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University of Washington
College of Engineering
Nuclear Engineering Laboratories
Mail Stop FD-10
Seattle, WA 98195
January 26, 1989

Mr. Ross A. Scarano, Director
Division of Radiological Safety and Safeguards Programs
U.S. Nuclear Regulatory Commission, Region V
Materials Radiation Protection Section
1450 Maria Lane, Suite 210
Walnut Creek, California 94596

Attention: Beth Riedlinger

Subject: Application for Renewal of Special Nuclear Materials License SNM-108
Docket No. 070-00115

Dear Mr. Scarano:

In accordance with notice of expiration dated 11/01/88 and the provisions of 10 Code of Federal Regulations, Part 70, Section 70.33, application for renewal of Special Nuclear Materials License SNM-108 is hereby submitted.

Please direct inquiries on the content of this application to either William P. Miller or Maurice A. Robkin at (206-543-4170).

The application is similar to the past renewal applications. Changes since the last application are:

1. Deletion of U-235 and Pu sample (Items 6(D) and 6(E)) on expiring license. Both items were reported on RIS HAY and when shipped were transferred on the 741 forms to the RIS indicated below.

   The U-235 metal shipped to Martin-Marrietta Energy Systems Inc., Y-12 Plant, Oak Ridge, TN on 4/10/84 to RIS FZF. Contaminated laboratory material and U-235 waste were shipped to Rockwell Hanford Operations, Richland, WA on 9/28/84 to RIS VRA to complete disposal of this material.

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The 5 Pu-Al foils were shipped to Rockwell Hanford Operations, Richland, WA on 6/6/84 to RIS HRA.

2. Revision of the values for the U-235 content of the General Electric Fission detectors to reflect the actual amount of U-235 in the detectors.

This application is being submitted as an up-to-date renewal application with no references to past documents.

I trust that this information will suffice to extend our license for an additional five year period.

Sincerely yours,

Maurice Robkin

Maurice Robkin, Ph. D.
Director
Nuclear Engineering Laboratories

Encl:

- Renewal Application for SNM 108
- Gamma Calibration of Ion Chamber Survey Instruments
- General Source Use Material
- Pulse Rate Meter Calibration
- Procedure for Receiving Packages Containing Radioactive Material
- Procedure for Opening Packages Containing Licensed Radioactive Material
- Radiological Control
- Radiation Emergency Procedure
- Emergency Phone List

University of Washington
Renewal Application for SNM 108
Docket No. 070-00115

Administration and Personnel

1. The University of Washington is a state university located in Seattle, Washington. Officials of the University include the following:

   President: William P. Gerberding

   Provost: Laurel L. Wilkening

   Executive Vice President: Tallman Trask, III

   Vice Provost for Research and Dean of the Graduate School: Gene L. Woodruff

2. Technical Qualifications of Persons Responsible for Radiation Safety Training and Experience.

   Maurice A. Robkin - Professor of Environmental Health and Professor of Nuclear Engineering.

   Dr. Robkin received his Ph. D. in Nuclear Engineering from MIT in 1961. He was employed by General Electric at their Vallecitos facility until 1967 and since that time has been on the faculty of the University of Washington. On July 1, 1983 he assumed the duties of Director of the Nuclear Engineering Laboratories.

   Albert L. Babb - Professor of Nuclear Engineering, Professor of Chemical Engineering

   Dr. Babb received his Ph. D. from the University of Illinois in 1951 and has been a member of the University of Washington faculty since August, 1952. He became responsible for the University of Washington Nuclear Engineering program in 1957 and in 1962 was named Director of the Nuclear Reactor Laboratories. In this latter capacity, he was project engineer for the installation and precritical testing of the Univerity's 100 kw nuclear reactor which commenced operation in 1961. Dr. Babb was chairman of the Department of Nuclear Engineering from 1965 through August of 1981.

   William P. Miller - Associate Director for Reactor Operations

   Mr. Miller received his Master's degree in Radiological Sciences at the University of Washington in 1963 and since that time has been employed at the University of Washington Nuclear Reactor Facility in various capacities. Through December 1988, he held a Senior Operator's License for the U. W. Nuclear Reactor. His duties include being the UWNR Health Physicist.

DeLoss L. Fry - Assistant Director for Facilities Engineering

Mr. Fry received his BS degree in Chemical Engineering from Purdue in 1958. He has been employed by the University of Washington since Jan 3, 1962, in the department of Nuclear Engineering since 1969, and in his present position since 1980. Until September 1988 he held a Senior Operator's License for the U.W. Nuclear Reactor.

Michael J. O'Brien - Radiation Safety Office, Department of Environmental Health and Safety

Mr. O'Brien received his Master's Degree in Hygiene from the University cf Pittsburgh in 1973. He has twenty seven years experience in professional health physics, including the University of Washinton, Brookhaven National Laboratory and the U. S. Public Health Service. He is certified by the American Board of Health Physics. His duties at the University of Washington cover radiation safety for all University radiation sources.

Description of Special Nuclear Material

1. Plutonium-Beryllium Neutron Sources

a. One-Curie Sources

The five 1-curie plutonium-beryllium sources are fabricated as virtually identical sources containing 15.9 grams of plutonium(0.98 curies) mixed with 7.94 grams of beryllium metal powder. Each source is encapsulated in a jacket of tantalum and stainless steel 0.90" high by 0.825" inner diameter and 1.596" overall x 1.025" outer diameter. Encapsulation was performed by Mound Laboratories.

Source	Pu Content	Neutron Emission August 1961 (neutrons/sec)
M-83	15.82 gm	1.70×10^6
M-84	15.96 gm	1.69×10^6
M-85	15.87 gm	1.70×10^6
M-86	15.99 gm	1.68×10^6
M-87	15.93 gm	1.68×10^6

Dose rate at 1 cm - unshielded = 1.9 rad/hr neutron and 0.2 rem/hr gamma.

b. Pu-Be source M-915

Source M-915 is a 2-curie source containing 31.99 grams of Pu and 15.91 grams of Be. The container is made of tantalum and stainless steel. Inside dimension: 0.82" I.D. x 1.49" high. Outside dimension: 1.02" O.D. x 2.19" high. The emission rate on February 5,1961 was 3.32×10^6 n/sec. The encapsulation was performed by Mound Laboratories. This source is authorized under License R-73 and has been used as the Reactor start-up source.

2. The Uranium-235 Fission Detectors

The Uranium-235 special nuclear material is contained as follows:

a. 1.72 gram cathode plate on the inner surface of the Westinghouse Electric Corporation Model WL-6375 Fission Counter

b. 2.286 milligrams U-235 in General Electric Fission Chambers as follows:

Model Number	Serial No.	Milligrams Uranium	Enrichment	Milligrams U-235
NA-200	6,584,953	1.76	93.035	1.637
NA-100	6,572,554	0.44	93.035	0.409
NA-200	TAETX4-1A	1.07	21.99	0.24

Description of Use of Special Nuclear Material

1. Plutonium-beryllium sources are used for the following purposes:

   a. Demonstration of neutron instrument technology

   b. Testing and checking detectors

   c. Operation of a standard pile

   d. Demonstration of physical properties of neutron activation, moderation and attenuation, etc.

   e. Calibration of neutron survey instruements.

   The term "demonstration" used in items above refers to use by University of Washington instructors(approved by the Director of the Nuclear Engineering Laboratories) for theoretical and practical laboratory instruction of duly enrolled students and auditors. The breadth of this program of intended use is justified in that it permits these materials to be used to meet a number of teaching commitments and permits the staff of the Nuclear Engineering Laboratories and the Radiological Safety Division to concentrate more attention on fewer materials, particularly the sources.

2. Uranium-235 Fission Detectors

   The fisson detectors are used for neutron flux measurements and demonstrations of neutron instrument characteristics.

Description of Storage of Special Nuclear Material

1. The Pu-Be sources and 235-U fission counters may be used or stored at the following locations:

   a. The reactor room of the Nuclear Reactor Building (Restricted Area) and used under supervision of listed personnel in controlled areas of building.

   b. Nuclear Engineering Laboratories in Benson Hall (Controlled Area)

2. This material, subject to authorizaton of the Director of the Nuclear Engineering Laboratories and the provision of control and radiation monitoring by the Radiological Safety Division may also be used in such locations as:

   a. Nuclear Physics Laboratory

   b. Physics Building student laboratories as required for instructional purposes

   c. Benson Hall student laboratories as required for instructional purposes.

Description of Equipment, Facilities and Equipment

1. The number, type and length of remote handling devices.

   Two sets of four foot long tongs. Various rods up to three feet in length with ends bent to hook-eye bolts on sources.

2. Storage Containers and Facilities

   Sources are stored between periods of use in a 55 gallon steel drum shielded with 150 pounds of paraffin. The steel drum has a mechanical clamp which can be locked to secure the contents.

3. Containers, devices, protective clothing, auxiliary shielding, etc. employed in using materials.

   For auxiliary shielding a supply of paraffin, polyethylene and lead bricks are available as needed. Smaller containers filled with paraffin are available for transporting and temporary storage of the Pu-Be sources. Protective clothing is not necessary with sealed sources and detectors.

4. Physical Plant, laboratory or working area facilties.

   See above for storage and use locations.

5. Radiation Detection Equipment Available for Use

a. Description of Instruments

Instrument	Manufacture Model No.	Radiation Detected	Sensitivity Range	Window Thickness mg/cm	Use
Snoopy-Portable Neutron Monitor	Tracerlab WR-1	Neutrons	0-2 mrem/hr	NA	Survey
Portable Survey Meter Ion Chamber	Bicron RSO-5	Gamma Beta	0-5 mr/hr	400 7	Survey
X-ray/Gamma Survey Meter Ion Chamber	Keithley 36100	Gamma Beta	0-200 mr/hr	417 50	Survey
Portable Alpha Survey Meter	Eberline AC-15AGA	Alpha	0-500 cpm	1.5	Survey
Alpha Survey Meter	Eberline RM-15	Alpha	0-500 cpm	1.5	Survey
Continous Air Monitor	Eberline Alpha-1	Alpha	0-500 cpm	0	Air Sample
ZnS on photo-multiplier	Baird Atomic 530 Spectrometer	Alpha	Cnts/unit time	0	Swipes and air samples

6. Instrument Calibration

Radiation survey meters are calibrated quarterly. See below for details for different types. Calibration data is attached to each unit after calibration. The calibrations are done by or under the supervision of W P Miller or M J O'Brien.

a. Ion Chambers for gamma.

The Northwest Regional Instrument Calibration Facility (NRICF) is located at the University of Washington with equipment and sources on loan from the National Bureau of Standards. The Facility is operated by the Radiation Safety Division of the University of Washington and is available to other radiation user groups.

Source Data:

J L Shepherd Model No. 81 S/N 7006 Cs-137 Nominal 3 Curie
J L Shepherd Model No. 10 S/N 11007 Cs-137 Nominal 0.03 Curie

Source accuracy not determined. Calibrations referred to measurement of gamma exposure rate with graphite chamber and associated equipment supplied to the Regional Calibration

Facility by NBS. The accuracy of survey meter calibration is presently ± 7 %.

See attached NRICF Procedures for gamma calibration of exposure meters and general source use.

b. For pulse type instruments, i.e., the portable alpha monitors.

Source Data:

New England Nuclear NES-300	Am-241	0.0072 microcures Oct1969
Eberline Model CS10	Th-230	Nominal 0.003 microcuries
Eberline Model CS12	Th-230	Nominal 0.01 microcuries

Source Accuracy for Am-241 from New England Nuclear is ± 4.5 % with direct comparison to a standard certified by National Bureau of Standards.

Th-230 sources are compared annually with Am-241 source.

See attached NRICF Procedure for pulse-type instrument calibration with the efficiency of the detector determined using a Th-230 source.

c. Neutron Survey Meter(Snoopy) calibration.

Source Data: Mound Laboratories M-87 Pu-Be Approximately 1 Curie Pu-239

In 1961, Mound Laboratory Calibration measured the output of the neutron sources with a standard error of ± 2 %. The present output of the sources has been corrected for buildup of Am-241 with the assumptions that the original Pu-241 content was 0.7 % and the plutonium was separated in 1957. The calculated neutron output is 2.12×10^6 n/sec.

For the calibration of the Tracerlab WR-1 Portable Neutron Monitor (Snoopy) the meter is positioned approximately 3 feet above the floor. Source M-87 is placed on an aluminum support at distances of 1 meter, 50 cm, 40 cm and next to the unit. The neutron scattering increases the meter response compared to the calculated dose rate. The calibration consists of checking that the unit reads consistently over time. With scattering and source buildup the absolute accuracy is not determined. If the conversion factor used for Pu-Be neutrons is 3.5×10^{-5} mrem per neutron/square centimeter then the dose rate from the above sources is approximately 2.2 mrem/hr at 1 meter with no scattering. The source is handled with a rod. The calibrator has a film badge and stands away from the source to read the meter.

d. ZnS Scintillation Counting System for air monitoring and swipe samples.

System is calibrated with an Americum-241 (New England Nuclear NES-300) and checked daily with a Th-230 source (calibrated against Am-241 source).

Source Data:

New England Nuclear NES-300	Am-241	0.0072 microcuries Oct 1969
Eberline Cs-10	Th-230	nominal 0.003 microcuries

Source accuracy for Am-241 source from manufacturer is ± 4.5 % with direct comparison to a standard certified by National Bureau of Standards.

The Am-241 source is used to calibrate the activity of the Th-230 source which is used for daily check of instrument.

Annually for intercomparison of Am-241 with Th-230 source which is used for daily check of instrument.

Other instruments available or new units acquired would be calibrated as appropriate before using for radiation monitoring.

Proposed Procedures to Protect Health and Minimize Danger

1. Appropriate shielding for reduction of neutron exposure hazards during use is provided.

2. Use of thermally fissionable plutonium sources and uranium detectors inside the UWNR will be consistent with limitations imposed by the UWNR license (R-73).

3. Exposed sources, experiment facilities or shields containing Pu-Be sources are identified with caution signs. Where applicable, exposed spaces adjacent to neutron sources facilities are barricaded and provided with caution signs.

4. Relocations of the sources to areas outside the immediate jurisdiction of the Director of the Nuclear Engineering Laboratories are performed by the Radiation Safety Division. The Radiation Safety Division provides a University owned vehicle for intercampus transfers of the materials. This provides security during transfer, and serves as notification that surveillance is needed at the receiving location.

5. See attached procedures for receiving packages containing radioactive material and opening packages containing licensed radioactive material.

6. A copy of the radiological control for the facility is posted on the door entering the reactor room is enclosed.

7. A copy of the radiation emergency procedure for the facility is enclosed.

8. The current list with names and telephone numbers of responsible persons to be called in case of an emergency is enclosed. This list is posted and updated as changes are made in personnel.

9. Training for Individuals Working in or Frequenting Restricted Areas.

Personnel using the licensed material under the supervision of authorized user are instructed as required by 10 CFR 19.12 in one of the following ways:

a. Take the 8 hour course offered by the University of Washington Radiation Safety Division. The course consists of four 2-hour sessions covering basic radiation physics, biological effects of radiation, radiation protection procedures, and University/State/ Federal regulations and rules governing the use of radioactive materials.

b. Due to schedule conflicts of personnel, a condensed version of the course described above has been presented by the University Radiation Safety Officer.

c. A lecture to subordinates covering the material will be given on occassion by the authorized user.

Any personel who will use any of the material covered by this license under the supervision of an authorized user will intially be instructed as above and refreshed on annual basis.

The ancillary personnel are few at this facility. For the most part they are University personnel doing maintenance and repair for short time span. The personnel involved are escorted upon entering a restricted area. At these times the sources would be in storage. Individuals are instructed prior to entry to the restricted area as to potential hazard, of any exposure they may receive.

Specification of Radiation Safety Responsibility and Duties

The Nuclear Engineering Laboratories of the Department of Nuclear Engineering and the Radiation Safety Division maintain the facilities to properly safeguard possible neutron exposure and alpha contamination hazards from these special nuclear materials. The responsibility is ultimately with the Director of the Nuclear Engineering Laboratory or the University Radiation Safety Officer depending upon the location and use of the sources.

Personnel Monitoring

Persons manipulating Pu-Be sources or performing unsupervised activities in connection with the sources are provided film badges or acceptable personnel monitors. Film badges are currently supplied to the University of Washington by R.S. Landauer, Glenwood, IL on a monthly basis. The film badges issued to this facility include neutron sensitive film.

Radiation Survey Program

1. In the areas used for storage or use of the sources, routine surveillance, including instrument monitoring and personnel dosimetry will be provided by the the Radiation Safety Division. The Radiation Safety Division will extend thse service to other interim locations of storage and use.

2. Sources are leak tested at quarterly intervals by the Radiation Safety Division which maintains a permanent record of the results. The leak tests are performed by wiping the source(or as close as feasible if in a holder) with a dry filter paper. The swipes are then analyzed for alpha activity.

Waste Mangement

There should be little or no waste with these sealed sources and detectors. Non-transuranic low-level radioactive waste is transferred to Radiation Safety for disposal at an approved burial site. At the present time we are not sure how we would dispose of transuranic(i.e. Pu-Be sources) waste. At the present time low level transuranics can be buried at Richland, WA.

Chapter 13

GAMMA CALIBRATION OF ION CHAMBER SURVEY INSTRUMENTS

13.1 DISCUSSION

These procedures apply to ion chamber survey instruments. Refer to Chapter 17, **Gamma Calibration of Geiger-Muller Instruments**, for the procedure applied to GM-type instruments used for gamma exposure rate measurements.

These calibrations are performed with a ^{137}Cs source (photon energy: 662 keV) between 3500 mR/hr and 3 mR/hr. The owner is advised that extension of this calibration to other photon energies and/or exposure rates is at the owner's risk.

The calibration values are based on readings normalized to one standard atmosphere (760 mm Hg) and to normal room temperature (22° C) for instruments with probes vented to the atmosphere. The user is advised that instrument readings taken at temperatures and pressures different from these conditions will need to be normalized back to 760 mm Hg and 22° C. Readings are multiplied by the temperature-pressure correction factor, C_{pt}, to normalize them back to the calibration conditions. C_{pt} is calculated by the formula:

$$C_{pt} = \frac{(273.15 + T)}{295.15} \times \frac{760}{P}$$

where $T \equiv$ the ambient temperature in °Celsius
$P \equiv$ the ambient pressure in mm Hg

The value of the reference field has been demonstrated to be within ±3% of the actual value as determined by comparison with the national standard.

13.2 ENVIRONMENTAL CONSTRAINTS

1. The temperature should be between 19°C and 25°C.
2. The barometric pressure should be between 730 mm Hg and 790 mm Hg.
3. The relative humidity should be between 15% and 65%.

13.3 EXPOSURE RANGES GREATER THAN 50 mR/hr

13.3.1 Equipment Required

1. 3 Ci ^{137}Cs source (refer to Chapter 4, **General Source Use Procedures**)
2. Calibration Track
3. Positioning Laser
4. Hewlett-Packard HP-34C calculator
5. Fluke 8022B DMM
6. Booklet containing NRICF Form 03-01-00 CALIBRATION WORKSHEET - Ion Chamber Exposure Rate Survey Meter (use NRICF Form 03-01-01 booklet for University of Washington instruments and NRICF Form 03-01-02 booklet for Washington State D.S.H.S. Instruments)

13.3.2 Source Start Up

(Refer to Figure 4.2 for calibration facility layout.)

1. Refer to and follow the source start up procedures in Chapter 4, **General Source Use Procedures**.
2. Begin filling out the first available calibration worksheet (see Figure 13.1) in the booklet for the instrument being calibrated.

NORTHWEST RADIATION INSTRUMENT CALIBRATION FACILITY

NRICF FORM 03-01-02(8/85)

CALIBRATION WORKSHEET

GAMMA RAY CALIBRATION
Calibration Report Number: 88-1

ION CHAMBER EXPOSURE RATE SURVEY METER
Dept. of Social and Health Services Instruments

OWNERSHIP INFORMATION

AUR Number: -1
Section: DSHS Office of Radiation Protection
Name: Radioactive Materials Section

INSTRUMENT INFORMATION

Manufacturer	Victoreen	Serial Number	1540
Model Name	Panoramic	DSHS Property Number	B42598
Model Number	470A	Other ID Number	none
Detector Type	ion chamber	(Type)	

MECHANICAL REPAIR AND CHECK

	ok	replaced	other (describe)
Batteries	☑	☐	
Meter Readout	☑	n/a	
General Condition	☑	n/a	
Other	n/a	n/a	

CALIBRATION ENVIRONMENT

Source	3 Ci	30 mCi
Calibration Room Temperature (°C)	21.51	21.55
Calibration Room Pressure (mm Hg)	770.8	770.9
Calibration Room Humidity (%)	33	33

Correction Factors

Type	Value	
Pressure-Temperature (C_{pt})	0.9744	0.9744

CALIBRATION SOURCE

Gamma Ray Source: 137Cs
Source Serial Number: 7006, 11007
Activity (millicuries): 3000, 30

COMMENTS

CALIBRATED BY: [signature] DATE: 2/1/88

Figure 13.1: Gamma Exposure Rate Meter Calibration Worksheet (NRICF Form 03-01-00), page 1

GAMMA RAY EXPOSURE DATA

EXPOSURE RATE (mR/hr)	SOURCE-DETECTOR (cm)	INSTRUMENT SCALE mR/hr	INSTRUMENT READING (mR/hr)	CORRECTED* READING (mR/hr)	PERCENT ERROR	TRUE EXPOSURE/ INSTRUMENT READING	ADJUSTED SCALE? (Y/N)	COMMENT
750	104.1	1000	760	748	-0.3	1.00	N	3 Ci Source
250	179.6	1000	275	271	8.3	0.92		
250	174.6	300	255	251	0.4	1.00		
75	326.4	300	78	77	2.4	0.98		
75	326.4	100	78	77	2.4	0.98		
25	634	100	26	25.6	2.4	0.98		30 mCi Source
25	634	30	24.5	24.1	-0.5	1.00		
7.5	115.0	30	7.6	7.5	-0.3	1.00		
7.5	115.0	10	7.5	7.4	-1.6	1.02		
2.5	198.0	10	2.45	2.41	-3.5	1.04		
2.5	191.0	3	2.6	2.56	2.4	0.98		
1.0	311.4	3	0.92	0.91	-9.4	1.10		

* observed readings are corrected to 22°C, 760 mm Hg for all vented or unsealed detectors by multiplying the instrument reading by the pressure-temperature correction factor (C_{pt}). Other correction factors may be applied to both sealed and unsealed detectors.

Figure 13.2: Gamma Exposure Rate Meter Calibration Worksheet (NRICF Form -01-00), page 2

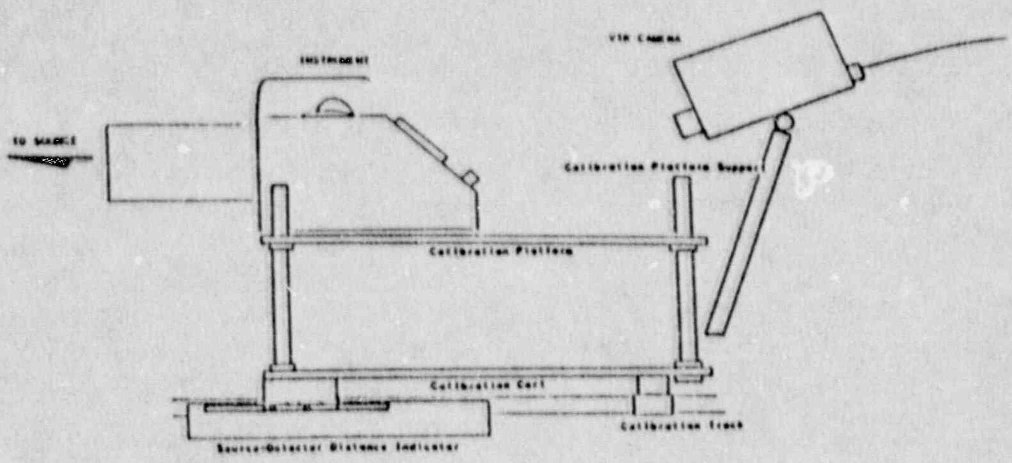


Figure 13.3: Equipment Setup for Exposure Rate Meter Calibration

13.3.3 Instrument Precheck

1. Test the batteries in the instrument. Use the "Battery Test" capability of the instrument, if available. Otherwise remove the batteries and test them with the Fluke 8022B DMM. Replace the batteries if they are less than 70% of their nominal value. Record the battery condition on the calibration worksheet (see Figure 13.1).

2. Examine the meter readout to see that it is in good condition. Return the instrument to the owner for repair if the meter readout is damaged. Record the meter readout condition on the calibration worksheet.

3. Examine the general condition of the instrument to see that it is in good condition. Return the instrument to the owner for repair if the instrument is damaged. Record the instrument's general condition on the calibration worksheet.

4. Record any other preliminary observations on the calibration worksheet.

13.3.4 Instrument Positioning

1. Be sure that the source is down.

2. Place the instrument on the cart and raise or lower the platform until the center of the instrument chamber is centered on the laser beam and the platform is level.

3. Check that the instrument is oriented on the cart as shown in Figure 13.3. The NRICF calibrates ion chamber survey instruments with the long axis of the chamber parallel with the photon beam axis, unless the client requests a different orientation. For those instruments which do not have a preferred axis, point the window end towards the source; leave the window closed or covered.

4. Position the video camera to view the instrument meter.

5. Roll the cart forward or backward until the center of the chamber is one (1) meter from the center of the source (the source center is 1.1 cm behind the front of the source window). Use the meter stick to measure a distance of 98.9 cm from the source window.

6. Set the cart position marker at one (1) meter (on the positioning tape). This allows the instrument to be accurately positioned at distances other than one (1) meter.

13.3.5 Instrument Calibration

1. Position cart at a distance from the source corresponding to the desired exposure rate. Refer to Appendix C, **Use of the HP-34C Calculator**, Section C.4, page 170 for the procedures used to calculate source-detector distances based on prior reference field measurements.

   Instruments with several scales will be calibrated at two (2) points on each scale. The first calibration point should be between 25% and 33% of full scale; the second point should be between 66% and 75% of full scale. The exact values should correspond to a meter scale marking for instruments with meter readouts or a round number for instruments with digital readouts. For an instrument with a logarithmic meter readout, choose one point near the midrange of each decade. For an autoranging instrument, choose four (4) points equally spaced over the instrument's range and within the range of the reference field exposure rates.

2. Secure the beam area and assure that all the interlocks are clear.

3. Press the red "Irradiate" button on the source control box. A piercing whistle will sound for fifteen (15) seconds and then the source will raise.

4. Read the instrument response on the VTR screen.

5. Press the green "Off" button on the source control box or turn off the approach interlock control box. Either of these actions will drop the source.

6. Correct the instrument reading for pressure and temperature if the instrument's detection chamber is vented to the atmosphere (unsealed). Refer to the HP-34C calculator procedures (Appendix C, **Use of the HP-34C Calculator**, Section C.3, page 168) for the procedures used to calculate this value.

7. Make any required adjustments of the calibration pots and re-irradiate the instrument. All corrected instrument readings are expected to be within ±10% of the reference field exposure rate at each calibration point. If the instrument cannot be adjusted such that readings on two points on the scale being tested fall within ±10%

of the reference field exposure rate, then calculate a correction factor for that scale. When readings on that scale are multiplied by the correction factor, all readings will come within ±10% of the reference field exposure rate.

8. Record the source-detector distance, the reference field value, $\dot{X}_T$, the observed instrument reading, $\dot{X}_O$, the corrected instrument reading, $\dot{X}_C$, the percent error between the corrected instrument reading and the true exposure rate, and the correction factor (ratio of the reference field reading to the corrected instrument reading) on the calibration worksheet. The percent error is calculated using the following equation:

$$PE = \frac{\dot{X}_C - \dot{X}_T}{\dot{X}_T} \times 100\%$$

where PE ≡ percent error in the instrument response
$\dot{X}_C$ ≡ instrument reading, corrected to 22°C and 760 mm Hg (mR/hr)
$\dot{X}_T$ ≡ reference field exposure rate (mR/hr)

The percent error is used to show compliance with the applicable NRC Regulatory Guides.

Use the following equation to calculate the correction factor:

$$CF = \frac{\dot{X}_T}{\dot{X}_C}$$

where CF ≡ correction factor
all other terms ≡ defined above

9. Prepare a Report of Calibration (see Figure 13.4) for each instrument using the relevant information on the calibration worksheet. Transfer the calibration number from the worksheet to the report. Follow the report audit procedure in Chapter 3, **Auditing of Data and Reports**. Make a copy of the report.

10. Unless requested otherwise by the owner, transfer the relevant information from the calibration worksheet to the calibration sticker for all scales of the instrument which have been calibrated. Place the sticker on the instrument. NRC Regulatory Guides require recalibration periods of not more than one (1) year. Enter a recalibration date of one (1) year from the current date, unless requested otherwise by the owner.

11. Return the instrument and the original of the calibration report to the owner. File the copy of the instrument calibration report.

13.3.6 Source Shutdown

1. Refer to and follow the procedures for source shutdown in Chapter 4, **General Source Use Procedures**.

NORTHWEST RADIATION INSTRUMENT CALIBRATION FACILITY

NRICF FORM 00-01-00(5/87)

REPORT OF CALIBRATION

Ion Chamber Exposure Rate Survey Meter

Calibration Report Number: 88-1

Calibration Performed for: Washington Dept of So
Radioactive Materials Section
Olympia, WA

Client Reference Number: -1

Survey Meter Information

Manufacturer: Victoreen
Model: Panoramic 470A
Serial Number: 1540

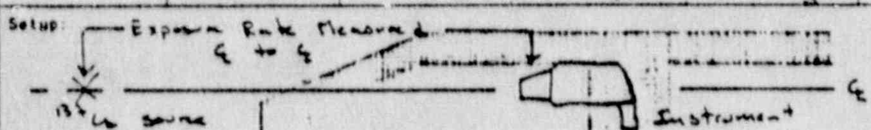
Detector Type: ion chamber
Model: —
Serial Number: —

Calibration Results

Battery OK on delivery: Y N

Radiation Source	Xray Tube Potential	Beam Energy	Exposure Rate	Range	Correction Factor at 22°C, 760 mm Hg
	(kVp)	(keV)	(mR/hr)	(mR/hr)	(true/observed)
137 Cs	N/A	662	750	1000	1.00
			250	1000	0.92
			250	300	1.00
			75	300	0.98
			75	100	0.98
			25	100	0.98
			25	30	1.00
			7.5	30	1.00
			7.5	10	1.02
			2.5	10	1.04
			2.5	3	0.97
			1.0	3	1.10

Setup:



Comments:

"This calibration was performed using a procedure which is ☑ is not ☐ included in the Scope of Accreditation issued by the Conference of Radiation Control Program Directors, Inc."

(Please see back of report)

Calibration Performed By: [signature] Date: 2/1/88
Calibration Report Checked By: [signature] Date: 2/1/88

Figure 13.4: Gamma Exposure Rate Meter Calibration Report (NRICF Form 00-01-00), page 1

The correction factors given in this report are quotients of the gamma-ray exposure and the response to that exposure by the instrument. The instrument was calibrated at two points on each scale, for multi-scaled instruments, and at three points on single-scaled instruments. If the chamber was open to the atmosphere the measurements were normalized to one standard atmosphere (760 mm Hg) and 22 degrees Celsius. Use of the chamber at other pressures and temperatures requires normalization of the results to these reference conditions. The normalizing factor (C_{pt}) is computed from the following expression:

$$C_{pt} = \frac{(273.15 + T)}{295.15} \cdot \frac{760}{P}$$

where: T = temperature in degrees Celsius
P = pressure in millimeters mercury

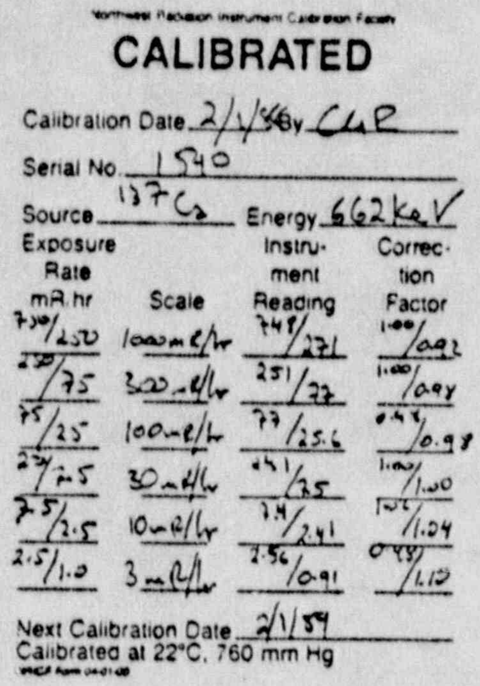
The exposure rates at the calibration positions are based on prior measurements by a Shonka-Wyckoff ionization chamber, and corrected to the date of calibration from previously measured values by decay corrections based on a half-life of 30.0 years for ^{137}Cs.

The value of the reference field has been demonstrated by a performance test to be within ±0.03% of the actual value as determined by comparison with the national standard.

Information on technical aspects of this report may be obtained from:

Curt G. Ruthes
Northwest Radiation Instrument Calibration Facility
Department of Environmental Health and Safety GS-05
University of Washington
Seattle, Washington 98195
(206) 543-0463
(206) 543-2545

Figure 13.5: Gamma Exposure Rate Meter Calibration Report (NRICF Form 00-01-00), page 2


Northwest Radiation Instrument Calibration Facility

CALIBRATED

Calibration Date 2/1/88 By CLP

Serial No. 1540

Source ^{137}Cs Energy 662 keV

Exposure Rate mR/hr	Scale	Instrument Reading	Correction Factor
750/250	1000 mR/hr	748/271	1.00/0.92
250/75	300 mR/hr	251/77	1.00/0.97
75/25	100 mR/hr	77/25.6	0.97/0.98
25/7.5	30 mR/hr	25.1/7.5	1.00/1.00
7.5/2.5	10 mR/hr	7.4/2.41	1.02/1.04
2.5/1.0	3 mR/hr	2.56/0.91	0.98/1.10

Next Calibration Date 2/1/89
Calibrated at 22°C, 760 mm Hg
NRICF Form 04-01-00

Figure 13.6: Gamma Exposure Rate Meter Calibration Sticker

13.4 EXPOSURE RANGES LESS THAN OR EQUAL TO 50 mR/hr

13.4.1 Equipment Required

1. 30 mCi ^{137}Cs source (refer to Chapter 4, **General Source Use Procedures**)
2. Calibration Track
3. Positioning Laser
4. Hewlett-Packard HP-34C calculator
5. Fluke 8022B DMM
6. Booklet containing NRICF Form 03-01-00 CALIBRATION WORKSHEET – Ion Chamber Exposure Rate Survey Meter (use NRICF Form 03-01-01 booklet for University of Washington instruments and NRICF Form 03-01-02 booklet for Washington State D.S.H.S. Instruments)

13.4.2 Source Start Up

1. Refer to and follow the **General Source Use Procedures**.

2. Begin filling out the first available calibration worksheet (see Figure 13.1) in the booklet for the instrument being calibrated.

13.4.3 Instrument Positioning

1. Place the second cart on the track and place the instrument on this cart as shown in Figure 13.3.

2. Raise or lower the platform until the center of the instrument chamber is centered on the laser beam and check that the instrument is positioned on the cart as shown in Figure 13.3 (excluding video camera). The instrument should be positioned with the long axis of the chamber parallel with the photon beam axis, unless requested otherwise by the client. For those instruments which do not have a preferred axis, point the window end towards the source; leave the window closed or covered.

3. Roll the cart forward or back until the center of the chamber is one (1) meter from the source. Use the tape attached to the side of the source to make this measurement. The tape is stiff so the slight slack in the tape introduces only a very small error in the distances measured.

13.4.4 Instrument Calibration

1. Position the cart holding the instrument at a desired distance from the source corresponding to the desired exposure rate. Measure the distance with the tape on the side of the source container. Refer to Appendix C, **Use of the HP-34C Calculator**, Section C.4, page 170 for the procedures used to calculate source-detector distances based on prior reference field measurements. Lock the cart in position with the thumbscrew lock on the front left side of the cart.

2. Remove the plug covering the source.

3. The instrument can be read directly as long as care is taken to limit the amount of time spent in the radiation field. The nominal exposure rate from this source is 10 mR/hr at one (1) meter.

4. Adjustments may also be made while the instrument is being irradiated as long as care is taken to limit radiation doses to the personnel involved.

5. Record the instrument response, the true exposure rate, the source-detector distance, the percent error between the instrument reading and the true exposure rate, and the correction factor on the calibration worksheet. The equations for calculating the percent error and the correction factor are given in Section 13.3.5, Exposure Ranges Above 50 mR/hr.

6. Prepare a "Report of Calibration" for the instrument based on the corresponding calibration worksheet. Transfer the relevent information, including the calibration number, to the calibration report. Follow the report audit procedure in Chapter 3, **Auditing of Data and Reports**. Make a copy of the calibration report.

7. Transfer the relevant information from the calibration worksheet to the calibration sticker for all the scales of the instrument which have been calibrated, unless otherwise requested by the client. Place the sticker on the instrument. Return the instrument and the original of the calibration report to the owner. File the copy of the instrument calibration report.

13.4.5 Source Shutdown

1. Refer to and follow the procedures for source shutdown in Chapter 4, **General Source Use Procedures**.

Chapter 4

GENERAL SOURCE USE PROCEDURES

4.1 3 CURIE ^{137}Cs SOURCE (Shepherd Model 81-8A)

4.1.1 Pre-operational Source Checks and Procedures

Refer to the calibration facility layout diagram (Figure 4.2).
Before operating the source:

1. Remove the lock pin from the source turntable and rotate the turntable until the 3 Ci ^{137}Cs source is aimed down the calibration track axis. Replace the lock pin in the turntable. Refer to the source stand detail diagram (Figure 4.1).
2. Check to be sure that the 20° collimator is in place.
3. Turn on the air supply to the 3 Ci ^{137}Cs source. There are two pressure meters along the supply line which should read 40 psi. The gas bottle pressure meter should read at least 80 psi. Adjust the supply line valves to read 40 psi if needed. Re-order a gas bottle (Nitrogen, 224 cubic foot bottle, 99.95% purity, available from UW Central Stores) if the gas bottle pressure drops below 80 psi.
4. Turn on the source interlock (on/off switch located on the source housing).
5. Turn on the alignment laser.
6. Turn on the beam monitor.
7. Plug in the approach interlock lights (on storage case).
8. Turn on the approach interlock control box (on the table next to the source control box). The source will not raise if the approach interlock is not turned on.

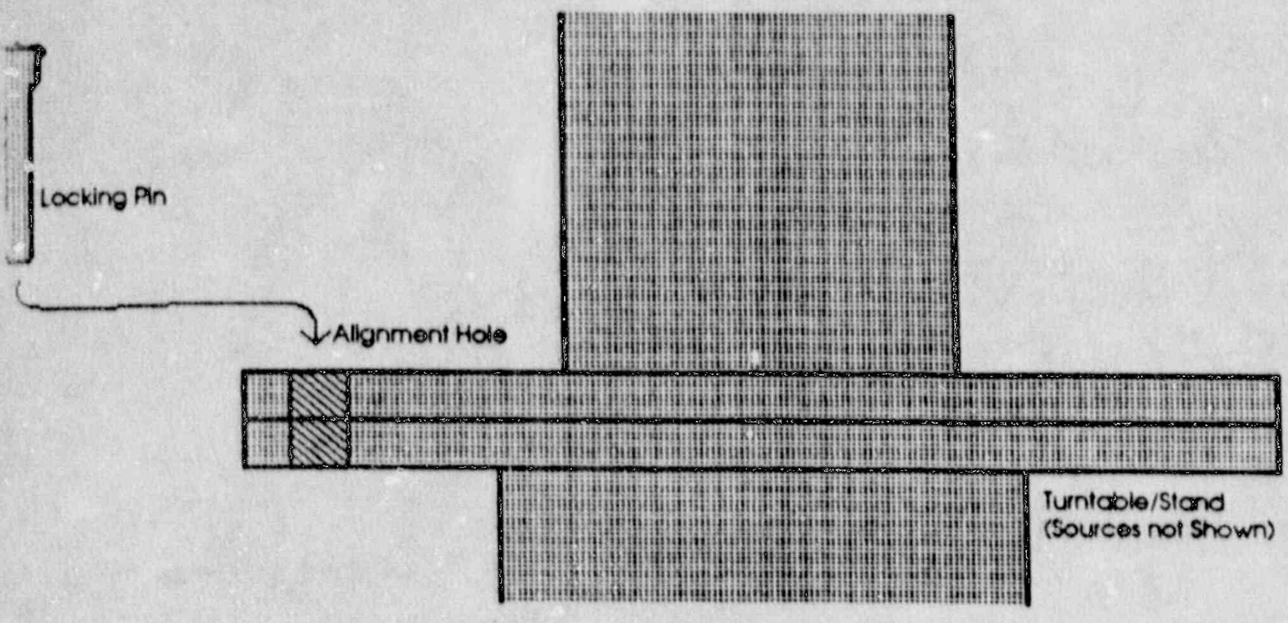


Figure 4.1: Source Stand Detail–Turntable

9. Turn on the source control box.
10. Turn on the VTR system.

.1.2 Source Use

Refer to the source control box diagram (Figure 4.3).

1. Irradiation control directions:
   (a) For manual source control set the time control toggle switch on the source control box to "Preset" and set the timer to 999.999 minutes.
   (b) For timed source control set the time control toggle switch on the source control box to "Preset" and set the timer to the irradiate time desired for automatic source drop, less 0.001 minutes. The source takes 0.001 minutes to rise and drop and the timer on/off switch is at the top of the source rod travel.
2. Visually inspect the beam area and assure that all the interlocks are clear.
3. Press the red "Irradiate" button on the source control box. A piercing whistle will sound for fifteen (15) seconds and then the source will raise.
4. Verify that the area monitor is responding.

Chapter 16

PULSE-RATE METER CALIBRATION

16.1 LIMITATIONS AND CONSTRAINTS

This is a general procedure for calibrating instruments used to detect *radioactive materials contamination*. Calibration of GM instruments for radiation field measurement is covered in Chapter 17, **Gamma Calibration of Geiger-Muller Instruments**. This procedure is limited to the classes of instruments listed in Table 16.1.

The electronic calibration is limited to rates between 1 Hz and 1 000 000 Hz. The radiation detection calibration is limited to the radionuclide check sources for which the NRICF has calibration data (refer to Appendix I, **Sealed Source and Check Source Data**). The efficiency calculated is for the geometry of the calibration jig used by the NRICF. Field use at other count rates, with other sources or in other geometries, must be at the discretion of the owner.

Refer to the notebook "PULSE-RATE METER CALIBRATION NOTES" for specific information concerning particular instruments. This notebook contains hand-written notes on pulse-rate instruments which have been through the facility and which had unusual properties or settings. There is also a file of operating and technical manuals for a limited number of instruments.

Instrument repairs are normally not made. If any problems with the instrument occur which are beyond the scope of calibration services, make a note of the condition on the calibration report and return the instrument to the owner.

Always make a copy of each calibration report. *Make a note of all adjustments and replacements on the calibration worksheet* (see Figure 16.2).

This procedure may not be accurate for instruments which have a logarithmic output. Check with the operating manual for such instruments, if possible. Log-scale instruments designed to measure exposure rates that are calibrated using this procedure will probably not read correctly in a radiation field. Refer to the chapter on calibration of GM exposure rate meters.

4.2 30 MILLICURIE ^{137}Cs SOURCE (Shepherd Series 10)

4.2.1 Source Start Up

Refer to the calibration facility layout diagram (Figure 4.2).

1. Turn on the positioning laser.
2. Remove the lock pin from the source turntable and rotate the turntable until the 30 mCi ^{137}Cs source is aimed down the calibration track axis. Replace the lock pin in the turntable.

4.2.2 Source Use

1. Remove the shield plug covering the source, thus allowing an external radiation beam.
2. Take care to limit the amount of time spent in the radiation field. The exposure rate from this source is about 20 mR/hr at one (1) meter from the source. The source beam is about 40 cm in diameter at one (1) meter and diverges to 80 cm at two (2) meters.
3. In keeping with the principles of ALARA, take care to limit radiation doses to the personnel involved.

4.2.3 Source Shutdown

1. Replace and lock the source cover plug.
2. Turn off the laser.

16.3 LINEARITY CHECK

16.3.1 Equipment Required

1. Instrument under test
2. Berkeley Nucleonics pulser
3. Tektronix 2215 oscilloscope
4. UW Nuclear Reactor built special NIM bin (high voltage/pulse divider)
5. Canberra Industries Model 2022 spectroscopy amplifier
6. Harshaw Type NC-12 single channel analyzer
7. Canberra Industries Model 2017 dual counter-timer
8. Fluke 8022B digital multimeter (DMM)
9. Fluke 80K-40 high voltage probe
10. Cables as needed
11. Booklet containing NRICF Form 03-04-00 CALIBRATION WORKSHEET – Count Rate Survey Meter

16.3.2 Linearity Check Procedure

1. Connect the test equipment as shown in Figure 16.1.
2. Turn on the instrument.
3. Turn on the NIM bin.
4. Turn on the pulser.
5. Turn on the oscilloscope.
6. Set the pulser to apply a fast, low voltage pulse about one microsecond (1 μs) wide with a fast (nearly vertical) rise time. This should result in a pulse with a fall time appropriate to the detector. Attach the oscilloscope to the pulser to set the pulse shape.

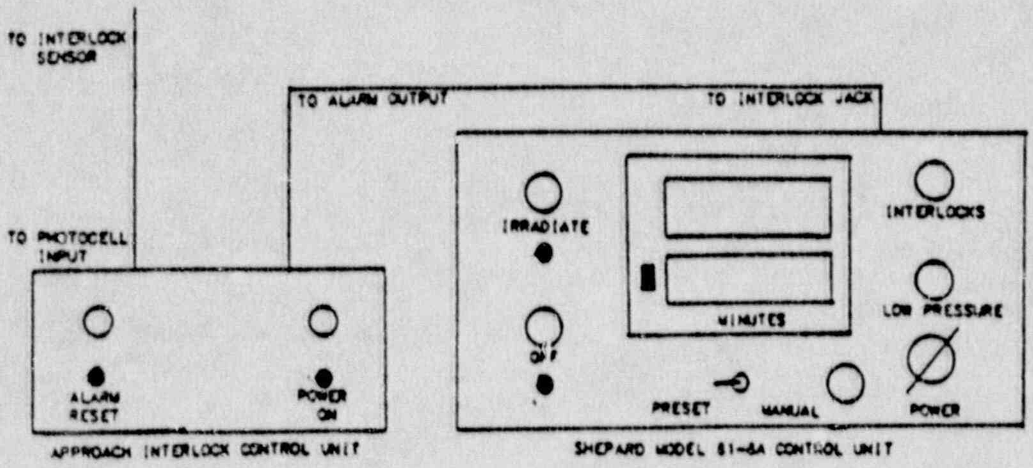


Figure 4.3: Shepherd 81-8A Control Box (front panel) and Approach Interlock Control Unit

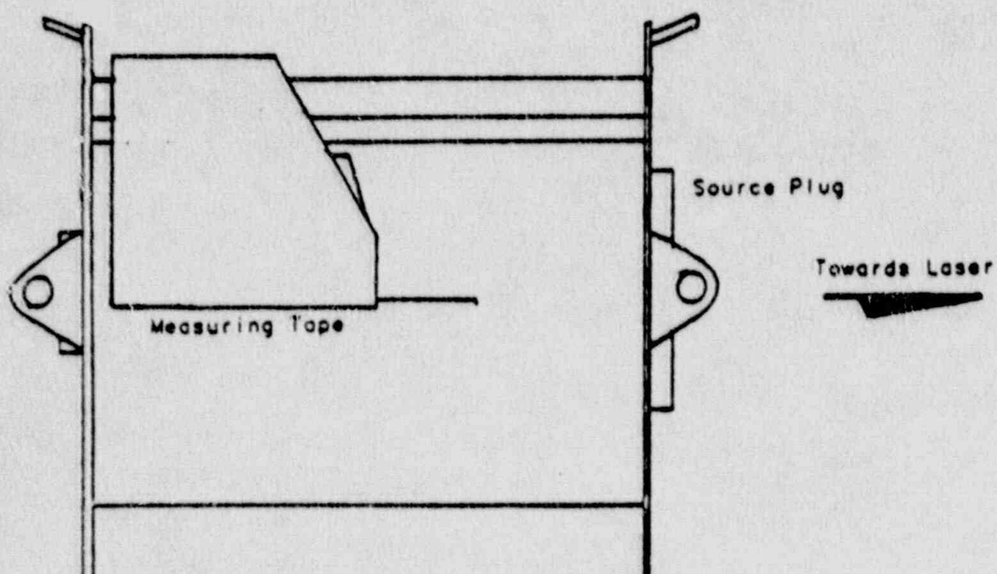


Figure 4.4: Shepherd Series 10 Calibrator (side view)

7. Set the pulser to provide a pulse of the proper size for the instrument being calibrated. This is an empirical process. In general, instruments which use an NaI probe accept a negative pulse about 10 millivolts high (use the oscilloscope to set the pulse height); and GM instruments accept a negative pulse about 2 volts high. (As specific examples. Ludlum instruments accept pulses about 10 millivolts high regardless of the probe, while Johnson instruments accept a 2 volt pulse regardless of the probe.) Check the notebook or the technical manual for specific information concerning the instrument at hand.

8. Disconnect the probe from the detector.

9. Check the mechanical zero of the meter, adjusting the meter to read zero (0) if necessary.

10. Check the condition of the batteries. Replace any battery that is less than 70% of its nominal voltage.

11. Connect the instrument to the test equipment.

12. Turn on the instrument. Use the multimeter to measure the high voltage bias applied to the probe. This tells us if the bias supply is working and will be compared to past measurements to tell if the bias is set correctly. (The value should be in the range of 900 V to 1000 V for GM probes and 650 V to 900 V for scintillation probes.)

13. Adjust the amplifier, single channel analyzer and timer/scaler in the NIM bin to measure the pulse being sent to the survey meter. Remember that most meters read in counts per minute (cpm, c/m) and that the pulser settings are in pulses per second (hertz, Hz). You can check the value shown on the timer/scaler against the frequency of pulses on the oscilloscope to be sure that the timer/scaler is reading correctly

14. For each scale:

    (a) Check each scale of the instrument at two (2) points. The first point should be about 25% to 33% of full scale; and the second point should be about 66% to 75% of full scale. (Check logarithmic scale instruments at the midpoint of each decade. Check autoranging instruments at three (3) points between 25% and 75% of full scale.) Set the pulser at a convenient count rate and adjust the scale potentiometer (usually inside the unit) until the meter reads properly, within ±10%. Record the pulser output, the meter scale and reading, and the ratio of the pulser output to the meter reading ($\frac{\text{pulser output}}{\text{meter reading}}$) on the calibration worksheet.

    (b) Recheck the other effected points tested if adjustments were made. Not all instruments have a separate pot for each scale, so a compromise may be necessary between having the "most often used" scales in better calibration than other

Portable GM Contamination Monitors	Bench-top GM Contamination Monitors
Portable NaI Contamination Monitors	Bench-top NaI Contamination Monitors
Portable ZnS Contamination Monitors	Bench-top ZnS Contamination Monitors

Table 16.1: Instrument Classes Acceptable for Pulse-Rate Meter Calibration

This procedure is not covered in the "Scope of Accreditation" issued from the CRCPD.

16.2 MECHANICAL REPAIR AND CHECK

16.2.1 Equipment Required

1. Instrument under test
2. Fluke 8022B digital multimeter
3. Booklet containing NRICF Form 03-04-00 CALIBRATION WORKSHEET - Count Rate Survey Meter

16.2.2 Mechanical Repair and Check Procedure

1. Begin filling out the first available calibration worksheet (see Figure 16.2) in the worksheet booklet with the calibration report number, ownership information and instrument information.
2. Check the batteries using the instrument's battery test function, if available, or using the Fluke DMM. Replace the batteries if the battery test indication is low or if the Fluke DMM reading is less than 70% of the nominal battery value. Record the state of the batteries on the calibration worksheet. (see Figure 16.2).
3. Check the meter readout for dirt, cracks and other signs of disrepair. Return the instrument to the owner for repair if the meter shows signs of disrepair. Record the condition of the meter on the worksheet.
4. Check the instrument for corrosion, dirt, physical abuse and other signs of disrepair. Return the instrument to the owner for repair if the instrument shows signs of disrepair. Record the condition of the instrument on the worksheet.
5. Record any other comments concerning the mechanical repair of the instrument on the worksheet.

DETECTOR EFFICIENCY EVALUATION

Probe Type: Thin NaI   Probe Serial: —   High Voltage: 680

Special Comments: Ludlum model 44-3 probe

Radiation Source	Radiation Emitted	Energy (KeV)	Activity (uCi)	Meter Reading	Efficiency (CPM/DPM)	Efficiency (CPM/Nanocurie)
background	—	—	—	1001	—	—
^{14}C	β	155	0.158	2500	0.007	15
^{36}Cl	β	720	0.0487	3600	0.08	140
^{129}I ([illegible])	xray	35	0.101	12600	0.05	120

Probe Type: ______   Probe Serial: ______   High Voltage: ______

Special Comments: ______

Radiation Source	Radiation Emitted	Energy	Activity (uCi)	Meter Reading	Efficiency (CPM/DPM)	Efficiency (CPM/Nanocurie)
background	—	—	—		—	—

Probe Type: ______   Probe Serial: ______   High Voltage: ______

Special Comments: ______

Radiation Source	Radiation Emitted	Energy	Activity (uCi)	Meter Reading	Efficiency (CPM/DPM)	Efficiency (CPM/Nanocurie)
background	—	—	—		—	—

Probe Type: ______   Probe Serial: ______   High Voltage: ______

Special Comments: ______

Radiation Source	Radiation Emitted	Energy	Activity (uCi)	Meter Reading	Efficiency (CPM/DPM)	Efficiency (CPM/Nanocurie)
background	—	—	—		—	—

Probe Type: ______   Probe Serial: ______   High Voltage: ______

Special Comments: ______

Radiation Source	Radiation Emitted	Energy	Activity (uCi)	Meter Reading	Efficiency (CPM/DPM)	Efficiency (CPM/Nanocurie)
background	—	—	—		—	—

Figure 16.3: Pulse-Rate Meter Calibration Worksheet (NRICF Form 03-04-00), page 2

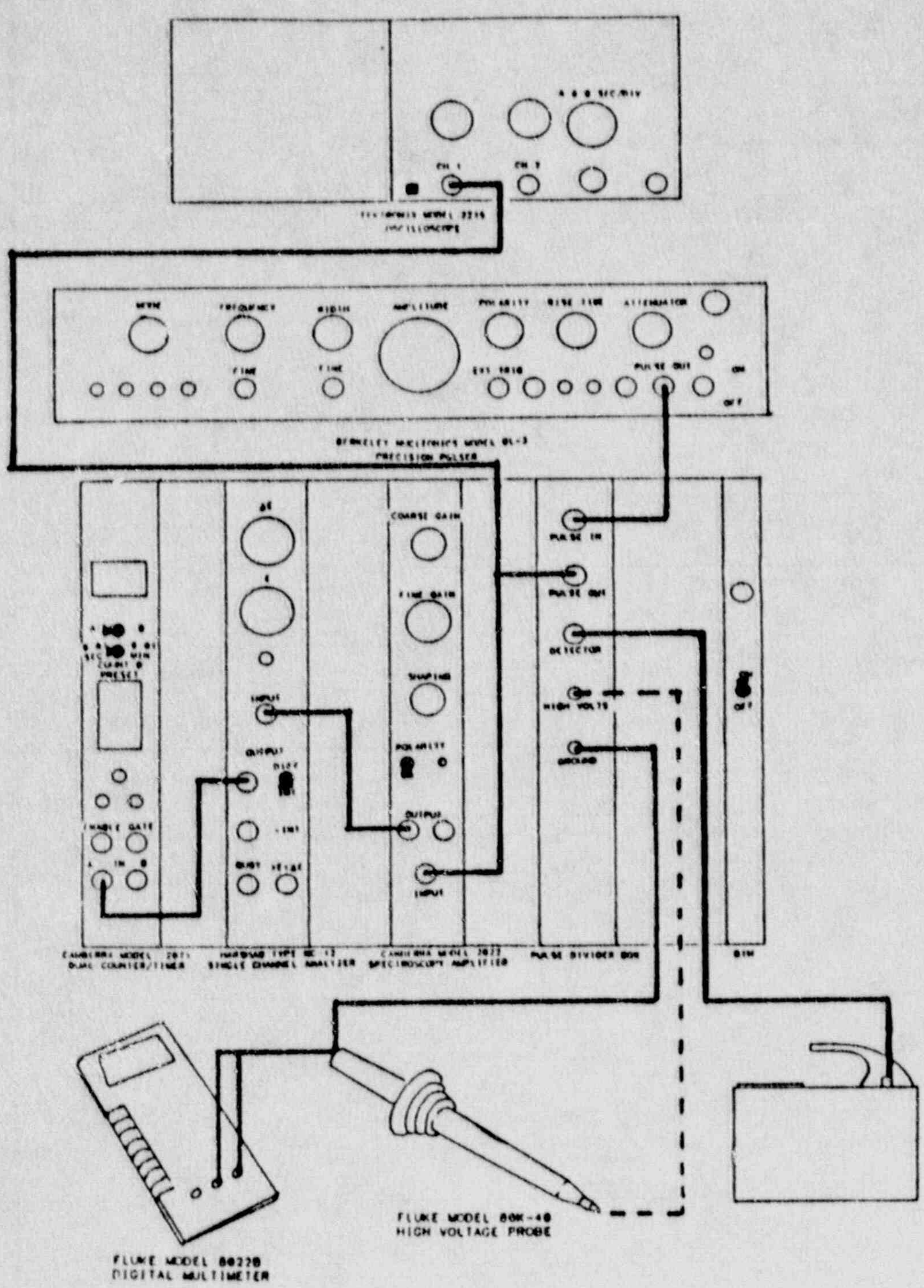


Figure 16.1: Pulse-Rate Meter Calibration Setup

6. Place the probe over the opening above each source and record the instrument reading on the worksheet. Repeat for each source used.

7. Place the probe over the table and away from the jig to determine the background count rate. Record the reading.

8. Turn off the instrument.

9. Calculate the following efficiencies:

   (a) Meter reading per disintegration rate (choose the units of disintegration rate to match the units of the instrument):

$$\epsilon_d = \frac{R_s - R_b}{D_A A_s}$$

where ϵ_d ≡ efficiency (e.g. for an instrument which reads out in counts per minute, the units of ϵ_d will be counts per minute per disintegration per minute, CPM/DPM)

R_s ≡ instrument reading from source s (e.g. in CPM)

R_b ≡ instrument reading due to background (e.g. in CPM)

D_A ≡ disintegration rate of source per nanocurie of activity ($= 2220 \frac{DPM}{nCi} = 37 \frac{DPS}{nCi}$)

A_s ≡ activity of source s in nanocuries, nCi

   (b) Meter reading per nanocurie of activity:

$$\epsilon_A = \frac{R_s - R_b}{A_s}$$

where ϵ_A ≡ efficiency (e.g. for an instrument which reads out in counts per minute, the units of ϵ_A will be counts per minute per nanocurie, $\frac{CPM}{nCi}$)

all other terms ≡ defined above

10. Record the above efficiencies on the worksheet.

11. Prepare a "Report of Calibration" by transferring the relevant material from the worksheet to the report (see Figure 16.5). Prepare one report for each probe calibrated.

00059

NORTHWEST RADIATION INSTRUMENT CALIBRATION FACILITY

NRICF FORM 03-04-01(8/85)

CALIBRATION WORKSHEET

Calibration Report Number: 88-1159

COUNT RATE SURVEY METER
University of Washington Instruments

OWNERSHIP INFORMATION

AUR Number: 100
Last Name: O'Brien
Department: EH&S / RSO

INSTRUMENT INFORMATION

Manufacturer: Ludlum
Model Name:
Model Number: 16
Detector Type: Ludlum 44-2 1x1 NaI
Serial Number: 7496
U.W. Property Number: 876543
Other ID Number: none
(Type):

MECHANICAL REPAIR AND CHECK

	ok	replaced	other (describe)
Batteries	☑	☐	
Meter Readout	☑	n/a	
General Condition	☑	n/a	
Batteries	n/a	n/a	

LINEARITY CHECK

Detector High Voltage (volts): 680
Pulser Output (volts): +/⊖ 0.01
Pulser Date:

Pulser Output	Instrument Scale	Meter Reading	Pulser Output/ Meter Reading	Comments
36000	x1000	38000	0.95	
14000		12000	1.17	
3600	x100	3750	0.96	
1400		1200	1.17	
360	x1	365	0.99	
140		135	1.04	

COMMENTS

BY: [signature] DATE: 2/1/88

Figure 16.2: Pulse-Rate Meter Calibration Worksheet (NRICF Form 03-04-00), page 1

NORTHWEST RADIATION INSTRUMENT CALIBRATION FACILITY

NRICF FORM 00-04-00(6, 85)

REPORT OF CALIBRATION

Count Rate Survey Meter

Please complete one form for each probe calibrated

Calibration Report Number: 88-1159

Calibration performed for: MJ O'Brien
Env. Health & Safety
UW

Client Reference Number: 100

Detector Information

Manufacturer: Ludlum
Model: 16
Serial Number: 7496

Probe Information

Manufacturer: Ludlum
Model: 44-3
Serial Number: none

Calibration Results

Battery OK on Delivery? (Y) N
Meter Response Linear (within ± 10%)? (Y) N
High voltage (bias) on chamber (volts): 680

Radiation Source	Radiation Emitted	Energy (keV)	Activity (uCi)	Meter Reading	Efficiency (CPM/DPM)	Efficiency (CPM/Nanocurie)
background	—	—	—	100	—	—
^{14}C	β	155	0.158	2500	0.007 !	15
^{36}Cl	β	720	0.0187	3600	0.08	190
^{129}I (1 in. dia.)	x-ray	35	0.101	12000	0.05	120

Setup:

Comments

This calibration was performed using a procedure which is ☐ is not ☑ included in the Scope of Accreditation issued by the Conference of Radiation Control Program Directors, Inc.

(Please see back of report)

Calibration Performed By: [signature] Date: 2/1/88
Calibration Report Checked By: [signature] Date: 2/1/88

Figure 16.5: Pulse-Rate Meter Calibration Report (NRICF Form 00-04-00), page 1

scales. Large discrepancies between the meter reading and the true rate should be clearly noted on the calibration report.

15. Turn off the oscilloscope.

16. Turn off the pulser.

17. Turn off the NIM bin.

18. Turn off the instrument and disconnect it from the test equipment.

16.4 DETECTION EFFICIENCY EVALUATION

16.4.1 Equipment Needed

1. Check source counting jig

2. Check sources appropriate to the instrument (refer to Appendix I, **Sealed Source and Check Source Data**)

3. Instrument under test

4. Booklet containing NRICF Form 03-04-00 CALIBRATION WORKSHEET - Count Rate Survey Meter

16.4.2 Detection Efficiency Evaluation Procedure

Measure the detection efficiency for each probe accompanying the instrument:

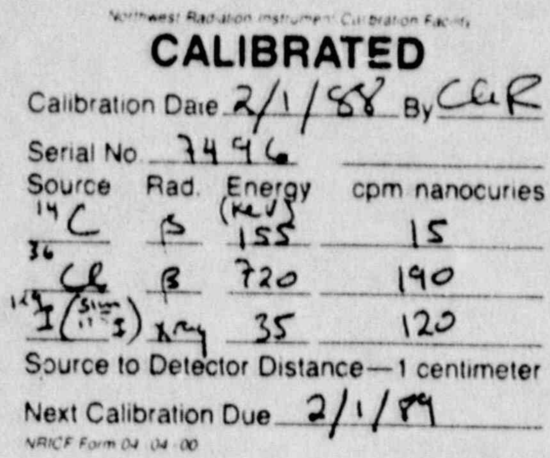
1. Attach the probe to the instrument.

2. Turn on the instrument.

3. Use check sources which match or simulate isotopes which are commonly found in the lab where the instrument is used. Refer to Appendix I, **Sealed Source and Check Source Data** for the check sources available. Record the check sources used, the radiation emitted from each source, the radiation energies and the activity of each source on the worksheet.

4. Place the check sources in the calibration jig. The jig can hold up to three (3) different sources. The jig places the probe one centimeter (1 cm) from the source. *Note on the worksheet if the detection efficiency is measured at a different distance.*

5. Place the plastic probe support platform over the calibration jig.


Northwest Radiation Instrument Calibration Facility
CALIBRATED
Calibration Date 2/1/88 By CLR
Serial No. 7496

Source	Rad.	Energy (keV)	cpm nanocuries
^{14}C	β	155	15
^{36}Cl	β	720	190
^{129}I (sim. ^{125}I)	x-ray	35	120

Source to Detector Distance—1 centimeter
Next Calibration Due 2/1/89
NRICF Form 04 04 00

Figure 16.4: Pulse-Rate Meter Calibration Sticker

12. Unless otherwise requested by the owner, prepare the instrument sticker (see Figure 16.4)and set the recommended recalibration date to one (1) year after the current date. This is in accordance with NRC Regulatory Guides. Attach the sticker to the instrument.

13. Return the instrument to the owner along with a copy of the calibration report. File the original report.

14. Record any special methods for calibrating the instrument, such as an unusual pulse size, lack of calibration pots, etc. in the "PULSE-RATE METER CALIBRATION NOTES" notebook.

The efficiency values reported are based on measurements from a disk source at a source-detector distance of one (1) centimeter. No evaluation of dead time or resolving time of the detector-probe combination is made.

The disk source activities are traceable to the national standard.

Information on technical aspects of this report may be obtained from:

Northwest Radiation Instrument Calibration Facility
Department of Environmental Health and Safety GS-05
University of Washington
Seattle, Washington 98195
(206) 543-0463
(206) 543-2545

Figure 16.6: Pulse-Rate Meter Calibration Report (NRICF Form 00-04-00), page 2

SPECIAL NOTE

Regulatory Guide 8.6 establishes ANSI Standard N42.3(1969), also known as IEEE Standard No. 309, as the preferred test/calibration procedure for Geiger-Müller counters. The present procedure above does not conform to all points of ANSI N42.3(1969).

Procedure for Receiving Packages Containing Radioactive Material

1. This procedure is written to cover 10 CRF 20.205(d) and should be checked for current regulations. It is advisable to know the current regulations as changes are made over the years. Therefore in anticipation of a receipt of radioactive material, the regulations should be consulted.

2. Check packing list and shipping papers for isotope(s), amount of activity, and shipper's survey data. Any special or unusual package opening requirements should be noted and followed.

3. For packages containing in excess of Type A quantities as listed in 10 CFR 20.205(b):

   Surveys of external dose rates and checks for removable contamination need to be performed within 3 hours of receiving a package containing radioactive material.

4. Survey of package for radiation levels:

   The dose rates should be determined at external surface of package and at three feet from package. The measurements should agree with shipper's data. In any event, if they exceed 10 mrem/hr at 3 feet or 200 mrem/hr at surface, the delivering carrier and Region V of the NRC need to be immediately notified.

5. Determination of removable contamination on external surface of package.

   Using a filter paper, swipe 100 square centimeters of the external surface of the package and determine the removable activity, if any. If the removable radioactive contamination exceeds 0.01 microcuries per 100 square centimeters the delivering carrier and Region V of the NRC need to be notified immediately.

PROCEDURE FOR OPENING PACKAGES CONTAINING LICENSED RADIOACTIVE MATERIAL

The receipt of radioactive shipments and the opening of such packages very seldom occurs at the U of W Nuclear Reactor. Hence it is advisable to have the assistance of the radiation safety division for opening packages involving activity greater than exempt amounts. The current regulations need to be consulted for the exempt amounts. In any case, the lead time would allow for specific planning needed for the package in question.

The packing list and shipping papers should indicate the isotope, activity, type of packaging, and the shipper's radiation survey information. There may be special packaging and consequently special opening procedures for the package which need to followed.

After the initial receiving procedure has been performed, the following basic procedure should be used for the safe opening of packages containg radioactive material.

Personnel opening the package should have their film badge, appropricte survey meters for the isotopes and activities in package, swipes, and plastic gloves.

Open the outer container, survey the inner container as appropriate. Take a swipe of the inner container and check with appropriate monitor for removable conatamination. If there is more than one inner container, repeat.

If any unexpected removable contamination is detected, the cause will need to be determined and appropriate actions taken. The aid of radiation safety in monitoring during the opening procedure would aid in determining these actions.

Depending upon the activity and isotope contained in the package, it may be advisable to have some temporary shielding available.

University of Washington Nuclear Reactor Building

RADIOLOGICAL CONTROL

General rules for the reactor room:

REQUIREMENTS

1. Personnel will wear a monitoring device (film badge, TLD, or personnel dosimeter).

2. Visitors are to be escorted.

3. When handling radioactive samples or chemicals, personnel will wear a labcoat.

4. All personnel leaving reactor room will normally exit through the door by the chemistry lab. This will facilitate personnel monitoring for alpha and beta-gamma as each person leaves the reactor room.

5. If any contamination is found, the help of a responsible person is needed, (facility personnel or radiation monitor), they should be contacted and appropriate action taken.

6. Personnel that have been in only the computor room and counting room will normally not be required to monitor upon exiting.

7. If radioactive samples are being handled, the samples need to be monitored by either the experimenter or reactor personnel. If radioactive materials samples are being handled, the person should wear plastic gloves for protection from contamination. Sample handling will require the person to monitor their hands after completion of the work.

8. Any opening of a reactor beam port, vertical hole, or thermal column requires that a facility staff member or radiation monitor be present and a radiation survey be performed.

9. Personnel using a sealed source(Pu-Be, Cs-137, Co-60) will need to use the appropiate survey meter(s) during source manipulation.

10. Items removed from the reactor romm must be monitored for contamination by Radiation Safety or Reactor Staff Personnel.

2.2 Radiation Emergency Procedure

A radiation emergency is any present, suspected or imminent situation involving radiation which threatens the health and safety of personnel and/or the public.

A. A radiation emergency is indicated by:
   1. Audible oscillating sound over P.A.
   2. "Radiation Emergency" light in reception area
   3. P.A. Announcement by building personnel
      Under emergency conditions, if necessary, an individual may remain in the Reactor Room until a 100 mrem dose is accumulated. An emergency dose up to 50 Rem for lifesaving and up to 3 Rem for equipment salvage may be allowed. An automatic alarm is set off by either (a) high area radiation monitor trip (set point is usually 1.5 to 10 mr/hr) or (b) high A-41 release or high stack monitor reading.

B. When the alarm sounds (or P.A. anouncement is made):
   1. Reactor operators shall do the following:
      a. Scram reactor
      b. Push emergency button on ventilation control panel
         Action:
         1) turns off fan and closes damper which is also the exhaust from the Reactor Room
         2) puts the Control Room on 100 per cent fresh air
         3) does not affect rest of building control
      c. Turn off Reactor Room fan on ventilation control panel
         Action:
         1) turns off the recirculation fan in Reactor Room only
         2) does not affect intake to the Reactor Room
      d. Turn Reactor Room fresh air to 0 on ventilation control panel
         Action:
         1) closes intake vent to reactor room by 99 per cent
      e. Observe the following:
         1) Area radiation monitors for high dose rates
         2) Stack monitor increase dose rates
         3) Remain at the Console and continue to observe and record conditions. If any monitor shows over 200 mr/hr when reactor is below one watt, consider leaving
      f. False Alarm
         If the reactor operator or other persons are cognizant of the radiation alarm situation and it does not constitute a radiation emergency this should be announced over the P.A. When this information is known in advance, the alarm system should be "held off" by another staff member before proceeding as usual, e.g., testing alarm or internal transfer of hot source.

   2. Other personnel
      a. Secure current project
      b. Observe area and people in immediate area
      c. Assemble immediately at reception desk area

   3. At reception desk
      a. Senior staff member present will be in charge

b. Account for all personnel in building
c. Attempt to identify the problem
d. Notify senior staff if not present
e. Notify radiation safety office

4. Search Operation
   a. If someone has remained inside or it is not certain that everyone has evacuated the Reactor Room a search operation should proceed. View Reactor Room from balcony. Check loft,all offices,rest rooms and counting room. If necessary search mechanical and chemistry room. Search operations should proceed without delay.

5. Rescue Operation
   a. Rescue operations should proceed with consideration for risks in moving injured personnel versus radiation levels. University Police should be notified to obtain medical assistance(ambulance).

6. Radiation monitoring and contamination control
   a. Radiation surveys should be made as soon as possible after life saving activities. Measurements should be recorded and persons in charge should be kept aware of conditions.
   b. Contamination control is very important. Anyone leaving the buffer zone inside the Reactor Room should be monitored, including injured personnel. This contamination control area must be respected except for the most serious injuries.
   c. Injured personnel who are contaminated should be decontaminated. If possible a radiation safety person should accompany the injured into the Emergency Room. Injured may be taken to either University Hospital or Harborview Medical Center.

7. Off-hours - building unoccupied
   a. University Police, becoming aware of the alarm, should not enter the building. They should notify M. J. O'Brien (University Radiaton Safety Officer) via the EH & S Paging and one of the following:
      W. P. Miller 527-2921
      D. F. Fry 522-5867
      M. A. Robkin 453-9401

8. Others to be notified:
   a. Radiological Assistance Team (Richland) should be called if needed.
   b. Notification of the Nuclear Regulatory Commission may be required by 10CFR20.
   c. State Radiation Control Unit should be notified according to provisions of WAC 402-24.
   d. NEPA(Insurance) should be notified if (a),(b), or (c) above is required.

9. Annual high radiation drill
   a. A radiation emergency drill shall be held least annually. This drill will cover sections 2.2A through 2.2B6. Refer to the beginning of this section for emergency dose limits.

EMERGENCY PHONE LIST

REACTOR STAFF	WORKING HOURS	NON-WORKING HOURS
Dr. M. Robkin	3-4170 3-0692	453-9401
William P Miller	3-4170	527-2921
DeLoss Fry	3-4170	522-5867

POLICE and FIRE DEPARTMENT

Seattle Fire Department	9-911
University Police - Emergency	9-911 or 222
University Police - Campus No.	3-9331

RADIATION SAFETY CONTACTS

Campus Radiation Safety Office
M.J. O'Brien Radiation Safety Officer 3-0463 Home - 525-8128

Monitor's Office(T-Wing Health Science) 3-6328

OTHERS

NRC Headquarters Bethesda 24 hour in case of emergency	(301)-951-0550
Backup Bethesda Numbers for NRC in case 301-951-0550 is not answering	(301)-427-4056 Backup (301)-427-4259 Backup (301)-492-8893 Backup
NRC-Walnut Creek Office(Region V)	(415)-943-3700
Insurance(NEPA)	(203)-677-7305
State of Washington Radiation Control	682-5327
Interagency Radiological Assistance Richland Operations Office DOE	(509)-376-7381

February 2, 1988