FORM NRC-313 I (1-79) 10 CFR 30

U.S. NUCLEAR REGULATORY COMMISSION

APPLICATION FOR BYPRODUCT MATERIAL LICENSE
INDUSTRIAL

See attached instructions for details.

Completed applications are filed in duplicate with the Division of Fuel Cycle and Material Safety, Office of Nuclear Material Safety, and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555 or applications may be filed in person at the Commission's office at 1717 H Street, NW, Washington, D. C. or 7915 Eastern Avenue, Silver Spring, Maryland.

1. APPLICATION FOR: *(Check and/or complete as appropriate)*

XXX a. NEW LICENSE

b. AMENDMENT TO LICENSE NUMBER

c. RENEWAL OF LICENSE NUMBER

2. APPLICANT'S NAME *(Institution, firm, person, etc.)*
RADIATION MEASUREMENTS, INC.
TELEPHONE NUMBER: AREA CODE – NUMBER EXTENSION
312-949-4290

3. NAME OF PERSON TO BE CONTACTED REGARDING THIS APPLICATION
GRANT R. WILTON
TELEPHONE NUMBER: AREA CODE – NUMBER EXTENSION
312-949-4290

4. APPLICANT'S MAILING ADDRESS *(Include Zip Code)*
RADIATION MEASUREMENTS, INC.
407 B WASHINGTON BLVD.
MUNDELEIN, ILLINOIS 60060

5. STREET ADDRESS WHERE LICENSED MATERIAL WILL BE USED *(Include Zip Code)*
407 B WASHINGTON BLVD.
MUNDELEIN, ILLINOIS 60060

(IF MORE SPACE IS NEEDED FOR ANY ITEM, USE ADDITIONAL PROPERLY KEYED PAGES.)

6. INDIVIDUAL(S) WHO WILL USE OR DIRECTLY SUPERVISE THE USE OF LICENSED MATERIAL *(See Items 16 and 17 for required training and experience of each individual named below)*

	FULL NAME	TITLE
a.	GRANT RICHARD WILTON	PRESIDENT
b.		
c.		

7. RADIATION PROTECTION OFFICER
GRANT RICHARD WILTON

Attach a resume of person's training and experience as outlined in Items 16 and 17 and describe his responsibilities under Item 15.

8. LICENSED MATERIAL

LINE NO.	ELEMENT AND MASS NUMBER A	CHEMICAL AND/OR PHYSICAL FORM B	NAME OF MANUFACTURER AND MODEL NUMBER (If Sealed Source) C	MAXIMUM NUMBER OF MILLICURIES AND/OR SEALED SOURCES AND MAXIMUM ACTIVITY PER SOURCE WHICH WILL BE POSSESSED AT ANY ONE TIME D
(1)	Am		EMSL - LAS VEGAS	10^4 dpm/gram
(2)	Sr^{89}	1 N HCL	AMERSHAM SMZ .24	0.54 uCi
(3)	Sr^{90}	1 N HCL	AMERSHAM SIZ .04	0.05 uCi
(4)				

LINE NO.	DESCRIBE USE OF LICENSED MATERIAL E
(1)	
(2)	EFFICIENCY CALIBRATION OF PROPORTIONAL COUNTER
(3)	SAME
(4)	SAME

Applicant June 3 III
Check No. 1004 $230
Amount Remitted $230
Type of Fee app
Date Check Rec'd 6/3/85
Received By C.G.

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9. STORAGE OF SEALED SOURCES

LINE NO.	CONTAINER AND/OR DEVICE IN WHICH EACH SEALED SOURCE WILL BE STORED OR USED. A.	NAME OF MANUFACTURER B.	MODEL NUMBER C.
(1)	SEE ATTACHED SHEET		
(2)			
(3)			
(4)			

10. RADIATION DETECTION INSTRUMENTS

LINE NO.	TYPE OF INSTRUMENT A	MANUFACTURER'S NAME B	MODEL NUMBER C	NUMBER AVAILABLE D	RADIATION DETECTED (alpha, beta, gamma, neutron) E	SENSITIVITY RANGE (milliroentgens/hour or counts/minute) F
(1)	PROPORTIONAL COUNTER	GAMMA PRODUCTS	G 110	1	ALPHA, BETA	> 100,000 cpm
(2)	ALPHA COUNTER	LUDLUM MEASUREMENTS	2000	1	ALPHA	50,000 cpm
(3)	GEIGER COUNTER	LUDLUM MEASUREMENTS	14C	1	ALPHA, BETA GAMMA	2000 mRem/hr
(4)	GEIGER-MUELLER PROBE	LUDLUM MEASUREMENTS	44-7	1	SAME	2000 mRem/hr

11. CALIBRATION OF INSTRUMENTS LISTED IN ITEM 10

[X] a. CALIBRATED BY SERVICE COMPANY

NAME, ADDRESS AND FREQUENCY (ANNUALLY)
LUDLUM MEASUREMENTS
P.O. BOX 510, 510 OAK STREET
SWEETWATER, TEXAS 79556

[X] b. CALIBRATED BY APPLICANT

Attach a separate sheet describing method, frequency and standards used for calibrating instruments.
SEE ATTACHED SHEET FOR INSTRUMENT CALIBRATION

12. PERSONNEL MONITORING DEVICES

TYPE (Check and/or complete as appropriate.) A	SUPPLIER (Service Company) B	EXCHANGE FREQUENCY C
☐ (1) FILM BADGE ☐ (2) THERMOLUMINESCENCE DOSIMETER (TLD) ☐ (3) OTHER (Specify): ______	SEE ATTACHED SHEET	☐ MONTHLY ☐ QUARTERLY ☐ OTHER (Specify): ______

13. FACILITIES AND EQUIPMENT (Check were appropriate and attach annotated sketch(es) and description(s).

[X] a. LABORATORY FACILITIES, PLANT FACILITIES, FUME HOODS *(Include filtration, if any)*, ETC.
[X] b. STORAGE FACILITIES, CONTAINERS, SPECIAL SHIELDING *(fixed and/or temporary)*, ETC.
☐ c. REMOTE HANDLING TOOLS OR EQUIPMENT, ETC.
☐ d. RESPIRATORY PROTECTIVE EQUIPMENT, ETC.

14. WASTE DISPOSAL

a. NAME OF COMMERCIAL WASTE DISPOSAL SERVICE EMPLOYED ADCO SERVICES
TINLEY PARK, ILLINOIS

b. IF COMMERCIAL WASTE DISPOSAL SERVICE IS NOT EMPLOYED, SUBMIT A DETAILED DESCRIPTION OF METHODS WHICH WILL BE USED FOR DISPOSING OF RADIOACTIVE WASTES AND ESTIMATES OF THE TYPE AND AMOUNT OF ACTIVITY INVOLVED. IF THE APPLICATION IS FOR SEALED SOURCES AND DEVICES AND THEY WILL BE RETURNED TO THE MANUFACTURER, SO STATE

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INFORMATION REQUIRED FOR ITEMS 15, 16 AND 17

Describe in detail the information required for Items 15, 16 and 17. Begin each item on a separate page and key to the application as follows:

15. RADIATION PROTECTION PROGRAM. Describe the radiation protection program as appropriate for the material to be used including the duties and responsibilities of the Radiation Protection Officer, control measures, bioassay procedures *(if needed)*, day-to-day general safety instruction to be followed, etc. If the application is for sealed source's also submit leak testing procedures, or if leak testing will be performed using a leak test kit, specify manufacturer and model number of the leak test kit.

16. FORMAL TRAINING IN RADIATION SAFETY. Attach a resume for each individual named in Items 6 and 7. Describe individual's formal training in the following areas where applicable. Include the name of person or institution providing the training, duration of training, when training was received, etc.

    a. Principles and practices of radiation protection.

    b. Radioactivity measurement standardization and monitoring techniques and instruments.

    c. Mathematics and calculations basic to the use and measurement of radioactivity.

    d. Biological effects of radiation.

17. EXPERIENCE. Attach a resume for each individual named in Items 6 and 7. Describe individual's work experience with radiation, including where experience was obtained. Work experience or on-the-job training should be commensurate with the proposed use. Include list of radioisotopes and maximum activity of each used.

18. CERTIFICATE

(This item must be completed by applicant)

The applicant and any official executing this certificate on behalf of the applicant named in Item 2, certify that this application is prepared in conformity with Title 10, Code of Federal Regulations, Part 30, and that all information contained herein, including any supplements attached hereto, is true and correct to the best of our knowledge and belief.

WARNING.–18 U.S.C., Section 1001; Act of June 25, 1948; 62 Stat. 749; makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

a. LICENSE FEE REQUIRED *(See Section 170.31, 10 CFR 170)*	b. CERTIFYING OFFICIAL *(Signature)* Grant R. Wilton c. NAME *(Type or print)* GRANT R. WILTON
(1) LICENSE FEE CATEGORY: 3 P	d. TITLE PRESIDENT
(2) LICENSE FEE ENCLOSED: $ 230.00	e. DATE MAY 23, 1985

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9. STORAGE OF SEALED SOURCES:

All radioisotope standards will be kept in a locked flame-proof cabinet. This cabinet will be stored in a closed room in our warehouse, the only person haveing access to the room and the cabinet will be Grant R. Wilton, Radiation Safety Officer, Attached is a sketch of the proximity of the storage cabinet to our laboratory facilities.

11A. SURVEY INSTRUMENT CALIBRATION:

The calibration of the Ludlum Measurements Model 14C survey meter and model 44-7 Geiger-Mueller probe will be conducted by Ludlum Measurements, Inc. A two-point calibration on each scale is performed using a source traceable to the National Bureau of Standards. Their license number is: Texas State Health Department 4-1963.

11B. COUNTING INSTRUMENT CALIBRATION:

There are two types of calibration that we perform on our instrumentation; efficiency and performance. These calibrations are performed as follows:

PERFORMANCE: gas proportional counter

A sealed-disk source of Sr-90 or Cs-137 (beta-emitters) is placed on the detector and counted for 21-five minute intervals. The counts per five minutes for all 21 counts is put to the Chi-square test and if the data is sound, a graph of counts per five minutes vs. time (days) is plotted from the date of the test and decay corrected to that date one year hence. If too many data points are eliminated the 21 count test must be re-done. A daily check for this test will be done and the results plotted on a an accompanying graph.

EFFICIENCY CALIBRATION: gas proportional counter

To determine the counting efficiencies for alpha and beta using a gas proportional counter, self absorption within a sample must be determined. With varying weights and thicknesses or precipitates, counting efficiency changes.

For determinationa of gross beta a series of tap water aliquots in the range of 0-300 mg/liter is spiked with a known amount of Sr-90. These aliquots are acidified with a few ml 16 N HNO_3 and evaporated to 10-15 ml on a hot plate. 5ml portions of the evaporated solution are quantitatively transferred to a tared stainless steel planchet and evaporated to dryness. After drying for two hours at 105°C the planchet is weighed and counted.

Americium-241 is the preferred standard for gross alpha calibrations. Tap water aliquots in the 0-100 mg (residue) range are spiked with standard Am-241 in the activity range of $\approx$ 1000 cpm. The aliquots are treated in the same manner as for gross beta determination and a graph of:

$$\frac{cpm}{dpm} \text{ vs. mg residue}$$

is drawn to correct the final calculation for % absorption.

Efficiency calibration for the gas proportional counter will be performed once a year provided the instrument does not need to have the detector window replaced. In the event the detector and/or window are damaged a new efficiency calibration will be performed.

All radioactive standards used will be obtained from either the National Bureau of Standards, EMSL-Las Vegas, or a licensed manufacturer such as Amersham and will be certified as to the specific activity and the percent error of the activity.

EFFICIENCY CALIBRATION: radon-flask counter

For determination of the efficiency of a radon-flask counting system a spike of ≈1000 cpm is added to a radon bubbler with D.I. water. The bubbler is purged of radium daughters with helium and after a predetermined period of Rn-222 ingrowth, the radon daughter collected in an evacuated Lucas-type cell and counted. The efficiency is determined as follows:

$$E = \frac{\text{cpm}}{\text{weight of spike (mg)} \times \text{dpm/g standard}}$$

The efficiency of the counter will be determined by the above method for every 50 samples counted and if the instrument has been repaired of P-M tube replaced.

The Ra-226 used in efficiency calibrations will be obtained from the National Bureau of Standards or the EMSL-Las Vegas and will have certification regarding the specific activity.

12. PERSONNEL MONITORING DEVICES:

Initially, personnel monitoring will not be done since I, Grant Wilton, personally will be the only handler and user of radionuclides. When the time comes to take on additional personnel, TLD monitoring will be utilized.

15. RADIATION PROTECTION PROGRAM:

The Radiation Protection Program for Radiation Measurements, Inc., covers the following areas:

A. Survey of Radionuclide standards upon receipt (see attached sheet).
B. Leak testing of sealed sources in excess of one microcurie.
C. Stoarge of Radionuclide standard solutions.
D. Use of specially marked glassware and apparratus in preparation or spiked solutions.
E. Procedures for safe storage of wipes, disposable pipettes, surgical gloves and tray liners used in standards preparation, prior to disposal.
F. Labeling of containers and posting signs warning of radioactivity in use.

Radiation
Measurements,
Inc.

RADIOACTIVE SHIPMENT RECEIPT REPORT

1. P.O. #__________ SURVEY DATE __________ TIME __________

   SURVEYOR: ____________________

2. CONDITION OF PACKAGE:

   ______ O.K. ______ PUNCTURED ______ STAINS ______ WET

   ______ CRUSHED ____________ OTHER

3. RADIATION UNITS OF LABEL: ____________ UNITS (mRem/hr)

4. MEASURED RADIATION LEVELS:

   a. PACKAGE SURFACE ____________ mRem/hr

   b. 3 FEET OR 1 METER FROM SURFACE ____________ mRem/hr

5. DO PACKING SLIP AND VIAL CONTENTS AGREE:

   a. RADIONUCLIDE ______ YES ______ NO; DIFFERENCE ______

   b. AMOUNT ______ YES ______ NO; DIFFERENCE ______

   c. CHEM FORM ______ YES ______ NO; DIFFERENCE ______

6. WIPE RESULTS FROM:

   a. OUTER ________ CPM = ________ DPM
      eff = (   )

   b. FINAL SOURCE CONTAINER ________ CPM = ________ DPM
      eff = (   )

7. SURVEY RESULTS OF PACKING MATERIAL AND CARTONS:

   ____________ mRem/hr, CPM

8. DISPOSITION OF PACKAGE AFTER INSPECTION: ____________

9. IF STATE/CARRIER NOTIFICATION REQUIRED, GIVE TIME, DATE, AND PERSONS NOTIFIED.

____________ Signature   ______ Date

407 B Washington Boulevard
Mundelein, Illinois 60060 (312)-949-4290

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Radiation Measurements, Inc.

PROCEDURES FOR SAFELY OPENING PACKAGES CONTAINING RADIOACTIVE MATERIAL

1. Visually inspect package for any sign of damage (i.e., wetness, crushed). If damage is noted, stop procedure and notify Radiation Safety Officer.

2. Measure exposure rate at 3 feet from package surface and record. If > 10 mR/hr, stop procedure and notify Radiation Safety Officer.

3. Measure surface exposure rate and record. If > 200 mR/hr, stop procedure and notify Radiation Safety Officer.

4. Put on gloves.

5. Open the outer package (following manufacturer's directions, if supplied) and remove packing slip. Open inner package to verify contents (compare requisition, packing slip, and label on bottle) and check integrity of final source container (inspecting for breakage of seals or vials, loss of liquid, discoloration of packaging material). Check also that shipment does not exceed possession limits.

6. Wipe external surface of final source container with moistened cotton swab or filter paper held with forceps; assay and record.

7. Monitor the packing material and packages for contamination before discarding.

   a. If contaminated, treat as radioactive waste

   b. If not contaminated, obliterate radiation labels before discarding in regular trash.

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Radiation Measurements, Inc.

RADIOISOTOPE IDENTIFICATION FORM

ISOTOPE NAME ____________________

COMPANY I.D. # ____________________

DATE ORDERED ____________________

DATE RECEIVED ____________________

P.O. # ____________________

SUPPLIER ____________________

AMPOULE # ____________________

REQUEST # ____________________

ACTIVITY PER GRAM ____________________

CALIBRATION DATE AND TIME ____________________

TOTAL MASS (GRAMS) ____________________

HALF-LIFE ____________________

EXPIRATION DATE ____________________

407 B Washington Boulevard
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G. IDNS Rules and Regulations
H. Procedures for the control of contamination for unsealed sources:
   1. The survey instrument employed by Radiation Measurements, Inc., is manufactured by Ludlum Measurements, Inc., Model No. 14C it is equipped with a Ludlum Measurements Model 44-7 end window Geiger-Mueller probe.
   2. Radionuclide sources will be kept in a locked, flameproof cabinet in the warehouse. Monitoring of the area around the cabinet will be performed quarterly and will also be performed when radionuclide sources are removed for use in the laboratory.
   3. The areas to be monitored include:
      a. Radioisotope standards preparation area.
      b. Radioisotope storage cabinet (internal and external) and surrounding area.
   4. Contamination of any sort is of course unhealthy and undersirable but in an environmental laboratory even slight contamination can wreak havoc with discrimination between background and non-background levels of radioactivity. At Radiation Measurements, Inc., decontamination will be done in the event spillage occurs or if apparatus in the radioactive standards preparation area is suspected of contamination. Action limits for decontamination are set at 10 pci/100 cm^2.
   5. The procedures for decontamination are as follows:
      a. Survey of suspected area(s) of contamination.
      b. If survey shows that action limits have been exceeded, person conducting the decontamination shall:
         1. Don disposable surgical gloves and disposable apron.
         2. Spray suspected area with radiacwash and wipe up until dry with disposable paper towels.
         3. Remove gloves and put on a clean unused pair.
         4. Perform smear test by wiping suspected area with radioactivity wipe test smears. Label each smear with area from which it came.
         5. Count each smear in a proportional counter & record counts.
         6. Repeat procedure until activity is under action limits.
         7. Dispose of gloves, aprons, towels, and smears in a waste receptacle expressly marked and used to contain contaminated materials.
         8. Record time, date, and area of contamination and verify that action limits are not exceeded during post-decontamination survey. This information will be recorded along with the specific radioisotope(s) as well as the activity of the contamination prior to clean-up. See attached log sheet.
      c. Emergency procedures for fire and theft or radioactive materials:
         1. In case of fire, theft, or other casualty the IDNS will be notified both by telephone and telegraph immediately and a letter describing the event will be sent at the earliest possible convenience.
      d. Upon receipt of radioactive material a radioisotope identification form (see attached sheet) will be filled out and filed along with the packing slip that accompanied the shipment.

CONTROL NO. 7 9 0 5 3

I. Protective equipmehh used for handling radioactive material:
   1. Disposable surgical gloves
   2. Absorbent bench top liners - white polyethylene foam
   3. Plastic goggles
   4. Disposable aprongs
   5. Disposable paper towels
   6. Respirator

J. Under no cirumstances will pipetting be done by mouth when radioisotopic standards are being prepared.

16. FORMAL TRAINING IN RADIATION SAFETY:

A. Principles and practices of radiation protection:
The sole purpose of Radiation Measurements, Inc., is to provide selected radiochemical analyses for the determination of radioactivity levels in environmental and low-level activity samples.

Our laboratory facilites and equipment are in accordance with guidelines set forth by the Illinois Department of Public Health and all analytical, calibration, and quality control procedures are followed with strict adherence to USEPA and USNRC regulations. The recepit, handling, and storage of nuclear materials necessary for calibration of counting instruments will be carried out as per Illinois Department of Nuclear Safety guidelines.

Initially, as the sole analyst and employee of Radiation Measurements, Inc., I will conduct all handling of the radionuclides described in this application. At that point in time which academically-trained personnel are employed, they will be trained in radiation safety and the safe handling and use of radionuclides. When lab personnel are hired TLD monitoring will be provided for the employee and the working environment. Also as sole analyst I will serve as Radiation Protection Officer. In this capacity I will oversee the implementation of a radiation safety program and will insure that proper records of training, personnel monitoring and program are kept.

B. Formal training was received at Teledyne Isotopes, Midwest Laboratories, in Northbrook, Illinois, in 1981. The training program covered theory and operation of isotope counting instrumentation and applied radiation safety. Radiation safety instruction included the theory and application of themoluminexcent dosimetry in the laboratory environment, safe handling and record keeping of radionuclides in the preparation of calibration standards, and movies/discussion sessions on the physical aspects, measurement and terminology, and the biological effects of radiation.

The supplement my training in radiation safety I have applied for plenary membership in the Health Physics Society.

Isotope Counting Instruments:
An alphascientillation detector consists of a photomultiplier

tube and base in a light-tight cylinder, a high voltage source, and a scaler/timer. When a photon hits the photomultiplier tube a voltage pulse equal in amplitude to the energy of the photon is produced. Through the applied voltage the pulse is amplified by each sucessive dynode in the photomultiplier tube. If the pulse is above a predetermined threshold set by the user, it is registered as a count by the scaler/timer. By adjusting the threshold level and the amplifier gain you can set the energy range for the isotope desired. The Lucas-type cells used in radon de-emanation are coated with a zinc-sulfide phosphor that emits photons from interactions with alpha particles. The Lucas cell containing the de-emanated radon daughters of Ra-226 is placed in the light-tight cylinder face-to-face with the P-M tube and is counted.

A gas filled proportional counter can count alpha and beta particles and works in the following way:

Particles emitted from the sample planchet enter the methane filled detector thru an ultra-thin mylar window. The particle interacts with a gas molecule resulting in ionization of the gas. The high voltage applied across the detector attracts the resulting ions to positive and negative terminals where a voltage pulse is produced. This pulse is amplified and registered as a count by the scaler/timer. The detector is surrounded by lead bricks to reduce background radiation and is operated in anti-coincidence with a guard detector just above it inside the brick shieding. The guard detector is operated in parallel to the main detector and functions to lower the background counts by intercepting cosmic rays. If two pulses are produced by the detectors within a pre-determined length of time they are taken to be from an outside source and are disregarded by the scaler/timer.

C. The spontaneous decay of unstable nuclei through the emission of charged particles and electromagnectic radiation is random. But even though it is random every radioisotope decays at a certain rate. The rate at which one element changes into another is an important characteristic of that element and it is described in terms of decay constant (λ)* or half-life (T). The decay constant (λ) describes the decay rate of the specific element and half-life (T) is the length of time required for half the element to change to its daughter.

The basic relationship between the rate of decay and the number of unstable atoms is:

$$\frac{\Delta N}{\Delta t} = \lambda N$$

This expression states that the decay rate in disintegrations per second at any time equals the decay constant times the number of atoms of the material at that instant. The equation $\frac{\Delta N}{\Delta t} = \lambda N$ can be expressed in more detail to calculate the change in the number of atoms present at elapsed time (t):

$$N = N_0 e^{-\lambda t}$$

N_0 = number of atoms at time zero
N = number of atoms at a later time
λ = decay constant
t = elapsed time
e = base of the natural logarithm

* Also referred to as specific activity

At time T = 0, N = N_0, to calculate how long it will be before one-half on the substance remains:

$$\frac{N_0}{2} = N_0 e^{-\lambda t}$$

$\frac{1}{2} = e^{-\lambda t}$

$2 = e^{\lambda t}$

$\ln 2 = \ln e^{\lambda t}$

$0.69 = \lambda T$

Thus, knowing either the half-life or decay constant permits calculation of the other.

To measure the amount of activity in a radioactive source (the number of disintegrations per second (dps) or nuclear transformations) the curie is the unit most often used. The cuie is that amount of radioactive material that undergoes the same number dps as one gram of radium. if we take the atomic weight of radium to be 226 (most stable isotope), and from Avogadro's Lab that 1 mole of an element must have 6.02×10^{23} atoms then:

$$\frac{6.02 \times 10^{23} \text{ atoms}}{226 \text{ grams Ra}} = \frac{x \text{ atoms}}{1 \text{ gram Ra}}$$

$x = 2.6 \times 10^{24}$ atoms in 1 gram radium

To determine the number of disintegrations per second solve the equation:

$$= \frac{0.69}{T}$$

T = the half-life of radium, i.e. 1590 year, Convert 1590 to seconds
$1590 \times 365 \times 24 \times 60 \times 60 = 5 \times 10^{10}$ seconds

$$= \frac{0.69}{5 \times 10^{10}}$$

Since $\frac{\Delta N}{\Delta T} = \lambda N$ we have all the variables needed to determine the disintegration rate of 1 gram of radium.

$$N = \frac{0.69}{5 \times 10^{10} \text{seconds}} \times 2.6\ 10^{24} = 3.7 \times 10^{10}$$

Thus there are 3.7×10^{10} disintegrations per second in one gram of radium. This number of disintegrations per secodn defines a radioactive source of 1 curie. It must be remebered that the curie does not define the type of activity only the number of transformations per second.

While the curie defines the activity of a radioactive source, the unit rad and roentgen define the effect of the source of any object.

D. Irradiation of an object by x or gamma rays produces ionization of atoms within the object. The roentgen is specifically defined as "that amount of x or gamma radiation that produces 1 esu of ion pairs in $1cm^3$ of air under standard conditions". The drawbacks to the use of the roentgen as a measurement unit are that the roentgen is defined only for x and gamma radiation although alpha and beta particles also produce ionization and that ionization is only an indirect measurement of the quantity of radiation. While the roentgen is a measure of "exposure

dose" the rad is a measurement of "absorbed dose". The rad is defined as: the energy absorption of 0.01 joules/kg. The rad is a more practical unit than the roentgen in radiation measurement because it refers to total energy absorbed in any material whereas the roentgen applies only to the ionization of air. The rad also refers to any type of radiation; the roentgen only to x and gamma rays. The rem (roentgen equivalent man) is a useful unit in that it incorporates the biological effect of radiation into the measurement. One rem is defined as that amount of radiation of any type that produces the same biological effect as is obtained from 1 rad of 200 kVp x-rays. For personnel monitoring, inspecting and leak testing, and general contamination surveillance, mRem/hr is the most common unit of measurement. The unique feature of the rem is that it is capable of being used on all types of radiation. The units of measurement described above are quantities only. Most often they are expressed per unit time, mRem/hr, uRad/day, etc.

In the field of environmental radiological monitoring the levels of radioactivity encountered are at the natural background level or slgihtly above. Aqueous samples are most often measured in pCi/l and solids as pCi/gr.

$$pCi/l = \frac{cpm_s - cpm_o}{2.22 \times E \times D \times R \times V \times B}$$

cpm_s = counts per minute sample

cpm_o = counts per minute background

2.22 = conversion factor dpm/pCi

E = counter efficiency

D = decay factor (if applicable)

V = sample volume or mass

R = chemical yield or self absorption factor (if applicable)

B = branching ratio (gamma only)

17. EXPERIENCE - RESUME OF GRANT R. WILTON

Education: Bachelor of Science in Water Science (1981)
Northern Michigan University
Marquette, Michigan

Work Exp.: Teledyne Isotopes, Midwest Laboratory (1981-1985)
Northbrook, Illinois

At Teledyne Isotopes I served in many capacities: radioisotope counting room manager, chemical analyst, sample collector, and sample preparator. As counting room manager my job primarily consisted of scheduling adn analyzing samples for gamma radiation. The Hewlett-Pacard, Ortec, and Canberra multichannel analyzer system all utilized Ge(Li) detectors and their calibration and maintenance were also my responsibility. Efficiency calibration was done using a mixed gamm (Eu and Sb isotopes) source from the NBS, the mixed-gamma standard was used for both solids and liquids for various geometrics. Thrice weekly performance tests for quality control were performed on the above instrumentation using a Cs-137 and Co-60 solid disk source. Also in the isotope counting room were three Beckman-Wide beta proportional counters for which I performed daily performance tests.

My area of responsibility as a chemical analyst was primarily the analysis of solids and aqueous solutions for Sr-89 and Sr-90/Y-90. One of the procedures used for Y-90 determination utilized Sr-85 as a tracer in the solvent extraction of Y-90 from concentrated nitric acid. The activity of the tracer spike was on the order of 100 cpm per sample which was counted for gamma radiation to determine Sr recovery. In addition to performing the Sr analysis I also was trained in the analysis of Ra-226 by the radon de-emanation method and analysis of Ra-228 by proportional counting of the short lived actinium daughter. I also learned the procedures for gross alpha and beta determination and various sample preparation methods.

Aside from the above mentioned responsibilities, I also conducted monthly environmental sampling at the Kewaunee Nuclear Power Plant in Kewaunee, Wisconsin. Milk, water, vegetation, soil, and aquatic biota, were collected on a monthly or quarterly basis as per NRS guidelines. My responsibility was the collection of an analyzable amount of sample, maintenance of the collection schedule, and collection of split samples for the Wisconsin Department of Public Health. Last, but not least, I was a troubleshooter for all the instruments when they malfunctioned.