GA Technologies

E-115-647 (Rev. 5)

CALIBRATION REPORT
FOR MODEL RD-52
OFFLINE BETA DETECTOR

October 1984

CHANGE RECORD

Issue	Date	Pages Affected
Original	April 1977	All
Rev. 1	May 1979	Cover, change record, 4
Rev. 2	March 1980	Cover, change record, 6, 7, 8, 9
Rev. 3	May 1980	Cover, change record, 1, 3, 7, 9
Rev. 4	January 1983	All
Rev. 5	October 1984	Cover, change record, 9

Wherever reference is made in this document to General Atomic Company or one of its divisions, it shall be understood to mean GA Technologies Inc.

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TABLES

1. INTRODUCTION

Since 1977, a series of calibration tests has been performed on the RD-52 offline gas detector. Response to xenon 133 gas has been corrected. Response to krypton 85 gas was confirmed. The effects of sample chamber pressures for xenon 133 and krypton 85 responses were obtained. The responses of detectors with various sizes of scintillators were obtained. Linearity tests to show the response of countrate versus activity strength were performed.

2. DETECTOR DESCRIPTION

The RD-52 is an offline beta detector assembly designed for detecting the radioactivity in a continuous gas sample.

3. SETUP AND PROCEDURE

The detector, a 0.1 to 20 mm Hg pressure gage, a 0 to 800 mm Hg pressure gage, a vacuum pump, and, alternatively, cylinders of Xe-133 and Kr-85 gases were connected to a manifold (see Fig. 1). Prior to injecting any radioactive material into the system, the detector was aligned using calibrated solid sources positioned in front of the light-tight window on the scintillator. The high voltage and discriminator voltage levels were set to obtain a good counting efficiency for the C-14 source. Background counts and counting efficiencies for C-14, Tc-99, Cl-36, and Sr-90 were recorded (see Tables 1 and 2). The system was then evacuated to less than 0.1 mm Hg abs and backfilled with the gas mixture to 755 mm Hg abs. Counting efficiencies obtained are shown in Table 3. All of the count rates were obtained on a scaler/timer.

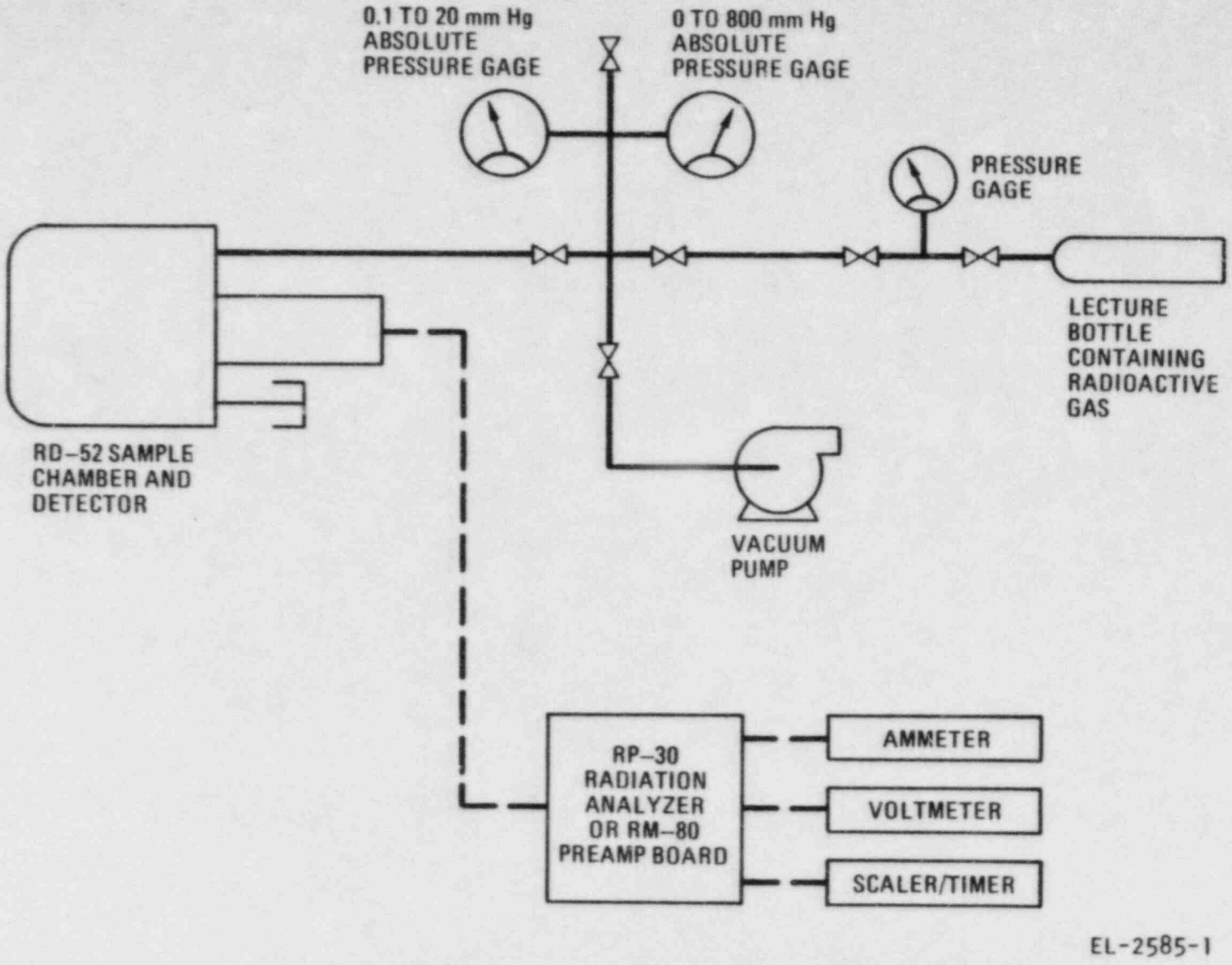


Fig. 1. RD-52 sensitivity test setup

TABLE 1
DETECTOR ALIGNMENT

(Detector removed from shield and sources positioned in contact with window)

	Activity (cpm)	GA Source No.
Background	113	—
C-14 (0.180 μCi - 13% eff)[(a)]	2,508 net	C-114-101
Tc-99 (0.170 μCi - 28% eff)	30,080 net	Tc-99-102
Cl-36 (0.184 μCi - 61% eff)	138,960 net	Cl-36-113
Sr-90 (0.185 μCi - 64% eff)	308,700 net	Sr-90-101

[(a)] See Appendix for assay and efficiency certification.

TABLE 2
DETECTOR ALIGNMENTS USING Cl-36 SOURCE SERIAL NO. CL36-113

Date	Net Countrate CL36-113 (cpm)
3-23-77	138,960
6-04-80	141,306
6-05-80	141,407
4-08-82	138,592
8-05-82	139,852

TABLE 3
Kr-85 AND Xe-133 CALIBRATIONS

Isotope	Ser. No. Activity ($\mu Ci/cm^3$)	Date of Assay	Date of Calibration	Half Life	Activity At Time of Calibration ($\mu Ci/cm^3$)	Net cpm for RD-52	Sensitivity $\frac{cpm}{\mu Ci/cm^3}$
Xe-133	1.P.L. #92012 1.5×10^{-2}	1200 hr 8-1-82	1315 hr 8-5-82	5.254 days	8.76×10^{-3}	2.57×10^{5}	2.93×10^{7}
	1.P.L. #84044 1.01×10^{-2}	1200 hr 4-6-82	1300 hr 4-8-82		7.71×10^{-3}	2.28×10^{5}	2.96×10^{7}
Kr-85	1.P.L. #20-121 GA #103 9.16×10^{-5}	12-16-75	3-23-77	10.72 years	8.43×10^{-5}	5.97×10^{3}	7.08×10^{7}
			6-5-80		6.85×10^{-5}	4.99×10^{3}	7.28×10^{7}
					0.157 diluted to 2.49×10^{-2}	1.79×10^{6}	7.19×10^{7}
	GA #106 0.168	5-7-79	6-4-80		0.157 diluted to 2.60×10^{-3}	1.87×10^{5}	7.19×10^{7}

Average Sensitivities

Xe-133 2.94×10^{7} cpm $(\mu Ci/cm^3)^{-1}$

Kr-85 7.19×10^{7} cpm $(\mu Ci/cm^3)^{-1}$

4. ENERGY RESPONSE CURVE

The energy response curve (see Fig. 2) can be useful when calculating a counting efficiency for an expected source term. The source term of interest must contain the following information when calculating an expected detector response.

1. Isotopes of interest and their intensities (the sum of the individual intensities is equal to one).

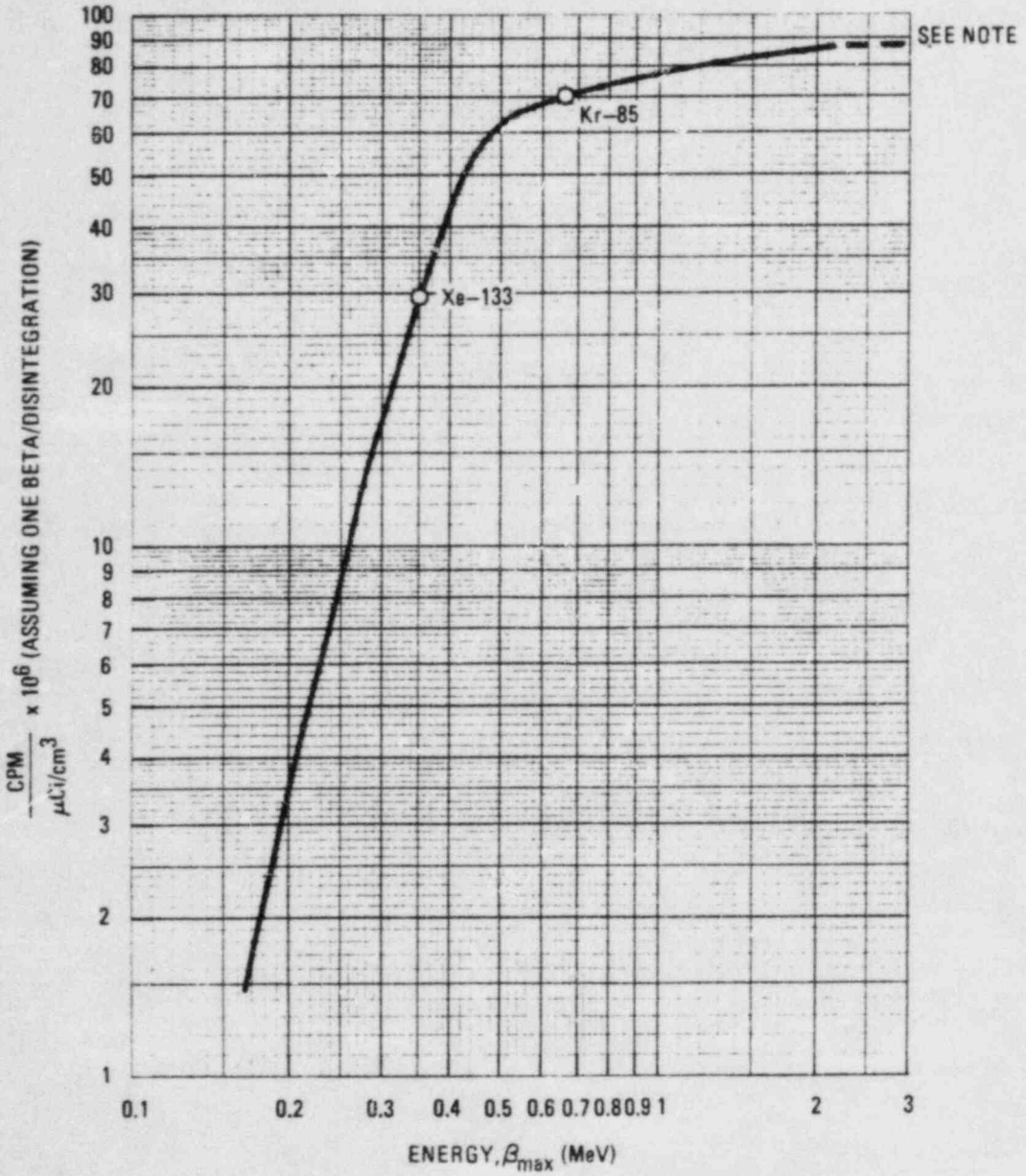
2. Each beta with its energy in MeV and number produced per disintegration.

Beta response can now be obtained from the energy response curve. This response in cpm/(microcuries/cm^3) (assuming one beta per disintegration) must be corrected for the intensities of the isotope and the number of betas produced per disintegration. The sum of these beta responses is the expected response in cpm/(microcuries/cm^3) for the source term of interest. The reciprocal of the detector response is the detector conversion factor (microcuries/cm^3)/cpm.

This conversion factor, when factored into the RM-80 data base, can provide a microcuries/cm^3 equivalent for a known source term.

The shape of the energy response curve was obtained from the solid source data in Table 1. After the shape of the curve was established, the curve was superimposed over the actual responses for Kr-85 and Xe-133 to provide the curve in Fig. 2.

ISOTOPE	AVERAGE ENERGY (MeV)	MAXIMUM ENERGY (MeV)
C–14	0.049	0.158
Tc–99	0.086	0.295
Cl–36	0.252	0.714
Sr–90/Y–90	0.200/0.931	0.544/2.245
Xe–133	0.099	0.343
Kr–85	0.249	0.672



NOTE: USE 87×10^6 CPM $(\mu Ci/cm^3)^{-1}$ FOR ALL BETA ENERGIES ABOVE 2.2 MeV. THIS WILL PROVIDE A CONSERVATIVE ESTIMATE OF THE EXPECTED RESPONSE.

Fig. 2. Energy response curve for RD-52 offline beta detector operating at 760 mm Hg abs and 25°C

5. CORRECTION FOR SAMPLE CHAMBER PRESSURE

Since the response (counts per minute for one microcurie per cm^3) of noble gases emitting beta radiations for GA's RD-52 gas detector chambers was determined at atmospheric pressure (760 mm Hg A), corrections may be required when operating the detector chambers at pressures other than atmospheric. The response to beta radiations will vary not only for increased or decreased amounts of microcuries in the chamber due to the pressure changes, but also will vary for differences in self absorption caused by density changes of the sampled gas. Tests were run during July and August of 1982 to determine these effects for Xe-133 and Kr-85 radioactive gases. Upon reducing the test data, empirical formulas were produced to provide pressure corrections for specific conditions. (See Table 4 and Fig. 3.) These test conditions may not exist at an operating power plant. Caution must be used when entering correction factors into the RM-80 data base so that the actual results are not overcorrected, thus causing additional errors.

Listed below are the correction factors obtained from the tests and the specific test conditions.

The following expression is used for correcting detector response in counts per minute (cpm) at various pressures to equivalent response in cpm at atmospheric pressure (760 mm Hg A) for Kr-85 and Xe-133 noble gases in a dry N_2 atmosphere.

TABLE 4
CORRECTION FOR SAMPLE CHAMBER PRESSURE

RD-52 Chamber Pressure	Detector Response (cpm)		Percent of Atmospheric (Sea Level) Response	
	Xe-133	Kr-85	Xe-133	Kr-85
15 psig	3.69×10^5	8.24×10^6	143	164
12 psig	3.53×10^5	7.76×10^6	137	155
9 psig	3.34×10^5	7.15×10^6	130	143
6 psig	3.12×10^5	6.50×10^6	121	130
3 psig	2.88×10^5	5.83×10^6	112	116
ATMOS	2.57×10^5	5.01×10^6	100	100
5 in. Hg vac	2.26×10^5	4.31×10^6	89	86
10 in. Hg vac	1.92×10^5	3.59×10^6	75	72
15 in. Hg vac	1.56×10^5	2.81×10^6	61	56
20 in. Hg vac	1.12×10^5	1.96×10^6	44	39

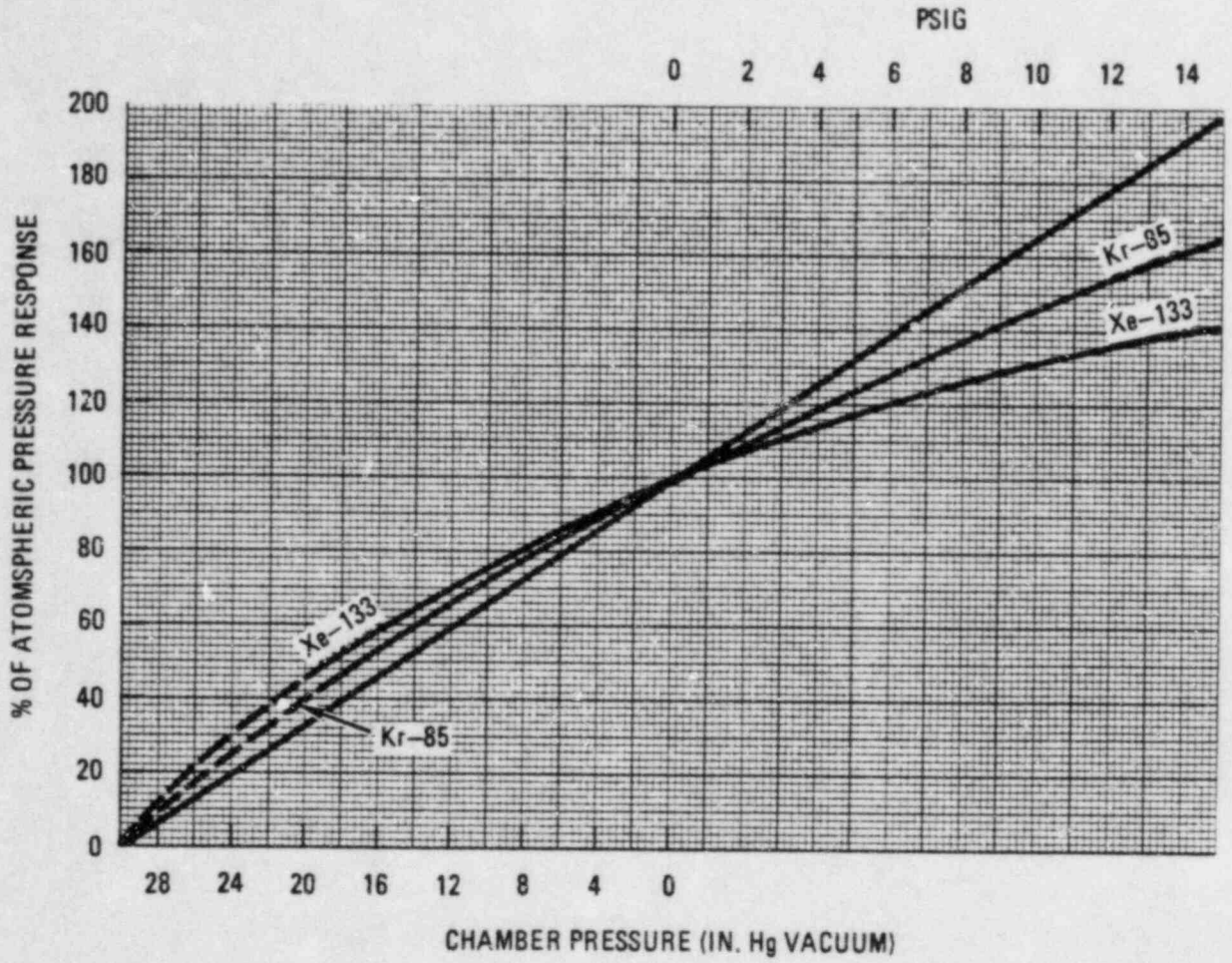


Fig. 3. RD-52 response versus chamber pressure

POSITIVE PRESSURE CORRECTION

$$CF = \frac{14.7}{(P_p + 14.7)(1-P_p A_p)}$$

where P_p = positive pressure in chamber (psig)

A_p = 0.021 for Xe-133 in RD-52 Chamber

= 0.009 for Kr-85 in RD-52 Chamber

The above correction is accurate to ±1% for 0 to 12 psig Xe-133 and 0 to 13 psig Kr-85.

NEGATIVE PRESSURE CORRECTION

$$CF = \frac{30}{(30-P_n)(1 + P_n A_n)}$$

where P_n = negative pressure in chamber (in. Hg vacuum)

A_n = 0.013 for Xe-133 in Rd-52 Chamber

= 0.004 for Kr-85 in RD-52 Chamber

The above correction is accurate to ±1% for 0 to 15 in. Hg vacuum.

Under some conditions it may not be necessary to correct for self attenuation and A_n, A_p can be equal to zero.

EXAMPLE:

If the overall error due to self absorption can be ±10% or less A_n, A_p can equal zero for:

RD-52 w/Xe-133, 5 in. Hg vac to 3 psig

RD-52 w/Kr-85, 15 in. Hg vac to 9 psig

6. DESENSITIZED DETECTORS

To meet special requirements, a detector may be desensitized. GA has manufactured detectors with varying sensitivities of approximately 0.1, 0.01 and 0.001 times the standard RD-52 sensitivity. The decreased response is obtained by varying the size of the plastic scintillator. The standard plastic scintillator has a nominal 2-in. diameter phosphor. Desensitized scintillators have been made with either round or square phosphors. It has been found that when producing the plastic phosphors, closer tolerances can be maintained when cutting a square. The desensitized phosphors are cut to have surface areas of 0.1, 0.01, and 0.001 of the nominal 2 in. diameter phosphor. The sizes used are 0.63 in. diameter, 0.2 in. diameter, and 0.063 in. diameter for the circular scintillators and 0.56 x 0.56 in., 0.177 x 0.177 in., and 0.056 x 0.056 in. for the square scintillators. The effective area of the standard RD-52 detector is 1-7/8 in. in diameter because of the sealing ring. It was also observed that the sides of the desensitized phosphors are effective scintillators. All the phosphors are 0.01 in. thick. See Table 5 for actual effective scintillator surfaces areas and ratios of areas.

Tests were performed with a standard nominal 2 in. diameter, 0.56 x 0.56 in., 0.177 x 0.177 in., and a 0.056 x 0.056 phosphor. See Table 6 for test results.

Tables 7 and 8 show the responses of the various size phosphors to GA standard sources. These counting efficiencies can be used when aligning production detectors to obtain similar counting efficiencies as in the prototype tests.

TABLE 5
NOMINAL AND EFFECTIVE PHOSPHOR SIZES AND RATIOS

Nominal Phosphor Size	Nominal Ratio of Areas to Std RD-52	Effective Surface Area	Effective Ratio of Areas to Std RD-52
2 in. diam std RD-52	1.0	$\pi/4\ (1\text{-}7/8)^2 = 2.76$ in.^{2}	1.0
0.63 diam	0.1	$\pi/4\ (0.63)^2 + \pi(0.63)(0.01) = 0.332$ in.^{2}	0.120
0.56 x 0.56 in.		$(0.56)^2 + (4)(0.56)(0.01) = 0.336$ in.^{2}	0.122
0.2 in. diam	0.01	$\pi/4\ (0.2)^2 + \pi(0.2)(0.01) = 0.0377$ in.^{2}	0.0137
0.18 x 0.18 in.		$(0.18)^2 + (4)(0.18)(0.01) = 0.0396$ in.^{2}	0.143
0.063 in. diam	0.001	$\pi/4\ (0.063)^2 + \pi(0.063)(0.01) = 0.00510$ in.^{2}	0.00185
0.056 x 0.05 in.		$(0.056)^2 + (4)(0.56)(0.01) = 0.00538$ in.^{2}	0.00195

TABLE 6
TEST RESULTS FOR DESENSITIZED DETECTORS

Nominal Phospor Size (in.)	Effective Ratio of Area to Std RD-52	Net cpm $T_{1/2}$ Correction to 1300 Hr 4-08-82	Ratio of cpm to Std RD-52	Sensitivity cpm/μCi/cm^3	
				Xe-133 Based on 2.94×10^7 cpm/μCi/cm^3	Kr-85 Based on 7.19×10^7 cpm/μCi/cm^3
Std 2.9 diam	1.0	2.28×10^5	1.0	2.94×10^7	7.19×10^7
0.56 x 0.56	0.122	2.73×10^4	0.120	$3.53 \times 10^{6(a)}$	$8.63 \times 10^{6(a)}$
0.63 diam	0.120	-	-	$3.47 \times 10^{6(b)}$	$8.49 \times 10^{6(b)}$
0.18 x 0.18	0.0143	3.30×10^3	0.0145	$4.26 \times 10^{5(a)}$	$1.04 \times 10^{6(a)}$
0.2 diam	0.0137	-	-	$4.08 \times 10^{5(b)}$	$9.96 \times 10^{5(b)}$
0.056 x 0.056	0.00195	4.48×10^2	0.00196	$5.76 \times 10^{4(a)}$	$1.41 \times 10^{5(a)}$
0.063 diam	0.00185	-	-	$5.46 \times 10^{4(b)}$	$1.34 \times 10^{5(b)}$

(a) Calculated: (Ratio of cpm to std) x (std sensitivity)

(b) Calculated: [(Sensitivity sq) x (eff area ratio round)] ÷ eff area ratio sq

TABLE 7
SOLID SOURCE RESPONSE

Phosphor Size (in.)	Source	Net cpm 4-09-82
STD RD-52	Cl-36 CL36-113	138,369
0.056 x 0.056 Square	Cs-137 CS81-542 Cs-137 CS81-530	615 4,895
0.18 x 0.18 Square	Cs-137 CS81-542 Cs-137 CS81-530	4,918 39,110
0.56 x 0.56 Square	Cs-137 CS81-542 Cs-137 CS81-530	43,494 339,455

The Cs-137 Sources CS81-542 and CS81-530 were positioned with a fixture that insured a repeatable geometry.

TABLE 8
CALCULATED SOLID SOURCE RESPONSE FOR ROUND PHOSPHORS

Phosphor Size (in.)	Source	Calculated cpm for 4-09-82
0.063 diam	Cs-137 CS81-542	5.83×10^2
	Cs-137 CS81-530	4.64×10^3
0.2 diam	Cs-137 CS81-542	4.71×10^3
	CS-137 CS81-530	3.75×10^4
0.63 diam	Cs-137 CS81-542	4.28×10^4
	Cs-137 CS81-530	3.34×10^5

7. BACKGROUND

The RD-52-30 detector was scanned from all directions with a Co-60 point source producing 2 mR/hr and a Cs-137 point source producing 20 mR/hr.

The RD-52-60 detector was scanned with a Co-60 point source producing 5 mR/hr.

Background data are compiled in Table 9.

TABLE 9
BACKGROUND DATA

Sampler	Ambient Background (cpm)	Co-60 $\left(\frac{\text{net cpm}}{\text{mR/hr}}\right)$	Cs-137 $\left(\frac{\text{net cpm}}{\text{mR/hr}}\right)$
RD-52-30 (3 in. lead)	20	43 (max)	6 (max)
RD-52-60 (6 in. lead)	19	No detectable increase above ambient in a 5 mR/hr Co-60 field	
RD-52-50[(a)]	44	2 (max)	

(a) Tests were conducted on March 21 and March 24, 1980, using a production detector. The detector was scanned with a Co-60 point source producing 5 mR/hr. Data are recorded in General Atomic Lab Notebook No. 8185 on pages 88, 89, and 90.

8. LINEARITY TEST

8.1. OBJECTIVE

The purpose of the linearity test is to show the response of the detection system for countrate versus activity strength.

8.2. METHOD

A monoenergetic radioactive nuclide, 10 millicuries of cesium 137, was placed at a fixed distance from the detector. Lead attenuators of similar thickness, 1/4 in. (approximately one-half-value layer thickness), were inserted one at a time between the detector and the source. Countrate readings taken before and after adding each attenuator were compared and the percentages of countrate changes were calculated. The tests were repeated to cover the operating range of the detection system for the decade above background (10^2 to 10^3 cpm) to the upper decade of response (10^6 to 10^7 cpm). See Fig. 4 for test setup and Table 10 for test data.

8.3. RESULTS

The actual change in countrate within the operating range of the detector from the decade above background (10^2 to 10^3 cpm) through the last decade (10^6 to 10^7 cpm) was found to be between 49% and 53% for one 1/4-in.-thick lead attenuator. The change varied $\pm$2% from a mean of 51%. Therefore, it can be concluded that the detection system is linear within $\pm$2% when actual countrate is compared to activity strength for the operating range of one decade above background to the uppermost decade.

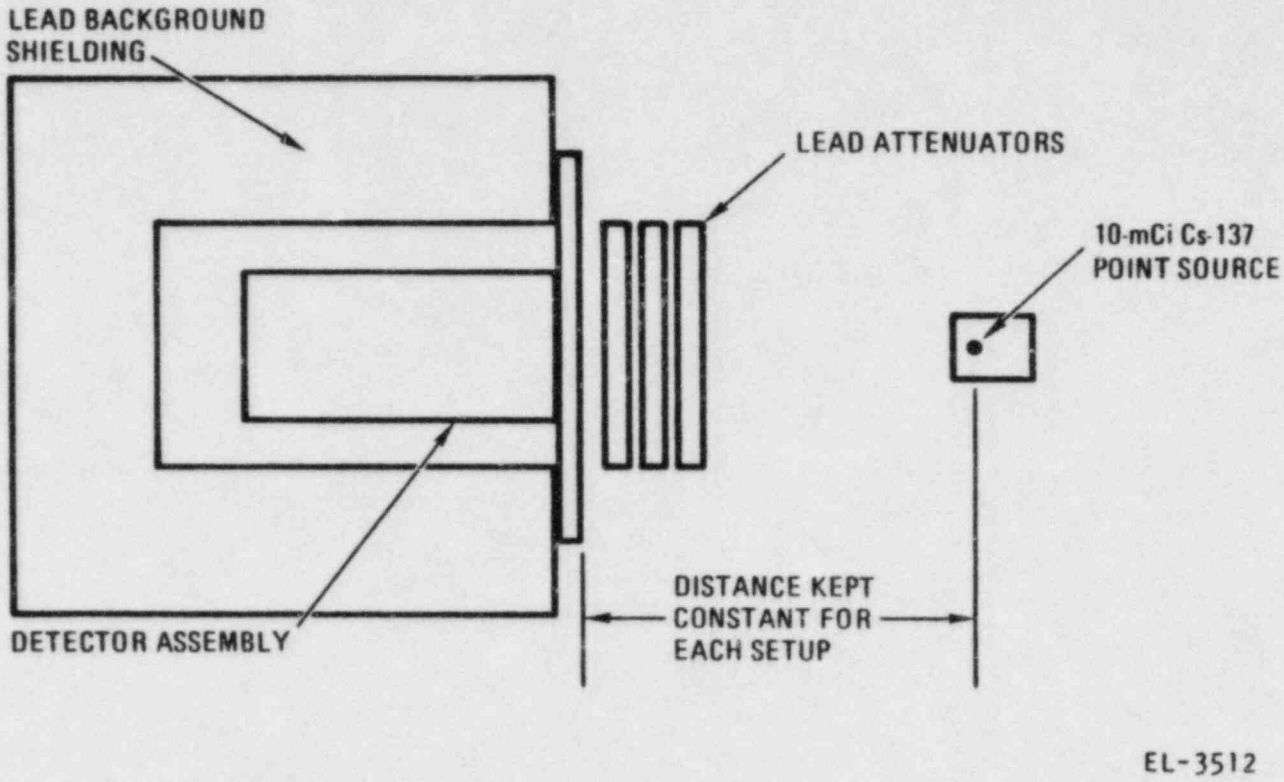


Fig. 4. Setup for RD-52 linearity test

TABLE 10
RD-52 LINEARITY TEST DATA[a]

	No. of 1/4 in. Lead Attenuators Added	cpm	Countrate Attenuation (%)	
Setup 1	0	4,148,259	51	
	1	2,039,384	52	
	2	970,229	53	Mean Attenuation
	3	456,534		in Countrate = 51%
Setup 2	0	500,260	50	
	1	248,600	50	
	2	123,504	51	
	3	60,651	51	
	4	29,816	52	
	5	14,236	50	
	6	7,067		
Setup 3	0	8,019	49	
	1	4,065	51	
	2	1,983	52	
	3	944	49	
	4	479		

[a] The above data are from General Atomic Lab Notebook 8169, pages 61 and 62.

8.4. CONCLUSION

On the linearity test requirement, consideration has been given to using sources that would provide countrates in the first, third, and sixth decades. Since individual sources are usually assayed to within only ±10%, this could place an uncertainty of 20% in countrate from one decade to the next and indicate the possibility of nonlinearity when in fact no nonlinearity exists. The method of using one source with a series of attenuators of the same thickness is a more positive method of determining linearity, as these test results show.

APPENDIX

ISOTOPE PRODUCTS LABORATORIES • 404 So. Lake St., Burbank, Calif. 91502 / 213-843-7000

GASEOUS STANDARD

DATA SHEET AND CERTIFICATION

Customer: General Atomic P.O. # 579539 W.O.# 4462 Date: 12/15/75

Catalog # GAS-85 Container: _____ Lecture Bottle: DOT 3E 1800

S/N: 20.121 (Item 1A)

Isotope: Kr-85

rrier Gas: N_2

Contained Activity: 3.65 μCi ± 0.18 μCi

Wt. of Gas: 45.3 ± 0.2 g

Concentration (uCi/cc): $0.916 \pm 0.064 \times 10^{-4}$

Calibration Date: 12/16/75 12:00

Gauge Reading at Time of Shipment: 1370 PSIG

Karl Amlauer,
Technical Director

CERTIFICATE OF
RADIOACTIVITY CALIBRATION

Carbon-14 Reference Source
NES-9999

Half-Life: 5730 ± 40 years
Lot Number:

The activity of Carbon-14 was found to be,

0.184 microcuries in June, 1972.

DESCRIPTION OF THE SOURCE

The activity was incorporated into a small amount of epoxy which was uniformly distributed in an aluminum mount. The mount has an inner diameter of 1.375", an outer diameter of 1.5", and a height of 0.062".

METHOD OF CALIBRATION

A stock solution was calibrated by liquid scintillation counting using toluene-C-14 as an internal standard. The toluene-C-14 had been previously calibrated using the National Bureau of Standards benzoic acid standard #4925 as an internal standard.

IMPURITIES

Less than 1% according to manufacturer specifications.

ERRORS

Random Errors (3 times the standard deviation)

Precision of the NEN measurement	± 2.5%

Systematic Errors

a. Accuracy of the NEN standard	± 3.0%
b. Error in preparation method	± 0.5%

Overall Error

2.5 + 3.0 + 0.5 = ± 6.0%

The counting rate of the source was found to be 13.03% of the counting rate of an essentially weightless source as determined by 2π internal proportional counting.

NEN New England Nuclear
575 Albany Street, Boston, Mass. 02118
CUSTOMER SERVICE: (617) 482-9595

CERTIFICATE OF RADIOACTIVITY CALIBRATION

Technetium-99 Reference Source
NES-9999

Half-Life: 2.1×10^5 years
Lot Number:

The activity of Technetium-99 was found to be,

0.172 microcuries in June, 1972.

DESCRIPTION OF THE SOURCE

The activity was incorporated into a small amount of epoxy which was uniformly distributed in an aluminum mount. The mount has an inner diameter of 1.375", an outer diameter of 1.5", and a height of 0.062".

METHOD OF CALIBRATION

A stock solution was calibrated by liquid scintillation counting at 100% efficiency by extrapolation of discriminator settings. The conditions for 100% efficiency were determined using standards based on National Bureau of Standards assays and are checked using Chlorobenzene-chlorine-36 as a reference standard. Then an aliquot of the stock solution was uniformly distributed throughout a weighed amount of epoxy.

IMPURITIES

Less than 1% according to manufacturer specifications.

ERRORS

Random Errors (3 times the standard deviation)

Precision of the NEN measurement	± 2.5%

Systematic Errors

a. Error in efficiency determination	± 0.5%
b. Error in preparation method	± 0.5%

Overall Error

2.5	+	0.5	+	0.5	= ± 3.5%

The counting rate of the source was found to be 27.6% of the counting rate of an essentially weightless source as determined by 2π internal proportional counting.

NEN New England Nuclear
575 Albany Street, Boston, Mass. 02118
CUSTOMER SERVICE: (617) 482-9595

CERTIFICATE OF RADIOACTIVITY CALIBRATION

Chlorine-36 Reference Source

NES-9999

Half-Life: 3.0×10^5 years
Lot Number:

The activity of Chlorine-36 was found to be,

0.184 microcuries in June, 1972.

DESCRIPTION OF THE SOURCE

The activity was incorporated into a small amount of epoxy which was uniformly distributed in an aluminum mount. The mount has an inner diameter of 1.375", an outer diameter of 1.5", and a height of 0.062".

METHOD OF CALIBRATION

A stock solution was calibrated by liquid scintillation counting at 100% efficiency by extrapolation of discriminator settings. The conditions for 100% efficiency were determined using standards based on National Bureau of Standards assays and are checked using Chlorobenzene-chlorine-36 as a reference standard. Then an aliquot of the stock solution was uniformly distributed throughout a weighed amount of epoxy.

IMPURITIES

Less than 1% of Sulfur-35 according to manufacturer specifications.

ERRORS

Random Errors (3 times the standard deviation)

a. Precision of the NEN measurement	± 2.5%

Systematic Errors

a. Error in efficiency determination	± 0.5%
b. Error in preparation method	± 0.5%

Overall Error

2.5 + 0.5 + 0.5 = ± 3.5%

The counting rate of the source was found to be 60.7% of the counting rate of an essentially weightless source as determined by 2π internal proportional counting.

NEN New England Nuclear
575 Albany Street, Boston, Mass. 02118
CUSTOMER SERVICE: (617) 482-9595

CERTIFICATE OF
RADIOACTIVITY CALIBRATION

Strontium-90 Reference Source
NES-9999

Half-Life: 28.5 ± 0.8 years
Lot Number:

The activity of Strontium-90 was found to be,

0.185 microcuries in June, 1972.

DESCRIPTION OF THE SOURCE

The activity was incorporated into a small amount of epoxy which was uniformly distributed in an aluminum mount. The mount has an inner diameter of 1.375", an outer diameter of 1.5", and a height of 0.062".

METHOD OF CALIBRATION

A stock solution was calibrated by liquid scintillation counting at 100% efficiency by extrapolation of discriminator settings. The conditions for 100% efficiency were determined using standards based on National Bureau of Standards assays and are checked using Chlorobenzene-chlorine-36 as a reference standard. Then an aliquot of the stock solution was uniformly distributed throughout a weighed amount of epoxy.

IMPURITIES

Less than 1% based on the isotope manufacturer's specifications and the period of time allotted for the decay of Strontium-89.

ERRORS

Random Errors (3 times the standard deviation)

Precision of the NEN measurement	± 2.5%

Systematic Errors

a. Error in efficiency determination	± 0.5%
b. Error in preparation method	± 0.5%

Overall Error

2.5% + 0.5% + 0.5% = ± 3.5%

The counting rate of the source was found to be 64.2% of the counting rate of an essentially weightless source as determined by 2π internal proportional counting.

NEN New England Nuclear
575 Albany Street, Boston, Mass. 02118
CUSTOMER SERVICE: (617) 482-9595

GENERAL ATOMIC COMPANY
P.O. BOX 81608
SAN DIEGO, CALIFORNIA 92138
(714) 455-3000

CERTIFICATION OF RADIOACTIVITY STANDARD

Radionuclide Kr-85-106

Nominal Activity 0.2 μCi/cc

Method of Measurement

[x] 1. Calibration derived from Sigma 2 Computer Gamma Ray Spectrometer calibrated with NBS Standards.

[ ] 2. Calibration derived from Ionization Chamber Calibrated to Sigma 2 Computer Gamma Ray Spectrometer.

[ ] 3. Calibration derived from 2π internal gas proportional counter calibrated to Sigma 2 Computer Gamma Ray Spectrometer.

Accuracy Overall Limit of Error (1σ + Systematic)

± 15%

Remarks

This standard is a IPL Kr-85 standard in argon.

We certify that the activity(ies) was(were) as follows:

1. Kr-85-106 681377
   0.168 μCi/cc at 1200 hours on 7 May 1979

Radiochemist

Analytical Chemistry Manager

DATA SHEET
AND CERTIFICATE OF
RADIOACTIVITY CALIBRATION
FOR GASEOUS STANDARD

Customer: General Atomic P.O.# 806252 W.O.# 9805 Date: 29 JULY 1982
GS-133-X
Catalog # GS-133-2 Container Lecture Bottle: DOT 3E 1800

Isotope: Xe-133 Half Life: 5.245 days

S/N: 92-011 A,B,C – 92-012

Contained Activity: (92-011) 177 mCi ea. Calibration Date: 12 PDT
(92-012) 326 μCi 28 JULY 1982

Concentration (uCi/cc): (92-011) 10.76 μCi/cc ea. STP
(92-012) 1.5×10^{-2} μCi/cc STP 1200 PDT 1 AUG 1982

Wt. of Gas: (92012) 27.3g
(92011) 20.5g ea.

Carrier Gas: dry N_2

Gauge Reading at Time of Shipment: (92011) 730 psig ea.
(92012) 850 psig

(✓) NBS Traceable (~~directly~~/indirectly) to SRM # 1800-1

Total Error at the 99 % confidence level is (92011) 7.6%
(92012) 8.0%

J. Mechelle Cortez
Signature

CHEMIST
Title

ISOTOPE PRODUCTS LABORATORIES
1800 North Keystone Street, Burbank, California 91504
213-843-7000

DATA SHEET
AND CERTIFICATE OF
RADIOACTIVITY CALIBRATION
FOR GASEOUS STANDARD

Customer: General Atomic P.O.# 796300 W.O.# 9551 Date: 1 Apr 1982

Catalog # GS-133-2 Container Lecture Bottle: DOT 3E 1800

Isotope: Xe-133 Half Life: 5.271 days

S/N: 84044

Contained Activity: 204.1 μCi Calibration Date: 1200 PST 6 Apr 1982

Concentration (uCi/cc): 1.01×10^{-2} μCi/cc STP

Wt. of Gas: 25.3g

Carrier Gas: Dry N_2

Gauge Reading at Time of Shipment: 810 PSIG

(X) NBS Traceable ~~(directly~~/indirectly) to SRM # 1800-1

Total Error at the 99 % confidence level is 9.6%

Edward C. Bernard Jr.
Signature

Chemist
Title

ISOTOPE PRODUCTS LABORATORIES

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