Impact on Detector Size/Geometry and Measured "Contact" Radiation Level Measurements

Background:

10 CFR 71.47 requires that "… each package of radioactive materials offered for transportation must be designed and prepared for shipment so that under conditions normally incident to transportation the radiation level does not exceed 2mSv/h (200mRem/h) at any point on the external surface of the package ..."

The measured radiation levels on external package surfaces are significantly dependant on the geometry of the detector used and the distance from the external surface of the package being measured to the "effective center" of the detection device.

To demonstrate this, measurements were performed using an Eberline RO-3 ion chamber and a Xetex Telescan Geiger detector at the Westinghouse Columbia Nuclear Fuel Facility. Radiation level measurements were obtained on contact with the bottom dome of UF6 cylinders that have essentially been emptied of low enriched UF6. (See exhibits 1-3 and the attached Comparison Between Contact Readings Using a Telescan Versus an RO3, prepared by J. Rankar).

The energy response curves for the different instruments are essentially identical in the energy range of the photons emitted by Pa234m and Pa234, the predominant radioactive material contributing to the radiation levels being measured. (See the attached excerpts, taken from the Radiological Health Handbook, Jan. 1970 edition).

Exhibit 1 shows the detector position for measurements taken with the RO3 instrument on "contact with the surface of the cylinder. In this case, the "effective center" of the RO3 ion chamber is approximately 2¼ inches from the surface being measured.

Exhibit 2 shows the detector position for measurements taken with the Telescan instrument where the "effective center" of the Telescan Geiger Tube is approximately 2 and ¼ inches from the surface being measured. This is the same distance from the surface being measured as the "effective center" of the RO3 ion chamber when the RO3 is placed on "contact" of the surface being measured as in exhibit 1).

Exhibit 3 shows the detector position for measurements taken with the Telescan instrument on contact with the surface of the cylinder. In this case, the "effective center" of the RO3 ion chamber is approximately 5/8 inches from the surface being measured.

- The contact readings obtained using the Telescan instrument yield significantly larger radiation level values than the RO3. This is because the distance from the surface of the cylinder to the "effective center" of the Telescan Geiger tube is much less than the distance from the surface being measured and the "effective center" of the RO3 ion chamber.

- It is also evident that when the distance between the surface of the cylinder and the "effective center" of the Telescan Geiger tube is equal to the distance from the surface of the cylinder and the "effective center" of the RO3 ion chamber, the measured radiation levels are equal.

Conclusion:

- Properly calibrated detectors with similar energy response characteristics and differing overall dimensions such that, the distance to the "effective center" of the detectors from the surface being measured are different, will yield different contact radiation level measurement results. The smaller the distance to the "effective center" of the detection device from the surface being measured, the higher the measured value will be. The converse of this statement would also be true.

Rodney D. Likes
Sr. Regulatory Engineer
Integrated Safety Engineering
Westinghouse Electric Company

Rod Likes 2/19/2001

Comparison Between Contact Readings Using a Telescan versus an RO-3

A study was performed in mid-December 2000 and on January 18, 2001 to compare the difference in contact readings between the Telescan (Geiger- Mueller probe) and the RO-3 (ion chamber probe). In addition, a study was performed to compare the difference between the readings on the Telescan and RO-3 when the probe centers were placed at an equal distance from the measured surface. The size of the probes is different so the center point of the different probes varies by 1.625 inches. This study was performed on UF6 cylinders stored on the UF6 Pad. The measurements were taken on the center of the bottom dome.

When contact readings are performed, the probe is placed in contact with the surface and there is no adjustments made for equalizing the probe centers. A contact reading with any probe is the probe in contact with the surface. When the probe size is considerably different, significantly different readings are obtained measuring the same point. This is the case with the Telescan versus the RO-3. When the probe centers are equalized, there is little difference between the readings.

All readings in mrem/hour

Cylinder Number	RO-3 Contact	Telescan Contact	Telescan center equal to RO-3
EURODIF 0040B	50	78	62
EURODIF 0004B	110	150	110
URENCO 20.892-47	100	150	100

These results are contact comparisons between the different instruments.

Cylinder Number	RO-3 Contact	Telescan Contact
LU2343	145	240
LU2202	100	150
LU2349	60	100
LU2489	19	24

At a variety of levels, there is a significant difference between the contact readings with a Telescan versus an RO-3. With different facilities using different instruments, discrepancies in measurement results can occur especially approaching the transportation limits. This can result in one facility releasing a shipment as acceptable and another facility reporting the shipment as above the limits.

Jim Rankar
Integrated Safety Engineer
Environment, Health and Safety
Westinghouse Nuclear Fuel
Columbia, South Carolina
803-647-3221

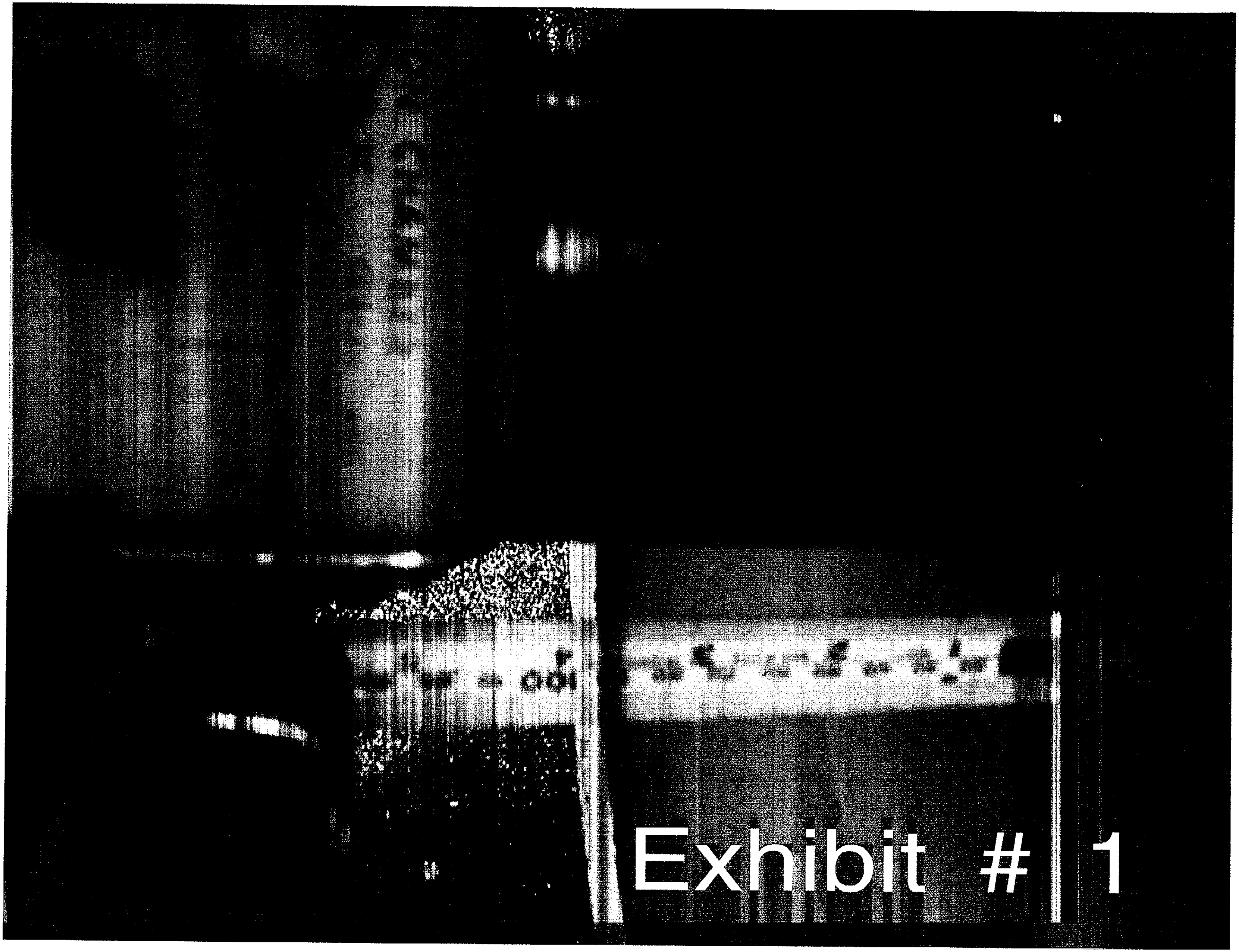


Exhibit # 1

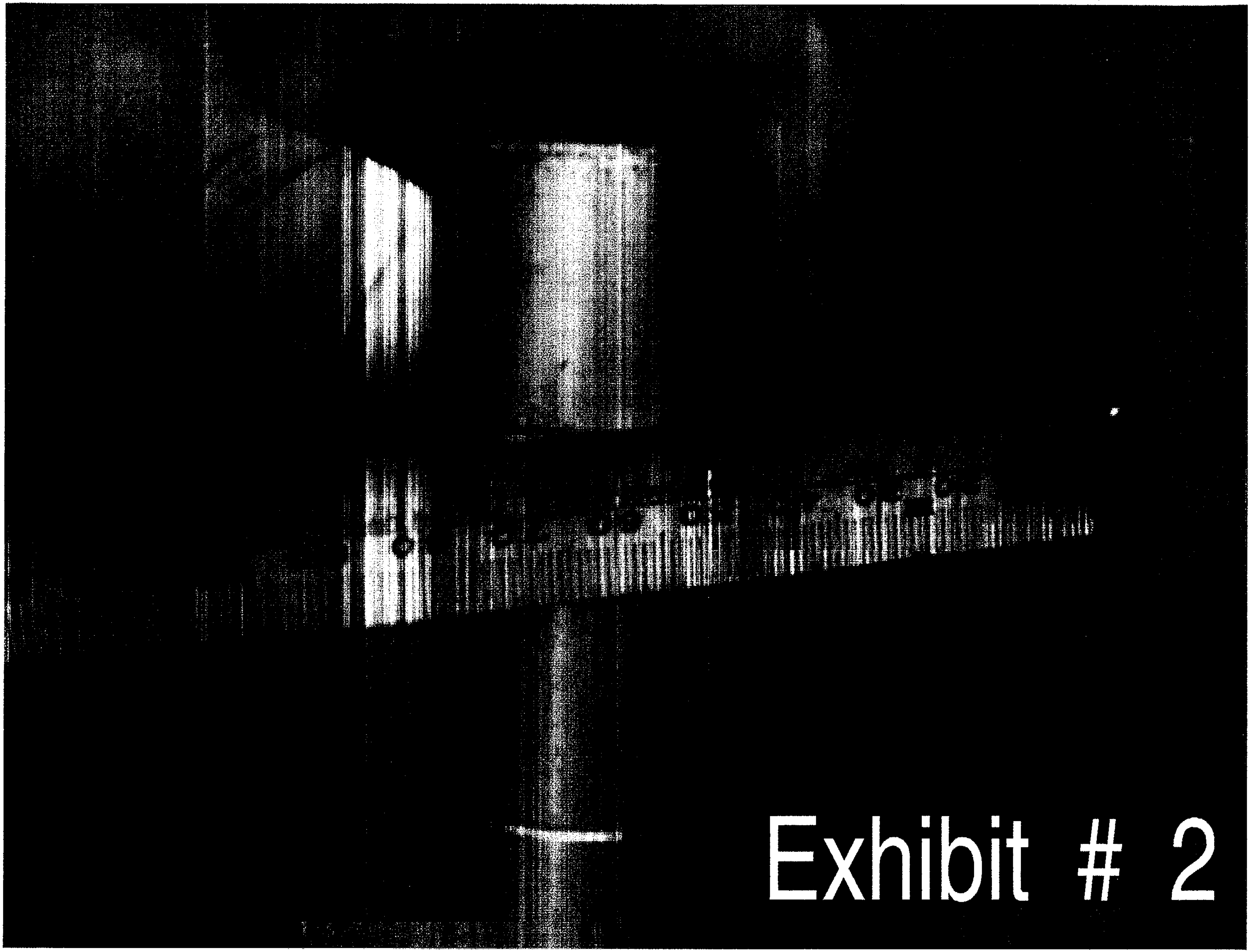


Exhibit # 2

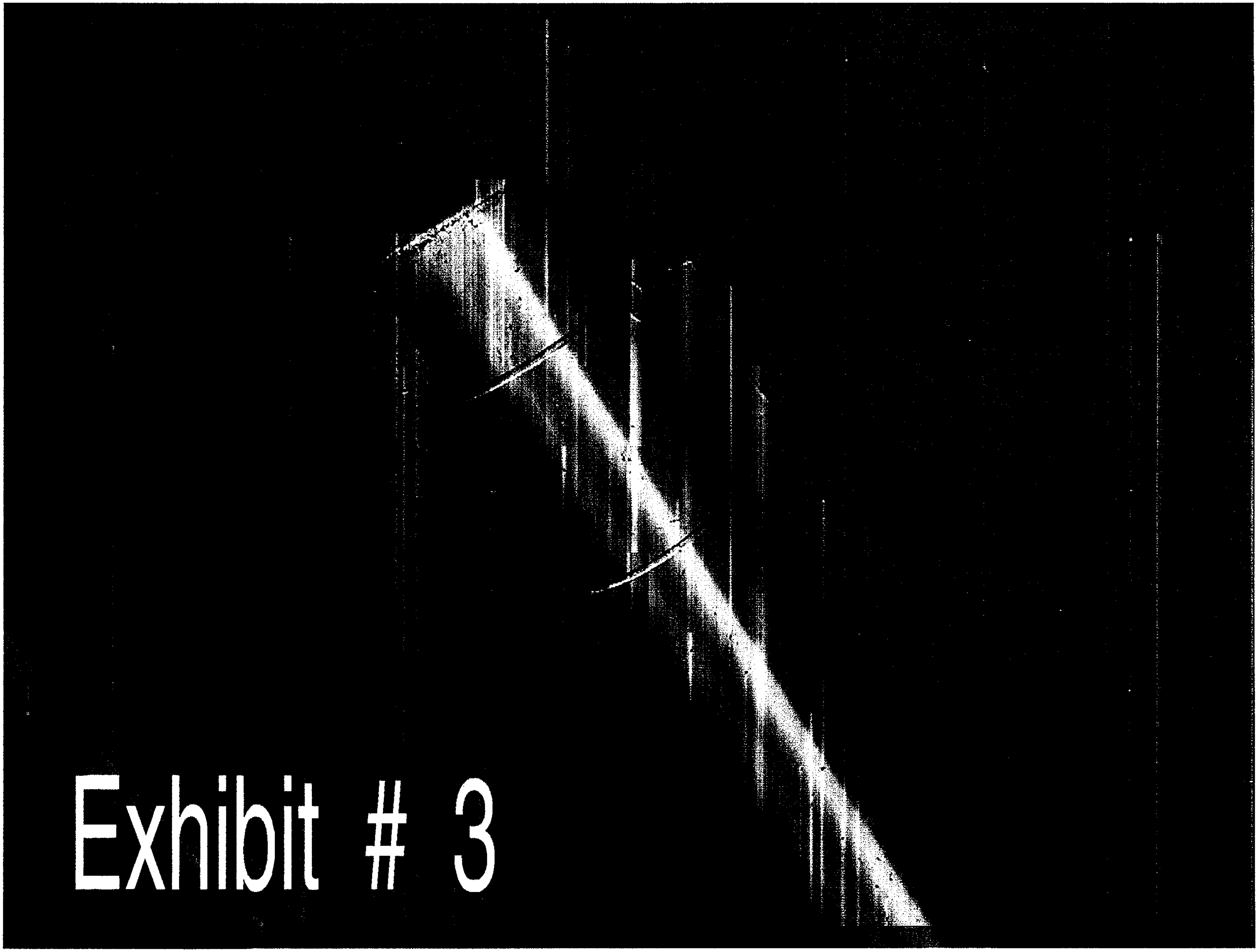
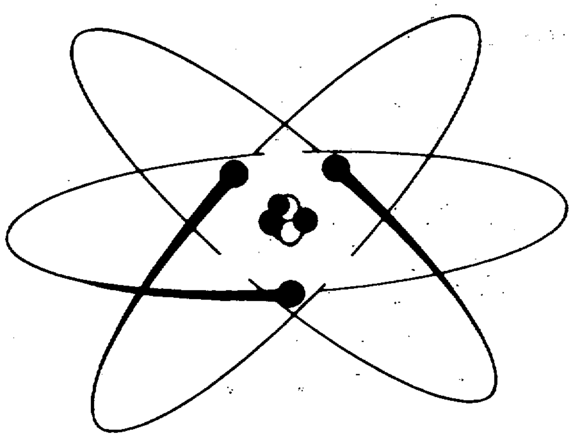


Exhibit # 3

RADIOLOGICAL HEALTH HANDBOOK



REVISED EDITION
JANUARY 1970

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Public Health Service

Uranium Series (4n + 2)*

Nuclide	Historical name	Half-life	Major radiation energies (MeV) and intensities† α	β	γ
$^{238}_{92}U$	Uranium I	4.51×10^9 y	4.15 (25%) 4.20 (75%)	---	---
$^{234}_{90}Th$	Uranium X_1	24.1d	---	0.103 (21%) 0.193 (79%)	0.063c‡ (3.5%) 0.093c (4%)
$^{234}_{91}Pa^m$ (99.87%, 0.13%)	Uranium X_2	1.17m	---	2.29 (98%)	0.765 (0.30%) 1.001 (0.60%)
$^{234}_{91}Pa$	Uranium Z	6.75h	---	0.53 (66%) 1.13 (13%)	0.100 (50%) 0.70 (24%) 0.90 (70%)
$^{234}_{92}U$	Uranium II	2.47×10^5 y	4.72 (28%) 4.77 (72%)	---	0.053 (0.2%)
$^{230}_{90}Th$	Ionium	8.0×10^4 y	4.62 (24%) 4.68 (76%)	---	0.068 (0.6%) 0.142 (0.07%)
$^{226}_{88}Ra$	Radium	1602y	4.60 (6%) 4.78 (95%)	---	0.186 (4%)
$^{222}_{86}Rn$	Emanation Radon (Rn)	3.823d	5.49 (100%)	---	0.510 (0.07%)
$^{218}_{84}Po$ (99.98%, 0.02%)	Radium A	3.05m	6.00 (~100%)	0.33 (~0.019%)	---
$^{214}_{82}Pb$	Radium B	26.8m	---	0.65 (50%) 0.71 (40%) 0.98 (6%)	0.295 (19%) 0.352 (36%)
$^{218}_{85}At$	Astatine	~2s	6.65 (6%) 6.70 (94%)	? (~0.1%)	---
$^{214}_{83}Bi$ (99.98%, 0.02%)	Radium C	19.7m	5.45 (0.012%) 5.51 (0.008%)	1.0 (23%) 1.51 (40%) 3.26 (19%)	0.609 (47%) 1.120 (17%) 1.764 (17%)
$^{214}_{84}Po$	Radium C'	164μs	7.69 (100%)	---	0.799 (0.014%)
$^{210}_{81}Tl$	Radium C''	1.3m	---	1.3 (25%) 1.9 (56%) 2.3 (19%)	0.296 (80%) 0.795 (100%) 1.31 (21%)
$^{210}_{82}Pb$	Radium D	21y	3.72 (.000002%)	0.016 (85%) 0.061 (15%)	0.047 (4%)
$^{210}_{83}Bi$ (~100%, .00013%)	Radium E	5.01d	4.65 (.00007%) 4.69 (.00005%)	1.161 (~100%)	---
$^{210}_{84}Po$	Radium F	138.4d	5.305 (100%)	---	0.803 (0.0011%)
$^{206}_{81}Tl$	Radium E''	4.19m	---	1.571 (100%)	---
$^{206}_{82}Pb$	Radium G	Stable	---	---	---

*This expression describes the mass number of any member in this series, where n is an integer.
Example: $^{206}_{82}Pb$ (4n + 2)......4(51) + 2 = 206

†Intensities refer to percentage of disintegrations of the nuclide itself, not to original parent of series.

‡Complex energy peak which would be incompletely resolved by instruments of moderately low resolving power such as scintillators.

Data taken from: Table of Isotopes and USNRDL-TR-802