen conditions dictate otherwise. Refer to Section IV for recommended spare parts list.

3.2.6 Atmospheric Monitors

Routine maintenance to be performed on atmospheric monitor systems consists mainly of changing filters. Frequency of change will depend on usage (paper speed, continuous operation, etc.).

3.2.6.1 841-1 Continuous Filter Air Sampler. See Figures 3-27, 3-30, and 3-34.

The continuous filter air sampler will require filter changes on approximately a monthly basis. The exact interval will depend upon the filter advance cycle selected and the number of fast advances performed.



	Valve #1	Valve #2	Valve #3	Valve #4	Valve #5	Valve #6	Valve #7
Operate	X	X	0	0	X	0	
Isolate	X	X	X	X	X	X	X
Purge	X	0	0	X	0	X	0
Decontaminate Solution	0	0	X	X	0	X	0
Remove Volume	X	X	X	X	X	X	X
Drain	0	0	X	X	0	X	0
By-Pass Sampler	X	X	X	X	0	0	0
Return To Sampler	X	X	0	0	0	X	0

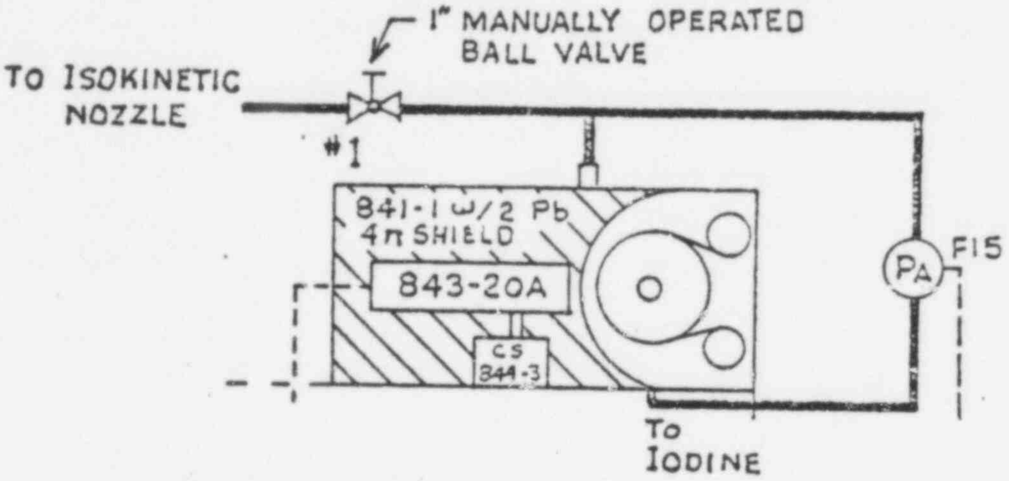
Figure 3-29. Gas Monitor Valve Sequence Table

CAUTION

The spent filter may contain radioactive material and should be checked by health physicist prior to removal.

3.2.6.1.1 Filter Change.

1. Turn off the sample pumping system, isolate the monitor per the valve sequence table of Figure 3-30, and remove the sampler lid by releasing the spring catches. Do not attempt to remove the sampler lid from the system with an operating vacuum pump.



	Valve #1	
	Open	Closed
Operate	0	
Isolate		X
Replace Filter		X
Return To Sampler	0	

Figure 3-30. Air Sampler Valve Sequence Table

2. Remove the takeup spool retaining nut and plate.

3. Remove the filter and place it in a suitable container.

4. Remove the lead shielding block from the top of the capstan drum by lifting straight up.

5. Remove the retaining nut and washer from the supply spool.

6. Move the filter roll hub from the supply spool to the takeup spool ensuring that it is properly seated in the notch.

7. Place the fresh filter on the supply spool and thread per Figure 3-32. Insure the filter gauze backing side is toward the capstan before threading.

8. Insure the filter is properly fixed to the takeup spindle or the spent filter will not be properly wound during operation.

9. Replace the takeup plate, retaining nut, and lead shielding block, being careful to properly position the lead shielding block with respect to the alignment pins, the supply washer, and retaining nut.

10. Operate the fast advance controls until satisfactory filter motion is observed.

11. Replace the sampler lid, return the valves to the operate position, and restart the pump.

3.2.6.1.3 Decontamination.

It is possible during filter change and from normal use for a small amount of radioactive material to build up on various parts near the sample inlet and filter paper. Periodically health physics personnel should survey the interior of the sampler with the filter removed. If decontamination is required, it should be performed by persons cognizant of decontamination procedures and methods. The unit should not be disassembled unless absolutely necessary for successful decontamination and even then, remove as few parts as possible to complete decontamination.

3.2.6.2 841-2 Iodine Sampler.

The iodine filter should be changed as required by the iodine ratemeter reading or standard plant operating procedures.

3.2.6.2.1 Filter Change.

1. Shut down the pumping system and/or isolate and by-pass the iodine sampler by sequencing the valves as shown in Figure 3-31.

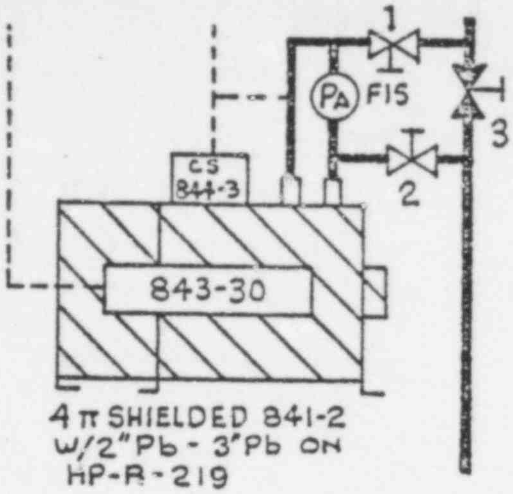
2. Loosen the 2 bolts fixing the filter holder to the sampler. See Figure 3-33 and remove the holder by turning to the left and pulling straight out of the shield.

3. Unscrew the top portion of the filter holder and remove the iodine filter cartridge.

4. Replace the spent cartridge with a fresh one and reverse the above procedure to return the unit to service.

3.2.6.2.2 Decontamination.

Contamination of the iodine sampler is very unlikely and if suspected should be surveyed by a health physicist. If decontamination is required, follow the steps 3.2.6.2.1 and decontaminate the unit while the filter is removed. Only persons cognizant of decontamination procedures and methods should attempt decontamination of the unit.



	Valve #1 Open	Valve #1 Closed	Valve #2 Open	Valve #2 Closed	Valve #3 Open	Valve #3 Closed
Operate	O		O			X
Isolate		X		X	O	
Removed Connection		X		X	O	
Return To Service	O		O			X

Figure 3-31. Iodine Sampler Valve Sequence

3.2.6.3 841-33 Gas Sampler.

The gas sampler used in the atmospheric monitoring system carries the same sample volume as that of the liquid monitors. The only maintenance which may be necessary to the gas samplers would be air purge and/or decontamination of the sample volumes. Air purge may be initiated by appropriate valve sequencing. See Figure 3-29.

If decontamination of the sample volumes becomes necessary they must be processed per paragraphs 3.2.3.1.4 step 2 through 10, following shut down and isolation of the gas sampler per Figure 3-29.

3.2.6.4 844-1 Pumping System.

The pumping system is identical to that covered under paragraph 3.2.4.2 which should be referred to for maintenance details. Shut down the pumping system and isolate the atmospheric monitors per Figure 3-27 prior to performing any pump maintenance.

3.2.6.5 Local Control Panel.

Maintenance of the local control panel will be limited to indicator lamp replacement and relay replacement due to contact wear.

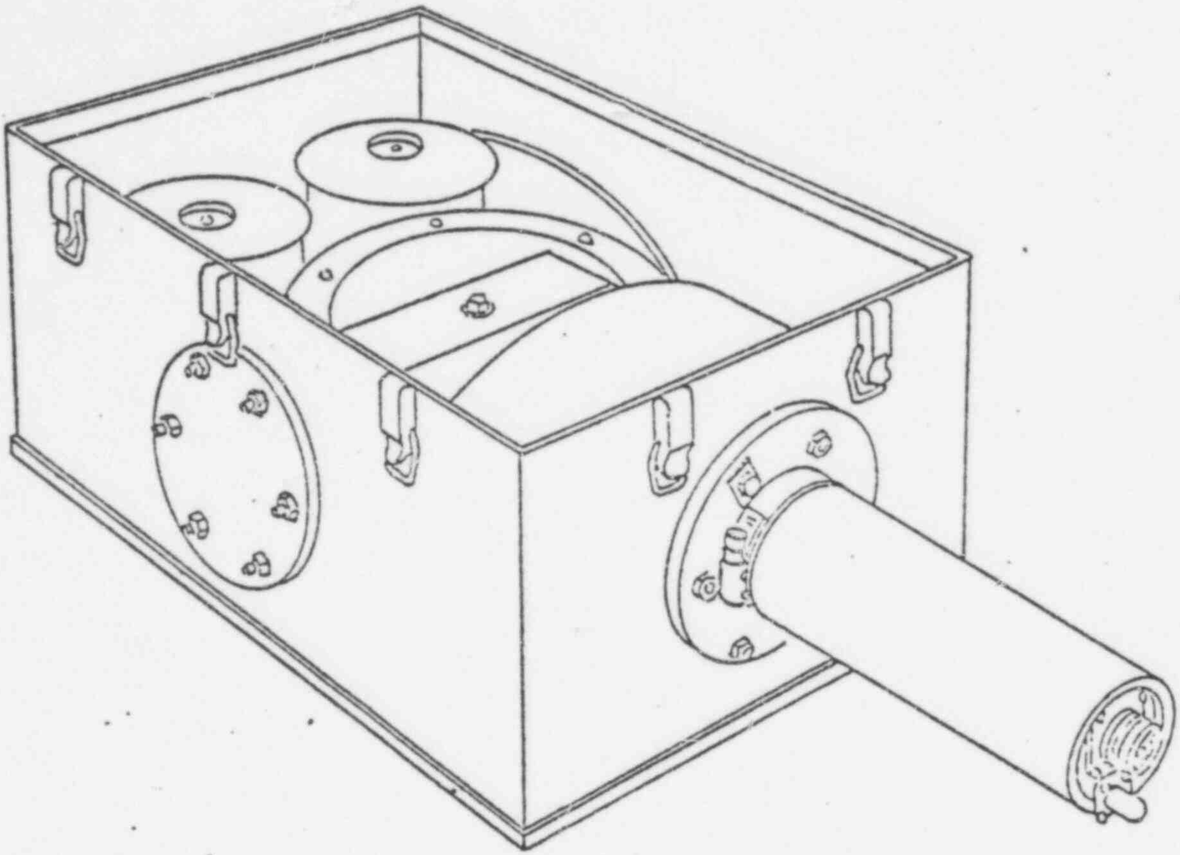


Figure 3-32. Continuous Air Sampler

3.2.6.6 Sample Flow Control System - Automatic Atmospheric Monitor.

The flow control devices used on the automatic isokinetic atmospheric monitor are covered in the manufacturers catalog section of this manual. Refer to the vendors manuals for maintenance details. Also refer to drawing 904549, sheets 1, 2, 3, and 4 and Figure 3-34.

Gas Flow Pump, #AF1-6KX - Hastings
Mass Flow Meter, #AHL-10C - Hastings
Basic Controller, #701 - Gelmac
Miniature Servo Recorder, #732 - Gelmac
Servo Amplifier, #A630 - Dahl
Motor Assembly, #SS-250 - Superior
dc Power Supply, #762 - Bailey
Signal Transmitter, #SC-1300 - Rochester
Signal Transmitter Isolator, #SC-1302 - Rochester
Differential Switch Catalog - Barksdale

3.2.6.6.1 Calibration.

Before turning on main power preset the 844-90 control panel as follows:

1. 844-90 auxiliary moving filter control panel; motor control HAND-OFF-AUTO switch to OFF.

2. Advance switch to OFF.

3. Local power switch to OFF.

3.2.6.6.2 844-90 Control Panel for HP-R-219 In Control Panel 12.

1. Program switch in NORMAL

2. Power switch to ON.

3.2.6.6.3 844-100 Control Panel - Iodine.

1. Turn motor control switch HAND-OFF-AUTO to the OFF position.

2. Turn power switch ON.

3.2.6.6.4 844-90 Auxiliary Moving Filter Control Panel.

1. Turn power switch ON. The automatic monitor is now on except for the pumping systems which will start after calibration.

3.2.6.6.5 Calibration - Cascade Input.

After unit is powered up calibrate the cascade input loop and the process variable loop in the following sequence:

1. Zero and calibrate the Hastings Gas Flow Probe as outlined in the manual listed in paragraph 3.2.6.6.

NOTE

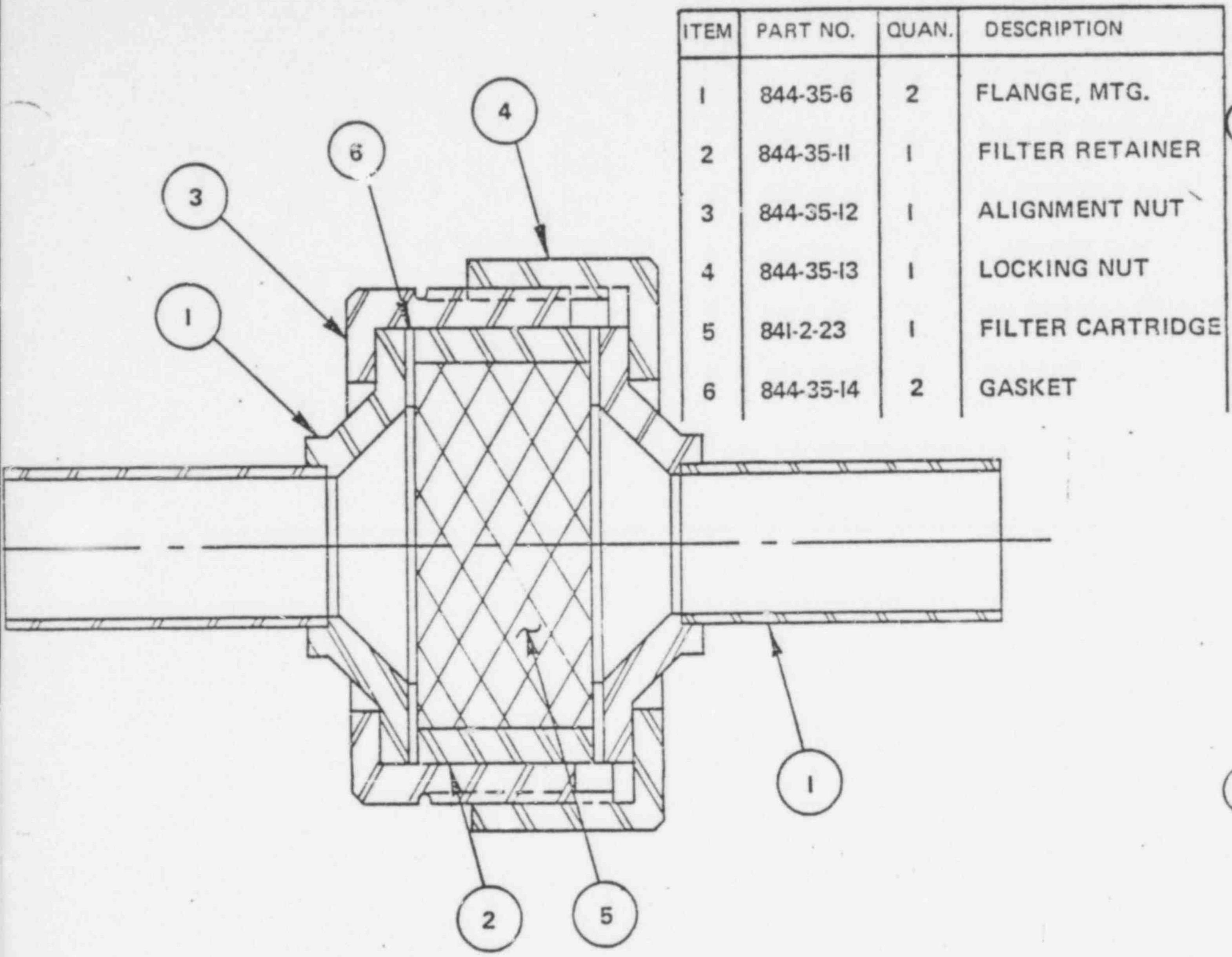
In this system the purge system with the stack flow probe is not used. See Dwg. 904549, sheet 2 and Figure 3-34.

2. Remove the signal input and signal ground from the stack flow probe, TB1 #6 & 7, Figure 3-35 and calibrate using a dc power supply and a digital voltmeter-ammeter. Use the calibration sheets in Figure 3-36, schematic drawing 906148, Figure 3-37 and 3-38. After calibration install the signal input to TB1 #6 & 7.

NOTE

This calibration is performed at 500 through 2500 fpm which is the range of the stack flow.

3. Remove the linearizer output leads from the linearizer TB1 #4 & 5 (10 - 50 ma). Figure 3-35, 3-37, and drawing 906148.



ITEM	PART NO.	QUAN.	DESCRIPTION
1	844-35-6	2	FLANGE, MTG.
2	844-35-11	1	FILTER RETAINER
3	844-35-12	1	ALIGNMENT NUT
4	844-35-13	1	LOCKING NUT
5	841-2-23	1	FILTER CARTRIDGE
6	844-35-14	2	GASKET

Figure 3-33. Inline Iodine Filter Assembly

Apply an input signal to the RIS SC-1302 Isolator and calibrate at zero and full scale. (10 - 50 ma). Refer to service manual.

4. After the isolator is calibrated, adjust the 2-pen recorder so that it tracks this same 10 - 50 ma signal applied to the isolator. Refer to service manual.

5. After the recorder is calibrated measure the voltage input of the cascade input on the controller terminal board (on guard rail) pin #6 (+) and pin #4 (common). 10 - 50 ma should correspond to 1 to 5V. After this cascade loop is calibrated go to the process variable side of the system.

3.2.6.6.6 Calibration Process Input.

1. Zero and check the Hastings Mass Flow Meter as outlined in the service manual, drawing 904549, sheet #2 and Figure 3-34.

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2. Remove the 0 - 5V input signal from the mass flow meter on signal transmitter #3, a Rochester SC-1300, TB1 #1 (-) and TB1 #2 (+). Refer to service manual and drawing 904549, sheet #2 and Figure 3-37 and using a power supply, calibrate

the zero and full scale signal of the SC-1300 0 - 5V input = 10 - 50 ma output.

NOTE

Leave power supply attached for recorder and isolator calibrations.

3. After the signal transmitter #3 is calibrated (10 - 50 ma), adjust the recorder to track the signal transmitter 0V is = to 10 ma = 0 fpm. 5V is = 50 ma = 3300 fpm. Reference service manual, drawing 904549, sheet #2 and Figure 3-37.

4. After the recorder calibration 0 - 3300 fpm, adjust the signal isolator #2 so that zero and full scale are calibrated using the power supply. Refer to service manual, drawing 904549, sheet #2, and Figure 3-37. 0V = 10 ma transmitter = 10 ma isolator, 5V = 10 ma transmitter = 10 ma isolator.

5. After the recorder and isolator are calibrated, measure the voltage input of the process variable input on the controller terminal board (on guard rail) pin #5 (+) and pin #4 (common). 10 - 50 ma should correspond to 1 - 5V. After the process loop is calibrated, go to the controller output loop.

3.2.6.6.7 Calibration Output.

1. Place controller in the manual mode, drawing 904549, sheet #2. measure output of controller as follows:

a) Depress left button marked OPEN and move the panel meter until it reaches zero. This should be 4.0 ma measured on controller TB pin #8 (+) & #9 (-) or 1.0V across Dahl valve operator input. Set controller for 4.0 ma or 1.0V.

b) Depress right button marked CLOSED and move the panel meter until it reads 100% full scale, this should be 20 ma on output TB or 5V measured at input.

2. Servo amplifier calibration, refer to service manual. Dahl servo amplifier (located behind blank panels). Turn power on and place operate switch in the AUTO position. Adjust the controller to 0% manually (4.0 ma output). Adjust electric valve for the CLOSED position. Adjust the controller to 100% manually (20 ma output). Adjust Diehl valve for the OPEN position.

3. Calibration is completed. Remove test leads.

3.2.6.6.8 Placing In Service.

1. Using the controller in the MANUAL mode adjust valve output to 50%.

2. Place continuous filter pump switch in the AUTO position.

3. Place iodine pump switch in the AUTO position.

4. Start pump from main control panel (panel 12).

5. After both pumps are running note stack flow in cfm.

6. Note sample flow in cfm.

7. Transfer the controller from the MANUAL mode to the AUTOMATIC mode.

8. Sample flow should automatically self adjust to stack flow. Unit is now operating properly and will automatically compensate for variances in stack flow and filter build-up.

9. Refer to Barksdale catalog section for pressure switch adjustments on flow alarms.

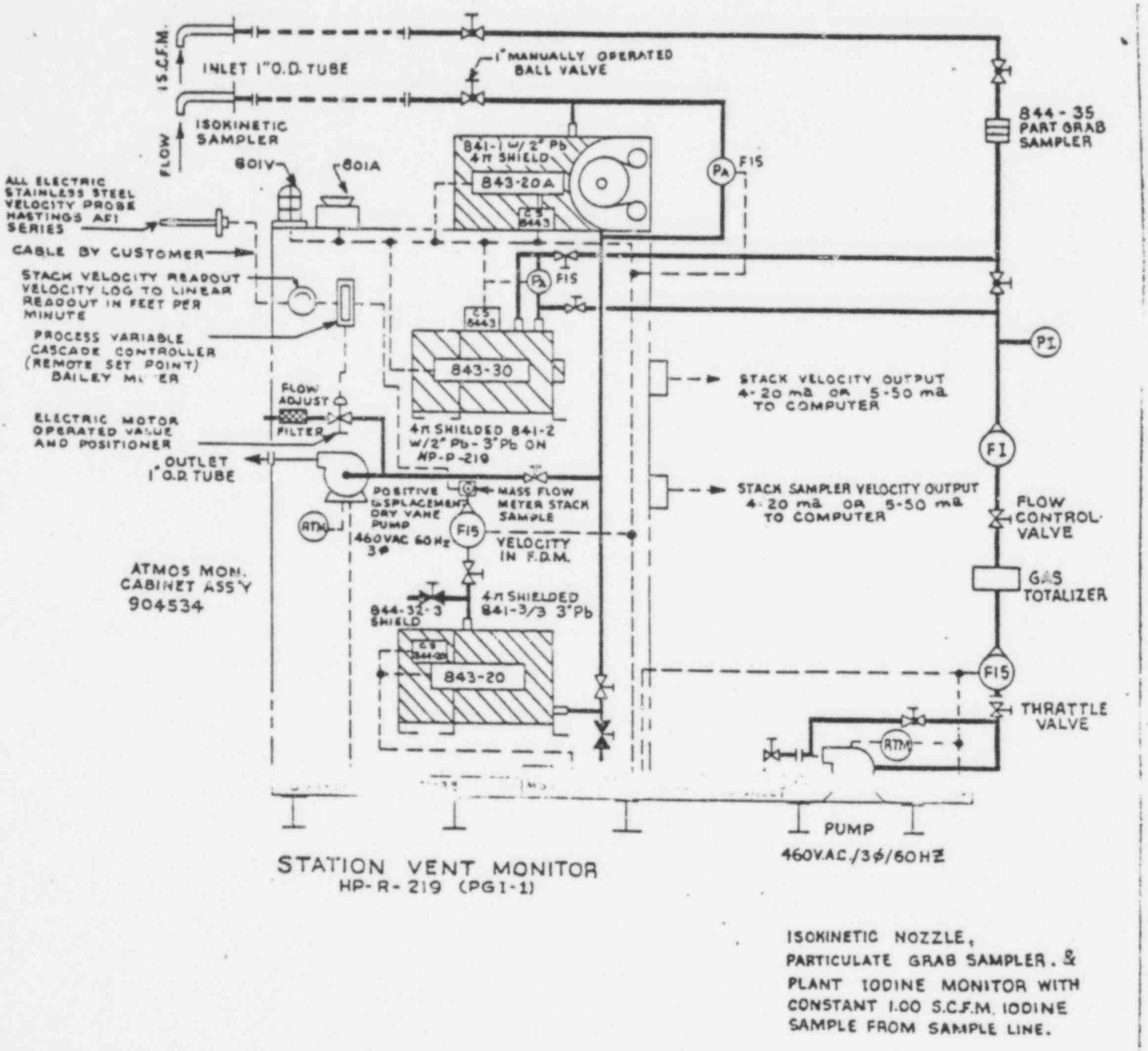

Figure 3-34. Station Vent Monitor HP-R 219 (PGI-1)

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TMI I STANDARD CALIBRATION FIXTURE

Background: Binary Counts 2131 Min. 20 = 213 CPM

Source	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
(Cal. Sources)						
^{133}Ba No. 177	.5		219271	2	219271	219058
^{133}Ba No. G-177	.05		38877	2	38877	38664
^{137}Cs No. 177	.5		139227	2	139227	139014
^{137}Cs No. G-177	.05		9448	2	9448	9235
(Linearity Sources)						
^{133}Ba No. #A	4.18		178371	2	178371	178158
^{133}Ba No. #D	.115		5185	2	5185	4972
^{133}Ba No. #I	.0041		4003	20	400	187
(Energy Response Sources)						
^{133}Ba No. SP-2	8		35576	2	35 576	35363
^{137}Cs No. SA-2	8		32063	2	32 063	31850
^{60}Co No. SP-2	8		47922	2	47 922	47709

POOR ORIGINAL

TMI II SAMPLER HP-R-220-

GROSS CHANNEL - UNATTENUATED

Background: Binary Counts 68 Min. 2 = 68 CPM

Source (Cal Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No. 177	.5		220683	2	220683	220615
^{133}Ba No. G-177	.05		38818	2	38818	38750
^{137}Cs No. 177	.5		139101	2	139101	139033
^{137}Cs No. G-177	.05		9265	2	9265	9197
Operational Check Source	8		3158	2	3158	3090

Background to .5 mR/hr ^{137}Cs 8 CPM
Background to 1.5 mR/hr ^{137}Cs 24 CPM

GROSS CHANNEL - ATTENUATED

Background: Binary Counts 56 Min. 2 = 56 CPM

Source (Cal Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No. 177	.5		225871	2	225871	225815
^{133}Ba No. G-177	.05		39577	2	39577	39521
^{137}Cs No. 177	.5		137715	2	137715	137659
^{137}Cs No. G-177	.05		9215	2	9215	[illegible]
Operational Check Source			2789	2	2789	2733

Background to .5 mR/hr ^{137}Cs 7 CPM
Background to 1.5 mR/hr ^{137}Cs 14 CPM

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CALIBRATION DATA SHEET

PROJECT TMI-2 Customer P.O. No. C-0132
Customer Burns + Roe Victoreen Job No. E-7522
Prepared By Don Strenio Date 5/29/75

CHANNEL DESCRIPTION Primary Coolant Letdown (Failed Fuel) - Channel with Analyzer Switch
CHANNEL NO. MU-R-720
Sampler Model No. 841-4P Serial No. N/A Type Failed Fuel
Detector Model No. 843-30 Serial No. 282 Type Gamma
Ratemeter Model No. 842-30 Serial No. 766 Type Log
^{133}Ba and ^{137}Cs Calibration Source Serial No. 177
Operational Check Source: Type ^{137}Cs Approximate µCi 8

VICTOREEN STANDARD PIG CALIBRATION FIXTURE

Background: Binary Counts 108 Min. 2 = 108 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
Vico Std. ^{133}Ba			12568	2	12568	12460
^{133}Ba No. 177	.5		141680	2	141680	141572
^{133}Ba No. 6-177	.05		21359	2	21359	21251
^{137}Cs No. 177	.5		87576	2	87576	87468
^{137}Cs No. 6-177	.05		5303	2	5303	5195

Clip Level .20 Volts P.M. High Voltage Set by the Gross Channel

POOR ORIGINAL

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TMI I STANDARD CALIBRATION FIXTURE

Background: Binary Counts 2/92 Min. 20 = 210 CPM

Source	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
(Cal. Sources)						
^{133}Ba No. 177	.5		223272	2	223272	223062
^{133}Ba No. 6-177	.05		39531	2	39531	39321
^{137}Cs No. 177	.5		180280	2	180280	180070
^{137}Cs No. 6-177	.05		9494	2	9494	9284
(Linearity Sources)						
^{133}Ba No. #A	4.18		179631	2	179631	179421
^{133}Ba No. #D	.115		5259	2	5259	5049
^{133}Ba No. #—	.0041		3403	20	390	180
(Energy Response Sources)						
^{133}Ba No. SR-2	8		35775	2	35775	35565
^{137}Cs No. SR-2	8		32394	2	32394	32184
^{60}Co No. SR-2	8		48231	2	48231	48021

TMI II SAMPLER MU-R-720.

POOR ORIGINAL

GROSS CHANNEL - UNATTENUATED

Background: Binary Counts 66 Min. 2 = 66 CPM

Source (Cal Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No. 177	.5		223544	2	223544	223478
^{133}Ba No. 6-177	.05		39713	2	39713	39647
^{137}Cs No. 177	.5		180359	2	180359	180293
^{137}Cs No. 6-177	.05		9820	2	9820	9754
Operational Check Source	8		3166	2	3166	3100

Background to .5 mR/hr ^{137}Cs 9 CPM

Background to 1.5 mR/hr ^{137}Cs 24 CPM

GROSS CHANNEL - ATTENUATED

Background: Binary Counts 57 Min. 2 = 57 CPM

Source (Cal Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No. 177	.5		220178	2	220178	220121
^{133}Ba No. 6-177	.05		39765	2	39765	39708
^{137}Cs No. 177	.5		136442	2	136442	136385
^{137}Cs No. 6-177	.05		9181	2	9181	9124
Operational Check Source			2742	2	2742	2685

Background to .5 mR/hr ^{137}Cs 7 CPM

Background to 1.5 mR/hr ^{137}Cs 14 CPM

KR Stafford Jr

To Set To ^{133}Ba Peak:

100 keV Window Centered On ^{133}Ba .356 MeV Peak. Window Width .25 Volts. Center Of Window .89 Volts. Upper Window Limit 1.015 Volts. Lower Window Limit .765 Volts. Th Set-Up Should Center ^{133}Ba Peak Exactly In Window. However, Fine Tuning May Be Done By Adjusting Analyzer Gain Until Maximum Countrate To ^{133}Ba Is Obtained.

Source (Cal. Source)	Nominal µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No. 177	.5		68329	2	68329	68323
Operational Check Source	8		486	2	486	480

Background: Binary Counts 6 Min. 2 = 6 CPM

POOR ORIGINA

To Set To ^{137}Cs Peak:

100 keV Window Centered On ^{137}Cs .662 MeV Peak. Window Width .25 Volts. Center Of Window 1.655 Volts. Upper Window Limit 1.78 Volts. Lower Window Limit 1.537 Volts. This Set-Up Should Center ^{137}Cs Peak Exactly In Window. However, Fine Tuning May Be Done By Adjusting Analyzer Gain Until Maximum Countrate To ^{137}Cs Is Obtained.

Source (Cal. Source)	Nominal µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		42485	2	42485	42482
Operational Check Source	8		791	2	791	788

Background: Binary Counts 3 Min. 2 = 3 CPM

To Set To ^{60}Co Peak:

100 keV Window Centered On ^{60}Co 1.17 MeV Peak. Window Width .25 Volts. Center Of Window 2.93 Volts. Upper Window Limit 3.055 Volts. Lower Window Limit 2.805 Volts. This Set-Up Should Center ^{60}Co Peak Exactly In Window. However, Fine Tuning May Be Done By Adjusting Analyzer Gain Until Maximum Countrate To ^{60}Co Is Obtained.

Source (Cal. Source)	Nominal µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{60}Co No. G-1002	N/A		17742	2	17742	17741
Operational Check Source	8		1	2	1	0

Background: Binary Counts 1 Min. 2 = 1 CPM

To Set To ^{135}I Peak:

100 keV Window Centered On ^{135}I 1.14 MeV Peak. Window Width .25 Volts. Center Of Window 2.85 Volts. Upper Window Limit 2.975 Volts. Lower Window Limit 2.725 Volts. Adjust Analyzer Gain Until Maximum Countrate To ^{60}Co 1.17 MeV Peak Is Obtained.

Source (Cal. Source)	Nominal µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{60}Co No. G-1002	N/A		17927	2	17927	17926

Background: Binary Counts 1 Min. 2 = 1 CPM

Increase Analyzer Gain Until Net Countrate To ^{60}Co 1.17 MeV Peak Is 10% ±1% Less Than Net Countrate Obtained Above. This Set-Up Should Center ^{135}I 1.14 MeV Peak Exactly In Window. (.9)(17926) = 16133.

749097

Source (Cal. Source)	Nominal µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{60}Co No. G-1002	N/A		16049	2	16049	16048
Operational Check Source.	8		1	2	1	[illegible]

Background: Binary Counts 1 Min. 2 = 1 CPM

Background .5 mR/hr ^{137}Cs [illegible] CPM

Background 1.5 mR/hr ^{137}Cs 2 CPM

$\frac{16133-16049}{16133} = .5\%$

POOR ORIGINAL

ANALYZER CHANNEL - ATTENUATED

To Set To ^{133}Ba Peak:

100 keV Window Centered On ^{133}Ba .356 MeV Peak. Window Width .25 Volts. Center Of Window .89 Volts. Upper Window Limit 1.015 Volts. Lower Window Limit .765 Volts. This Set-Up Should Center ^{133}Ba Peak Exactly In Window. However, Fine Tuning May Be Done By Adjusting Analyzer Gain Until Maximum Countrate To ^{133}Ba Is Obtained.

Source (Cal. Source)	Nominal µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No. 177	.5		68377	2	68377	68375
Operational Check Source	8		486	2	486	484
Background: Binary Counts	2	Min.	2	= 2	CPM	

To Set To ^{137}Cs Peak:

100 keV Window Centered On ^{137}Cs .662 MeV Peak. Window Width .25 Volts. Center Of Window 1.655 Volts. Upper Window Limit 1.78 Volts. Lower Window Limit 1.537 Volts. This Set-Up Should Center ^{137}Cs Peak Exactly In Window. However, Fine Tuning May Be Done By Adjusting Analyzer Gain Until Maximum Countrate To ^{137}Cs Is Obtained.

Source (Cal. Source)	Nominal µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5	-	42736	2	42736	42735
Operational Check Source	8		771	2	771	770
Background: Binary Counts	1	Min.	2	= 1	CPM	

To Set To ^{60}Co Peak:

100 keV Window Centered On ^{60}Co 1.17 MeV Peak. Window Width .25 Volts. Center Of Window 2.93 Volts. Upper Window Limit 3.055 Volts. Lower Window Limit 2.805 Volts. This Set-Up Should Center ^{60}Co Peak Exactly In Window. However, Fine Tuning May Be Done By Adjusting Analyzer Gain Until Maximum Countrate To ^{60}Co Is Obtained.

Source (Cal. Source)	Nominal µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{60}Co No. G-1003	N/A		17847	2	17847	17846
Operational Check Source	8		1	2	1	0
Background: Binary Counts	1	Min.	2	= 1	CPM	

To Set To ^{135}I Peak:

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100 keV Window Centered On ^{135}I 1.14 MeV Peak. Window Width .25 Volts. Center Of Window 2.85 Volts. Upper Window Limit 2.975 Volts. Lower Window Limit 2.725 Volts. Adjust Analyzer Gain Until Maximum Countrate To ^{60}Co 1.17 MeV Peak Is Obtained.

Source (Cal. Source)	Nominal µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{60}Co No. G-1003	N/A		17815	2	17815	17814
Background: Binary Counts	1	Min.	2	= 1	CPM	

Increase Analyzer Gain Until Net Countrate To ^{60}Co 1.17 MeV Peak Is 10% ±1% Less Than Net Countrate Obtained Above. This Set-Up Should Center ^{135}I 1.14 MeV Peak Exactly In Window. $(.9)(17814) = 16033$ $\frac{16033-15967}{16033} = .4\%$

Source (Cal. Source) G-1003	Nominal µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{60}Co No.	N/A		15968	2	15968	15967
Operational Check Source	8		1	2	1	0
Background: Binary Counts	1	Min.	2	= 1	CPM	

Background .5 mR/hr ^{137}Cs <1 CPM

Background 1.5 mR/hr ^{137}Cs <1 CPM

Certified By: ____________ (Quality Assurance)

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CALIBRATION DATA SHEET

PROJECT TMI-2 Customer P.O. No. C-0102

Customer Burns & Roe Victoreen Job No. E-7582

Prepared By Don Strenio Date 5/22/75

CHANNEL DESCRIPTION Liquid Waste Discharge Plant No. 2

CHANNEL NO. WDL-R-1311 (Liquid)

Sampler Model No. 841-33 Serial No. N/A Type Offline

Detector Model No. 843-30 Serial No. 149 Type Gamma

Ratemeter Model No. 842-10 Serial No. 675 Type Log

^{133}Ba and ^{137}Cs Calibration Source Serial No. 177

Operational Check Source: Type ^{137}Cs Approximate µCi 8

VICTOREEN STANDARD PIG CALIBRATION FIXTURE

Background: Binary Counts 126 Min. 2 = 126 CPM

Source (Cal. Sources)	Nom. µCi	N/A	Binary Counts	Min.	Gross CPM	Net CPM
Vico Std. ^{133}Ba			12835	2	12835	12709
^{133}Ba No. 177	.5		144464	2	144464	144338
^{133}Ba No. 6-177	.05		21644	2	21544	21518
^{137}Cs No. 177	.5		84512	2	84612	84486
^{137}Cs No. 6-177	.05		5155	2	5155	5029

Clip Level .20 Volts P.M. High Voltage 750 Volts

POOR ORIGINAL

TMI I STANDARD CALIBRATION FIXTURE

Background: Binary Counts 2496 Min. 20 = 250 CPM

Source	Nom. µCi	N/A	Binary Counts	Min.	Gross CPM	Net CPM
(Cal. Sources)						
^{133}Ba No. 177	.5		223014	2	223014	222764
^{133}Ba No. 6-177	.05		38771	2	38771	38521
^{137}Cs No. 177	.5		139845	2	139845	139595
^{137}Cs No. 6-177	.05		8787	2	8787	8537
(Linearity Sources)						
^{133}Ba No. #A	4.18		134395	2	184395	184145
^{133}Ba No. #0	.115		5380	2	5380	5130
^{133}Ba No. #I	.0041		4274	20	427	177
(Energy Response Sources)						
^{133}Ba No. SR-2	8		35790	2	36790	36540
^{137}Cs No. SR-2	8		31999	2	31999	31749
^{60}Co No. SR-2	8		47749	2	47749	47499

TMI II SAMPLER WDL-R-1311 (Liquid)

GROSS CHANNEL

Background: Binary Counts 239 Min. 2 = 239 CPM

Source (Cal Sources)	Nom. µCi	N/A	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No. 177	.5		220206	2	220206	219967
^{133}Ba No. 6-177	.05		40123	2	40123	39884
^{137}Cs No. 177	.5		125662	2	125662	125423
^{137}Cs No. 6-177	.05		9074	2	9074	8835
Operational Check Source	8		7390	2	7390	7151

ANALYZER CHANNEL - Not Applicable

10% Window Centered on ^{133}Ba .356 MeV Peak. Center of Window 4.0 Volts
Upper Window Limit 4.2 Volts. Lower Window Limit 3.8 Volts.
Adjust Analyzer Gain Until Maximum Countrate To ^{133}Ba Source Is Obtained.

Source (Cal Source)	Nom. µCi	N/A	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No.		✓				
Background: Binary Counts		✓	Min.		=	CPM

10% Window Centered on ^{131}I .364 MeV. Decrease Analyzer Gain Until Net Countrate Due To ^{133}Ba Source Is 7% ±1% Less Than Net Countrate Obtained Above.

Source (Cal. Source)	Nom. µCi	N/A	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No.		✓				
Operational Check Source		✓				
Background: Binary Counts		✓	Min.		=	CPM

Background to .5 mR/hr ^{137}Cs 24 CPM
Background to 1.5 mR/hr ^{137}Cs 76 CPM

Certified By: K E Stafford
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CALIBRATION DATA SHEET

PROJECT TMI-2 Customer P. O. No. C-0102

Customer Burns & Roe Victoreen Job No. E-7582

Prepared By Ron Brashear Date 6/12/75

CHANNEL DESCRIPTION WASTE GAS DISCHARGE

CHANNEL NO. WDG-R-1480 (Gas)

Sampler Model No. 841-33 Serial No. N/A Type Off line Gas

Detector Model No. 843-20 Serial No. 269 Type Beta

Ratemeter Model No. 843-10 Serial No. 733 Type Log

^{133}Ba and ^{137}Cs Calibration Source Serial No. 177

Operational Check Source: Type ^{137}Cs Approximate uCi 8

VICTOREEN STANDARD DRUM CALIBRATION FIXTURE

Background: Binary Counts 54 Min. 2 = 54 CPM

Sources (Vico Std. ^{129}I Source & Energy Response Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{129}I	.1125		1265	2	1265	1211
^{90}Sr	.1515		9028	2	9028	8974
^{99}Tc	.0146		24902	2	24902	24848
^{36}Cl	.130		77914	2	77914	77860

Clip Level .20 Volts P.M. High Voltage 600 Volts

VICTOREEN STANDARD PIG CALIBRATION FIXTURE

Background: Binary Counts 18 Min. 2 = 18 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		46502	2	46502	46484
^{137}Cs No. S-177	.05		6326	2	6326	6308
^{133}Ba No. 177	.5		1512	2	1512	1494
^{133}Ba No. S-177	.05		819	2	819	[illegible]

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TMI I STANDARD CALIBRATION FIXTURE

Background: Binary Counts 16 Min. 2 = 16 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		47505	2	47505	47489
^{137}Cs No 6-177	.05		6495	2	6495	6479
^{133}Ba No. 177	.5		1743	2	1743	1727
^{133}Ba No. 6-177	.05		933	2	933	917

TMI II STANDARD DRUM CALIBRATION FIXTURE

Background: Binary Counts 560 Min. 20 = 56 CPM

Source (Linearity Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{90}Sr	1.3		835047	2	835047	834991
^{90}Sr	.04		29615	2	29615	29559
^{90}Sr	.002		11745	20	1172	1116

TMI II SAMPLER WDG-R-1480 (Gas)

Background: Binary Counts 12 Min. 2 = 12 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		47026	2	47026	47014
^{137}Cs No. 6-177	.05		6431	2	6431	6419
^{133}Ba No. 177	.5		1763	2	1763	1715
^{133}Ba No 6-177	.05		915	2	915	903
Operational Check Source	8		599	2	599	587

Background to .5 mR/hr ^{137}Cs <1 CPM
Background to 1.5 mR/hr ^{137}Cs <1 CPM

Certified By: K E Stafford
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CALIBRATION DATA SHEET

PROJECT TMI-2 Customer P. O. No. C-0102

Customer Burns & Roe Victoreen Job No. E-9582

Prepared By Ron [illegible] Date 6-26-75

CHANNEL DESCRIPTION STATION VENT

CHANNEL NO. HP-R 219 (Gas)

Sampler Model No. 741-33 Serial No. 133 Type OFFLINE Gas

Detector Model No. 743-20 Serial No. 140 Type [illegible]

Ratemeter Model No. 742-10 Serial No. 743 Type Log

^{133}Ba and ^{137}Cs Calibration Source Serial No. 177

Operational Check Source: Type 137 Cs Approximate uCi 8

VICTOREEN STANDARD DRUM CALIBRATION FIXTURE

POOR ORIGINAL

Background: Binary Counts 110 Min. 2 = 110 CPM

Sources (Vico Std. ^{129}I Source & Energy Response Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{129}I	.1125		1315	2	1315	1205
^{90}Sr	.1515		8735	2	8735	8625
^{99}Tc	.0146		24118	2	24118	24008
^{36}Cl	.130		74944	2	74944	74834

Clip Level .20 Volts P.M. High Voltage 700 Volts

VICTOREEN STANDARD PIG CALIBRATION FIXTURE

Background: Binary Counts 22 Min. 2 = 22 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		46107	2	46107	46085
^{137}Cs No. 6778	.05		6275	2	6275	6253
^{133}Ba No. 177	.5		1647	2	1647	1625
^{133}Ba No. 6778	.05		820	2	820	798

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TMI I STANDARD CALIBRATION FIXTURE

Background: Binary Counts 27 Min. 2 = 27 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		47535	2	47535	47508
^{137}Cs No 6-177	.05		6475	2	6475	6448
^{133}Ba No 177	.5		1739	2	1739	1712
^{133}Ba No 6-177	.05		938	2	938	911

TMI II STANDARD DRUM CALIBRATION FIXTURE

Background: Binary Counts 464 Min. 20 = 46 CPM

Source (Linearity Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{90}Sr	1.3		833266	2	833266	833220
^{90}Sr	.04		28956	2	28956	28910
^{90}Sr	.002		11342	20	1134	1088

POOR ORIGINAL

TMI II SAMPLER HP-R-219 (Gas)

Background: Binary Counts 15 Min. 2 = 15 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		47425	2	47425	47410
^{137}Cs No 6-177	.05		6437	2	6437	6422
^{133}Ba No. 177	.5		1780	2	1780	1765
^{133}Ba No 6-177	.05		969	2	969	954
Operational Check Source	8		337	2	337	322

Background to .5 mR/hr ^{137}Cs 2 CPM

Background to 1.5 mR/hr ^{137}Cs 5 CPM

Certified By:
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POOR ORIGINAL

CALIBRATION DATA SHEET

PROJECT TMI-2 Customer P. O. No. C-0102

Customer Burns & Roe Victoreen Job No. E-7582

Prepared By Ron [illegible] Date 6-26-75

CHANNEL DESCRIPTION REACTOR BLDG. PURGE EX. DUCT A

CHANNEL NO. HPR-225 (G25)

Sampler Model No. 841-33 Serial No. 120 Type OFFLINE G25

Detector Model No. 843-20 Serial No. 127 Type BETA

Ratemeter Model No. 842-10 Serial No. 755 Type LOG

^{133}Ba and ^{137}Cs Calibration Source Serial No. -177--

Operational Check Source: Type ^{137}Cs Approximate uCi 8

VICTOREEN STANDARD DRUM CALIBRATION FIXTURE

Background: Binary Counts 79 Min. 2 = 79 CPM

Sources (Vico Std. ^{129}I Source & Energy Response Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{129}I	.1125		1276	2	1276	1197
^{90}Sr	.1515		8719	2	8719	8640
^{99}Tc	.0146		25007	2	25007	24928
^{36}Cl	.120		75220	2	75220	75141

Clip Level .20 Volts P.M. High Voltage 570 Volts

VICTOREEN STANDARD PIG CALIBRATION FIXTURE

Background: Binary Counts 16 Min. 2 = 16 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		45327	2	45327	45312
^{137}Cs No. 6-177	.05		6246	2	6246	6230
^{133}Ba No. 177	.5		1477	2	1477	1461
^{133}Ba No. 6-177	.05		829	2	829	813

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TMI I STANDARD CALIBRATION FIXTURE

Background: Binary Counts 17 Min. 2 = 17 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No 177	.5		45955	2	45955	45938
^{137}Cs No 6-77	.05		6178	2	6178	6161
^{133}Ba No 177	.5		1530	2	1530	1513
^{133}Ba No 6-77	.05		864	2	864	847

TMI II STANDARD DRUM CALIBRATION FIXTURE

Background: Binary Counts 465 Min. 20 = 46 CPM

Source (Linearity Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{90}Sr	1.3		793935	2	793935	793889
^{90}Sr	.04		28009	2	28009	27963
^{90}Sr	.002		11147	20	1114	1068

POOR ORIGINAL

TMI II SAMPLER HP-R-225 (625)

Background: Binary Counts 13 Min. 2 = 13 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		45161	2	45161	45148
^{137}Cs No 6-77	.05		6198	2	6198	6185
^{133}Ba No. 177	.5		1536	2	1536	1523
^{133}Ba No. 6-177	.05		909	2	909	896
Operational Check Source	8		262	2	262	249

Background to .5 mR/hr ^{137}Cs 2 CPM

Background to 1.5 mR/hr ^{137}Cs 5 CPM

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CALIBRATION DATA SHEET

PROJECT TMI-2 Customer P. O. No. C-0102
Customer Burns + Roe Victoreen Job No. E-7582
Prepared By Wayne [illegible] Date 6-27-75

CHANNEL DESCRIPTION REACTOR BLDG. PURGE EX. DUCT B
CHANNEL NO. HP-R-226 (Gas)

Sampler Model No. 841-33 Serial No. 127 Type OFF-LINE GAS
Detector Model No. 843-20 Serial No. 215 Type BETA
Ratemeter Model No. 842-10 Serial No. 676 Type Log

^{133}Ba and ^{137}Cs Calibration Source Serial No. #177
Operational Check Source: Type ^{137}Cs Approximate uCi 8

POOR ORIGINAL

VICTOREEN STANDARD DRUM CALIBRATION FIXTURE

Background: Binary Counts 46 Min. 2 = 46 CPM

Sources (Vico Std. ^{129}I Source & Energy Response Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{129}I	.1175		1242	2	1242	1196
^{90}Sr	.1515		8635	2	8635	8589
^{99}Tc	.0146		24089	2	24089	24043
^{36}Cl	.120		75150	2	75150	75104

Clip Level .20 Volts P.M. High Voltage 790 Volts

VICTOREEN STANDARD PIG CALIBRATION FIXTURE

Background: Binary Counts 18 Min. 2 = 18 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		45390	2	45390	45372
^{137}Cs No G-[illegible]	.05		6204	2	6204	6186
^{133}Ba No. 177	.5		1579	2	1578	1560
^{133}Ba No G-[illegible]	.05		829	2	829	811

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TMI I STANDARD CALIBRATION FIXTURE

Background: Binary Counts 22 Min. 2 = 22 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		47318	2	47318	47296
^{137}Cs No 6-177	.05		6645	2	6645	6623
^{133}Ba No. 177	.5		1807	2	1807	1775
^{133}Ba No 6-77	.05		962	2	962	940

TMI II STANDARD DRUM CALIBRATION FIXTURE

Background: Binary Counts 473 Min. 20 = 47 CPM

Source (Linearity Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{90}Sr	1.3		716,835	2	716,835	716 788
^{90}Sr	.04		28659	2	28659	28612
^{90}Sr	.002		11329	20	1133	1086

POOR ORIGINAL

TMI II SAMPLER HP-R-225 (G25)

Background: Binary Counts 25 Min. 2 = 25 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		45698	2	45698	45673
^{137}Cs No 6-177	.05		6494	2	6494	6469
^{133}Ba No. 177	.5		1811	2	1811	1786
^{133}Ba No. 6-177	.05		928	2	928	903
Operational Check Source	8		133	2	133	108

Background to .5 mR/hr ^{137}Cs <1 CPM
Background to 1.5 mR/hr ^{137}Cs 2 CPM

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CALIBRATION DATA SHEET

PROJECT TMI-2 Customer P. O. No. C-0102

Customer Burns & Roe Victoreen Job No. E-7552

Prepared By Wayne Carlson Date 6-25-75

CHANNEL DESCRIPTION REACTOR BLDG. AIR SAMPLER LINE

CHANNEL NO. HP-R-227 (G25)

Sampler Model No. 841-33 Serial No. 135 Type OFF LINE G25

Detector Model No. 843-20 Serial No. 123 Type BETA

Ratemeter Model No. 842-10 Serial No. 660 Type LOG

^{133}Ba and ^{137}Cs Calibration Source Serial No. #177

Operational Check Source: Type ^{137}Cs Approximate uCi 8

POOR ORIGINAL

VICTOREEN STANDARD DRUM CALIBRATION FIXTURE

Background: Binary Counts 70 Min. 2 = 70 CPM

Sources (Vico Std. ^{129}I Source & Energy Response Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{129}I	.1195		1267	2	1267	1197
^{90}Sr	.1515		8318	2	8318	8248
^{99}Tc	.0146		23910	2	23910	23840
^{36}Cl	.120		70348	2	70348	70278

Clip Level .20 Volts P.M. High Voltage 625 Volts

VICTOREEN STANDARD PIG CALIBRATION FIXTURE

Background: Binary Counts 22 Min. 2 = 22 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. #177	.5		46102	2	46102	46080
^{137}Cs No. G-179	.05		6294	2	6294	6272
^{133}Ba No. 977	.5		1573	2	1573	1551
^{133}Ba No. G-179	.05		816	2	816	794

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TMI I STANDARD CALIBRATION FIXTURE

Background: Binary Counts 12 Min. 2 = 12 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No.177	.5		45822	2	45822	45810
^{137}Cs No.6-177	.05		6566	2	6566	6554
^{133}Ba No.177	.5		1876	2	1876	1864
^{133}Ba No 6-177	.05		1009	2	1009	997

TMI II STANDARD DRUM CALIBRATION FIXTURE

Background: Binary Counts 651 Min. 20 = 65 CPM

Source (Linearity Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{90}Sr	1.3		735510	2	735510	735,445
^{90}Sr	.04		29155	2	29155	29090
^{90}Sr	.002		11711	20	1171	1106

POOR ORIGINAL

TMI II SAMPLER HP-R-227 (G25)

Background: Binary Counts 25 Min. 2 = 25 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No.177	.5		48084	2	48084	48059
^{137}Cs No.6-177	.05		6635	2	6635	6610
^{133}Ba No.177	.5		1814	2	1814	1789
^{133}Ba No.6-177	.05		953	2	953	928
Operational Check Source	8		184	2	184	159

Background to .5 mR/hr ^{137}Cs 2 CPM
Background to 1.5 mR/hr ^{137}Cs 4 CPM

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CALIBRATION DATA SHEET

PROJECT TMI-2 Customer P.O. No. C-0102
Customer Burns + Roe Victoreen Job No. E-2552
Prepared By Ron Andersen Date 7-10-75

CHANNEL DESCRIPTION STATION VENT

CHANNEL NO. HP R 219 (Particulate)

Sampler Model No. 841-1-4D Serial No. 173 Type Moving Filter Particulate
Detector Model No. 843-20A Serial No. 144 Type BETA
Ratemeter Model No. 842-10 Serial No. 762 Type LOG

^{133}Ba and ^{137}Cs Calibration Source Serial No. 177
Operational Check Source Type 137 cs. Approximate µCi 8

VICTOREEN STANDARD DRUM CALIBRATION FIXTURE

Background: Binary Counts 16 Min. 2 = 16 CPM

Sources 99Tc (Vico Std. ~~129I~~ Source & Energy Response Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{129}I	.1175		72	2	72	56
^{90}Sr	.1515		847	2	847	831
^{99}Tc	.0146		2459	2	2459	2443
^{36}Cl	.120		7142	2	7142	7126

Clip Level .20 Volts P.M. High Voltage 630 Volts

VICTOREEN STANDARD PIG CALIBRATION FIXTURE

Background: Binary Counts 5 Min. 2 = 5 CPM

Source (Cal Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		18554	2	18554	18549
^{137}Cs No. G-177	.05		1969	2	1969	1964
^{133}Ba No. 177	.5		226	2	226	221
^{133}Ba No. G-177	.05		271	2	271	216

POOR ORIGINAL

TMI I STANDARD CALIBRATION FIXTURE

Background: Binary Counts 7 Min. 2 = 7 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		26476	2	26476	26469
^{137}Cs No. 6-177	.05		3583	2	3583	3576
^{133}Ba No. 177	.5		330	2	330	323
^{133}Ba No. 6-177	.05		476	2	476	469

TMI II STANDARD CALIBRATION DRUM - PLACED INSIDE SAMPLER

Background: Binary Counts 134 Min. 20 = 13 CPM

Source (Linearity Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{90}Sr	1.2		78006	2	78006	77993
^{90}Sr	.04		2161	2	2161	2148
^{90}Sr	.002		1213	20	121	108

TMI II SAMPLER HP-R-219 (Particulate)

Background: Binary Counts 10 Min. 2 = 10 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		26573	2	26573	26563
^{137}Cs No. 6-177	.05		3827	2	3827	3817
^{133}Ba No. 177	.5		341	2	341	331
^{133}Ba No. 6-177	.05		487	2	487	477
Operational Check Source	8		70	2	70	60

Background to .5 mR/hr ^{137}Cs 6 CPM

Background to 1.5 mR/hr ^{137}Cs 18 CPM

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CALIBRATION DATA SHEET

PROJECT TMI-2 Customer P.O. No. C-0102

Customer Burns & Roe Victoreen Job No. E-7582

Prepared By Ron Brashear Date 6/12/75

CHANNEL DESCRIPTION STATION VENT - Iodine

CHANNEL NO. HP-R-219 (Iodine)

Sampler Model No. 841-3 Serial No. N/A Type Iodine

Detector Model No. 843-30 Serial No. 178 Type Gamma

Ratemeter Model No. 842-30 Serial No. 720 Type Log

^{133}Ba and ^{137}Cs Calibration Source Serial No. 177

Operational Check Source: Type ^{133}Ba Approximate μCi 8

VICTOREEN STANDARD PIG CALIBRATION FIXTURE

Background: Binary Counts 98 Min. 2 = 98 CPM

Source (Cal. Sources)	Nom. μCi	N/A	Binary Counts	Min.	Gross CPM	Net CPM
Vico Std. ^{133}Ba			12826	2	12826	12728
^{133}Ba No. 177	.5		144345	2	144345	144247
^{133}Ba No. 6-177	.05		21431	2	21431	21333
^{137}Cs No. 177	.5		86280	2	86280	86182
^{137}Cs No. 6-177	.05		5260	2	5260	5162

Clip Level .20 Volts P.M. High Voltage 750 Volts

POOR ORIGINAL

TMI I STANDARD CALIBRATION FIXTURE

Background: Binary Counts 1683 Min. 20 = 168 CPM

Source	Nom. µCi	N/A	Binary Counts	Min.	Gross CPM	Net CPM
(Cal. Sources)						
^{133}Ba No. 177	.5		227753	2	227753	227585
^{133}Ba No. 6-177	.05		39776	2	39776	39608
^{137}Cs No. 177	.5		137612	2	137612	137444
^{137}Cs No. 6-177	.05		9295	2	9295	9127
(Linearity Sources)						
^{133}Ba No. #A	4.18		184220	2	184220	184052
^{133}Ba No. #D	.115		5224	2	5224	5056
^{133}Ba No. #I	.0041		3572	20	357	189
(Energy Response Sources)						
^{133}Ba No. SR-2	8		36048	2	36048	35880
^{137}Cs No. SR-2	8		31676	2	31676	31508
^{60}Co No. SR-2	8		47545	2	47545	47377

TMI II SAMPLER HP-R-219 (Iodine)

POOR ORIGINAL

GROSS CHANNEL

Background: Binary Counts 67 Min. 2 = 67 CPM

Source (Cal Sources)	Nom. µCi	N/A	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No. 177	.5		88480	2	88480	88413
^{133}Ba No. 6-177	.05		13346	2	13346	13279
^{137}Cs No. 177	.5		67997	2	67997	67930
^{137}Cs No. 6-177	.05		4091	2	4091	4024
Operational Check Source	8		3813	2	3813	3746

ANALYZER CHANNEL

10% Window Centered on ^{133}Ba .356 MeV Peak. Center of Window 4.0 Volts
Upper Window Limit 4.2 Volts. Lower Window Limit 3.8 Volts.
Adjust Analyzer Gain Until Maximum Countrate To ^{133}Ba Source Is Obtained.

Source (Cal. Source)	Nom. µCi	N/A	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No. 177	.5		17660	2	17660	17658
Background: Binary Counts		2	Min.	2 =	2	CPM

10% Window Centered on ^{131}I .364 MeV. Decrease Analyzer Gain Until Net Countrate Due To ^{133}Ba Source Is 7% ±1% Less Than Net Countrate Obtained Above. (17658)(93%) = 16422

749114

Source (Cal. Source)	Nom. µCi	N/A	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No. 177	.5		16353	2	16353	16352
Operational Check Source	8		418	2	418	417
Background: Binary Counts		1	Min.	2 =	1	CPM

Background to .5 mR/hr ^{137}Cs 2 CPM
Background to 1.5 mR/hr ^{137}Cs 5 CPM

$$\frac{16422-16353}{16422} = .4\%$$

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CALIBRATION DATA SHEET

PROJECT TMI-2 Customer P.O. No. C-0102

Customer Burns & Roe Victoreen Job No. E-7582

Prepared By Ron [illegible] Date 7-2-75

CHANNEL DESCRIPTION REACTOR BLDG. PURGE EX. DUCT A

CHANNEL NO. HP R-225 -(Particulate)

Sampler Model No. 841-1-4T Serial No. 181 Type Moving Filter Particulate.

Detector Model No. 843-20A Serial No. 180 Type BETA

Ratemeter Model No. 842-10 Serial No. 668 Type LOG

^{133}Ba and ^{137}Cs Calibration Source Serial No. 177

Operational Check Source Type 137 cs Approximate µCi 8

VICTOREEN STANDARD DRUM CALIBRATION FIXTURE

Background: Binary Counts 13 Min. 2 = 13 CPM

Sources 99Tc (Vico Std. ~~100~~ 1 Source & Energy Response Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{129}I	.1175		67	2	67	54
^{90}Sr	.1515		763	2	763	750
^{99}Tc	.0146		2442	2	2442	2429
^{36}Cl	.180		6962	2	6962	6949

Clip Level .20 Volts P.M. High Voltage 700 Volts

VICTOREEN STANDARD PIG CALIBRATION FIXTURE

Background: Binary Counts 6 Min. 2 = 6 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		15878	2	15878	15872
^{137}Cs No. 6-[illegible]	.05		1878	2	1838	1832
^{133}Ba No. 177	.5		193	2	193	187
^{133}Ba No. 6-[illegible]	.05		276	2	276	270

POOR ORIGINAL

TMI I STANDARD CALIBRATION FIXTURE

Background: Binary Counts 10 Min. 2 = 10 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		25329	2	25329	25319
^{137}Cs No. 6-177	.05		3323	2	3323	3313
^{133}Ba No. 177	.5		386	2	386	376
^{133}Ba No. 6-177	.05		531	2	531	521

TMI II STANDARD CALIBRATION DRUM - PLACED INSIDE SAMPLER

Background: Binary Counts 147 Min. 20 = 15 CPM

Source (Linearity Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{90}Sr	1.3		80894	2	80894	80879
^{90}Sr	.04		2344	2	2344	2329
^{90}Sr	.002		1376	20	138	123

TMI II SAMPLER HP-R-225 (Particulate)

Background: Binary Counts 12 Min. 2 = 12 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		29311	2	29311	29299
^{137}Cs No. 6-177	.05		3824	2	3824	3812
^{133}Ba No. 177	.5		390	2	390	378
^{133}Ba No. 6-177	.05		566	2	566	554
Operational Check Source	8		72	2	72	60

Background to .5 mR/hr ^{137}Cs 6 CPM

Background to 1.5 mR/hr ^{137}Cs 18 CPM

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CALIBRATION DATA SHEET

PROJECT TMI-2 Customer P.O. No. C-0102

Customer Burns & Roe Victoreen Job No. E-7582

Prepared By Ron [illegible] Date 7-1-75

CHANNEL DESCRIPTION REACTOR BLDG. PURGE EXHAUST DUCT B

CHANNEL NO. HP-R-226 (Particulate)

Sampler Model No. 841-1-4TA Serial No. 187 Type Moving Filter Particulate

Detector Model No. 843-20 A Serial No. 123 Type BETA

Ratemeter Model No. 742-10 Serial No. 679 Type Log

^{133}Ba and ^{137}Cs Calibration Source Serial No. #177

Operational Check Source Type 137 cs Approximate μCi 8

VICTOREEN STANDARD DRUM CALIBRATION FIXTURE

Background: Binary Counts 13 Min. 2 = 13 CPM

Sources 99 Tc (Vico Std. ~~125~~I Source & Energy Response Sources)	Nom. μCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{129}I	.1175		76	2	76	63
^{90}Sr	.1515		818	2	818	805
^{99}Tc	.0146		2430	2	2430	2417
^{36}Cl	.120		[illegible]588	2	7588	7[illegible]65

Clip Level .20 Volts P.M. High Voltage 690 Volts

VICTOREEN STANDARD PIG CALIBRATION FIXTURE

Background: Binary Counts 3 Min. 2 = 3 CPM

Source (Cal. Sources)	Nom. μCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		18815	2	18815	18812
^{137}Cs No. 6-177	.05		2148	2	2148	2145
^{133}Ba No. 177	.5		232	2	232	229
^{133}Ba No. 6-177	.05		292	2	292	289

POOR ORIGINAL

TMI I STANDARD CALIBRATION FIXTURE

Background: Binary Counts 10 Min. 2 = 10 CPM

Source (Cal. Sources)	Nom. μCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		25996	2	25996	25986
^{137}Cs No. 6-177	.05		3834	2	3834	3824
^{133}Ba No. 177	.5		325	2	325	315
^{133}Ba No. 6-177	.05		544	2	544	534

TMI II STANDARD CALIBRATION DRUM - PLACED INSIDE SAMPLER

Background: Binary Counts 134 Min. 20 = 13 CPM

Source (Linearity Sources)	Nom. μCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{90}Sr	1.3		74480	2	74480	74467
^{90}Sr	.04		2120	2	2120	2107
^{90}Sr	.002		1158	20	116	103

TMI II SAMPLER HP-R-226 (Particulate)

Background: Binary Counts 10 Min. 2 = 10 CPM

Source (Cal. Sources)	Nom. μCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		26499	2	26499	26489
^{137}Cs No. 6-177	.05		3766	2	3766	3756
^{133}Ba No. 177	.5		330	2	330	320
^{133}Ba No. 6-177	.05		472	2	472	462
Operational Check Source	8		54	2	54.	44

Background to .5 mR/hr ^{137}Cs 8 CPM
Background to 1.5 mR/hr ^{137}Cs 22 CPM

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CALIBRATION DATA SHEET

PROJECT TMI-2 Customer P.O. No. C-0102

Customer Burns & Roe Victoreen Job No. E-7582

Prepared By Ron Druckman Date 7-17-75

CHANNEL DESCRIPTION REACTOR BUILDING AIR SAMPLE LINE

CHANNEL NO. HPR-227 (PARTICULATE)

Sampler Model No. 841-1-4D Serial No. 189 Type Moving Filter Particulate.

Detector Model No. 843-20A Serial No. 182 Type B-7A

Ratemeter Model No. 843-10 Serial No. 749 Type LOG

^{133}Ba and ^{137}Cs Calibration Source Serial No. 177

Operational Check Source Type 137 Approximate µCi 8

VICTOREEN STANDARD DRUM CALIBRATION FIXTURE

Background: Binary Counts 16 Min. 2 = 16 CPM

Sources (Vico Std. ^{129}I 91/10 Source & Energy Response Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{129}I	.1175		55	2	55	39
^{90}Sr	.1515		914	2	914	898
^{99}Tc	.0146		2439	2	2439	2423
^{36}Cl	.120		8026	2	8026	8010

Clip Level 0.20 Volts P.M. High Voltage 620 Volts

VICTOREEN STANDARD PIG CALIBRATION FIXTURE

Background: Binary Counts 9 Min. 2 = 9 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		21787	2	21787	21778
^{137}Cs No. G-177	.05		2573	2	2573	2564
^{133}Ba No. 177	.5		289	2	289	280
^{133}Ba No. G-177	.05		331	2	331	322

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TMI I STANDARD CALIBRATION FIXTURE

Background: Binary Counts 8 Min. 2 = 8 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		30296	2	30296	30288
^{137}Cs No. G-177	.05		3798		3798	3790
^{133}Ba No. 177	.5		351	2	351	343
^{133}Ba No. G-177	.05		537	2	537	529

TMI II STANDARD CALIBRATION DRUM - PLACED INSIDE SAMPLER

Background: Binary Counts 80 Min. 20 = 8 CPM

Source (Linearity Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{90}Sr	1.2		76482	2	76482	76474
^{90}Sr	.04		2236	2	2236	2228
^{90}Sr	.002		1117	20	112	104

TMI II SAMPLER HP-R-227 (Particulate)

Background: Binary Counts 6 Min. 2 = 6 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{137}Cs No. 177	.5		26664	2	26664	26658
^{137}Cs No. G-177	.05		3402	2	3402	3396
^{133}Ba No. 177	.5		306	2	306	300
^{133}Ba No. G-177	.05		524	2	524	516
Operational Check Source	8		74	2	74	68

Background to .5 mR/hr ^{137}Cs 6 CPM

Background to 1.5 mR/hr ^{137}Cs 18 CPM

Certified By: K. E. Stafford
Quality Assurance

POOR ORIGINAL

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CALIBRATION DATA SHEET

PROJECT TMI-2 Customer P.O. No. C-0102

Customer Burns & Roe Victoreen Job No. E-7582

Prepared By Don Strenio Date 6/5/75

CHANNEL DESCRIPTION Reactor Bldg. Purge Ex. Duct A

CHANNEL NO. HP-R-225 Iodine

Sampler Model No. 841-2 Serial No. N/A Type Iodine
Detector Model No. 843-36 Serial No. 157 Type Gamma
Ratemeter Model No. 842-30 Serial No. 734 Type Log

^{133}Ba and ^{137}Cs Calibration Source Serial No. 177

Operational Check Source: Type ^{133}Ba Approximate µCi 8

VICTOREEN STANDARD PIG CALIBRATION FIXTURE

Background: Binary Counts 98 Min. 2 = 98 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
Vico Std. ^{133}Ba			12823	2	12823	12725
^{133}Ba No. 177	.5		140938	2	140938	140840
^{133}Ba No. 6-177	.05		21513	2	21513	21415
^{137}Cs No. 177	.5		87741	2	87741	87643
^{137}Cs No. 6-177	.05		5283	2	5283	5185

Clip Level .20 Volts P.M. High Voltage 800 Volts

POOR ORIGINAL

TMI I STANDARD CALIBRATION FIXTURE

Background: Binary Counts 1631 Min. 20 = 163 CPM

Source	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
(Cal. Sources)						
^{133}Ba No. 177	.5		206872	2	206872	206709
^{133}Ba No. G-177	.05		37422	2	37422	37259
^{137}Cs No. 177	.5		133800	2	133800	133637
^{137}Cs No. G-177	.05		8950	2	8950	8787
(Linearity Sources)						
^{133}Ba No. #A	4.18		173244	2	173244	173081
^{133}Ba No. #D	.115		5044	2	5044	4881
^{133}Ba No. #I	.0041		3442	20	344	181
(Energy Response Sources)						
^{133}Ba No. SR-2	8		35513	2	35513	35350
^{137}Cs No. SR-2	8		31820	2	31820	31657
^{60}Co No. SR-2	8		47392	2	47392	47229

TMI II SAMPLER HP-R-225

POOR ORIGINAL

GROSS CHANNEL

Background: Binary Counts 169 Min. 2 = 169 CPM

Source (Cal Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No. 177	.5		126446	2	126446	126277
^{133}Ba No. G-177	.05		19357	2	19357	19188
^{137}Cs No. 177	.5		73664	2	73664	73495
^{137}Cs No. G-177	.05		4448	2	4448	4279
Operational Check Source	8		9061	2	9061	8892

ANALYZER CHANNEL

10% Window Centered on ^{133}Ba .356 MeV Peak. Center of Window 4.0 Volts
Upper Window Limit 4.2 Volts. Lower Window Limit 3.8 Volts.
Adjust Analyzer Gain Until Maximum Countrate To ^{133}Ba Source Is Obtained.

Source (Cal. Source)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No. 177	.5		17211	2	17211	17205
Background: Binary Counts			6	Min. 2	= 6	CPM

10% Window Centered on ^{131}I .364 MeV. Decrease Analyzer Gain Until Net Countrate Due To ^{133}Ba Source Is 7% ±1% Less Than Net Countrate Obtained Above. (17205)(93%) = 16001

Source (Cal. Source)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No. 177	.5		15981	2	15981	15977
Operational Check Source	8		1848	2	1848	1844
Background: Binary Counts			4	Min. 2	= 4	CPM

Background to .5 mR/hr ^{137}Cs 37 CPM
Background to 1.5 mR/hr ^{137}Cs 111 CPM

$\frac{16001 - 15977}{16001} = .1\%$

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CALIBRATION DATA SHEET

PROJECT TMI-2 Customer P.O. No. C-0122

Customer Burns & Roe Victoreen Job No. E-7582

Prepared By Don Strenio Date 6/4/75

CHANNEL DESCRIPTION Auxiliary Bldg. Ex. Duct B

CHANNEL NO. HP-R-220 (Iodine)

Sampler Model No. 841-2 Serial No. N/A Type Iodine

Detector Model No. 843-30 Serial No. 245 Type Gamma

Ratemeter Model No. 842-30 Serial No. 764 Type Log

^{133}Ba and ^{137}Cs Calibration Source Serial No. 177

Operational Check Source: Type ^{133}Ba Approximate μCi 8

VICTOREEN STANDARD PIG CALIBRATION FIXTURE

Background: Binary Counts 106 Min. 2 = 106 CPM

Source (Cal. Sources)	Nom. μCi	N/A	Binary Counts	Min.	Gross CPM	Net CPM
Vico Std. ^{133}Ba			12842	2	12842	12736
^{133}Ba No. 177	.5		144853	2	144853	144747
^{133}Ba No. 6-177	.05		21865	2	21865	21759
^{137}Cs No. 177	.5		87850	2	87850	87744
^{137}Cs No. 6-177	.05		5209	2	5209	5103

Clip Level .20 Volts P.M. High Voltage 725 Volts

POOR ORIGINAL

TMI I STANDARD CALIBRATION FIXTURE

Background: Binary Counts 1606 Min. 20 = 161 CPM

Source	Nom. µCi	N/A	Binary Counts	Min.	Gross CPM	Net CPM
(Cal. Sources)						
^{133}Ba No. 177	.5		222348	2	222348	222187
^{133}Ba No. G-177	.05		37456	2	37456	37295
^{137}Cs No. 177	.5		137727	2	137727	137566
^{137}Cs No. G-177	.05		9256	2	9256	9095
(Linearity Sources)						
^{133}Ba No. #A	4.18		174162	2	174162	174001
^{133}Ba No. #D	.115		5030	2	5030	4869
^{133}Ba No. #I	.0041		3379	20	338	177
(Energy Response Sources)						
^{133}Ba No. SR-2	8		35188	2	35188	35027
^{137}Cs No. SR-2	8		31472	2	31472	31311
^{60}Co No. SR-2	8		47211	2	47211	47050

TMI II SAMPLER HP-R-226 (Iodine)

POOR ORIGINAL

GROSS CHANNEL

Background: Binary Counts 154 Min. 2 = 154 CPM

Source (Cal Sources)	Nom. µCi	N/A	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No. 177	.5		134482	2	134482	134328
^{133}Ba No. G-177	.05		21531	2	21531	21377
^{137}Cs No. 177	.5		76966	2	76966	76812
^{137}Cs No. G-177	.05		4834	2	4834	4680
Operational Check Source	8		10659	2	10659	10505

ANALYZER CHANNEL

10% Window Centered on ^{133}Ba .356 MeV Peak. Center of Window 4.0 Volts
Upper Window Limit 4.2 Volts. Lower Window Limit 3.8 Volts.
Adjust Analyzer Gain Until Maximum Countrate To ^{133}Ba Source Is Obtained.

Source (Cal. Source)	Nom. µCi	N/A	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No. 177	.5		21242	2	21242	21239
Background: Binary Counts		3	Min. 2	=	3 CPM	

10% Window Centered on ^{131}I .364 MeV. Decrease Analyzer Gain Until Net Countrate Due To 133Ba Source Is 7% ±1% Less Than Net Countrate Obtained Above. (21239)(93%) = 19752

749124

Source (Cal. Source)	Nom. µCi	N/A	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No. 177	.5		19667	2	19667	19665
Operational Check Source	8		2205	2	2205	2203
Background: Binary Counts		2	Min. 2	=	2 CPM	

Background to .5 mR/hr ^{137}Cs 38 CPM
Background to 1.5 mR/hr ^{137}Cs 114 CPM

$$\frac{19752-19665}{19752} = .4\%$$

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CALIBRATION DATA SHEET

PROJECT TMI-2 Customer P.O. No. C-0102

Customer Burns & Roe Victoreen Job No. E-7582

Prepared By Don Strenin Date 5/28/75

CHANNEL DESCRIPTION REACTOR BLDG. AIR SAMPLE LINE

CHANNEL NO. HP-R-227 (Iodine)

Sampler Model No. 841-2 Serial No. N/A Type Iodine

Detector Model No. 843-30 Serial No. 191 Type Gamma

Ratemeter Model No. 842-30 Serial No. [illegible] Type Log

^{133}Ba and ^{137}Cs Calibration Source Serial No. 177

Operational Check Source: Type 133 Ba Approximate µCi 8

VICTOREEN STANDARD PIG CALIBRATION FIXTURE

Background: Binary Counts 110 Min. 2 = 110 CPM

Source (Cal. Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
Vico Std. ^{133}Ba			12871	2	12871	12761
^{133}Ba No. 177	.5		143726	2	143726	143616
^{133}Ba No. G-177	.05		21374	2	21374	21264
^{137}Cs No. 177	.5		85033	2	85033	84923
^{137}Cs No. G-177	.05		5104	2	5104	4994

Clip Level .20 Volts P.M. High Voltage 850 Volts

POOR ORIGINAL

749125

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TMI I STANDARD CALIBRATION FIXTURE

Background: Binary Counts 230.5 Min. 2 = 231 CPM

Source	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
(Cal. Sources)						
^{133}Ba No. 177	.5		220056	2	220056	219825
^{133}Ba No. G-177	.05		38873	2	38873	38642
^{137}Cs No. 177	.5		131831	2	131831	131600
^{137}Cs No. G-177	.05		8988	2	8988	8757
(Linearity Sources)						
^{133}Ba No. #A	4.18		182641	2	182641	182410
^{133}Ba No. #D	.115		5306	2	5306	5075
^{133}Ba No. #E	.0041		4220	20	422	191
(Energy Response Sources)						
^{133}Ba No. SR-2	8		36605	2	36605	36374
^{137}Cs No. SR-2	8		32433	2	32433	32202
^{60}Co No. SR-2	8		48034	[illegible]	48034	47803

TMI II SAMPLER HP-R-[illegible] (Iodine)

POOR ORIGINAL

GROSS CHANNEL

Background: Binary Counts 948 Min. 2 = 248 CPM

Source (Cal Sources)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No. 177	.5		148777	2	148777	148546
^{133}Ba No. G-177	.05		23036	2	23036	22805
^{137}Cs No. 177	.5		81846	2	81846	81615
^{137}Cs No. G-177	.05		5040	2	5040	4809
Operational Check Source	8		11298	2	11298	11067

ANALYZER CHANNEL

10% Window Centered on ^{133}Ba .356 MeV Peak. Center of Window 4.0 Volts Upper Window Limit 4.2 Volts. Lower Window Limit 3.8 Volts. Adjust Analyzer Gain Until Maximum Countrate To ^{133}Ba Source Is Obtained.

Source (Cal. Source)	Nom. µCi	N/A ✓	Binary Counts	Min.	Gross CPM	Net CPM
^{133}Ba No. 177	.5		18449	2	18449	18439
Background: Binary Counts			10	Min. 2	= 10 CPM	

10% Window Centered on ^{131}I .364 MeV. Decrease Analyzer Gain Until Net Countrate Due To ^{133}Ba Source Is 7% ±1% Less Than Net Countrate Obtained Above. (18439)(93%) = 17148

749126

Source (Cal. Source)	Nom. µCi	N/A ✓	Binary Counts	Mi	Gross CPM	Net CPM
^{133}Ba No. 177	.5		17173	2	17173	17169
Operational Check Source	8		2580	2	2580	2576
Background: Binary Counts			4	Min. 2	= 4 CPM	

Background to .5 mR/hr ^{137}Cs 37 CPM

Background to 1.5 mR/hr ^{137}Cs 116 CPM

$\frac{17148 - 17169}{17148} = .1\%$

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PROCESS RADIATION MONITORING CALIBRATION DATA

Channel No.	Monitor Type	Type Detect.	Detect Counting Mode	Discrim. Level (Volts)	High Voltage (Volts)	Cal. Source and Serial No.	Sampler Net CPM	Cal. Source and Serial No.	Sampler Net CPM	Date of Cal. Reading
DC-R-3400	Offline Liq	Gamma	Gross	.20	830	^{133}Ba #177	231575	^{137}Cs #177	133612	5/21/75
DC-R-3399	Offline Liq	Gamma	Gross	.20	700	^{133}Ba #177	226945	^{137}Cs #177	134878	5/20/75
IC-R-1091	Offline Liq	Gamma	Gross	.20	775	^{133}Ba #177	223491	^{137}Cs #177	134673	5/22/75
IC-R-1092	Offline Liq	Gamma	Gross	.20	600	^{133}Ba #177	210229	^{137}Cs #177	137121	5/20/75
IC-R-1093	Offline Liq	Gamma	Gross	.20	790	^{133}Ba #177	230352	^{137}Cs #177	133737	5/21/75
MU-R-720	Failed Fuel	Gamma	Gross unattenuated	.20	780	^{133}Ba #177	220615	^{137}Cs #177	139033	5/28/75
MU-R-720	Failed Fuel	Gamma	Gross attenuated	.20	·780	^{133}Ba #177	225815	^{137}Cs #177	137659	5/28/75
MU-R-720	Failed Fuel	Gamma	Analyzer unattenuted	N/A	N/A	^{60}Co#G1002 set to ^{135}I Peak	16048			5/29/75
MU-R-720	Failed Fuel	Gamma	Analyzer attenuated	N/A	N/A	^{60}Co#G-1002 set to ^{135}I Peak	15967			5/29/75
NS-R-3401	Offline Liq	Gamma	Gross	.20	710	^{133}Ba #177	214690	^{137}Cs #177	134024	5/15/75
SF-R-3402	Offline Liq	Gamma	Gross	.20	700	^{133}Ba #177	233843	^{137}Cs #177	135882	5/14/75
WDL-R-1311	Offline Liq	Gamma	Gross	.20	750	^{133}Ba #177	219967	^{137}Cs #177	125423	5/22/75
WT-R-3894	Offline Liq	Gamma	Gross	.20	720	^{133}Ba #177	220196	^{137}Cs #177	134300	8/12/75
WT-R-3895	Offline Liq	Gamma	Gross	.20	710	^{133}Ba #177	222119	^{137}Cs #177	133200	5/23/75
VA-R-748	Offline Gas	Beta	Gross	.20	575	^{137}CS #177	44209	^{133}Ba #177	1500	6/27/75

PROCESS RADIATION MONITORING CALIBRATION DATA

Channel No.	Monitor Type	Type Detect.	Detect Counting Mode	Discrim. Level (Volts)	High Voltage (Volts)	Cal. Source and Serial No.	Sampler Net CPM	Cal. Source and Serial No.	Sampler Net CPM	Date of Cal. Reading
WDG-R-1480	Offline Gas	Beta	Gross	.20	600	^{137}Cs #177	47014	^{133}Ba #177	1715	6/19/75
WDG-R-1485	Offline Gas	Beta	Gross	.20	750	^{137}Cs #177	45721	^{133}Ba #177	1593	6/30/75
WDG-R-1486	Offline Gas	Beta	Gross	.20	495	^{137}Cs #177	41960	^{133}Ba #177	1222	6/19/75
HP-R-219	Offline Gas	Beta	Gross	.20	700	^{137}Cs #177	47410	^{133}Ba #177	1765	6/26/75
HP-R-219	Moving Filter Particulate	10/1 Beta	Gross	.20	630	^{137}Cs #177	26563	^{133}Ba #177	331	7/10/75
HP-R-219	Iodine	Gamma	Gross	.20	750	^{133}Ba #177	88413	^{137}Cs #177	67930	6/12/75
HP-R-219	Iodine	Gamma	Analyzer	N/A	N/A	^{133}Ba #177 Set to ^{131}I Peak	16352			6/12/75
HP-R-220	Offline Gas	Beta	Gross	.20	660	^{137}Cs #177	46986	^{133}Ba #177	1665	6/25/75
HP-R-220	Moving Filter Particulate	10/1 Beta	Gross	.20	705	^{137}Cs #177	28335	^{133}Ba #177	380	7/3/75
HP-R-220	Iodine	Gamma	Gross	.20	750	^{133}Ba #177	137458	^{137}Cs #177	80903	6/11/75
HP-R-220	Iodine	Gamma	Analyzer	N/A	N/A	^{133}Ba #177 set to ^{131}I Peak	15379			6/11/75
HP-R-221A	Offline Gas	Beta	Gross	.20	680	^{137}Cs #177	45532	^{133}Ba #177	1531	6/23/75
HP-R-221A	Moving Filter Particulate	10/1 Beta	Gross	.20	620	^{137}Cs #177	25028	^{133}Ba #177	293	7/11/75

PROCESS RADIATION MONITORING CALIBRATION DATA

Channel No.	Monitor Type	Type Detect.	Detect Counting Mode	Discrim. Level (Volts)	High Voltage (Volts)	Cal. Source and Serial No.	Sampler Net CPM	Cal. Source and Serial No.	Sampler Net CPM	Date of Cal. Reading
HP-R-221A	Iodine	Gamma	Gross	.20	775	^{133}Ba #177	154952	^{137}Cs #177	87563	6/11/75
HP-R-221A	Iodine	Gamma	Analyzer	N/A	N/A	^{133}Ba #177 set to 131$_{I}$ Peak	19318			6/11/75
HP-R-221B	Offline Gas	Beta	Gross	.20	660	^{137}Cs #177	48533	^{133}Ba #177	1677	6/23/75
HP-R-221B	Moving Filter Particulate	10/1 Beta	Gross	.20	560	^{137}Cs #177	21104	^{133}Ba #177	309	7/16/75
HP-R-221B	Iodine	Gamma	Gross	.20	790	^{133}Ba #177	167243	^{137}Cs #177	93525	6/9/75
HP-R-221B	Iodine	Gamma	Analyzer	N/A	N/A	^{133}Ba #177 Set to 131$_{I}$ Peak	21637			6/9/75
HP-R-222	Offline Gas	Beta	Gross	.20	550	^{137}Cs #177	48004	^{133}Ba #177	1603	6/26/75
HP-R-222	Moving Filter Particulate	10/1 Beta	Gross	.20	550	^{137}Cs #177	34287	^{133}Ba #177	542	6/30/75
HP-R-222	Iodine	Gamma	Gross	.20	700	^{133}Ba #177	116895	^{137}Cs #177	65905	6-3-75
HP-R-222	Iodine	Gamma	Analyzer	N/A	N/A	^{133}Ba #177 Set to 131$_{I}$ Peak	17501			6/3/75
HP-R-223	Offline Gas	Beta	Gross	.20	700	^{137}Cs #177	43263	^{133}Ba #177	1437	6/17/75
HP-R-223	Moving Filter Particulate	10/1 Beta	Gross	.20	690	^{137}Cs #177	23531	^{133}Ba #177	282	7/8/75

PROCESS RADIATION MONITORING CALIBRATION DATA

Channel No.	Monitor Type	Type Detect.	Detect Counting Mode	Discrim. Level (Volts)	High Voltage (Volts)	Cal. Source and Serial No.	Sampler Net CPM	Cal. Source and Serial No.	Sampler Net CPM	Date of Cal. Reading
HP-R-223	Iodine	Gamma	Gross	.20	700	^{133}Ba #177	119626	^{137}Cs #177	66299	6/13/75
HP-R-223	Iodine	Gamma	Analyzer	N/A	N/A	^{133}Ba #177 Set to 131 I Peak	14661			6/13/75
HP-R-224	Offline Gas	Beta	Gross	.20	580	^{137}Cs #177	42551	^{133}Ba #177	1444	6/27/75
HP-R-224	Moving Filter Particulate	10/1 Beta	Gross	.20	630	^{137}Cs #177	22567	^{133}Ba #177	262	7/8/75
HP-R-224	Iodine	Gamma	Gross	.20	650	^{133}Ba #177	122938	^{137}Cs #177	71697	6/13/75
HP-R-224	Iodine	Gamma	Analyzer	N/A	N/A	^{133}Ba #177 Set to 131 I Peak	16490			6/13/75
HP-R-225	Offline Gas	Beta	Gross	.20	570	^{137}Cs #177	45148	^{133}Ba #177	1523	6/26/75
HP-R-225	Moving Filter particulate	10/1 Beta	Gross	.20	700	^{137}Cs #177	29299	^{133}Ba #177	378	7/2/75
HP-R-225	Iodine	Gamma	Gross	.20	800	^{133}Ba #177	126277	^{137}Cs #177	73495	6/5/75
HP-R-225	Iodine	Gamma	Analyzer	N/A	N/A	^{133}Ba #177 set to ^{131}I Peak	15977			6/5/75
HP-R-226	Offline Gas	Beta	Gross	.20	790	^{137}Cs #177	45673	^{133}Ba #177	1786	6/27/75

7491131

PROCESS RADIATION MONITORING CALIBRATION DATA

Channel No.	Monitor Type	Type Detect.	Detect Counting Mode	Discrim. Level (Volts)	High Voltage (Volts)	Cal. Source and Serial No.	Sampler Net CPM	Cal. Source and Serial No.	Sampler Net CPM	Date of Cal. Reading
HP-R-226	Moving Filter Particulate	10/1 Beta	Gross	.20	690	^{137}Cs#177	26489	^{133}Ba #177	320	7/1/75
HP-R-226	Iodine	Gamma	Gross	.20	725	^{133}Ba #177	134328	^{137}Cs #177	76812	6/4/75
HP-R-226	Iodine	Gamma	Analyzer	N/A	N/A	^{133}Ba #177 set to ^{131}I Peak	19665			6/4/75
HP-R-227	Offline Gas	Beta	Gross	.20	625	^{137}Cs #177	48059	^{133}Ba #177	1789	6/25/75
HP-R-227	Moving Filter Particulate	10/1 Beta	Gross	.20	620	^{137}Cs #177	26658	^{133}Ba #177	300	7/17/75
HP-R-227	Iodine	Gamma	Gross	.20	850	^{133}Ba #177	148546	^{137}Cs #177	81615	5/28/75
HP-R-227	Iodine	Gamma	Analyzer	N/A	N/A	^{133}Ba #177 set to ^{131}I Peak	17169			5/28/75
HP-R-228	Offline Gas	Beta	Gross	.20	675	^{137}Cs #177	48064	^{133}Ba #177	[illegible]15	6/25/75
HP-R-228	Moving Filter Particulate	10/1 Beta	Gross	.20	700	^{137}Cs	31848		374	7/3/75
HP-R-228	Iodine	Gamma	Gross	.20	690	^{133}Ba #177	142078	^{137}Cs #177	80007	6/2/75

PROCESS RADIATION MONITORING CALIBRATION DATA

							Sampler		Sampler	
Channel No.	Monitor Type	Type Detect.	Detect Counting Mode	Discrim. Level (Volts)	High Voltage (Volts)	Cal. Source and Serial No.	Net CPM	Cal. Source and Serial No.	Net CPM	Date of Cal. Reading
HP-R-228	Iodine	Gamma	Analyzer	N/A	N/A	^{133}Ba #177 Set to ^{131}I Peak	17315			6/2/75
HP-R-229	Offline Gas	Beta	Gross	.20	610	^{137}Cs #177	47195	^{133}Ba #177	1543	6/23/75
HP-R-229	Moving Filter Particulate	10/1 Beta	Gross	.20	720	^{137}Cs #177	28956	^{133}Ba #177	396	7/2/75
HP-R-229	Iodine	Gamma	Gross	.20	760	^{133}Ba #177	144565	^{137}Cs #177	81913	6/6/75
HP-R-229	Iodine	Gamma	Analyzer	N/A	N/A	^{133}Ba #177 Set to ^{131}I Peak	17307			6/6/75

APPENDIX II

TMI II CALIBRATION PROCEDURE PECULIARITIES

TMI II CALIBRATION PROCEDURE PECULIARITIES

Many more calibration sources and fixtures were supplied to TMI II than are normally supplied by Victoreen to calibrate process radiation monitor systems. Many of the sources and fixtures are used for specific purposes (linearities, energy response, etc.) and are not used in the general point source calibration of the system. Using the Calibration Data sheets in Appendix I and the information about the calibration sources and fixtures, the procedures for these "special purpose" calibrations are self-explanatory. In instances where further clarification is needed, it will be given in this section.

The general point source calibration of the TMI II system is the same as the general point source calibration given in Section III, with a few peculiarities. These peculiarities will be noted and explained here.

A. Liquid Monitors

General point source calibration of all TMI II Liquid Monitors is identical to the procedure in Section III.

B. Iodine Monitors

The point source is to be attached to the charcoal filter cartridge and the filter holder is to be placed in the sampler as explained in the steps below:

1. Remove the filter holder and existing charcoal filter.
2. Tape the point source to the center of a clean charcoal filter so that the printed side of the source will be pointing away from the detector face.
3. Place the charcoal filter in the holder so that it is properly retained.

4. Position the detector so that the detector face is 1/4 inch back from the lip in the sampler tube. A jig is supplied to be used from the filter holder end for this purpose. The lip is a stop which positions the filter holder.
5. Place the filter holder in the sampler. It is to be inserted as far in as possible without removing the red rubber circular gasket around its perimeter or tightening the thumb screws.

C. Primary Coolant Letdown Monitor (MU-R-720)

This monitor contains a 3 inch lead plug which is used to attenuate the count rate when high level activity is present. In the sampler, all point source calibration was done both with the plug inserted and with the plug removed.

The point source is to be attached to the detector face with the source holder, and the detector is to be inserted as far down as possible into the sampler.

The high voltage is set by the gross channel ratemeter pot R115. (Ratemeter that does not contain the analyzer switch). For purposes of reference let this Ratemeter be designated as Ratemeter #1. The high voltage pot on the ratemeter containing the analyzer switch is non-functional since it receives its input pulses from the other Ratemeter. For purposes of reference let the ratemeter be designated as Ratemeter #2. If correlation of gross count rates registered by both meters is desired, the gross discriminator on ratemeter #2 can be varied until the gross count rate of ratemeter #2 agrees with the gross count rate of ratemeter #1. This procedure does nothing to alter the analyzer setting of ratemeter #2. However, all gross count rates should be read from ratemeter #1, and ratemeter #2 should remain in the analyzer mode to monitor plant effluent radiation.

D. Gas Monitors

General point source calibration of all TMI II gas monitors is identical to the procedure in Section IV.

E. Particulate Monitors

General point source calibration of all TMI II particulate monitors is identical to the procedure in Section III. A scribe mark is provided on the detector. The detector is properly positioned when the scribe mark is aligned with the aluminum retaining ring. The detector is also properly positioned when it is aligned as shown in Section IV.

The linearity calibration is to be done with the TMI II Standard Calibration Drum (contains the Sr-90 sources) placed inside the sampler. The following procedure is to be followed:

1. Remove the filter paper from the existing Capstan.
2. Take the background counts with the Capstan in place.
3. Remove the Capstan and install the TMI II Standard Calibration Drum on the mounting spindle.
4. Take count rates to each source, being particularly careful that each source is centered with respect to the detector face. A dot is scribed on the Calibration Drum that lies on the center line of each source.

   If a beta detector in any of the particulate monitors is to be replaced, it may be recalibrated to the Sr-90 1.3 µCi source with the TMI II Standard Calibration Drum placed inside the sampler. The average count rate of all the particle Monitors supplied to TMI II to the Sr-90 1.3 µCi source with the TMI II Standard Calibration Drum placed inside the sampler was 73,517 + 4.4% at one standard deviation (1 σ) on 7/8/75.

APPENDIX III

FACTORY POINT SOURCE CALIBRATION

Factory Point Source Calibration (For Field Calibration see Manual Section III)

NOTE:

All pertinent data generated during the factory calibration is recorded on a Victoreen Standard Calibration Data Sheet (Appendix I). On a multi-channel system, critical parameters for each channel are tabulated on a Victoreen Process Radiation Monitoring Calibration Data Table (Attachment II). This data will be used by the customer to maintain the NBS traceability on all future calibrations.

1 Beta Scintillation Detector (843-20)

Four area sources are used to calibrate the beta detector. These sources are attached to a Capstan assembly (shown in Figure 10) to simulate the geometry of the moving particulate filter sampler. The four sources are ^{99}Tc, ^{129}I, ^{90}Sr, and ^{35}Cl. The ^{129}I source provides the traceability to NBS.

1.1 Requirements

a. Beta source Capstan assembly with 4 area sources.

b. Counter/scaler

c. Oscillator

d. Pulse generator

e. Oscilloscope

f. Victoreen Standard Geometry, Model 844-36

g. Customer's Serialized Button Sources

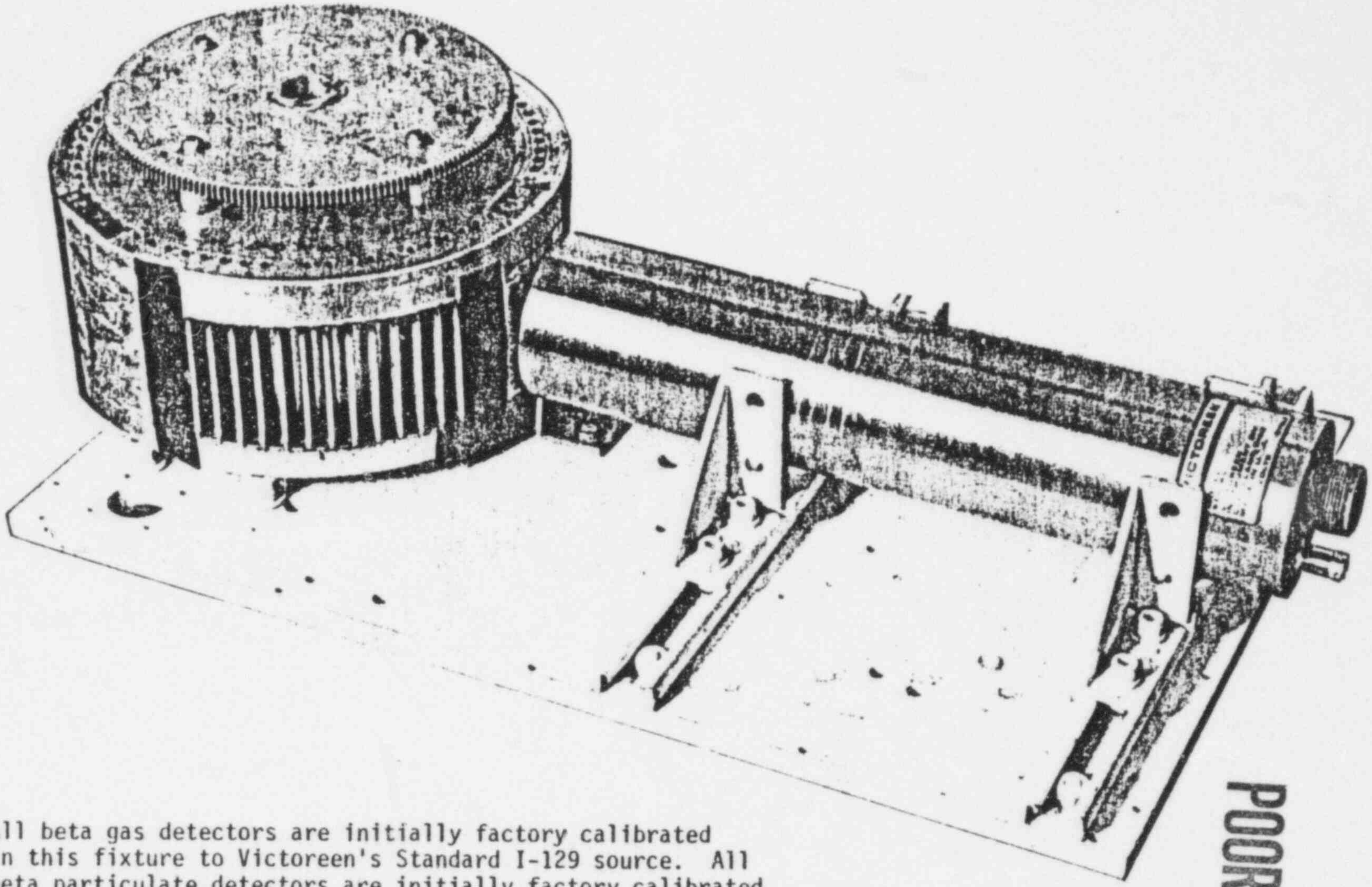
h. Masking Tape

i. Calibration Data Sheet

1.2 Discriminator and High Voltage Adjustment

a. Connect the detector to be calibrated to the LCRM. Record the serial numbers of the detector and LCRM, as well as all other pertinent data on the front of a Calibration Data Sheet.

b. Place the beta detector in the test figure, and install the source Capstan. Position the detector such that the foil window is 3/16" from the center of the sources.



All beta gas detectors are initially factory calibrated in this fixture to Victoreen's Standard I-129 source. All beta particulate detectors are initially factory calibrated in this fixture to Victoreen's Standard Tc-99 Source. Count rates to I-129, Tc-99, Sr-90, and Cl-36 are taken in this fixture to check energy responses.

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Figure 10. Victoreen Standard Drum Calibration Fixture

c. Turn all equipment on and allow 15 minutes for warm-up and stabilization.

d. While the equipment is warming up, compute the net count rate of the ^{90}Sr source using the equation presented below, and the data from Table 4.

$$N = N_o e^{(-\lambda t)}$$

where N = present count rate
N_o = count rate at time of factory calibration
e = base of natural logarithms
$\lambda = 0.693 \div T_{\frac{1}{2}}$ (See Table 4 for $T_{\frac{1}{2}}$)
t = elapsed time (yrs.)

Table 4: Beta Calibration Sources

Isotope	$T_{1/2}$ (Half-life)	t_o Count Rate
^{129}I	1.7×10^7 yrs	1200 cpm
^{90}Sr	27.7 yrs.	
^{36}Cl	3.08×10^5 yrs.	75, 177 cpm
^{99}Tc	2.12×10^5 yrs.	24, 217 cpm

NOTE: Due to the long half-life of ^{129}I, ^{36}Cl, and ^{99}Tc, the N_o count rate can be used for calibration purposes.

e. Remove the detector input Signal and High Voltage cables.

f. Connect an oscillator and pulse generator to the input of the ratemeter as shown in Figure 4. Adjust the signal input to:

pulse rate - 10^5 cpm.

pulse polarity - negative

pulse amplitude - 0.200 ± 0.002 volt

pulse width - 1.0 µsec

g. Adjust the Discriminator level control, R3, so that the 0.2 volt negative pulses are just counting. The ratemeter will now discriminate against all pulses lower than 0.2 volt.

NOTE: This is the final setting of R3. Record this value on the channel Calibration Data Sheet.

h. Remove the test equipment from the LCRM and reconnect the detector and High Voltage cables.

i. Place the Function Switch in the H.V. position.

j. Adjust the HV adjust, R115, for an indication of 500 vdc on the front panel meter.

NOTE: This is not the final HV setting but is simply a starting point for the calibration.

k. Place the Function Switch in the OPER position.

l. Position the ^{129}I source attached to the source capstan toward the sensitive end of the Beta Detector making sure the source and the crystal are centered. Assure the center of the source is 3/16" from the foil window.

m. Connect a Counter/Scaler between the junction of R14 and R18 or TP7 on the log ratemeter card and ground. Adjust the scaler for a 2 minute time base.

n. Assuming a 50 cpm background count rate, adjust the High Voltage using R115, until a count rate of 1250 cpm is measured on the Counter/Scaler.

o. Remove the source from the detector and take a 2 minute count of the actual ambient background.

p. Compute the sum of the measured background count rate plus 1200 cpm from the ^{129}I source. Replace the ^{129}I source over the active end of the detector.

q. Fine tune the HV using R115, for a gross count rate equal to the sum computed in the previous step. Record this value on the Calibration Data Sheet.

NOTE: Required accuracy is ± 1% of the net source count rate.

r. Remove the source capstan and take a 2 minute background count. Record this value on the Calibration Data Sheet.

s. Compute the net count rate of the ^{129}I by subtracting the background (step r) from the gross count rate (step q). The net count rate must be 1200 cpm ±1%. If the accuracy is not within ±1%, repeat steps q through s.

1.3 Energy Response Check

a. Replace the source capstan on the test fixture and position the ^{90}Sr source over the active end of the detector.

b. Take a 2 minute count and record the gross cpm on the Calibration Data Sheet.

c. Compute the net cpm by subtracting the background measured in step B.1.2.r. The allowable tolerance of the measured net cpm to the anticipated cpm is ±6%. Record the gross and net cpm on the calibration data sheet.

d. Repeat step a through c for the ^{36}Cl area source.

e. Repeat step a through c for the ^{99}Tc area source.

f. Observe all data taken in the energy response check. If the ±6% tolerance cannot be met, repair of the detector is required.

g. Place the Function Switch in the H.V. position. Record the HV value indicated on the front panel meter in the appropriate locations on the Calibration Data Sheet. This is the final high voltage adjustment.

h. Place the Function Switch in the OPER position.

1.4 Calibration of Secondary Button Sources (Standard Geometry)

1.4.1 Standard Geometry

a. Remove the detector from the beta calibration fixture and install it in a Victoreen Standard Geometry, Model 844-36.

b. With a Counter/Scaler connected between the junction of R14 and R18 or TP7 on the ratemeter card and ground, take a 2 minute count of background in the standard geometry. Record this value on the Calibration Data Sheet.

c. Slide open the source holder on the standard geometry and insert the customer's serialized ^{90}Sr button source, with the blank side towards the detector.

d. Take a 2 minute gross count of the ^{90}Sr source and record this value on the Calibration Data Sheet. Compute the net count rate by subtracting the background (from step b) and record this value on the data sheet.

e. Remove the ^{90}Sr source.

f. Repeat steps b thru e in the customer's standard geometry to obtain cross calibration data.

g. Remove the detector from the standard geometry and install it in the sampler. All accessories, i.e., operational check sources and shielding, must be in the operating position.

1.4.2 Sampler Geometry

a. Gross Gaseous

NOTE: Use this procedure for a beta detector which is used to monitor gross gaseous activity, i.e., no particulate filter.

1.) The detector must be installed in the sampler with all associated accessories in place.

2.) With a Counter/Scaler connected between the junction of R14 and R18 or TP7 on the ratemeter card and ground take a 2 minute background count and record the value on the Calibration Data Sheet.

3.) Attach the serialized ^{90}Sr button source to the active end of the detector as shown in Figure 5, or by using the plastic source cup, with the blank side of the source towards the detector. Place the detector in the sampler

4.) Take a 2 minute count of gross cpm. Record this value on the Calibration Data Sheet. Compute the net count rate by subtracting the background (step 2) and record this value on the data sheet.

5.) Remove the ^{90}Sr button source from the detector.

6.) With the detector in the sampler, depress and hold the check source pushbutton on the ratemeter.

7.) Take a 2 minute count of the check source activity and record the gross cpm on the Calibration Data Sheet. Subtract the background (step 2) from the gross cpm to find the net cpm and record this value on the data sheet. Release the check source pushbutton when the 2 minute count is completed.

8.) Remove the test instrumentation from the LCRM, and secure the detector in the sampler.

9.) Calibration completed.

b. Moving Particulate Filter (Model 841-1)

NOTE: Use this procedure for beta detectors employed on moving particulate filters, Model 841-1.

1.) The detector must be installed in the sampler with all accessories in place, except remove the filter paper and capstan.

2.) With a Counter/Scaler connected between the junction of R14 and R18 or TP7 on the ratemeter card and ground, take a 2 minute background count and record the value on the Calibration Data Sheet.

3.) Attach the serialized ^{90}Sr button source to the active and at the detector as shown in figure 5, or by using plastic source cup provided with the system, with the blank side of the source towards the detector. Place the detector on the sampler.

4.) Take a 2 minute count of gross cpm. Record this value on the Calibration Data Sheet. Compute the net count rate by subtracting the background (step 2) and record this value on the data sheet.

5.) Remove the ^{90}Sr button source from the detector.

6.) With the detector in the sampler, depress and hold the check source pushbutton on the ratemeter.

7.) Take a 2 minute count of the check source activity and record the gross cpm on the Calibration Data Sheet. Subtract the background (step 2) from the gross cpm to find the net cpm and record this value on the data sheet. Release the check source pushbutton when the 2 minute count is completed

8.) Remove the test instrumentation from LCRM.

9.) Replace the filter capstan and filter paper.

10.) Calibration completed.

c. Fixed Particulate Filter (Model 841-2)

<u>NOTE:</u> Use this procedure for a beta detector employed in a fixed particulate filter sampler, Model 841-2.

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1.) The detector must be installed in the sampler with all associated accessories in place.

2.) Remove the filter and gasket from the filter holder.

3.) With a Counter/Scaler connected between the junction of R14 and R18 or TP7 on the ratemeter card and ground, take a 2 minute background count and record the value on the Calibration Data Sheet.

4.) Center the serialized ^{90}Sr button source on the end of the filter holder assembly with the blank side towards the detector. Attach the button source to the filter holder by placing two small pieces of tape on the edge of the source and over the top of the filter assembly (or use double sided tape) as shown in Figure 5 or place the source in the plastic cup and over the end of the detector. Do not cover source with tape, as it will attenuate the beta emission.

5.) Place the filter holder into the sampler and secure it with the thumb screws.

6.) Take a 2 minute count of gross cpm. Record this value on the Calibration Data Sheet. Compute the net count rate by subtracting the background (step 3) and record this value on the data sheet.

7.) Remove the ^{90}Sr button source from the detector.

8.) Replace the gasket on the filter holder and insert in the sampler without the filter paper.

9.) With the detector installed in the sampler, depress and hold the check source pushbutton on the ratemeter.

10.) Take a 2 minute count of the check source activity and record the gross cpm on the Calibration Data Sheet.

Subtract the background (Step 3) from the gross cpm to find the net cpm and record this value on the data sheet. Release the check source pushbutton when the 2 minute count is completed.

11. Remove the test instrumentation from the LCRM.

12. Calibration completed.

1.5 Linearity Source Check (Optional)

NOTE: Linearity sources are provided only upon specific request of the customer. Three ^{90}Sr button sources of varying activities will be used.

a. Remove the detector from the sampler and install it in a Victoreen Model 844-36 Standard Geometry.

b. Connect a Counter/Scaler between the junction of R14 and R18, or TP7 on the Log ratemeter card, and ground.

c. Place the highest activity ^{90}Sr source in the standard geometry, blank side up. Take a 2 minute count and record the count rate.

d. Repeat Step c using the medium activity source.

e. Repeat Step c using the smallest activity source. Count the source for 6 minutes. Compute the count rate by dividing the binary counts displayed on the Counter/Scaler by one-half of the counting time (ie.,3)

f. Remove the sources from the standard geometry and take a 10 minute background count. Compute the count rate by dividing the binary count by 5.

g. Replace the detector on the sampler assembly.

h. Compare the measured results, taking into account the radioactive decay of the linearity sources, with the actual activity of the sources. The channel must be linear within ± 15% of the cpm/ µCi/cc (source efficiency) factor.

Scintillation Detector (Model 843-30)

a button source is used as a factory standard to calibrate the s[illegible]llation detectors. This source, through an isotopic effluent cation, provides NBS traceability.

Requirements

a. Victoreen Standard ^{133}Ba Button Source

b. Victoreen Standard Geometry, Model 844-36

c. Counter/Scaler

d. DVM

e. Oscilloscope

f. Alligator Clip Jumper

g. Oscillator

h. Pulse Generator

i. Oscilloscope

j. Customer's serialized button sources

[illegible]. Masking tape

l. Calibration data sheet

2.2 Discriminator and High Voltage Adjustment

a. Connect the detector to be calibrated to the LCRM. Record the serial numbers of the detector and LCRM, as well as all other pertinent data on the front of a Calibration Data Sheet.

b. Place the gamma detector in the Victoreen Standard Geometry Model 844-36.

c. Turn all equipment on and allow 15 minutes for warm-up and stabilization.

d. While the equipment is warming up, compute the net count rate of the ^{133}Ba factory button source using the equation and data presented below:

$$N = N_o e^{-0.693t/T_{1/2}}$$

where N = present count rate

N_o = elapsed time (years)

t_o = date of initial calibration = 1-1-76

$T_{1/2}$ = half life of isotope = 10.7 years

e. Remove the detector input signal and high voltage cables. If the LCRM contains an analyzer board it must be bypassed by placing the analyzer card and place a jumper across pins L and K on J2 on the main board.

f. Connect an oscillator and pulse generator to the input of the ratemeter as shown in Figure 4. Adjust the signal input to:

pulse rate - 10^5 cpm
pulse polarity - negative
pulse amplitude - 0.200 ± 0.002 volt
pulse width - 1.0 µsec

g. Adjust the Discriminator level control, R3, so that the 0.2 volt negative pulses are just counting. The ratemeter will now discriminate against all pulses lower than 0.2 volt.

NOTE: This is the final setting of R3. Record this value on the channel Calibration Data Sheet.

h. Remove the test equipment from the LCRM and reconnect the detector and High Voltage cables. Leave the LCRM in the Gross Mode

i. Place the Function Switch in the H.V. position.

j. Adjust the HV adjust, R115, for an indication of 700 vdc on the front panel meter.

NOTE: This is not the final HV setting but is simply a starting point for the calibration.

k. Place the Function Switch in the OPER position.

l. Place the ^{133}Ba factory button source, blank side up, into the source holder on the Standard Geometry.

m. Connect a Counter/Scaler between the junction of R14 and R18 or TP7 on the log ratemeter card and ground. Adjust the scaler for a 2 minute time base.

n. Assuming a 100 cpm background count rate, adjust the High Voltage using R115, until the computed net count rate of the ^{133}Ba source plus 100 cpm is measured on the Counter/Scaler.

o. Remove the source from the detector and take a 2 minute count of the actual ambient background.

p. Compute the sum of the measured background count rate plus the computed net count rate of the ^{133}Ba source. Replace the ^{133}Ba source in the Standard Geometry.

q. Fine tune the HV using R115, for a gross count rate equal to the sum computed in the previous step. Record this value on the Calibration Data Sheet:

<u>NOTE:</u> Required accuracy is ± 1% of the net source count rate.

r. Remove the source from the standard geometry and take a 2 minute background count. Record this value on the Calibration Data Sheet.

s. Compute the net count rate of the ^{133}Ba button source by subtracting the background (step r) from the measured gross coun rate (step q). The net count rate must equal that value computed in step d with a tolerance of ± 1%. If the accuracy is not within that specified, repeat steps q through s.

t. Leave the detector in the standard geometry for the field button source calibration, section B.2.3.1.

2.3 Calibration of Field Button Sources

NOTE: The LCRM must remain in the Gross Mode for this section

2.3.1 Standard Geometry

a. Install the gamma scintillation detector in the Victoreen Standard Geometry, Model 844-36.

b. With a Counter/Scaler connected between the junction of R14 and R18 or TP7 on the ratemeter card and ground, t a 2 minute count of background in the standard geometry. Record this value on the Calibration Data Sheet.

c. Slide open the source holder on the standard geometry and insert the customer's serialized ^{133}Ba button source, with the blank side towards the detector.

d. Take a 2 minute gross count of the ^{133}Ba source and record this value on the Calibration Data Sheet. Compute the net count rate by subtracting the background (from Step b) and record this value on the data sheet.

e. Remove the ^{133}Ba source and install the ^{137}Cs source in the same manner.

f. Repeat Step d for the ^{137}Cs source.

g. Remove the detector from the Victoreen standard geometry and install it in the customer's standard geometry. Repeat Steps b thru f.

2.3.1 Sampler Geometry

a. The detector must be installed in the sampler with all associated accessories in place. The LCRM should remain in the GROSS mode if it contains an analyzer function.

b. With a Counter/Scalar connected between the junction of R14 and R18 or TP7 on the ratemeter card and ground, take a 2 minute background count and record the value on the Calibration Data Sheet.

c. Attach the ^{133}Ba source with the blank side of the source towards the detector to the sensitive end of the detector and place the detector in the sampler. Take a 2 minute count of gross cpm. Record this value on the Calibration Sheet. Compute the net count rate by subtracting the background (Step b) and record this value on the data sheet.

d. Remove the ^{133}Ba button source and install the ^{137}Cs button source on the detector in the same manner.

e. Repeat Step d for the ^{137}Cs source.

f. Remove the ^{137}Cs button source from the detector.

g. With the detector in the sampler, depress and hold the check source pushbutton on the ratemeter.

h. Take a 2 minute count of the check source activity and record the gross cpm on the Calibration Data Sheet. Subtract the background (Step b) from the gross cpm to find the net cpm and record this value on the data sheet. Release the check source pushbutton when the 2 minute count is completed.

2.4 Linearity Source Check (Optional)

NOTE: Linearity sources are provided only upon specific request of the customer. Three ^{133}Ba button sources of varying activities will be used.

a. Remove the detector from the sampler and install it in a VICTOREEN Model 844-36 Standard Geometry.

b. Connect a Counter/Scaler between the junction of R14 and R18, or TP7 on the Log ratemeter card, and ground.

c. Place the highest activity ^{133}Ba source in the standard geometry, blank side up. Take a 2 minute count and record the count rate.

d. Repeat Step c using the medium activity source.

e. Repeat Step c using the smallest activity source. Count the source for 6 minutes. Compute the count rate by dividing the binary counts displayed on the Counter/Scaler by one-half of the counting time (ie., 3).

f. Remove the sources from the Standard Geometry and take a 10 minute background count. Compute the count rate by dividing the binary count by 5.

g. Replace the detector on the sampler assembly.

h. Compare the measured results, taking into account the radioactive decay of the linearity sources, with the actual activity of the sources. The channel must be linear within ± 15% of the cpm/µCi/cc (source efficiency) factor.

2.5 Analyzer Calibration

NOTE: In many cases, an Analyzer function is included in a LCRM to enable it to be used to monitor a specific Isotope. Isotopic calibration of the analyzer should be performed in accordance with Section A.7.

2.5.1 Iodine Analyzer Calibration

NOTE: An Iodine Analyzer is adjusted to respond to the 364 Kev photopeak of ^{131}I. This adjustment is made using the 356 Kev photopeak of ^{133}Ba.

a. Place the LCRM in the Analyzer mode by one of the following methods:

1.) place the GROSS/ANALYZER switch in the ANALYZER position

or

2.) remove the jumper across pins L and K on J2 and install the analyzer board.

b. Attach the customer's serialized ^{133}Ba button source to the active end of the detector or by using the plastic source cup, then place the detector in the sampler.

c. Connect an oscilloscope to monitor the output of the linear amplifier of the analyzer (TP302 and GND). Adjust the analyzer gain control, R334, until the 356 keV photopeak of the ^{133}Ba source is approximately 4.0 volt (positive pulse).

d. Connect a DVM between TP304 and ground to measure the upper window level. Adjust the "delta E" control R323, for an indication of 4.2 ± 0.02 vdc.

e. Connect the DVM between TP303 and ground to measure the lower window level. Adjust the "delta Y" potentiometer, R313, for an indication of 3.8 ± 0.02 vdc.

f. Connect an oscillator and pulse generator to the input of the LCRM. Adjust the input signal for:

Count rate:	10^5cpm
Pulse Width:	1 μsec
Pulse Polarity:	Negative
Pulse Amplitude:	Minimum

g. With the LCRM in the analyzer mode, gradually increase the input pulse height while observing the response of the front panel meter and the output of the linear amplifier on the oscilloscope. The front panel meter should indicate downscale except when the input height is within the 10% window of the ^{133}Ba. If the window width appears less than or greater than the desired value, or multiple windows are observed, readjustment or repair of the analyzer is required.

h. Remove the test equipment and reconnect the detector.

meter, carefully adjust the analyzer gain, R334, for a maximum, or peak count rate from the ^{133}Ba 356 keV photo-peak. This will require only a small adjustment on R334. Allow several minutes for the reading to stabilize.

j. Connect a Counter/Scaler at the junction of R18 and R14 on TP7 on the ratemeter card, and ground. Take a 2 minute count of the count rate and record this value on the Calibration Data Sheet.

k. Reduce the value recorded in Step h by 7%. While monitoring the output count rate with the Counter/Scaler, decrease the analyzer gain (CCW reduces gain) until the count rate decreases to within 1.0% of the computed value. Record the final reading on the calibration Data Sheet.

l. Remove the ^{133}Ba button source and take a 2 minute background count. Record this value on the Calibration Data Sheet.

m. Reinstall the detector in the shield assembly. Install a clean charcoal filter.

n. Depress the check source button and hold. Allow time to stabilize, then take a 2 minute count. Record the value on the Calibration Data Sheet, then release the check source button.

o. Calibration completed.

2.5.2 Analyzer Calibration for any other Energy Peak (.08 to 2 MeV)

The analyzer gain can be adjusted such that a range of .08 - 2 MeV corresponds to the instrument voltage range of .2 - 5 volts. Figure 7 is a plot of this energy verses voltage relationship. Once the analyzer gain has been adjusted so that this energy - voltage relationship has been obtained, an analyzer "window" of any desired width can be centered on any energy peak within this range. Determination of voltage values for the window center and discriminators for a desired energy peak and window width can be obtained directly from Figure 7 or calculated from the slope of the "straight line" relationship. The slope was adjusted to 2.5 volts/MeV in Section B.2.2, the high voltage adjustment.

a. Perform the High Voltage adjustment in accordance with Section B.2.2.

b. Obtain a point source whose energy peak is identical to or as close as possible in magnitude to the energy peak to be analyzed, in order to minimize error resulting from interpolation using the graph of Figure 7.

c. Attach the source to the active end of the detector with tape or by using a plastic source cup, and place the detector in the sampler.

d. Connect an oscilloscope between TP302 on the analyzer board, and ground. Adjust the scope to display position pulses. A complete spectrum of peaks will appear along with the point source characteristic peak(s) due to Compton scattering.

e. Using the point-slope equations, determine the desired pulse height (in volts) to be set for the point source characteristic photo-peak.

NOTE: Calculation of the pulse height for the ^{60}Co, 1.117 keV photopeak, is presented as an example.

$$V_{TP302} = (1.17\text{ MeV})\ (2.5\ \frac{\text{volts}}{\text{MeV}})$$

$$V_{TP302} = \underline{\underline{2.925\text{ volts}}}$$

f. Adjust the analyzer gain, R334, until the top of the desired peak is set at the voltage derived in Step e. The gain of the analyzer is now approximately set.

g. Calculate the upper and lower discriminator settings based on the desired window width. Most windows are set to a width of 100 keV centered on the energy peak or a width of 10% of the voltage at which the energy peak is set.

NOTE: An example of the calculations for both the 100 keV window and the 10% window is presented below:

100 keV Window

100 keV = .100 MeV

(.100 MeV) (2.5 Volts/MeV) = .25 Volts

$$\frac{.25\text{ Volts}}{2} = .125\text{ Volts}$$

Center of window = 2.925 Volts (previously calculated)

Lower Discriminator = 2.925 Volts - .125 Volts=2.80 Volt

Upper Discriminator = 2.925 Volts + .125 Volts=3.05 Volt

10% Window

Center of Window = 2.925 Volts (previously calculated)

(2.925 Volts)X(10/2) = 0.14625 Volts

Lower Discriminator = 2.925 Volts - 0.14625 Volts =2.78 Vol

Upper Discriminator = 2.925 Volts - 0.14625Volts = 3.07 Volt

h. Connect a DVM between TP304 and ground and adjust the upper window level using R323, for the value computed in step g + 0.02 V dc. Record the voltage value on the Calibration Data Sheet.

i. Connect the DVM between TP303 and ground and adjust the lower window level using R313, for a value computed in Step g ± 0.02 V dc. Record the voltage value on the Calibration Data Sheet.

j. Connect an oscillator and pulse generator to the input of the LCRM as shown in Figure 4. Adjust the input signal for:

Count rate:	10^5cpm
Pulse Width:	1 µsec.
Pulse Polarity:	Negative
Pulse Amplitude:	Minimum

k. With the LCRM in the analyzer mode, gradually increase the input pulse height while observing the response of the front panel meter and the output of the linear amplifier on the oscilloscope. The front panel meter should indicate downscale except when the input pulse height is within the 10% window of the button source. If the window width appears less than or greater than the desired value, or multiple windows are observed, re-adjustment or repair of the analyzer is required.

l. Remove the test equipment and reconnect the detector.

m. The energy peak has been approximately centered in the window with Steps d through i. Fine tuning the gain to achieve a maximum count rate from the energy peak assures that the peak is exactly centered in the window and that the correct energy-voltage relationship is obtained. To fine tune the gain, alternately increase and decrease the analyzer gain, R334, slightly until the maximum count rate to the point source energy peak is obtained as indicated by the ratemeter or scaler. Record this value on the Calibration Data Sheet.

m. If the energy peak to be analyzed is identical to the point source peak already utilized in setting the gain and window settings, the calibration is complete. If not, Steps d through j assure the gain has been properly adjusted and that the energy versus voltage relationship has been obtained. Determine the center of the voltage window for the energy peak to be analyzed and calculate the upper and lower discriminator settings as illustrated by the previous examples. Set the upper and lower discriminator as described in step h and i. The window is now properly set to analyze the desired energy peak. Record the upper and lower discriminator voltages if different from step g. Take a 2 minute count of the calibration source supplied with the system and record the gross cpm on the Calibration Data Sheet.

2.53 "Delta E" Scan Calibration

a. Remove the detector from the shield assembly and install it in a Victoreen Model 844-36 Standard Calibration Geometry. Place a ^{60}Co button source in the source holder of the 844-36.

b. Connect channel A of a dual trace oscilloscope to the signal input terminals of the ratemeter.

c. Adjust the scope controls for a ^{60}Co energy display so that the 1.17 and 1.33 MeV energy peaks are observed.

d. Adjust the high-voltage adjustment, R115, so that the 1.17 and 1.33 MeV energy peaks occur at 2.95 and 3.25 volts on the scope respectively.

e. Connect channel B of the oscilloscope across the aperture network (TP304 and TP303) on the analyzer plug-in board (scope GND lead to TP304).

NOTE: Scope must float with respect to GND.

f. Set the aperture for 140 keV (350 millivolts) on the scope by adjusting the "Delta E" control, R313.

h. Turn the gain control, R334, on the analyzer board to the extreme CCW position, then CW slowly for maximum deflection on the meter of the 1.17 MeV peak.

i. Turn "Delta E" scan control to 66.5% on the dial and observe the 1.33 MeV peak. Repeat steps h and i if necessary to correct for interaction.

j. Replace the ^{60}Co source with a ^{133}Ba button source.

k. Set the aperture for 40 keV (90 millivolts) on the scope by adjusting the "Delta E" control R313.

l. Set the "Delta E" Scan control to 18.3% on the dial.

m. Adjust the calibration control, R337, and observe a maximum deflection of the meter of the 0.335-0.380 MeV peak.

n. Turn the "Delta E" Scan control slowly toward 4% (80 keV) on the dial and observe the 80 keV energy peak. Re-adjust R337 as necessary for maximum deflection on the meter of the 80 keV energy peak at precisely 4% on the dial.

o. Since there is some interaction between the adjustments, it may be necessary to repeat steps f through m.

p. Remove the Scope Leads. Calibration completed.

3 Geiger-Mueller Detectors

3.1 Requirements

a. Counter/Scaler

b. Electrostatic Voltmeter, range 0-2000 V dc

c. ^{137}Cs button source

d. 5 cycle semi-log graph paper

3.2 Procedure

a. Set the High Voltage adjustment, R115, to the extreme counter-clockwise position (minimum high voltage).

b. Connect an electrostatic voltmeter between the junction of R126 and terminal point 36 on the power supply board, and ground (refer to Victoreen Drawing No. 842-10-50 in the LCRM manual).

CAUTION: Use extreme caution when connecting the voltmeter; potential of approximately 500 V dc is present.

c. Connect a Counter/Scaler between the junction of R14 and R18 or TP7 on the log ratemeter card and ground. Adjust the scale for a 2 minute time base.

d. Place a ^{137}Cs source in close proximity with the G-M tube, and secure it in place with tape if necessary.

CAUTION: Do not dent or puncture the tube while attaching the source.

e. Using 5 cycle semi-log graph paper, plot a curve of high voltage vs. counts per minute at intervals of 25 volts, over a range from minimum HV to the maximum value given in Table 5.

f. On the graph, identify the "knee" and the "plateau". Adjust the high voltage to a value 50 volts above the "knee", on the plateau. If the HV value is not within the range specified in Table 5 for the type of G-M tube being used, reject the tube and install a replacement, then repeat this procedure.

g. Record the count rate of the ^{137}Cs source and high voltage.

h. Remove the test equipment and button source.

i. Measure and record the background count rate on the Calibration Data Sheet.

j. Calibration completed.

Detector Type	Nominal HV Value	Maximum HV
18509	550 - 650 volts	800 volts
18550	550 - 650	800
912	850 - 950	1100
1B85	650 - 750	900

Table 5: G-M Tube Adjustment Data

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APPENDIX IV

REPORTS OF PRIMARY EFFLUENT CALIBRATIONS

NOTE: This appendix describes calibration procedures performed at the VICTOREEN plant to verify performance of the various kinds of monitors. It is not intended as an instruction for field calibration. For field calibration procedure, see the end of Section III in the body of the manual.

Each design which is a part of a standard Victoreen product line receives at least one primary effluent isotopic calibration. If the monitor being supplied to the customer is an existing design, it has already received a complete isotopic calibration as described in A below. A calibration of the monitor supplied is performed only upon customer request. Calibrations performed at the request of TMI are described in B below.

Linearity checks for each detector are made with a group of calibrated point sources. For this reason only one concentration of the isotope or isotopes used in the calibration is necessary.

A. Factory Effluent Isotopic Calibration

1 Liquid Monitors

Using nuclides having single, closely spaced double, or widely separated gamma lines, a smooth curve of response per unit activity versus energy (response or efficiency curve) is empirically determined for a given type of gamma detector in the specific sampler geometry. Solutions of Cobalt 57, Barium 133 or Iodine 131, Cesium 137, and Cobalt 60 are normally used. A calculation of liquid self-absorption from Xenon 133 gas data is used to complete the low energy portion of the response curve.

1.1 Requirements

- a. Electronic Counter/Scaler
- b. Peristaltic Pump and Flexible Rubber Tubing
- c. ^{57}Co, ^{133}Ba or ^{131}I, ^{137}Cs, ^{60}Co solutions or other required solutions

1.2 Procedure

NOTE: A point source calibration, using Victoreen's standard Ba-133 point source and Victoreen's standard geometry, Model 844-36 is to be performed immediately prior to the effluent calibration to assure proper response to radiation. Refer to Section B.2 for the point source calibration procedure.

a. Pump demineralized water into the sampler volume until it is entirely filled.

NOTE: For offline and inline Monitors, liquid is to be pumped directly into the sampler volume. For snowplow Monitors, liquid is introduced directly into a pipe which simulates the in-service pipe line, and the active end of the detector is to be placed 1/4 inch back from the pipe boundary.

b. Connect a Counter/Scaler between the junction of R14 and R18 or TP7 on the log ratemeter card and ground. Count the ambient background for a time period sufficient to reduce the background counting error to a statistically insignificant value.

c. Compute the ambient background count rate.

d. Empty the water from the sampler volume.

e. Pump the nuclide solution into the sampler volume until it is completely filled.

f. Record the counts due to the nuclide solution (gross counts) with a Counter/Scaler for a time period sufficient to reduce the counting error to within the desired tolerance.

g. Compute the gross count rate.

h. Compute the net count rate due to the nuclide solution by subtracting the ambient background count rate from the gross count rate.

i. Empty the nuclide solution from the sampler volume.

j. Thoroughly decontaminate the sampler volume with soap and water.

k. Calculate the response of the detector (efficiency) by dividing the net count rate by the concentration. The units of the calculated efficiency are in (counts per minute)/(microcuries per cubic centimeter), abbreviated as (CPM)/(μCi/cc).

l. Repeat the procedure for the next nuclide solution.

m. After calibration to all nuclide solutions is complete, decontaminate the sampler volume until the background count rate inside the sampler approaches its initial value.

<u>NOTE</u>: For monitors also utilizing single channel analyzers. Section 1.2 is to be followed with the analyzer window set to the desired window width.

2 Fixed Filter Iodine Monitor

An Iodine 131 source is constructed which simulates the collection distribution of the charcoal cartridge used in the sampler. A 10% voltage window is set on the ^{13}[illegible]364 Mev peak and the response (efficiency) is determined. A multi-cha[illegible]nalyzer is usually used in addition to the procedure presented below to insure that the window is centered on the ^{131}I peak.

2.1 Requirements

- a. Electronic Counter/Scaler
- b. ^{131}I volume source
- c. Digital Volt Meter
- d. Oscilloscope

2.2 Procedure

<u>NOTE</u>: A point source calibration using Victoreen's standard ^{133}Ba point source and Victoreen's standard geometry, Model 844-36 is to be performed immediately prior to the effluent calibration to assure proper response to radiation. Refer to Section B.2 for the point source calibration procedure.

a. Remove the charcoal cartridge from the holder assembly and replace it with the ^{131}I volume source.

b. Position the ratemeter switch or jumper so that the ratemeter is counting in the analyzer mode.

c. Connect an oscilloscope to monitor the output of the linear amplifier of the analyzer (TP302 and GND). Adjust the analyzer gain control, R334, until the ^{131}I .364 Mev photopeak is approximately 4.0 volts.

d. Connect a DVM between TP304 and ground to measure the upper window level. Adjust the "delta E" control R323, for an indication of 4.2 ± 0.02 vdc.

e. Connect the DVM between TP303 and ground to measure the lower window level. Adjust the "delta Y" potentiometer, R313, for an indication of 3.8 ± 0.02 vdc.

f. While monitoring the count rate on the front panel meter, carefully adjust the analyzer gain, R334, for a maximum, or peak count rate from the ^{131}I .364 Mev photo-peak. This will require only a small adjustment on R334. Allow several minutes for the reading to stabilize.

g. Connect a Counter/Scaler between the junction of R14 and R18 or TP7 on the log count ratemeter card and ground. Record the counts to the ^{131}I source (gross counts) count for a time period sufficient to reduce the counting error to within the desired tolerance.

h. Compute the gross count rate.

i. Remove the ^{131}I source from the holder assembly and replace the assembly.

j. Count the ambient background for a time period sufficient to reduce the background counting error to a statistically insignificant value.

k. Compute the ambient background count rate.

l. Compute the net count rate by subtracting the ambient background countrate from the gross count rate.

m. Calculate the response of the detector (efficiency) by dividing the net count rate by the source activity. The units of the calculated efficiency are in (counts per minute)/(microcuries), abbreviated as (CPM)/(μCi).

n. Calculate the efficiency in units of (counts per minute/minute)/(micocuries per cubic centimeter), abbreviated as (CPM/M)/(μCi/cc) using the following formula:

$$S = 2.83 \times 10^4 FE$$

Where:

S is the efficiency expressed as (CPM/M)/(μCi/cc)

F is the flow rate in standard cubic feet per minute (SCFM)

E is the efficiency calculated in step m.

2.83×10^4 is a conversion factor converting cubic feet (ft^3) to cubic centimeters (cm^3)

3 Gas Monitors

For monitors with gamma detectors Section C.1 is followed and calculations are performed to account for absorption differences between air and water media. The response per unit activity versus energy (response or efficiency curve) is determined from these results.

For channels with beta detectors, nuclides having single significant beta emissions of known maximum energy are used to determine the response per unit activity versus energy. Krypton 85 and Xenon 133 gases are normally used to determine two points on the response curve. The remainder of the curve is determined from relative responses to Iodine 129, Technetium 99, Chlorine 36 and Strontium 90-Yttrium 90 area sources. These area sources are also used in calibration of the particulate monitors Section C.4 and the beta factory point source calibration.

3.1 Requirements

a. Electronic Counter/Scaler

b. Peristaltic Pump and Flexible Polyethylene Tubing

c. Plastic Bottle with Steel Plungers.

d. ^{85}Kr and ^{133}Xe Gas Ampoules.

3.2 Procedure

NOTES: 1) A point source calibration using Victoreen's standard ^{129}I source is to be performed immediately prior to the effluent calibration to assure proper response to radiation. Refer to B.1 for the point source calibration procedure.

2) If more than one monitor is to be calibrated, the monitors may be connected in series with one another.

a. Determine the total volume of the complete calibration set-up.

b. Connect a Counter/Scaler between the junction of R14 and R13 or TP7 on the log count ratemeter card and ground. Count the ambient background counting error to a statistically insignificant value.

c. Compute the ambient background count rate.

d. Attach the gas ampoule to the steel plunger on the bottle lid. Screw the lid on the bottle until a tight seal is formed.

e. Break the gas ampoule by striking the steel plunger with a hammer. This forces the plunger further into the bottle, breaking the ampoule against the bottom of the bottle. Tighten the rubber gland around the plunger to assure a tight seal between the plunger and the bottle.

<u>CAUTION:</u> To check for gas leaks, frequently monitor the calibration area with a survey meter.

f. Pump the gas through the system. Observe the scaler readings until a stable reading is obtained. This assures that the gas is thoroughly and evenly mixed throughout the system.

g. Turn off the pumping system and record the counts due to the gas (gross counts) with a Counter/Scaler. Count for a time period sufficient to reduce the counting error to within the desired tolerance.

h. Compute the gross count rate.

i. Compute the net count rate due to the gas by subtracting the ambient background count rate from the gross count rate.

j. Purge the system until the background count rate approaches its initial value,

k. Calculate the concentration of the gas by dividing the ampoule activity by the volume of the system.

l. Calculate the response of the detector (efficiency) by dividing the net count rate by the concentration. The units of the calculated efficiency are in (counts per minute)/(microcuries per cubic centimeter), abbreviated as (CPM)/(μCi/cc).

m. Repeat the procedure for the next gas ampoule.

NOTE: For gas monitors whose geometries are such that they cannot be practically simulated (Detectors placed directly into ducts and vents) the response in a standard geometry is found as in Section C.3. Calculations are then performed using these results, geometrical differences, and air absorption to determine the response (efficiency).

4 Moving Filter Particulate Monitor

Nuclides having single significant beta emissions of known maximum energy are used to empirically determine a smooth curve of response per unit activity versus energy (response or efficiency curve). Area sources of Iodine 129, Technetium 99, Chlorine 36, and Strontium 90-Yttrium-90 are used. These sources are the same sources used in the beta factory point source calibration, Section B.1 and are attached to a Capstan.

4.1 Requirements

a. Electronic Counter/Scaler

b. ^{129}I, ^{99}Tc, ^{36}Cl, and ^{90}Sr - ^{90}Yr Area Sources attached to Capstan

4.2 Procedure

NOTE: A point source calibration using Victoreen's standard ^{129}I source is to be performed immediately prior to the effluent calibration to assure proper response to radiation. Refer to Section B.1 for the point source calibration procedure.

a. Remove the filter paper from the existing Capstan assembly leaving the Capstan in place.

b. Connect a Counter/Scaler between the junction of R14 and R18 or TP7 on the log count ratemeter card and ground. Count the ambient background for a time period sufficient to reduce the background counting error to a statistically insignificant value.

c. Compute the ambient background count rate.

d. Remove the existing capstan and install the capstan containing the mounted sources.

e. Record the counts to each source (gross counts), being particularly careful to center each source with respect to the detector face. Count for a period of time sufficient to reduce the counting error to within the desired tolerance.

f. Compute the gross count rate.

g. Compute the net count rate by subtracting the ambient background countrate from the gross countrate.

h. Calculate the response of the detector (efficiency) by dividing the net count rate to each source by the source activity. The units of the calculated efficiency are in (counts per minute)/(microcuries), abbreviated as (CPM)/(μCi).

i. Calculate the efficiency to each nuclide in units of (counts per minute)/(microcuries per cubic centimeter), abbreviated as (CPM)/(μCi/cc), using the following formula:

$$S = \frac{VE}{2}$$

Where:

S is the efficiency at equilibrium (after an elapsed time pf twp. hours from start-up at a Capstan speed of one inch per hour) expressed as (CPM)/(μCi/cc)

E is the efficiency calculated in h

V is the volume of air which flows through the sampling area during the time the filter paper moves a distance equal to the length of the sampling area and is calculated as follows:

$$V = \frac{(1.7 \times 10^6)FL}{C}$$

Where:

F is the flow rate in standard cubic feet per minute (SCFM)

L is the length of the active Capstan collection area in inches

C is the Capstan speed in inches/hour

1.7×10^6 is a conversion factor converting cubic feet hours $[(ft^3)\ (hr.)]$ to cubic centimeter minutes $[(cm)^3\ (Min.)]$

5 Fixed Filter Particulate Monitors

Nuclides having single significant beta emissions of known maximum-energy are used to empirically determine a smooth curve of response per unit activity per unit time versus energy (response or efficiency curve).

Area sources of Iodine-29, Technetium-99, Chlorine-36, and Strontium-90 - Yttrium-90 are used. These sources are 1.75 inch diameter circular filter papers made to fit exactly into the filter holder.

5.1 Requirements

a. Electronic Counter/Scaler

b. ^{129}I, ^{99}Tc, ^{36}Cl, and ^{90}Sr - ^{90}Yr Circular Sources.

5.2 Procedure

NOTE: A point source calibration using Victoreen's standard ^{129}I source is to be performed immediately prior to the effluent calibration to assure proper response to radiation. Refer to Section B.1 for the point source calibration procedure.

a. Remove the filter paper from the filter holder. Insert the filter holder in place.

b. Connect a Counter/Scaler between the junction of R14 and R18 on TP7 on the log count ratemeter card and ground. Count the ambient background for a time period sufficient to reduce the background counting error to a statistically insignificant value.

c. Compute the ambient background count rate.

d. Insert the source in the filter holder and record the counts to each source (gross counts). Count for a time period sufficient to reduce the counting error to within the desired tolerance.

e. Compute the gross count rate.

f. Compute the net count rate by subtracting the ambient background count rate from the gross count rate.

g. Calculate the response of the detector (efficiency) by dividing the net count rate to each source by the source activity. The units of the calculated efficiency are in (counts per minute)/(microcuries), abbreviated as (CPM)/(μCi).

h. Calculate the efficiency to each nuclide in units of (counts per minute/minute)/(microcuries per dubic centimeter), abbreviated as (CPM/M)/(μCi/cc) using the following formula:

$S = 2.83 \times 10^4 FE$

Where:

S is the efficiency expressed as (CPM/M)/ μCi/cc)

F is the flow rate in standard cubic feet per minutes (SCFM)

E is the efficiency calculated in g.

2.83×10^4 is a conversion factor converting cubic feet (ft^3) to cubic centimeters $(cm)^3$.

B. Customer Requested Calibrations

1 Liquid Effluent Calibrations

(Victoreen Model 841-30 Samplers with 843-30 Gamma Detectors)

A point source calibration, using Victoreen's standard Ba-133 point source, was performed prior to the effluent calibration on each channel to assure proper response to radiation. The point source calibration procedure for gamma monitors is described in Section V.

. It was required per specification that the countrates to Cs-137, I-131, and Co-58 solutions be obtained for monitors WDL-R-1311, WT-R-3894, and WT-R-3895.

EFFLUENT SOLUTIONS

Cs-137, I-131, Co-58, and Co-60 solutions were used to calibrate the monitors. The Co-60 solution, though not required by the specification, was utilized so that a typical response curve could be generated based upon data derived from these calibrations.

The Cs-137 solution was formulated by diluting a nominal concentration of commercially available Cs-137 with demineralized water. A 5±.01 milliliter sample was taken for assay. The assay consists of comparison of countrates between Victoreen's standard Cs-137 solution and the sample. Victoreen's standard Cs-137 solution is catalogue number LST-7, standard number 32, obtained from Tracerlab and is traceable to N.B.S. standards. Documentation data for this is included in Section IX. The assay was performed on 8/13/75 and the concentration was determined as 2.86 x 10^{-4} µCi/cc ± 5.8%. ± 5.8% is the overall error and is the sum of a systematic error of 4.4% and a random error of 1.4% at 2.σ.

The I-131 solution was formulated by diluting an N.B.S. traceable concentration obtained from New England Nuclear with 6 liters of demineralized water.

Documentation data is supplied in Section IX. The diluted solution concentration at 3:30 P.M. on 8-14-75 was 1.53 x 10^{-4} µCi/cc ± 3.9%. ± 3.9% is the overall error and is the sum of a systematic error of 2.4% and a random error of 1.5% at 3 σ.

The Co-58 solution was formulated by diluting an N.B.S. traceable concentration obtained from New England Nuclear with 6 liters of demineralized water. Documentation data is supplied in Section IX. The diluted solution concentration on 8-15-75 was 9.29 x 10^{-5} µCi/cc ± 4.4%. ± 4.4% is the overall error and is the sum of a systematic error of 3.2% and a random error of 1.2% at 3 σ.

The Co-60 solution was formulated by diluting a nominal concentration of commercially available Co-60 with demineralized water. A 5 ± .01 milliliter sample was taken for assay. The assay consists of comparison of countrates between Victoreen's standard Co-60 solution and the sample. Victoreen's standard Co-60 solution is catalogue number LST-6, standard number 141, obtained from Tracerlab and is traceable to N.B.S. standards. Documentation data for this is included in Section IX. The assay was performed on 8-15-75 and the concentration was determined as 5.63 x 10^{-5} µCi/cc ± 8.5%. 8.5% is the overall error and is the sum of a systematic error of 5.0% and a random error of 3.5% at 2 σ. Table 2 below lists the concentration and associated errors for each solution.

Table 2.

Nuclide	Concentration (µCi/cc)	date	Random Error	Systematic Error	Overall Error
Cs-137	2.86 x 10^{-4}	8-13-75	±1.4% at 2 σ	4.4%	5.8%
I-131	1.53 x 10^{-4}	8-14-75 3:30P.M.	±1.5% at 3 σ	2.4%	3.9%
Co-58	9.29 x 10^{-5}	8-15-75	±1.2% at 3 σ	3.2%	4.4%
Co-60	5.63 x 10^{-5}	8-15-75	±3.5% at 2 σ	5.0%	8.5%

CALIBRATION PROCEDURE

Demineralized water is introduced into the sampler volume before each calibration and the background counts are taken with a scalar counter. The background counts per minute are determined. The water is completely drained from the sampler volume and the nuclide solution is pumped into the sampler volume until it is entirely filled. Counts due to the nuclide solution are then taken with a scalar counter and the gross countrate is determined. The net countrate due to the nuclide solution is calculated by subtracting the background countrate from the gross countrate. The nuclide solution is then completely drained from the sampler volume and the volume is thoroughly decontaminated with soap and water. The procedure is repeated for the next nuclide solution.

After calibration to all nuclide solutions is complete, the sampler volume is decontaminated as thoroughly as possible until the background countrate inside the sampler approaches its initial value.

RESULTS

The results of the effluent calibration for each monitor channel are presented in Table 3 below..

A random error (counting error) is incurred in determining the countrate to the nuclide solution inside the sampler volume. This random error is 1.1% at 2 σ. A systematic error results from errors incurred through experimental technique and procedure. This systematic error is 1%. The overall error in Table 2 is the sum of the overall error of the nuclide concentration plus the random and systematic errors stated above.

Efficiency is defined as (counts per minute)/(microcuries per cubic centimeter) and is abbreviated as CPM/(μCi/cc).

Table 3

Monitor Channel Number	Nuclide Solution	Solution Concentration (μCi/cc)	Net Counts Per Minute (CPM)	Efficiency CPM/(μCi/cc)	Overall Error
WT-R-3894	Cs-137	2.86×10^{-4}	26,076	9.11×10^{7}	± 7.9%
	I-131	1.53×10^{-4}	19,101	1.24×10^{8}	± 6.0%
	Co-58	9.29×10^{-5}	13,291	1.43×10^{8}	± 6.5%
	Co-60	5.63×10^{-5}	10,617	1.88×10^{8}	± 10.6%
WT-R-3895	Cs-137	2.86×10^{-4}	25,877	9.04×10^{7}	± 7.9%
	I-131	1.53×10^{-4}	19,035	1.24×10^{8}	± 6.0%
	Co-58	9.29×10^{-5}	13,374	1.44×10^{8}	± 6.5%
	Co-60	5.63×10^{-5}	10,549	1.87×10^{8}	± 10.6%
WDL-R-1311	Cs-137	2.86×10^{-4}	26,406	9.23×10^{7}	± 7.9%
	I-131	1.53×10^{-4}	19,147	1.25×10^{8}	± 6.0%
	Co-58	9.29×10^{-5}	13,644	1.46×10^{8}	± 6.5%
	Co-60	5.63×10^{-5}	10,677	1.89×10^{8}	± 10.6%

The average efficiency of the three monitors to each nuclide is given in Table 4 below. Figure 1 was derived from this table and other acquired calibration data. Figure 1 states efficiencies as a function of energy normalized to 100% gamma intensity. (one gamma per disintegration).

TABLE 4

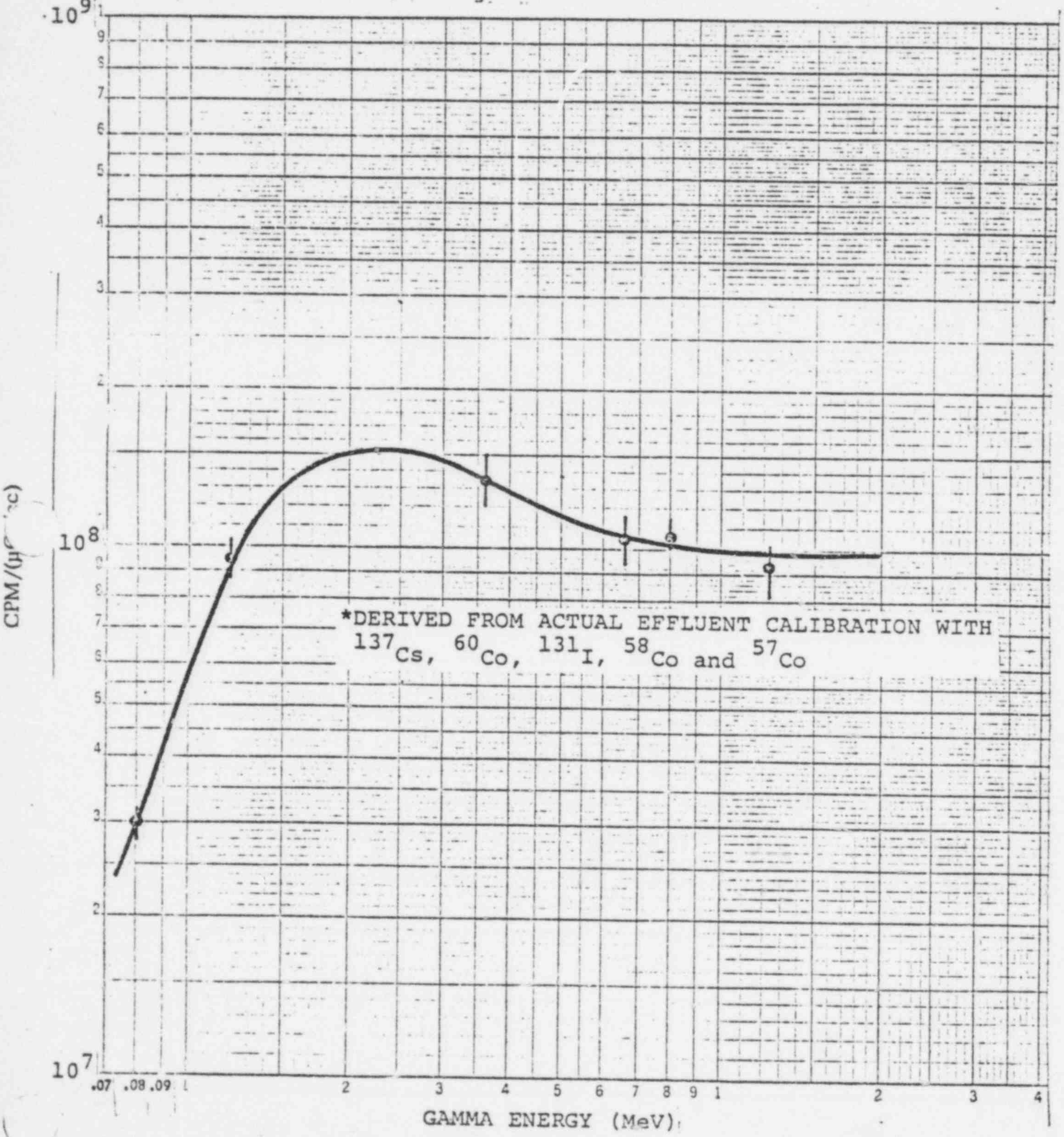
Nuclide Solution	Average Efficiency CPM/(μCi/cc)
Cs-137	9.13×10^{7} ± 7.9%
I-131	1.24×10^{8} ± 6.0%
Co-58	1.44×10^{8} ± 6.5%
Co-60	1.88×10^{8} ± 10.6%

MODEL 841-30 SERIES 4π SHIELDED OFF-LINE EFFLUENT SAMPLERS WITH MODEL 843-30 GAMMA SCINTILLATION DETECTOR

SENSITIVITY VS. GAMMA ENERGY*

AT:

1 GAMMA PER DISINTEGRATION
GROSS COUNTING WITH .2 VOLT BASELINE SET ON
133Ba FOR POINT SOURCE CALIBRATION



*DERIVED FROM ACTUAL EFFLUENT CALIBRATION WITH ^{137}Cs, ^{60}Co, ^{131}I, ^{58}Co and ^{57}Co

POOR ORIGINAL

E. SUMMARY AND CONCLUSION

The required effluent calibrations were completed by Victoreen. The efficiencies obtained for each monitor to a specific nuclide are in close agreement and within acceptable tolerance. These results along with other acquired calibration data enabled a typical response curve to be generated. This curve may be utilized to find efficiencies to any nuclide for this type monitor.

Prepared by __________________
Don Strenio

Certified by K E Stafford J
K.E.Stafford, Jr.Mgr.
Quality Assurance

Date: 8-15-75

2 Gaseous Effluent Calibrations

(Victoreen Model 841-30 Samplers with 843-20 Beta Detectors)

A point source calibration, using Victoreen's standard ^{129}I, ^{99}Tc ^{36}Cl, and ^{90}Sr - ^{90}Yr area sources, was performed prior to the effluent calibration to assure proper response to radiation. The point source calibration procedure for beta detectors is described in Section V .

It was required per specification that the count rates to three activity levels of Kr-85 and two activity levels of Xe-133 be obtained for the following monitors.

- VA-R-748
- WDG-R-1480
- WDG-R-1485
- WDG-R-1486
- HP-R-219
- HP-R-221B
- HP-R-225
- HP-R-226
- HP-R-227
- HP-R-228
- HP-R-229

The monitors were grouped as shown below. Monitors within the same group were connected in series.

Group 1	Group 2	Group 3
VA-R-748	HP-R-225	HP-R-219
WDG-R-1480	HP-R-226	HP-R-221B
WDG-R-1485	HP-R-227	HP-R-229
WDG-R-1486	HP-R-228	

AMPOULE ACTIVITIES

Kr-85 and Xe-133 gas were used to calibrate the monitors. Three ampoules of Kr-85, each at a different activity level, were used for each group of monitors. One ampoule of Xe-133 was used for each group of monitors. The low level Xe-133 concentration was obtained by breaking the Xe-133 ampoule in a closed volume, withdrawing a calculated portion of that closed volume with a gas tight syringe and injecting the desired low level activity into the system. The Kr-85 ampoules were procured from New England Nuclear and assayed at Victoreen.

The assay consists of comparison of countrates between Victoreen's standard Kr-85 ampoule and the ampoules used. Victoreen's standard ^{85}Kr ampoule is standard Reference Material 4235-14 traceable to N.B.S. standards. Refer to Section IX for documentation. The activity of the ampoules at the date of assay and percentage error at 2σ are shown below.

Kr-85 Ampoule Activity (µCi)	Date Of Assay	Percentage Error at 2σ
Group #1 (VA-R-748, WDG-R-1480, WDG-R-1485, WDG-R-1486)		
.115	11/21/73	±13.2%
1.40	11/21/73	± 8.6%
31.8	11/21/73	± 7.5%
Group #2 (HP-R-225, HP-R-226, HP-R-227, HP-R-228)		
.115	11/21/73	± 13.2%
1.30	11/21/73	± 8.6%
33.0	11/21/73	± 7.5%
Group #3 (HP-R-219, HP-R-221B, HP-R-229)		
.115	11/21/73	±13.2%
1.28	11/21/73	± 8.6%
33.6	11/21/73	± 7.5%

The Xe-133 ampoules were procured and assayed by Union Carbide Corp., Oak Ridge National Laboratory. Refer to Section IX for documentation.

The activity of each ampoule on the date of assay and the percentage error are presented in the table below. The percentage error was obtained from telephone conversations with Oak Ridge National Laboratories (ORNL).

ORNL indicated that the percentage error is approximately ±25% at 2σ.

133Xe Ampoule Activity (μCi)	Date of Assay		Percentage Error at 2σ
Group#1 (VA-R-748, WDG-R-1480, WDG-R-1485, WDG-R-1486)			
1.57	8/14/75	11:40 A.M.	±25%
Group #2 (HP-R-225 HP-R-226, HP-R-227, HP-R-228)			
1.35	8/14/75	11:40 A.M.	±25%
Group #3 (HP-R-219, HP-R-221B, HP-R-229)			
1.62	8/14/75	11:40 A.M.	±25%

CALIBRATION PROCEDURE

During calibration, each sampler within the specified group is connected in series to a pumping system. The pumping system consists of a peristaltic pump and a plastic bottle which holds the gas ampoules. This bottle, whose volume, including the valves, has been previously determined by liquid displacement is capable of being connected in series with the system or sealed off from the system. The ampoules are fastened to steel plungers which pass through rubber glands in the top of the bottle. The volume of the rest of the system is determined by standard sampler dimensions and dimensions of the various connecting lines.

The procedure for calibrating to three different activity levels of Kr-85 will be presented in the following paragraph.

Background counts inside the samplers are taken with a scalar counter. The background counts per minute are determined. The ampoules are placed in the bottle, which is connected in series with the system. The lowest activity ampoule is broken, and the gas is circulated through the system. Ratemeter readings are observed until a stable reading is obtained for each sampler. The gas is now thoroughly mixed throughout the system. Counts due to the gaseous effluent concentration are then taken with a scalar counter and the gross countrate is determined. The procedure is designed such that the ampoules can be broken, in order of lowest to highest activity, without purging the system of gas from the previous ampoule. The intermediate activity ampoule is broken and circulated through the system immediately after the gross countrate due to the low activity ampoule has been determined. Ratemeter readings are observed until a stable reading is obtained for each sampler, and the gross countrate is determined with a scalar counter. After the gross countrate due to the low plus intermediate activity has been determined, the high activity ampoule is broken and circulated through the system. Ratemeter readings are observed until a stable reading is obtained for each sampler and the gross countrate is determined with a scalar counter.

Gross countrates to the (1) low level activity (2) low level + intermediate level activity and (3) low level + intermediate activity + high level activity have been determined.

Net countrates at each interval of the experiment are calculated by subtracting the background countrate from the gross countrate. The concentration at each interval is obtained by directly summing the ampoule activities and dividing by volume of the system. The efficiency (CPM/(μCi/cc)) is obtained by dividing the net countrate by the concentration at each interval. After the calibration is complete, the system is purged until the background countrate approaches its initial value.

The procedure for calibrating to Xe-133 at two different activity levels will be presented below. Background counts inside the sampler are taken by a scalar counter. The background counts per minute are then determined. The ampoule is pla in the bottle and the bottle is closed from the system through a valving arrangement. The ampoule is broken in the bottle and sufficient time is allowed for the gas to diffuse evenly throughout the bottle. A 50ml sample is withdrawn from the bottle by a Hamilton Gas tight Syringe. The 50ml sampler is injected into the system and circulated through the system. Ratemeter readings are observed until the countrate has stabilized. Countrates due to the gaseous effluent concentration are then taken with a scalar counter and the gross countrate is determined. The Xe-133 left in the bottle is then released and circulated throughout the system. Ratemeter readings are observed until a stable reading is obtained for each sampler, and the gross countrate is determined. The net countrate at each interval of the experiment is calculated by subtracting the background countrate from the gross countrate. The concentrations are calculated by dividing the activity at each interval of the experiment by the volume. The activity injected by the 50ml syringe can be calculated from the volume of bottle and the activity of the ampoule broken in the bottle. The efficiency (CPM/(μCi/cc)) is determined by dividing the net countrate by the concentration. After the calibration is complete the system is purged until the background countrate approaches its initial value.

DATA AND CALCULATIONS

Table 1 contains the following:

(1) The date of the calibration.

(2) The volume of each system.

(3) The effluent concentrations. The concentration is obtained by decaying the activity of the ampoules given in Section B of this report and dividing the ampoule activity, or sum of ampoule activities where applicable, by the volume. A half life of 10.7 years is used for Kr-85 and a half life of 5.27 days is us for XE-133.

(4) The net countrates obtained at each concentration.

(5) The efficiency expressed as counts per minute per microcuries per cubic centimeter (CPM/(μCi/cc)). The efficiency is obtained by dividing the net countrates by the concentration.

(6) The mean (average) of each set of efficiencies.

(7) Twice the unbiased standard deviation of the mean expressed as a percentage of the mean efficiency. This is abbreviated by 2σ.

Further information and details concerning the effluent calibration not included in this report may be obtained upon request at Victoreen.

TABLE I

Channel No.	Date of Calib.	Volume (CM^3)	Effluent Concentration (uCi/cc)	Net Countrate (CPM)	Efficiency (CPM/(µCi/cc))	Mean of Efficiencies (CPM/(µCi/cc))	Twice th Standard Deviation 2σ
val #1 Kr-85 (Low activity ampoule)							
VA-R-748	8/27/75	19823	5.17×10^{-6}	400	7.73×10^{7}	6.75×10^{7}	±37%
WDG-R-1480	8/27/75	19823	5.17×10^{-6}	399	7.71×10^{7}		
WDG-R-1485	8/27/75	19823	5.17×10^{-6}	389	7.52×10^{7}		
WDG-R-1486	8/27/75	19823	5.17×10^{-6}	378	7.31×10^{7}		
HP-R-225	9/2/75	20066	5.10×10^{-6}	257	5.04×10^{7}		
HP-R-226	9/2/75	20066	5.10×10^{-6}	266	5.21×10^{7}		
HP-R-227	9/2/75	20066	5.10×10^{-6}	263	5.16×10^{7}		
HP-R-228	9/2/75	20066	5.10×10^{-6}	270	5.29×10^{7}		
HP-R-219	9/12/75	15901	6.43×10^{-6}	486	7.56×10^{7}		
HP-R-221B	9/12/75	15901	6.43×10^{-6}	506	7.87×10^{7}		
HP-R-229	9/12/75	15901	6.43×10^{-6}	503	7.82×10^{7}		
Interval #2 Kr-85 (Low activity ampoule + intermediate activity ampoule)							
VA-R-748	8/27/75	19823	6.81×10^{-5}	5525	8.11×10^{7}	7.46×10^{7}	± 26.1%
WDG-R-1480	8/27/75	19823	6.81×10^{-5}	5346	7.85×10^{7}		
R-1485	8/27/75	19823	6.81×10^{-5}	5373	7.89×10^{7}		
WDG-R-1486	8/27/75	19823	6.81×10^{-5}	5230	7.68×10^{7}		
HP-R-225	9/2/75	20066	6.27×10^{-5}	3934	6.26×10^{7}		
HP-R-226	9/2/75	20066	6.27×10^{-5}	4031	6.42×10^{7}		
HP-R-227	9/2/75	20066	6.27×10^{-5}	3944	6.29×10^{7}		
HP-R-228	9/2/75	20066	6.27×10^{-5}	3870	6.16×10^{7}		
HP-R-219	9/12/75	15901	7.79×10^{-5}	6519	8.36×10^{7}		
HP-R-221B	9/12/75	15901	7.79×10^{-5}	6683	8.58×10^{7}		
HP-R-229	9/12/75	15901	7.79×10^{-5}	6601	8.47×10^{7}		

Channel No.	Date of Calib.	Volume (CM^3)	Effluent Concentration (µCi/cc)	Net Countrate (CPM)	Efficiency (CPM/(µCi/cc))	Mean of Efficiencies (CPM/(µCi/cc))	Twice the Standard Deviation 2σ
Interval #3 Kr-85 (Low activity + intermediate activity + high activity ampoules)							
-748	8/27/75	19823	1.50×10^{-3}	133672	8.92×10^{7}	8.09×10^{7}	±14.2%
WDG-R-1480	8/27/75	19823	1.50×10^{-3}	130391	8.70×10^{7}		
WDG-R-1485	8/27/75	19823	1.50×10^{-3}	130050	8.67×10^{7}		
WDG-R-1486	8/27/75	19823	1.50×10^{-3}	126346	8.43×10^{7}		
HP-R-225	9/2/75	20066	1.52×10^{-3}	110922	7.28×10^{7}		
HP-R-226	9/2/75	20066	1.52×10^{-3}	114804	7.54×10^{7}		
HP-R-227	9/2/75	20066	1.52×10^{-3}	112632	7.41×10^{7}		
HP-R-228	9/2/75	20066	1.52×10^{-3}	114673	7.53×10^{7}		
HP-R-219	9/12/75	15901	1.96×10^{-3}	157140	8.02×10^{7}		
HP-R-221B	9/12/75	15901	1.96×10^{-3}	163096	8.33×10^{7}		
HP-R-229	9/12/75	15901	1.96×10^{-3}	160478	8.19×10^{7}		
*Interval #1 Xe-133 (Activity from 50 ml syringe)							
VA-R-748	9/15/75	17319	1.02×10^{-4}	4628	4.52×10^{7}	4.37×10^{7}	±17.6%
WDG-R-1480	9/15/75	17319	1.02×10^{-4}	4581	4.48×10^{7}		
WDG-R-1485	9/15/75	17319	1.02×10^{-4}	4692	4.60×10^{7}		
WDG-R-1486	9/15/75	17319	1.02×10^{-4}	4838	4.73×10^{7}		
-R-225	9/4/75	17532	1.00×10^{-4}	3905	3.90×10^{7}		
-226	9/4/75	17532	1.00×10^{-4}	3890	3.89×10^{7}		
HP-R-227	9/4/75	17532	1.00×10^{-4}	3900	3.90×10^{7}		
HP-R-228	9/4/75	17532	1.00×10^{-4}	3907	3.90×10^{7}		
HP-R-219	9/11/75	13397	6.23×10^{-5}	2900	4.65×10^{7}		
HP-R-221B	9/11/75	13397	6.23×10^{-5}	2991	4.80×10^{7}		
HP-R-229	9/11/75	13397	6.23×10^{-5}	2932	4.70×10^{7}		
*Cal. done at 4:00 P.M. on 9/15/75, 1:00 P.M. on 9/4/75, 3:00 P.M. on 9/11/75 Volume of the bottle is 2403 CM^3							
**Interval #2 Xe-133 (Total activity of ampoule)							
VA-R-748	9/15/75	19823	4.39×10^{-3}	190608	4.34×10^{7}	4.26×10^{7}	±14.7%
WDG-R-1480	9/15/75	19823	4.39×10^{-3}	190351	4.33×10^{7}		
WDG-R-1485	9/15/75	19823	4.39×10^{-3}	193599	4.41×10^{7}		
WDG-R-1486	9/15/75	19823	4.39×10^{-3}	197531	4.49×10^{7}		
HP-R-225	9/4/75	20066	4.33×10^{-3}	165874	3.83×10^{7}		
HP-R-226	9/4/75	20066	4.33×10^{-3}	168331	3.88×10^{7}		
HP-R-227	9/4/75	20066	4.33×10^{-3}	168437	3.89×10^{7}		
HP-R-228	9/4/75	20066	4.33×10^{-3}	171583	3.96×10^{7}		
-219	9/11/75	15901	2.58×10^{-3}	116356	4.50×10^{7}		
R-221B	9/11/75	15901	2.58×10^{-3}	121671	4.71×10^{7}		
HP-R-229	9/11/75	15901	2.58×10^{-3}	117622	4.55×10^{7}		

**Cal. done at approximately 4:00 P.M. on 9/15/75, 1:00 P.M. on 9/4/75, 3:00 P.M. on 9/11/75

RESULTS

For evaluation of the uncertainties in the data a precision of ± 2σ (95% confidence level) expressed as a percentage of the mean was chosen. This range encompasses most random variations that can occur about the mean.

The precisions stated in Table 1 are results of (1) the precision of the activity of the ampoule as stated in Section B of this report (2) the counting error encountered in obtaining net count rates and (3) the precision of the calibration measurements. The contribution of each of the errors to the total error is known. However, since the statement of each of these separate errors is not necessary in evaluations of the data, a complete breakdown will not be presented in this report.

From the data obtained and the stated precisions, an average efficiency for this type gas monitor to Kr-85 and Xe-133 will be obtained. Linearity of response to differing concentrations of each nuclide for each channel will also be shown.

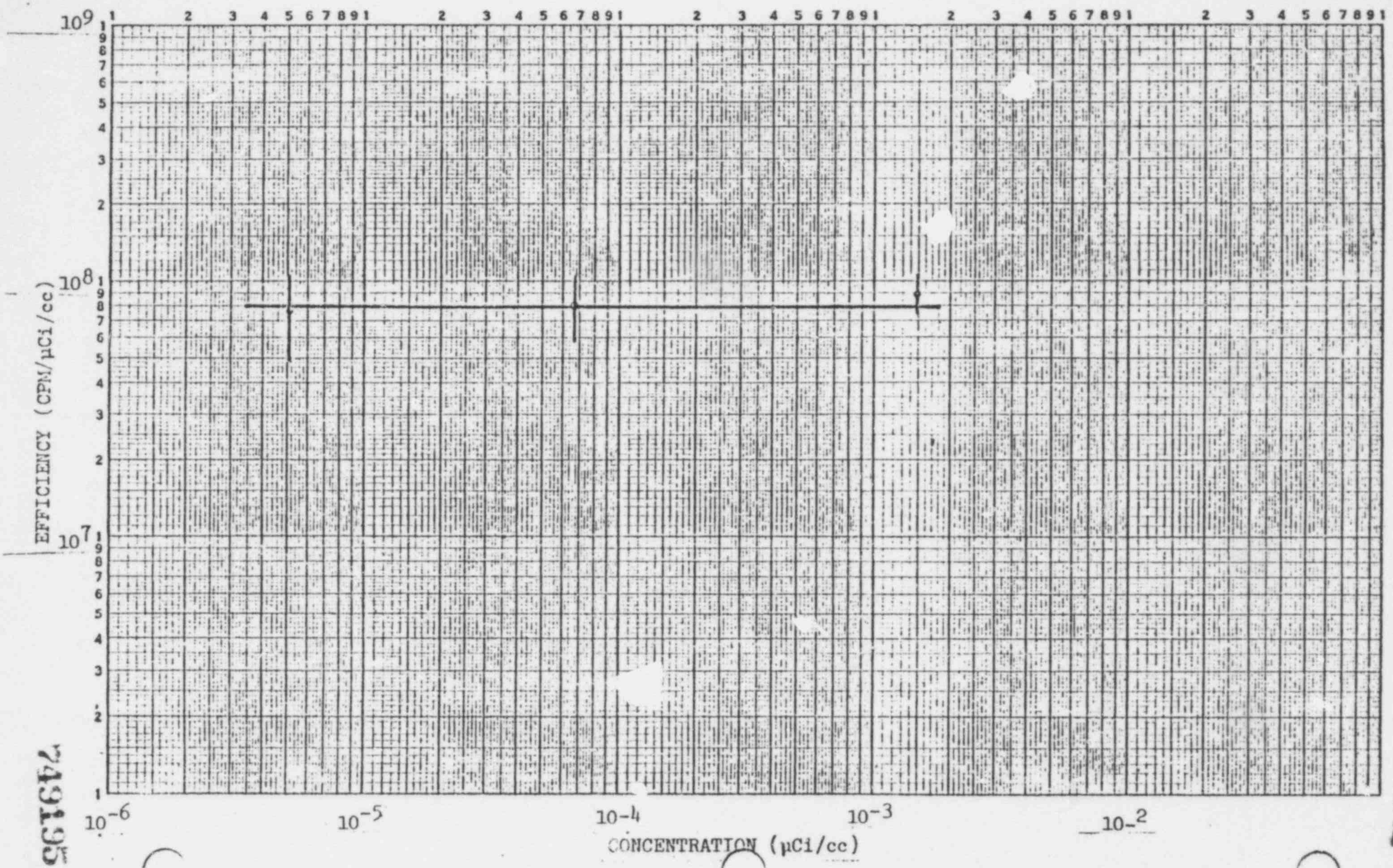
Since the precision for Kr-85 is the best for Interval #3 the mean value obtained from this data will be used as the average efficiency to Kr-85. The mean efficiency from Table 1 for Kr-85 Interval #3 is 8.10×10^7 CPM/(μCi/cc) ± 13.8% at 2σ. This value can be used as an average efficiency to Kr-85 for a monitor of this type.

There is linearity of response between Intervals #1, #2, and #3 for each channel and between the mean efficiencies of each Interval. This has been confirmed for each channel by multiplying the efficiency by the stated precision and observing if the limits overlap. An example for channel VA-R-748 will be presented below. Graphing, though not necessary in recognizing if the channels are linear, enables linearity to be more easily observed. A plot for channel VA-R-748 will be presented as an example.

Channel VA-R-748

	Efficiency	Precision	Upper Limit	Lower Limit
Interval #1	7.73×10^7	± 36.6%	1.05×10^8	4.90×10^7
Interval #2	8.11×10^7	± 26.2%	1.02×10^8	5.98×10^7
Interval #3	8.92×10^7	± 13.8%	1.01×10^8	7.68×10^7

^{85}Kr LINEARITY PLOT FOR VA-R-748

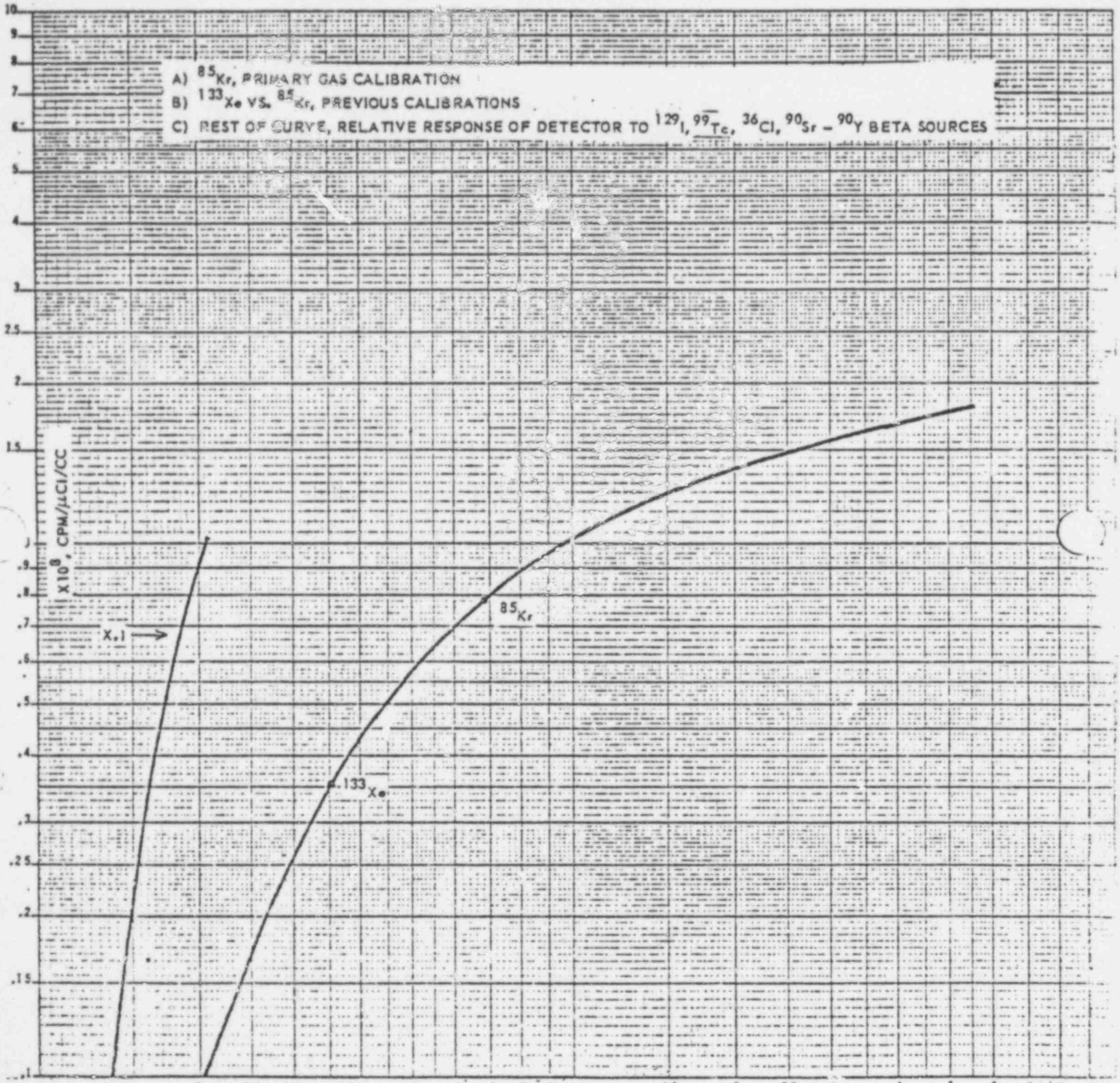


Since the precision for Xe-133 is the best for Interval #2 the mean value obtained from this data will be used as the average efficiency to Xe-133. However, since the ampoule activity error is greater than the error given in Table 1, the ampoule activity error of ± 25% at 2σ should be used for determining the limits of precision for the average value. The mean efficiency from Table 1 for Xe-133 Interval #2 is 4.26 x 10^7 CPM/(μCi/cc). The average efficiency to Xe-133 for a monitor of this type is therefore 4.26 x 10^7 CPM/(μCi/cc) ± 25% at 2σ. There is linearity of response between Intervals #1 and #2 for each channel and between the mean efficiencies of each interval. This has been confirmed for each channel by multiplying the efficiency by the stated precision in Table 1 and observing if the limits overlap. An example for VA-R-748 has already been presented in this report which illustrates this method for Kr-85.

A response curve which has been generated from experiments utilizing nuclides in addition to Kr-85 and Xe-133 is presented on the following page. The average efficiencies to Kr-85 and Xe-133 obtained from the gaseous calibrations done for TMI II agree within the prescribed tolerances to the values derived from this curve. This curve can be used to derive efficiencies of this type Offline Gas Monitor to any desired nuclide.

SENSITIVITY VS. MAXIMUM BETA ENERGY OF GAS EFFLUENTS

MODEL 841-30 (4π SHIELD) OFF-LINE SAMPLER SERIES
WITH MODEL 843-20 BETA SCINTILLATION DETECTOR
AT ATMOSPHERIC PRESSURE



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CONCLUSION

The required gaseous effluent calibrations were performed by Victoreen. The efficiencies to Kr-85 and Xe-133 obtained for each channel, and the average efficiencies obtained for Kr-85 and Xe-133 are stated in the report. A response curve which has been generated from experiments utilizing nuclides in addition to Kr-85 and Xe-133 has been included. The average efficiencies to Kr-85 and Xe-133 obtained from the TMI II gaseous calibrations agree within the prescribed tolerances to the values derived from this curve. This curve may be utilized to determine efficiencies to any nuclide for this type monitor.

Prepared by Don Strenio
Don Strenio

Certified by K E Stafford Jr
K. E. Stafford, Jr.,Mgr.
Quality Assurance

Date: 8-21-75

MEANING AND USE OF ENERGY RESPONSE CURVES

The energy response curve for a radiation monitor is a plot of the response of a monitor's detector to a normalized nuclide activity or concentration at each energy over a selected energy range. The detector's response to a normalized activity or concentration at a certain energy or for a certain nuclide is often called its efficiency.

The abscissa of the energy response curves consists of a range of energy values. The ordinate of the energy response curve consists of the detector's response to a normalized activity or concentration over the given energy range. Units used for ordinates and abscissas for monitors that Victoreen supplies are listed below.

List of abbreviations:

CPM = Counts per minute

µCi = Microcuries

CC = Cubic centimeters

M = Minutes

MeV = Million electron volts

	Ordinate Units	Abscissa Units
Liquid Monitors	(CPM)/(µCi/cc)	MeV
Gaseous Monitors	(CPM)/(µCi/cc)	MeV
Moving Filter Particulate Monitors	(CPM)/(µCi/cc)	MeV
Fixed Filter Particulate Monitors	(CPM/M)/(µCi/cc)	MeV
Iodine Monitors	(CPM/M)/(µCi/cc)	MeV

Response curves are generated from effluent isotopic calibrations. A series of data points is determined from these calibrations. The response curve is generated from these data points and response characteristics found in standard scientific literature.

Nuclides having single, closely spaced double, or widely separated gamma lines are used in the generation of gamma energy response curves. These curves are normalized to $1\mu Ci/cc$ at 100% gamma intensity over the energy range. With this type of curve it is possible to predict the response of the monitor for any gamma emitter if the energies and intensities of the gamma emissions from the nuclide are known. The following formula is used.

$$R = (Re_1)\ I_1 + (Re_2)\ I_2 + (Re_n)\ I_n = \sum (Re_n)\ I_n$$

R = Overall efficiency of the monitor to the nuclide

Re_n= Efficiency to the nth gramma in the decay scheme of energy e at 100% intensity

In_1 = Intensity of the gamma emitted at energy e. (Expressed as a decimal)

Nuclides having single beta emissions of known maximum energies are used in the generation of beta energy response curves.

These curves are normalized in the same manner as the gamma energy response curves. To determine the beta efficiencies of the nuclide, the beta emissions and intensities must be found. The same formula presented for finding gamma efficiencies is used with substitution of these values.

The following is an example in which the gamma efficiency of a Victoreen standard offline liquid monitor to Mn-56 is found.

Mn-56 Gamma Energies	Corresponding Intensity of each energy	*Normalized Efficiency for each energy read from energy response curve
.847	99%	8.6×10^7 CPM/(μCi/cc)
1.811	29%	8.8×10^7 CPM/(μCi/cc)
2.110	15%	8.9×10^7 CPM/(μCi/cc)

Using the formula,

$$R = (8.6 \times 10^7)\ (.99) + (8.8 \times 10^7)\ (.29) + (8.9 \times 10^7)(.15)$$

$$R = 1.24 \times 10^8 \text{ CPM/(}\mu\text{Ci/cc)}$$

*NOTE

Due to continuous equipment redesign, these values may differ somewhat from those read off the supplied response curve.

The energy response curve included for the Gas Effluent Monitors is applicable to all TMI II gaseous monitors.

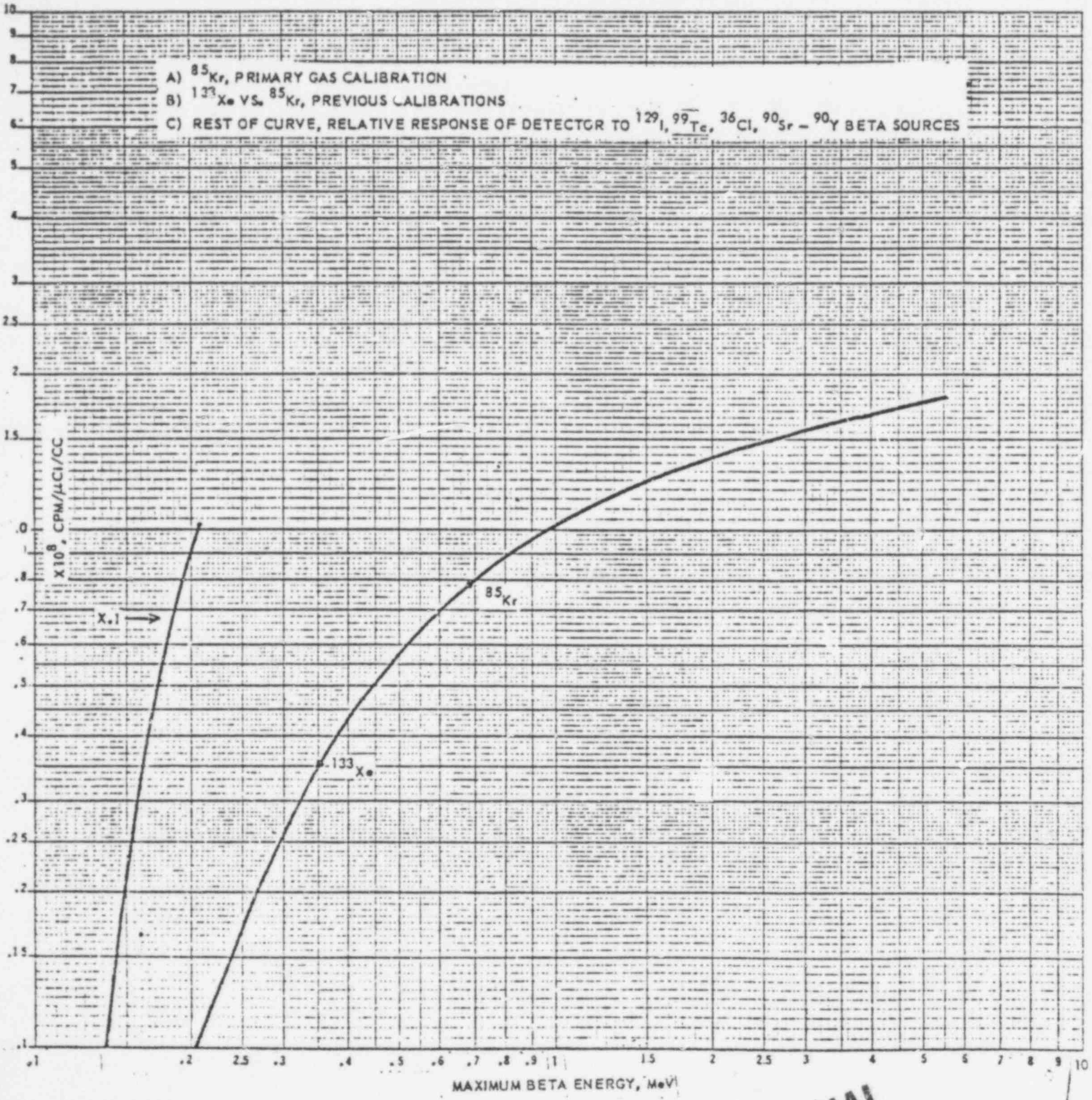
The energy response curve included for the Moving Tape Particulate Monitors is applicable to all TMI II particulate monitors if the values read from the curve are divided by 10.

The energy response curve included for the Liquid Effluent Monitors is applicable to all TMIII liquid monitors except MU-R-720.

The energy response curve included for the Failed Fuel Monitor is applicable to MU-R-720.

SENSITIVITY VS. MAXIMUM BETA ENERGY OF GAS EFFLUENTS

MODEL 841-30 (4π SHIELD) OFF-LINE SAMPLER SERIES
WITH MODEL 843-20 BETA SCINTILLATION DETECTOR
AT ATMOSPHERIC PRESSURE



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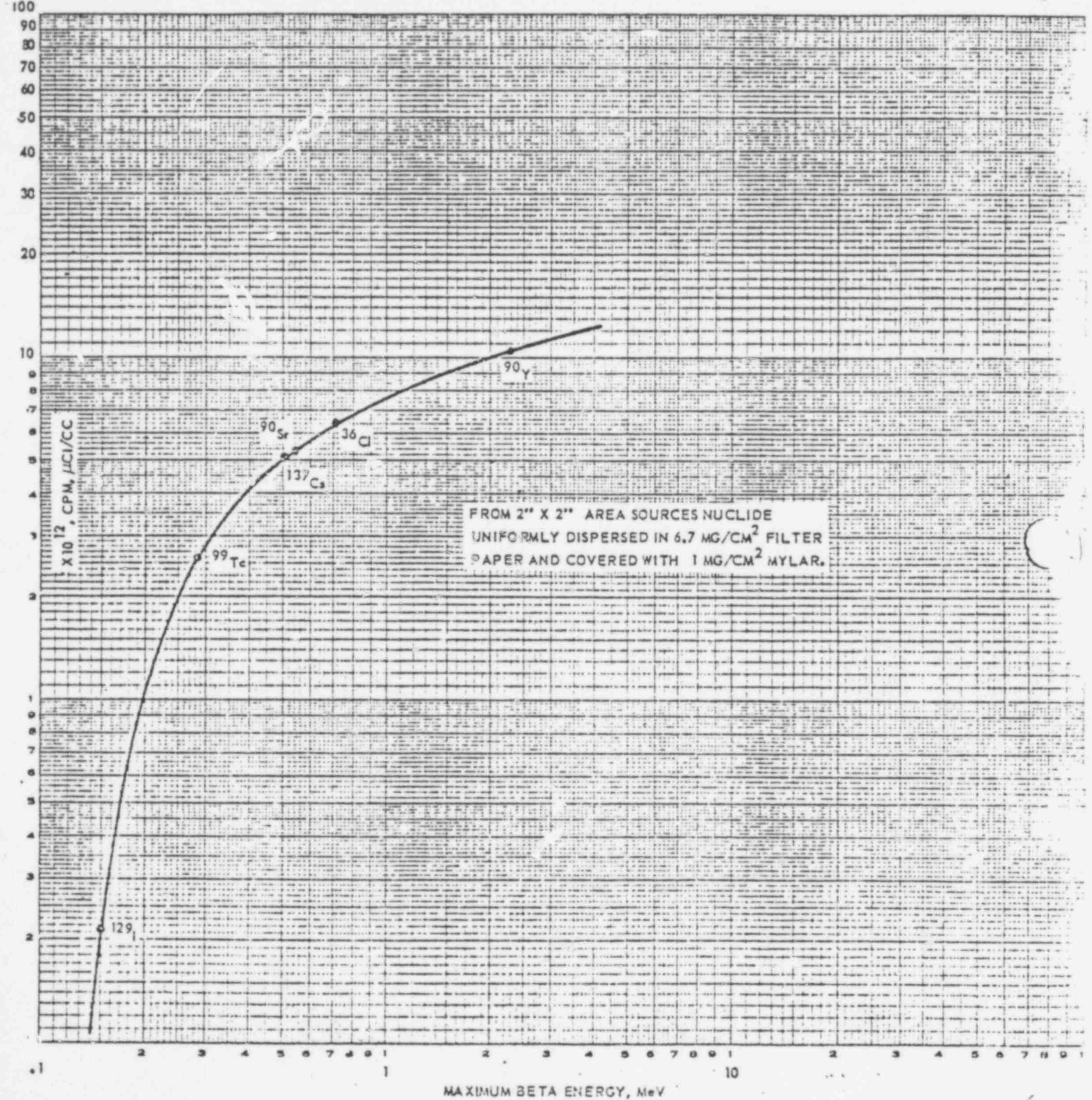
NOTE: DIVIDE VALUES BY 10 FOR TMI I, MOVING TAPE PARTICULATE SAMPLERS WITH [illegible]3-2A DETECTORS

VICTOREEN MODEL 841-1 MOVING TAPE PARTICULATE SAMPLER WITH
MODEL 843-2 BETA SCINTILLATION DETECTOR

SENSITIVITY VS. MAXIMUM BETA ENERGY AT 8.5 SCFM



FROM 2" X 2" AREA SOURCES NUCLIDE UNIFORMLY DISPERSED IN 6.7 MG/CM^2 FILTER PAPER AND COVERED WITH 1 MG/CM^2 MYLAR.

NOTE: EFFICIENCIES ARE DIRECTLY PROPORTIONAL TO THE FLOW RATE. FOR FLOW RATES OTHER THAN 8.5 SCFM MULTIPLY THE VALUE READ FROM THE GRAPH BY: $\frac{\text{ACTUAL FLOW RATE}}{\text{8.5 SCFM}}$

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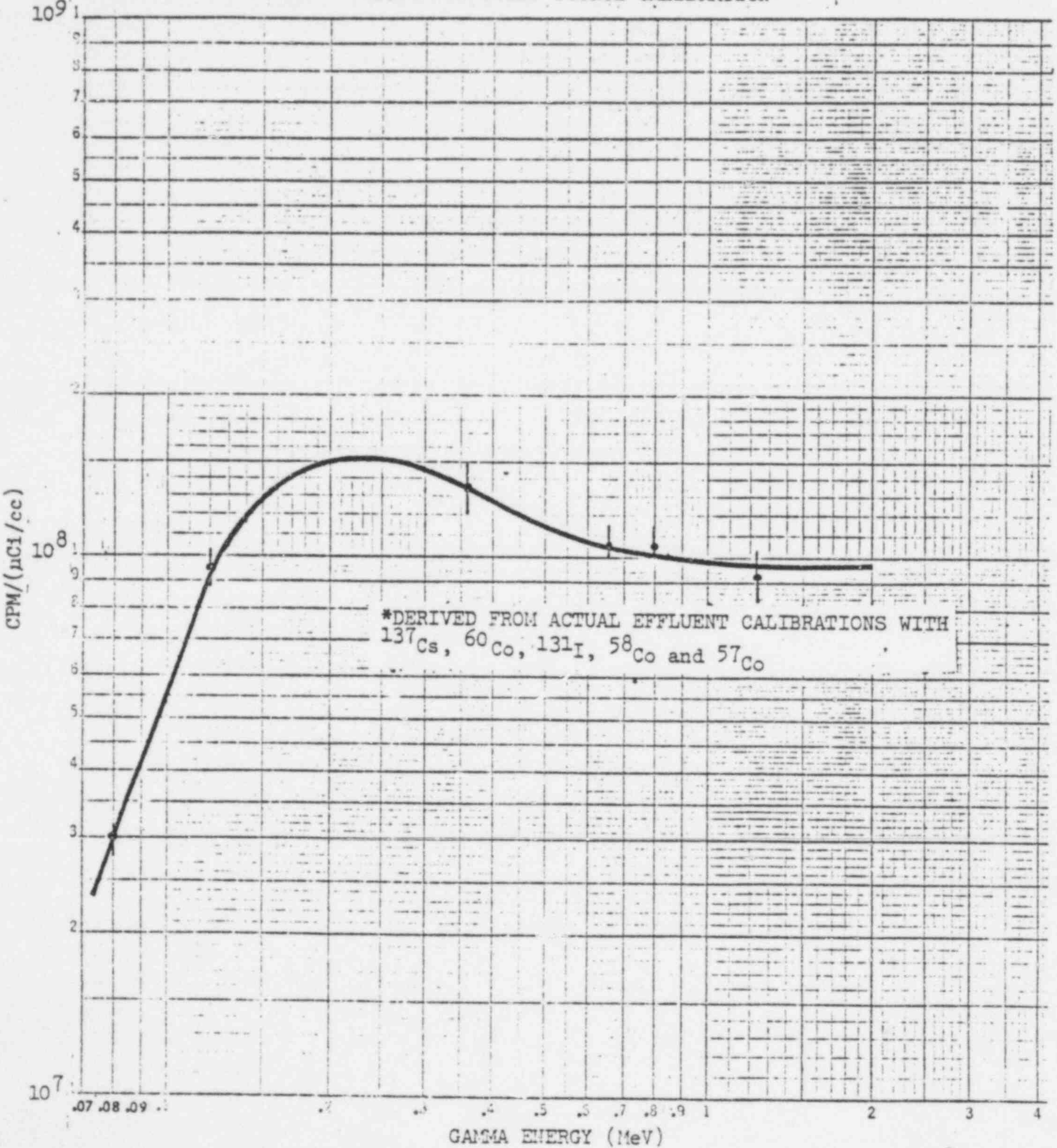
MODEL 841-30 SERIES 4 π SHIELDED OFF-LINE EFFLUENT SAMPLERS
WITH MODEL 843-30 GAMMA SCINTILLATION DETECTOR

SENSITIVITY VS. GAMMA ENERGY*

AT:

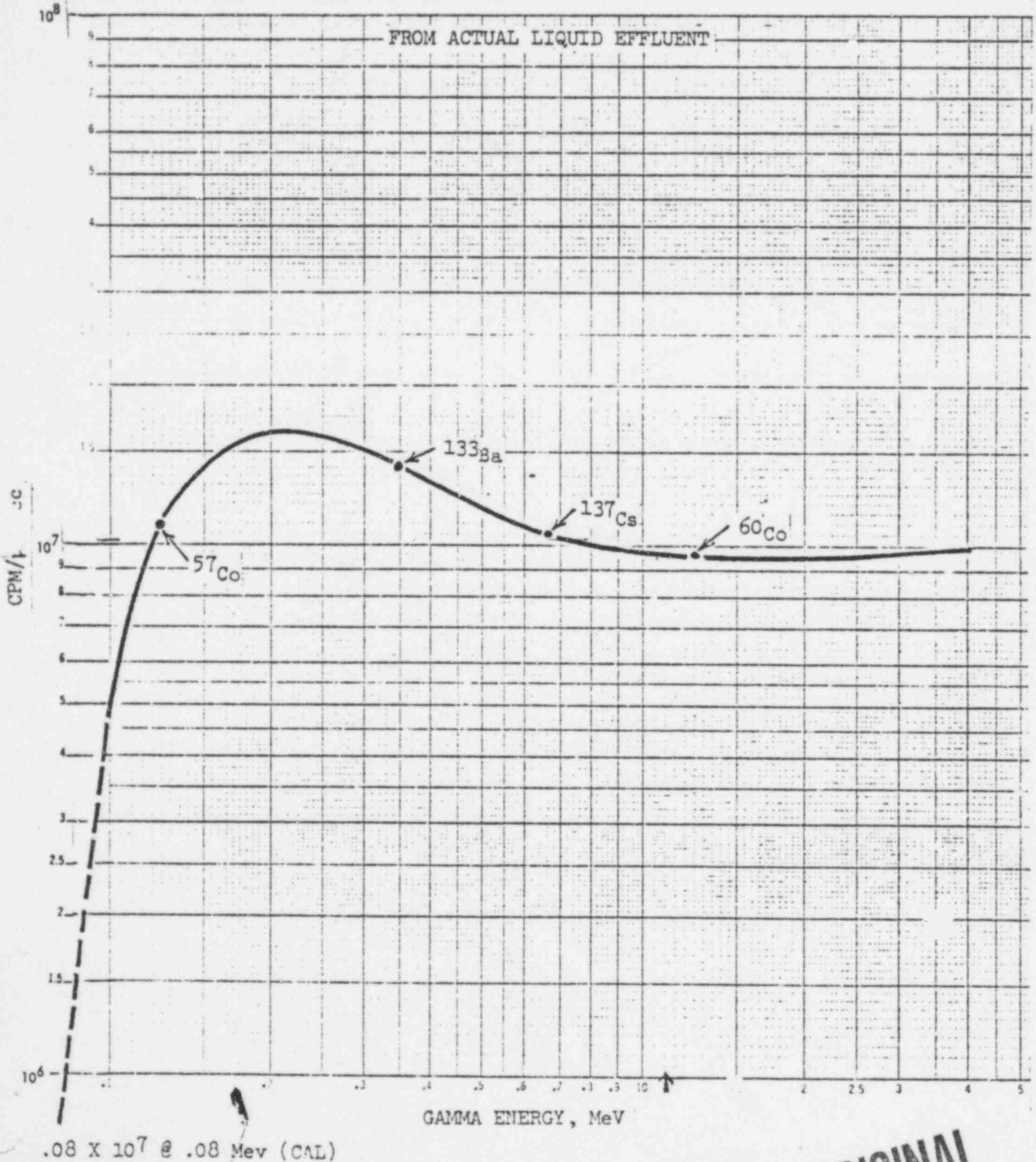
1 GAMMA PER DISINTEGRATION
GROSS COUNTING WITH .2 VOLT BASELINE SET ON
^{133}Ba FOR POINT SOURCE CALIBRATION



*DERIVED FROM ACTUAL EFFLUENT CALIBRATIONS WITH
^{137}Cs, ^{60}Co, ^{131}I, ^{58}Co and ^{57}Co

FAILED FUEL SYSTEM:
SAMPLER 840-4P
DETECTOR 843-30
GROSS COUNTING RATEMETER 842-10 OR 842-30

SENSITIVITY IN CPM ÷ 1μCi/cc @ 1 GAMMA PER DISINTEGRATION
"HIGH" SENSITIVITY POSITION (WITHOUT LEAD ATTENUATOR)

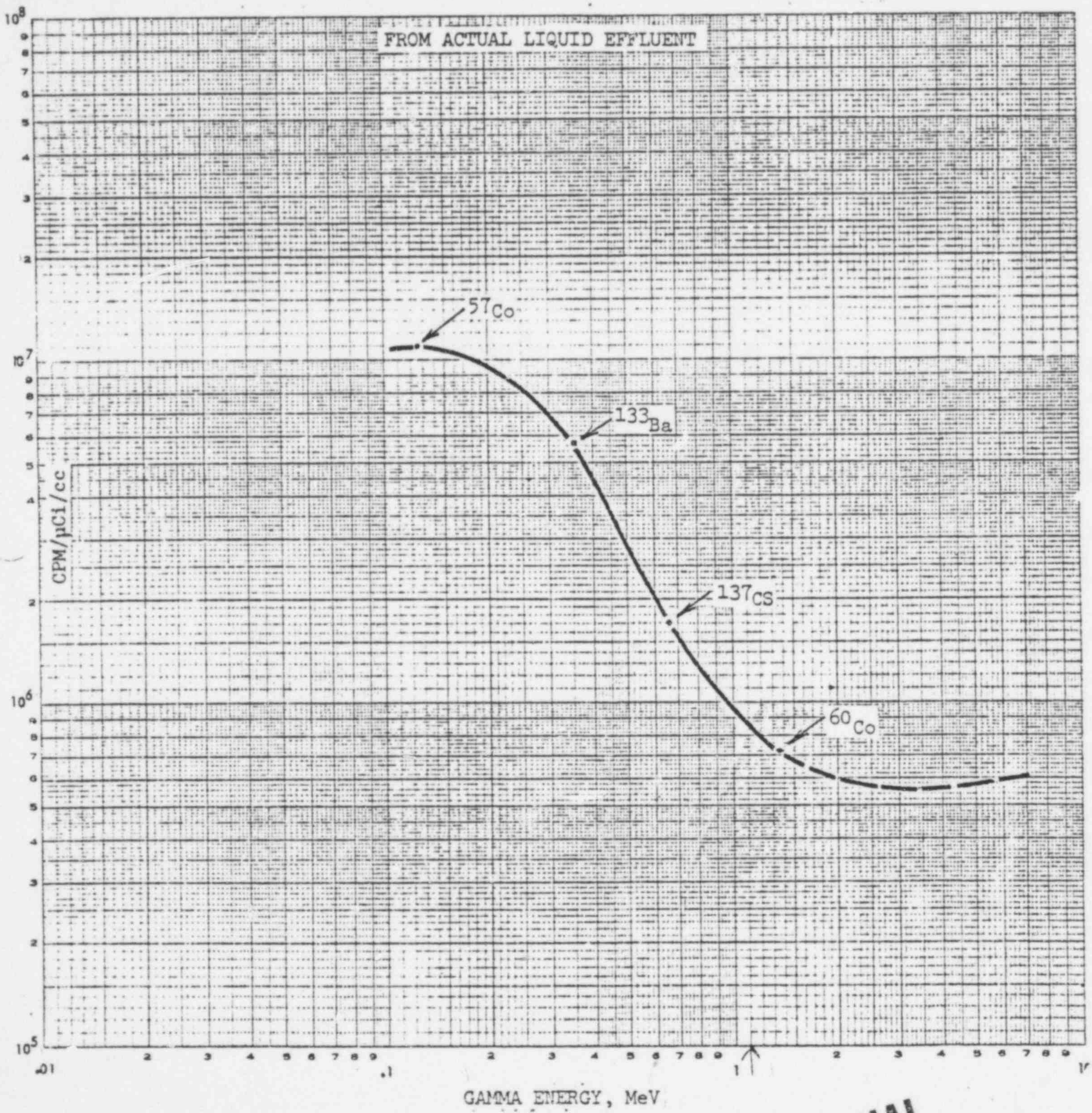


.08 X 10^7 @ .08 Mev (CAL)

FAILED FUEL SYSTEM:
SAMPLER 840-4P
DETECTOR 843-30
RATEMETER/ANALYZER 842-20 OR 842-40

ANALYZER MODE WINDOW SETTING = 100 keV

SENSITIVITY IN CPM ÷ 1μCi/cc @ 1 GAMMA PER DISINTEGRATION
"HIGH" SENSITIVITY POSITION (WITHOUT LEAD ATTENUATOR)



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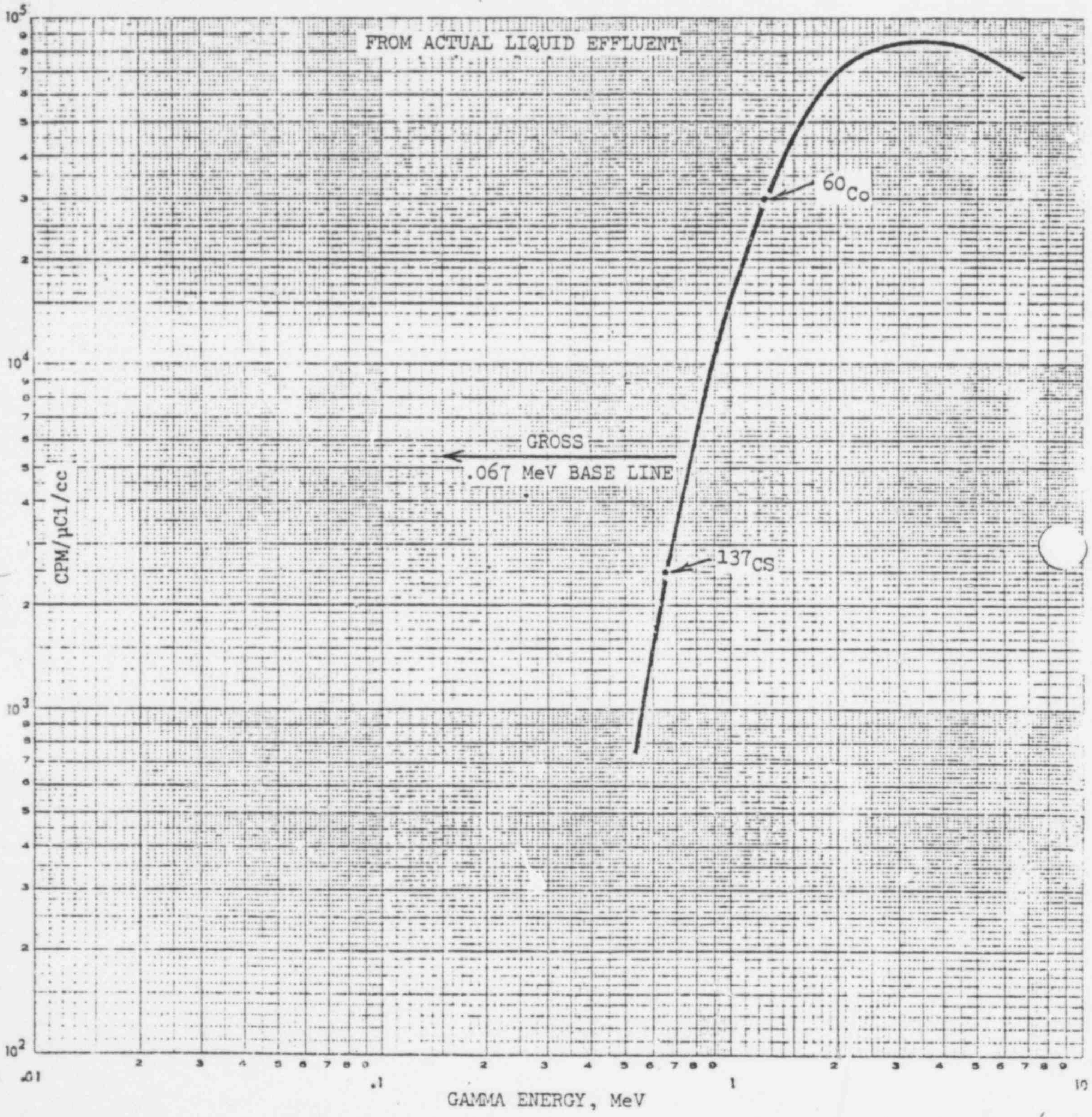
749207

FAILED FUEL SYSTEM:

SAMPLER 840-4P
DETECTOR 843-30
CROSS COUNT RATEMETER 842-10 OR 842-30

well

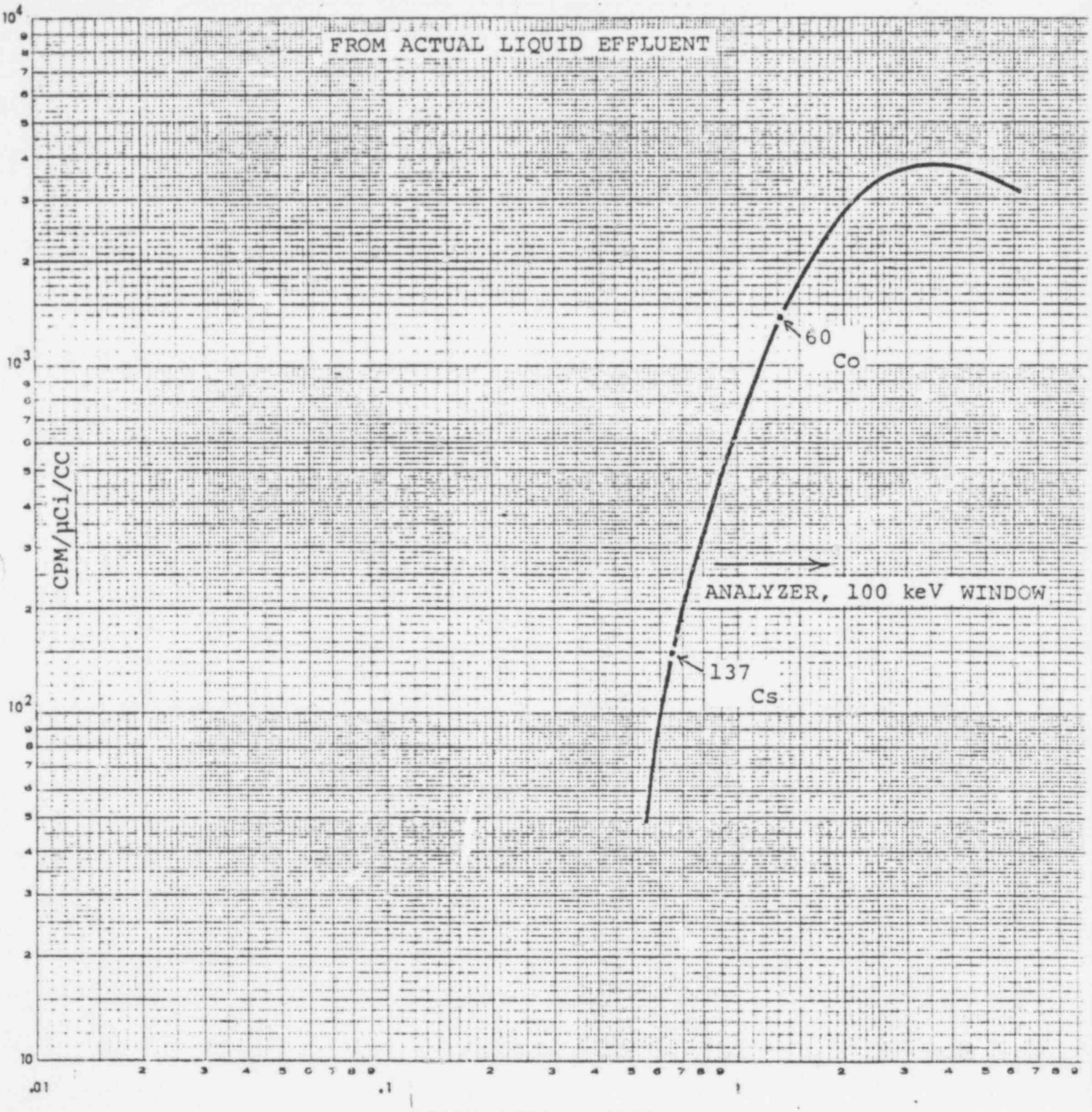
SENSITIVITY IN CPM ÷ μCi/cc @ 1 GAMMA PER DISINTEGRATION



POOR ORIGINAL

FAILED FUEL SYSTEM:
SAMPLER 840-4P
DETECTOR 843-30
RATEMETER/ANALYZER 842-20 OR 842-40
WINDOW SETTING 100 keV

SENSITIVITY IN CPM ÷ 1µCi/cc at 1 GAMMA PER DISINTEGRATION
"LOW" SENSITIVITY POSITION (WITH ATTENUATOR)



POOR ORIGINAL

Efficiency of Fixed Filter Iodine Monitors to ^{131}I

1.24×10^9 (CPM/Min)/(µCi/cc) at 1 CFM

Efficiency is directly proportional to the flow rate. For flow rates other than 1 CFM, multiply the value by $\frac{\text{Actual Flow Rate*}}{\text{1 SCFM}}$

*NOTE: Factors such as collection efficiency at higher flow rates, humidity and temperature can alter values computed for higher flow rates.

PROCESS RADIATION MONITORING SENSITIVITY DATA

Channel No.	Monitor Type	Inches Lead	(1) Flow Rate	(2) Pipe Dia.	Type Detect.	Detect. Counting Mode	Efficiencies		Backgrounds			Min. Detect. Con. (µCi/CC)		Max. Det Con. (µCi/ at 10^6 CF
							Ref. Isotope	(3) Efficiency	Inherent CPM	Mr/hr .662 Mev	Total CPM	CPM to equal bkg	CPM equal ___ C.L.	
Liquid Channels														
DCR-3400	Liquid	3			Gamma	Gross	Cs-137	$9.13x10^7$	104	1.5	143	$1.6x10^{-6}$		$1.1x10^{-2}$
DCR-3399	Liquid	3			Gamma	Gross	Cs-137	$9.13x10^7$	160	1.5	193	$2.1x10^{-6}$		$1.1x10^{-2}$
NSR-3401	Liquid	3			Gamma	Gross	CS-137	$9.13x10^7$	106	1.5	132	$1.5x10^{-6}$		$1.1x10^{-2}$
ICR-1093	Liquid	3			Gamma	Gross	Cs-137	$9.13x10^7$	183	1.5	213	$2.3x10^{-6}$		$1.1x10^{-2}$
WDL-1311	Liquid	3			Gamma	Gross	Cs-137	$9.13x10^7$	239	1.5	309	$3.4x10^6$		$1.1x10^2$
SFR-3402	Liquid	4			Gamma	Gross	Cs-137	$9.13x10^7$	71	5	131	$1.4x10^{-6}$		$1.1x10^{-2}$
ICR-1091	Liquid	4			Gamma	Gross	Cs-137	$9.13x10^7$	143	5	186	$2.0x10^{-6}$		$1.1x10^{-2}$
ICR-1092	Liquid	4			Gamma	Gross	Cs-137	$9.13x10^7$	137	5	177	$1.9x10^{-6}$		$1.1x10^{-2}$
WTR-3894	Liquid	4			Gamma	Gross	Cs-137	$9.13x10^7$	74	5	94	$1.0x10^{-6}$		$1.1x10^{-2}$
WTR-3895	Liquid	4			Gamma	Gross	Cs-137	$9.13x10^7$	76	5	93	$1.0x10^{-6}$		$1.1x10^{-2}$

(1) Flow rate is applicable only to particulate and iodine monitors and is expressed in CFM.

(2) Pipe diameter is applicable only for Snowplow type monitors.

(3) Efficiency is expressed as (CPM)/(µCi/CC) for gaseous, liquid, and moving filter particulate monitors. Efficiency is expressed as (CPM/M)/(µCi/CC) for fixed filter particulate and iodine monitors.

743211

PROCESS RADIATION MONITORING SENSITIVITY DATA

hannel No.	Monitor Type	Inches Lead	(1) Flow Rate	(2) Pipe Dia.	Type Detect.	Detect. Counting Mode	Efficiencies		Backgrounds			Min. Detect. Con. (µCi/CC)		Max. Detect Con. (µCi/CC) at 10^6 CPM
							Ref. Isotope	(3) Efficiency	Inherent CPM	Mr/hr .662 Mev	Total CPM	CPM to equal bkg	CPM equal ___ C.L.	
iquid Channels														
JR-720	Liquid	5			Gamma	Gross Un-attenuated	I-135	1.37×10^7	68	5	148	1.0×10^{-5}		7.3×10^{-2}
JR-720	Liquid	5			Gamma	Gross attenuated	I-135	4.47×10^4	56	5	119	2.7×10^{-3}		2.2×10^1
UR-720	Liquid	5			Gamma	Analyzer Unattenuated	I-135	3.0×10^5	1	5	2	6.7×10^{-6}		3.3
UR-720	Liquid	5			Gamma	Analyzer attenuated	I-135	3.5×10^2	1	5	2	5.7×10^{-3}		2.85×10^3

(1) Flow rate is applicable only to particulate and iodine monitors and is expressed in CFM.

(2) Pipe diameter is applicable only for Snowplow type monitors.

(3) Efficiency is expressed as (CPM)/(µCi/CC) for gaseous, liquid, and moving filter particulate monitors. Efficiency is expressed as (CPM/M)/(µCi/CC) for fixed filter particulate and iodine monitors.

PROCESS RADIATION MONITORING SENSITIVITY DATA

Channel No.	Monitor Type	Inches Lead	(1) Flow Rate	(2) Pipe Dia.	Type Detect.	Detect. Counting Mode	Efficiencies		Backgrounds			Min. Detect. Con. (µCi/CC)		Max. De Con. (µC at 10^6 C
							Ref. Isotope	(3) Efficiency	Inherent CPM	Mr/hr .662 Mev	Total CPM	CPM to equal bkg	CPM equal ___ C.L.	
Gas Channels														
HPR-220	Gas	3			Beta	Gross	Kr-85	8.10×10^7	21	.5	22	2.7×10^{-7}		1.2×10^{-2}
HPR-221A	Gas	3			Beta	Gross	Kr-85	8.10×10^7	13	.5	15	1.9×10^{-7}		1.2×10^{-2}
HPR-224	Gas	3			Beta	Gross	Kr-85	8.10×10^7	17	.5	18	2.2x10-7		1.2×10^{-2}
VAR-748	Gas	3			Beta	Gross	Kr-85	8.10×10^7	16	.5	17	2.1×10^{-7}		1.2×10^{-2}
HPR-221B	Gas	3			Beta	Gross	Kr-85	8.10×10^7	14	1.5	17	2.1×10^{-7}		1.2×10^{-2}
HPR-229	Gas	3			Beta	Gross	Kr-85	8.10×10^7	14	1.5	15	1.9×10^{-7}		1.2×10^{-2}
HPR-225	Gas	3			Beta	Gross	Kr-85	8.10×10^7	13	1.5	18	2.2×10^{-7}		1.2×10^{-2}
HPR-226	Gas	3			Beta	Gross	Kr-85	8.10×10^7	25	1.5	27	3.4×10^{-7}		1.2×10^{-2}
HPR-222	Gas	3			Beta	Gross	Kr-85	8.10×10^7	11	1.5	17	2.1×10^{-7}		1.2×10^{-2}
HPR-228	Gas	3			Beta	Gross	Kr-85	8.10×10^7	40	1.5	44	5.4×10^{-7}		1.2×10^{-2}

(1) Flow rate is applicable only to particulate and iodine monitors and is expressed in CFM.

(2) Pipe diameter is applicable only for Snowplow type monitors.

(3) Efficiency is expressed as (CPM)/(µCi/CC) for gaseous, liquid, and moving filter particulate monitors. Efficiency is expressed as (CPM/M)/(µCi/CC) for fixed filter particulate and iodine monitors.

PROCESS RADIATION MONITORING SENSITIVITY DATA

hannel No.	Monitor Type	Inches Lead	(1) Flow Rate	(2) Pipe Dia.	Type Detect.	Detect. Counting Mode	Efficiencies		Backgrounds			Min. Detect. Con. (µCi/CC)		Max. Detect Con. (µCi/CC at 10^6 CPM
							Ref. Isotope	(3) Efficiency	Inherent CPM	Mr/hr .662 Mev	Total CPM	CPM to equal bkg	CPM equal ____ C.L.	
as Channels														
DGR1480	Gas	3			Beta	Gross	Kr-85	$8.10x10^7$	12	1.5	13	$1.6x10^{-7}$		$1.2x10^{-2}$
DGR1485	Gas	3			Beta	Gross	Kr-85	$8.10x10^7$	18	1.5	21	$2.2x10^{-7}$		$1.2x10^{-2}$
DGR1486	Gas	3			Beta	Gross	Kr-85	$8.10x10^7$	13	1.5	16	$2.0x10^{-7}$		$1.2x10^{-2}$
PR-223	Gas	3			Beta	Gross	Kr-85	$8.10x10^7$	17	1.5	22	$2.7x10^{-7}$		$1.2x10^{-2}$
PR-227	Gas	3			Beta	Gross	Kr-85	$8.10x10^7$	25	1.5	29	$3.1x10^{-7}$		$1.2x10^{-2}$
PR-219	Gas	3			Beta	Gross	Kr-85	$8.10x10^7$	15	5	32	$4.0x10^{-7}$		$1.2x10^{-2}$

(1) Flow rate is applicable only to particulate and iodine monitors and is expressed in CFM.

(2) Pipe diameter is applicable only for Snowplow type monitors.

(3) Efficiency is expressed as (CPM)/(µCi/CC) for gaseous, liquid, and moving filter particulate monitors. Efficiency is expressed as (CPM/M)/(µCi /CC) for fixed filter particulate and iodine monitors.

PROCESS RADIATION MONITORING SENSITIVITY DATA

Channel No.	Monitor Type	Inches Lead	(1) Flow Rate	(2) Pipe Dia.	Type Detect.	Detect. Counting Mode	Efficiencies		Backgrounds			Min. Detect. Con. (μCi/CC)		Max. Detect Con. (μCi/CC at 10^6 CPM
							Ref. Isotope	(3) Efficiency	Inherent CPM	Mr/hr .662 Mev	Total CPM	CPM to equal bkg	CPM equal ___ C.L.	
articulate Channels Efficiencies and Min. Detect. Con. are based on an elapsed collection time of 15 minutes														
PR-220	Part.	2	8.5		Beta	Gross	Cs-137	$1.09x10^{12}$	9	.5	17	$1.6x10^{-11}$		$9.1x10^{-7}$
PR-221A	Part.	2	8.5		Beta	Gross	Cs-137	$1.09x10^{12}$	14	.5	21	$1.9x10^{-11}$		$9.1x10^{-7}$
PR-224	Part.	2	8.5		Beta	Gross	Cs-137	$1.09x10^{12}$	14	.5	19	$1.7x10^{-11}$		$9.1x10^{-7}$
PR-221B	Part.	2	8.5		Beta	Gross	Cs-137	$1.09x10^{12}$	15	1.5	39	$3.5x10^{-11}$		$9.1x10^{-7}$
PR-229	Part.	2	3.5		Beta	Gross	Cs-137	$4.48x10^{11}$	14	1.5	36	$8.0x10^{-11}$		$2,2x10^{-6}$
PR-225	Part.	2	8.5		Beta	Gross	Cs-137	$1.09x10^{12}$	12	1.5	30	$2.8x10^{-11}$		$9.1x10^{-7}$
PR-226	Part.	2	8.5		Beta	Gross	Cs-137	$1.09x10^{12}$	10	1.5	32	$2.9x10^{-11}$		$9.1x10^{-7}$
PR-222	Part.	2	3.5		Beta	Gross	Cs-137	$1.09x10^{12}$	17	1.5	33	$3.0x10^{-11}$		$9.1x10^{-7}$
PR-228	Part.	2	8.5		Beta	Gross	Cs-137	$1.09x10^{12}$	12	1.5	29	$2.6x10^{-11}$		$9.1x10^{-7}$
PR-223	Part.	2	8.5		Beta	Gross	Cs-137	$1.09x10^{12}$	11	1.5	31	$2.8x10^{-11}$		$9.1x10^{-7}$

(1) Flow rate is applicable only to particulate and iodine monitors and is expressed in CFM.

(2) Pipe diameter is applicable only for Snowplow type monitors.

(3) Efficiency is expressed as (CPM)/(μCi/CC) for gaseous, liquid, and moving filter particulate monitors. Efficiency is expressed as (CPM/M)/(μCi/CC) for fixed filter particulate and iodine monitors.

PROCESS RADIATION MONITORING SENSITIVITY DATA

hannel No.	Monitor Type	Inches Lead	(1) Flow Rate	(2) Pipe Dia.	Type Detect.	Detect. Counting Mode	Efficiencies		Backgrounds			Min. Detect. Con. (µCi/CC)		Max. Detect Con. (µCi/CC) at 10^6 CPM
							Ref. Isotope	(3) Efficiency	Inherent CPM	Mr/hr .662 Mev	Total CPM	CPM to equal bkg	CPM equal ____ C.L.	
rticulate Channels Efficiencies and Min. Detect. Con. are based on an elapsed collection time of 15 minutes														
R-227	Part.	2	8.5		Beta	Gross	Cs-137	$1.09x10^{12}$	6	1.5	24	$2.2x10^{-11}$		$9.1x10^{-7}$
R-219	Part.	2	7.5		Beta	Gross	Cs-137	$9.61x10^{11}$	10	5	70	$7.2x10^{-11}$		$1.0x10^{-6}$

(1) Flow rate is applicable only to particulate and iodine monitors and is expressed in CFM.

(2) Pipe diameter is applicable only for Snowplow type monitors.

(3) Efficiency is expressed as (CPM)/(µCi/CC) for gaseous, liquid, and moving filter particulate monitors. Efficiency is expressed as (CPM/M)/(µCi/CC) for fixed filter particulate and iodine monitors.

PROCESS RADIATION MONITORING SENSITIVITY DATA

Channel No.	Monitor Type	Inches Lead	(1) Flow Rate	(2) Pipe Dia.	Type Detect.	Detect. Counting Mode	Efficiencies		Backgrounds			Min. Detect. Con. (μCi/CC)		Max. Detec Con. (μCi/C at 10^6 CPM
							Ref. Isotope	(3) Efficiency	Inherent CPM	Mr/hr .662 Mev	Total CPM	CPM to equal bkg	CPM equal ___ C.L.	
Iodine Channels		Efficiencies and Min. Detect. Con. are based on an elapsed collection time of 8 Hrs. and 99% collection Efficiency to I-131												
HPR-220	Iodine	2	8.5		Gamma	Analyzer	I-131	$5.06x10^{12}$	2	.5	39	$7.7x10^{-12}$		$1.9x10^{-7}$
HPR-221A	Iodine	2	8.5		Gamma	Analyzer	I-131	$5.06x10^{12}$	5	.5	44	$8.7x10^{-12}$		$1.9x10^{-7}$
HPR-224	Iodine	2	8.5		Gamma	Analyzer	I-131	$5.06x10^{12}$	4	.5	43	$8.5x10^{-12}$		$1.9x10^{-7}$
HPR221B	Iodine	2	8.5		Gamma	Analyzer	I-131	$5.06x10^{12}$	3	1.5	117	$2.3x10^{-11}$		$1.9x10^{-7}$
HPR-229	Iodine	2	3.5		Gamma	Analyzer	I-131	$2.08x10^{12}$	3	1.5	123	$5.9x10^{-11}$		$4.8x10^{-7}$
HPR-225	Iodine	2	8.5		Gamma	Analyzer	I-131	$5.06x10^{12}$	4	1.5	115	$2.3x10^{-11}$		$1.9x10^{-7}$
HPR-226	Iodine	2	8.5		Gamma	Analyzer	I-131	$5.06x10^{12}$	2	1.5	116	$2.3x10^{-11}$		$1.9x10^{-7}$
HPR-222	Iodine	2	8.5		Gamma	Analyzer	I-131	$5.06x10^{12}$	3	1.5	119	$2.4x10^{-11}$		$1.9x10^{-7}$
HPR-228	Iodine	2	8.5		Gamma	Analyzer	I-131	$5.06x10^{12}$	2	1.5	122	$2.4x10^{-11}$		$1.9x10^{-7}$
HPR-223	Iodine	2	8.5		Gamma	Analyzer	I-131	$5.06x10^{12}$	7	1.5	123	$2.4x10^{-11}$		$1.9x10^{-7}$

(1) Flow rate is applicable only to particulate and iodine monitors and is expressed in CFM.

(2) Pipe diameter is applicable only for Snowplow type monitors.

(3) Efficiency is expressed as (CPM)/(μCi/CC) for gaseous, liquid, and moving filter particulate monitors. Efficiency is expressed as (CPM/M)/(μCi/CC) for fixed filter particulate and iodine monitors.

743217

PROCESS RADIATION MONITORING SENSITIVITY DATA

Channel No.	Monitor Type	Inches Lead	(1) Flow Rate	(2) Pipe Dia.	Type Detect.	Detect. Counting Mode	Efficiencies		Backgrounds			Min. Detect. Con. (μCi/CC)		Max. Detect Con. (μCi/CC at 10^6 CPM
							Ref. Isotope	(3) Efficiency	Inherent CPM	Mr/hr .662 Mev	Total CPM	CPM to equal bkg	CPM equal ___ C.L.	
Iodine Channels		Efficiencies and Min. Detect. Con. are based on an elapsed collection time of 8 Hrs. and 99% collection Efficiency to I-131												
HPR-227	Iodine	2	8.5		Gamma	Analyzer	I-131	$5.06x10^{12}$	4	1.5	120	$2.4x10^{-11}$		$1.9x10^{-7}$
HPR-219	Iodine	3	7.5		Gamma	Analyzer	I-131	$4.46x10^{12}$	1	5	18	$4.0x10^{-12}$		$2.2x10^{-7}$

(1) Flow rate is applicable only to particulate and iodine monitors and is expressed in CFM.

(2) Pipe diameter is applicable only for Snowplow type monitors.

(3) Efficiency is expressed as (CPM)/(μCi/CC) for gaseous, liquid, and moving filter particulate monitors. Efficiency is expressed as (CPM/M)/(μCi/CC) for fixed filter particulate and iodine monitors.

Channel No: HPR-219 Iodine Date: 1/19/78

Sampler Serial No: _______ Detector Serial No: ~~148~~ 423 Ratemeter Serial No: 720

Discriminator Setting .2 Final H.V. _______

TMI-I STANDARD CALIBRATION FIXTURE

Background: Binary Count _______ Minutes _______ = Net CPM 143

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		189324	189181
^{133}Ba-No. 138		33481	33338
^{133}Ba-No. 192		287819	287685
^{137}Cs-No. 177		7727	7684
^{137}Cs-No. 138		287819	287685
^{137}Cs-No. 192		99544	99401
ENERGY RESPONSE SOURCES			
^{133}Ba-No. SR2			
^{137}Cs-No. SR2			
^{60}Co-No. SR2			

POOR ORIGINAL

CHANNEL SAMPLER

Background: Binary Count _______ Minutes _______ = Net CPM 430

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		185542	185112
^{133}Ba-No. 138		30696	30266
^{133}Ba-No. 192		281066 ~~280636~~	280636
^{137}Cs-No. 177		8378	7948
^{137}Cs-No. 133		281066	280636
^{137}Cs-No. 192		96617	96187

ANALYZER CHANNEL Window set at 3.8 to 4.2; Iodine centered at 4.0V

Background: Binary Count _______ Minutes _______ = CPM 2

749219

Source	Iodine Peaked CPM	Desired 93%	Actual CPM	Net CPM
^{133}Ba-No. 177	~~28450~~ 28215	26240	26458	26456
^{133}Ba-No. 192	~~43960~~ 45501	42315	40883	40881

Check Source Final Reading 350 cpm

Performed by: _______ Approved by: _______

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Channel No: H.D.R. 219 643 Date: 1/11/78

Sampler Serial No: 133 Detector Serial No: 140 Ratemeter Serial No: 743

Discriminator Setting .2 Final H.V. ______

TMI-1 STANDARD CALIBRATION FIXTURE

Background: Binary Count ______ Minutes ______ = Net CPM 210

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		1681	1471
^{133}Ba-No. 138		1724	1514
^{133}Ba-No. 192		2640	2430
^{137}Cs-No. G177		45141	44931
^{137}Cs-No. 138		2267	2057
^{137}Cs-No. 192		17599	17389
ENERGY RESPONSE SOURCES			
^{133}Ba-No. SR2			
^{137}Cs-No. SR2			
^{60}Co-No. SR2			

CHANNEL SAMPLER

Background: Binary Count ______ Minutes ______ = Net CPM ______

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		1708	1547
^{133}Ba-No. 138		1446	1285
^{133}Ba-No. 192		2231	2070
^{137}Cs-No. 177		44487	44326
^{137}Cs-No. 133		2146	1985
^{137}Cs-No. 192		18623	18462

ANALYZER CHANNEL Window set at 3.8 to 4.2; Iodine centered at 4.0V

749220

Background: Binary Count ______ Minutes ______ = CPM ______

Source	Iodine Peaked CPM	Desired 93%	Actual CPM	Net CPM
^{133}Ba-No. 177				
^{133}Ba-No. 192				

Check Source Final Reading 20

Performed by: ______ Approved by: ______

[illegible]

Channel No: HP-R-219 Part Date: 1/10/78

Sampler Serial No: 173 Detector Serial No: 144 Ratemeter Serial No: 762

Discriminator Setting .12 Final H.V.

TMI-I STANDARD CALIBRATION FIXTURE

Background: Binary Count 70 Minutes 10 = Net CPM 7

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		309	302
^{133}Ba-No. 138		305	298
^{133}Ba-No. 192		610	603
^{137}Cs-No. ~~1~~177		26073	26066
^{137}Cs-No. 138		593	586
^{137}Cs-No. 192		10,677	10670
ENERGY RESPONSE SOURCES			
^{133}Ba-No. SR2			
^{137}Cs-No. SR2			
^{60}Co-No. SR2			

POOR ORIGINAL

CHANNEL SAMPLER

Background: Binary Count 138 Minutes 10 = Net CPM 14

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		304	290
^{133}Ba-No. 138		253	239
^{133}Ba-No. 192		554	540
^{137}Cs-No. 177		25107	25093
^{137}Cs-No. 133		547	533
^{137}Cs-No. 192		9896	9882

ANALYZER CHANNEL Window set at 3.8 to 4.2; Iodine centered at 4.0V

749221

Background: Binary Count Minutes = CPM

Source	Iodine Peaked CPM	Desired 93%	Actual CPM	Net CPM
^{133}Ba-No. 177				
^{133}Ba-No. 192				

Check Source Final Reading 60 cpm 1/13/78

Performed by: Approved by: CCWeaver

Fj 36

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UNIT II RMS BASELINE DATA SHEET

Channel No: MVR-720 Gross Date: ____

Sampler Serial No: ____ Detector Serial No: 280 Ratemeter Serial No: 646

Discriminator Setting .2 Final H.V. ____

TMI-I STANDARD CALIBRATION FIXTURE

Background: Binary Count ____ Minutes ____ = Net CPM 130

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		184291	184161
^{133}Ba-No. 138		187733	187603
^{133}Ba-No. 192		279840	279710
^{137}Cs-No. 177		131369	131259
^{137}Cs-No. 138		79350	79220
^{137}Cs-No. 192		99995	99865
ENERGY RESPONSE SOURCES			
^{133}Ba-No. SR2			
^{137}Cs-No. SR2			
^{60}Co-No. SR2			

CHANNEL SAMPLER

Background: Binary Count ____ Minutes ____ = Net CPM 54

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		185837	185783
^{133}Ba-No. 138		191435	191381
^{133}Ba-No. 192		278356	278302
^{137}Cs-No. 177		133426	133372
^{137}Cs-No. 133		80622	80568
^{137}Cs-No. 192		101603	101549

~~60Co~~

ANALYZER CHANNEL Window set at 3.8 to 4.2; Iodine centered at 4.0V

Background: Binary Count ____ Minutes ____ = CPM ____

Source	Iodine Peaked CPM	Desired 93%	Actual CPM	Net CPM
^{133}Ba-No. 177				
^{133}Ba-No. 192				

Check Source Final Reading 3000 - pg. H App by D.O. Weaver

UNIT II RMS BASELINE DATA SHEET

Channel No: MU-R-720 Analyzer Date: ______

Sampler Serial No: ______ Detector Serial No: 280 Ratemeter Serial No: 766

Discriminator Setting .2 Final H.V. ______

TMI-I STANDARD CALIBRATION FIXTURE

Background: Binary Count ______ Minutes ______ = Net CPM 132

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		186095	185965
^{133}Ba-No. 138		189115	188983
^{133}Ba-No. 192		277507	277375
^{137}Cs-No. 177		131532	131400
^{137}Cs-No. 138		79473	79341
^{137}Cs-No. 192		99733	99601
ENERGY RESPONSE SOURCES			
^{133}Ba-No. SR2			
^{137}Cs-No. SR2			
^{60}Co-No. SR2			

POOR ORIGINAL

CHANNEL SAMPLER

Background: Binary Count ______ Minutes ______ = Net CPM 55

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		183360	183305
^{133}Ba-No. 138		189628	189573
^{133}Ba-No. 192		274113	274057
^{137}Cs-No. 177		133131	133068
^{137}Cs-No. 138		80472	80417
^{137}Cs-No. 192		101362	101307

ANALYZER CHANNEL (I-135) window width .25 VDC; centered at 2.85 VDC (2.725 VDC to 2.975 VDC)

Co-60 = G-1002

Background: Binary Count ______ Minutes ______ = CPM 4

749223

Source ^{60}Co = G-1002	Iodine Peaked CPM	Desired 90%	Actual CPM	Net CPM	Bkg
Fixture	9899 (calc.)		8909	8905	4
Sampler	10148	9133	9089	9083	6

Check Source Final Reading 80

Performed by: G. Harsh pg 11A Approved by:

[illegible] RMS BASELINE DATA SHEET

Channel No: WDL - R 1311 Date: 3/21/78

Sampler Serial No: ______ Detector Serial No: 199 Ratemeter Serial No: 675

Discriminator Setting c2 Final H.V. ______

TMI-I STANDARD CALIBRATION FIXTURE

Background: Binary Count ______ Minutes ______ = Net CPM 107

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		179710	179603
^{133}Ba-No. 138		168993	168886
^{133}Ba-No. 192		270536	270429
^{137}Cs-No. 177		121736	121629
^{137}Cs-No. 138		68074	67967
^{137}Cs-No. 192		92374	92267
ENERGY RESPONSE SOURCES			
^{133}Ba-No. SR2			
^{137}Cs-No. SR2			
[illegible]-No. SR2			

CHANNEL SAMPLER

Background: Binary Count ______ Minutes ______ = Net CPM 165

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		183478	183313
^{133}Ba-No. 138		180643	180478
^{133}Ba-No. 192		272479	272314
^{137}Cs-No. 177		124410	124245
^{137}Cs-No. 133		74994	74829
^{137}Cs-No. 192		94829	94664

ANALYZER CHANNEL

Window set at 3.8 to 4.2; iodine centered at 4.0V

Background: Binary Count ______ Minutes ______ = CPM ______

Source	Iodine Peaked CPM	Desired 93%	Actual CPM	Net CPM
^{133}Ba-No. 177				
^{133}Ba-No. 192				

Check Source Final Reading 3000

Performed by: G.Harsh Approved by:

Channel No: WDG-R-1480 Date: 1/24/78

Sampler Serial No: ______ Detector Serial No: 269 Ratemeter Serial No: 733

Discriminator Setting .2 Final H.V. ______

TMI-I STANDARD CALIBRATION FIXTURE

Background: Binary Count ______ Minutes ______ = Net CPM 27

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		1848	1521
^{133}Ba-No. 138			
^{133}Ba-No. 192		2344	2317
^{137}Cs-No. 177		44840	44813
^{137}Cs-No. 138			
^{137}Cs-No. 192		17430	17403
ENERGY RESPONSE SOURCES			
^{133}Ba-No. SR2			
^{137}Cs-No. SR2			
^{60}Co-No. SR2			

POOR ORIGINAL

CHANNEL SAMPLER

Background: Binary Count ______ Minutes ______ = Net CPM 48

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		1425	1377
^{133}Ba-No. 138			
^{133}Ba-No. 192		2292	2244
^{137}Cs-No. 177		44705	44657
^{137}Cs-No. 133			
^{137}Cs-No. 192		17326	17278

ANALYZER CHANNEL Window set at 3.8 to 4.2; Iodine centered at 4.0V

Background: Binary Count ______ Minutes ______ = CPM ______

Source	Iodine Peaked CPM	Desired 93%	Actual CPM	Net CPM
^{133}Ba-No. 177				
^{133}Ba-No. 192				

Check Source Final Reading 100

Performed by: J. B. P377 Approved by: D. C. Weaver

Channel No: HP. R. 225 Part Date: 12/4/77 (192's = 1/14/78)

Sampler Serial No: 181 Detector Serial No: 180 Ratemeter Serial No: 668

Discriminator Setting .2 Final H.V. ______

TMI-I STANDARD CALIBRATION FIXTURE

Background: Binary Count ______ Minutes ______ = Net CPM 178

Source	Expected Net Count	Gross CPM	Net CPM	
^{133}Ba-No. 177		506	328	
^{133}Ba-No. 138		419	241	
^{133}Ba-No. 192		631	620	Bkg 11
^{137}Cs-No. 177		24207	24029	
^{137}Cs-No. 138		717	539	
^{137}Cs-No. 192		10437	10426	Bkg 11
ENERGY RESPONSE SOURCES				
^{133}Ba-No. SR2				
^{137}Cs-No. SR2				
^{60}Co-No. SR2				

POOR ORIGINAL

CHANNEL SAMPLER

Background: Binary Count ______ Minutes ______ = Net CPM 165

Source	Expected Net Count	Gross CPM	Net CPM	
^{133}Ba-No. 177		452	287	
^{133}Ba-No. 138		473	308	
^{133}Ba-No. 192		656	641	Bkg 1
^{137}Cs-No. 177		27551	27386	
^{137}Cs-No. 133		760	575	
^{137}Cs-No. 192		11039	11024	Bkg 15

ANALYZER CHANNEL Window set at 3.8 to 4.2; Iodine centered at 4.0V

Background: Binary Count ______ Minutes ______ = CPM ______

749226

Source	Iodine Peaked CPM	Desired 93%	Actual CPM	Net CPM
^{133}Ba-No. 177				
^{133}Ba-No. 192				

Check Source Final Reading 50

Performed by: A Ha

Approved by: D C Weaver

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Channel No: HP.R.225 I.d. Date: 1/18/78

Sampler Serial No: ______ Detector Serial No: 157 Ratemeter Serial No: 734

Discriminator Setting .2 Final H.V. ______

TMI-I STANDARD CALIBRATION FIXTURE

Background: Binary Count ______ Minutes ______ = Net CPM 136

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		175127	174891
^{133}Ba-No. 138			
^{133}Ba-No. 192		259954	259818
^{137}Cs-No. 177		~~[illegible]~~	~~23508~~
^{137}Cs-No. 138			
^{137}Cs-No. 192		~~35186~~	~~35182~~
ENERGY RESPONSE SOURCES			
^{133}Ba-No. SR2			
^{137}Cs-No. SR2			
^{60}Co-No. SR2			

POOR ORIGINAL

CHANNEL SAMPLER

Background: Binary Count ______ Minutes ______ = Net CPM 163

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		169007	168844
^{133}Ba-No. 138			
^{133}Ba-No. 192		255618	255455
^{137}Cs-No. 177			
^{137}Cs-No. 138			
^{137}Cs-No. 192			

ANALYZER CHANNEL Window set at 3.8 to 4.2; Iodine centered at 4.0V

749227

Background: Binary Count ______ Minutes ______ = CPM 4

Source	Iodine Peaked CPM	Desired 93%	Actual CPM	Net CPM
^{133}Ba-No. 177	23830		22162	22158 ~~34102~~
^{133}Ba-No. 192	36669		34102 ~~32158~~	~~34098~~

Check Source Final Reading 200

Performed by: ______ Approved by: ______

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Channel No: HP.R.225 GAS Date: 1/15/78

Sampler Serial No: 120 Detector Serial No: 127 Ratemeter Serial No: 755

Discriminator Setting .2 Final H.V. ______

TMI-1 STANDARD CALIBRATION FIXTURE

Background: Binary Count ______ Minutes ______ = Net CPM 26

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		1354	1328
^{133}Ba-No. 138			
^{133}Ba-No. 192		2133	2107
^{137}Cs-No. #177		43550	43524
^{137}Cs-No. 138			
^{137}Cs-No. 192		16975	16949
ENERGY RESPONSE SOURCES			
^{133}Ba-No. SR2			
^{137}Cs-No. SR2			
^{60}Co-No. SR2			

POOR ORIGINAL

CHANNEL SAMPLER

Background: Binary Count ______ Minutes ______ = Net CPM 25

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		1365	1340
^{133}Ba-No. 138			
^{133}Ba-No. 192		2138	2123
^{137}Cs-No. 177		42660	42635
^{137}Cs-No. 133			
^{137}Cs-No. 192		16826	16801

ANALYZER CHANNEL Window set at 3.8 to 4.2; Iodine centered at 4.0V

Background: Binary Count ______ Minutes ______ = CPM ______

748228

Source	Iodine Peaked CPM	Desired 93%	Actual CPM	Net CPM
^{133}Ba-No. 177				
^{133}Ba-No. 192				

Check Source Final Reading 80

Performed by: ______ Approved by: DAWeaver

7985

Channel No: H.P.R. 226 Part. Date: 12/20/78 (192 - 1/15/78)

Sampler Serial No: 187 Detector Serial No: 123 Ratemeter Serial No: 679

Discriminator Setting .2 Final H.V. ______

TMI-I STANDARD CALIBRATION FIXTURE

Background: Binary Count ______ Minutes ______ = Net CPM 3 (192 - 15)

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		273	270
^{133}Ba-No. 138		262	259
^{133}Ba-No. 192		548	530
^{137}Cs-No. 177		24522	24519
^{137}Cs-No. 138		537	534
^{137}Cs-No. 192		9503	9485
ENERGY RESPONSE SOURCES			
^{133}Ba-No. SR2			
^{137}Cs-No. SR2			
^{60}Co-No. SR2			

POOR ORIGINAL

CHANNEL SAMPLER

Background: Binary Count ______ Minutes ______ = Net CPM 8 (192 - 11)

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		307	299
^{133}Ba-No. 138		288	280
^{133}Ba-No. 192		580	569
^{137}Cs-No. 177		25015	25007
^{137}Cs-No. 133		872	864
^{137}Cs-No. 192		24770	24757

ANALYZER CHANNEL Window set at 3.8 to 4.2; Iodine centered at 4.0V

749229

Background: Binary Count ______ Minutes ______ = CPM ______

Source	Iodine Peaked CPM	Desired 93%	Actual CPM	Net CPM
^{133}Ba-No. 177				
^{133}Ba-No. 192				

Check Source Final Reading 39

Performed by: ______ Approved by: DAWeaver

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Channel No: HP-R-222 Part Date: 2/16/78

Sampler Serial No: 189 Detector Serial No: 182 Ratemeter Serial No: 749

Discriminator Setting .2 Final H.V. ____

TMI-1 STANDARD CALIBRATION FIXTURE

Background: Binary Count ____ Minutes ____ = Net CPM ____

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		335	319
^{133}Ba-No. 138		325	309
^{133}Ba-No. 192		611	595
^{137}Cs-No. ~~3~~177		25850	25834
^{137}Cs-No. 138		637	621
^{137}Cs-No. 192		10173	10157
ENERGY RESPONSE SOURCES			
^{133}Ba-No. SR2			
^{137}Cs-No. SR2			
^{60}Co-No. SR2			

POOR ORIGINAL

CHANNEL SAMPLER

Background: Binary Count ____ Minutes ____ = Net CPM 24

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		587	563
^{133}Ba-No. 138		378	354
^{133}Ba-No. 192		793	769
^{137}Cs-No. 177		22181	22157
^{137}Cs-No. 138		765	741
^{137}Cs-No. 192		9240	9216

ANALYZER CHANNEL Window set at 3.8 to 4.2; Iodine centered at 4.0V

Background: Binary Count ____ Minutes ____ = CPM ____

Source	Iodine Peaked CPM	Desired 93%	Actual CPM	Net CPM
^{133}Ba-No. 177				
^{133}Ba-No. 192				

Check Source Final Reading 80

Performed by: #9 93 Approved by:

[illegible] Date: 12/20/77 (192 - 1/14/78)

Sampler Serial No: 127 Detector Serial No: 215 Ratemeter Serial No: 676

Discriminator Setting .2 Final H.V. ______

TMI-I STANDARD CALIBRATION FIXTURE

Background: Binary Count ______ Minutes ______ = Net CPM 20 (#192-21)

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		1550	1480
^{133}Ba-No. 138		1530	1460
^{133}Ba-No. 192		2218	2197
^{137}Cs-No. ~~$~~177		44635	44565
^{137}Cs-No. 138		2029	1957
^{137}Cs-No. 192		16663	16642
ENERGY RESPONSE SOURCES			
^{133}Ba-No. SR2			
^{137}Cs-No. SR2			
^{60}Co-No. SR2			

POOR ORIGINAL

CHANNEL SAMPLER

Background: Binary Count ______ Minutes ______ = Net CPM 100 (#192-14)

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		1556	1456
^{133}Ba-No. 138		1403	1303
^{133}Ba-No. 192		2228	2214
^{137}Cs-No. 177		43579	43479
^{137}Cs-No. 133		2009	1909
^{137}Cs-No. 192		16540	16526

ANALYZER CHANNEL Window set at 3.8 to 4.2; Iodine centered at 4.0V

Background: Binary Count ______ Minutes ______ = CPM ______

749231

Source	Iodine Peaked CPM	Desired 93%	Actual CPM	Net CPM
^{133}Ba-No. 177				
^{133}Ba-No. 192				

Check Source Final Reading 60

Performed by: J. K

Approved by: D. E. Werner

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No: HP-R-227 Iodine Date: 2/17/78

Sampler Serial No: ______ Detector Serial No: 191 Ratemeter Serial No: 685

Discriminator Setting .2 Final H.V. ______

TMI-I STANDARD CALIBRATION FIXTURE

Background: Binary Count ______ Minutes ______ = Net CPM 135

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		183471	183236
^{133}Ba-No. 138		177003	176868
^{133}Ba-No. 192		281316	281181
^{137}Cs-No. 8177		123626	123491
^{137}Cs-No. 138		73603	73468
^{137}Cs-No. 192		93166	93031
ENERGY RESPONSE SOURCES			
^{133}Ba-No. SR2			
^{137}Cs-No. SR2			
^{60}Co-No. SR2			

POOR ORIGINAL

CHANNEL SAMPLER

Background: Binary Count ______ Minutes ______ = Net CPM 136

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		179910	179784
^{133}Ba-No. 138		175319	175183
^{133}Ba-No. 192		274236	274100
^{137}Cs-No. 177		118300	118164
^{137}Cs-No. 133		71029	70893
^{137}Cs-No. 192		90256	90120

ANALYZER CHANNEL Window set at 3.8 to 4.2; Iodine centered at 4.0V

749232

Background: Binary Count ______ Minutes ______ = CPM 5

Source	Iodine Peaked CPM	Desired 93%	Actual CPM	Net CPM
^{133}Ba-No. 177	24775		23041	23036
^{133}Ba-No. 192	38014		35353	35348

Check Source Final Reading 200

Performed by: ______ Approved by: ______

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Channel No: HP.R 227 GAS Date: 2/17/78

Sampler Serial No: 135 Detector Serial No: 123 Ratemeter Serial No: 660

Discriminator Setting c Final H.V. ______

TMI-I STANDARD CALIBRATION FIXTURE

Background: Binary Count ______ Minutes ______ = Net CPM 25

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		1378	1353
^{133}Ba-No. 138		1270	1245
^{133}Ba-No. 192		2974	2949
^{137}Cs-No. 177		45187	45162
^{137}Cs-No. 138		2001	1976
^{137}Cs-No. 192		16258	16233
ENERGY RESPONSE SOURCES			
^{133}Ba-No. SR2			
^{137}Cs-No. SR2			
^{60}Co-No. SR2			

POOR ORIGINAL

CHANNEL SAMPLER

Background: Binary Count ______ Minutes ______ = Net CPM 49

Source	Expected Net Count	Gross CPM	Net CPM
^{133}Ba-No. 177		1924	1875
^{133}Ba-No. 138		1630	1581
^{133}Ba-No. 192		3053	3004
^{137}Cs-No. 177		45488	45439
^{137}Cs-No. 133		2068	2019
^{137}Cs-No. 192		17858	17809

ANALYZER CHANNEL Window set at 3.8 to 4.2; Iodine centered at 4.0V

Background: Binary Count ______ Minutes ______ = CPM ______

749233

Source	Iodine Peaked CPM	Desired 93%	Actual CPM	Net CPM
^{133}Ba-No. 177				
^{133}Ba-No. 192				

Check Source Final Reading 100

Performed by: ______ Approved by: ______

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TMI UNIT II   MTX 123

INST. CAL. DATA SHEET

EM R.M.S.

INST. NO. HP-R-3240

LOCATION Panel 12

SERIAL NO Ratemeter ~~Detector~~ Rp+

TOLERANCE ____ ENG. UNIT OR ____ % OF SPAN

MODEL OR TYPE VICTOREEN, Area Gamma G-M

FUNCTION

MAX. ERROR OF % OF SPAN ____ OR MAX. ERROR ENG. UNITS ____

RANGE 0.1 to 10^4 mR/hr

OUTPUT

STATIC PRESSURE ERROR N/A

ACTION

REFERENCE DATA

DC AMP OUTPUT AT FULL SCALE = 5.151 vDC

SPECIAL DATA

CALIB.	DESIRED 10 mV OUTPUT	DESIRED INDICATION mR/HR	ACTUAL PANEL METER INDICATION	REMOTE METER INDICATION	RECORDER READING	DESIRED 50 mV OUTPUT	ACTUAL 50 mV OUTPUT		
1	0.00	.1	.1	[illegible]	.1	0.0	1.34		
2	2.00	1.0	.9		1.0	10.00	10.69		
3	4.00	10	8.5		10	20.00	20.[illegible]		
4	6.00	1.0×10^2	9.0×10^1		1.0×10^2	30.00	30.26		
5	8.00	1.0×10^3	9.5×10^2		1.0×10^3	40.00	40.09		
6	10.00	1.0×10^4	1.0×10^4	7	1.0×10^4	50.00	49.94		

POOR ORIGINAL

REMARKS: ALERT ALARM 10 AS FOUND $\geq 10^4$ AS LEFT 10 mR/hr
HIGH ALARM 30 AS FOUND $>10^4$ AS LEFT 30 mR/hr

TEST EQUIPMENT USED

EQUIP. Fluke DVM SER. NO. 530310 LAST CAL. 10/10/77 CAL. FREQ. 6 mo
EQUIP. Digitec SER. NO. 61260567 LAST CAL. 1/24/78 CAL. FREQ. 6 mo
EQUIP. ____ SER. NO. ____ LAST CAL. ____ CAL. FREQ. ____
EQUIP. ____ SER. NO. ____ LAST CAL. ____ CAL. FREQ. ____
EQUIP. ____ SER. NO. ____ LAST CAL. ____ CAL. FREQ. ____
IP. ____ SER. NO. ____ LAST CAL. ____ CAL. FREQ. ____

743234

MACHINERY HISTORY ENTRY: DATE 2/2/78 INITIALS TJW

PERFORMED BY T. J. WRIGHT DATE 2/1/78 APPROVED BY DCWeaner DATE 2/2/78

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Description	Manufacturer, Model Number, Etc.	Victoreen Part No.	Qty.
Detector	Victoreen Instrument Div.		1
Check Source	"		1
Alarm Horn	Edwards		1
Alarm Light	Federal		1

4.2.6 Gas Monitor

Motor Starter	GE, 200 line with "Hand, Off, Auto" Switch		1
Relay	Square D, KP12, 2PDT		2
H. V. Connector	Amphenol, MHV-Bulkhead		1
Terminal Board	States, 10-Position		3
3/4" Valve	Dynaquip, Full Port, Brass		5
Pumping System	Victoreen Instrument Div.	844-1	1
Lead Shield	"		1
Sample Volume	"		1
Detector	"		1
Check Source	"		1

4.2.7 Atmospheric Monitor

4.2.7.1 Atmospheric Monitor - Standard

Elapsed Time Meter	Hayden		1
Differential Pressure Switch	Barksdale		2
Motor Starter	GE, CR206BO with 3-C2.68A O.L. Heaters		1
Relay	Square D, KP12, 2PDT		6
Terminal Board	States, 20-Position		1
Terminal Board	States, 10- Position		3
1" Valve	Dynaquip, Full Port, Stainless		2
1" Valve Inlet	Dynaquip, VFB25A1		-
3/4" Valve	Dynaquip, Full Port, Brass		5
Moving Filter Sampler w/CS	Victoreen Instrument Div.	841-1	1
Gas Sampler w/CS	"	841-33	1
Iodine Sampler w/CS	"	841-2	1
Pumping System	"	844-1	1
Control Panel	" (Located in Panel #12)		1
Control Panel	" (Located on Local Enclosure)	844-90	1
Flow Control Panel	" (Modified for Elapsed Time Meter)		1
Alarm Horn	Edwards		1
Alarm Light	Federal		1

4.2.7.2 Atmospheric Monitor -Portable

749235

Relay	Square D, KP12, 2PDT		6

Description	Manufacturer, Model No., Etc.	Victoreen Part No.	Qty.
Relay	Agastat, GPI		9
Terminal Board	States, 24-Position		2
Terminal Board	States, 16-Position		2
Terminal Board	States, 10-Position		1
Pressure Switch	Barksdale		2
Elapsed Time Meter	Hayden		1
Recorder	Leeds & Northrup - 3 Pen		1
1" Valve	Dynaquip, Full Port, Stainless		2
3/4" Valve	Dynaquip, Full Port, Brass		5
Alarm Horn	Edwards		1
Alarm Light	Federal		1
Moving Filter Sampler	Victoreen Instrument Div.	841-1	1
Iodine Sampler	"	842-1	1
Gas Sampler	"	841-33	1
Ratemeter	"	842-10	3
Control Panel	"	844-90	1
Electrical Panel	"		
Flow Panel	"		

4.2.7.3 Atmospheric Monitor - Automatic

In addition to those parts under 4.2.7.1, the following are used to complete the automatic monitor.

Valve	Dahl, Electric w/controller		1
Signal Converter	Rochester Instrument Systems, SC1300, E/I Conv.		3
Terminal Board	States, 9-Position		5
Gas Flow Equipment	Hastings		1
Mass Flowmeter	Hastings (Probe located in stack)		1
Recorder	GE, 2-Pen		
Controller	GE		

4.2.8 Pumping System, Model 844-1

Vacuum Pump	Victoreen Instrument Div.	844-1-6	1
Vacuum Relief Valve	"	944-1-9	1
Bushing (Brass)	" (3/8 to 1/2 inch)	10-486	1
Brass Tee	"(1/2 x 3/4 x 3/4)	10-487	1
Close Nipple(Brass)	" (3/4 inch)	10-488	2
3/4" Valve	"	10-340	1
Exhaust By-Pass Assembly	"	844-1-12	1
Exhaust Assembly	"	844-1-13	2
Intake Assembly	"	844-1-11	1
Pure Gum Tubing	" (3/16 O.D. x 3/14 I.D.)		48 in.

Description	Manufacturer, Model No., Etc.	Victoreen Part No.	Qty.
Male Connector (Brass)	Victoreen Instrument Div.	10-485	1
Vacuum Switch	"	844-1-14	1
Vibration Isolator	"	844-1-24	1
Drive Pulley Std.	"	844-1-19	1
V Belt	"	844-1-20	1
Motor, Std.	"	844-1-17	1
Mtg. Base, Std.	"	844-1-16	1
Box Conn.- Cable	"	844-5-16	1
Spacer, Shcok Mtd.	"	844-1-22	4

4.2.9 Moving Filter Sampler - Model 841-1

Rectifier (Diode) 1N2071	"	52-48	2
Diode MDA 920A-7	"	52-124	2
Check Source Solenoid	"	716-50	1
Tear Switch Ass'y.	"	841-1-65	1
Solenoid	"	841-1-78	1
Take-Up Spool Motor	"	841-1-79	1
*Cycling Timer, Cont.	"	841-1-107	1
*Cycling Timer, Advance	"	841-1-106	1
*Time Switch	"	841-1-90	1

*Located on Electrical Control Panel

4.2.10 Iodine Sampler - Model 841-2

There are no replaceable parts to this unit other than the filter holder. Consult factory.

4.2.11 Gas/Liquid Sampler - Model 841-33

Volume Assembly	Victoreen Instrument Div.	841-33-28	1

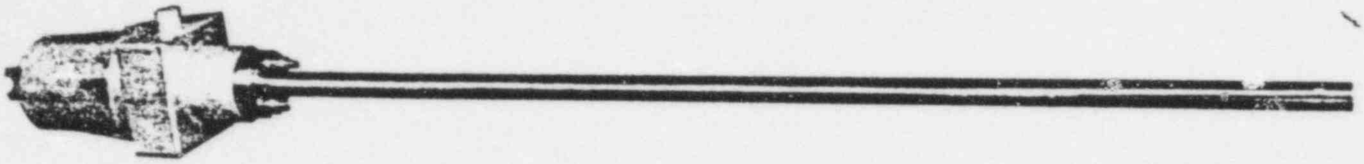
4.2.12 Control Panel-Moving Filter Sampler, Model 844-90

Indicator Light Base	Victoreen Instrument Div.	20-48	1
Replacement Lamp	"	17-54	3
Fuse: 3AG, 3/4 Amp	"	19-2	1

4.2.13 Control Panel - Gas Sampler, Model 844-100

Indicator Light Base	Victoreen Instrument Div.	20-48	1
Replacement Lamp	"	17-54	3
Fuse; 3 AG, 3/4 Amp	"	19-2	1

MODEL AFI-SERIES



HASTINGS
GAS FLOW PROBE

FOR MEASURING VELOCITY OF WET AND DIRTY GASES

MODEL ______________ SERIAL ______________

WITH

HASTINGS PURGE MANIFOLD

MODEL ______________ SERIAL ______________

HASTINGS POWER CONVERTER

MODEL ______________ SERIAL ______________

____

____

____

TELEDYNE HASTINGS-RAYDIST HAMPTON, VIRGINIA 23661 U.S.A. PHONE (804) 723-6531

HASTINGS GAS FLOW PROBE

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TELEDYNE HASTINGS-RAYDIST

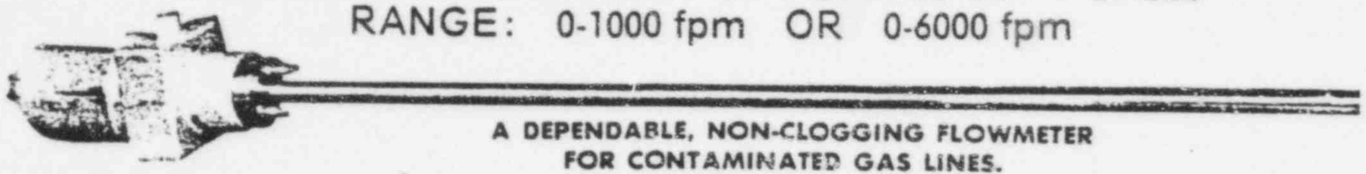
HAMPTON, VIRGINIA 23661 • (804) 723-6531

Specification Sheet No. 513A

HASTINGS GAS FLOW PROBE MODEL AFI - SERIES

FOR MEASURING VELOCITY OF WET AND DIRTY GASES

RANGE: 0-1000 fpm OR 0-6000 fpm



A DEPENDABLE, NON-CLOGGING FLOWMETER FOR CONTAMINATED GAS LINES.

POOR ORIGINAL

FEATURES

- CONTINUOUS PURGE PRINCIPLE
- NO EXPOSED SENSORS or WIRES
- EASILY INSTALLED or MOVED
- EXPLOSION-PROOF TYPE HOUSING
- 0-5 VOLT D-C OUTPUT SIGNAL
- PROVIDES LONG LINE TRANSMISSION CAPABILITY
- REMOTE: RECORDING, CONTROL, ALARM, INDICATION
- PURGE WITH AIR, N_2 OR PROCESS GAS
- CHOICE OF TWO RANGES: 0-1000 or 0-6000 fpm

GENERAL

The Hastings Gas Flow Probe is the result of nearly two decades of experience in dealing with difficult-to-measure, corrosive, or inflammable gases. Using a unique Hastings thermal principle with continuous purging, the measured gas does not come in contact with the internal parts of the probe. Thus plugging, fouling, condensation, corrosion, etc., are no longer problems.

steel for all parts (internal and external) through which any gas flows. Solid-state circuits are built into the explosion-proof type housing and require only connection to a 24 volt d-c power source and remote read out. The output signal of 0-5 volts may be connected to any remote data logging device, meter, recorder or readout desired. The purge gas required is quite small and normally is less than 30 cu.ft. / hr. The probe may also be used without the purge system in relatively clean and dry lines where plugging is not a problem.

PRINCIPLE OF OPERATION

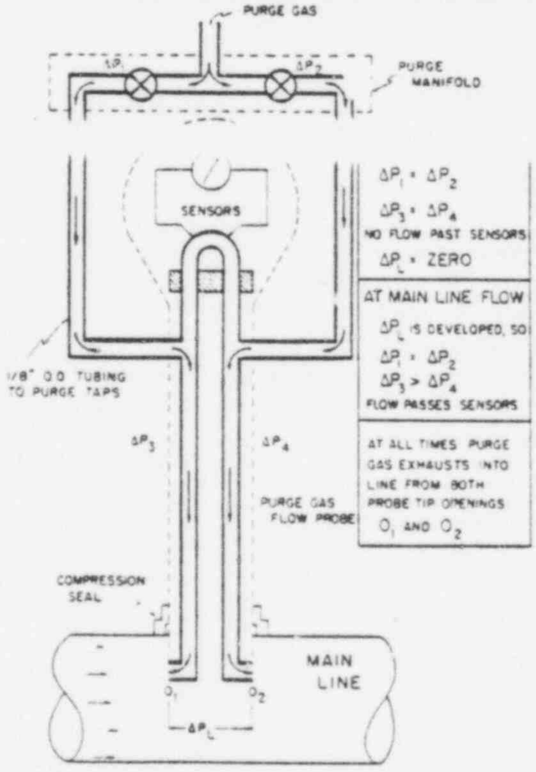
CONTINUOUS PURGE MODE

The probe is constructed with two openings at the probe tip. These openings are connected together by an internal stainless steel tube. A portion of this tube is heated and thermo-electric sensors measure temperature gradients along the wall of the tube, external to the flow stream.

Purge gas is injected into the tubing in an arrangement which forms a pneumatic bridge. At zero line velocity, the bridge is balanced so that no flow occurs through the sensing portion of the tube. The purge gas exhausts out both openings equally at the probe tip.

As flow across the tip occurs, a differential pressure is developed, unbalancing the bridge and causing a small amount of purge gas to flow through the sensing section. Purge gas still exhausts out both openings, but now they are slightly unequal. The thermo-electric sensors measure the shift in temperature gradients along the heated portion of the tube which are related to the main gas flow creating the differential pressure at the tip.

Since the purge gas is continuously exhausting into the main line, it prevents the main line gas from entering the probe and prevents fouling.



CONTINUOUS PURGING PRINCIPLE of OPERATION

749240

(Manufactured under one or more U.S. Patents and Pat. Pending)

PURGE GAS REQUIREMENTS

Regulated, clean dry air, nitrogen or process gas may be used as the purge gas. Consumption is less than 30 standard cu. ft. / hr. at a pressure approximately 15 psi above the static pressure of the line being measured. Since such a small amount is flowing into relatively large lines, the percentage of air added to the whole is insignificant. If inert gases are desired, nitrogen is recommended.

PURGE MANIFOLD

Included with the probe is a purge gas balancing manifold built into a weatherproof conduit type enclosure. This may be mounted anywhere near the probe. It includes two valves for balancing the bridge and zeroing the probe.

POWER CONVERTER

An optional 24 volt d-c converter is offered for those installations where 24 vdc is not available. Built into a Crouse Hinds explosion-proof type housing and rated at ½ amp, it is available for use from either 115 volt or 230 volt a-c lines.

CALIBRATION

Calibration is related to the gas density and the velocity profile.

Velocity = $K_1 \cdot K_2 \cdot V_{IND}$

where

K_1 = Velocity Profile Factor; typically .8

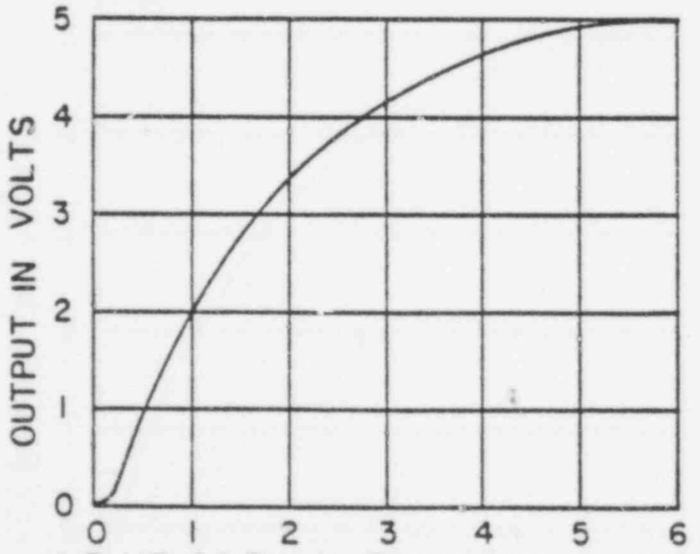
K_2 = Density Factor; $\sqrt{.075 / \text{gas density}}$

V_{IND} = Velocity from probe calibration curve

Example: What is the full scale (5 volt) range of an AFI-6K when measuring stack gas having a density of .092 lbs. / ft.?

$$\text{Velocity} = K_1 \cdot K_2 \cdot V_{IND}$$
$$= (.8)\ (\sqrt{.075 / .092}\ )\ (6000)$$
$$= 4333 \text{ fpm}$$

TYPICAL CALIBRATION CURVE



SELECTION CHART

Model	Air Range
AFI-1K	0-1000 fpm
AFI-6K	0-6000 fpm

Above includes: Probe, Purge Manifold, and curve of Air Velocity versus 0-5 volts.

ACCESSORIES

Model ADC-2	115 v. a-c/24 v. d-c power converter
Model ADC-3	230 v. a-c/24 v. d-c power converter
Meter 24-1-419	0-5 volt meter for remote readout
Meter 24-1-420	0-5 volt meter relay single point control
Meter 24-1-421	0-5 volt meter relay double point control

SPECIFICATIONS

POOR ORIGINAL

POWER: 24 v. d-c (∓ 4 v.) @ 320 ma
OUTPUT: 0-5 v. d-c, @ 4 ma (max).
PURGE GAS: AFI-1K 5 cfh
AFI-6K 30 cfh
@ 15 psig regulated
DIMENSIONS: Probe—47" x 4" x Overall
with 36" x 7/ 8" O.D. Wand
MANIFOLD: 8" x 6" x 3½" Weatherproof Type Box
MATERIALS: 304 and 316 Stainless Steel for all parts in contact with gas
HOUSING: Crouse-Hinds Type
COMPRESSION SEAL FOR PROBE: Male 1¼" NPT Threaded Connection
MANIFOLD CONNECTIONS: ⅛" O.D. Tubing to Probe, ⅛" NPT to Purge Gas Supply

INSTALLATION

The probe is supplied with a compression seal fitting for easy installation. The fitting has a 1¼" NPT male thread that will easily connect to a 1¼" female threaded gate valve. It may be mounted in any position if used in the purge mode.

The purge manifold is connected to a regulated gas supply at 10-30 psig. The manifold should be connected to the probe by means of ⅛" O.D. tubing.

Electrically, 2 wires from the probe are required for the 24 v. d-c input power, and 2 wires for connection to the [illegible]

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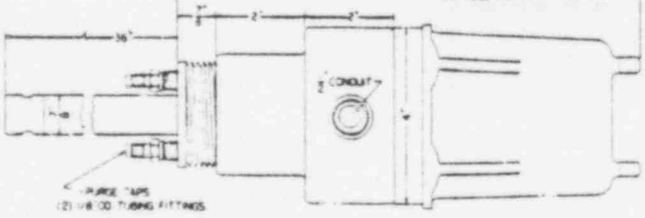

OUTLINE DIMENSIONS AFI-SERIES

Literature Available upon request:

Hastings Vacuum Gauges	Catalog No. 300D
Hastings McLeod Gauge	Spec. Sheet No 340B
Hastings Gauge Tube Accessories	Spec. Sheet No. 352
Hastings Vacuum Gauge Reference Tubes	Spec. Sheet No. 353A
Hastings Air-Meters	Catalog No. 400D
Hastings Mass Flowmeters for Gases	Catalog No. 500D
Hastings Calibrated Gas Leaks	Spec. Sheet No. 904D

TELEDYNE
HASTINGS-RAYDIST

HAMPTON, VIRGINIA 23661, U.S.A.
PRINTED IN U.S.A.
SPECIFICATION SHEET #513A

PHONE (804) 723-6531
TWX: 710-882-0085

1.0 INTRODUCTION

1.1 GENERAL - The Hastings Gas Flow Probe is the result of nearly two decades of experience in measuring corrosive and flammable gases. It uses a unique Hastings patented thermal purge principle so the measured gas does not come in contact with the internal parts of the probe and plugging, fouling, condensation, and corrosion are no longer problems.

The probe is constructed entirely of stainless steel for all parts (internal and external) through which any gas flows. Solid-state circuits are built into an explosion-proof type housing and only require connection to a 24 volt d-c power source and a remote readout. The output signal of 0-5 volts d-c, (4 ma) may be connected to a remote data logging device, meter, recorder, etc.

1.2 USES - The Hastings Gas Flow Probe has been used in a variety of applications. Although originally designed for monitoring stack emissions in the petrochemical industry, its inherent reliability in extremely wet, corrosive, and particle-laden gas emissions makes it useful in other types of stacks, including those in power plants, cement factories, and paper mills. It can be used to adjust an isokinetic sampling system or to supply data to a computerized gas analyzing system. A common use in refineries is to control the rate of steam injection to promote more effective burning of gases in the flares. It is also being used in feeder lines to monitor the various sources of emissions.

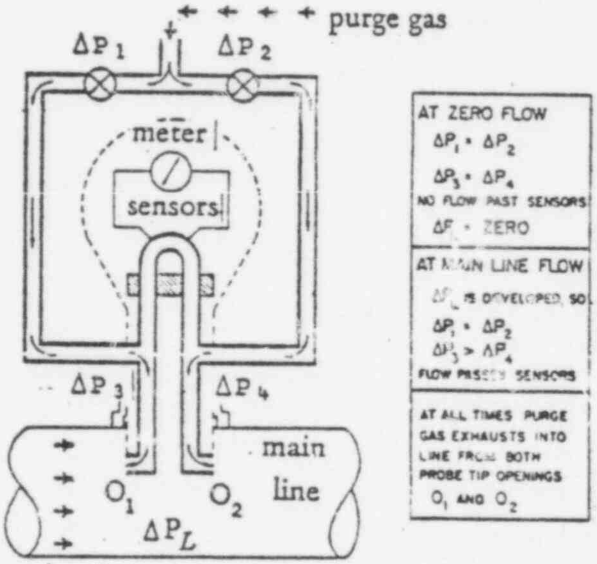

Figure 1 - CONTINUOUS PURGE PRINCIPLE

1.3 PRINCIPLE OF OPERATION - The probe is constructed with two openings at the tip. These openings are connected by an internal stainless steel tube. A portion of this tube is heated and thermo-electric sensors measure temperature gradients along the wall of the tube external to the flow stream. Purge gas is injected into a pneumatic bridge arrangement. At zero velocity the bridge is balanced so that no flow occurs through the sensing portion of the tube and the purge gas exhausts equally through both openings at the probe tip.

When there is flow in the main line (Figure 1) a differential pressure is developed across the openings at the tip, unbalancing the bridge and causing a small part of the *purge* gas to flow through the sensing section. Purge gas still exhausts through both openings, but the rate of discharge is less from the upstream opening. Since the purge gas is continuously exhausting into the main line, it prevents the main line gas from entering the probe and thereby prevents fouling of the probe.

Thermo-electric sensors measure the shift in temperature gradients along the heated portion of the tube and the shift is related to the main gas flow creating the differential pressure at the tip.

2.0 INSPECTION

Several preliminary checks on the Hastings Gas Flow Probe should be made to insure that it has been received in good working order.

2.1 INPUT - OUTPUT CONNECTIONS

2.1.1 PROBE - Place the probe on a workbench and connect it to a 24 ±4 volt d-c, ½ amp power supply such as the Hastings Model ADC-2 Power Converter. Connect a 0-5 volt d-c meter to the output terminals (see Figure 2).

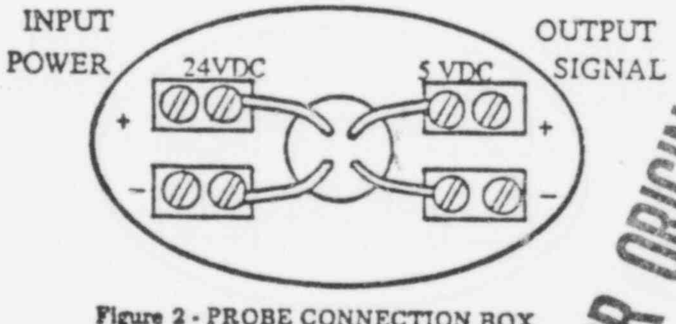

Figure 2 - PROBE CONNECTION BOX

2.1.2 POWER CONVERTER - The Hastings Model ADC-2 24 volt d-c Power Converter requires 115 volts, 60 Hz at 0.1 amps. The 5 volt d-c SIGNAL terminals are simply tie points for connecting the cable coming from the probe. The output signal can therefore be routed directly to the readout, if desired.

2.2 PROBE OUTPUT

2.2.1 ZERO - Turn the power supply ON. The initial transient output signal from the probe will drive the indicating meter off scale several times and then stabilize at less than 0.5 volts after 2 or 3 minutes. Block off the openings in the probe tip and purge taps with pieces of masking tape to eliminate any output caused by air movements. Allow 30 minutes for warm-up before making zero adjustments.

2.2.2 OUTPUT SIGNAL - Remove the tape from the probe and blow into the *upstream* opening. The output should increase, indicating that the probe is in good working order.

3.0 PRELIMINARY OPERATION

It is recommended that the Hastings AFI-Series Gas Flow Probe be set-up and operated before installation to familiarize personnel with problems which may occur due to improper installation procedures.

3.1 ELECTRICAL - Connect the probe to a 24 volt d-c power supply and to a 0-5 volt d-c indicator as described in section 2.1. Turn the power supply ON and allow 30 minutes for warm-up.

3.1.1 ZERO ADJUST - Block the openings in the probe tip and the purge taps to eliminate shifts in output which may be caused by drafts. Set the output to .00±.02 volts d-c by adjusting the ZERO potentiometer (Figure 3).

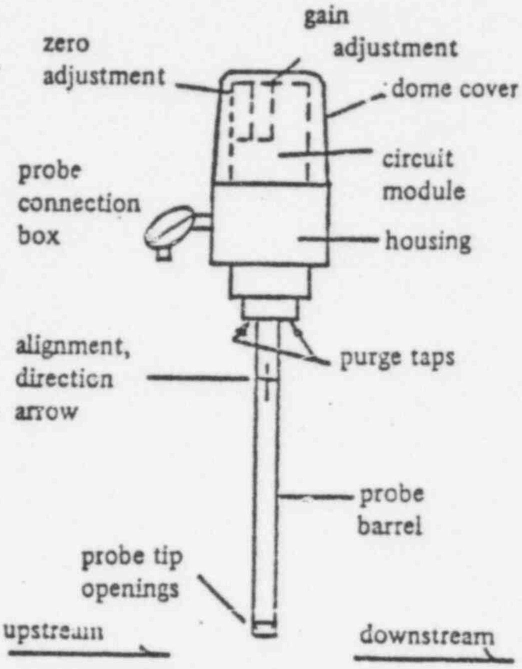

Figure 3 - GAS FLOW PROBE

3.1.2 POSITION EFFECT - Pick up the probe and rotate it through several planes. The output may change momentarily due to air moving inside the probe, but once the probe is stationary in any one position the output should be .00±.10 volts. Any slight change in output due to a change in position can be eliminated by setting the zero adjust with the probe in the desired position.

3.1.3 DIRECTION OF FLOW - Remove the tape from the openings in the probe tip and blow gently into the *upstream* opening. The output should increase as the velocity of air going into the probe increases.

Blow gently into the downstream opening and the output should decrease (become negative) and then increase and become positive again. Reverse flow indications will always be lower than indications for the same flow in the proper direction. *The probe must be installed so the flowing gas approaches the probe from the upstream side.*

3.1.4 OVERFLOWS - If the probe is exposed to a *sudden* large increase in the velocity of the main stream, such as zero to full scale, the output may momentarily increase to a value greater than 5.0 volts. However, it will drop to the correct value in less than one minute.

3.2 PNEUMATIC – The Hastings Purge Manifold is a pneumatic system used to balance the flow of purge gas through the probe.

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3.2.1 PURGE CONNECTION - Connect the Hastings Purge Manifold to a 10-20 psig regulated source of clean dry purge gas. The air purge rates required for an AFI-1K and AFI-6K are about 2 scfh and 20 scfh, respectively. Connect the RANGE tap on the purge manifold to the RANGE purge tap (upstream) on the probe. If the purge manifold is located less than 20 feet from the probe, 1/8" O.D. tubing is satisfactory, but if the distance is more than 20 feet 1/4" O.D. tubing should be used. (See Figure 4).

3.2.2 RANGE ADJUST* - Close off the zero taps on the purge manifold, and the *downstream* purge tap on the AFI-6K. Close off the *upstream* opening in the probe tip with tape and fully open the ZERO valve. Adjust the pressure regulator so there is sufficient pressure to drive the probe output to 5.0 vdc (normally 15 psig). This adjustment is not critical, but does set a limit on the velocity that can be measured at the probe tip before line gas starts entering the probe. *NOTE: When the pressure is being adjusted the output may rise above 5.0 volts d-c, but will stabilize in about one minute. Remove the tape from the probe tip.*

3.2.3 ZERO ADJUST - Connect the ZERO outlet on the purge manifold to the *downstream* tap on the probe. Adjust the ZERO valve for zero output from the probe, and the pneumatic bridge will be balanced. Opening the valve further may cause the output to become negative, then return to a FALSE ZERO and start increasing in a positive direction (see Figure 5). Blow *very gently* on the upstream opening in the probe tip. If a TRUE ZERO has been established the output will immediately increase. If a FALSE ZERO has been established, the output will become negative. Tap the valve gently to be sure the stem is seated securely. The probe is now operational.

3.2.4 LEAK CHECKING - Check all connections for leaks by applying a soap solution to the connection and watching for a stream of bubbles. Check for leaks with the openings in the probe tip taped closed.

3.3 TYPICAL PROBLEMS - Although the probe is now completely operable it is suggested that the following problems be deliberately created so their effect on the output signal may be more easily and quickly recognized if they should occur during installation or operation.

* A RANGE valve is included in the Model MP-1K Purge Manifold. Refer to the instruction sheet in the cover of the purge manifold before making adjustments.

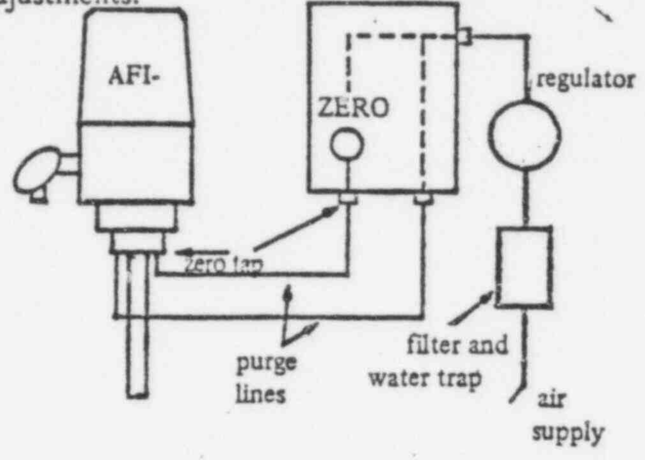

Figure 4 - PURGE CONNECTIONS

NOTE: It may not be possible to open the valve enough to cause a false zero on some models.

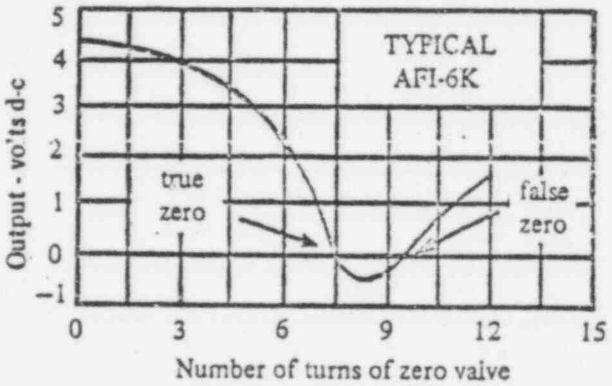

Figure 5 - TRUE ZERO AND FALSE ZERO

3.3.1 INSTALLING PROBE BACKWARDS - Blow into the upstream opening in the probe tip from a distance of about 6", first very gently and then vigorously. The output should immediately increase in a positive direction by a small amount (about 0.5 volt d-c) and then to a much higher value (1 to 5 volts d-c depending on the velocity created). Repeat this procedure at the downstream opening in the tip. The output should immediately become negative (about -0.5 volt d-c) and then become positive. If the probe is installed backwards the output will always be low, indicating a lower velocity than actually exists in the stack.

3.3.2 FALSE ZERO - Open the ZERO valve slowly until the FALSE ZERO is reached (see Sec. 3.2.3 and Figure 5). Blow very gently into the upstream opening and the output will become negative. Blow vigorously and the output will indicate a positive, but low value. The results are almost identical to those described in Section 3.3.1 for a backward probe installation. Return to the TRUE ZERO setting.

3.3.3 EFFECT OF LEAKS - Loosen the fitting on the RANGE purge tap of the Probe until a small leak occurs. The output will be negative for very small leaks and positive for larger leaks. Tighten the RANGE tap fitting and loosen the fitting on the ZERO tap of the probe until it leaks. The output will be positive regardless of the size of the leak. Tap or wiggle the tubing at the fitting. In all probability the leak rate will be erratic which would appear as instability in the output signal under normal operating conditions. When such leaks exist, it is very possible that they will vary in magnitude with ambient temperature or other changing environmental conditions. Tighten all fittings to remove leaks.

3.3.4 VALVE SETTING - Close the ZERO valve slightly so the output increases to about +0.5 volt d-c. After the output stabilizes tap the ZERO valve soundly. The output may change slightly, but additional tapping will not cause further changes once the valve stem has seated. If the purge manifold is subjected to vibration the valve setting may change. Once the valve is set it is advisable to lock it in place with a locking compound such as Glyptal or wax.

3.3.5 PURGE GAS PRESSURE VARIATIONS - With the output still about + .5 volts d-c, change the purge gas regulator pressure ±.1 psig. The output will change approximately 0.1 volt, indicating that the output signal will vary if pressure regulation is inadequate.

4.0 PREPARING FOR INSTALLATION

4.1 MOUNTING

4.1.1 PROBE MOUNTING - Since the probe barrel must be inserted through the stack into the gas stream, it is necessary to install suitable entrance fittings (see Figure 6). A compression fitting having 1 1/4" NPT threads is provided with the probe and can be screwed directly into a suitable tap in the line. Some users prefer to include a 1" I.D. gate shutoff valve to seal off the line. When the probe is mounted in a horizontal position as shown in figure 6 it is sometimes necessary to provide additional support at the housing. If a choice is available it is better to install the probe in a vertical position so any liquid that might collect in the probe can drain. However, with continuous purging such condensation is not normally a problem.

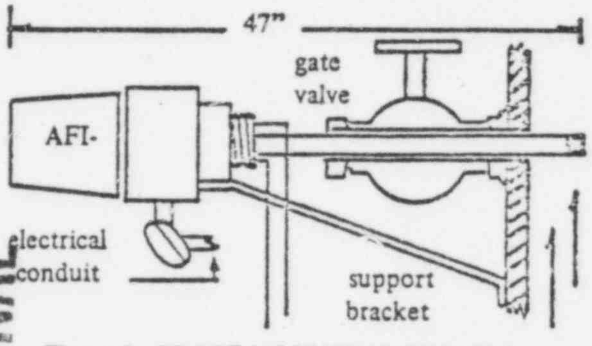

Figure 6 - PROBE MOUNTING DETAILS

4.1.2 PURGE MANIFOLD MOUNTING - The purge Manifold should be mounted as close to the probe as practical in a location that makes periodic adjustments convenient. Most users mount it next to the probe or close to the base of the stack. A regulated (15 psig) source of clean, dry air (or other purge gas) is required, and a filter and liquid trap should be installed in front of the regulator since particles or liquids can foul the valve and cause erratic indications and shifts in output. The purge lines should be flexible enough to remove the probe from the line for periodic zero checks without disconnecting the purge lines (see Figure 7).

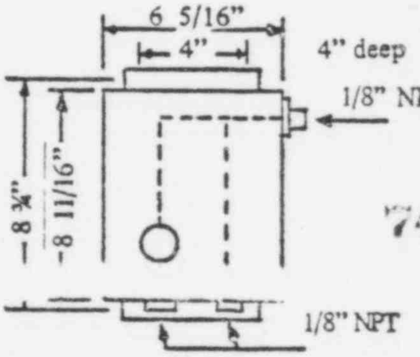

Figure 7 - PURGE MANIFOLD

4.1.3 POWER CONVERTER - Mounting the ADC-[illegible] be [illegible] location near the probe, or it can be mounted remotely if allowances are made for voltage drops (see Figure 8 and Section 4.2.1, Cable Conductor Size).

4.2 ELECTRICAL CONNECTIONS - Several factors should be considered when installing and connecting wiring between the various components.

4.2.1 CABLE CONDUCTOR SIZE - No. 18 conductors should be used for carrying the 24 vdc supply voltage between the power converter and the probe. If the transmission lines are 500-1000 feet long, No. 14 conductors should be used. The conductor size is determined by the voltage drop in the cable between the power converter and the probe, since the minimum allowable voltage at the probe is 20 vdc.

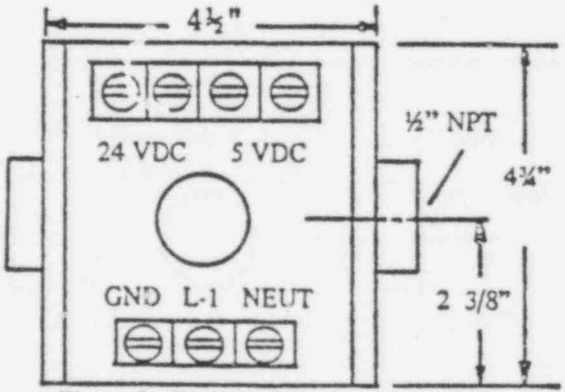

Figure 8 - POWER CONVERTER

4.2.2 ELECTRICAL SHIELDING - Normally cables should not be run in the same conduit with wires carrying high transient or high frequency currents such as those powering solenoid valves or motors. If conduit is not used the cable should be shielded, and if electrical noise is excessive the 24 vdc input and the 0-5 vdc output should be shielded separately (also refer to section 4.2.3).

4.2.3 ELECTRICAL NOISE - In areas of high electrical noise a small change in output may occur when the dome cover is removed from the probe. A .47 mfd capacitor connected between the + 24 vdc terminal and the housing (case-ground) will usually eliminate this problem. The capacitor can be installed in the probe terminal connection box.

5.0 ACTUAL INSTALLATION

After all of the preliminary checks outlined in Section 3.0 have been made and the preliminary installation work outlined in Section 4.0 has been completed, locate the probe at the installation site but do not insert it into the stack.

5.1 ELECTRICAL AND PNEUMATIC ADJUSTMENTS

5.1.1 ELECTRICAL CONNECTIONS - Connect the 24 volt d-c power input leads and the 0-5 volt d-c signal output leads to the probe terminal connection box. Apply power so the probe can be warming up.

5.1.2 ELECTRICAL ZERO - After the probe has been on for 30 minutes the output should be zero with both openings in the probe tip closed. Adjust the output to zero if necessary, and replace the dome cover.

5.1.3 PURGE CONNECTIONS - Connect the purge lines to the probe, set the regulated pressure to 10-20 psig and check for leaks, tapping fittings and lines briskly while leak checking.

5.1.4 PURGE RANGE ADJUST - Remove the tape from the downstream side of the probe tip. Block off the zero taps on the probe and on the purge manifold. Adjust the purge pressure slowly until the output reaches about 5 volts d-c (section 3.2.2)

5.1.5 PURGE ZERO ADJUST - Reconnect the zero taps and remove the tape from the upstream opening in the probe tip. The output should drop about 40% for an AFI-1K, or about 15% for an AFI-6K. The probe tip can be shielded from air currents when setting the zero by placing the tip in a deep cup with the tip openings at least 1/2" from the walls of the cup. Open the ZERO valve slowly until a TRUE ZERO is reached (see Section 3.2). To insure that you actually have a TRUE ZERO, blow very gently on the upstream opening of the probe tip. If the output goes negative a FALSE zero has been set and must be corrected.

5.2 ALIGNMENT AND POSITIONING

5.2.1 ALIGNING THE PROBE - Insert the probe in the stack and align the tip so that the line gas approaches the upstream opening of the probe tip. The arrow on the probe barrel will facilitate this alignment.

Slowly rotate the probe 90°. Notice that there is no appreciable change for the first 15° and then the output starts dropping rapidly, almost reaching zero at 90° rotation. If the probe becomes misaligned by more than 15°, the output signal will be low. Return the probe to the proper alignment.

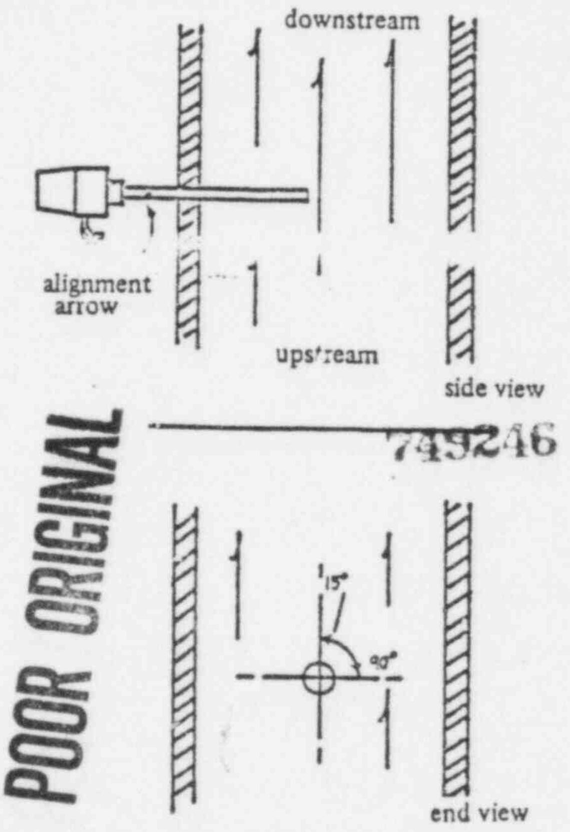

Figure 9 - PROBE ALIGNMENT

5.2.2 POSITIONING THE PROBE - Insert the probe into the center of the stack or to the point of Average Velocity.

6.0 VELOCITY PROFILE

The VOLUME FLOW through a line or stack is equal to the AREA x VELOCITY. However, the velocity at various points across the diameter of a stack is not a constant so it is necessary to determine the AVERAGE VELOCITY. Measuring the variation in velocity across the diameter of the stack is known as VELOCITY TRAVERSE and the plot of velocity versus diameter is known as a VELOCITY PROFILE. The velocity variation depends on many factors, including Reynolds number, upstream and downstream disturbances, stack surface, etc. It is therefore most difficult to accurately predict the AVERAGE VELOCITY in any installation with out making an actual velocity traverse.*

Normally, the probe is placed at the center of the stack and the indicated velocity is multiplied by a factor (K_1) to convert Center Velocity to Average Velocity. This factor is typically about .82 but should be empirically determined for each system by performing a velocity traverse. The probe can also be inserted in the stack to a position that makes K_1 unity.

6.1 AVERAGE VELOCITY - The average velocity is determined by dividing the area of the stack into concentric rings of equal area and measuring the velocity in the center of each ring on either side of the pipe. The AVERAGE VELOCITY is then the sum of the velocity readings taken divided by the number of readings. A typical velocity traverse would consist of ten velocity readings (see Figure 10).

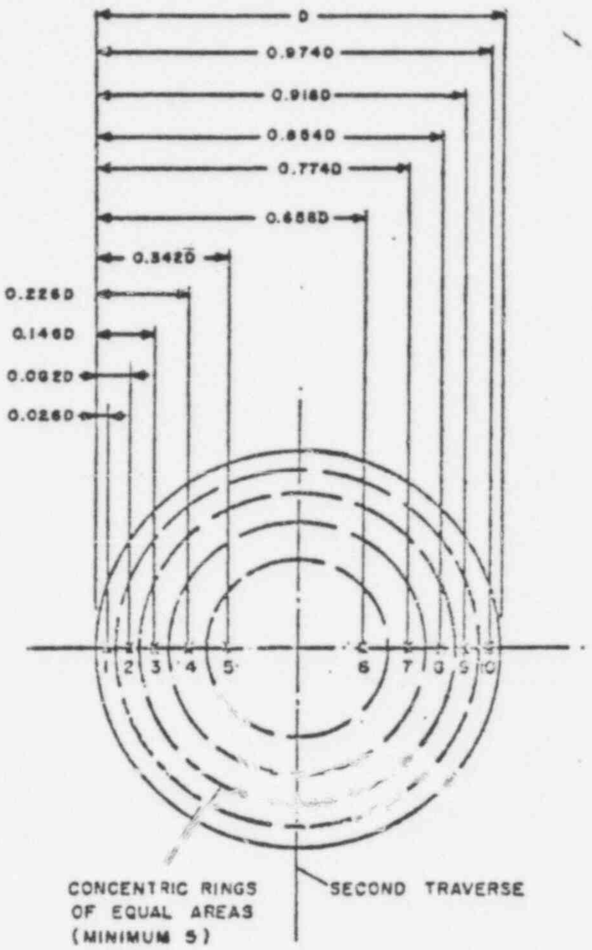

Figure 10 - TRAVERSING METHOD

EXAMPLE:

Find the average velocity and the K_1 factor, and plot the velocity profile for the installation described in Figure 11

Step 1: [illegible] the 10 Probe INSERTION DEPTHS:

(Eq. 1) DEPTH = (Diameter Ratio) x (Diameter) = (.026) x (36") = .9"

Step 2: Measure and record the Velocity at the 10 insertion depths previously determined (equal area points) across the diameter of the stack:

Step 3: Measure and record the Velocity at the center of the stack.

Step 4: Determine Normalized Velocities for each of the 10 readings in step 2:

(Eq. 2) NORMALIZED VELOCITY = $\frac{\text{Measured Velocity}}{\text{Center Velocity}} = \frac{810 \text{ fpm}}{1250 \text{ fpm}} = .65$ etc.

---

*Spink, L.K. Principles and Practice of Flow Meter Engineering 9th ed. Norwood, Mass. Plimpton Press 1967. Pg 50-53

Owner, E. and Pankhurst, R.C., The Measurement of Air Flow 4th ed. London: Pergamon Press 1966. Pg 117

Step 5: Plot the Velocity Profile:

STACK DESIGNATION EAST FLARE
STACK DIAMETER 36" DATE 1-20-72
PROBE SER. NO. 186 BY WCB

DIAMETER RATIO	INSERTION DEPTH [1]	MEASURED VELOCITY [2]	NORMALIZED VELOCITY [4]
.026	.9"	810	.65
.082	3.0"	960	.77
.146	5.3"	1050	.84
.226	8.1"	1130	.90
.342	12.3"	1210	.97
.658	23.7"	1200	.96
.774	27.9"	1140	.91
.854	30.7"	1050	.84
.918	33.1"	975	.78
.974	35.1"	795	.64

CENTER VELOCITY 1250 FPM [3]
AVERAGE VELOCITY 1030 FPM [6]
K_1 FACTOR .82 [7]
INSERTION DEPTH 4.3" (K_1=1) [8]

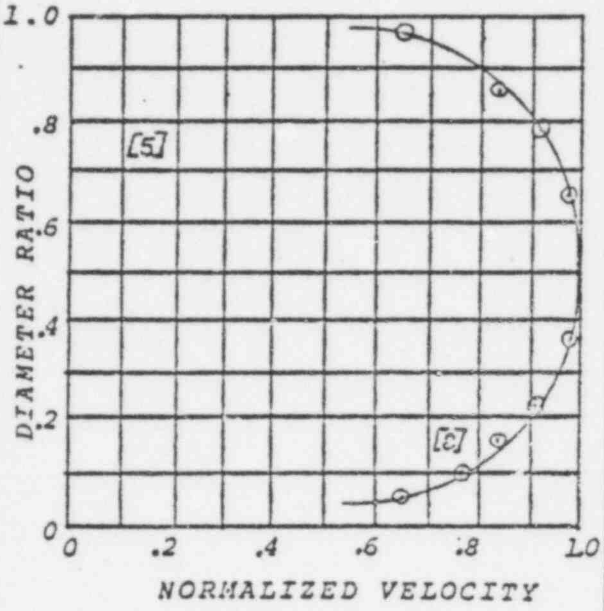

Figure 11 - VELOCITY PROFILE CURVE

Step 6: Determine the Average Velocity, $\overline{V}$

(Eq. 3) $\overline{V} = \frac{\Sigma_1^{10} \text{ Measured Velocity}}{10} = \frac{810 + 960 + \ldots\ldots + 795}{10} = 1030$ fpm

Step 7: Determine K_1 Factor

(Eq. 4) $K_1 = \frac{\text{Average Velocity}}{\text{Center Velocity}} = \frac{1030}{1250} = .82$

Step 8: Determine INSERTION DEPTH for Unity K_1 Factor (K_1 = 1)

a) Determine Normalized Insertion Depth for a Normalized Velocity equal to the K_1 factor determined in Step 7 (.82) using Velocity Profile curve.

b) Normalized Insertion Depth = .12 Diameter

c) Insertion Depth = (.12) X (36") = 4.3"

6.2 INSERTION DEPTH FOR UNITY K_1 FACTOR - Observe caution in attempting to insert the probe to the point of Average Velocity (Unity K_1 Factor). It can be seen from the Velocity Profile curve that a small error in inserting the probe to the Average Velocity point will result in large velocity errors, whereas a large error in inserting the probe to the center will not cause serious velocity errors. The center method is therefore preferred.

6.3 VELOCITY TRAVERSE OF STACK - Make a velocity traverse of the line or stack and determine the velocity profile and the K_1 factor as illustrated in the above example. (See page 17 for Profile Charts.)

7.0 OPERATING INSTRUCTIONS-

It is assumed that the probe is installed in the center of the stack and is transmitting a 0-5 volts d-c signal to some remote monitoring station. It is necessary to determine the relationship between the voltage signal and the AVERAGE VELOCITY in the stack.

7.1 DENSITY FACTOR, K_2 - The average velocity ($\overline{V}$) in the stack is a function of the velocity profile factor K_1, the gas density factor (K_2) , and the indicated velocity (V_{ind}).

(Eq. 5) $$\overline{V} = (K_1) \text{ X } (K_2) \text{ X } (V_{ind})$$

$$K_1 = \frac{\text{AVERAGE VELOCITY}}{\text{CENTER VELOCITY}}$$

(Eq. 6) $$K_2 = \sqrt{\frac{\text{density of AIR @ STP conditions}}{\text{density of GAS @ ACTUAL conditions}}}$$

$$= \sqrt{\frac{.075 \text{ lbs/Ft}^3}{(\gamma_{std} \text{ of Gas}) \cdot \frac{528}{460 + Tm} \cdot \frac{Pm}{29.92}}}$$

T_{sta} = 68°F (528°R absolute)

T_m = gas temperature in °F

γ_{std} = density of gas at STP

P_m = gas pressure in inches of Hg

P_{std} = 29.92 inches of Mercury

V_{ind} = Velocity obtained from the voltage calibration curve

EXAMPLE:

What is the average velocity in a stack flowing Propane at 200°F and 29.54 in. of Hg if the output signal for an AFI-6K is 2.00 volts d-c? The density of Propane at STP is .117 lbs/ft.^{3} Assume the velocity profile factor K_1 has been determined to be .82.

$$K_2 = \sqrt{\frac{(.075)}{(.117) \cdot (528/660) \cdot (29.54/29.92)}} = \sqrt{\frac{.075}{.092}} = .90$$

V_{ind} = 2.00 volts d-c = 1000 fpm (from calibration curves)

$$V_{avg} = (K_1) \cdot (K_2) \cdot (V_{ind}) = (.82) \cdot (.90) \cdot (1000 \text{ fpm}) = 738 \text{ fpm}$$

7.2 VOLUME FLOW AND MASS FLOW - Normally the desired indication is either Volume Flow at actual flowing condition Q_{act}, Volume Flow referred to standard conditions Q_{std}, or Mass Flow M .

a) $Q_{act} = (V_{avg}) \times (\text{AREA})$

b) $Q = (Q_{act}) \cdot \frac{528}{460 + Tm} \cdot \frac{Pm}{29.92}$

c) $M = (Q_{std}) \cdot (\gamma_{std}) \text{ or } (Q_{act}) \cdot (\gamma_{act})$

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EXAMPLE:

What is the Actual Volume Flow, Standard Volume Flow, and the Mass Flow in the previous example, if the stack diameter is 36" ID?

$$\text{Area} = \frac{\pi d^2}{4} = \frac{(3.14)\ (3 \text{ ft.})^2}{4} = 7.07 \text{ ft.}^2$$

a) $Q_{act} = (738\ \text{fpm}) \cdot (7.07\ \text{ft}^2) = 5218\ \text{CFM}$

b) $Q_{std} = (5218\ \text{cfm}) \cdot \frac{528}{660} \cdot \frac{29.54}{29.92} = 4121\ \text{SCFM}$

c) $M = (4121\ \text{scfm})\ (.117\ \text{lbs/ft}^3) = 482\ \text{lbs/min}$ or

$M = (5218\ \text{cfm})\ (.0924\ \text{lbs/ft}) = 482\ \text{lbs/min}$

7.3 GAS DENSITY - It is necessary to know the DENSITY of the gas in the stack to calculate the actual velocity. If gas mixtures are present a densitometer can be used to obtain the actual velocity. In practice the density of a gas mixture is usually estimated from knowledge of the expected composition of the mixture. Since the density correction for the mixture appears under the radical sign in the velocity equation, the uncertainty in velocity is always less than the uncertainty in density.

EXAMPLE: If the density of a gas mixture is estimated to be .100 lbs/ft³ ± 10% what is the uncertainty in velocity? Assume $K_1 = .82$ and $V_{ind} = 1000$ fpm

$\gamma_{mix}\ (-10\%) = .090\ \text{lbs/ft}^3$ $\quad V_{avg}\ (-10\%) = (.82)\ (\sqrt{.075/.090})\ (1000) = 749$

$\gamma_{mix} = .100\ \text{lbs/ft}^3$ $\quad V_{avg} = (.82)\ (\sqrt{.075/.100})\ (1000) = 710$

$\gamma_{mix}\ (+10\%) = .110\ \text{lbs/ft}^3$ $\quad V_{avg}\ (+10\%) = (.82)\ (\sqrt{.075/.110})\ (1000) = 677$

The uncertainty in velocity due to the ±10% uncertainty in the density of the gas mixture is only ±30 to 40 fpm or approximately ±5%.

PURGE GAS

The Hastings AFI Probe is calibrated with an air purge. While air is usually the most convenient and economical gas to use, it is possible to use other gases. Nitrogen can be used instead of air with no change in calibration. Gases such as Methane, Propane, or Natural Gas may also be used but the original air calibration curve is no longer applicable. Although it is not possible to multiply the air purge curve by a constant factor to obtain the purge curve for some other gas, Figure 12 shows several typical calibration curves for purge gases other than air. Changing the purge gas only changes the relationship between the output voltage and the indicated velocity, so calculation of factors K_1 and K_2 is unaffected. Consult the factory for additional information on purge gases.

9.0 ACCURACY

The calibrated accuracy of the Hastings Gas Probe is ±2%, but overall accuracy is determined by the combined parameters of the total system, such as zero stability, the accuracy of the readout, ambient temperature changes, velocity profile, probe alignment, density estimates, etc.

9.1 ACCURACY OF PROBE - The accuracy of the probe calibration is ±2% (±.10 volts) of the full scale output voltage. Since the velocity vs voltage curve is non-linear, the velocity tolerance must be determined for each segment of the curve. For example, ±.10 volts represents a velocity tolerance of ±50 fpm at 1000 fpm (2.00 volts), but represents ±150 fpm at 2500 fpm (4.00 volts).

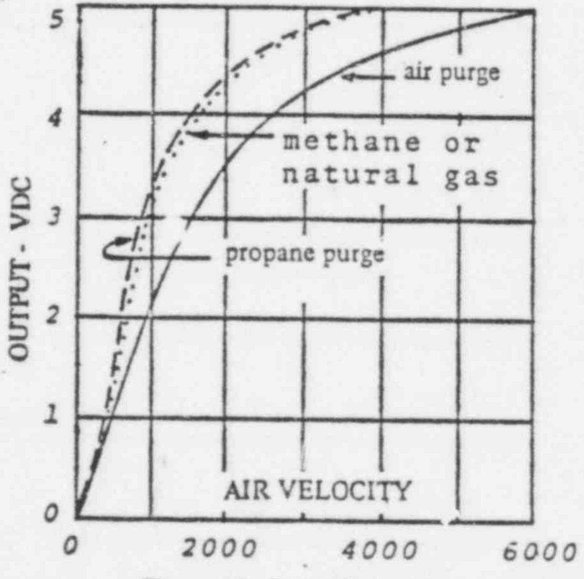

Figure 12 - PURGE GASES

9.2 ZERO SHIFTS - The high sensitivity of the probe at low velocities tends to accentuate small zero drifts. A ±5% shift in zero results in less than ±2% error for velocities above 1000 fpm, assuming the shift was caused by purge imbalance and not by electrical components.

9.3 READ-OUT - Typical panel or test meters used to read the 0-5 volt output signal are accurate to 1 to 2% of F.S. High quality recorders or digital voltmeters are accurate to about 0.5%. Devices used to convert the 0-5 volt output to either a current or pneumatic signal also contribute some error.

9.4 AMBIENT TEMPERATURE - The probe will operate satisfactorily at ambient temperatures of -30°F to + 120°F but the electrical zero will shift approximately 5% over this range. However, if the zero is adjusted seasonally the shift is generally eliminated.

9.5 VELOCITY PROFILE - The velocity profile factor is typically .82 for fully developed turbulent flow in a long, straight, relatively smooth pipe. Such ideal conditions rarely exist in typical stacks so the velocity profile factor could vary from .50 to .95 and must be determined accurately for each installation. Flat or skewed profiles are not uncommon and it is also possible for the profile to change somewhat with flowrate. It would therefore be advisable to traverse the stack at typical high and low velocities.

9.6 INSERTION DEPTH - The placement of the probe in the stack is important. It can be seen from the typical profile in Figure 11 that a positional error of ±1" at the center of a 36" stack would cause a velocity error of approximately 0.5%. However, at the Average Velocity location the 1" positional error would cause a velocity error of about ±5%.

9.7 DENSITY FACTORS - There will be some error in determining the density of the gas. If the density is simply estimated this error could be appreciable. However, the resulting velocity error is much less than the original density error.

9.8 OVERALL ACCURACY - It is impossible to put an accuracy figure on stacks in general. However, with care a good installation should be able to achieve accuracies within ±5%.

10.0 OPTIONAL EQUIPMENT

The following optional equipment may be used with the AFI-Series Gas Flow Probe.

10.1 POWER CONVERTER - The ADC-2 and ADC-3 are power converters which convert 115 volts, 50-60 Hz to 24 volts d-c (ADC-2), or 230 volts, 50-60 Hz to 24 volts d-c (ADC-3). Although the output may be be as high as 28 volts, it is regulated to ±.5 volts for line voltage variation of ±10% of the specified input. A surge limiting circuit is included to protect against transients in the a-c line.

The power converter is constructed in a Crouse-Hinds type FDC-12 condulet box (see Figure 8).

10.2 METER READOUT - The meter readouts available are 0-5 volts d-c, 1000 ohm/volt, 1% indicators.

10.2.1 DIMENSIONS - The following dimensions apply to both the standard meters and the control meters. The meter illustrated is a double-point control meter (Figure 13).

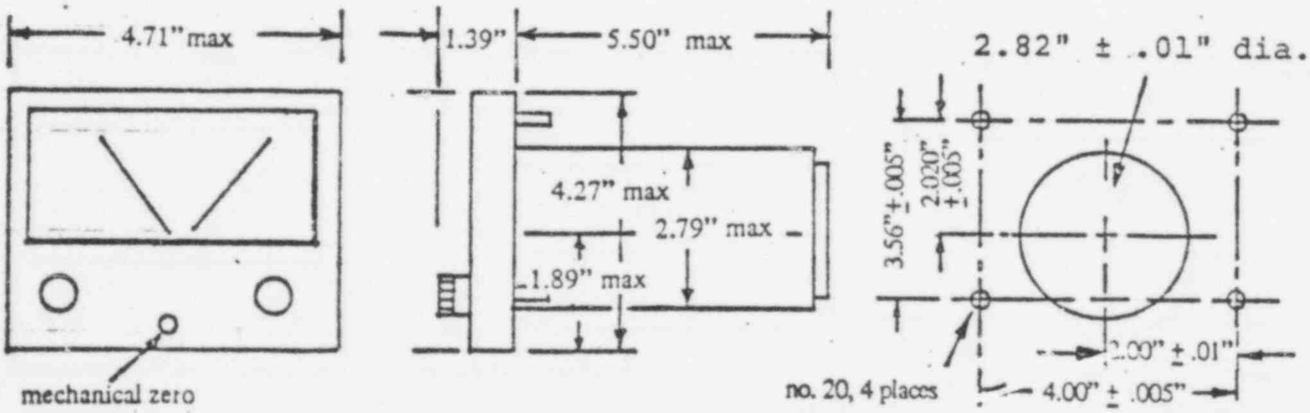

Figure 13 - METER DIMENSIONS

10.2.2 STANDARD METERS - The standard meter (type 24-1-419) is furnished with a 0-5 volt linear scale and an air velocity scale in feet per minute (Figure 14).

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10.2.3 ALARM METERS - The single alarm meter-relay (type 24-1-420) and the double alarm meter-relay (24-1-421) have one or two adjustable set-points which control a 125 volt a-c(25 volt d-c) 5 amp SPDT relay. The meter-relay operates on 115 volts, 50-60 Hz at 10 watts. Each alarm meter is furnished with a 0 - 5 volt linear scale.

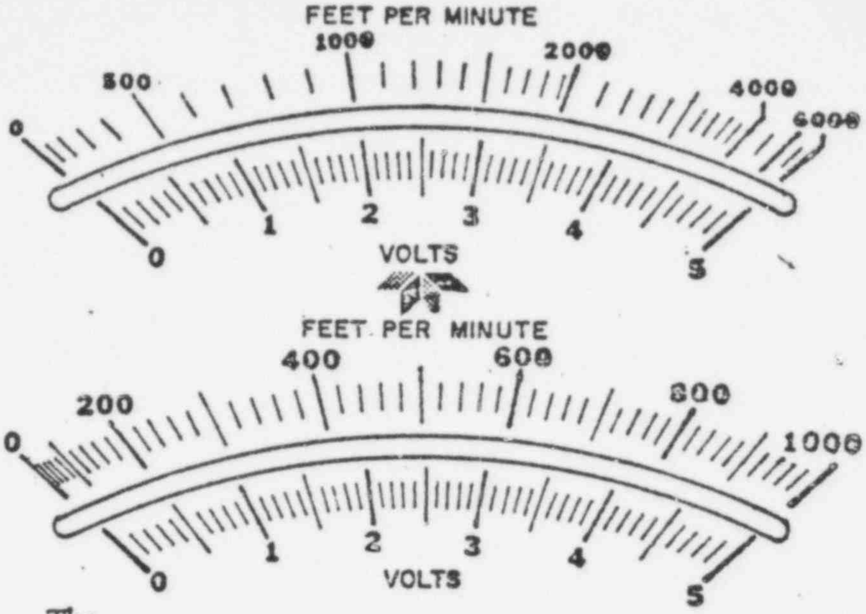

Figure 14 - TYPICAL DIAL FACES

10.3 VOLTAGE TO CURRENT CONVERTER - The Model CC-20 Voltage to Current Converter accepts the 0-5 volt d-c output from the probe and converts it to a 4-20 ma current signal. The converter requires a 115 volt a-c power source, and provides isolation between the input and output signals. Other current output ranges available are 1-5 ma (CC-5), and 10-50 ma (CC-50). See Figure 15.

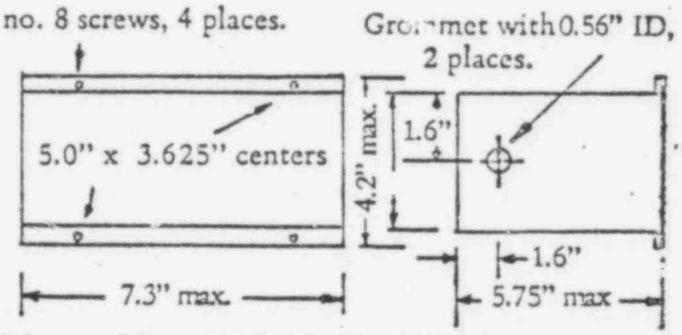

Figure 15 - VOLTAGE TO CURRENT CONVERTER

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VOLTAGE TO PNEUMATIC CONVERTER - The Model CC-20 PM Voltage to Pneumatic Converter is a combination of the Voltage to Current Converter (section 10.3) and a Current to Pneumatic Converter. The 0-5 volt d-c signal from the probe is converted first to a 4-20 ma signal, and then to a 3-15 psig signal. (See Figure 16).

[illegible] characteristic [illegible] the pneumatic Converter:

Supply pressure	20 psig, ±2 psig
Pneumatic output	3-15 psig
Reproducibility	0.2% of full scale
Calibration accuracy	±¼% of full scale
Supply pressure effect	less than 1%
Ambient temperature limits	-40 to 180°F

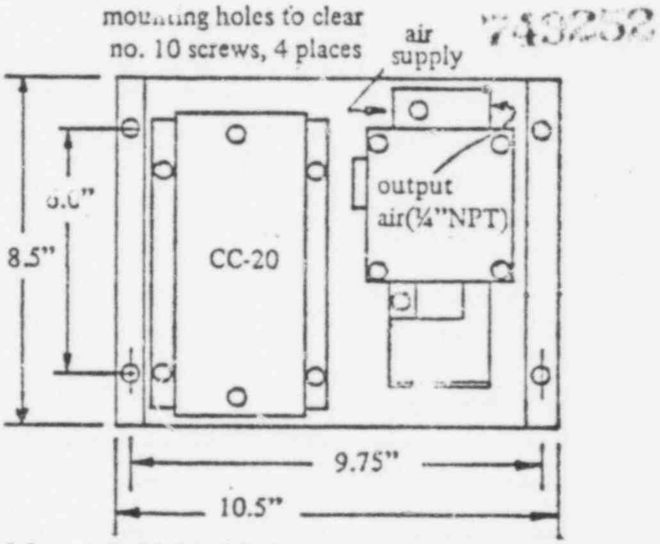

Figure 16 - VOLTAGE TO PNEUMATIC CONVERTER

10.5 EXPLOSION-PROOF HOUSINGS - Any optional equipment can be housed in a Crouse-Hinds type GUB-03 explosion-proof housing (Figure 17). Any equipment in this type housing will have the suffix EX- added to the model number.

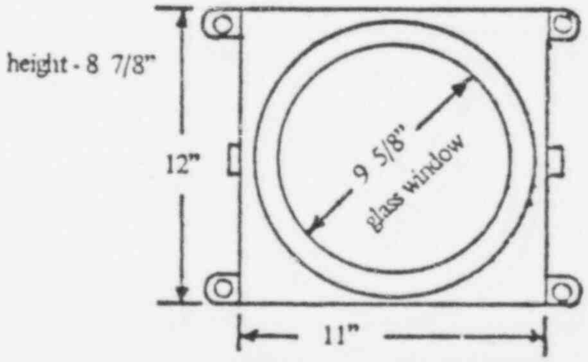

Figure 17 - EXPLOSION–PROOF HOUSING

11.0 TROUBLESHOOTING

11.1 TROUBLESHOOTING GUIDE

Trouble	Check	Reference
No output signal	Input power(24vd-c)	2.1, 4.2, 11.7
	Readout	10.2
	Wiring	2.1, 4.2
	Insufficient velocity for indication	Calibration curve
	Electronics	11.7
	Sensing element...........	11.7
Velocity indication high	Velocity calculations....	6.0, 7.0
	Accuracy.........................	9.0
	Probe placement...........	5.2 - 6.3
	Velocity profile............	6.0
	Not using air for purge gas..........................	8.0
	Leaks in purge system ..	3.3.3
	Zero valve setting.........	3.2.2, 3.2.3

Trouble	Check	Reference
Velocity indication low	Same as for high indication, plus probe tip not aligned	5.2
	False zero.........................	3.2.3
Intermittent operation	Dirty or moist purge gas.......................................	3.2.1, 11.6
	Wiring	4.2
	Fouling of probe.............	11.5
	Electronics	11.7
	Power supply	2.1, 11.7
Unstable zero	Leaks in purge system...	3.3.3
	Unregulated purge	3.3.5
	Dirty or moist purge gas	3.2.1, 11.6
	Pneumatic shifts...........	3.2.1, 3.2.4,
	Electronic noise	4.2
	Drafts in stack	

11.2 CALCULATIONS - When the calculated flow differs from the expected flow, re-examine all the terms used in the flow equation (sections 6 and 7), being sure that the values used are correct for the particular stack and conditions.

11.3 ESTIMATED ACCURACY - The accuracy of the flow obtained from the flow equation can best be shown by a hypothetical example.

Example: Assume that the output signal from the probe is 3.00 volts and density of the gas mixture is estimated to be .141 lbs/ft^3 ±5%. Also assume the stack diameter to be 36" ±1" and K_1 = .82 ±3% (Taken from velocity profile measurements). What is the worst possible error?

At 3.00 volts output the velocity indicated by the probe would be 1570 ± 70 fpm, or about ± 4½% The cross-sectional area of the stack is 7.07 ft^2 ±5½%. K_2 is calculated to be .73±2½%. The worst possible error is the sum of the individual errors, or 20½%.

A more realistic value for the [illegible] error would be the RMS of the sum of the errors, or about 4½%.

If the calculated flow differs from the expected flow, then the expected flow should also be re-examined to be sure that the same density, area, etc., were used. If the calculated and expected flow rates still differ greatly re-examination of the flow equations, then a general inspection of the probe installation and operation should be performed.

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11.4 INSPECTION OF INSTALLATION - Check the following items, referring to the appropriate sections.

1. Alignment of the probe in the stack .... section 5.2.1
2. Insertion depth to obtain center velocity or average velocity .... section 6.0
3. Adjustment of purge pressure, zero valve, connection of purge lines .... section 3.2
4. Connection of electrical cables, including inspection for loose or shorted connections.. section 4.2
5. 24 volt d-c input (±4 volts d-c) at probe housing .... section 11.7
6. Probe output at probe housing and at monitoring station .... section 11.7

11.5 PROBE FOULING - The continuous purging of the probe normally prevents the line gas from entering the probe. In the case of very dirty gases a deposit will sometimes build up on the outside of the probe tip and eventually close the openings in the probe tip.

Should fouling occur the probe can be cleaned with steam or with a suitable solvent injected at the purge taps. In case of severe blockage a wire can be inserted into the openings in the probe tip. The wire will not normally go past the purge taps due to the internal turns, but no damage will occur should the wire negotiate these turns.

11.6 FOULING OF THE PURGE MANIFOLD - Unfiltered or moist purge gas can cause fouling of the zero valve in the purge manifold. Excessive moisture in the purge lines can freeze and block the lines completely. Although the purge lines are pressurized, the pressure is only a few inches of water, which is insufficient to clear the lines.

If the valve should become clogged, it can be cleaned by removing the nut on the valve, lifting the panel, and carefully unscrewing the valve stem. Wipe the stem with a clean cloth, flush with a solvent, and carefully replace all the parts.

11.7 ELECTRICAL PROBLEMS - The electrical circuit has a conformal coating of epoxy to protect it from corrosive atmospheres and to provide added safety in hazardous environments. Electrical troubleshooting is therefore limited to the measurement of input and output characteristics.

With the probe in the stack and the purge ON, the input voltage should be 24 ± 4 volts d-c at the probe, and the output voltage should be between -0.5 and +5.00 volts d-c. Disconnect the output leads to the remote readout and the output at the probe should not change. If it does change check for a grounded positive output lead or a low resistance (less than 2000 ohms) across the remote readout leads.

With the probe removed from the stack and the purge OFF, the following readings should be obtained from the test points on the printed circuit board inside the probe housing. Remove the dome cover from the probe (in a safe environment), and locate the 10 test points on the board. See Figure 18.

TEST POINT	TO	TEST POINT	READING
1		2	24 ±4 volts d-c (same as power input terminals)
3		4	17.5 volts a-c (5kHz Square wave)
6		7	-.5 to +5 volts d-c (Same as output)
8		case	output should increase to +6 to +7 volts d-c
7		case	output should decrease to -6 to -7 volts d-c

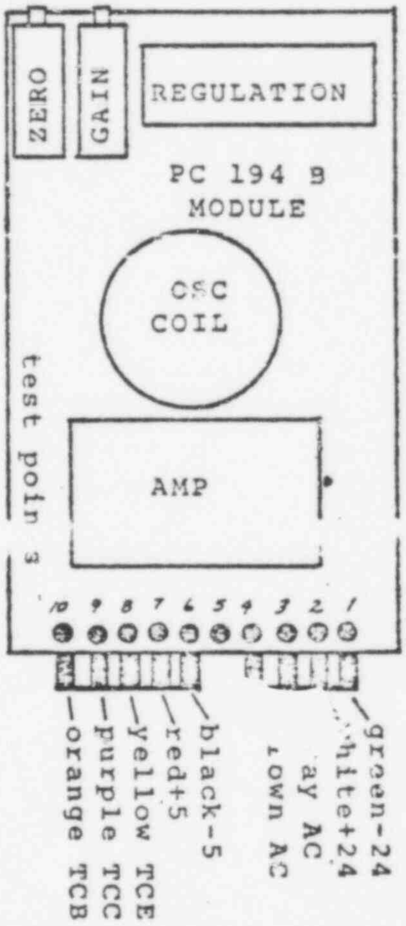


Figure 18 - CIRCUIT MODULE

The electrical output from the probe is obtained from thermocouples attached to the outer wall of the sensing element. The following measurements will verify that the sensing portion of the probe is intact.

TEST POINT	TO	READING
10	case	—4.5 mvdc (power ON)
8	case	—3.5 mvdc (power ON)
9	case	—2.5 mvdc (power ON)
10	case	2.0 ohms (powerOFF)
9	case	2.0 ohms (powerOFF)
8	case	2.0 ohms (powerOFF)

The above voltages may vary by ±0.5 mvdc, but the reading at test point 8 must be between the readings at test points 9 and 10. The resistive values may vary by ±1 ohm.

The zero adjust trim potentiometer should change the output (under no flow conditions) about ±2 volts on either side of zero as the potentiometer is adjusted from one end to the other.

The current from the 24 volt power source should be 250 ma±50 ma.

STACK DESIGNATION__________

STACK DIAMETER_____ DATE______

PROBE SER. NO.______BY________

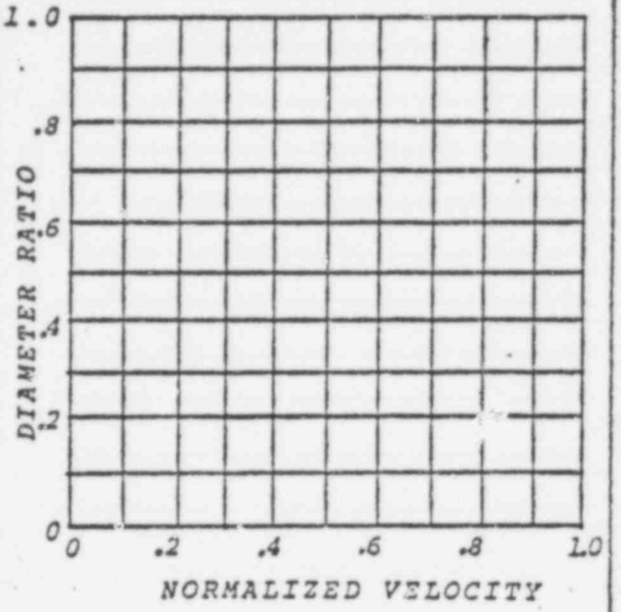
DIAMETER RATIO	INSERTION DEPTH [1]	MEASURED VELOCITY [2]	NORMALIZED VELOCITY [4]

CENTER VELOCITY_______FPM [3]

AVERAGE VELOCITY______FPM [6]

K_1 FACTOR_____________ [7]

INSERTION DEPTH_____(K_1=1) [8]



STACK DESIGNATION__________

STACK DIAMETER_____ DATE______

PROBE SER. NO.______BY________

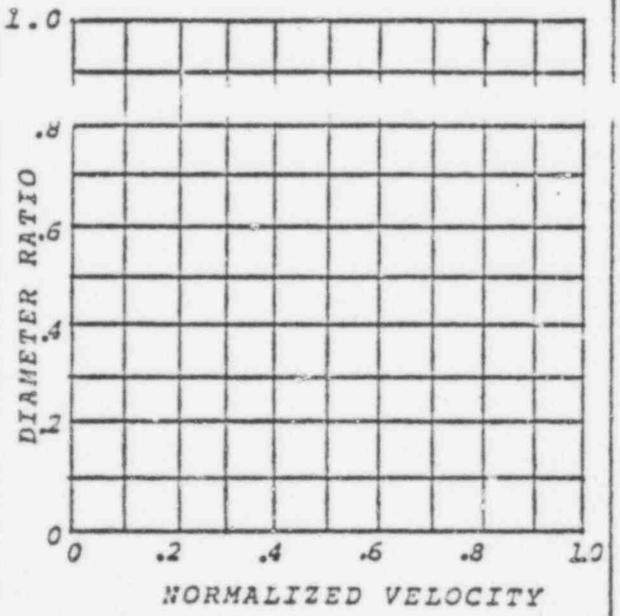
DIAMETER RATIO	INSERTION DEPTH [1]	MEASURED VELOCITY [2]	NORMALIZED VELOCITY [4]

CENTER VELOCITY_______FPM [3]

AVERAGE VELOCITY______FPM [6]

K_1 FACTOR_____________ [7]

INSERTION DEPTH_____(K_1=1) [8]



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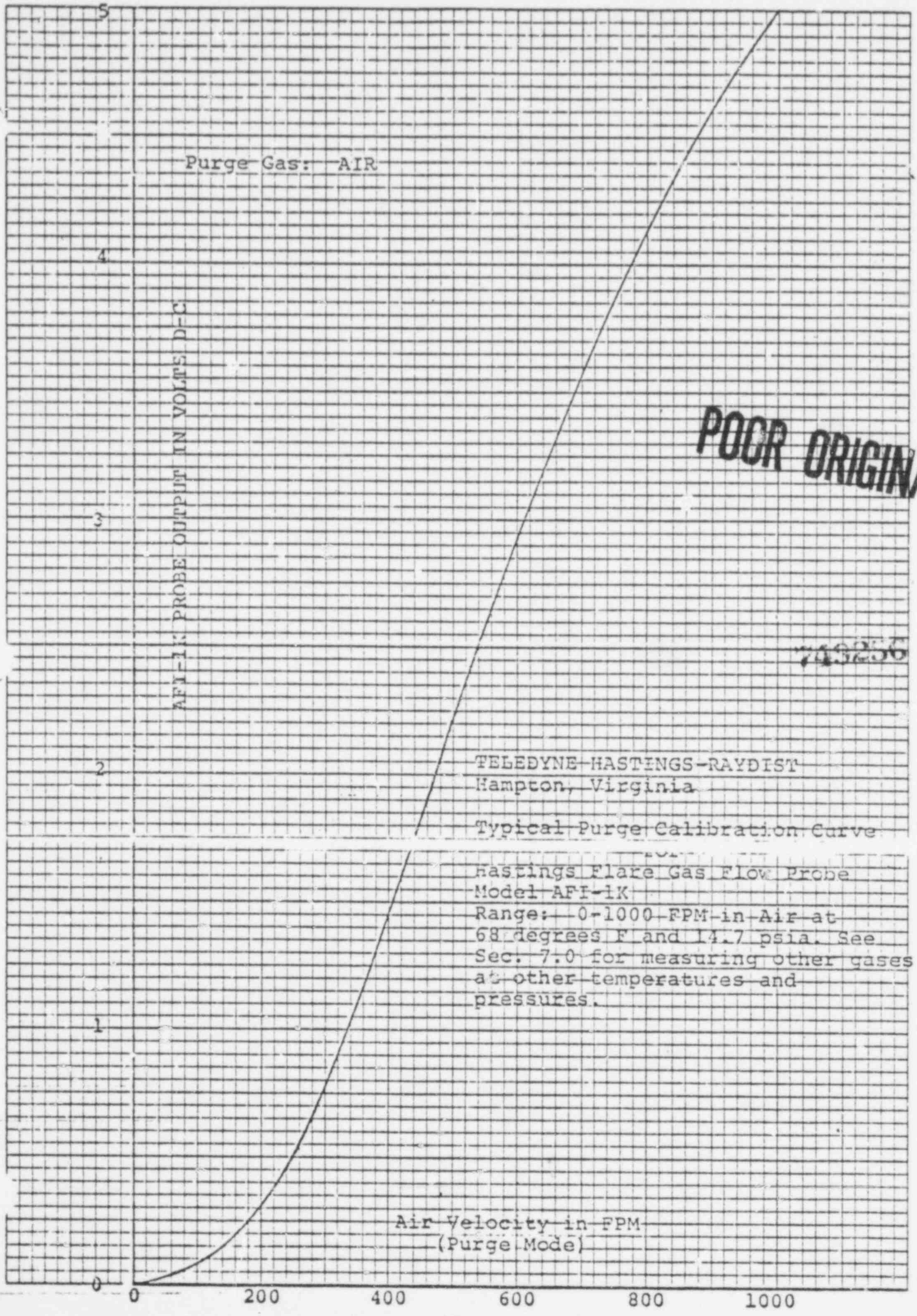
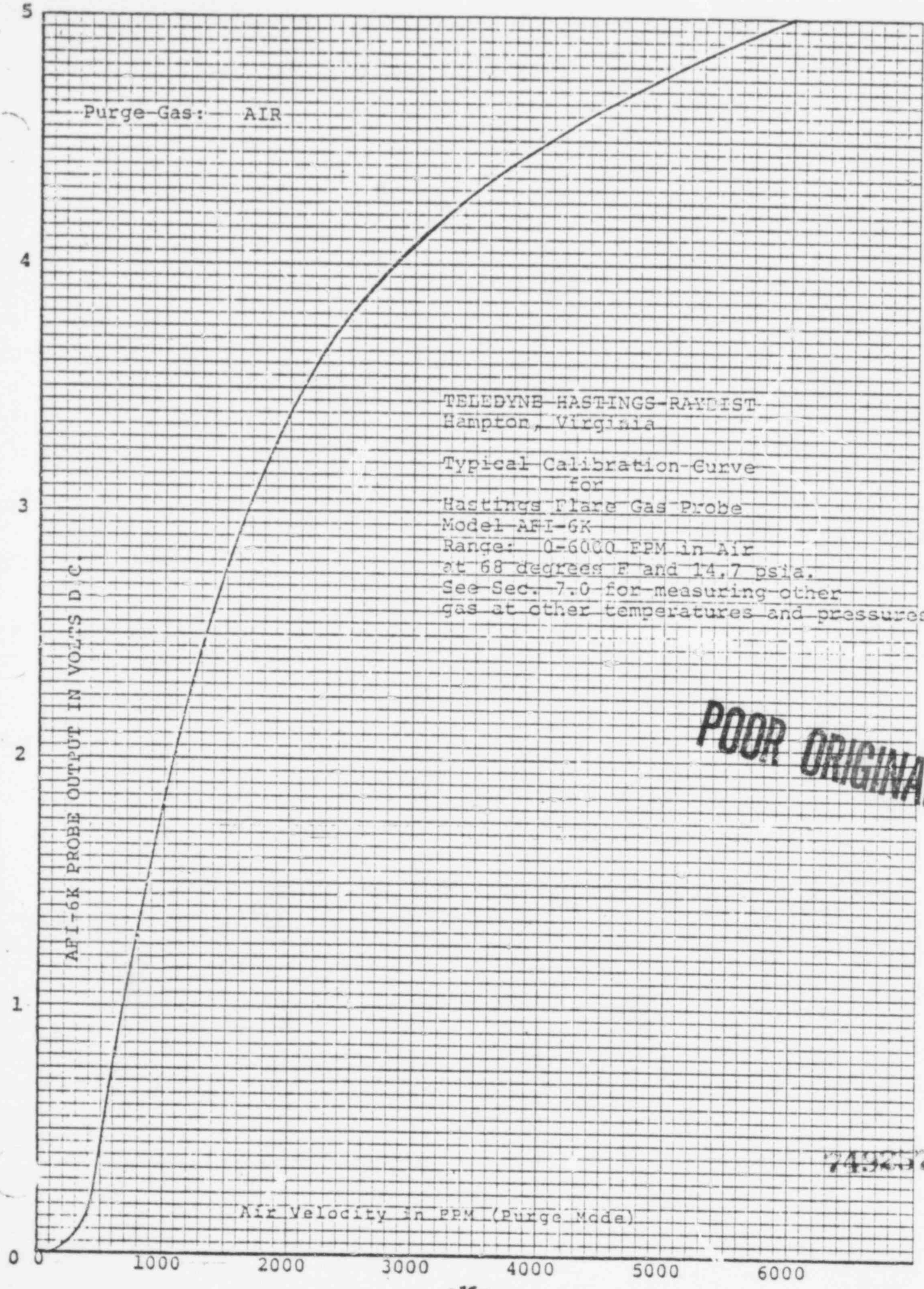


TELEDYNE HASTINGS-RAYDIST
Hampton, Virginia

Typical Purge Calibration Curve
for
Hastings Flare Gas Flow Probe
Model AFI-1K
Range: 0-1000 FPM in Air at
68 degrees F and 14.7 psia. See
Sec. 7.0 for measuring other gases
at other temperatures and
pressures.



Purge Gas: AIR

TELEDYNE HASTINGS-RAYDIST
Hampton, Virginia

Typical Calibration Curve
for
Hastings Flare Gas Probe
Model AFI-6K
Range: 0-6000 FPM in Air
at 68 degrees F and 14.7 psia.
See Sec. 7.0 for measuring other
gas at other temperatures and pressures.

POOR ORIGINAL

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INSTRUCTION MANUAL

HASTINGS MASS FLOWMETER

MODEL ______________________ SERIAL ______________________

USING
HASTINGS MASS FLOW TRANSDUCER

MODEL ______________________ SERIAL ______________________

749258

TELEDYNE HASTINGS-RAYDIST
HAMPTON, VIRGINIA 23661 U.S.A.
PHONE (804) 723-6531

INSTRUCTION MANUAL
ALL-, AHL-, EALL-, EAHL- Series

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Specification Sheet No. 508D

POOR ORIGINAL

TELEDYNE
HASTINGS-RAYDIST

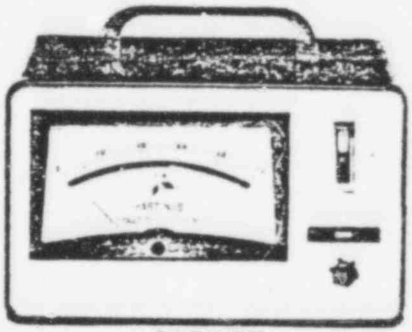
HAMPTON, VIRGINIA 23661 • (804) 723-6531

HASTINGS LINEAR MASS FLOWMETERS

FOR MASS FLOW MEASUREMENTS OF GASES

TOTALIZER

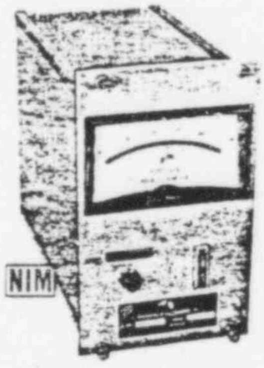
INDICATOR—ALARM



CABINET

Transducer

DIGITAL FLOWMETER
3½ Digit Readout.



PANEL-MOUNTED

FLOW RECORDER

Features

- **Mass flow with no correction for changes of temperature and pressure.**
- **Accurate to within 1% of range.**
- **Linear 0-5 volt d-c signal.**
- **Transmits over long distances.**
- **Starts at zero. No zero shift due to position of transducer, types of gas or line pressure.**
- **Rugged transducer with no moving parts, low pressure drop and may be installed at a remote location.**
- **Transducer available in brass or Monel.**
- **NIM type panels available.**

Description

Hastings Linear Mass Flowmeters operate on a unique electrical principle which measures the true mass flow without corrections or compensations for the temperature and pressure of the gas.

The flowmeters are ideal for use with integrators, totalizers, and recorders due to the linear electrical signal. Circuits are of solid state construction. Output is 0-5 volt d-c to high impedance devices and the signal can be transmitted over long distances with no loss of accuracy.

The remote transducer is constructed of nickel plated brass, Monel family alloys and solder. Models with all Monel family alloys with silver brazed ceramic seals are available for measuring flow rates of corrosive gases.

The flowmeters start at zero and no rezeroing is required when changing gases.

Principle of Operation

Hastings Linear Mass Flowmeters operate on a unique patented* thermal principle which depends on the mass flow of the gas and its heat capacity to change the temperature along a heated conduit. This temperature change is measured by an external arrangement of thermocouples and does not require any delicate sensing elements or projections into the flowstream. For higher flow ranges the heated flow conduits are installed in a flow dividing network which utilizes a laminar flow element.

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Long Life

Hastings Linear Flowmeters do not require any periodic maintenance under normal operating conditions with clean gases.

No damage will occur from the use of liquid solvents, overflows or moderate overpressures.

NIM (Nuclear Instrument Module) is a standardized panel mounting arrangement devised by the AEC. A frame 8¾" x 19" wide will mount up to 3 of these modules side-by-side. If less than three are utilized, blank panels fill the unused space. The frames fit standard 19" instrument racks.

Hastings NIM packages conform to the NIM mounting standards but do not have NIM electrical connectors on the rear. The Hastings transducer cable connector and power cords may be adapted by the customer to NIM types if desired.

---

*Manufactured under one or more U.S. and Foreign Patents and Patents Pending.

Specifications

Indicator Dimensions: 7¾" x 5¾" x 5¾", approx. 6 lbs.

Power: 115 volt a-c, 50/60 cycle, 15 watts, or 230 volt a-c, 50/60 cycle as selected from chart.

Cables: 8 ft. power and transducer cables supplied. Longer cables for transducers to 100 ft. optional at time of order.

Output: 0-5 volts d-c into a load of 2,000 ohms or greater. The signal is available at binding posts along with readout indication.

Accuracy: ±1% of range for 20% variation in pressure and temperature.
±2% of range over entire pressure and temperature ratings.

Linearity: ±½% of range.

Repeatability: ½% of range.

Calibrations: Direct reading for air. Scales are available for oxygen, nitrogen, hydrogen or carbon monoxide at no additional cost. Other gases at extra cost.

Pressure Rating: 0.1 psia to 250 psig. High pressure units for 1,000 psig available with the ALL-Series only.

Pressure Drop: Less than 6 inches of water at full scale flow for all ranges except 0-10 sccm which is 10" H_2O.

Temperature: Gas temperature up to 100° C. Ambient for transducer and indicator, 0-40° C.

Response Time: 7 sec. to 67% of reading.

Selection Chart

Range sccm	Model 115 volt	Model 230 volt	Transducer Brass	Transducer Monel
0-5	ALL-5	EALL-5	H-5	H-5M
0-10	ALL-10	EALL-10	H-10	H-10M
0-50	ALL-50	EALL-50	H-50	H-50M
0-100	ALL-100	EALL-100	H-100	H-100M
0-500	ALL-500	EALL-500	H-500	H-500M
0-1,000	ALL-1K	EALL-1K	H-1K	H-1KM
0-5,000	ALL-5K	EALL-5K	H-5K	H-5KM
0-10,000	ALL-10K	EALL-10K	H-10K	H-10KM
0-50,000	ALL-50K	EALL-50K	H-50K	H-50KM

Range SCFM	Model 115 volt	Model 230 volt with Metric Scale in Std Liters/Min	LFE and Transducer
0-5	AHL-5	EAHL-5 (0-150)	L-5 w/ H-3M
0-10	AHL-10	EAHL-10 (0-300)	L-10 w/ H-3M
0-25	AHL-25	EAHL-25 (0-750)	L-25 w/ H-3M
0-50	AHL-50	EAHL-50 (0-1500)	L-50F w/ H-3M
0-100	AHL-100	EAHL-100 (0-3000)	L-100F w/ H-3M
0-200	AHL-200	EAHL-200 (0-6000)	L-200F w/ H-3M

Laminar flow elements are "Monel" or stainless steel. Transducer construction for all AHL ranges is "Monel."

REQUEST CATALOG 500-D FOR INFORMATION ON HASTINGS AUTOMATIC FLOW CONTROLLERS, MINI-FLO CALIBRATORS, FAST RESPONSE FLOWMETERS, GAS FLOW PROBES, AND STACK GAS VELOCITY METERS.

GAS CONVERSION FACTORS FOR HASTINGS LINEAR FLOWMETERS

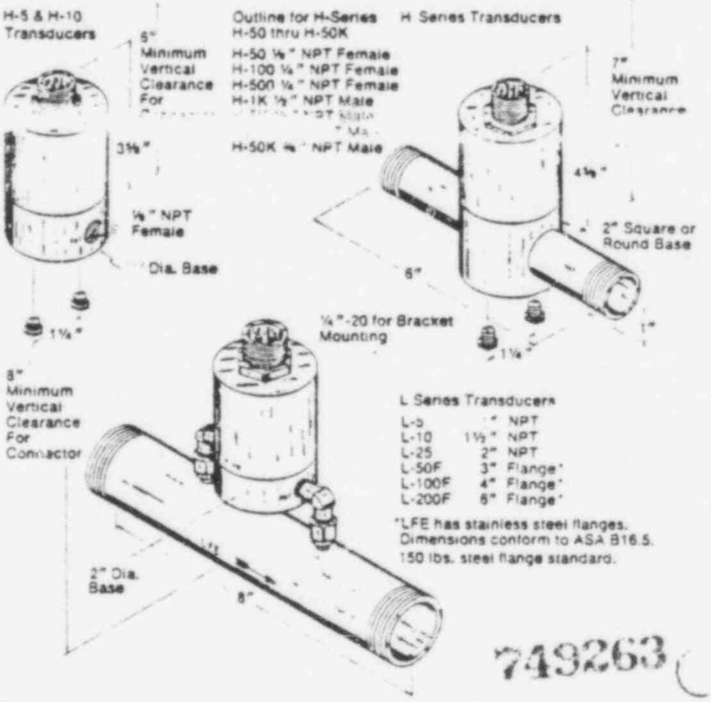
(Multiply Air scale by these Hastings Conversion factors)

*Empirical data; others theoretical

Gas	Conversion Factor	Gas	Conversion Factor
ACETYLENE	.67	HYDROGEN	*1.03
AIR	*1.00	HYDROGEN CHLORIDE	1.01
AMMONIA	.77	HYDROGEN FLUORIDE	1.00
ARGON	*1.43	HYDROGEN SULFIDE	.85
ARSINE	.76	ISOBUTANE	.31
BROMINE	.88	KRYPTON	1.39
BUTANE	.30	METHANE	*.69
BUTENE 1	.34	NEON	1.38
CARBON DIOXIDE	*.73	NITRIC OXIDE	1.00
CARBON MONOXIDE	*1.00	NITROGEN	*1.02
CHLORINE	.85	NITROUS OXIDE	.75
CHLORINE TRIFLUORIDE	* .45	OXYGEN	*.97
CYCLOPROPANE	.52	PENTABORANE	.15
DIBORANE	.54	n-PENTANE	.22
ETHANE	.55	PHOSPHINE	.79
ETHENE - (ETHYLENE)	.69	PROPANE	*.32
ETHYLENE OXIDE	.60	SILANE	.68
FLUORINE	.93	SULFUR DIOXIDE	.70
FREON 11	.36	SULFUR HEXAFLUORIDE	.28
FREON 12	*.36	TUNGSTEN HEXAFLUORIDE	.23
FREON 13	.42	URANIUM HEXAFLUORIDE	.23
FREON 14	.48	WATER VAPOR	.80
FREON 22	*.43	XENON	1.37
FREON 114	*.22		
HELIUM	*1.43		

Example: Flowmeter ALL-1K, 0-1000 sccm in air would be 1000 x 1.43 = 1430 sccm at full scale in Helium.

TRANSDUCER OUTLINE DIMENSIONS



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TELEDYNE HASTINGS-RAYDIST

SPECIFICATION SHEET 508D
HAMPTON, VIRGINIA 23661, U.S.A.
PRINTED IN U.S.A. JULY 1974

PHONE (804) 723-6531
TWX: 710-882-0085

INSTRUCTION MANUAL

ALL-, AHL-, EALL-, EAHL- Series

1.0 Receiving and Inspection:

1.1 Damage in Shipment:

Carefully unpack the Hastings Linear Mass Flowmeter and inspect it for any obvious signs of damage due to shipment. Immediately advise carrier who delivered the shipment of any suspected damage.

1.2 Packing List:

The basic flowmeter consists of three separate parts;

1. The power supply (ALL, AHL, EALL, EAHL)
2. The transducer (H-50, H-100, etc.)
3. The connecting cable (NF-8-NM, etc.)

Optional equipment or accessories will be listed as part of the model number or listed separately on the packing list. (Sec. 9.0 - Options and Accessories)

1.3 Mechanical Zero:

It is necessary to check the mechanical zero on the meter since it is sometimes disturbed in shipment. Adjust the black mechanical zero screw on the front of the meter until the meter pointer is directly over the zero mark on the dial face. (This section does not apply to models with recorders or digital meters.)

1.4 Power Source:

Connect the power supply to a 115 volt (±10%) 50-60 Hz line. (The prefix "E" indicates that the power supply is to be connected to a 230 volt (±10%) 50-60 Hz line.) Connect the power supply to the transducer by means of the NF-8-NM cable. When the flowmeter is first turned on the meter pointer will go off-scale in one direction and then off-scale in the opposite direction before settling to a steady indication.

1.5 Electrical Zero:

Close off the INLET and OUTLET connections on the transducer with the protective plastic end caps shipped on the transducer. If the meter does not indicate zero flow, adjust the "ZERO" potentiometer (R-9) located on the front panel until the meter indicates zero flow. (Do not confuse the "ZERO" potentiometer with the "Mechanical Zero" screw on the meter).

1.6 Indication of Flow:

Remove the end plug or end cap from each end of the transducer and blow air into the inlet side. The meter pointer should move upscale indicating the flowmeter is in good working order and ready for installation.

2.0 Installation Instructions:

2.1 Transducer:

2.1.1 Orientation of the Transducer:

The transducer may be mounted in any position, as long as the direction of gas flow through the transducer is from "IN" to "OUT" as marked on the transducer base.

2.1.2 Mounting the Transducer:

There are two 1/4-20 threaded holes 3/8" deep in the bottom of the transducer that can be used to secure it to a mounting bracket, if desired. When the transducer is used in combination with an L- Series Laminar Flow Element (LFE) the LFE should be supported instead of the transducer to prevent undue strain on the connectors between the transducer and the LFE. Standard pipe support rings or pipe hangers are usually satisfactory for supporting the LFE.

2.1.3 Inlet and Outlet Connections:

Table I below describes the inlet and outlet connections for all standard transducers. If it is necessary to reduce the pipe size or install an elbow on either side of an L- Series Laminar Flow Element, it is recommended that a straight length of pipe 12" in length be connected directly to the LFE before connecting a smaller diameter pipe or an elbow.

TABLE I - TRANSDUCER CONNECTIONS

TRANSDUCER TYPE	PIPE SIZE	LAMINAR FLOW ELEMENT	PIPE OR FLANGE SIZE
H-5	1/8" NPT F	L-5	1" NPT
H-10	1/8" NPT F	L-10	1 1/2" NPT
H-50	1/8" NPT F	L-25	2" NPT
H-100	1/4" NPT F	L-50	3" ASA 150 lb Flange
H-500	1/4" NPT F		
H-1K	1/2" NPT M	L-100	4" ASA 150 lb Flange
H-5K	1/2" NPT M		
H-10K	3/4" NPT M	L-200	6" ASA 150 lb Flange
H-50K	3/4" NPT M		

2.1.4 Sealing the Threaded Connections:

Many users find that Teflon tape is an excellent sealant for most applications, but any sealant material compatible with the flow system is acceptable. Caution must be exercised during assembly and disassembly of the threaded connections to prevent shreds of the sealant or Teflon tape from entering the flow line where they could block the small passages in the transducer.

The use of O-ring seal connectors on the transducers with female threads is often more convenient for many low pressure applications.

2.1.5 Checking for leaks:

Check the transducer connections for leaks by pressurizing the line to the operating pressure (not to exceed 250 psig except on special models), and applying a diluted soap solution to the pipe joints. Any gas escaping from the pipe joints will cause a continual stream of bubbles.

2.2 Filters:

If the flow stream carries particles large enough to block the small passages inside the transducer (approximately .02" ID) a filter should be installed in the flow line on the inlet side of the transducer.

2.3 Cables:

2.3.1 Description:

A standard 5-conductor 20 gauge shielded 8-foot long cable (NF-8-NM) is normally shipped with each standard model and is used for connecting the power supply and the transducer.

2.3.2 Cable Length:

The cable length can be extended to 25 feet without changing the calibration of the flowmeter by more than ±1% of the rated full scale flow. Cables longer than 25 feet will cause the indicated flowrate to be lower than the actual flowrate and recalibration may be required. (See Section 7.0 for calibration procedures).

2.3.3 Cable Conductor Size:

If cable conductors larger than #20 are used, the connecting cable can be extended to greater lengths without having to recalibrate the flowmeter. Table II shows the relationship of the conductor size to the maximum cable length that can be used without changing the calibration by more than 1% of full-scale.

TABLE II - CABLE CONDUCTOR SIZE

Conductor (wire) size in connecting cable	Maximum length without recalibration
#20	25 feet
#18	40 feet
#16	65 feet
#14	100 feet

2.4 Power Supply:

2.4.1 Mounting:

The standard housing for the power supply is a small metal cabinet, 7 3/4" x 5 3/4" x 5 3/4", which can sit on a table or desk or can be mounted securely on a bracket or rack-panel. Optional housings, such as a "NIM" type module, rack-panel, chassis, etc., are described in Section 10 with details for mounting.

2.4.2 Electrical Connections:

Connect the power supply to the transducer with the connecting cable (Sec. 2.3) and connect the AC line cord to a suitable power source (Sec. 1.4).

2.4.3 Mechanical Zero Check:

With the power supply "OFF" check to be sure the mechanical zero has not been disturbed during installation (Sec. 1.3).

2.4.4 Electrical Zero Check:

Turn the power supply "ON" and allow 20 minutes for the flowmeter to warm up. Stop all flow through the transducer and check the electrical zero. CAUTION: DO NOT ASSUME THAT ALL METERING VALVES WILL COMPLETELY SHUT OFF FLOW. EVEN A SLIGHT LEAKAGE THROUGH A VALVE WILL CAUSE AN INDICATION ON THE METER WHICH WILL FALSELY APPEAR TO BE A ZERO SHIFT. If necessary, adjust the "ZERO" potentiometer (R-9) located on the front panel of the power supply until the meter indicates zero.

3.0 Using the Hastings Linear Mass Flowmeter:

3.1 Warm-up Time:

When the flowmeter is first turned on, the meter indicates off-scale in one direction and then in the opposite direction before settling to a stable indication. The flowmeter indicates the mass flow ±3% of full-scale in about 5 minutes, but should be allowed to warm up for 20 minutes to achieve maximum accuracy.

3.2 Response Time:

The response time to a change in flow is logarithmic and is approximately 5 secs. for a 67% change and 20 secs. for a 99% change. Pneumatic imbalance in the associated plumbing will often cause the response time to appear longer due to the additional time required for flow to stabilize in the system.

3.3 Mass Flow Units:

The unit of mass flow used for the models ALL- and EALL- mass flowmeters is the "standard cubic centimeter per minute" (SCCM). It is the volume occupied by a given mass of gas at a specified temperature and pressure known as standard conditions (STP). These conditions are defined as 20°C (68°F) and 760mm of Hg (14.7 psia). The unit of mass flow for the Model AHL- mass flowmeters is the "standard cubic foot per minute" (SCFM), and the unit of mass flow for the Model EAHL- mass flowmeter (230 volts, 50-60 Hz) is the "standard liter per minute." To convert to other units of mass flow multiply the mass flow rate of the gas by the density of the gas at standard conditions.

Example: What is the equivalent mass flow in grams per minute of 100 SCCM of air?

Solution: The density of air at 20°C and 760 mm of Hg is .00121 gm/cm^3.

$(100 \text{ std } cm^3/min) \times (.00121 \text{ } gm/cm^3) = 0.121 \text{ } gm/min.$

3.4 Special Factory Calibrations:

All Hastings Mass Flowmeters are calibrated for air unless otherwise specified. Calibrations [illegible] range or for a gas other than air are clearly indicated by the meter dial face on standard models, by the recorder scale on recorder models, or by special comments or curves in the manual if no indicator is included.

3.5 Gas Conversion Factors:

The Hastings Linear Mass Flowmeter can be used for many different gases as long as the gas is compatible with the materials of construction, and remains in a gaseous state during the measuring cycle. No electrical adjustments are necessary when using the gas conversion factors so the original calibration is undisturbed.

3.5.1 Flowmeters Factory Calibrated for Air:

A flowmeter originally calibrated for air can be used for other gases by using the Hastings Gas Conversion Factors on sheet C-194C of this manual. Simple multiply the dial face indication by the appropriate gas conversion factor (K).

Example: What is the actual flow rate of Helium when the air dial face indicates 50 SCCM?

Solution: From sheet C-194C the gas conversion factor for Helium is 1.43.

Actual flow = meter reading x (K)

= 50 SCCM x 1.43

= 71.5 SCCM of Helium

3.5.2 Flowmeters Factory Calibrated for a Special Gas:

If the Hastings Linear Mass Flowmeter is calibrated for a gas other than air, it may also be used to measure the flow rates of many gases. The flow rate will be equal to the meter reading multiplied by the ratio of the gas conversion factors.

Example: What is the actual flow rate of Carbon Dioxide through a flowmeter calibrated for Helium, if the meter reading is 96 SCCM?

Solution:
$$\text{Flow of } CO_2 = (\text{meter reading}) \frac{(K)\text{ for } CO_2}{(K)\text{ for He}}$$

$$= (96\text{ SCCM}) \frac{.73}{1.43}$$

$$= 49\text{ SCCM}$$

3.5.3 Theoretical Conversion Factors:

A theoretical conversion factor can be obtained for gases not listed in the table by determining the ratio of the heat capacity of air to the heat capacity of the gas in question. Both values of heat capacity (Cp) should be obtained at approximately the normal operating temperature and pressure of the gas, normally 20°C and 760 mm Hg.

Example: What is the conversion factor (K) for Neon?

Solution:
$$K\ (\text{Neon}) = \frac{\text{Heat cap. of Air @ STP}}{\text{Heat cap. of Neon @ STP}}$$

$$= \frac{.291\text{ cal/liter °C}}{.210\text{ cal/liter °C}}$$

$$= 1.38$$

3.5.4 Gas Mixtures:

If a mixture of gases is used and the percentage by volume of each gas is reasonably constant, a conversion factor for the gas mixture can be obtained.

$$K\ (mix) = \frac{Cp\ (air)}{\overline{V}_{(a)}\ Cp_a + \overline{V}_{(b)}\ Cp_{(b)} + \ldots.}$$

where

K = conversion factor

$Cp_{(a,b\ldots)}$ = heat capacity of gas a,b...at constant pressure

$\overline{V}_{(a,b,\ldots)}$ = percent of gas a,b,...

From section 3.5.3

$$K_{(a)} = \frac{Cp\ (air)}{Cp\ (a)}\ , \quad K_b = \frac{Cp\ (air)}{Cp\ (b)}, \text{ etc.}$$

Therefore:

$$K\ (mix) = \frac{Cp\ (air)}{\underline{\overline{V}(a)\ Cp\ (air)} + \underline{\overline{V}(b)\ Cp\ (air)} + \ldots}$$

$$\qquad\qquad\quad Ka \qquad\qquad\qquad Kb$$

$$= \frac{1}{\frac{Va}{Ka} + \frac{Vb}{Kb} + \ldots.}$$

K can be obtained from C-194C for many gases.

Example: What is the conversion factor for a mixture of 20% Hydrogen, 40% Argon, and 40% Oxygen?

Solution:

$$K\ (mix) = \frac{1}{\frac{\overline{V}a}{Ka} + \frac{\overline{V}b}{Kb} + \ldots}$$

$$= \frac{1}{\text{[illegible]}}$$

$$= 1.13$$

3.6 Output Signal:

The two output terminals on the back of the power supply provide a 0-5 volt d-c signal for recording or operating auxiliary equipment such as totalizers or converters. The output signal is linear with respect to mass flow and has a sensitivity equal to the rated full-scale flow rate divided by 5.00 volts d-c.

Example: (A) What is the output sensitivity of an ALL-1K?
(B) What is the flow rate for a 2.71 volt output?

Solution: (A) Sensitivity = $\frac{\text{rated flow}}{\text{rated output}}$

$$= \frac{1000\ SCCM}{5.00\ \text{volts d-c}}$$

$$= 200\ SCCM/\text{volts d-c}$$

(B) Mass Flow = output x sensitivity
= (2.71 volts d-c) x
(200 SCCM/volt d-c)
= 542 SCCM

3.7 Accuracy:

The accuracy of the flow indication is ±1% of full scale for the output signal and ±2% of full scale for the meter reading.

Example: What is the accuracy of a 70 SCCM indication for an EALL-100?

Solution: Output Signal (Accuracy) = 3.50 ±.05 volts
(70 ±1 SCCM)
Meter Reading (Accuracy) = 70 ±2 SCCM

3.8 Repeatability:

The repeatability over a six-month period is ± 1/2% of full scale for the output signal and ±1% of full scale for the meter, assuming the flowmeter is operating in a normal manner in a clean system. Under reasonably constant conditions a repeatability of ±1 to ±2% of INDICATION can be expected on a day-to-day basis.

3.9 Over-range:

The flowmeter has an output signal which is directly proportional to mass flow and linear to ±1% of full scale from zero flow to the normal full-scale flowrate.

The flowmeter can be used to measure flow rates higher than the rated full-scale flow, but the output signal normally becomes non-linear above 5 volts d-c. A calibration curve for volts d-c vs flow can be made for outputs up to 10 volts d-c. At some point above 10 volts d-c the output will no longer increase as the flow increases. The flow rate required to produce this condition is several times the normal full-scale flow rate. Once the flow is reduced to the proper level the flowmeter will again indicate mass flow correctly. The flowmeter will not be damaged by excessive flow rates as long as the pressure in the line does not exceed the pressure rating for the transducer.

4.0 Pressure Effects:

4.1 Standard Transducers:

The Hastings Linear Mass Flowmeter can measure mass flow accurately with no corrections necessary for a variation in line pressure of one psia (≈ .068 ATM) to 250 psig (≈18 ATMS). Mass flow indications are accurate with downstream pressures as low as 100 μHg (≈.0001 ATM), but the upstream pressure must be much higher because of the increase in pressure drop across the transducer (see Sec. 6.0).

4.2 High Pressure Transducers (Optional):

The Hastings H-Series Monel Transducer can be obtained pressure-rated to 1000 psig for the ALL- and EALL- Series flowmeters. When it is used at pressures above 250 psig there may be both a zero shift and a calibration shift. These shifts can be minimized by installing the transducer in a horizontal position (lying on its side) and setting the zero while the transducer is at zero flow under pressure. Normally, the calibration will be off by no more than 5% of full scale (the indicated flow will be lower than the actual flow) with most of the error occuring above 500 psig.

5.0 Temperature Effects:

5.1 Ambient Temperature:

5.1.1 Transducer:

In order to maintain accuracies of ±1% of full scale with changes in ambient temperature it is necessary to keep the temperature of the base of the transducer between 10°C and 50°C. (The temperature of the base is normally about 10°C above ambient due to internal heat.) There are two 1/4" -20 bolt holes in the base to facilitate mounting the transducer to an external heat sink. The maximum ambient temperature range of the transducer is -30°C to +120°C, but calibration shifts up to ±20% may occur at these extremes.

5.1.2 Power Supply:

The power supply can be operated over an ambient temperature range of 0°C to 60°C without causing a shift in calibration of more than ±1% of full scale. Since this error is primarily a zero shift, it can be eliminated by adjusting the flowmeter ZERO potentiometer at the given operating temperature.

5.2 Gas Temperature:

The Hastings Linear Mass Flowmeter measures mass flow accurately with no corrections necessary for gas temperatures of 0°C to 40°C. For gas temperatures of -100°C to 200°C the error in the mass flow indication will be less than ±5% of full scale if the temperature of the base of the transducer is kept within ±20°C of the ambient temperature.

When using the AHL- series and EAHL- series flowmeters it is recommended that both the laminar flow element and the Type H-3M transducer operate at the same temperature.

NOTE: The Hastings Linear Mass Flowmeter measures GAS flow. Do not let the temperature and/or pressure of the gas reach a point that would cause the gas to change to a liquid state or erroneous indications will result.

6.0 Differential Pressure:

6.1 Typical Pressure Drops:

The typical differential pressure drops (DP) across the Hastings H-Series Mass Flow Transducer are given in Table III. The table is based on full-scale flowrates of air at 20°C and 760mm Hg, with the flowmeter in operation.

TABLE III - TYPICAL PRESSURE DROPS

Transducer Type	DP ("H_2O) @ F. S. Flow	Transducer Type	DP ("H_2O) @ F. S. Flow
H-5/H-5M	5	L-5/H-3M	4
H-10/H-10M	10	L-10/H-3M	4
H-50/H-50M	1	L-25/H-3M	5
H-100/H-100M	1	L-50/H-3M	4
H-500/H-500M	3	L-100/H-3M	4
H-1K/H-1KM	1	L-200/H-3M	4
H-5K/H-5KM	2		
H-10K/H-10KM	2		
H-50K/H-50KM	4		

6.2 Changes in DP with Changes in Line Pressure:

The typical differential pressure drops listed in Table III are for operation at atmospheric pressure. As the line pressure changes, the differential pressure drop for the same flow rate will also change.

6.2.1 Increases in Line Pressure:

The differential pressure drop across the transducer will decrease proportionally as the absolute line pressure increases.

Example: What is the full-scale DP of an [illegible] transducer at 67 psig?

Solution: From Table III the DP for an H-500 at atmospheric pressure is 3" H_2O. The DP at 67 psig will be:

$$DP = DP\ (@STP)\ \frac{\text{Pressure (Standard)}}{\text{Pressure (Actual)}}$$

$$= 3"\ H_2O \times \frac{14.7\ \text{psia}}{14.7 + 67.0\ \text{(psia)}}$$

$$= .54"\ H_2O$$

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6.2.2 Decreases in Line Pressure:

As the absolute line pressure decreases the DP increases. The relationship noted in Section 6.2.1 holds true until the DP becomes a significant part of the total absolute line pressure. When this occurs the relationship becomes more complex but the effect is still the same. The change in DP does not affect the accuracy of the mass flow indications, but it causes a change in the minimum upstream pressure necessary to force a given amount of flow through the transducer.

6.3 DP Increase Due to Fouling of the Transducer:

A DP measurement across the transducer can often provide a good indication of fouling inside the transducer. The values given in Table III are typical and may vary as much as 50% for any given model. However, an increase in DP of two or three times the typical value is definitely an indication of fouling. When checking for changes in DP the flowmeter should be in operation at or near standard conditions of 20°C and 760mm Hg in order to relate the measured DP to those listed in Table III. If there is an indication of fouling, refer to Section 8.1.

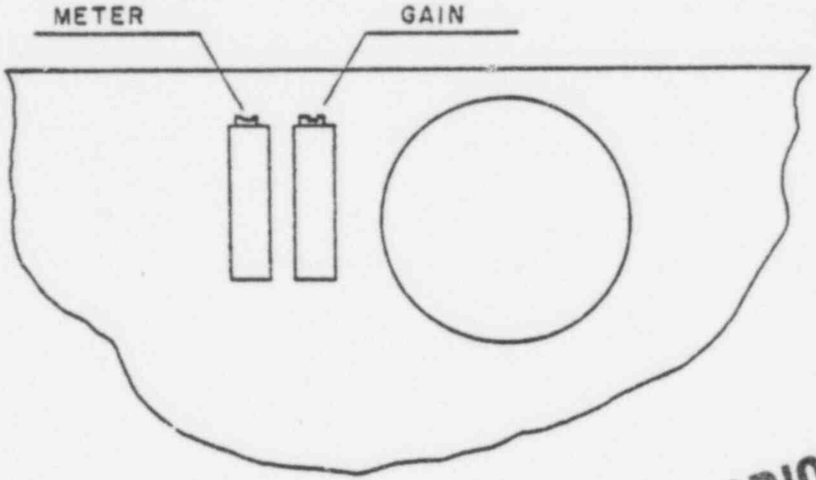
7.0 Calibration Instructions:

The Hastings Mass Flowmeter has been carefully inspected and calibrated at the factory before shipment and will give long and reliable service. The calibration is very stable and recalibration is seldom necessary. Should it be necessary to recalibrate the flowmeter, the following procedure will be of assistance:

1. Connect the power supply to the proper power source (Section 1.4).
2. With the power "OFF" adjust the mechanical zero [illegible]
3. Turn the power supply "ON" and allow 20 minutes for warm-up.
4. Set the "electrical zero" (Section 1.5).
5. Connect the inlet side of the transducer to a well-regulated air source and the outlet to a reliable flow reference such as the Hastings Mini-Flo Calibrator.
6. Adjust the flow to a value slightly less than its full-scale range. Measure the flow rate with the reference flow standard and compare it with the meter indication and the 0-5 volt d-c output.

   CAUTION: Most flow standards are volumetric devices and must be corrected for temperature and pressure to standard conditions of 20°C and 760mm Hg. This correction often amounts to several percent at normal room temperatures and pressures and should not be neglected.

7. If it is necessary to correct the output at the recorder terminals, do so by making a small adjustment with the "GAIN" potentiometer located on the circuit board inside the power supply.
8. If it is necessary to correct the meter indication to agree with the flow standard, do so by making a small adjustment with the "METER" trim potentiometer located on the circuit board inside the power supply.



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8.0 Maintenance:

8.1 Transducer:

8.1.1 Cleaning:

With proper care in installation and use the transducer will require little or no maintenance. Should the small passages in the transducer become partially clogged they can be cleaned with any suitable solvent such as acetone, toluene, etc. and/or blown out with clean air under moderate pressure (up to 250 psig).

NOTE: If solvents are used for cleaning the transducer, sporadic indications may occur when it is returned to service until the liquid solvent has completely evaporated from the passages in the transducer.

8.1.2 Damage to the Transducer:

The transducer can be checked for internal electrical damage by disconnecting the cable and using an ohmmeter to measure resistances at the 6-pin connector.

Internal repairs to the transducer are not recommended and should only be done at the factory. Attempting to remove the transducer cover or the nut on the connector may result in irreparable damage to the transducer. The table below is for determining whether or not some damage has occured and is not to be used as a guide for repairs.

TABLE IV - TRANSDUCER CONTINUITY CHECK

PIN	TO PIN	RESISTANCE	NO CONNECTION TO
A	D	< 1Ω	B, C, E, or F
B	C	< 5Ω	A, D, or F
B	E	< 20Ω	A, D, or F
F	BASE	0Ω	A, B, C, D, or E

8.2 Power Supply:

The power supply is very stable and should require little or no maintenance. An occasional check of the mechanical and electrical zeroes may be required, but any changes in calibration due to these factors will be small under normal operating conditions.

If it is necessary to return the flowmeter for repair, please return the transducer, power supply, and cables to Teledyne Hastings-Raydist with a statement describing the problem experienced.

9.0 Options and Accessories:

9.1 Single and Double Point Relay Controllers:

9.1.1 Description:

Single point control flowmeters have the letter "C" preceding the model number and double point [illegible] the model number (CALL- or DALL-). Both models include an optical meter relay providing continuous reading and "ON-OFF" control. There is a control terminal strip at the rear of the single control indicator and two control terminal strips, identified as "LOW" and "HIGH", at the rear of the double control indicator. Each terminal strip is connected to a set of load relay contacts operated by the indicator control circuit. The relays are rated to handle up to 115 volts a-c at 5 amps into a resistive load or 230 volts a-c at 2.5 amps.

Flowmeters with relay control meters are available in several style packages, such as a sloping front cabinet, a U-shaped chassis, or a "NIM" type module. The control markings will be similar on each type of package and a special hook-up drawing will be included, if necessary.

9.1.2 The single control circuit and both of the double control circuits function in the same manner. When power is applied to the indicator the load relay will be in a de-energized condition as long as the meter needle is on the low flow side of the adjustable control arm. Under this condition the load relay contacts are positioned as marked on the control terminal strip at the rear of the indicator, "NO" meaning Normally Open, "NC" meaning Normally Closed, and " C " meaning Common. When the meter needle is on the high flow side of the control set point, the load relay is energized and the load relay contacts reverse position. (The Normally Open contact "NO" closes and the Normally Closed contact "NC" opens.) The relay remains energized as long as the meter needle indicates a higher flow rate than the control arm set point. Should a loss of power occur the load relays de-energize and return to their normal positions.

The control arms are adjustable over 100% of the meter scale but the two control arms on the double control cannot cross over each other and inadvertently reverse the "LOW" and "HIGH" setpoints.

9.2 Recorders:

Recording flowmeters have the letter "R" preceding the model number (RALL-, and ERALL-).

9.2.1 Specifications:

Except for special orders the recorder is a Model GE-520, 4" strip chart recorder having the following specifications. These specifications apply only to the recorder and not to the recorder/flowmeter combination.

Chart Speed	15"/hour (65 ft. chart runs for 52 hrs.)
Pen Speed	1 sec (0 to F.S.)
Chart Size	4 3/8" wide x 65' long (4" Calib. Width)
Chart Markings	0-100% with 2% Divisions
Power	115 volts a-c; 15 watts
Accuracy	±1/2% of recorder F.S. Movement
Dead Band	±1/3% of recorder F.S Movement

9.2.2 Output Signal:

The Hastings Linear Mass Flowmeter Power Supply fits into a space inside the recorder to form a single package. A 0-5 volt d-c output signal is available at terminals 13 (+) and 14 (-) on the back of the recorder. The 5 volt d-c output from the flowmeter is reduced to 2.5 mv d-c through a voltage divider network before being applied to the recorded. The recorder scale is in mass flow units and the chart paper is normally 0-100% linear. To convert chart readings to flow multiply the chart reading by the full-scale flow rate.

Example: What is the flow rate for a chart reading of 68% for an RALL-5K?

Solution: Flow = Chart readings X F.S. Flow Rate
= .68 x 5000 SCCM
= 3400 SCCM

9.2.3 Controls:

The power switch and ZERO adjustment for the flowmeter power supply are located on the front panel of the power supply. There are two power switches on the recorder, one for the chart drive and one for the recorder electronics. Both switches are located on the right hand side of the recorder chassis and can be reached by sliding the recorder chassis out about 6 inches.

9.2.4 Maintenance of Recorder:

The attached recorder manual will be of assistance if problems arise. We advise contacting your local G.E. service representative if repairs are necessary.

9.3 Totalizers:

9.3.1 Description:

The Hastings Mass Flow Totalizer is an electronic device which, when used in conjunction with a Hastings Linear Mass Flowmeter, will accumulate the total mass flow of a gas over a period of time.

a. Specifications: (For Totalizer Only)

Accuracy: (25°C and 115 volts a-c) .25% F.S
[illegible]
Voltage Change .00% F.S.
0-50°C Ambient Change < .06%/°C F.S.

Count Rate: (Full Scale)
Standard: 5,10,50,100 Counts/Min.
Field Selectable by Customer

Power: 115 volts a-c, 50-60Hz, 10 watts

b. Circuit:

The circuit for the totalizer is a voltage to frequency converter which produces a pulse rate accurately and linearly proportional to the 0-5 volts d-c input signal. The pulse rate is set at the factory on standard units for 5,10,50 and 100 counts/min. Any of the four ranges can be selected by the customer at any time by changing a jumper on the back panel. Normally ranges are 5 cpm for a 5 range or 50 cpm for a 50, 500, 5k or 50k range. Ten cpm would be used for a 10 range and 100 cpm for a 100, 1k or 10k range. Other count rates up to 1000 counts/min. are available on special order.

Connection of jumper for different full scale count rates for standard ranges is as follows:

BACK PANEL BARRIER STRIP

PIN	TO	PIN	STD. COUNT RATE	*SPECIAL COUNT RATE
5		4	100 Counts/Min.	_____Counts/Min.
5		3	50 Counts/Min.	_____Counts/Min.
5		2	10 Counts/Min.	_____Counts/Min.
5		1	5 Counts/Min.	_____Counts/Min.

*On special count rates a tag attached to the back panel will also list connections and count rates.
See Section 9.3.3 for determining sensitivity of totalizer when changing count rates.

c. Counter:
The pulses from the totalizer circuit are accumulated by a six-digit electro-mechanical counter. The counter recycles automatically at 999,999 or can be manually reset to zero at any time.

9.3.2 Mounting:
The Hastings Mass Flow Totalizer is normally packaged in a "NIM" type module. The front panel of the module is 8.72" x 5.40" and the module is .2.25" deep overall. The totalizer package is portable and is suitable for table, bench-top, panel or rack-mounting.

9.3.3 Using the Totalizer:

Connect the line cord to a 115 volt 50-60 Hz supply and turn the totalizer on. Connect the 0-5 volts d-c output signal from the Hastings Linear Mass Flow meter to the binding posts on the rear of the totalizer module, being careful to observe polarity . Do not ground either input terminal. As the output from the flowmeter varies the totalizer count will vary in direct proportion. The total number of counts over a period of time can then be related to the total flow for that period by determining the sensitivity of the flowmeter/totalizer combination. The sensitivity is the full-scale flow rate (flow rate at 5 volts d-c) of the flowmeter divided by the full-scale count rate of the totalizer.

Example: An ALL-10 Flowmeter is used with a TR-100P Totalizer. Over a period of 7 hours a total of 13,500 counts has accumulated on the counter.

a) What is the sensitivity for the totalizer when used with the ALL-10?

b) What is the total flow indicated by the 13,500 counts?

c) What is the average flow rate over the 7 hour period?

Solution: a) The full scale flow rate for the ALL-10 is 10 SCCM. The full-scale count rate for the totalizer is 100 counts per minute (indicated by "100" in the model number TR-100P).

$$\text{Sensitivity} = \frac{\text{F.S. flowrate}}{\text{F.S. countrate}}$$

$$= \frac{10 \text{ sccm}}{100 \text{ counts/min}}$$

$$= .1 \text{ std cm}^3/\text{count}$$

b) The total flow indicated by 13500 counts is

Total Flow = total counts x sensitivity
= 13500 counts x .1 std cm^3/count
= 1350 std cm^3

c) The average flow rate over the 7 hour period is the total flow divided by the time.

$$\text{Average Flow} = \frac{\text{Total Flow}}{\text{Time}}$$

$$= \frac{1350 \text{ std cm}^3}{7 \text{ hrs x } 60 \text{ min/hr}}$$

$$= \frac{1350 \text{ std cm}^3}{420 \text{ min}}$$

$$= 3.2 \text{ std cm}^3/\text{min}$$

If a special gas is used with the flowmeter (other than that for which it was originally calibrated), refer to Sec. 3.4 to determine the new full-scale flow rate for the special gas. Once the full-scale flow rate for the special gas is obtained, it may be used with the equations above to determine the sensitivity of the totalizer in std. cm^3/count.

9.3.4 Maintenance:

The totalizer is all solid-state and is designed for a long life expectancy and no maintenance is recommended. Should the totalizer or counter need repair return them to Teledyne Hastings-Raydist with a statement describing the problem.

9.4 Digital Panel Meter:

9.4.1 Specifications for digital panel meter:

Power - 115 volts ±10%, 50-60 Hz, 6 watts

Operating Temperature Range - 0°C to + 55°C

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Reading Rate - 5 readings/sec. Typical

Temperature Co-effecient - .003% of full scale per °C change.

Ambient Operating Temperature - 0 °C to 50 °C

Storage Temperature - -40°C to + 75°C

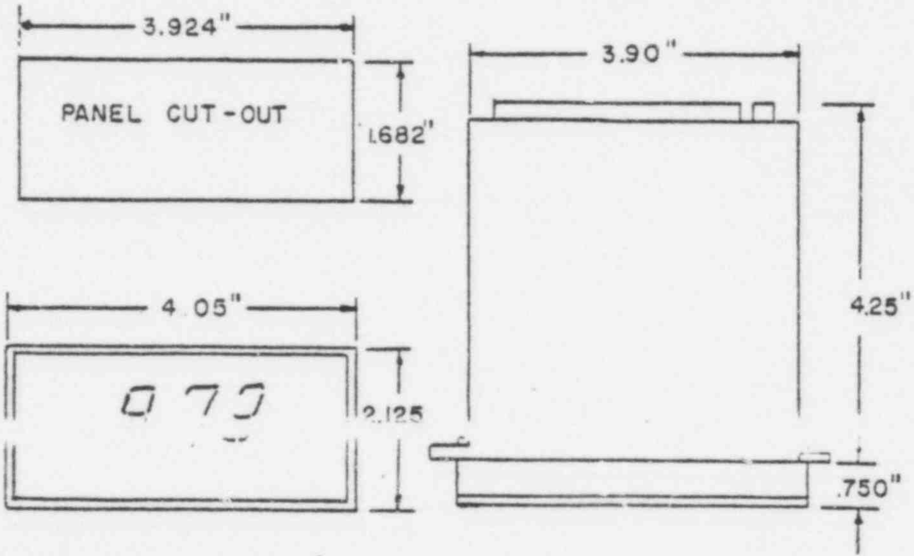
Step Response Time - less than 300 ms

9.4.2 Description:

a) Packaging:

The digital panel meter is normally packaged with the flowmeter power supply in a "NIM" type module (Sec 10.1). When the flowmeter is ordered as a chassis unit the digital panel meter must be mounted separately.

b) Panel cut-out for separate mounting of digital meter



9.4.3 Using the digital panel meter:

a) Calibration Adjustments:

Zero and full-scale (span) adjustments are accessible at the front of the meter by removing the front bezel.

NOTE: These adjustments are only for the digital panel meter and should not be confused with the flowmeter calibration adjustments.

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b) Over-range:

The digital panel meter indicates an over-range for all indications greater than 1999. When the meter is over-ranged the lighted numbers all flash on and off in unison (NOTE: the meter indications vs. mass flow becomes non-linear above the specified full-scale flow rate. See Sec. 3.9).

Example: An NALL-500 may indicate as high as 1999, but above an indication of 500 it no longer reads flow directly.

c) Negative signals:

If the input signal is negative, the meter displays a minus sign to the left of the numerical display.

d) Mass Flow units:

The meter indicates the output from the flowmeter and is calibrated to read directly in mass flow units (std cm^3/min, lbs/hr, etc.), which are noted on the front of the meter.

e) Maintenance:

The digital panel meter has been carefully tested and calibrated and should require no periodic maintenance other than adjustments for zero and full scale (span). (Sec. 9.4.3a). Should the digital panel meter need repair return the meter, flowmeter, and cables to Teledyne Hastings-Raydist with a statement describing the problem.

10.0 Miscellaneous drawings

10.1 "NIM" Module Dimensions

10.2 Chassis Dimensions

10.3 Recorder Dimensions

10.4 Mass Flowmeter Schematic HA-9751

10.5 Conversion Factors C181A

10.6 Gas Factors C194C

CONVERSION FACTORS AND EQUIVALENTS

VOLUME, WEIGHT, MASS, AND PRESSURE

TO CONVERT FROM	SYMBOL	TO	SYMBOL	MULTIPLY BY
Atmospheres	atm	feet of H_2O inches of Hg kilograms/sq. cm. millimeters of Hg pounds/sq. inch	' H_2O "Hg kg/cm^2 mm Hg psi	33.9 29.9 1.03 $7.60 \times 10^{+2}$ 14.7
Cubic centimeters	cm^3 cc	cubic feet cubic inches cubic meters liters	ft^3 in^3 m^3 l	3.53×10^{-5} 6.10×10^{-2} 1.00×10^{-6} 1.00×10^{-3}
Cubic feet	ft^3	cubic centimeters cubic meters liters	cm^3 m^3 l	$2.83 \times 10^{+4}$ 2.83×10^{-2} 28.3
Cubic meters	m^3	cubic centimeters cubic feet cubic inches liters	cm^3 ft^3 in^3 l	$1.00 \times 10^{+6}$ 35.3 $6.10 \times 10^{+4}$ $1.00 \times 10^{+3}$
Grams	gm	kilograms pounds	kg lb	1.00×10^{-3} 2.20×10^{-3}
Inches of H_2O @ 4^oC	" H_2O	millimeters of Hg pounds/sq. inch	mm Hg psi	1.87 3.61×10^{-2}
Kilograms	kg	grams pounds	gm lb	$1.00 \times 10^{+3}$ 2.20
Liters	l	cubic centimeters cubic feet cubic meters	cm^3 ft^3 m^3	$1.00 \times 10^{+3}$ 3.53×10^{-2} 1.00×10^{-3}
Millitorr (Microns of Hg)	mtorr µ Hg	atmospheres millimeters of Hg	atm mm Hg	1.32×10^{-6} 1.00×10^{-3}
Pounds/sq. inch	psi lb/in^2	atmospheres feet of H_2O inches of H_2O inches of Hg millimeters of Hg	atm ' H_2O " H_2O " Hg mm Hg	6.80×10^{-2} 2.31 27.7 2.04 [illegible]
Torr (Millimeters of Hg)	torr mm Hg	atmospheres bars inches of Hg inches of H_2O microns of Hg millibars millitorr	atm bar " Hg " H_2O µ Hg mb mtorr	1.32×10^{-3} 1.33×10^{-3} 3.94×10^{-2} 5.36×10^{-1} $1.00 \times 10^{+3}$ 1.33 $1.00 \times 10^{+3}$

1 pound AIR (STP) occupies 13.30 cu. ft. = 376.5 liters

1 cu. ft. AIR (STP) weighs 0.752 lbs. = 0.03411 Kg. = 34.11 gm.

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1 pound-mole of ideal gas (STP) occupies 385 cu. ft.

1 gram-mole of ideal gas (STP) occupies 24.0 liters @ 20^oC.

STP = STANDARD TEMP. AND PRESSURE = 20^oC (68^oF) and 760 mm Hg (29.92" Hg).

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Hampton, Virginia 23661
Phone: (804) 723-6531

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* CORRECTION

1 cu. ft. AIR (STP) weighs .0752 lbs.

C181B

GAS CONVERSION FACTORS FOR HASTINGS LINEAR MASS FLOWMETERS

NAME OF GAS	SYMBOL	HASTINGS CONVERSION FACTOR †	NAME OF GAS	SYMBOL	HASTINGS CONVERSION FACTOR †
ACETYLENE	C_2H_2	.67	HELIUM	He	*1.43
AIR		*1.00	HYDROGEN	H_2	*1.03
AMMONIA	NH_3	.77	HYDROGEN CHLORIDE	HCl	1.01
ARGON	A	*1.43	HYDROGEN FLUORIDE	HF	1.00
ARSINE	AsH_3	.76	HYDROGEN SULFIDE	H_2S	.85
BROMINE	Br_2	.88	ISOBUTANE	C_4H_{10}	.31
BUTANE	C_4H_{10}	.30	KRYPTON	Kr	1.39
BUTENE 1	C_4H_8	.34	METHANE	CH_4	*.69
CARBON DIOXIDE	CO_2	*.73	NEON	Ne	1.38
CARBON MONOXIDE	CO	*1.00	NITRIC OXIDE	NO	1.00
CHLORINE	Cl_2	.85	NITROGEN	N_2	*1.02
CHLORINE TRIFLUORIDE	ClF_3	.45	NITROUS OXIDE	N_2O	.75
CYCLOPROPANE	C_3H_6	.52	OXYGEN	O_2	*.97
DIBORANE	B_2H_6	.50	PENTABORANE	B_5H_9	.15
ETHANE	C_2H_6	.56	n-PENTANE	C_5H_{12}	.22
ETHENE (ETHYLENE)	C_2H_4	.69	PHOSPHINE	PH_3	.79
ETHYLENE OXIDE	C_2H_4O	.60	[illegible]	[illegible]	[illegible]
FLUORINE	F_2	.93	SILANE	SiH_4	.68
FREON 11	CCl_3F	.36	SULFUR DIOXIDE	SO_2	.70
FREON 12	CCl_2F	*.36	SULFUR HEXAFLUORIDE	SF_6	.28
FREON 13	$CClF_3$	.42	TUNGSTEN HEXAFLUORIDE	WF_6	.23
FREON 14	CF_4	.48	URANIUM HEXAFLUORIDE	UF_6	.23
FREON 22	$CHClF_2$	*.43	WATER VAPOR	H_2O	.80
FREON 114	$CClF_2$	*.22	XENON	Xe	1.37

mpirical data;
others theoretical

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† Multiply Air scale
by correction factor

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February, 1974

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C194D

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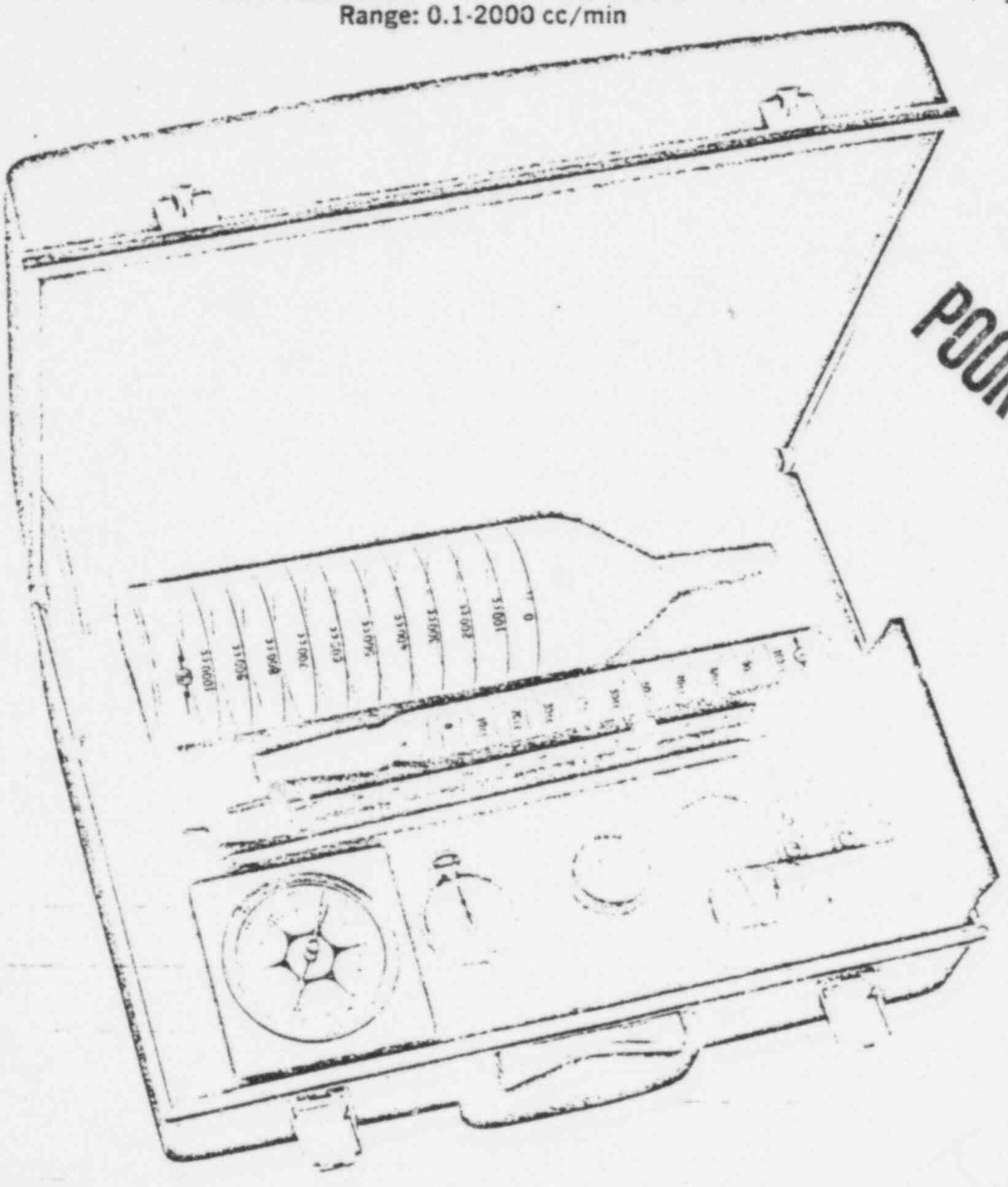
Specification Sheet No. 520

HASTINGS MINI-FLO CALIBRATOR

MINIMUM SIZE—MAXIMUM ACCURACY

Range: 0.1-2000 cc/min



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FEATURES:

- Accuracy 0.25%
- NBS Traceability
- Compact Carrying Case
- Portable—Non-Electric
- Set-Up Time 5 Minutes

CALIBRATOR INCLUDES:

THREE CALIBRATED VOLUME STANDARDS

10 cc, 100 cc, 1000 cc, each with 10 equal divisions

ANEROID BAROMETER	BBD-3 FILM SOLUTION
THERMOMETER	STAND AND FITTINGS
STOPWATCH	CARRYING CASE

INSTRUCTION MANUAL WITH CONVERSION DATA FOR TEMPERATURE AND BAROMETRIC PRESSURE

NBS TRACEABILITY CERTIFICATE

749285

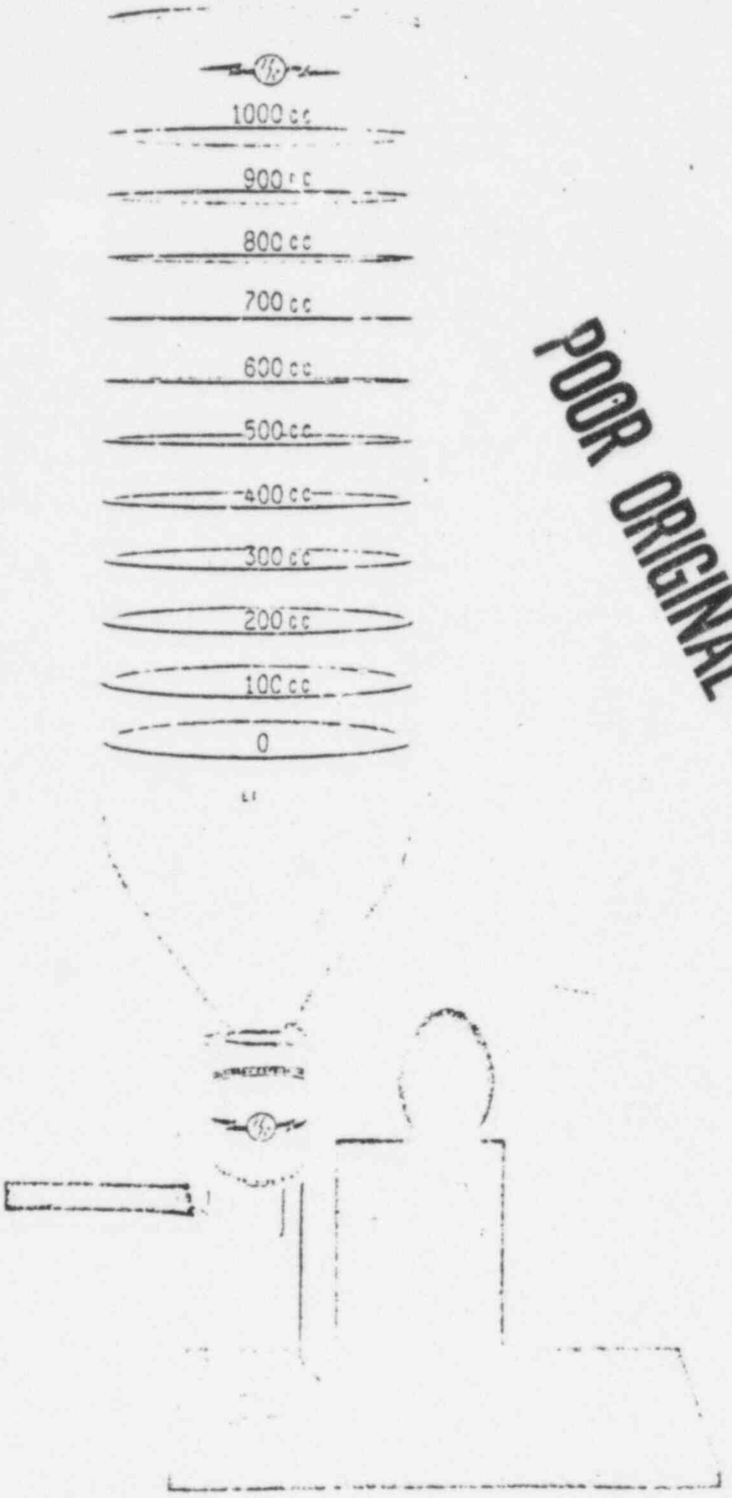
Hastings Mini-Flo Calibrator is a complete compact unit for laboratory or on-site calibration of flowmeters. The calibrated volume, barometer, thermometer, stopwatch, film solution and all necessary accessories are provided. Total weight including the carrying case is approximately seven pounds.

The principle of operation is a volume displacement method where a thin liquid film similar to soap film rises in a calibrated standard. It is suitable for use with gases which are not hazardous or which do not react with glass or water.

Three calibrated standards with volumes of 10 cc, 100 cc and 1000 cc each divided into 10 equal parts allow the user to calibrate over the range of 0.1 cc/min to 2000 cc/min.

The NBS Traceability Certificate included in the manual is applicable to the three calibrated volume standards. The furnished commercial type barometer, thermometer and stopwatch are normally adequate for precise volume displacement flow calibration.

Assembly of the calibrator takes less than five minutes. Calibrated volumes can be interchanged without dismantling the unit.



Stand with Calibrated Volume

Literature Available upon request:

Hastings Vacuum Gauges	Catalog No. 3000
Hastings McLeod Gauge	Spec. Sheet No. 340
Hastings Gauge Tube Accessories	Spec. Sheet No. 352
Hastings Vacuum Gauge Reference Tubes	Spec. Sheet No. 353A
Hastings Air-Meters	Catalog No. 4000
Hastings Mass Flowmeters for Gases	Catalog No. 5000
Hastings Calibrated Gas Leaks	Spec. Sheet No. 904C

HASTINGS MINI-FLO CALIBRATOR
MODEL HBM-1 $460.00

Price Subject to Change Without Notice
FOB: Hampton, Virginia
Terms: Net 30 Days

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HAMPTON, VIRGINIA 23661, U.S.A.
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SPECIFICATION SHEET #520

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