LIQUID SCINTILLATION COUNTING METHOD FOR THE RADIOASSAY OF WIPE TEST SAMPLES

ES-280

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by

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ABSTRACT

A general method has been established and validated for assaying a variety of isotopes on wipe test swabs by immersion counting with currently used liquid scintillation counters. The method can be used to assay wipe test samples originating from leak test surveys of sealed radioactive sources and from laboratory surveys for loose contamination, in compliance with NRC regulations.

INTRODUCTION

In order to comply with NRC regulations in our Radioactive By-Products Material License, it has been necessary to make bi-annual leak tests of the exterior surfaces of the radioactive sealed sources in use at The Dow Chemical Company. According to our license, the test should be sufficiently sensitive to detect 0.005 µCi of removable beta or gamma emitting radioactive materials. If any removable contamination greater than .005 µCi is found, it must be reported to the NRC within five days after completion of the test.

Wipe tests are made by using cotton swabs to wipe an area around the source to pick up any loose contamination. We have developed a liquid scintillation counting method that rapidly and automatically screens up to 300 swabs with assorted isotopes.[1] A minimum of sample preparation is required, and the counting data calculations are handled with a computer.

The purpose of this report is to establish and validate a general method for assaying a variety of isotopes on wipe test swabs by immersion counting with currently used liquid scintillation counters.

SCOPE

This method is used to assay the wipe test samples originating from a leak test survey of sealed radioactive sources and from laboratory surveys for loose contamination. The limit of detection is at least 2×10^{-5} of µCi of beta or alpha radioactivity on wipes containing isotopes such as ^{137}Cs, ^{60}Co, ^{210}Po, ^{226}Ra, ^{90}Sr, ^{204}Tl, ^{32}P, ^{14}C, ^{63}Ni, ^{55}Fe, ^{109}Cd, and ^{3}H.

PRINCIPLE

Wipes are immersed in a liquid scintillator solution and counted on a three channel liquid scintillation spectrometer. Three beta energy ranges are monitored at one time. Background counts are determined with a clean swab sample. The counting data outputted on punch tape is averaged, corrected for background, and converted to dpm and µCi with pre-standardized counting efficiencies. The data handling is done with a Fortran program and an IBM 370 computer. Up to 300 swab samples can be counted in any one counting run.

PROCEDURE FOR COUNTING WIPE TEST SAMPLES

The cotton swabs used to wipe the sealed source or surface are placed in 20 ml low potassium glass counting vials and covered

with 10 ml of a toluene-based scintillator, such as Econofluor® (New England Nuclear). A three channel liquid scintillation spectrometer with channels set for the three beta energy ranges of interest (low ~.015 Mev, medium ~.15 Mev, and high ~1 Mev) is used to count the samples. A Packard Tri-Carb® Model 3330 or 3380 liquid scintillation spectrometer is used in this laboratory. All three energy ranges are screened at one time. Three five-minute counts are obtained for each sample. A blank swab immersed in scintillator is counted for the same length of time as the sample to obtain the background counts. An average predetermined counting efficiency for each channel is used to convert the channel with the highest net cpm to dpm and µCi per sample. The method used to determine the counting efficiency for each channel is described in the Standardization section.

CALCULATIONS

The wipe test counting data outputted on punch tape is processed with a Fortran program and an IBM 370 computer using the calculation on the following page. Repeat counts are averaged, cpm computed, background subtracted, the channel with maximum net counts selected, and using the predetermined counting efficiency, the dpm and µCi per sample are computed. The samples showing greater than 50 dpm (0.00002 µCi) are specially noted. Those counting less than 10 net cpm over background are identified as less than detection limit.

Calculations:

C = Average cpm in channel with maximum counts

B = Background cpm

E = Predetermined counting efficiency in channel with maximum counts

$$\frac{C - B}{2.22 \times 10^6 E} = \mu\text{Ci per sample}$$

Figure 1 shows a typical computer output of wipe test data.

STANDARDIZATION OF RADIOASSAY METHOD

An updated method validation has recently been completed on our Packard Tri-Carb® Liquid Scintillation Spectrometers. Basically, swabs containing known amounts of various isotopes were prepared. The standard swabs were immersed in a toluene-based scintillator and counted with a Packard Tri-Carb® Liquid Scintillation Spectrometer.*

*Three Packard Tri-Carb® Liquid Scintillation Spectrometers are in use in our labs at this time. These include two Tri-Carb® Model 3330 Liquid Scintillation Spectrometers and one Tri-Carb® Model 3380 Liquid Scintillation Spectrometer. For the purposes of this paper, the instruments will be identified as Tri-Carb® 3330-A, 3330-B, and 3380. These can be distinguished from one another by their serial numbers as follows:

Tri-Carb® 3330-A	Serial # 22452
3330-B	21463
3380	10785

The upper descriminator setting was kept at 1000 v for all instruments and the lower setting at 20 v for the Tri-carb® 3380 and 30 v for the Tri-Carbs® 3330-A and 3330-B. These are the widest discriminator settings that will not introduce electronic noise from the instrument. The counting efficiency for each isotope on the swabs could then be calculated. The standardization of the solutions used, and the preparation and counting of standard swabs are described in the following sections.

STANDARDIZATION OF SOLUTIONS

This section deals with the method used for calibrating stock solutions of various isotopes. If calibrated standards were available, this step would be unnecessary.

In this lab, only three calibrated standards of ^{3}H, ^{14}C, and ^{36}Cl were immediately available. These were used to calibrate seven other isotopes.

Variably quenched solutions of the calibrated standards were prepared by adding various amounts of chloroform to the ^{14}C and ^{36}Cl standards. This was to simulate, for plotting purposes, other isotopes of slightly lower energy. Gain spectra, variation of count rate with percent gain, for these chemically quenched, as well as unquenched, standards were obtained and are shown in Figure 2. When the balance point gains (where counts are maximum) obtained

from Figure 2 were plotted versus counting efficiency, a curve approaching 100% counting efficiency at low gains (corresponding to higher energy isotopes) was obtained (Figure 3). This curve was then used to obtain the counting efficiency at balance point gain for the stock isotope solutions listed in the next section. The balance point gains for these solutions were obtained from the normalized gain spectra for each isotope (Figures 4A & 4B).

The specific activity, dpm/ml, of each stock solution was determined by dividing the counts per minute at the balance point gain by the counting efficiency obtained from the curve in Figure 3.

Alpha emitters in our counting system behave like betas with 0.1 of the energy of the alpha emitters and count at approximately 100% counting efficiency.[3]

Preparation and Counting of Swab Samples

Solutions Used	dpm/ml	
1. Polyethylenimine-^{14}C in water	8.46×10^5	
2. Succinic Acid-^{3}H in ethanol	5.02×10^6	(9-13-78)
3. Nickel-^{63}Ni Chloride in HCl	1.09×10^7	
4. Promethium-^{147}Pm Chloride in HCl	1.16×10^6	(9-13-78)
5. Cesium-^{137}Cs Chloride in HCl	3.62×10^5	
6. Sodium Chloride-^{36}Cl (.1 N)	4.20×10^5	
7. ^{55}Fe in .5 M HCl	4.07×10^6	(9-13-78)
8. ^{210}Po in 1 M HNO_3	2.23×10^5	(9-13-78)
9. ^{109}Cd in .5 M HCl	6.86×10^6	(9-13-78)
10. $^{90}Sr(^{90}Y)$ in .5 M HCl	3.27×10^5	
11. ^{60}Co in .5 M HCl	1.17×10^6	

The solutions listed were pipetted onto cotton swabs with a 5, 10, or 100 µl Eppendorf pipet. Cotton swabs were prepared in triplicate and allowed to dry for approximately three hours. All of the swabs were immersed directly in 10 ml of Econofluor® scintillator and counted in all three Tri-Carb® Liquid Scintillation Spectrometers.

The discriminators of the Tri-Carb® Models 3330 were set at 30-1000 and those of the 3380 at 20-1000. The gain settings selected for screening wipe test samples are 2% (red channel), 10% (green channel), and 50% (blue channel), which cover the energy regions of interest. Tables I and II show the counting efficiencies of the standard swabs on each instrument and the average counting efficiencies for the isotopes on all three instruments according to maximum channel. Table II also lists the average of the counting efficiencies for the isotopes that peak in each channel.

In order to determine the effects of color quenching, as happens with dirty swab samples, on balance point gain and counting efficiency, an attempt was made to simulate a "dirty swab" condition. To do this, 100 µl of a 0.1% Methyl Red solution were added to two out of three of each set of swabs containing ^{63}Ni, ^{36}Cl, ^{14}C, and ^{210}Po. This gave an orange color which roughly corresponds to a moderately dirty swab solution. The colored samples, along with the clear sample of each set, were counted on the Tri-Carb® 3330-B

and 3380 using the previously described instrument settings. Table III shows the counting efficiencies of the colored swab samples in the maximum channels as compared to the clear swab solutions.

Gain spectra were obtained for all isotopes on swabs in clear solutions as well as those in colored solutions. Figures 5A & B compare the gain spectra of clear versus color quenched samples, and Figures 6A & B show the gain spectrum of each isotope on swabs in clear solutions.

The counting efficiency was determined at the balance point gain setting for each isotope on swabs. Using this data, a plot was made of the counting efficiency versus balance point gain setting (Figure 7). A plot of maximum beta energy versus balance point gain for each isotope on swabs was made also (Figure 8).

RESULTS

A method has been established and validated for assaying a variety of isotopes on swabs by immersion counting with currently used liquid scintillation counters.

An intermediate standardization step for the calibrating of stock solutions of various isotopes was developed. This uses a curve of balance point gain versus counting efficiency (Figure 3). This wa

based upon the gain spectra of variably quenched known standards of ^{14}C and ^{36}Cl as given in Figure 2, as well as on the gain spectrum of unquenched ^{3}H standard. The specific activities of an additional eleven isotope solutions were derived in this way. Their values are reported in the text under STANDARDIZATION OF SOLUTIONS. The balance point gain of each isotope, used to get the counting efficiency from Figure 3, was obtained from the peak values of Figures 4A and 4B.

To determine the radioactivity on a variety of swabs, the relationship between beta energies, balance point gain, and counting efficiency was established. Counting efficiency was related to balance point gain (as obtained from Figure 6) in Figure 7. A curve approaching 100% counting efficiency at low gains (high energies) was obtained.

Balance point gain was related to maximum beta energy as shown in Figure 8. An almost linear relationship was found, except in the low energy end of the curve. This was consistent with previous reports.[1,2] Thus, for any beta emitter on a swab, the balance point gain at which it would count in a 30-1000 window could be found.

Appropriate instrument settings were found to be: wide windows of 20-1000 v for Tri-Carb® 3380, and 30-1000 v for Tri-Carbs® 3330-A and 3330-B, and gain settings of 2%, 10%, and 50% for the red, green, and blue channels respectively.

Average values of counting efficiency for each of these channels for all three of our instruments can be used as shown in Table I

Colored samples may lead to the misidentification of the energy of the isotope on the swabs since colored samples may peak in a channel corresponding to a lower energy isotope, and count at a lower counting efficiency than expected for the isotope (see Tab III). However, with the shift to a lower energy window, the prep: grammed counting efficiency for that lower energy window will co: pensate fairly well for the quenched condition of the higher energy isotope. Thus, for wipe test purposes, the change in counting efficiency caused by a slightly colored (red) solution should not seriously affect the quantitative results (Table II).

A wide variety of isotopes can be well represented by these standard counting conditions as seen in Table II. The appropriate average counting efficiencies for the red, green, and blue channels a: taken from Table II, are 88%, 77%, and 32% respectively.

Based on a minimum detection limit of ten counts per minute above background, the detection limits in each channel with the gain settings of 2%, 10%, and 50% are 5×10^{-6}, 6×10^{-6}, and 14×10^{-6} microcuries respectively.

This method is designed to quickly screen a wide range of mixed isotopes on swabs. The objective is to be able to detect any removable activity greater than 0.005 µCi. The method is not intended to exactly identify and quantitate the radioactivity on every swab. Should the need arise to quantitate the activity on a swab, the optimum gain setting and counting efficiency of the isotope would be used.

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TABLE I

Counting Efficiencies of Standard Swabs

Isotope	Energy of Predominant α or β, Mev	Max. Channel (Red 2%, Grn 10%, Blue 50%)	Counting Efficiency (%) in Maximum Channel: 3330-A (window 30-1000)	3330-B (window 30-1000)	3380 (window 20-1000)	Average
^{3}H	0.019 (β)	Blue	38.95	46.74	34.54	40.08 ± 6.18
^{63}Ni	0.066 (β)	Blue	45.02	40.96	38.70	39.87 ± 1.11
^{55}Fe	0.0064*	Blue	15.39	22.60	14.08	17.36 ± 4.59
^{14}C	0.156 (β)	Green	63.18	66.94	65.82	65.31 ± 1.93
^{147}Pm	0.225 (β)	Green	73.05	79.19	77.89	76.71 ± 3.24
^{109}Cd	0.182 (β)	Green	86.88	88.42	87.63	87.64 ± 0.77
^{36}Cl	0.709 (β)	Red	81.71	83.61	82.59	82.64 ± 0.95
^{137}Cs	0.52 (β)	Red	91.65	95.30	94.86	93.94 ± 1.99
^{90}Sr	0.546 (β)	Red	94.34	86.61	90.02	90.32 ± 3.87
^{210}Po	5.3 (α)	Red	89.26	89.88	88.76	89.30 ± 0.56
^{60}Co	0.306 (β)	Red	71.41	90.78	85.32	82.50 ± 9.99

*Electron capture, X-ray

TABLE II

Average Counting Efficiencies of Standard Swabs in the Maximum Channels

Isotope	Average Counting Efficiency* in Maximum Channel		
	Red (2% Gain)	Green (10% Gain)	Blue (50% Gain)
^{3}H			40.08
^{63}Ni			39.87
^{55}Fe			17.36
^{14}C		65.31	
^{147}Pm		76.71	
^{109}Cd		87.64	
^{36}Cl	82.64		
^{137}Cs	93.94		
^{90}Sr	90.32		
^{210}Po	89.30		
^{60}Co	82.50		
Average	87.74 ± 5.02	76.55 ± 11.17	32.45 ± 13.06
Colored Swab Solutions**			
^{63}Ni			28.75
^{14}C			40.51
^{36}Cl		77.64	
^{210}Po		71.96	
Average		74.80 ± [illegible]	34.63 ± [illegible]

TABLE III

Counting Efficiencies of Standard Swabs in Colored Solution

Isotope		Maximum Channel (Red 2%, Grn 10%, Blue 50%)	Counting Efficiency (%) Maximum Channel		
			3330-B (window 30-1000)	3380 (window 20-1000)	Average
^{63}Ni	Clear	Blue	40.90	38.70	39.80
	Colored	Blue	33.57	23.93	28.75
^{14}C	Clear	Green	66.94	65.82	66.38
	Colored	Blue	40.36	40.65	40.51
^{36}Cl	Clear	Red	83.61	82.59	83.10
	Colored	Green	76.59	78.69	77.64
^{210}Po	Clear	Red	89.88	88.76	89.32
	Colored	Green	67.68	76.23	71.96

FIGURE 1

Typical Computer Output of Wipe Test Data

CALCULATIØN ØF ACTIVITY IN WIPE TEST SAMPLES

FILE NØ.3KB- -8.

SAMPLE NØ	MAX CHANNEL	NET CPM	DPM	UCI
1	GREEN	0.0	LESS THAN DETECT LIM.	
8	GREEN	0.0	LESS THAN DETECT LIM.	
14	GREEN	0.0	LESS THAN DETECT LIM.	
21	GREEN	0.0	LESS THAN DETECT LIM.	
22	GREEN	0.0	LESS THAN DETECT LIM.	
24	GREEN	0.0	LESS THAN DETECT LIM.	
26	GREEN	0.0	LESS THAN DETECT LIM.	
30	GREEN	0.0	LESS THAN DETECT LIM.	
31	GREEN	0.0	LESS THAN DETECT LIM.	
101	GREEN	0.0	LESS THAN DETECT LIM.	
102	GREEN	0.0	LESS THAN DETECT LIM.	
103	GREEN	0.0	LESS THAN DETECT LIM.	
104	GREEN	0.0	LESS THAN DETECT LIM.	
105	GREEN	0.0	LESS THAN DETECT LIM.	
106	GREEN	0.0	LESS THAN DETECT LIM.	
107	RED	2.33	LESS THAN DETECT LIM.	
108	GREEN	10.20	14.17	0.0000064
109	GREEN	0.0	LESS THAN DETECT LIM.	
110	GREEN	0.0	LESS THAN DETECT LIM.	
111	GREEN	0.0	LESS THAN DETECT LIM.	
112	GREEN	0.0	LESS THAN DETECT LIM.	
113	GREEN	0.0	LESS THAN DETECT LIM.	
114	RED	3.53	LESS THAN DETECT LIM.	
115	GREEN	0.0	LESS THAN DETECT LIM.	
116	GREEN	0.0	LESS THAN DETECT LIM.	
117	GREEN	0.0	LESS THAN DETECT LIM.	
118	GREEN	0.0	LESS THAN DETECT LIM.	
119	GREEN	0.0	LESS THAN DETECT LIM.	
120	GREEN	0.0	LESS THAN DETECT LIM.	
121	BLUE	16.27	62.56	0.0000282
122	GREEN	0.0	LESS THAN DETECT LIM.	
123	GREEN	0.0	LESS THAN DETECT LIM.	
124	BLUE	0.67	LESS THAN DETECT LIM.	
125	GREEN	0.0	LESS THAN DETECT LIM.	
126	BLUE	5.80	LESS THAN DETECT LIM.	
127	RED	0.53	LESS THAN DETECT LIM.	
128	GREEN	0.0	LESS THAN DETECT LIM.	
129	GREEN	0.0	LESS THAN DETECT LIM.	
130	GREEN	0.0	LESS THAN DETECT LIM.	
131	GREEN	0.0	LESS THAN DETECT LIM.	
132	GREEN	0.0	LESS THAN DETECT LIM.	
133	GREEN	0.0	LESS THAN DETECT LIM.	
134	GREEN	0.0	LESS THAN DETECT LIM.	

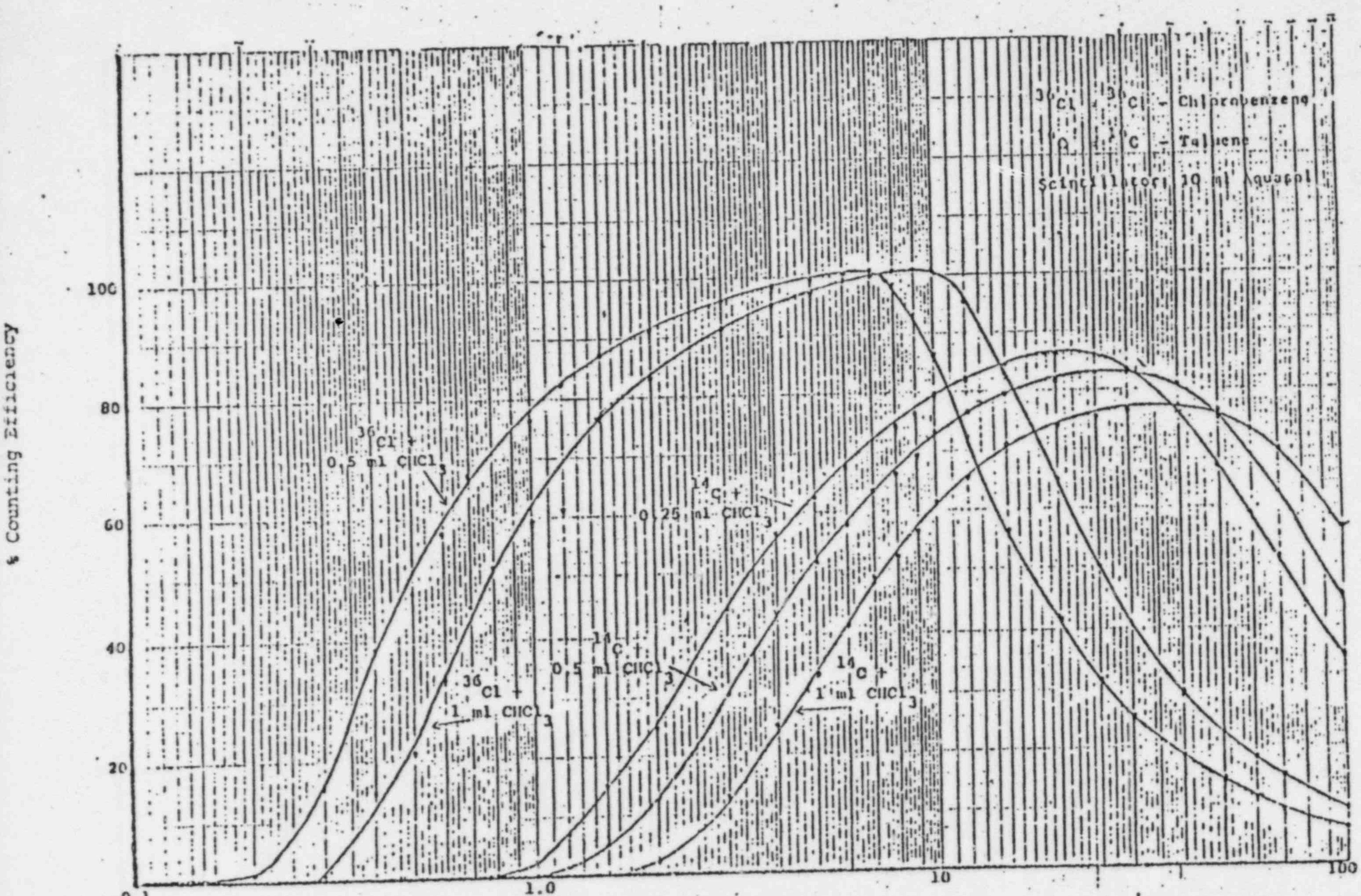
DETECTIØN LIMITS

RED	11 DPM	0.0000050 UCI
GN	14 DPM	0.0000063 UCI
BL	38 DPM	0.0000173 UCI

READY

FIGURE 2

Counting Efficiency versus Gain for Chemically Quenched Calibrated Standards



Counting Efficiency versus Balance Point

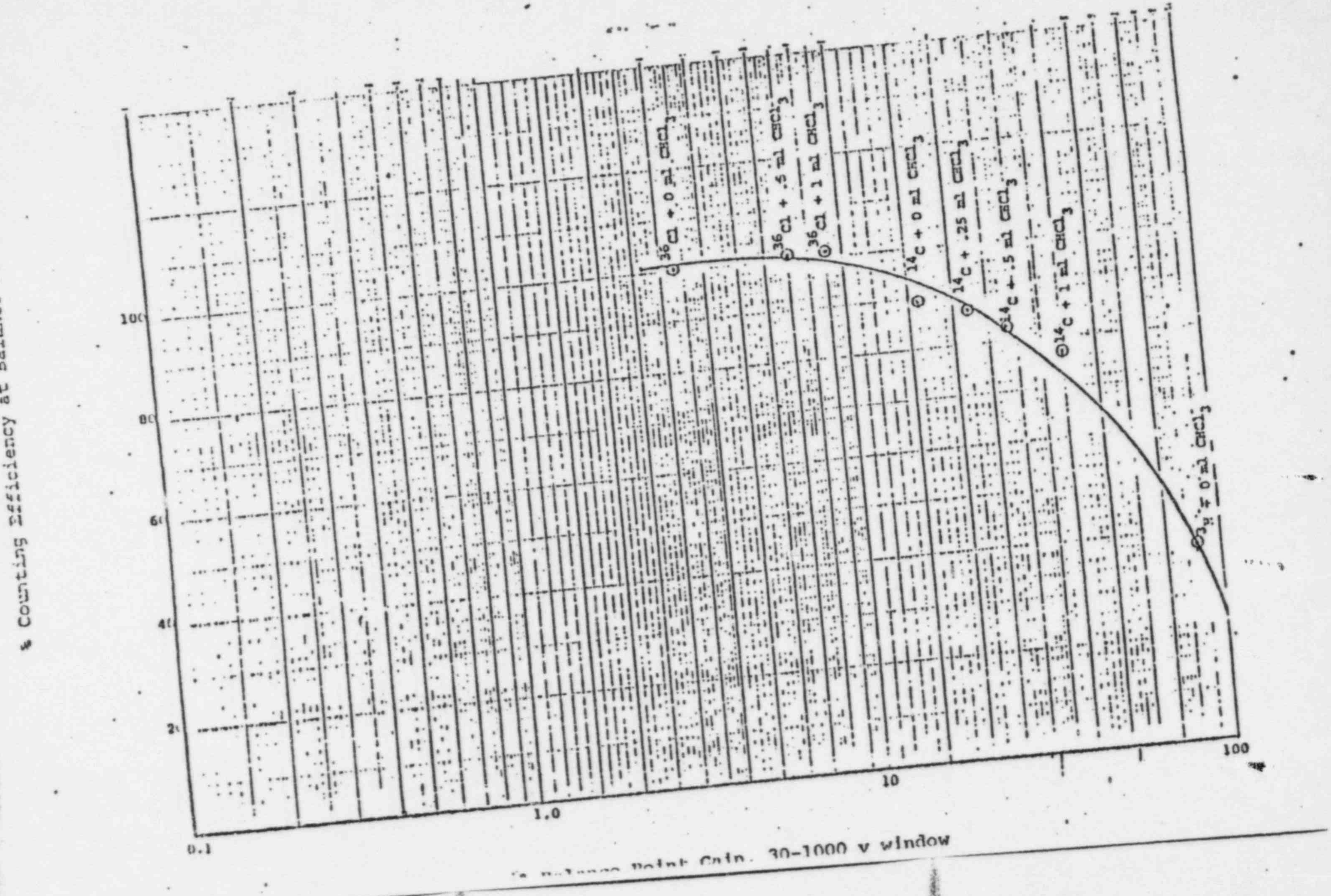
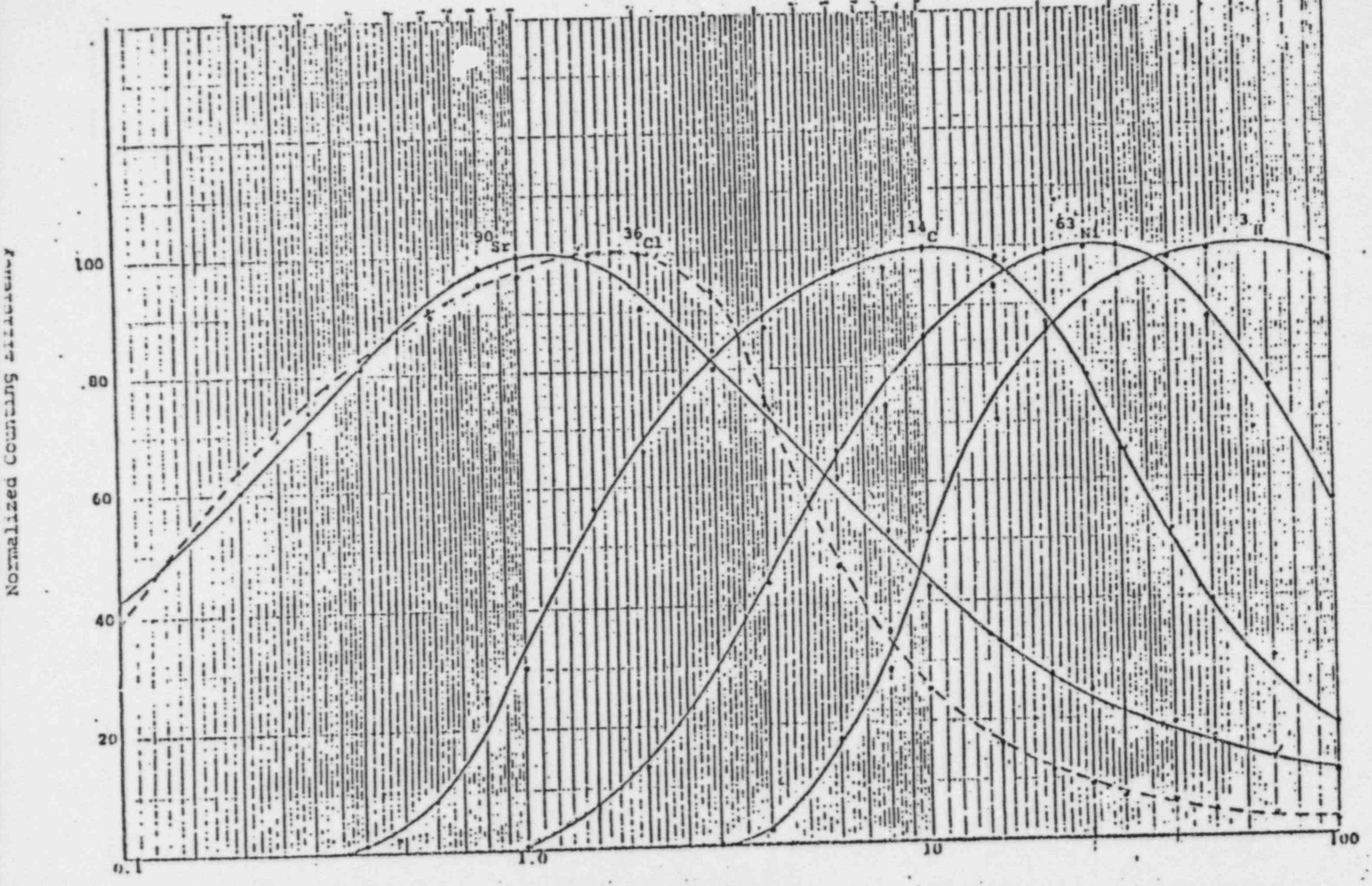


FIGURE 4A

Normalized Counting Efficiency versus Gain of Isotope Solutions



Normalized Counting Efficiency

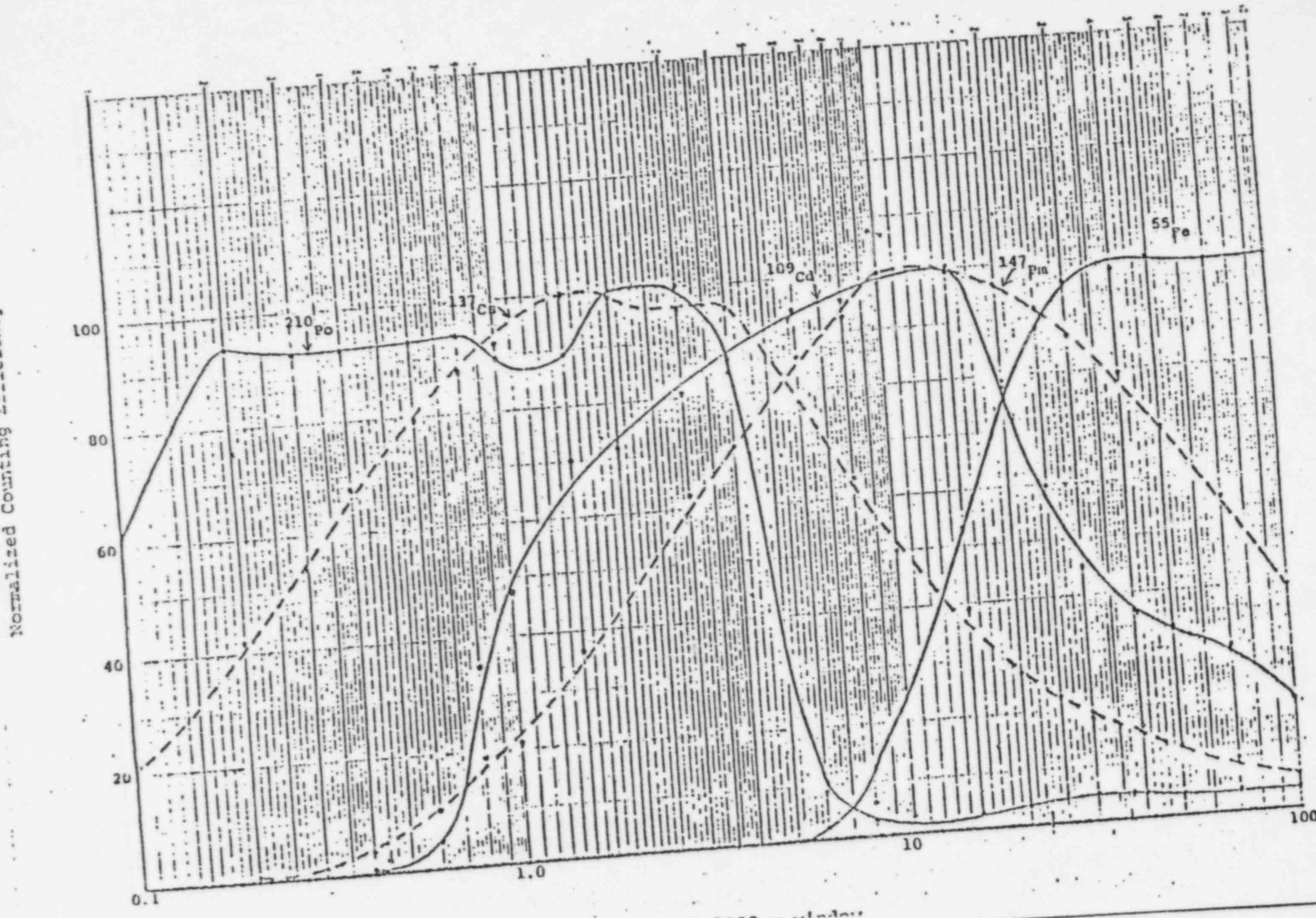


FIGURE 5A

Counting Efficiency versus Gain of Clear and Color Quenched Standard Swabs

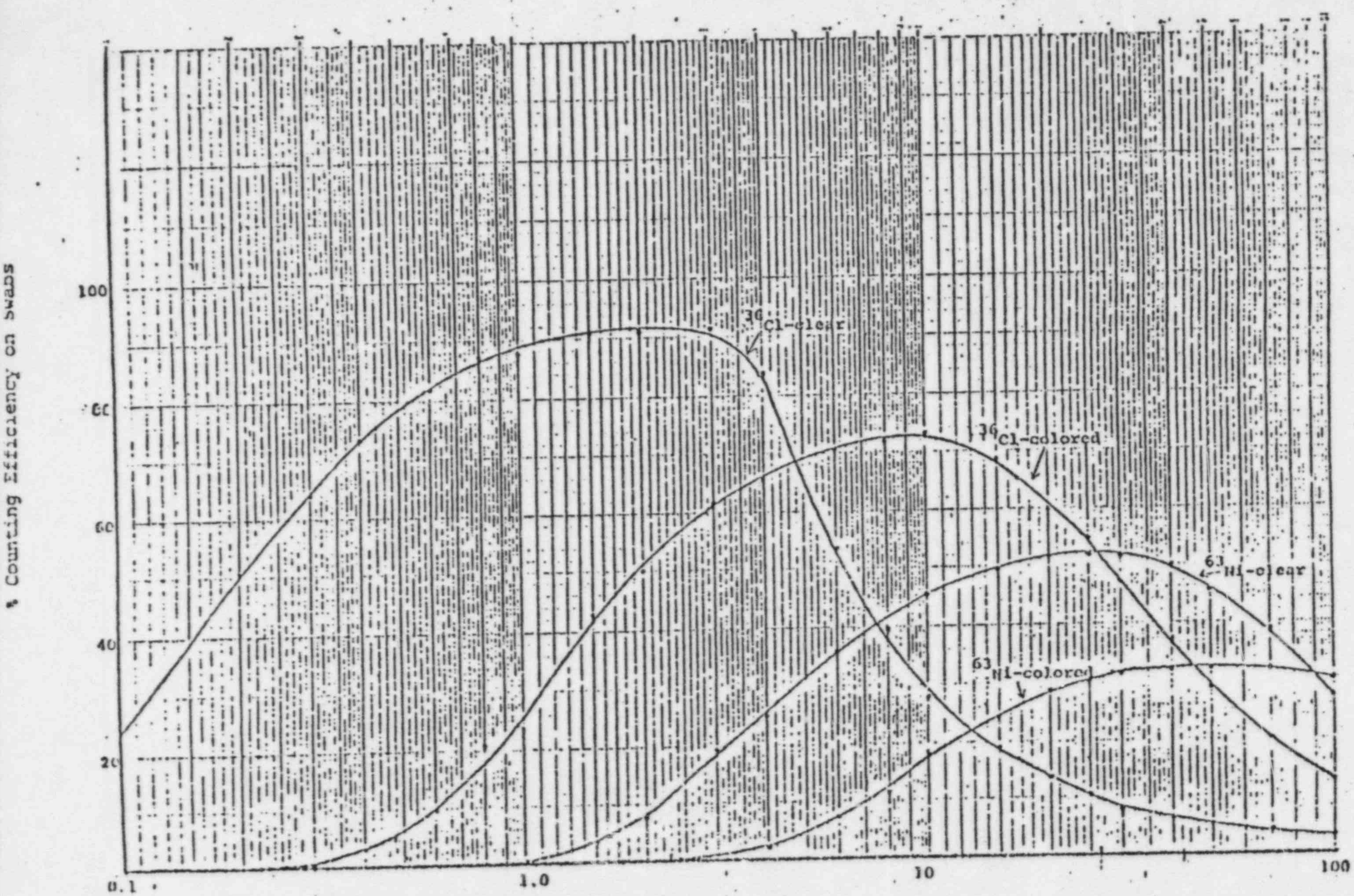


FIGURE 5B

Counting Efficiency versus Gain of Clear and Color Quenched Standard Swabs

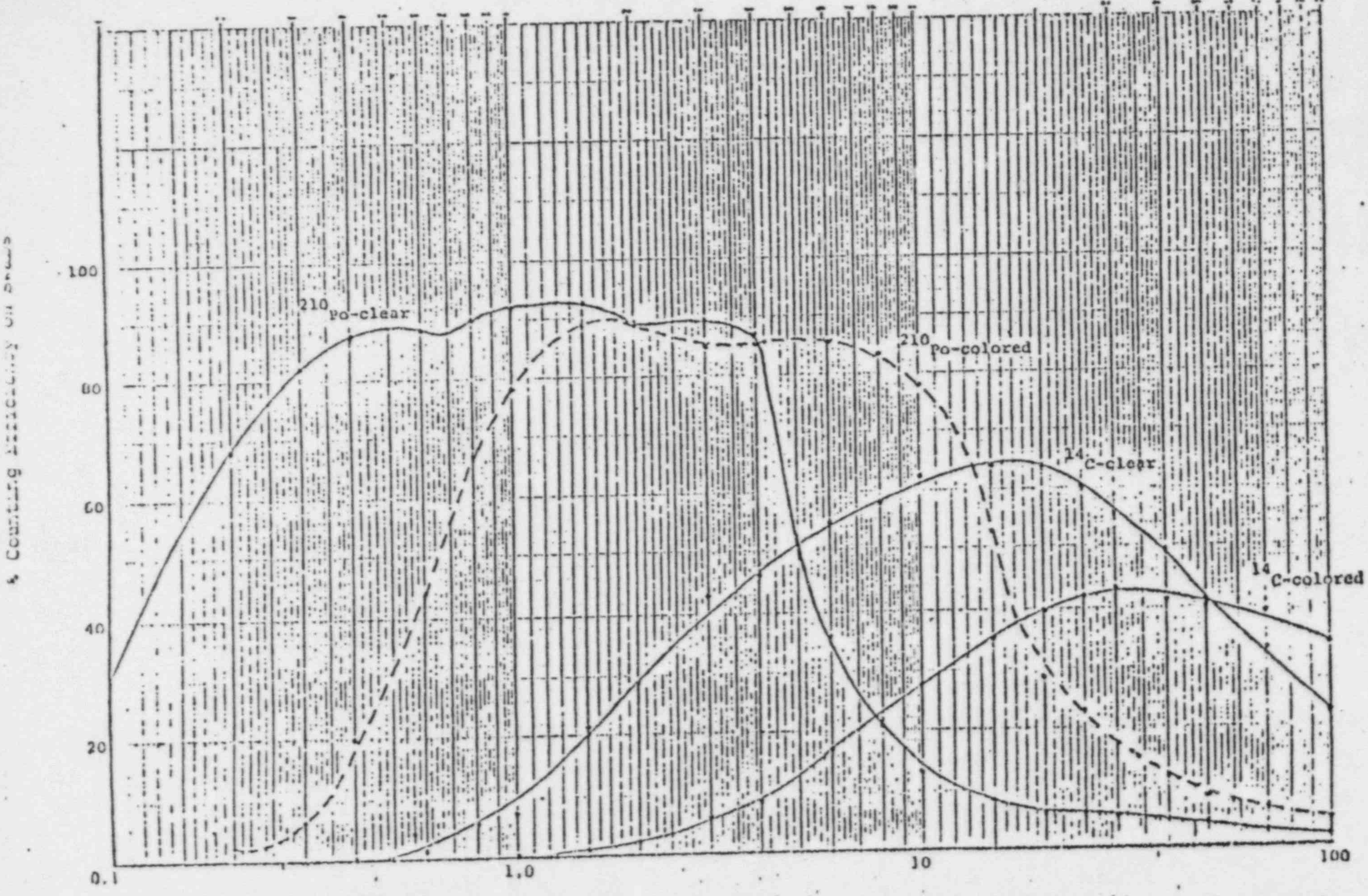


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FIGURE 6A

Counting Efficiency versus Gain of Standard Isotopes on Swabs

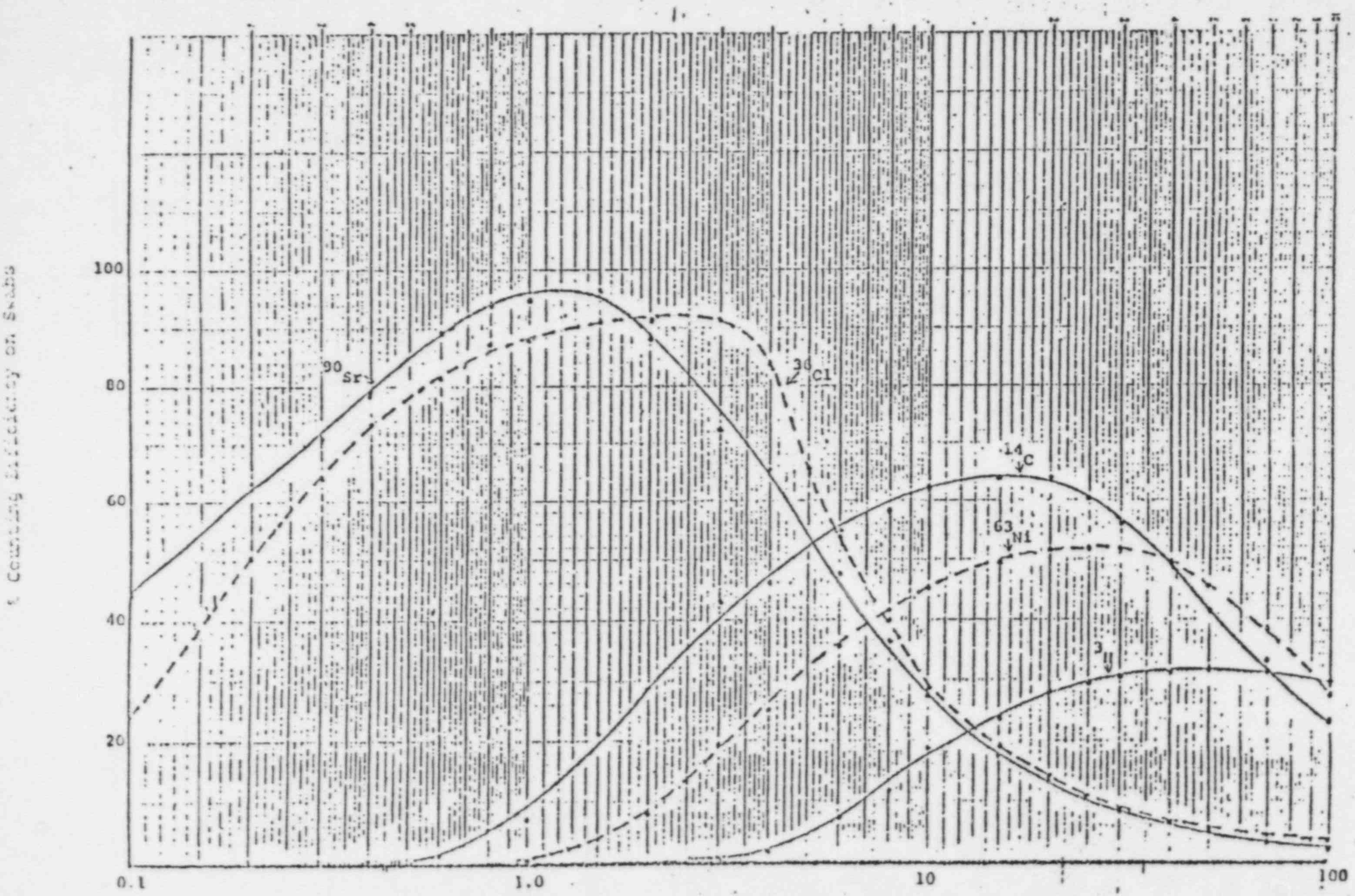

FIGURE 6B

Counting Efficiency versus Gain of Standard Isotopes on Swabs

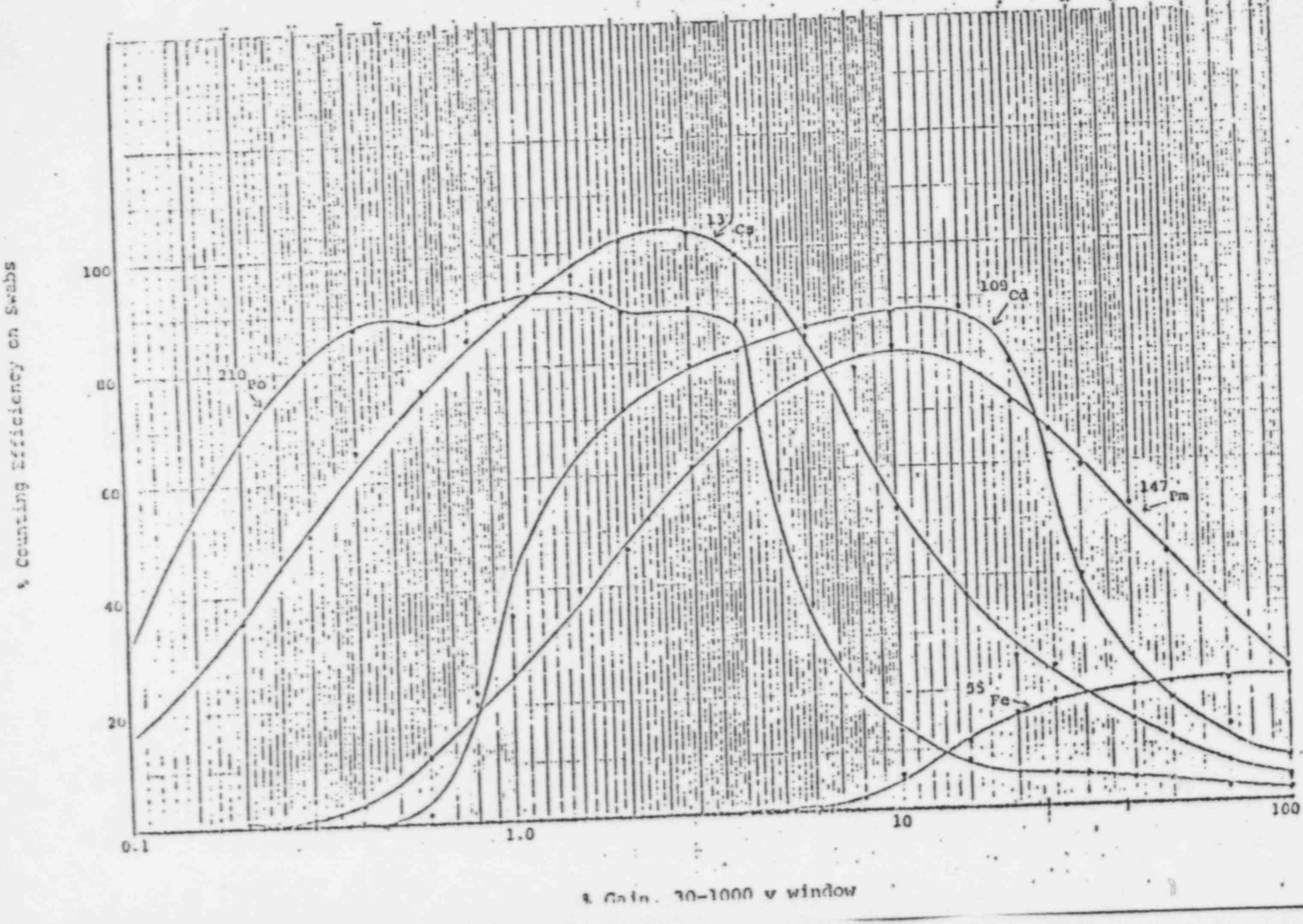

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FIGURE 7

Counting Efficiency versus Balance Point Gain for Isotopes on Swabs
(Counted on Tri-Carb® 3330-B)

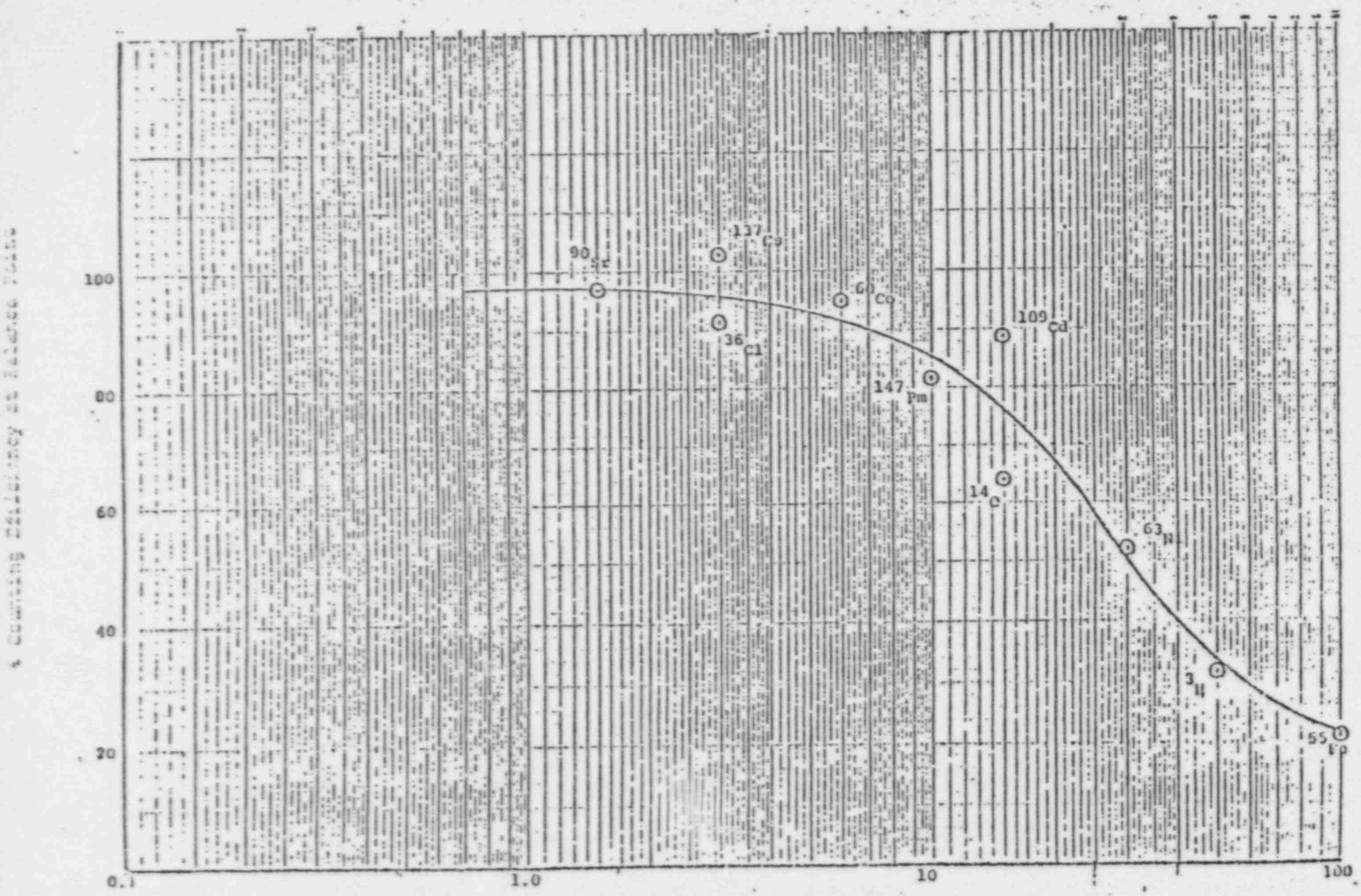
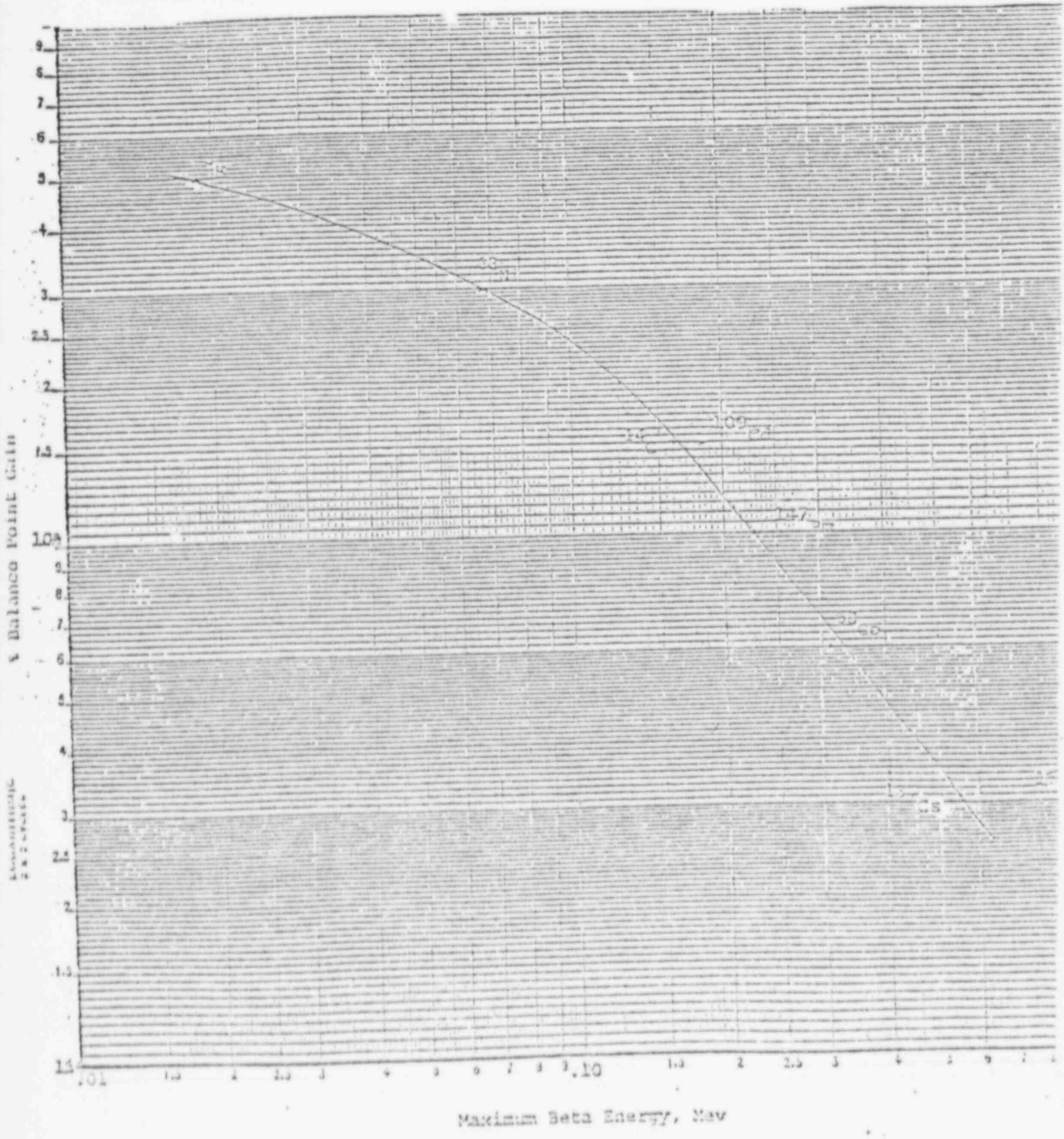


FIGURE 8

Relationship Between Maximum Beta Energy and Balance Point Gain Setting



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ITEM 12(3) BIOLOGICAL MONITORING

The need for biological monoitoring is dependent upon a number of factors:

a. High level contamination from infrequent events.

b. Variable but repeated contamination of the work area.

c. Suspected accidental inhalation or injestion.

Additionally, there may be other times when biological monitoring is needed. This is dependent upon amount and type of radioactive material as well as volatility of compounds. The health physicist then determines a need for biological monitoring based on 20.103(3)c.

ITEM 14(b)(1) NON-COMMERCIAL WASTE DISPOSAL

Dow will dispose of low level radioactive waste by incineration. The incineration of low level radioactive waste is already authorized by the State of Michigan Department of Natural Resources Under permit 93-73I.

The incinerator is located inside the fenced boundary of Dow's Midland, Michigan, site. Five warehouses are located from 300-450 feet east of the incinerator. Other than the administrative offices for these buildings, the nearest occupied building is approximately 600 feet to the southeast and is a single story structure. The Dow boundary fenceline relative to the incinerator is 800 feet south, 1200 feet west, 4400 feet north and 4400 feet east. The Tittabawassee River traverses the boundary on the west and south sections of the Michigan Division. Prevailing winds are from the southwest.

The incinerator is a rotary kiln design that discharges 27,000 to 32,000 cubic feet per minute of exhaust gases through a stack 200 feet in height with an inner diameter of 12 feet. The normal operation schedule is 24 hours per day, 7 days a week. Under normal conditions, it suspends operations only for breakdowns and scheduled shutdowns. Plant rubbish, industrial solid wastes and liquid organics are examples of typical nonradioactive wastes being incinerated.

Based on the following calculations and assumptions, Dow wishes to incinerate the radionuclides and activities as presented in Table 1. The most conservative incinerator exit gas volume of 27,000 cubic feet per minute is alternatively expressed as the following:

$27{,}000\ ft^3/min \times 28{,}316\ mL/ft^3 = 7.65 \times 10^8\ mL/min$
$7.65 \times 10^8\ mL/min \times 60\ min/hr = 4.59 \times 10^{10}\ mL/hr$
$4.59 \times 10^{10}\ mL/hr \times 24\ hr/day = 1.10 \times 10^{12}\ mL/day$
$1.10 \times 10^{12}\ mL/day \times 300\ day/yr = 3.30 \times 10^{14}\ mL/yr$

In calculating the exit gas volumes on a yearly basis, it was conservatively assumed that the incinerator operates 300 days per year which account for breakdowns and planned shutdowns.

Based on this operation schedule, calculations were made to determine the average concentrations in effluents at the top of the stack. It was assumed that all the radioactivity would be released through the stack for the purpose of these calculations. Note that none exceed the most restrictive limits specified in 10 CFR 20, Appendix B, Table II.

All activities listed are for single radionuclide burns. If radionuclides are combined in a single burn, the maximum activity of each radionuclide to be burned would be calculated by the "sum of the ratios" method described in "Note to Appendix B" of 10 CFR 20.

Radioactive material is shipped to the incinerator from Dow's local waste generating laboratories with adherence to Department of Transportation regulations. Since these regulations require that all packages must be below the contamination limits specified in 49 CFR 173.397, no radionuclide contamination of the incinerator operators is expected. The packages are fed into the incinerator by a conveyor that may be loaded either manually or with a forklift truck.

Because of the near certainty that H-3 and C-14 will be released as gaseous products of combustion, ash from burns involving one or both of these radionuclides will be treated like the ash generated during incineration of nonradioactive waste and will be disposed of as a nonradioactive ash in a landfill. If a burn includes one or more of any other radionuclide, the ash will be treated as if it contained all of the radioactivity originally incinerated. If appropriate surveys verify the 10% of the concentrations (in terms of microcuries per gram) specified for water in Appendix B, Table II, 10 CFR 20 are not exceeded, these ash residues will be disposed of as nonradioactive ash. If ash residues are found to exceed 10% of the Appendix B, Table II, concentration limits due to the incineration of known radionuclides, the ash will be segregated and packaged for shipment to a federally licensed burial site.

Ash produced during combustion is automatically removed from the incinerator by a conveyor system that transports ash to a dumpster for volume reduction and further disposal. Since the incineration operation is automated and the radionuclide levels are low, no special precautions, other than normal safety procedures (i.e. protective clothing, gloves, safety glasses, etc.), are required of incinerator operators.

It is not possible to characterize the maximum number of burns of radioactive material to be performed on a weekly or yearly basis since incineration of nonradioactive rubbish is a continuous process. Regardless of the number of burns performed, the activity limits specified in Table 1 will be adhered to.

Dow intends to incinerate solid waste, animal carcasses, tissue, combustible liquids, liquid scintillation vials and fluids and any other combustible waste generated from the use of Dow's byproduct materials license. The Radiation Safety Officers of the Industrial Hygiene Laboratory will monitor the radionuclides and their activities to be incinerated so as not to exceed the limits specified in Table 1.

must specify each radionuclide

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TABLE 1. SUMMARY OF INCINERATION CALCULATIONS

6.6 Ci/yr

Radionuclide	Maximum Activity Incinerated (uCi/day)	Stack* Concentration (uCi/mL)	Table II Concentration Limits (uCi/mL)
H-3	2.20×10^4	2×10^{-8}	2×10^{-7}
C-14	1.10×10^4	1×10^{-8}	1×10^{-7}
Any byproduct material licensed to Dow	**	**	See 10 CFR 20 Appendix B

22 mCi/day

*Based on daily exhaust volume (1.10×10^{12} mL/day)
**Activity incinerated per day will be based on 10% of the most restrictive air and ash concentrations from 10 CFR 20, Appendix B

ITEM 14(b)(2) When applicable, sealed sources may be returned to the manufacturer.

ITEMS 15, 16, AND 17. "RADIATION PROTECTION PROGRAM", "FORMAL TRAINING IN RADIATION SAFETY" AND "EXPERIENCE"

A. RADIATION SAFETY COMMITTEE
B. RADIATION SAFETY OFFICIERS
C. RADIATION PROTECTION PROCEDURES
D. RADIATION SAFETY TRAINING PROGRAM

A. RADIATION SAFETY COMMITTEE

✓L. W. Rampy, Chairman
✓O. U. Anders
F. A. Blanchard
✓D. J. Ducommon, M.D.
✓W. H. Lee

I. Radiation Safety Committee

The Radiation Safety Committe is composed of physicians, engineers, scientists, and management with a broad background in the use of radioisotopes and radiation sources. The Committee has jurisdiction over all activites involving the use of radioactive materials and radiation sources. The Committee is directly answerable to the general manager of the Michigan Division and the corporate director of Research and Development, and will carry out such other duties as are assigned it by these offices. The Committee will meet at least twice a year.

A. Functions

1. Recommend policies regarding radiation safety within Dow Chemical U.S.A.

2. Determine radiation safety policies and standards under all Midland location NRC and state licenses.

3. Receive, review and act on all applications for the use of radiation sources and material in the Midland location used by Dow employees in which a radiation hazard may exist.

4. Receive and review periodic reports from the Industrial Hygiene Laboratory on monitoring, contamination and personnel exposure.

5. Certify employees who may receive and work with radioactive materials or radiataion sources. Interim certification may be granted by the Industrial Hygiene Laboratory.

6. Develop administrative procedures for properly safe-garding against hazards associated with radiation sources and radioactive materials.

7. Evaluate all incidents or defects which may cause a substantial safety hazard and report if necessary.

8. Carry out correspondence with the NRC and state on incident reports, license applications and license amendments.

CURRICULUM VITAE: LARRY WILSON RAMPY

Personal

Home:

Telephone:

Business: Dow Chemical U.S.A.
1803 Building
Midland MI 48640

Telephone: 517/636-6260

Birthdate:
Birthplace:
Home Territory:

Married:
Children:

Education

1961: A.B., Chemistry
Indiana University, Bloomington IN

1963: M.S., Medicinal Chemistry
The University of Michigan, Ann Arbor MI

1966: Ph.D., Medicinal Chemistry
The University of Michigan, Ann Arbor MI
Thesis: The total synthesis of B-homoestrone and approaches to azaestrone

Employment

1961-62: Research Fellow, College of Pharmacy
The University of Michigan, Ann Arbor MI

1962-65: E. Mead Johnson Memorial Fellow
American Foundation for Pharmaceutical Education
The University of Michigan, Ann Arbor MI

1966-Present - The Dow Chemical Company

1966-67: Chemist, Michigan Division Special Assignments, Midland MI
1967-68: Manager, Patent Department, Human Health R&D, Indianapolis IN
1968-71: Assistant to Director, Human Health R&D, Midland MI
1971-73: Research Toxicologist, Toxicology Laboratory, Midland MI
1973-78: Group Leader, Inhalation, Toxicology Laboratory, Midland MI
1978-82: Manager, Industrial Hygiene Laboratory, Midland MI
9/82: Director, Industrial Hygiene Laboratory, Midland MI

Start date in Industrial Hygiene: August 1978

Professional Memberships

American Chemical Society
American Industrial Hygiene Association
Michigan Industrial Hygiene Society

Professional Certifications

1980: Certified in the Comprehensive Practice of Industrial hygiene, American Board of Industrial Hygiene (Certificate #1962)
1980: Diplomate, American Academy of Industrial Hygiene
1980: Diplomate, American Board of Toxicology

Publications: Available upon request.

Date: September 1982

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CURRICULUM VITAE: OSWALD U. ANDERS

Research Scientist
The Dow Chemical Company
Midland, MI 48640

Education

1952: B.S., Georgetown University
1957: Ph.D., Chemistry, University of Michigan

Experience: The Dow Chemical Company, Midland, Michigan

1957: Radiochemist, Neutron Activation Analysis
1963: Associate Scientist, Radiochemistry Research
1967: Supervisor, 100 KW Triga Reactor
1978 - Present: Research Scientist

Other Experience

Carried additional responsibilities for hot cell work, industrial and nuclear decontamination and neutron activation plant stream analyzers. Authored more than 30 scientific papers.

1965-1965: Advisory Board, Analytical Chemistry
1968-1976: Organizing Committee for International Conference - Modern Trends in Activation Analysis
1972-1975: ANS, Executive Committee, Division of Isotopes and Radiation
1975-1976: ANS, Treasurer, Division of Isotopes and Radiation
1976-1977: ANS, Vice Chairman, Division of Isotopes and Radiation
1977-1978: ANS, Chairman, Division of Isotopes and Radiation
1977-Present: Advisory Board, Radioanalytical Chemistry
1979-1981: Secretary, AAS/NRC Subcommittee on Nuclear and Radiochemistry

Memberships

American Chemical Society
American Institute of Chemists
American Nuclear Society
SIGMA XI

CURRICULUM VITAE

NAME:
Fred A. Blanchard

DATE COMPLETED:
Revised 1/13/83

BIRTHPLACE:

BIRTHDATE:

EDUCATION:

School	Degree	Subject	Date
Univ. of Cincinnati	--	Chemical Engr.	1941-43
Louisiana State Univ.	BS	Mech. Engr.	1944
Univ. of Cincinnati	MS	Physics	1948
Univ. of Cincinnati	PhD	Physics (Biophysics)	1951

Additional Studies:

EMPLOYMENT: (LIST MOST RECENT LAST)

Employer	Time Period	Major Responsibility
Cincinnati General Hospital	Jan.-Sept. 1941	Research assistant in cardiology
Hilton Davis Chem. Co.	1941-1943	Co-op chemist in control lab
U.S. Army	1943-1947	Engineering school, draftsman, personnel
Dow Chemical Company		
Radio. Chem.	1951-1970	Applications of radiotracers to industrial and biological problems
Chem. Physics	1970-1971	
Anal. Lab.	1971-1974	
Env. Sci. Res.	1974-present	Environmental Studies

MEMBERSHIPS: (SOCIETIES, ETC.)

American Chemical Society
Sigma XI
AAAS
Society of Environmental Toxicology and Chemistry

SPECIAL ASSIGNMENTS:

Dow Task Force on use of process steam from Nuclear Power Plant

CURRENT JOB TITLE:
Associate Scientist

DR. FRED A. BLANCHARD

Dr. Blanchard attended the University of Cincinnati in Chemical Engineering from 1941 to 1943. He received his undergraduate degree in Mechanical Engineering from Louisiana State University in 1944 and graduate degrees from the University of Cincinnati, an M.S. in Physics in 1948, and a Ph.D. in Physics (biophysics program) in 1951. He was selected to the Tau Beta Pi and Sigma Xi.

In July, 1951, he joined the Dow Chemical Company as a Radiochemist in the Spectroscopy Laboratory, working on a variety of radiotracer applications to industrial analytical problems. He was promoted to Project Leader in the Radiochemistry Laboratory in 1961; was named a Senior Research Chemist in the Analytical Laboratory in 1971, Analytical Specialist in 1972, and Senior Analytical Specialist in 1974.

He is currently in the Environmental Sciences Research Laboratory of the Health and Environmental Research Department of Dow Chemical U.S.A. His principal field of work has been in the applications of radioisotopes to biological, chemical and industrial tracer problems. He has worked extensively with adsorption effects, polyelectrolytes, aqueous gel permeation chromatography, trace amounts of extractives from paper products, residues of cleaning operations, uptake and translocation of herbicides, penetration of wood preservatives, residues of food

additives, bioconcentration effects in fish, biodegradation of organic chemicals, migration of chemicals in soil, and systems for low level monitoring for trace activity in steam and chemical products.

ENVIRONMENTAL SCIENCES RESEARCH
HEALTH & ENVIRONMENTAL RESEARCH
DOW CHEMICAL COMPANY
MIDLAND, MICHIGAN

TRAINING FILE FOR: F. A. Blanchard

Training (Description)	Conducted By	Date From	To
Radioisotope & Radioactivity Safety	L. Silverstein	1955	
Computer Programming in FORTRAN	IBM	1960	
Computer Programming in ALGOL	Comp Lab	1965	
Biometrics	CMU R. E. Building	1981	
Biostatistics	CMU Colin Park	1981	

PUBLICATIONS

"Technique for Growing Plants with Roots in a Sterile Medium," Plant Physiology, Vol. 25, No. 4, pp. 767-769 (1950), F. A. Blanchard, V. M. Diller.

"Uptake of Aureomycin Through the Roots of Phaseolus Lunatus," Am. Jrnl. of Botany, Vol. 38, No. 2, pp. 111-112, Feb. 1951, F. A. Blanchard, V. M. Diller.

"Aureomycin Chemotherapy of Crown Gall in Tomatoes," Phytopathology, Nov. 1959, Vol. XLI, No. 11, pp. 954-958, F. A. Blanchard.

"Effect of Soft X-Rays on Aureomycin," The Ohio Jrnl. of Science, Vol. LIII, No. 6, November 1953, F. A. Blanchard, V. M. Diller, H. Kersten.

"Uptake Ditribution, and Metabolism of Carbon-14 Labeled Trichloroacetate in Corn and Pea Plants," Weeds, Vol. III, No. 3, July 1954, F. A. Blanchard.

"Terpolymer Rubbers: Standardization of Infrared Analysis by Chemical and Radiotracer Methods," Analytical Chemistry, Vol. 31, No. 10, pp. 1612-1615 (Oct. 1959), G. Sterling, J. Cobler, D. Erley, and F. A. Blanchard.

"Synthesis of Carbon-14 Labeled Dalapon and Trial Applications to Soybean and Corn Plants," Ag. and Food Chem., Vol. 8, No. 2, pp. 124 (1960), F. A. Blanchard, W. Muelder, G. N. Smith.

"Use of Submicron Silica to Prevent Count Loss by Wall Adsorption in Liquid Scintillation Counting," Analytical Chemistry, Vol. 33, pp. 975 (June 1961), F. A. Blanchard, I. T. Takahashi.

"A Computer Program for Automated Testing and Reduction of Liquid Scintillation Counting Data," Int. Jrnl. of Applied Rad. and Isotopes, Vol. 14, pp. 213-219 (1963), F. A. Blanchard.

"Liquid Scintillation Counting: Automated Mathematical Fitting and Use of Channels Ratio Methods by Computer Program," Advances in Tracer Methodology, Vol. 4 (1968), F. A. Blanchard, M. R. Wagner, and I. T. Takahashi.

"Liquid Scintillation Counting: Determination of Background Counts of Quenched Samples Using an External Standard Channels Ratio," Anal. Biochem., Vol. 29, pp. 154-163 (1969), I. T. Takahashi, F. A. Blanchard.

"Counting Quenched Liquid Scintillation Samples Using an Outside-the-Instrument Gamma Source and an External Standard Channels Ratio Method," Anal. Biochem., Vol. 35, pp. 411 (1970), I. T. Takahashi, and F. A. Blanchard.

"Quench Correction in Cerenkov Counting: Channels Ratio and External Source Channels Ratio Methods," Anal. Biochem., Vol. 44, pp. 369-380 (1971), A. J. Kamp and F. A. Blanchard.

"Biodegradation of ^{14}C-Phenol by Activated Sludge," At symposium on Processing of Phenolic Wastes; Division of Fuel Chemistry, National ACS meeting, Atlantic City, NJ, September 11, 1974, H. C. Alexander, F. A. Blanchard, and I. T. Takahashi.

"Biodegradability of Methylcellulose by Activated Sludge," Applied and Envir. Microbiology, 32 (4) pp. 557-560 (1976), F. A. Blanchard, I. T. Takahashi, H. C. Alexander.

"Uptake, Clearance and Bioconcentration of ^{14}C-Sec-Butyl-4-Chlorodiphenyl Oxide in Rainbow Trout," F. A. Blanchard, I. T. Takahashi, H. C. Alexander, E. A. Bartlett, Aquatic Toxicology and Hazard Evaluation, ASTM STP634, F. L. Mayer and J. L. Hamelink, Eds., American Society for Testing and Materials, 1977, pp. 162-177.

CURRICULUM VITAE

Dale J. Ducommun, M.D.
Senior Industrial Physician
Dow Chemical U.S.A.
Michigan Division Medical Department
607 Building
Midland, Michigan
(517)636-9795

Home:

Education	Degree
DePauw University	B.A.
University of Iowa	M.S.
University of Iowa	M.D.

Internship

Munson Medical Center, Traverse City, Michigan
Twelve months rotating internship from July 1, 1958 to June 30, 1959

Residencies

Licensure(s)

Michigan
Iowa
Wisconsin
California
New York

Professional Experience and Workplace(s)

Date	Workplace
1959 - 1967	Harrison Radiator Division of General Motors Corporation, Lockport, New York (Assistant Medical Director)
1967 - Present	Dow Chemical U.S.A., MI Division Medical Department

Professional Affiliations

American Academy of Dermatology - Affiliate Member
Aerospace Medical Association - Associate Fellow
Civil Aviation Medical Association - Board of Trustees Member
American Occupational Medical Association - Fellow
Society of Medical Consultants to the Armed Forces - Member
Assocation of Military Surgeons of the U.S. - Member
American Medical Association - Member
Michigan State Medical Society - Member
Midland Medical Center Medical Staff - Member (currently a member of the Pharmacy and Therapuetics Committee)

Publications

The Effect of Hetrazan Upon Experimental Infectious of Trichinella spiralis in the Golden Hampster and Swiss Albino Mouse, Master's Thesis, University of Iowa, 1953.

Civil Aviation Medical Association Bulletin, Editor - 1978 - 1980

Military Service

1959 - 1961 United States Navy, active duty. (Served one year as Research Medical Officer, Naval Unit, Fort Detrick, Frederick, Maryland; the second year as Medical Officer and Industrial Health Officer, Naval Research Laboratory, Washington, D.C. Rank: Lieutenant.) Active in the Naval Reserve previously serving as Commanding Officer of three different medical units. Currently affiliated with PERSMOBTEAM 1713, Naval Reserve Center, Southfield, MI. Rank: Captain. Twenty-seven years satisfactory Federal service.

Public Services

Board of Directors, Visiting Nurse Association of Midland County (Serving second term as Vice President.)

Influenza Coordinating Committee of Midland County - Member, 1976

Board of Directors, Mildand County Chapter of the American National Red Cross - Member, 1968 - 1971

Tri-City Council of the Navy League - Director

Berryhill Post 165 of the American Legion - Member

Quarantine Branch Contract Physician for the Port of Bay City, MI under Center for Disease Control, Atlanta, GA, since 1972.

Federal Aviation Administration - Senior Aviation Medical Examiner

Administrative Board, First United Methodist Church - Member

Naval Reserve Association, Reserve Officers Association, and the National Rifle Association - Life Member of all three associations.

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Master Number: [redacted]　　　　Date Hired: 5/1/67

Marital Status: [redacted]　　　　Spouse' Name: [redacted]

Date of Birth: [redacted]

Dow Work Experience

Publications

Presentations

1968 - 1969 Multiple presentations to Dow-Midland location pipe coverers about the medical effects of asbestos exposure

April, 1970 "Circadian Rhythm and Long Distance Air Travel" talk given at Dow Physicians' Meeting in Houston, TX

May 6, 1971 "Orf" talk at Dow Physicians' Meeting in Ironton, OH

Through the years have given plant talks on "Exercise and Physical Fitness" and "Coronary Risk Factors", others.

Promotions

Staff Physician to Senior Industrial Physician in 1975

Transfers

DJD/srm
typed 8/31/82

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September 21, 1983

RESUME

Personal:

Name: William H. Lee

Address:

Telephone: Home:
Business: (517) 636-3652

Age:

Height:

Weight:

Physical Condition:

Martial Status:

Wife:

Children:

Work History:

Present December 1979 Michigan Division	Manager - Distribution, Safety, Security & Services and member of General Manager's Staff Responsible for Division Traffic, Emergency Response, In-Plant Services, Garages, Shipping and Warehousing, Railroad Operations, Road Maintenance, Stock and Receiving, Loss Prevention, Business Insurance, Security, Safety, Laundry, Mail and Sanitation Services. Approximately 430 salaried and hourly employees.
December 1979 September 1978 Michigan Division	Manager - Traffic, Distribution and General Services and member of Major Manager's Staff Responsible for Division Traffic (rate negotiations for rail, truck and marine scheduling and shipment of product). Emergency Response, In-Plant Services, Garages, Shipping and Warehousing of product, Railroad Operations and Road Maintenance. Approximately 340 salaried and hourly employees.
September 1978 July 1, 1975 Michigan Division	Director of Safety and Health and member of General Manager's Staff Responsible for the safety and health functions for the Michigan Division - 7,500 employees. These responsibilities include Emergency Planning, Fire Department, Fire Protection Engineering, Safety, Industrial Hygiene, Capital Insurance, Workers' Compensation, Medical, Loss Prevention, Plant Protection and Security. Approximately 240 professional, salaried and hourly employees with an annual operating budget of $7 million.
July 1, 1975 June 1974 Rocky Flats Division	Production Manager and Major Building Superintendent and member of Division Management Information Board Responsible for all production at the Rocky Flats Division as well as various supporting functions such as design

engineering and fabrication of tools, jigs, gages and fixtures. The function included responsibility for the rolling, casting, forming, machining and assembling of unique and highly sophisticated parts and components within extremely close tolerances of a wide variety of specialized metals and other materials. Approximately 400 technical, supervisory and hourly employees with an annual operating budget of approximately $8 million.

Major Building Superintendent function included accountability for environmental, health and safety conditions associated with the successful operation of a 200,000 square foot, $50 million complex, with special emphasis on utilities (such as the design, construction and operation of air control including filtration, temperature and humidity control).

June 1974
March 1972
Rocky Flats Division

Fabrication Manager and Major Building Superintendent and member of Division Management Information Board

Responsible for one of the major production units within the Rocky Flats Division, as well as the supporting design engineering and fabrication of tools, jigs, gages and fixtures. The function included responsibility for the rolling, casting, forming and machining of unique and highly sophisticated parts and components within extremely close tolerances of a wide variety of specialized metals and other materials. Approximately 350 technical, supervisory and hourly employees with an annual operating budget of approximately $7 million.

See above for Major Building Superintendent responsibilities.

March 1974
August 1971
Rocky Flats Division

Administration Manager and member of the Rocky Flats Operating Board

Responsibility for Management Systems (Computer Operation for all Rocky Flats), Nuclear Materials Control, Security (Document Accountability and Plant Protection), Purchasing and Traffic. The Purchasing and Traffic functions included responsibilities for procurement, expediting and traffic control of all operating supplies and capital equipment for new construction and additions to the existing plant. Approximately 325 technical, supervisory and hourly employees.

August 1971
February 1970
Rocky Flats Division

Environment Control Manager and member of the Rocky Flats Operating Board

Responsible for Health Physics, Industrial Hygiene, Waste Management, Safety and Loss Prevention, Medical, Fire Department, Nuclear Safety and Utilities (steam, heating and ventilating, water treatment and distribution, and sewage plant). Approximately 400 supervisory, technical and hourly employees.

February 1970
July 1968
Rocky Flats Division

Product Engineering Manager

Responsible for the final design and definition of manufactured product. Also responsible for technical sales and development activities with Design Agencies customers and other operating contractors. Approximately 100 supervisory and technical employees.

July 1968 October 1967 Rocky Flats Division	Albuquerque Plant Manager and member of Rocky Flats Division Operating Board Responsible for the acquisition of a production facility operated by ACFI and its orderly integration into the Rocky Flats operation. Was also responsible for the operations of the existing plant in Albuquerque, New Mexico, for seven months. Approximately 260 supervisory, technical and hourly employees.
October 1967 August 1964 Rocky Flats Division	Product Engineering Manager (See July 1968 to February 1970)
August 1964 May 1962 Rocky Flats Division	Production Control Superintendent Responsible for the scheduling, procurement, shipment and inventorying all production items and materials. Approximately 100 supervisory and hourly employees.
May 1962 February 1958 Rocky Flats Division	Production Control Supervisor Essentially the same responsibility as Production Control Superintendent but on a smaller scale.
February 1958 August 1951 Rocky Flats Division	Plant Engineering Employed as a mechanical engineer and supervisor with various responsibilities in the Plant Engineering Group. Responsible for mechanical design, construction coordination and preparation of proposals for work.

Note: All of the above work experience was with Dow Chemical, U.S.A.

June 1951 January 1951	United States Atomic Energy Commission, Control Branch, Wilmington, Delaware, Mechanical Engineer, Savannah River project.
January 1951 August 1950	United States Geological Survey, General Engineer, Topographic Division, Denver, Colorado

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B. RADIATION SAFETY OFFICIERS

G. W. Engdahl
T. W. Parsons

II. RADIATION SAFETY OFFICIER

A. Responsibilities

1. General surveillance of all activities involving radioactive materials and radiation sources including both personnel and environmental monitoring.

2. Furnish consulting services to personnel at all levels of responsibility on all aspects of radiation protection and applicable regulations.

X 3. Ensure specific procedures for use of radioactive material are developed and implemented.

4. Audit individual radioisotope user's records, techniques and procedures.

5. Routinely monitor all machines and material capable of producing hazardous amounts of penetrating radiations.

6. Distribute personnel monitoring equipment and keep records of internal and external personnel exposure.

7. Notify individuals of significant radiation exposures.

8. Instruct personnel in proper radiation safety procedures, and applicable regulations for the use of radioactive materials.

9. Coordinate the disposal of radioactive waste which includes the keeping of waste disposal records at the Midland location.

10. Storage of all radioactive materials not in current use.

11. Ensure the required leak tests and surveys are performed on sealed sources.

12. Maintain a continuing inventory of all radioactive materials for all licenses.

13. Supervise decontamination in cases of contaminating accidents. This includes health physics supervision and training of laboratory, medical, fire, and plant protection personnel who may be involved in the emergency.

14. Report radiation accidents and incidents to the Committee.

15. Calibrate and certify for use all radiation survey instruments employed.

GORDON W. ENGDAHL
CURRICULUM VITAE
SEPTEMBER, 1983

EDUCATION:

B.A. degree in Chemistry, Cum Laude, Augustana College, 1972.

M.S. degree in Environmental Health with specialties in Radiological Health and Industrial Hygiene, University of Minnesota, 1973.

Professional Qualifications:

Professionally trained in chemistry, environmental health, radiological health and industrial hygiene. Experience includes special projects at the Lawrence Livermore Radiation Laboratory (1973), University of California (air monitoring for radioactivity) and the 3M Company, working with radioactive waste handling, evaluation of radioisotope laboratory ventilation and beta-gauge safety evaluation. Seven years of experience working with the radiation safety program at DOW.

Professional Certifications:

1979 - Certified Industrial Hygienist - Comprehensive Practice - Cert. 1669.

Employment History:

Number of years with Dow Chemical: 10

Experience:

1973 to October, 1976 — Corporate Industrial Hygiene Laboratory. Responsible for Eastern Division radiation safety program coordination. Safety auditing and consulting for Dow Industrial Service radiographic operations. Participation in the planning and power decontamination project. Responsible for TRIGA research reactor health physics, member of reactor operations committee. Experienced in coordinating toxicology, medical and plant operating personnel in industrial hygiene programs.

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October, 1976 to May, 1979 — Dow Europe

Responsible for developing and coordinating industrial hygiene programs for seven manufacturing locations in Italy. Developed a radiological safety program for the manufacturing process involving radioisotope diagnostic kit production.

May, 1979 to May, 1980 — Michigan Division Industrial Hygiene Service

Responsible for coordinating the industrial hygiene program in several manufacturing plants and assisting with the overall management of the Michigan Division industrial hygiene program.

May, 1980 to September, 1982 — Agricultural Products Marketing Department

Dealer marketing specialist responsible for the sales of agricultural chemicals in a midwest territory. Responsibilities included development and implementation of new uses for N-Serve nitrogen stabilizer in the fertilizer market.

September, 1982 to September, 1983 — Agriculture Products Department, Research and Development

Responsible for technical service and development of agricultural products in North Dakota and Minnesota. Provided technical support to Ag field salesmen. Established University test plots to evaluate ag products and gain supporting performance data for marketing.

September, 1983 to present — Corporate Industrial Hygiene Laboratory

Responsible for the radiation safety program coordination. Coordination of the industrial hygiene programs in an area of the corporate operation.

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Professional Activities:

Health Physics Society - 1972 to 1980.

American Industrial Hygiene Association - 1974 to present.

American Academy of Industrial Hygiene - 1979 to present.

TRACY WAYNE PARSONS

PERSONAL:

Business Address: 474 Building, Midland, Michigan 48640
Business Telephone: (517)636-5641
Birthdate:
Marital Status:
Sex:
Height:
Weight:

EDUCATION:

1977: B.S., Environmental Health
Purdue University, W. Lafayette, Indiana

1977: Summer Health Physics Fellow
Brookhaven National Lab, Upton, New York

1980: M.S., Health Physics
Purdue University, W. Lafayette, Indiana

EMPLOYMENT:

1977 - 1979: Graduate Instructor in Research
Bionucleonics Department
Purdue University, W. Lafayette, Indiana

1979 - Present: The Dow Chemical Company, Midland, Michigan

1979 - 1981: Industrial Hygienist, Industrial Hygiene Laboratory

1981 - 1983: Research Industrial Hygienist, Industrial Hygiene Laboratory

1983 - : Research Industrial Hygienist, Industrial Hygiene Services

PROFESSIONAL EXPERIENCE:

I have administered a radiation health and safety program for various NRC licenses (Type A Broad Scope, TRIGA Reactor, Source Material and Special Nuclear Material) and State of Michigan authorized x-ray machines and accelerators. Primary areas of emphasis included sealed and unsealed isotopes, instrument calibration, personal dosimetry, waste management, environmental monitoring and ALARA training.

I have supervised various health physics project teams and have coordinated industrial hygiene programs for several chemical production and research facilities.

PROFESSIONAL MEMBERSHIPS:

Health Physics Society
Great Lakes Chapter, Health Physics Society

C. RADIATION PROTECTION PROCEDURES

1. Loose Radioisotope Procedures
2. Sealed Source Owner and User Responsibilities

In reference to Regulatory Guide 10.5 subnote 7, Dow will update or improve radiation procedures without prior notification (license amendment) of the NRC. For example, the following changes would not require NRC notification; (1) changes dictated by NRC Rule changes, (2) changes in internal management forms, (3) changes in contracted waste disposal firms, (4) changes in personal dosimeter contractor or (5) other changes of similar nature. The significance of the change and thus the need for NRC notification would be determined by the Radiation Safety Committee and/or Radiation Safety Officer.

1. LOOSE RADIOISOTOPE PROCEDURES

The following section pertains to those individuals who supervise and/or work with loose radioisotopes. It should be the goal of all individuals involved to provide a safe working environment, ensure public safety, and avoid contamination of equipment and facilities.

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A. Supervisor Responsibility, in Advance of Any Isotope Work

1. Attend a session on "Radiation Information for Supervisors" to gain familiarity with Nuclear Regulatory Commission regulations and supervisor's responsibilities.

2. Discuss with the employees the work to be done and the necessary safety precautions in accordance with Code of Federal Regulations, Title 10, Chapter 1, Part 19.

X3. Outline in writing the procedure for each job (make the amount of detail commensurate with the hazard). When an experiment involves the use of medium or high level radioisotopes, (as defined on page 8) a protocol of the experiment should be submitted to the Industrial Hygiene Laboratory for review.

4. Stock the laboratory with plastic or rubber gloves, lab coats, warning tags and labels, wipes, appropriate survey/counting instruments, forms for necessary records, plastic bags and tape for waste disposal, absorbent paper, etc. The use of good procedures is greatly facilitated by having proper tools/supplies AT HAND.

5. Have available and use when appropriate, remote handling devices, automatic pipettes or dispensers, tongs, etc., for the manipulation and transfer of radioactive preparations.

6. Obtain proper training for individuals who have access or work in restricted areas. Personnel such as janitors and building managers who have routine access to restricted areas are required to attend a Class I radiation training course conducted by the Industrial Hygiene Laboratory prior to working in the area. All radiation training can be arranged with the Industrial Hygiene Laboratory by calling 636-0860.

7. Provide for the instruction of those employees for whom they are responsible in the use of safe techniques and the application of approved radiation safety practices.

x 8. Contact the Industrial Hygiene Laboratory whenever major changes in operational procedures, new techniques, alteration in physical plant (e.g. the removal of radiochemical fume hoods) or when new operations which might lead to personnel exposure are anticipated.

9. Comply with the regulations governing the use of radioactive material as established by the Nuclear Regulatory Commission and the Dow Radiation Safety Committee for:

   a. Procurement of radioactive materials by purchase or transfer.

   b. Posting of notices to workers as required by 10 CFR 19.11.

   c. Posting of caution signs where radioisotopes are kept or used, or where radiation fields may exist.

   d. Record the receipt, transfer and disposal of radioactive materials in his/her area.

   e. Assure that the Industrial Hygiene Laboratory is notified of all radioactive waste disposal.

   f. Prevent the transfer of radioactive materials to unauthorized individuals. This includes the proper disposition of radioactive materials possessed by terminating workers.

   g. Keep the stock of stored radioactive materials to a minimum within the work areas. Establish designated areas for storage of radioactive materials when not needed for current research.

   h. Furnish the Industrial Hygiene Laboratory with the following reports at the end of each calendar quarter:

      (1) inventory report of radioisotopes

      (2) survey summary report of all wipe testing and/or radiation surveys completed

B. Individual User Responsibility

1. Obtain proper training given by the Industrial Hygiene Laboratory. Handlers or possessors of loose materials upon successful completion of training will be given written certification by the Radiation Safety Committee. Periodic review or retraining is expected to be obtained to maintain certification.

2. Keep his/her exposure to radiation as low as is reasonably achievable.

3. When ordering radioactive materials order only the amount needed not by unit price, if at all possible, to limit excess waste.

4. Designate and label a storage area for radionuclides. Keep them there when not in immediate use.

5. Measure and record the radiation levels (in mR/hr) in the work and storage area and adjacent non-controlled areas, with an appropriately calibrated detector (e.g. air ionization chamber). A GM or scintillation probe is useful to detect "hot spots" even if not calibrated for that particular energy. Provide sufficient shielding to keep radiation exposures as low as is reasonably achievable and always below established limits.

6. Designate and label the radioactive work area(s). Consider the consequences of leakage or equipment failure. Choose nonporous benchtops. Cover work surfaces with absorbent paper that has plastic backing to protect furniture and facilitate cleanup. Use stainless steel or plastic trays to help confine liquids if spilled. All contaminated tools should be set aside for special attention when cleaning.

7. When working with radioactive materials, wear a lab coat and plastic or rubber gloves for protection of clothes and skin. To avoid spread of contamination, remove gloves at work area before leaving laboratory.

8. Where appropriate wear personnel radiation monitors (TLD, film, dosimeter, etc.) on body and hands while working. Bioassay tests are the principal means for evaluating possible internal exposure to radionuclides such as C-14 and H-3 (see Laboratory Work Conditions F.4.).

9. Confine work with gaseous, volatile or dust-forming radioactive material to hoods or glove boxes, if at all possible.

10. Confine radioactive solutions in covered containers plainly identified and labeled with name of compound, radionuclide, date, activity, and radiation level if applicable. Do not use glass containers if practicable. Never use glass to house strong alpha emitters due to weakening of glass. Aqueous liquid waste that is to be stored in a freezer should not be stored in glass containers.

11. Never pipette radioactive solutions by mouth. Mechanical devices shall be used.

12. Prohibit eating, drinking, smoking or applying cosmetics in radioisotope work areas. Failure to do so can lead to accidental ingestion of radioactive material.

13. Never perform extensive radiochemical work with hazardous levels of material until the procedure has been tested by a "dry run" to preclude unexpected complications. Aerosoling problems should be addressed if applicable.

14. Supply fiber paks lined with plastic bags or appropriate containers for radioactive waste and contaminated glassware at the work location. If waste is in liquid form, absorbent material should also be present. Label containers so that custodial employees do not empty. Avoid transporting contaminated articles from the work area through clean lab areas. Shield the waste containers as required to prevent unnecessary exposure.

15. Hands, feet and clothing should be checked with a thin window GM meter for contamination after handling radioactive materials at the end of the day and <u>always</u> before eating. Radioactive work areas should be surveyed as necessary.

16. In case of spill or other accident, alert nearby personnel, confine spill, block off and mark area, decontaminate, and monitor before moving temporary signs or barricade. If personnel contamination is involved, remove contaminated outer clothing, wash and monitor skin, and report to Medical. Report all accidents and injuries involving radioactive material to the Industrial Hygiene Laboratory and laboratory supervisor.

17. The individual responsible for a spill is responsible for decontamination. Do not use custodial personnel unless specifically assigned the task by the laboratory supervisor.

18. Keep "hot" vials and syringes in shielded containers. Always use protective barriers when the radiation emitted warrants shielding.

C. Classification of Laboratory Areas

1. Since the laboratories within buildings vary widely with regard to maximum activity, physical and chemical form of radionuclides, and the various procedures involving byproduct material, it is proper to attempt some classification. The purpose of classification is to determine how frequently the laboratory should be surveyed. The method recommended, which is taken from Report of Committee V, ICRP, 1965, designates 3 levels (low, medium, high) of survey frequency based on radionuclide, activity, and use. On the table on page 8, multiply the activity range under low, medium and high survey frequency by the appropriate modifying factor.

Classification of Isotopes According to Relative Radiotoxicity per Unit Activity

Group 1

Pb-210	Po-210	Ra-223	Ra-226	Ra-228	Ac-227	Th-227	Th-228	Th-230
Pa-231	U-230	U-232	U-233	U-234	Np-237	Pu-238	Pu-239	Pu-240
Pu-241	Pu-242	Am-241	Am-243	Cm-242	Cm-234	Cm-244	Cm-245	Cm-246
Cf-249	Cf-250	Cf-252						

Group 2

Na-22	Cl-36	Ca-45	Sc-46	Mn-54	Co-56	Co-60	Sr-89	Sr-90
Y-91	Zr-95	Ru-105	Ag-110m	Cd-115m	In-114m	Sb-124	Sb-125	Te-127m
Tc-129m	I-124	I-125	I-126	I-131	I-133	Cs-134	Cs-137	Ba-140
Ce-144	Eu-152(13 y)		Eu-154	Tb-160	Tm-170	Hf-181	Ta-182	Ir-192
Tl-204	Bi-207	Bi-210	At-211	Pb-212	Ra-224	Ac-228	Pa-230	Th-234
U-236	Bk-249	MFP						

Group 3

Be-7	C-14	F-18	Na-24	Cl-38	Si-31	P-32	S-35	A-41
K-42	K-43	Ca-47	Sc-47	Sc-48	V-48	Cr-51	Mn-52	Mn-56
Fc-52	Fc-55	Fc-59	Co-57	Co-58	Ni-63	Ni-65	Cu-64	Zn-65
Zn-69m	Ga-72	As-73	As-74	As-76	As-77	Sc-75	Br-82	Kr-85m
Kr-87	Rb-86	Sr-85	Sr-91	Y-90	Y-92	Y-93	Zr-97	Nb-93m
Nb-95	Mo-99	Tc-96	Tc-97m	Tc-97	Tc-99	Ru-97	Ru-103	Ru-105
Rh-105	Pd-103	Pd-109	Ag-105	Ag-111	Cd-109	Cd-115	In-115m	Sn-113
Sn-125	Sb-122	Te-125m	Te-127	Te-129	Te-131m	Te-132	I-130	I-132
I-134	I-135	Xe-135	Cs-131	Cs-136	Ba-131	La-140	Ce-141	Ce-143
Pr-142	Pr-143	Nd-147	Nd-149	Pm-147	Pm-149	Sm-151	Sm-153	Eu-152
Eu-155	Gd-153	Gd-159	Dy-165	Dy-166	Ho-166	Er-169	Er-171	(9.2 hr)
Tm-171	Yb-175	La-177	W-181	W-185	W-187	Re-183	Re-186	Re-188
Os-185	Os-191	Os-193	Ir-190	Ir-194	Pt-191	Pu-193	Pt-197	Au-196
Au-198	Au-199	Hg-197	Hg-197m	Hg-203	Tl-200	Tl-201	Tl-202	Pb-203
Bi-206	Bi-212	Rn-220	Rn-222	Th-231	Pa-233	Np-239	H-3	O-15
A-37	Ni-59	Zn-69	Gc-71	Kr-85	Sr-85m	Rb-87	Y-91m	Zr-93
Nb-97	Tc-96m	Tc-99m	Rh-103m	In-113	I-129	Xe-131m	Xe-133	Cs-134m
Ca-135	Sm-147	Re-187	Os-191m	Pt-193m	Pt-197m	Th-232	Th-Nat	U-235
U-238	U-Nat							

TO

INFORMATION FOR CLASSIFYING LABORATORIES*

Radionuclide Group**	Survey Frequency Category: Low	Medium	High
1	<10 μCi	10 μCi to 1 mCi	>1 mCi
2	<1 mCi	1 mCi to 100 mCi	>100 mCi
3	<100 mCi	100 mCi to 10 Ci	>10 Ci

Proportional fractions are to be used for more than one isotope.

Modifying Factors	Factors
Simple storage	x100
Very simple wet operations (e.g. preparation of aliquots of stock solutions)	x10
Normal chemical operations (e.g. analysis, simple chemical preparations)	x1
Complex wet operations (e.g. multiple operations, or operations with complex glass apparatus)	x0.1
Simple dry operations (e.g. manipulation of powders) and work with volatile radioactive compounds	x0.1
Exposure on nonoccupational persons	x0.1
Dry and dusty operation (e.g. grinding)	x0.01

The object is to determine how often to survey the laboratory. To do this, multiply the activity range under low, medium, and high survey frequency by the appropriate modifying factor to construct a new set of mCi ranges for low, medium, and high survey frequency.

EXAMPLE: A lab in which 10 mCi of Group 2 radionuclide is used in normal chemical operations should be surveyed on a medium frequency. However, if only simple storage is done, then a low frequency is adequate (<1 mCi x 100 = <100 mCi new low range). But if a dry grinding operation is done, a high frequency is required (>100 mCi x 0.01 = >1 mCi new high range).

*Patterned after the Recommendation of the International Commission on Radiological Protection-Report of Committee V, Pergamon Press, New York, New York (1965).

**See table on page 9.

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D. Minimum Frequency of Survey

Low level areas -- Not less than once per month.
Medium level areas -- Not less than once per week.
High level areas -- Not less than once per normal working day.

E. Method of Survey

Routine surveys should be carried out in two parts to determine both radiation levels and removable contamination levels.

1. Radiation levels

This may be waived when using C-14 and H-3, however, spot checking for contamination does apply. Monitoring area with a radiation survey meter sufficiently sensitive to detect 0.1 mR/hr. The results of this survey should be recorded on a standard form which should show:

a. Location, date, and type of equipment used.

b. Identification of person conducting the survey.

c. Drawing of area surveyed, identifying relevant features such as active storage areas, active waste areas, etc.

d. Measured exposure rates, keyed to location on drawing (point out rates that require corrective action).

e. Corrective action taken in the case of excessive exposure rates, reduced exposure rates after corrective action, and any appropriate comments.

2. Contamination levels

A series of wipe tests should be taken in all areas where activity is handled in unsealed form. The location of wipe tests should be indicated on the above mentioned survey form and should be chosen for maximum probability of contamination, e.g. areas where individual doses are drawn up, incoming packages received, frequent pipetting carried out.

Floors, particularly adjacent to doorways, lead syringe shields, refrigerator handles, and door and drawer handles should also be wipe tested frequently. Care should be taken that cross contamination does not occur.

A thin window GM or gas flow proportional counter normally may be used for assaying beta emitters at or above C-14 energies; low energy beta emitters will require liquid scintillation counting.

A gamma scintillation counter (e.g. NaI well counter), should be used for pure gamma emitters. Make sure that the analyzer threshold is set below the lowest gamma energy used in the lab (usually I-125).

Record a background count of 5-10 minutes using the same counting conditions used with the wipes.

In the case of wipes contaminated with gamma emitters, the radionuclide can be identified from successive counts with different analyzer settings if the settings have been calibrated with known energy standards.

F. Acceptable limits

1. Radiation dose limits

a. Noncontrolled area

Personnel must not receive >2 mRem in any one hour, or >100 mRem in 7 consecutive days, or >500 mRem in any one year.

b. Controlled area

An employee's total exposure must be ≤1.25 Rem/13 wks. On a basis of 40 hour/wk of exposure, the maximum exposure rate would have to be ≤2.5 mR/hr. In practice, the radiation levels should be kept as low as is reasonably achievable and always below applicable limits.

c. Personnel dose limits

Area of Exposure	Rems/calendar quarter
Whole body; head and trunk; active blood-forming organs; lens of eyes; or gonads	1.25
Hands and forearms; feet and ankles	18.75
Skin of whole body	7.50

The limit for air and water concentrations must be kept below the levels listed in 10 CFR 20, Appendix B, Table I, Column 1, "Standards for Protection Against Radiation" contained in Section III of this manual.

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2. Contamination limits

An individual wipe test should routinely cover approximately 100 cm^2. Ideally, any removable contamination more than a few dpm above background should be cleaned up; however, a more usual level for beta and gamma at which cleanup is initiated is about 50 dpm. At approximately 1000 dpm for beta and gamma and 100 dpm for alpha, a contamination zone should be established until the contamination is removed.

Contamination levels may also be estimated with a survey meter. As a rough rule of thumb, establish a contamination zone if readings are >100 cpm for Group 1 and 2 radionuclides and >1000 cpm for group 3 radionuclides when measured with a thin window GM meter. Of course, this particular instrument will not detect low energy beta emitters such as tritium.

3. Airborne radioactivity monitoring

The sampling of the workroom airborne activity is generally required when the use of radioactive materials is not controlled by exhaust ventilation or complete enclosure. However, in some cases it may be demonstrated that because of the physical state, the low volatility and/or the use of a special handling technique, the airborne radioactivity is negligible and air sampling is not warranted. The need for air sampling should be determined as follows:

a. Exhaust ventilation and/or enclosure available

If approved local exhaust ventilation and/or complete enclosure are provided during the use or handling of radioactive materials, an extensive sampling program for airborne radioactivity is not required but spot sampling to document nonexposure is advisable.

The user must be sure that releases to unrestricted areas from the exhaust ventilation system are within the limit specified in Tab[illegible] 2 of Appendix B, 10 CFR 20.

b. Use of isotope without enclosure or ventilation control

Due to the potential for inhalation exposures to airborne radioactive materials, the use of radioactive materials without enclosure or ventilation control will require special procedures and precautions. To ensure that the exposure is as low as reasonably achievable, sampling of workroom air while the radioactive material is being used is required in order to document satisfactory exposure. The amount and type of sampling will depend on the following:

(1) the radioisotope

(2) the volatility

(3) the amount being used

(4) the frequency of use

(5) how the material is used, and

(6) the duration of the project.

A health physicist of the Industrial Hygiene Laboratory should be consulted when the project is in the planning stage in order to design a suitable sampling program. In general, if the use of a radioisotope in a calendar quarter is less than one quarter of Appendix B, Table 1, Column 1 times 6.3×10^8 ml there is no need for air sampling.

4. Biological monitoring

Biological monitoring should be considered for medium and high level radioisotope work. The need for biological monitoring should be determined as follows:

a. High level contamination from infrequent events.

b. Variable but repeated contamination of the work area.

c. Suspected accidental inhalation or ingestion.

d. High air sampling results.

5. Personnel monitoring

The following personnel monitoring devices for external radiation shall be used as decided by a health physicist from the Industrial Hygiene Laboratory.

a. Film badge or TLD dosimeter

Shall be used when the external whole body radiation dose has the potential to exceed 300 millirem (mRem) per calendar quarter. Film badge or TLD dosimeters shall also be used by anyone entering a radiation area (>5 mRem/hr).

For lost or damaged badge, an administrative dose of 417 mrem will be assigned to the individual.

b. Extremity badge (finger ring)

Shall be used if external extremity (hands or arms) exposure has the potential to exceed 4000 mRem/calendar quarter.

G. Documentation and Record Keeping

The following documents of records need to be preserved in order to meet the Nuclear Regulatory Commission requirements:

1. Radioisotope inventory

While the Industrial Hygiene Laboratory maintains an overall inventory of isotopes for the Midland location license, each isotope owner is responsible for keeping an accurate inventory of isotopes in his/her possession. To obtain an accurate balance of isotopes in an owner's possession, records of the quantity and date of the isotope received, transferred, shipped, and disposed of as waste should be kept. <u>All</u> <u>transactions</u> regarding the owner's inventory should be reported to the Industrial Hygiene Laboratory so that the overall inventory can be updated.

2. Records of radiation survey and monitoring results

   All records of radiation surveys and wipe test results should be preserved for a period of seventy-five years from the day of the survey.

3. Records of radiation dose and radioactive waste disposal.

   Results of personnel air sampling, bioassay, radiation surveys which are used to determine radiation dose, and results of surveys to determine radioactive effluents to the environment are to be kept indefinitely or until the Nuclear Regulatory Commission has authorized their disposal.

4. Protocols (for medium and high level) which have been reviewed by the Industrial Hygiene Laboratory shall be kept until the end of the project and final monitoring of the laboratory has been performed and documentation of records completed.

5. Documentation of environmental releases shall be kept indefinitely.

H. Posting Requirements for Working with Radioactive Materials

1. Area posting

   Certain areas where exposure to radioactive materials could occur must be posted with approved caution signs. The name and home telephone number of the individual responsible for the area should also be posted to facilitate contact in case of emergency. All signs can be obtained from the Industrial Hygiene Laboratory. The following radiation signs should be posted as appropriate:

   a. "Caution Radiation Area"

      Should be posted in an area where whole body radiation levels are >5 mRem/hr or >100 mRem in five consecutive days.

   b. "Caution High Radiation Area"

      Should be posted in an area where whole body radiation levels are >100 mRem/hr.

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RADIATION TRAINING RECORD

Name ______________________________ Dow Phone No. __________
(Last) (First) (Middle)

Department ______________________________ Building __________

Charge Number ______________ Sex ________ Dow Master No. __________

Social Security No. ____________________ Birthdate __________

Radiation experience prior to Dow? ☐ Yes ☐ No

If yes, was personal dosimetry provided? ☐ Yes ☐ No

If yes, please include the following information (use reverse side if needed).

____

Employer Contact Person

____

Street Address City State Zip Code

Additional training and remarks:

Class of Training: ☐ I ☐ II ☐ III

Type of Radiation Source: ☐ Unsealed __________ ☐ Sealed __________

☐ Radiation Machine ____________________ ☐ Other __________

The fundamentals of radiation have been explained emphasizing the specific hazards of the radiation source used. I understand the procedures for ordering, receiving and disposing of radiation sources. My responsibilities have been explained according to 10CFR19.12 and Michigan Department of Public Health Rule 213.

Females only, I have read and understand Regulatory Guide 8.13 "Instruction Concerning Prenatal Radiation Exposure" and Michigan Department of Public Health Rule 203. ______ (Initials)

Signed ______________________________ Date __________
(Applicant)

Signed ______________________________ Date __________
(Health Physicist)

Signed ______________________________ Date __________
(Radiation Safety Committee)

For Office Use Only

Permanent ______ or Temporary (months) ______ Badge (type) & No. __________

Job code ____________________ License __________

TLD Ring No. ____________________

IX. Radiation Protection Program
   A. Responsibilities
   B. Exposure and Contamination Control
      1. Exposure
      2. Contamination
      3. Signs and Labels
   C. Personnel Exposure Control
   D. Emergency Procedures (Planning)
   E. Waste
   F. Inspections

X. Summary

XI. Definitions

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c. "Caution Airborne Radioactivity Area"

Should be posted in an area where the airborne activity levels of the radionuclide exceed the MPC (Maximum Permissible Concentration). This is specified in Appendix B, Table 1, Column 1 of 10 CFR 20, contained in Section D of this manual.

d. "Caution Radioactive Materials"

Each area or room where radioactive materials are used or stored if the quantities are more than specified in Appendix C of 10 CFR 20. Designated storage cabinets or refrigerators should also be posted with this sign.

2. Container labeling

a. "Caution Radioactive Materials"

Any equipment or containers which come in contact with radioactive materials should be labeled with this sign. If equipment is under direct surveillance the labeling requirement can be waived. The signs on any equipment or container which do not contain radioactive material shall be removed.

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I. Procedures for Ordering, Receiving, Unpackaging and Transferring of Radioactive Materials

1. Ordering

Because of Nuclear Regulatory Commission license limitations, the Industrial Hygiene Laboratory should be informed before any orders are placed for radioactive materials.

The initiator must be sure that his/her requisition and purchase order contain the following:

"Package containing radioactive material must bear a label: 'DO NOT OPEN. CONTACT INDUSTRIAL HYGIENE, 636-0860, IMMEDIATELY UPON RECEIPT'"

Copies of the requisition and purchase order must be sent to the Industrial Hygiene Laboratory, 1803 Bldg.

If the order is phoned in, contact the Industrial Hygiene Laboratory with the amount of material ordered and when it will arrive.

Route all shipments through the Receiving Department.

If refrigeration is required upon arrival, the user should have a refrigerator designated for radioactive materials storage and be prepared to pick up the package upon arrival. No refrigeration will be provided at the Receiving Department.

2. Receiving

Only approved individuals may receive and use radioactive material.

Promptly upon receipt of any package identified as containing radioactive material, call the Industrial Hygiene Laboratory, 636-0860, before opening.

Wipe testing may be required within 3 hours of arrival; refer to Page 20.

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3. Reporting

If leakage of radioactivity of excessive levels (>22,000 dpm/100 cm^2, >200 mR/hr contact, or 10 mR/hr at 3 ft.) of radiation are measured on incoming packages, a report must be made promptly to the Nuclear Regulatory Commission. Reporting shall be done only by a health physicist or a member of the Radiation Safety Committee.

4. Opening

Procedures for opening packages follow. Nuclear Regulatory Commission regulations require that procedures be established and followed, with proper consideration for special instructions from the supplier. To assure the safety of Dow employees and compliance with regulations, the Industrial Hygiene Laboratory must be advised of all packages received, <u>before they are opened</u>.

Table 2. EXEMPT (LIMITED QUANTITY) AND TYPE A QUANTITIES

DOT 49 CFR 173.391 Transport Group	Upper Limit of Exempt Quantity (in millicuries)	Type A Limit (in curies)
I	.01	0.001
II	0.1	0.050
III	1.	3.
IV	1.	20.
V	1.	20.
VI	1.	1000.
VII	25000.	1000.
Special Form	1.	20.

EXCEPTIONS

Isotope	Form	Amount (mCi) (Upper limit of exempt quantity)
C-14	Normal	<10
H-3	Normal	<10
I-125	Normal	<10
Sealed Source	Special	<20,000
Any isotope with T 1/2 of <30 days	Normal	<100

Isotopes received in amounts greater than or equal to upper limit of exempt quantity in Table 2 above, (exceptions listed above) must be wipe tested within three hours of arrival. Additionally, if the isotope content is greater than Type A the external surface must be surveyed.

OPENING SMALL PACKAGES

LESS THAN UPPER LIMIT EXEMPT QUANTITY IN TABLE 2

1. Visual Inspection

   Any visual evidence of damage is reason to make a wipe test for leakage, before proceeding.

2. Supplier's Instructions

   Any special instructions for opening must be read before opening and must be followed carefully.

3. Survey the package and document the results.

4. Open the package carefully in an acceptable hood.

5. Inspect the package at each layer of packaging for visual evidence of leakage. Do not proceed if leakage is suspected. Call the Industrial Hygiene Laboratory, 636-0860. Keep the package and associated materials isolated in the hood.

6. Remove the isotope container and place it in storage.

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TYPE A

OPENING LARGE PACKAGES

GREATER THAN UPPER LIMIT EXEMPT QUANTITY IN TABLE 2

1. All procedures outlined for opening small packages apply; additionally:
2. Provide plastic sheet or other contamination protection, adequate for packaging materials to be removed.
3. Provide wipe test, personnel monitoring and survey equipment appropriate to task.
4. Provide for storage container and site.
5. Proceed to open, following supplier's instructions and Industrial Hygiene's precautions.
6. Wipe test for contamination if any leakage is suspected at each layer of packaging. Do not proceed without Industrial Hygiene's approval if there is detectable contamination.
7. Remove the sample and store as prearranged in Step 4.
8. Survey storage site and document survey results.
9. Clean up area and package all radioactive waste for storage.
10. Monitor area by wipe test to assure cleanliness.
11. Monitor all participants.

2. SEALED SOURCE OWNER & USER RESPONSIBILITIES

TRAINING

Prior to working directly with the sources (not to be construed to mean riggers, electricians or those not working on the source itself) one must obtain approval from the Radiation Safety Committee. This is accomplished by successfully completing a radiation training course given by the Industrial Hygiene Laboratory. A signed "Radiation Training Record" is documentation of this training. See page 4.

A. Source User Responsibilities

1. Keeping his/her exposure to radiation as low as reasonably achievable.

2. Code of Federal Regulations, Title 10, Chapter 1, Part 20.101 requires the following external occupational dose limits to be observed.

Part of Body	Quarterly Dose (rems) Limit	Annual Dose (rems) Limit
Whole body, gonads, active blood-forming organs, head and trunk, lens of eyes	1.25	5
Skin of whole body	7.5	30
Hands and forearms, feet and ankles	18.75	75

3. Each individual must have approval from the Industrial Hygiene Laboratory before exceeding a daily whole body dose of 50 mRem.

   a. Wearing the prescribed monitoring equipment such as film badges, TLD's and pocket dosimeters.

   b. Survey the areas near the source, documenting the survey results and posting each area as required by 10 CFR 20.203.

4. Personnel doses shall be controlled as follows:

   a. Utilizing all appropriate protective measures such as:

      (1) Using protective barriers and other shields whenever possible.

      (2) By maximizing the distance between you and the source by using mechanical devices whenever their aid will assist in reducing exposure.

      (3) Planning the job so the time spent in radiation areas is minimized.

5. Immediately reporting to the Industrial Hygiene Laboratory any defect or incident which could cause a substantial safety hazard.

B. Supervisor's Responsibilities

Supervisors are responsible for ensuring that the preceding individual responsibilities are discharged by those under their control, and are further responsible for:

1. Adequate planning. Before an experiment or job is performed, the supervisor should determine the types and amount of radiation or radioactive material to be used. This will generally give a good indication of the protection required. The procedure must be well outlined. In many cases, before the procedure is actually performed with radiation, it should be rehearsed so as to preclude accidents, minimize exposures and unexpected circumstances. In any situation where there is appreciable radiation hazards, the Industrial Hygiene Laboratory shall be consulted before proceeding.

2. Instructing those employees for whom they are responsible in the use of safe techniques and the application of approved radiation safety practices.

3. Furnish the Industrial Hygiene Laboratory with information concerning individuals and activities in their areas particularly, pertinent changes in their personnel rosters. This requires immediate notification of new or terminating personnel.

4. Contacting the Industrial Hygiene Laboratory whenever major changes in operational procedures, new techniques, or when new operations which might lead to personnel exposure are anticipated.

5. Ensuring that all personnel have obtained a signed "Radiation Training Record" prior to working with radioisotopes. Contact the Industrial Hygiene Laboratory for training sessions.

6. Complying with the regulations governing the use of radioactive materials, as established by the Nuclear Regulatory Commission and the Dow Radiation Safety Committee for the following.

   a. Correct procedure for the procurement of radioactive samples.

   b. Proper posting of work areas where radioactive materials are kept or used or where radiation fields may exist. This may include caution signs and general posting such as Nuclear Regulatory Commission Form 3.

   c. Ensuring that all radioactive waste material is disposed of properly.

OBTAINING RADIOACTIVE SOURCES

Sealed radioactive sources may be obtained in two ways. (1) Ordering from another company and (2) internal transfers.

A. Ordering from another company

1. Ordering

Because of Nuclear Regulatory Commission license limitations, the Industrial Hygiene Laboratory should be informed before any orders for radioactive materials are initiated.

The initiator must be sure that his requisition and purchase order contain the following:

"Package containing radioactive material must bear a label: 'DO NOT OPEN. CONTACT INDUSTRIAL HYGIENE, 636-0860, IMMEDIATELY UPON RECEIPT'"

Copies of the requisition and purchase order must be sent to the Industrial Hygiene Laboratory, 1803 Building.

If the order is phoned in, contact the Industrial Hygiene Laboratory with the amount of material and when it will arrive.

Route all shipments through the Receiving Department.

2. Receiving

Only approved individuals may receive and use radioactive material.

Promptly upon receipt of any package identified as containing radioactive material, call the Industrial Hygiene Laboratory, 636-0860, before opening.

3. Opening

Nuclear Regulatory Commission regulations require that procedures be established and followed, with proper consideration for special instructions from the supplier. To assure the safety of Dow employees and compliance with regulations, the Industrial Hygiene Laboratory must be advised of all packages received, before they are opened.

4. Reporting

If leakage of radioactivity of excessive levels (>22,000 dpm/cm^2, >200 mR/hr contact, or 10 mR/hr at 3 ft.) of radiation are measured on incoming packages, a report must be made promptly to the Nuclear Regulatory Commission. Reporting shall be done only by a health physicist or a member of the Radiation Safety Committee.

B. Internal transfer of sealed radioactive sources

1. A sealed source owner is assigned to each sealed source within The Dow Chemical Company. The owner is responsible for all uses of the source and the source should not be worked on or moved without his and Industrial Hygiene approval. The source itself has a unique number assigned to it for Industrial Hygiene accounting purposes. The source number is found on a 2 x 2 tag.

All communications on sealed sources should include the Dow source number, the isotope and the amount (number of curies).

C. Transferring of Source and its Responsibilities

1. Contact the proposed sealed source owner to inform the individuals of the impending transfer. Inform the individual that the Industrial Hygiene Laboratory will certify ownership.

2. Contact the Industrial Hygiene Laboratory to set up a time with the proposed owner for an owner certification meeting. See page 5.

3. In the event that the source is being installed for the first time it will be necessary to contact the Industrial Hygiene Laboratory so that the source can be removed from storage and wipe tested.

4. Contact the individuals needed to remove, move, and install the source (i.e. electricians, riggers, service station, etc. The Industrial Hygiene Laboratory should be informed of the time and date of the move.

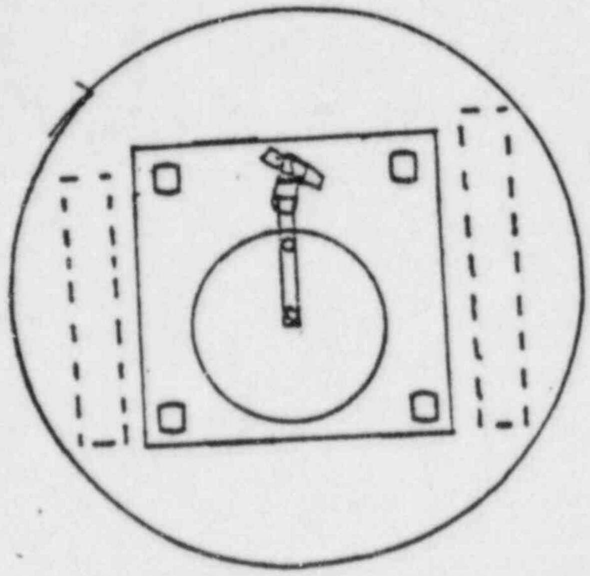
5. If the source is being moved from an on-line process, lock the source shutter shut and survey. If the source is not on-line see #7 below.

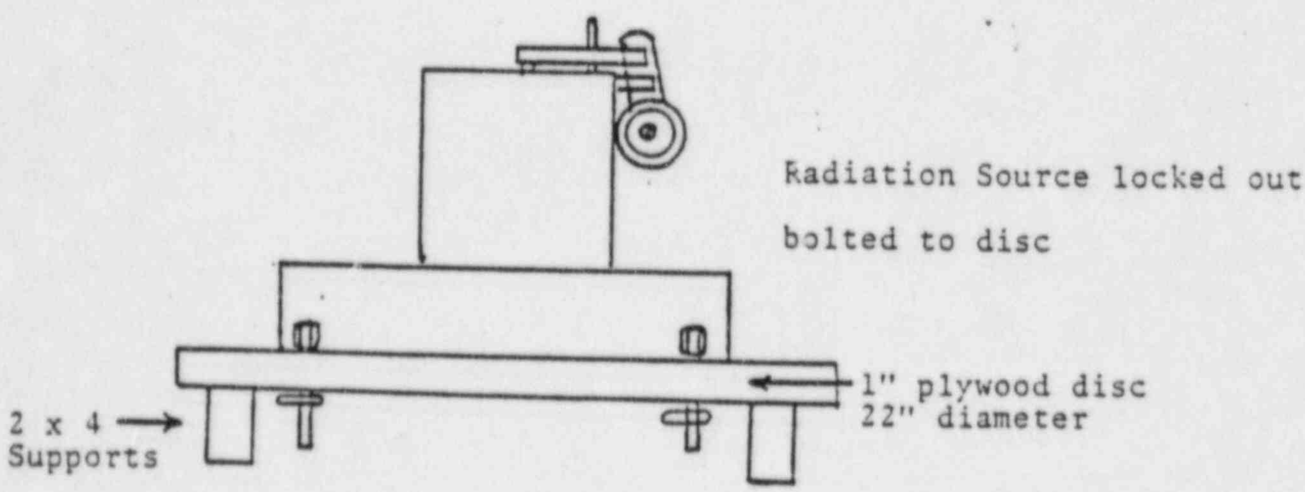
6. Remove the source from the position and survey before loading on vehicle and move to new location provided survey reads less than 5 mR/hr at 1 foot from all points. (If greater, notify the Industrial Hygiene Laboratory immediately.)

7. Install and survey source being certain new owner is aware of source's presence. Document and notify the Industrial Hygiene Laboratory of the results.

8. The source should be removed from storage and installed in the same day. Under no circumstances should a source be left unattached and uncontrolled overnight.

TOP VIEW





SIDE VIEW

WORKING WITH SEALED SOURCES

If sealed radioactive sources are handled properly, they pose no hazard to the user. Failure to follow safe handling procedures could result in a serious injury, a citation, fine, and loss of our Nuclear Regulatory Commission license.

Most sealed sources can produce measurable external radiation levels. It is necessary to know how to measure the radiation levels near a source and the regulations for posting requirements. Contact Industrial Hygiene for specific instructions in your area.

Only the external radiation hazard is of concern with sealed radioactive sources. Sources which are found to be leaking radioactive material beyond 0.005 µCi are removed from service. If you have a source which may be leaking contact the Industrial Hygiene Laboratory immediately. Therefore, internal radiation exposure is not a concern with sealed sources.

Remember, minimize radiation exposure by time, distance and shielding.

The general procedures for handling sealed sources are as follows:

A. Personnel monitoring

Anyone who works with sealed sources which have the potential for a whole body radiation area >5 mRem/hr must wear a personnel dosimeter. Contact the Industrial Hygiene Laboratory for these dosimeters. Once the proper personnel monitoring equipment has been obtained, the source can be surveyed.

1. Film badge or TLD dosimeter

   Must be used when the external whole body radiation dose is likely to exceed 300 mRem/calendar quarter or 60 mRem/calendar quarter for individuals under 18 years of age. Film badge or TLD dosimeters shall also be used by anyone entering a radiation area (>5 mRem/hr).

   For a lost or damaged badge, an administrative dose of 417 mRem will be assigned to the individual.

2. Extremity badge (finger ring)

   Should be used if external extremity (hands or arms) is likely to exceed 4000 mRem/calendar quarter.

   The need for personnel monitoring and the type of monitors should be determined by consulting a health physicist of the Industrial Hygiene Laboratory.

B. Survey and documentation

Before a radiation survey of a sealed source can begin, the type of radiation emitted and which meter to use must be known. The survey results should be documented. Once the external radiation levels have been determined, the proper signs must be posted.

C. Posting

Signs may be obtained from the Industrial Hygiene Laboratory. The areas which must be posted are as follows:

1. "Caution Radiation Area"

   If the whole body dose of 5 mRem/hr exists at a distance of >1 ft. of source.

2. "Caution Radioactive Materials"

   If an area has a sealed source in excess of the quantities of Appendix C, 10 CFR 20.

3. "Caution High Radiation Area"

   At the point where a whole body dose of 100 mRem/hr exists. This area requires constant direct surveillance or securing the area.

D. Nonradiation hazards

When one is overconcerned about one particular hazard there may be a tendency to forget about the other hazards. Don't forget about securing the source, an unsecured heavy radiation source could be more hazardous from falling on someone than from the radiation. Also when electrical equipment is involved make sure you are properly trained and use the correct techniques and tools. Don't be blinded by the radiation symbol. Approach with common sense.

E. Complete work

One of the most important words when considering work on radiation sources is planning. Have you planned ahead? What type of radiation will I be exposed to? What levels of radiation will exist? What type of protective equipment will I need? What type of signs will I need? What type of people will I need to support my task? Where will I do my task? These types of questions need to be answered and provided for before work with a sealed source is begun. Often a procedure will be useful in working with a sealed source.

DISPOSAL OF SEALED SOURCES

All sealed radioactive sources need to be accounted for. Disposal must be accomplished through the Industrial Hygiene Laboratory and source owner.

D. DOW RADIATION SAFETY TRAINING PROGRAM

The Dow Chemical Company requires that all employees who work with radioactive material participate in a formal training program which ensures the safe use and understanding of ionizing radiation. The employee's level of instruction is dependent upon the potential for radiation exposure. Individuals who routinely work with radioactive material have a greater hazard potential than those individuals not directly involved with radiation. Therefore, routine radioisotope users receive a more intensive training program.

During the training program, employees are instructed in the aspects of radiation protection related to their work and the applicalbe regulations. Radiation definitions, radiation work procedures, and radiation work responsibilities are also discussed.

The levels of training are not rigid but are subject to evaluation by the Dow Radiation Safety Officer. This evaluation will result in hybrid training courses tailored to meet the specific needs of the employees. A training outline is attached. The Radiation Safety Officer covers any portion or all of the outline dependent on the need of the individual being trained.

At the end of the training session, a radiation training record sheet is filled out (see enclosed copy), signed and dated by the individual trained, the Radiation Safety Officer doing the training and the Chairman of the Radiation Safety Committee. The training records are kept of file in the radiation safety office.

Direct supervision by department supervisors is used to determine competency. In the event that supervision within each department feels an individual needs additional training health physics is notified and a more intensive training session is held. Periodic safety meetings within each department are held to update and upgrade the department's awareness and safety standards.

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TRAINING OUTLINE

I. Course Description
   A. Introduction
   B. Objectives
   C. Lesson Format
   D. Responsibility

II. Radiation Fundamentals
   A. The Nature of Radioacitivity
   B. Sources of Radioactivity
      1. Natural
      2. Manmade
   C. Types of Radiation
      1. Alpha
      2. Beta
      3. Gamma, X-Ray
      4. Neutron
   D. Decay Characteristics
      1. Half Life
      2. Energy
      3. Decay Mode

III. Units of Radiation
   A. Curie
   B. Roentgen
   C. Rad
   D. Rem

IV. Radiation Exposure Calculations
   A. Point Gamma Sources
   B. Shielding Effects
      1. Attenuation
      2. Half Valve Layer
   C. Source Strengths

V. A. General Principles
   B. Survey Instruments
      1. Ionization Chamber
      2. Geiger-Mueller Counter
   C. Personal Monitoring
      1. Film Badge
      2. Pencil Dosimeters
      3. Thermoluminescent Dosimeters
   D. Leakage Measurements

VI. Biological Effects of Radiation
   A. Celluar Damage
   B. Acute Symdrome
      1. Hematopoietic
      2. Gastrointestinal
      3. Central Nervous
   C. Chronic
      1. Cancer
      2. Genetic
      3. Prenatal/Postnatal (Regulatory Guide 8.13)
   D. Risks of Radiation Exposure

VII. Protection From Radiation
   A. As Low As Reasonably Achievable (ALARA)
   B. External Exposure Control
      1. Time
      2. Distance
      3. Sheilding
   C. Internal Exposure Control
      1. Contamination Control
      2. Contamination Prevention
      3. Respiratory Protection

VIII. Radiation Protection Standards
   A. Standard Setting Organizations
      1. Recommendations
      2. Regulations
      3. Regulatory Guide
      4. Licenses
   B. Pertinent NRC Regulations
      1. 10 CFR 19, 20, and 21
      2. Dose Limits
         a. history
         b. present standards
         c. maximum permissable concentrations
      3. Personal Monitoring
      4. Posting Requirements
         a. radioactive materials area
         b. radiation area
         c. high radiation area
         d. airborne radioacitivity area
      5. Reporting and Records Requirements
      6. Receiving Requirements
         a. license requirements
         b. surveys
      7. Waste Disposal
   C. DOT Regulations
      1. Packaging
      2. Labels
      3. Marking
      4. Contamination Control
      5. Certification