SUPPLEMENT E

ADDITIONAL DOCUMENTS FOR RADIATION PROTECTION PROGRAM

1. Health Physics Memo No. 2, Bioassay Program
2. USAMRIID Memo No. 40-11, Health Physics Regulations
3. Health Physics Memo No. 9, Laboratory Facilities
4. Health Physics SOP No. 1-6, Leak Testing and Inventory of Sealed Sources
5. Health Physics SOP No. 1-7, Ventilation in Radiation Controlled Areas
6. Health Physics SOP No. 1-2, Counting Procedures
7. Health Physics SOP No. 2-2, Radioactivity Analysis Laboratory
8. Health Physics Memo No. 14, Gas Chromatograph Operating Procedures

HEALTH PHYSICS
WALTER REED ARMY MEDICAL CENTER
Washington, D.C. 20012

MEDEC-YHP
MEMO 2 BIOASSAY PROGRAM 14 May 1974

1. PURPOSE. To establish procedures for bioassay measurements that are necessary or desirable to aid in determining the extent of an individual's exposure to concentrations of radioactive material.

2. GENERAL. All models, equations, assumptions and requirements for internal dosimetry are derived from those concepts outlined in ICRP publications 2, 6, 9, 10, 10A, and 12.

3. PROCEDURES.

a. It is the responsibility of the Principal User to notify Health Physics prior to the beginning of any operation that will utilize, at any one time, non-contained quantities of radioactive material greater than the operational level indicated in Table 1.

b. The proposed operation will be reviewed to determine the probable extent of individual exposure and the bioassay measurements required.

c. Scheduling of bioassay measurements will usually be made as indicated in Table 1. If the chemical form of an isotope is not readily detectable in the type of measurement indicated, other appropriate methods will be employed.

4. REPORTS AND INVESTIGATIONS.

a. An inquiry will be made of any positive results of bioassay measurements and where possible recommendations will be made to reduce exposure.

b. An investigation will be performed and submitted to the WRAMC Subcommittee for Medical Evaluation of Radiation Workers whenever continued operations have or would cause an indivudual user to exceed one-tenth of the Maximum Permissable Body Burden. The report will include all pertinent information concerning the particular operation: confirmation of analysis, time and nature of intake(s), chemical form of isotope(s) dosage calculations if required, and action taken or recommendations.

5. NON-ROUTINE OPERATIONS. Other monitoring procedures will be instituted when desirable or necessary in circumstances such as:

a. The conduct of non-routine operations with a known or suspected high hazard. The Principal User should contact the Health Physics Office if there is any doubt concerning the hazards of a planned operation.

MEDEC-YHP
MEMO 2

b. A known accident.

c. Confirmation of internal contamination.

d. Repeated findings of spreadable radioactive contamination in laboratories.

1 Incl
Table 1

BOBBY R. ADCOCK
LTC, MSC
Health Physics Officer

BIOASSAY PROGRAM - TABLE 1

13 May 1974

ISOTOPE	OPERATIONAL LEVEL (mCi)	TYPE OF MEASUREMENT	FREQUENCY OF MEASUREMENT
H-3	100	Urine, 24 hour sample	Weekly and completion of study
Na-22	1	Urine, 24 hour sample	Monthly and completion of study
P-32	10	Urine, 24 hour sample	Monthly and completion of study
S-35	10	Urine, 24 hour sample	Monthly and completion of study
Cl-36	10	Urine, 24 hour sample	Monthly and completion of study
Ca-45	1	Urine, 24 hour sample	Monthly and completion of study
Fe-59	10	Whole body count Blood count	Every six months Monthly
Co-60	1	Urine, 24 hour sample	Monthly and completion of study
Zn-65	10	Urine, 24 hour sample	Monthly and completion of study
Rb-86	10	Urine, 24 hour sample	Semi-weekly and completion of study
Sr-90	1	Urine, 24 hour sample	Monthly and completion of study
Tc-99	1	Thyroid count	Monthly or upon any suspected injection
I-125	5	Thyroid count	Monthly
I-131	1	Thyroid count	Monthly
Cs-137	1	Urine, 24 hour sample Whole body count	Monthly and completion of study Every six months

DEPARTMENT OF THE ARMY
HEADQUARTERS, U.S. ARMY MEDICAL RESEARCH INSTITUTE OF INFECTIOUS DISEASES
FORT DETRICK, FREDERICK, MARYLAND 12701

MEMORANDUM
NUMBER 40-11

28 January 1974

Change No. 1

HEALTH PHYSICS REGULATION FOR RADIOISOTOPE UTILIZATION

1. The following changes should be made to Para 2, "RESPONSIBILITIES"

(a) Add (3) The USAMRIID representative on the WRAMC and Ft. Detrick Isotope committees.

(b) Change b. USAMRIID Radiological Safety Officer to read: "The Chief, Radiological Section, USAMRIID Animal Assessment Division, serves as the USAMRIID Radiological Safety Officer and the principal user of the Cobalt Irradiation Unit in Animal Assessment Suite 4. The Chief, Animal Assessment Division serves as the alternate".

2. This change sheet should be filed in front of the publication.

FOR THE COMMANDER:

DAVID E. LYNN
CPT, MSC
Adjutant

DISTRIBUTION
C
PLUS
1 - C, Health Physics, WRAMC

DEPARTMENT OF THE ARMY
HEADQUARTERS, U.S. ARMY MEDICAL RESEARCH INSTITUTE OF INFECTIOUS DISEASES
FORT DETRICK, FREDERICK, MARYLAND 21701

MEMORANDUM
NUMBER 40-11*

30 October 1973

HEALTH PHYSICS REGULATION FOR RADIOISOTOPE UTILIZATION

1. PURPOSE.

To establish policy and procedure for radioisotope utilization at USAMRIID. This memorandum supplements Walter Reed Army Medical Center (WRAMC) Regulation 40-10 (WR 40-10) dated 15 June 1973 governing the radiological safety program for the use of material or equipment that produces ionizing radiation. USAMRIID personnel utilize radioisotopes in accordance with WRAMC Authorization #506A and WR 40-10 as implemented by this memorandum.

2. RESPONSIBILITIES.

a. Principal User - Scientific Advisor, USAMRIID.

(1) The single senior individual at USAMRIID who serves as the Principal User of isotopes for the entire Institute in accordance with WRAMC Authorization Number 506A.

(2) The responsible individual who insures that inventory quantities of each isotope available at USAMRIID do not exceed authorized maximum limits (Appendix A).

*This memorandum supersedes Memorandum 40-11 dated 14 April 1972.

b. USAMRIID Radiological Safety Officer.

The Chief, Radiological Section, USAMRIID Animal Assessment Division, serves as both the Radiological Safety Officer and the USAMRIID representative on the WRAMC Isotope Committee. The Chief, Animal Assessment Division serves as the alternate USAMRIID Radiological Safety Officer.

c. Health Physics Technician, USAMRIID.

Technician(s) assigned to the Logistics Division, USAMRIID, who are specially trained under the WRAMC Health Physics Officer, and who serve at USAMRIID as the full-time representative(s) of the WRAMC Health Physics Officer.

d. USAMRIID Isotope Committee Members.

The Scientific Advisor serves as the Chairman, Isotope Committee, and advises the Commander, USAMRIID, on all matters pertaining to the use of radioisotopes in research studies conducted at this Institute. The Radiological Safety Officer serves as the recording secretary; other members are designated by official orders and include at least one representative of each USAMRIID research division.

e. Division Chiefs, USAMRIID.

Report to the Principal User their nominations of candidates for designation as isotope co-users, trainees, or technicians. Disposition Form 2496 is used for this purpose. Such nominations are processed for approval in accordance with the provisions of WR 40-10.

f. Chief, Medical Division, USAMRIID.

Provides immediate local medical support as required in Annex F to WR 40-10.

g. Co-users at USAMRIID.

Individual research investigators who require isotopes for conducting their research studies.

3. LICENSES.

a. Isotope utilization at USAMRIID is conducted under the provisions of WRAMC's Atomic Ennergy Commission (AEC) Biproduct Material License Number 08-01738-02, and is specifically approved by the WRAMC Radioisotope Committee Authorization Number 506A (for non-human use) which is updated annually.

b. The model 81-16 CO-60 Irradiation Unit located in Suite AA4, Bldg 1425 is approved under WRAMC license 08-01738-05.

4. RADIATION EQUIPMENT UTILIZATION.

Model 81-16 CO-60 Irradiation Unit and the 1MEV Therapy X-ray unit: Use of these instruments is limited to trained personnel operating under the overall supervision of Chief, Animal Assessment Division.

5. ISOTOPE WASTE DISPOSAL PROCEDURE.

a. The disposal of radioactive waste is accomplished by the Health Physics Technician(s) in accordance with established WRAMC procedures, Safety Division, Fort Detrick regulations, and USAMRIID Safety Memorandum No. 385-3.

b. Disposal of radioactive waste by co-users: See appendixes B and C.

c. Isotope waste is normally transferred from USAMRIID collection areas on scheduled days by the Health Physics Technician; however, additional or special disposal problems are referred to the Health Physics Technician whenever they arise.

d. Co-users are responsible for providing the Health Physics Technician an accurate estimate of the amount of radioactive material by type in each waste container. The Health Physics Technician must report this information to the Chief of the Safety Division, Fort Detrick at the time waste containers are transferred to him for disposal.

e. Animal carcass waste is kept separate from all other types.

6. PROCEDURE FOR REMOVAL OF RADIOACTIVE CARCASSES FROM INFECTIOUS SUITES.

See Appendix C.

7. FIRE DEPARTMENT RESPONSIBILITIES.

The procedures specified in WRAMC Reg. 40-10, Annex V, Health Physics Aspects of Fire Fighting, apply to the Fort Detrick Fire Department. In case of fire, additional notification must be given to the USAMRIID Health Physics Technician or Principal User.

8. REFERENCES.

a. AR 755-15.

b. WRAMC Reg 40-10.

c. USAMRIID Memo 385-3.

FOR THE COMMANDER:

DAVID E. LYNN
CPT, MSC
Adjutant

DISTRIBUTION:
C plus
1-C, Health Physics, WRAMC

APPENDIX A

TABLE OF MAXIMUM INVENTORY OF RADIOACTIVE MATERIALS
(WRAMC AUTHORIZATION 506A)
As of 22 May 73

Item	Maximum Inventory Authorized
$^{3}H_{1}$ (Tritium)	550mCi
^{14}C (Carbon)	60mCi
^{32}P (Phosphorous)	200mCi
^{35}S (Sulfur)	20mCi
^{42}K (Potassium)	50mCi
^{45}Ca (Calcium)	20mCi
^{47}Ca (Calcium)	1mCi
^{51}Cr (Chromium)	20mCi
^{59}Fe (Iron) (Ferrous)	10mCi
^{65}Z (Zinc)	50mCi
^{85}Sr (Stronium)	10mCi
^{125}I (Iodine)	100mCi
^{131}I (Iodine)	100mCi
^{169}Yb (Ytterbrium)	10mCi
^{198}Au (Gold)	35mCi
^{238}U (Uranium)	1 lb.

APPENDIX B

SUBJECT: Disposal of Radioactive Waste by Co-User.

1. Radioactive waste will not be disposed of through other than an approved means; all isotopes acquired by co-workers must be accounted for in toto, and all waste disposal must be accomplished in coordination with the USAMRIID Health Physics Technician(s). Discarding radioactive materials in sinks is not an approved disposal method for isotope co-users.

2. The isotope co-user will provide the USAMRIID Health Physics Technicians(s) a complete recording of the isotope contents of each radioactive waste disposition. The following information will be included on the tag attached to each bag of solid waste.

a. The name of the co-user responsible for the isotope(s) being used. This is the person charged for the isotope(s) in the health physics records.

b. The isotope(s) contained in the waste disposition.

c. An estimate of the total activity for each isotope contained in the package of waste. This estimate must be in millicuries or in microcuries; DPM or CPM will not be acceptable.

d. The date of the entry.

e. The type of waste, as explained in item 5 below.

3. The Health Physics Technicians will pick up the waste from the individual laboratories. The times of pick up will be coordinated with each investigator.

4. Except for the packaging of radioactive carcasses, only magenta colored plastic bags will be used for packaging radioactive waste. These bags should be sealed at the top and properly labeled. If there is danger of the bag tearing or being damaged by the contents, multiple bags should be used.

5. Radioactive waste must be packaged by the co-user according to the following classification and given to the Health Physics Technician(s).

a. Burnable solid waste: Waste products including paper, plastic, rubber, and other solid burnable materials.

b. Non-burnable solid waste: Glass and metal waste.

c. Bulk liquid waste: Liquids in large quantities. Keep isotopes separated as much as possible.

d. Flammable liquid waste: This consists of scintillation vials which contain flammable scintillation fluid. Test tubes or vials from gamma counters may be placed in non-burnable solid waste unless they contain flammable liquids.

e. Animal carcasses: This category includes serum or tissues which would decay if kept unfrozen.

APPENDIX C

SUBJECT: Procedure for Removal of Radioactive Carcasses from Infectious Suites

1. Carcasses of an individual monkey or groups of small animals are placed in 20" x 30" Chieftain nylon bags (an American Hospital Supply product). The bag is sealed by tightly rolling the open end and applying autoclave tape. Only this specific type of nylon bag should be used to prevent bag destruction by autoclave heat. This nylon bag is placed in a waterproof paper bag (Stock No. 8105-001-3245) and then placed in a hat box. The box is marked "Radioactive Waste" in pencil, and the contents of the box identified as outlined in Appendix B.

2. Multiple monkey carcasses may be removed simultaneously by an alternative method. Monkey carcasses may be placed in a 55-gallon barrel and permitted to accumulate until the barrel is 2/3 full. Wood shavings must be added periodically to absorb moisture during autoclaving. The barrel must be labeled as containing radioactive waste. The monkey number, date, and amount of radiation given to each is entered on a card on the barrel lid; the barrel is then kept in the walk-in cooler until ready to be autoclaved.

3. The box or barrel is placed in the exit-autoclave of the suite with its lid off and autoclaved on "dry" cycle. A one hour sterilizing time is used.

4. The Health Physics Technician(s) should be notified both 24 hours prior to the time that waste is passed through the autoclave and at the time it is to be picked up.

5. At the time of pick up, the Health Physics Technician will seal and properly relabel the container as radioactive and check to insure that the complete description of radioactive material within the container is listed on its lid.

6. In the event that the Health Physics Technician is not immediately available to remove the sterilized container, it will be retained within the suite, stored in the cold room, and steps 3, 4 and 5 above will be repeated.

APPENDIX D

SUBJECT: USAMRIID Procedures for Ordering Radioactive Materials

1. Ordering.

a. A request for purchase of radioisotopes will be submitted by co-user to the secretary of the Physical Sciences Division who will prepare five copies of Request for Issue or Turn-in (DA 3161) for each request for radioactive materials. Each request must be cleared through the alternate principle user and the Scientific Advisor. In the absence of the Scientific Advisor, the next senior member of the USAMRIID Isotope Committee may sign the request. The request will then be forwarded to the Medical Supply Office. Before the order is placed, the approval of Health Physics is obtained to assure compliance with license.

b. Distribution of DA 3161 is as follows:

(1) Original and 1 copy - retained by Medical Supply Officer.

(2) 1 copy - to Health Physics Officer, (WRAMC).

(3) 1 copy - to Health Physics Technician, (USAMRIID)

(4) 1 copy - to Physical Sciences Division.

2. Charge Account Sources for radioactive materials are as follows:

a. Abbott Laboratories.

b. Amersham/Searle.

c. Cambridge Nuclear Corporation.

d. Curtis Nuclear Corporation.

e. International Chemical & Nuclear Corporation.

f. Mallinckrodt/Nuclear Corporation.

g. New England Nuclear.

h. Schwarz/Mann.

i. E.R. Squibb & Sons.

3. Requests costing less than $250.00:

a. Requests costing less than $250.00 will be ordered by the Blanket Purchase Agreement (BPA) Ordering Officer, USAMRIID, provided the requested source is on Charge Account and approval is obtained through Health Physics Technician and the BPA Ordering Officer, USAMRIID. Approval will normally be granted when the requests are within the allowances set forth by the AEC License Number and USAMRIID maximum authorized inventory quantity.

b. Three weeks should be allowed for delivery of materials form the time the request is initiated. Delivery time is contingent upon availability of item(s) at the requested source.

4. Requests costing $250.00 or more:

a. Requests in excess of $250.00 must be forwarded to the Medical Supply Office, USAMRIID, for processing through Finance & Accounting, Logistics Division, and Material Branch, WRAMC.

b. Four weeks should be allowed for delivery of materials from the time the request is initiated. Delivery time is contingent upon availability of item(s) at the requested source.

5. Receipt of Radioactive Material.

a. During normal duty hours:

Upon receipt of radioactive material by personnel of the Medical Supply Office, a call will be placed to the Health Physics Technician, USAMRIID, notifying him of the receipt. The Health Physics Technician, NCOIC, or assistant NCOIC, Physical Sciences Division will pick up the shipment at the Medical Supply Office and verify the order and record its receipt in the Health Physics Log Book.

b. After normal duty hours:

(1) If received on post after normal duty hours, radioactive isotopes will be delivered to the CQ (Phase 1) by the Post Transportation Officer or other delivery agent.

(2) The CQ will inspect the package and sign receipts if required. Damage to any containers must be fully documented.

(3) The CQ will then read the storage instructions on the container. If refrigeration is required the container will be placed in the refrigerator located in room 883. If refrigeration is not required, the container will be placed on the workbench in room 883.

(4) Receipt and disposition of all radioactive material will be noted in the CQ report. If additional information or assistance is required the CQ will consult emergency procedures on file.

6. Actions to be Taken after Receipt:

a. Correct shipment:

If the shipment is correct, the packing list and/or invoice will be forwarded to the BPA Ordering Officer, USAMRIID. The purchase requisition will then be sent to the NCOIC, Physical Sciences Division, or his assistant, for signature. The Health Physics Technician, USAMRIID will then notify the Health Physics Officer, WRAMC, of the completed action.

b. Incorrect shipment:

If the shipment is incorrect, the individual checking the shipment should contact the BPA Ordering Officer, USAMRIID, who will in turn notify the Health Physics Officer, WRAMC, of the discrepancy. No action will be taken on the shipment until specific instructions have been received from the Health Physics Officer, WRAMC. If the shipment is to be returned, the shipping will be coordinated between the Transportation Officer, Fort Detrick Medical Supply Sergeant, and the Health Physics Technician, USAMRIID.

7. Authorized Allowance for Radioactive Materials.

Requests for radioactive materials will not exceed authorized allowances set forth by WRAMC Regulation 40-10 and WRAMC Authorization 506A (See Appendix A).

HEALTH PHYSICS
WALTER REED ARMY MEDICAL CENTER
Washington, D.C. 20012

*MEMO
No. 9

29 July 1969

LABORATORY FACILITIES (Radioactive Materials)

1. General. Walter Reed Army Medical Center devotes a considerable amount of effort to medical diagnosis, treatment and research and development, and as such all of the major activities of the Center maintain adequate laboratory facilities to support these endeavors.

2. Laboratories for the Use of Radioactive Material.

a. General. The principal user must provide the laboratory facilities and equipment necessary for the safe handling, storage, and use of all radioactive materials authorized for his project and insure that laboratory procedures and practices are instituted to provide protection of all personnel from the hazards associated with the use of this material. (Reference: ANNEX B, WR 40-10)

b. Specific.

(1) At the time the application is submitted to use radioactive material, the applicant must submit a description of the proposed use in sufficient detail so that Health Physics may evaluate the radiation hazards involved and the facilities available to the applicant.

(2) Health Physics will advise the applicant if additional facilities, equipment, supplies, and/or storage space for the safe use and disposal of the requested radioactive material is required.

3. Equipment Available for Temporary Loan from Health Physics.

a. Remote Handling. Several varieties of niptongs and griptongs, Atomic Accessories Remote Handling Tool Model RHT-60, assorted jaws and vices, remote forceps and magnetic handlers, remote pipettes, electric lift devices, etc.

b. Storage Containers. Several varieties of portable lead storage containers, steel safes, lead-lined boxes, metal drums filled with paraffin for neutron sources, concrete wells, steel drums for radioactive waste.

c. Shielding. A limited supply of lead bricks, high density concrete blocks, paraffin blocks, boraxal blocks, lead sheets, lead shot, steel plates, etc.

4. Instrumentation Available for Temporary Loan from Health Physics. See HP MEMO No. 10 - Radiation Detection Instruments.

5. Ventilation Control.

a. A fume hood of acceptable design must be available in the laboratory

* This MEMO supersedes HP MEMO No. 9, Title as above, dated 29 Apr 65

intended for the use of radioactive material when such a device is prescribed by the Health Physics Officer. Health Physics will perform all necessary inspections and surveys of fume hoods intended for the use of radioactive material; these will include the following:

(1) Measuring the pressure differential

(2) Measuring the flow rate

(3) Measuring the integrity of absolute filter installations when provided

(4) Any other test as directed by the Health Physics Officer after a review of the intended use of the facility.

b. Fume hoods with absolute filter assemblies, glove boxes, and hot cell facilities may be made available for temporary use upon request to Health Physics. These facilities are not necessarily mobile and some are located at other government agencies; therefore, if use of these facilities is determined to be necessary, coordination for this will be provided by Health Physics.

William F Kendall

WILLIAM F. KENDALL
MAJ, MSC
Health Physics Officer
WRAMC

HEALTH PHYSICS
WALTER REED ARMY MEDICAL CENTER
Washington, DC 20012

MEDEC-YHP
SOP
Number 1-6

15 February 1974

LEAK TESTING AND INVENTORY OF SEALED SOURCES

1. Purpose. The purpose of this SOP is to provide continuity in the standard leak testing procedures for sealed sources containing alpha, beta, and/or gamma emitting radionuclides possessed, used and stored at WRAMC and DORF. This SOP supplements WR 40-10.

2. General.

a. Despite the fact that many precautions are taken to prevent leakage, the radioactive materials do occasionally leak from the capsule. Steps must be taken to determine whether or not the sources are leaking. Radioactive material which leaks from a source is a major health hazard in that it may become airborne or transported in some other way to become inhaled or ingested by personnel in the vicinity. The purpose of leak-testing sealed sources is to detect the leakage of the radionuclide before it becomes a major health hazard.

b. The necessity for leak testing sealed sources can be appreciated when the damage that can be caused by one leaking source is considered. In the conduct of all leak-tests, personnel must be constantly aware of the techniques of safe handling and limit radiation exposure by considering distance, shielding, length of exposure, and total activity of the source(s) to be leak tested.

c. Each Health Physics Section (DORF, WRAIR, and Radiation Therapy, WRAMC) will leak-test each sealed source under their control in coordination with the NCOIC, HP Survey Section, Room 3, WRAIR.

d. Where a conflict of regulations (to include applicable USAEC Licenses and DA Authorizations) exists, the more restrictive regulation will be followed.

e. Sealed Source means any radioactive material that is inclosed in, or is to be used in, a container in a manner intended to prevent leakage of the radioactive material or any of its daughter products (See AR 40-37 and AR 700-52).

f. Each sealed source with an activity greater than 100 microcuries of beta and/or gamma and 10 microcuries of alpha received at WRAMC and DORF, containing radioactive material, other than 3-Hydrogen (Tritium), with a half-life greater than thirty (30) days and in any form other than gas, will be tested by Health Physics, WRAMC, for contamination and/or leakage prior to

*This SOP supersedes HP SOP Number 1-6, 15 August 1972

release to the user. However, if the vendor or source supplier furnishes a certificate indicating that a test has been made, the source need not be tested. Thereafter, all sources will be tested for leakage by Health Physics, WRAMC, at intervals not to exceed six (6) months, except that each source emitting alpha particles will be tested at intervals not to exceed three (3) months.

g. If there is reason to suspect that a sealed source might have been damaged, it will be tested for leakage before further use.

h. All sealed sources found to be leaking and/or contaminated will be immediately withdrawn from use by Health Physics. The Health Physics Officer will determine whether or not the source is leaking. If it is leaking, he will direct that it be resealed or disposed of in accordance with existing regulations.

3. Methods of Leak-testing.

a. Non-radium Sources

(1) Wipe test (for Alpha, Beta, and/or Gamma) - All exposed external surfaces of the object to be tested is wiped thoroughly with a piece of filter paper (paper towel cut in one (1) inch diameter circles is sufficient) of high wet strength and absorption capacity. The wipes may be wet or dry depending on the circumstances. The solution should not attack the material of which the source capsule or source holder is made. The wipe is allowed to dry, then the wipe is analyzed to determine the activity of the removable contamination.

(2) Scrub test (for Beta and/or Gamma) - The object to be tested is immersed in a solution which will not attack the material of which the container or source holder is made and which has been demonstrated to be effective in removing the radionuclide involved when the object is scrubbed with a brush under the surface of the liquid. All surfaces of the object are brushed thoroughly under these conditions. The total activity is determined in the residue obtained by evaporation of the solution.

(3) Immersion Test (for Beta and/or Gamma) - The object to be tested is immersed in a solution which will not attack the material of which the container or source holder is made and which, under condition of this test, has been demonstrated to be effective in removing the radionuclide involved. The solution is heated to 50° ± 5°C and held at this temperature for eight (8) hours. The absence of bubbles does not indicate that the source is not leaking. The total activity is determined in the residue obtained by evaporation of the solution. This test cannot be used on sources which are mounted in large assemblies, nor on sources having container material which will be adversely affected by the high temperature and water. This method often allows one to detect a leak before the material has had a chance to

leak from the source. It is the most difficult, time-consuming, and requires a greater radiation exposure to the individual than other techniques.

(4) Cellulose Tape Test (for Beta and/or Gamma) - This test is applicable to a device containing a sealed source in a source holder which has an opening through which the radiation emerges. This opening is kept covered for a minimum of seven (7) days with a piece of thin adhesive cellulose tape. The tape is carefully removed and the activity which may have been deposited on its adhesive side is determined.

b. Radium Sources

(1) Charcoal Sorption Test - Approximately 1/2 gram of activated charcoal is placed in a stoppered, glass test tube or equivalent container. The source may be placed directly on the charcoal or separated from it by a small wad of cotton. The source should remain sealed in the tube for 24 hours. Remove the source and immediately recap the test tube. Allow the sealed charcoal to stand for four (4) hours after which time, the sealed tube is counted by a gamma counting system. A blank charcoal control will be used to distinguish environmental radon from that produced by the source.

(2) Cocoon Test (Radium) - This test is applicable only to Radium or other sources from which a gaseous radionuclide, which is the parent of a particulate radioactive material, may leak. The source is completely surrounded by cotton (cocoon). This cocoon is placed inside a glassine envelope or other container and kept for twenty-four (24) hours. At the end of this period the source is removed from the container and the cocoon is counted with a portable alpha survey meter (PAC-1S or PAC-3G) or the source is removed and the bag resealed for a subsequent gamma spectral analysis for Radon daughter products.

(3) Another satisfactory method of leak testing is to line the source storage container with absorbent material and to analyze the lining material for radioactive contamination. The source should fit snugly in its storage well so that it is wiped by the absorbent material when being inserted and removed.

4. General Leak Test Procedures Employed at WRAMC and DORF.

a. In general, all beta and/or gamma sealed sources are leak tested by taking a one (1) inch diameter filter paper disc and obtaining a dry or wet wipe of the most accessible surfaces of the source or source holder in which the sealed source is permanently mounted.

(1) Gas chromatograph cells - Dry wipes are taken from the gas exhaust ports.

(2) AECL Gammacells - Dry wipes are obtained from:

(a) Upper external part of the ram

(b) Inside the irradiation chamber.

(c) Lower external portion of the ram.

(d) Floor beneath the ram.

(3) Cobalt Teletherapy and Cesium Calibration Units - Dry wipes will be taken from selected accessible surfaces of the teletherapy head or calibration port. The selected accessible surfaces should be those surfaces on which one might expect contamination (if there were to be leakage) to accumulate and shall include the inner surfaces of the most frequently used treatment cones or beam collimating device. The test sample shall be taken with the source in the "off" position.

(4) Other Beta or Gamma Sealed Sources - Dry wipes are obtained from the source directly or the most accessible surfaces of the source mount and/or container.

(a) Alpha sources are divided into four (4) groups: Radium check and calibration sources, brachytherapy sources, fission foils, and other alpha sources.

(1) Radium Check and Calibration Sources - A modification of the Cocoon Test is generally employed. The Radium source is sealed in a glassine bag or rubber-stoppered vial with a wad of cotton for a period of not less than twenty-four (24) hours. Immediately after the bag or vial is unsealed, remove the Radium source and reseal the bag or vial. The sample should be checked with an appropriate survey instrument prior to sending the sample to the HP R/A Lab. The sample shall be processed immediately due to the short-lived Radon daughter products.

(2) Brachytherapy Sources - These are leak-tested primarily by the Charcoal Sorption test.

(3) Fission Foils - Dry wipes will be obtained by wiping the most accessible surfaces of the mount and/or container.

(4) Other Alpha Sources - Dry and wet wipes will be obtained by wiping thoroughly the external surfaces of the mount, other than the radioactive surface of the source. Also, wet wipes will be made inside containers used for storage of alpha sources.

5. Routine Procedure for Handling Leak-test Samples.

a. Wipes

(1) Indicate on the filter paper (wipes) the side actively used in performing the leak-test.

(2) After performing the wipe test, place the wipe in a glassine envelope and/or plastic carrying block with tweezers. DO NOT CROSS-CONTAMINATE! Identify each wipe by source or reference number as applicable.

(3) Forward all wipes to the R/A Lab, HPO, WRAMC, for quantitative analysis with completed WRAMC Form 708 requesting appropriate analysis with proper identification as to radionuclide, serial number, location at time of sample, date, and time.

b. Cocoon tests and scintillation vials

(1) Indicate on each sample (top of scintillation vial) container the log reference number for the HP Section performing the test.

(2) Forward all samples to the R/A Lab, HPO, WRAMC, for quantitative analysis with a completed WRAMC Form 708 requesting appropriate analysis with proper identifications as to radionuclides, serial numbers (if appropriate), date, and time.

6. Evaluation.

a. Radium sources (Brachytherapy): A leakage range shall be established for each source or group of sources by repeated testing. If any leakage is detected greater than the baseline range at the 3σ level, the source(s) will be suspected as leaking; however, the maximum value of the upper limit will not exceed 0.001 microcuries. When the upper limit is exceeded by a group of sources, each source will be tested individually. If leakage is confirmed, the source(s) will be disposed of in accordance with existing regulations.

b. All others: If after analysis the amount of contamination removed from the source or surface is equivalent to 0.005 μCi (1.11×10^4 dpm), the source will be suspected of leaking. The source will be isolated, decontaminated if practical, and leak-tested twice more, at one-week intervals. If leakage is confirmed, the source will be disposed of in accordance with existing regulations.

7. Leaking Sealed Sources. All sealed sources found to be leaking will be handled in accordance with 10 CFR 34.25 and 10 CFR 20, and will be disposed of in accordance with AR 700-52 and AR 755-15.

8. Equipment, as required

a. Items utilized in leak test sampling; such as, filter paper discs, test tubes, etc.

b. Pair of long tweezers or forceps.

c. Rubber gloves.

d. Remote handling tools.

e. Film badge, wrist badge, and self-reading pocket dosimeter.

f. Protective clothing.

g. Glassine and/or plastic carrying block.

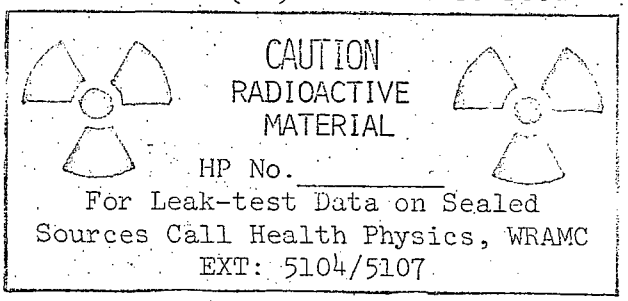
h. Appropriate radiation detection instrument.

9. Inventory of Sealed Sources

a. The WRAMC Form 0993(OT) will also constitute a record of inventory of the sealed sources at WRAMC and DORF with an activity equal to or greater than that specified in Appendix C, 10 CFR 20.

b. In accordance with the provisions of AR 700-52 the inventory records will document the specific item of equipment and/or radioisotope, the location of the item, activity, serial number of the source, responsible user, applicable USAEC or DA Authorization number, expiration date, date and initials of the inventory officer. Entries will also be made when the source is transferred or disposed of in accordance with AR 700-52, AR 755-15, and/or TM 3-261.

c. All sealed sources or their containers will be labeled as shown below and identified with a Health Physics Control Number which will also be recorded on the WRAMC Form 0993(OT) for that source.



10. Records

a. Records of all WRAMC sealed sources will be maintained at HP, Room 3, WRAIR by consecutive entries on WRAMC Form 0993(OT) in terms of microcuries (μCi) pursuant to the provisions of 10 CFR 34.25 and AR 40-37.

b. Records of all HDL sealed sources at DORF will be maintained at the HP Section, DORF by consecutive entries on WRAMC Form 0993(OT) in terms of microcuries (μCi) pursuant to the provisions of 10 CFR 34.25.

c. Each Health Physics Section possessing or storing sealed sources (except HDL-DORF sealed sources) will forward a duplicate copy of the WRAMC Form 708 to the NCOIC, HP Section, Room 3, WRAIR for record purposes each time the sources under their jurisdiction are leak-tested.

d. Records of leak tests will be maintained as prescribed in the USAEC Licenses and DA Authorizations in accordance with the provisions of AR 340-18-1 through AR 340-18-15.

11. References

a. Title 10, Code of Federal Regulations, USAEC

b. AR 40-37, Radioisotope License Program (Human-Use)

c. AR 700-52, Licensing and Control of Sources of Ionizing Radiation

d. AR 755-15, Disposal of Unwanted Radioactive Material

e. TB MED 249 (NBSH-73), Protection Against Radiation from Sealed Gamma Sources

f. TM 3-261, Handling and Disposal of Unwanted Radioactive Material

g. NCRP Reports 28, 30, 33, 34, and 40

h. NBS Handbook 93

i. WRAMC Regulation (WR) 40-10, Health Physics Regulations

j. HP SOP 1-2, Counting Procedures

k. HP SOP 2-2, Radioactivity Analysis Laboratory

1. ANSI N44.2 - 1973 American National Standard for leak-testing radioactive brachytherapy sources.

BOBBY R. ADCOCK
LTC, MSC
Health Physics Officer

HEALTH PHYSICS
WALTER REED ARMY MEDICAL CENTER
Washington, D. C.

*SOP
Number 1-7

2 March 1972

VENTILATION IN RADIATION CONTROLLED AREAS

1. Purpose. To establish standards and methods for evaluating ventilation control in laboratories using radioactive materials.

2. General. Procedures resulting in the generation of radioactive aerosols, dusts or gaseous products shall be conducted in a hood, dry box or other suitable closed system. Radioactive gases or material with radioactive gaseous daughters shall be stored in gas tight containers and kept in areas having approved ventilation.

3. Methods and Procedures. Ventilation rates of the laboratory hoods are measured with a calibrated Velometer. All rooms containing either laboratory hoods or gas chromatographs are checked to determine if a positive or negative pressure exists. This is accomplished by emitting a smoke cloud from a smoke tube (Mine Safety Appliance Co,, Ventilation Smoke Tube, Cat. No. BH5645, or equal) at a room exit, such as an undercut door, and observing the flow direction of the smoke. If the smoke cloud moves towards the interior of the room, more air is being exhausted than supplied and therefore a negative pressure exists. If the smoke cloud moves out of the room, more air is being supplied than removed and therefore a positive pressure exists. During this check all hoods and other exhaust fans are operating, as well as all air-supply equipment, including the air-conditioning systems.

4. Inspection of Ventilation Control Devices Used in Radiation Controlled Areas. Survey of these areas will be made as directed by the Health Physics Officer to determine that adequate pressure differential and flow rates exist, and that airflow characteristics of the hoods and rooms containing hoods are correct. For handling low to moderate levels of radioactive materials; the average velocity through openings in the hood shall be 100 fpm. For highly toxic or high-level radioactive material, the velocity thru the opening must be raised to an average of 125-200 fpm

5. Testing of Absolute Filters. Health Physics will periodically evaluate the quality of absolute filters by use of the Dioctyl Phthalate Smoke (DOP) test.

6. References.

* This SOP supersedes SOP Number 1-7, 24 January 1967

a. Title 10, Code of Federal Regulations, U.S. Atomic Energy Commission.

b. National Bureau of Standards Handbooks 51, 73, and 92.

c. Schulte, H. P., et al.: "Evaluation of Laboratory Fume Hoods," AECU 2859, U. S. Atomic Energy Commission.

d. May, J. W.: "The Physics of Air," American Air Filter Company, Inc., Louisville 8, Kentucky.

e. Blatz, H., Ed: "Radiation Hygiene Handbook," McGraw-Hill Book Company, Inc., New York.

f. Blatz, H.: "Introduction to Radiological Health," McGraw-Hill Book Company, Inc., New York.

g. Parrish & Schneider: "Inplace Testing of High Efficiency Filters," NRL, August 1963.

Handy L. Miller

VANDY L. MILLER
LTC, MSC
Health Physics Officer
WRAMC

2 Incl
ANNEX A
ANNEX B

GUIDELINES IN VENTILATION CONTROL

ANNEX A to
SOP 1-7
Health Physics, WRAMC

2 March 1972

1. Purpose. To provide guidelines in ventilation control.

2. General. The ventilation system should be designed to permit air flow in such a direction that any radioactive material picked up by the air will flow away from the worker. In the design of new installations, the air flow should always be from a noncontaminated area toward the contaminated or potentially contaminated area. Poor ventilation is difficult to correct after an installation has been completed. It is always more satisfactory to install a correct system initially than to try to overhaul a poorly designed setup. A good system of laboratory ventilation will confine the toxic contaminant, exhaust it with suitable duct work and fans, and pass this material through a collector or scrubber as needed before releasing it to the neighborhood. The design of a proper ventilation system will also provide sufficient air to make up for the amount exhausted.

a. Hood Design. A laboratory hood is a simple enclosure in which work can be carried out without toxic materials escaping. Materials in the enclosure can become airborne and escape by agitation from chemical or mechanical action; by thermal action from chemical reactions or heating devices, and by the syphon action from cross-currents of air. In order to keep the material from escaping from the enclosure, sufficient air should be exhausted to create an indraft through the face of the hood. This indraft must be strong enough to overcome the actions which tend to allow materials to escape. For handling low to moderate levels of radioactive materials, the average velocity through openings in the hood should be 100 fpm. For highly toxic or high-level radioactive material, the velocity through openings should be raised to an average of 125 to 200 fpm. At excessively high velocities, on the other hand, radioactive materials can be drawn out of open containers, contaminating the entire hood area.

In some cases, faulty circulation of air through the hood opening can be improved by increasing the volume of air exhausted and thus the velocity through the hood face by restricting the opening or by providing streamlining baffles along the edges of the air opening. Instrument checks on the velocity of air entering the hood should be performed under the various conditions encountered during actual operations. Checks of air flow patterns with a small source of smoke can indicate the presence of cross-drafts and the possibility of pulling material from the hood.

The placement of the hood in the laboratory is important in respect to cross-drafts, which can pull material out of the hood. In general, a hood should be located well away from the doorway where the supply air must enter.

In some cases, during periods when the hood is unattended, it may be practical to use somewhat lower velocities, 75 to 80 fpm. Dual speed fans will permit operation at the higher velocity while the hood is in use and at the lower velocity when it is closed.

(1) Changes to Remedy Defects in Commercial Hoods.

(a) To reduce excessive use of conditional air.

1. "Pressurized" hoods, with jets of unconditioned air along sides and top, which furnish most of hood air. Unsuitable for work with radioactive materials since exhaust failure would cause positive outward flow of air which would contaminate the entire area.

2. Use of 50 fpm face velocity with airfoil sides and bottom. This may cause excessive susceptibility to cross-drafts.

3. Reduction in face area is the best solution. It may be accomplished by sliding doors, limiting open face area while giving access to entire hood.

(b) To remedy increase of face velocity with door closing.

1. By-pass dampers.

a. Mechanical linkage with door.

b. Gravity-operated damper.

c. Electronic control.

2. Better hood design (shape).

a. Remove corner and center posts.

b. Avoid excessively depressed bottom.

c. Provide airfoils on bottom edges for best airflow pattern.

(2) Proper Use of Hoods.

(a) Avoid cross-drafts from propeller fans, open doors and windows, and rapidly walking past the hood.

(b) Check air velocity; if velocity is less than 100 fpm, mark positons of door for 100 and 150 fpm on hood edge.

(c) Keep sources of contamination, flames, and vapor sources at least 6 inches inside hood.

(d) Avoid leaning into hood.

(e) The inside walls of the hood should be painted with strippable paint; this aids in decontamination.

(3) Design Factor.

(a) Conventional duct design.

1. Approximately 4,000 feet per minute velocity.

2. Elbows should have a radius of at least two (2) diameters.

(b) Airflow Resistance.

1. Varies as the square of the velocity.

2. Filter resistance must be added to duct resistance; high-efficiency filter will have one (1) inch of water resistance when clean; should be discarded when resistance reaches two (2) or three (3) inches of water.

(c) Fan Selection.

1. Fan must be able to move a specified amount of air against the resistance of the duct and fittings plus the resistance of a dirty filter.

2. Centrifugal fan is most suitable; axial flow (propeller type) fans cannot move air against resistance.

3. Fan should be located at end of duct so that all duct work is under suction, and leakage is into the duct system.

b. Glove Boxes. Elements emitting only alpha particles (or very soft beta rays, i.e., ^{3}H or ^{14}C) can be handled even at high levels in completely enclosed containers known as glove boxes. Rubber gloves extend through hermetically sealed ports into the box and enable one to handle the radioactive material without contaminating his hands or lungs. For higher energy beta particles and gamma rays gloves do not offer sufficient protection, and they are frequently replaced by mechanical manipulators operated from outside the box. This complication, along with

the shielding required for medium or high level work, makes the dry box much more expensive than the larger chemical hood.

Glove boxes should be provided with air locks through which samples can be inserted or removed. In such air locks, the sample is inserted in the air lock through one door which is then closed and the other door opened to remove the sample. Since all facilities are totally enclosed in the hood, it may be desirable to provide exterior controls for all services such as water, gas, electricity, etc.

Glove boxes are frequently provided with exhaust ports or fans and filters. Exhaust volumes of 20 to 30 cubic feet per minute will maintain a 50 feet per minute velocity indraft at any opening in a typical size and design of glove box. If intake filters are used, they should be located in such a position that the worker's body will not be exposed to the escaping material if there is an explosion or surge of pressure which could rupture the filter.

c. Exhaust Systems. The exhaust system is designed to remove from the laboratory the airborne materials which are picked up in the hood. To safely vent the contaminated air, it may need to be filtered, scrubbed (or otherwise treated) and discharged at such velocities and elevations that it will not reach ground level at more than maximum permissible concentrations. Cleaning equipment should be selected with a view to the corrosive and toxic materials handled and the varying requirements for removal of radioactive materials. A choice of improper cleaning equipment will frequently result in efficiencies lower than needed or rapid deterioration of the cleaning material. Filters are available to achieve the high decontamination necessary for radioactive materials and for the particle size range which results in the greatest retention following inhalation exposure.

In a proper laboratory ventilation system, the duct work inside the building is under negative pressure. Under these conditions any leakage due to poor construction or corrosion of the duct system will be into the ducts and the radionuclides will be confined. To accomplish this, the fan must be located not on top of the hood but outside the building or at the point where the exhaust leaves the building. Although this may require weather-proofing the motor, it may be an advantage when flammable material is handled, because explosion-proof construction is not then required for the motor. Duct work connecting several hoods should have streamlined connections. Branch ducts should enter at angles of 30 to 45 degrees in order to permit better passage of air at high velocities. In such multiple installations, care should be taken to see that the exhaust system is balanced so that one hood does not provide the bulk of the air for the system.

Velocities of air in ducts should be great enough to maintain minimum transport velocities for the material being conveyed. Usual range of transport velocities for particulate material is 3500 to 4500 fpm.

In hoods where large quantities of water are handled, it is necessary to provide some means of removing the condensation which collects in the duct. When the system is intended to handle corrosive materials, the duct work should be of material resistant to corrosion.

The discharge should be at least five to ten feet above the laboratory roof, located so that fumes will not be carried back into the laboratory or into the air intake of adjacent buildings. Caps for weather protection obstruct the exhaust, directing it back down to the roof where it may be carried into the air intakes. The most practical fan discharge is the straight vertical stack suitable drain connection in the housing. When necessary to discharge high level wastes to the atomsphere, independent stacks may be located downwind from the tallest nearby building at a distance of two or three times the building height. Details of the metereology and dilution of radioactive materials in the atmosphere are found in other references.

Clean air must be supplied to replace the air in the room with an exhaust system if contamination control is to be successful. If adequate air is not supplied to the room, the capacity of the exhaust system and the air velocity at the face of the hood is reduced. If there are multiple exhaust hoods and no makeup air, the airflow may be reversed through a hood that has a smaller fan or is turned off.

In building design, ventilating air may be admitted to offices, corridors, etc., and exhausted through rooms for low and high level work in order by control of static pressures. In a large laboratory with several rooms for radioactivity work, controls should be supplied to properly balance the flow of air from one room to the next and from one hood to another. High velocity air movements can be responsible for spread of contamination and should be avoided.

3. Airborne Hazards.

a. Laboratory air and air discharged from the laboratory should be monitored for radioactivity if there is any possibility of airborne contamination at hazardous levels.

b. Continuous sampling of airborne particulates can be used provided the samples truly represent the air being breathed. Airborne contamination may remain localized and fixed instruments may fail to indicate the extent of contamination.

c. Assays for long-lived alpha-emitting particulates are complicated by the fact that maximum permissible concentrations may be less than the naturally occurring decay products of radon and thoron. Studies on concentrates may be required in order to evaluate the hazard properly. Any assays for airborne alpha-emitters should be supplemented by a careful analysis of the physical circumstances giving rise to the hazard. Protective measures should be instituted if there is a chance that alpha emitters may become airborne.

d. Radioactive, chemically active gases can be concentrated by chemical methods from a known volume of air and assayed by laboratory counting techniques.

e. In general, methods for assaying radioactive, noble gases are unsatisfactory because of the difficulty of concentrating a suitable sample. Some noble gases can be condensed with liquid air, but others require lower temperatures.

f. Radon and thoron present particular problems because each has a number of radioactive daughter products. Radon and thoron can be condensed with liquid air. To evaluate properly the hazard associated with these isotopes, it is necessary to know the stage of decay of the sample assayed. Consideration should be given to the need for ventilation of rooms used for radium storage facilities.

4. Air-Sampling Equipment and Methods.

a. The concentration of radioactive materials in air is determined by a laboratory count made on suitably collected and prepared samples. Filters, electrostatic precipitators, or impingers of various designs can be used to collect the samples. Care must be taken to insure that the sampling device collects all particle sizes desired.

b. In a filter collector a known volume of air is drawn through a specially designed filter paper on which the particulates are deposited. The activity of the paper is determined with a suitable laboratory-type instrument.

c. Particulates carried by a known volume of air can be deposited in an electrostatic precipitator from which the collecting electrode can be removed and either used as an electrode in a proportional counter or counted by other means.

d. Electrostatic precipitators should not be used where explosive fumes may be present.

e. Impingers collect particulates as a jet of air is directed against a glass slide or other suitable backing which is usually coated with a thin layer of oil or vaseline. The deposit from a known air volume is counted by usual methods.

f. Non-condensable gases should be sampled with special equipment devised for the particular material.

g. The size of the air sample may vary depending on the conditions. A sample of 10 m^3 is sufficient for practical assays of alpha contaminants down to one-tenth of the maximum permissible concentration.

h. Direct counting from the surfaces on which the sample has been collected is desirable. Beta and gamma radiations can be determined by using a G-M tube of known geometrical efficiency. Alpha particles can be counted in a proportional counter or an ionization chamber of known geometrical efficiency.

i. When alpha particles are being counted, corrections should be made for the loss due to penetration into the filter material. Such correction factors can be obtained by chemical analysis of a number of filters exposed in the same location.

This guideline was prepared by Captain Gordon M. Lodde, Health Physicist, Chief, Reactor and Survey Branch, Health Physics, Walter Reed Army Medical Center, Washington, D. C. 20012

*ANNEX B to
SOP 1-7
HP, WRAMC

2 March 1972

Absolute (High Efficiency) Filters

1. Purpose. To provide guidelines for acceptence, testing and inspecting absolute filters.

2. General.

a. Requisitions for filters should state that compliance with Military Specification MIL-F-51068A is required.

b. To insure the high degree of filtration required for high (99.97%) efficiency filters, each filter should be checked for possible leakage and filter damage before and after initial installation.

c. There is the possibility of undetected leakage developing through improper installation. Typical causes of leakage are: improper filter gasket seating in the frames, gaps between filter frame and housing, mishandling during installation, and the inherent fragility of high efficiency filters.

d. Because of these possible causes of leakage, an in-place test for filter efficiency will be made after installation.

3. Acceptance and Storage

a. On Receipt:

(1) Inspect shipping container for any obvious damage (absolute filters are easily damaged and if the container shows signs of abuse it is very likely that the filter also suffered.) before removal from carrier.

(2) Carefully remove filters from container and visually inspect filter.

(3) With a strong light behind the filter inspect for breaks, cracks and pinholes.

(4) Ascertain that the gasket is complete and unbroken.

(5) Examine the adhesive seal around the filter face to be certain it is complete and has not separated from the frame.

(6) Reverse filter and inspect the other side.

* This Annex supersedes Annex B to SOP 1-7, 24 March 1972

b. Storage:

(1) If the filter is not to be installed immediately it must be returned to its original container with packing inserts.

(2) Filters should not be stored with other materials because of possible damage from such material.

(3) Filters larger than 20" x 20" x 5" should not be stacked more than 3 high.

4. In-place Filter Testing.

a. Test Method and Equipment.

(1) The method for field checking the integrity of the particulate filter is an adaptation of the method developed by NRL.

(2) The method consists of generating an aerosol upstream of the filter and measuring the aerosol concentrations, both upstream and downstream of the filter.

(3) The major pieces of equipment are an aerosol generator and a particle detection instrument.

(4) The aerosol generator produces a polydispersed aerosol by the atomization of liquid dioctylphthalate (DOP) with compressed air.

(5) From 20 to 30 PSI air pressure the aerosol particle size generated ranges between 0.1 and 2.0 micron with 95% under 1.0 micron. Average size is 0.9 micron.

(6) Particle detection is based on measuring the light scattering power of the aerosol in the air stream.

(7) The 0.3-μ particle was selected by the Army Chemical Corps as the optimum size, since it is considered to be the most difficult to remove by filtration. In general, particles of this size are too small to be collected by impaction and too large to have a tendency to be caught by random Brownian motion. ORNL tests have shown the difference in particle sized 0.9 and 3-μ to be relatively unimportant for practical testing applications within the precision of measurement requirements.

(8) A polydispersed aerosol of DOP, produced by atomization of the liquid with compressed air, is discharged into the system through any convenient air intake ahead of the filter bank.

(9) The concentration of the unfiltered smoke is then measured, by means of the forward light scattering photometer, from samples removed from the system ahead of the filter bank.

(10) The concentration of the filtered air is measured downstream of the filters. The efficiency of the filtration system is then calculated from the concentration of the aerosol before and after the filters.

(11) In order to conduct this test properly, there must exist a sufficient length of duct between where the aerosol is introduced and the filter bank, to induce thorough mixing of the air and DOP particles.

(12) If a representative upstream sample cannot be obtained for the reasons indicated above, a reliable in situ test is still possible. In this instance the aerosol is introduced in the same manner, but only filtered samples are removed for concentration determinations. The equivalent upstream concentration is then measured indirectly by installing the smoke generator downstream of the filter bank and sampling further downstream before or after the blower. This indirect method is reliable if care is exercised in maintaining the output of aerosol and airflow through the system constant during the testing period.

(13) An alternate, indirect method of determining the upstream aerosol concentration is based on the fact that the output of a generator depends only on the pressure of the compressed air at the generator and the level of the DOP. Each smoke generator is calibrated in a system of known airflow, and an Output vs Pressure is drawn. Then, if the airflow in the system under test is known or can be accurately measured, the upstream aerosol concentration is calculable from the calibration curves.

b. Filter Facility Preparation.

(1) Each filter facility to be tested must be provided with a sampling port upstream and downstream of the filter.

(2) The diameter of this port should not be smaller than two inches and need not be larger than four inches in diameter.

(3) It is also necessary to provide a means of injecting the aerosol into the system. The aerosol should be injected far enough upstream to provide thorough mixing before it arrives at the upstream sampling probe location.

c. See WRAMC HP TP 1-7-1 for DOP test procedures.

5. Reference. TID-7023 High Efficiency Particulate Air Filter Units, USAEC

HEALTH PHYSICS
WALTER REED ARMY MEDICAL CENTER
Washington, D.C. 20012

SOP
Number 1-2*

10 June 1974

COUNTING PROCEDURES

1. Purpose. To provide standard counting procedures and methods for statistical analysis in order to insure valid, economic, and rapid assays of samples submitted for radioanalysis.

2. Evaluation of Counting System Performance.

a. General. Before anyone attempts to calibrate a counting system he should have assurance that the system is electronically adjusted for optimum efficiency and that it will, when so adjusted, detect radiation with an acceptable degree of accuracy and dependability.

b. Electronic Adjustment. In accordance with the counting system instruction manual the high voltage, sensitivity, and attenuation should be adjusted for optimum counting efficiency.

c. Chi-Square (χ^2) Test. Each counting system should be given the following performance test before it is calibrated and every month thereafter. It it does not pass the test it should be turned in to the Combined Maintenance Section for service.

(1) Obtain a sturdy, long half-life, moderate curiage source of approximately 10^4 dpm. This will be known as the "check source".

(2) Make 20 one-minute counts with the check source. Tabulate the following data in three columns (See Figure 1, page 4):

(a) Net Counts Per Minute (Gross cpm - BG cpm) $\equiv \chi$

(b) Deviation of χ from $\overline{\chi} \equiv (\chi - \overline{\chi})$

Note: $\overline{\chi} \equiv$ average value of the 20 one-minute counts

(c) $(\chi - \overline{\chi})^2$

(3) Sum the entries in the third column and divide this number by $\overline{\chi}$. The quotient thus obtained is called chi-squared (χ^2).

$$\chi^2 = \frac{\Sigma(\chi - \overline{\chi})^2}{\overline{\chi}}$$

(4) Table I, following, lists the numerical values of χ^2.

* This SOP supersedes SOP 1-2 dated 1 September 1971.

5 - 17

TABLE I

TABLE OF CHI-SQUARED

(N-1) Degrees of Freedom	Probability						
	0.99	0.95	0.90	0.50	0.10	0.05	0.01
	Values of Chi-Squared						
2	0.020	0.103	0.211	1.386	4.605	5.991	9.210
3	0.115	0.352	0.584	2.366	6.251	7.815	11.345
4	0.297	0.711	1.064	3.357	7.779	9.488	13.277
5	0.554	1.145	1.610	4.351	9.236	11.070	15.086
6	0.872	1.635	2.204	5.348	10.645	12.592	16.812
7	1.239	2.167	2.833	6.346	12.017	14.067	18.475
8	1.646	2.733	3.490	7.344	13.362	15.507	20.090
9	2.088	3.325	4.168	8.343	14.684	16.919	21.666
10	2.558	3.940	4.865	9.342	15.987	18.307	23.209
11	3.053	4.575	5.578	10.341	17.275	19.675	24.725
12	3.571	5.226	6.304	11.340	18.549	21.026	26.217
13	4.107	5.892	7.042	12.340	19.812	22.362	27.688
14	4.660	6.571	7.790	13.339	21.064	23.685	29.141
15	5.229	7.261	8.547	14.339	22.307	24.996	30.578
16	5.812	7.962	9.312	15.338	23.542	26.296	32.000
17	6.408	8.672	10.085	16.338	24.769	27.587	33.409
18	7.015	9.390	10.865	17.338	25.989	28.869	34.805
19	7.633	10.117	11.651	18.338	27.204	30.144	36.191
20	8.260	10.851	12.443	19.337	28.412	31.410	37.566
21	8.897	11.591	13.240	20.337	29.615	32.671	38.932
22	9.542	12.338	14.041	21.337	30.813	33.924	40.289
23	10.196	13.091	14.848	22.337	32.007	35.172	41.638
24	10.856	13.848	15.659	23.337	33.196	36.415	42.980
25	11.524	14.611	16.473	24.337	34.382	37.382	44.314
26	12.198	15.379	17.292	25.336	35.563	38.885	45.642
27	12.879	16.151	18.114	26.336	36.741	40.113	46.963
28	13.565	16.928	18.939	27.336	37.916	41.337	48.278
29	14.256	17.708	19.768	28.336	39.087	42.557	49.588

The acceptable limits of probability are from 0.90 to 0.10. The number of determinations (N) is 20 and there is one restriction in this type of test; therefore, (N-1) = 19 degrees of freedom. From Table I, the acceptable value of χ^2 is a number between 11.651 and 27.204.

d. Quality-Control Charts (Figure 1)

(1) Purpose. The quality-control chart provides a guide for:

(a) Judging when and how much correction of instrument operation is required.

(b) Reducing tolerances when desirable.

(c) Anticipating or diagnosing faulty instrument behavior.

(2) Preparation. The quality-control chart will be prepared monthly after performance of the χ^2 test. The data derived from the χ^2 test will be used in the preparation of the plot in the following manner:

(a) Calculate the standard deviation (σ). For discussion see para 3a.

$$\sigma = \sqrt{\frac{\Sigma(\chi-\bar{\chi})^2}{N-1}}$$

(b) Multiply the σ by 1.645 (the 90% Confidence Factor)

(c) On a linear plot of cpm (vertical axis) vs time in days (1-31) draw a horizontal line midway on the vertical axis. Label this line with the numerical value of $\bar{\chi}$ determined on the χ^2 test.

(d) Above and below this line draw dotted lines. The distance from the solid line to the dotted line will be equal to the product of 1.645σ as determined in para 2d(2)(b) above.

(e) This is the quality-control chart. The solid line is the "true count rate" of the check source. The dotted lines above and below the solid line indicate the limits of acceptable statistical variations. If the counting system is performing satisfactorily, 90% of a statistically large number of one-minute counts of that check source should fall within the area bounded by the dotted lines.

(3) Use of the Quality-Control Chart. At the start of each counting day the check source should be counted for five one-minute counts. The Net Counts Per Minute (NCPM) obtained are then plotted on the quality control chart at the appropriate calendar date position. If the plotted

Figure 1
QUALITY-CONTROL CHART

CHI-SQUARED TEST
NaI(Tl) XTAL 4x4"
Date: 7 Jun 65
Geometry: Marinelli Beaker
Source: Cs-137

	X	$\bar{X}$	$(X-\bar{X})$	$(X-\bar{X})^2$*
1	6399	6369	30	900
2	6405		36	1296
3	6448		79	6241
4	6414		45	2025
5	6327		42	1764
6	6296		73	529
7	6120		249	62001
8	6424		55	3025
9	6438		69	4761
10	6339		30	900
11	6251		118	13924
12	6401		32	1024
13	6342		27	729
14	6544		175	30625
15	6365		4	16
16	6317		52	2704
17	6270		99	9801
18	6451		82	6724
19	6475		106	11236
20	6407		38	1444

$\Sigma(X-\bar{X})^2 = 161,669$

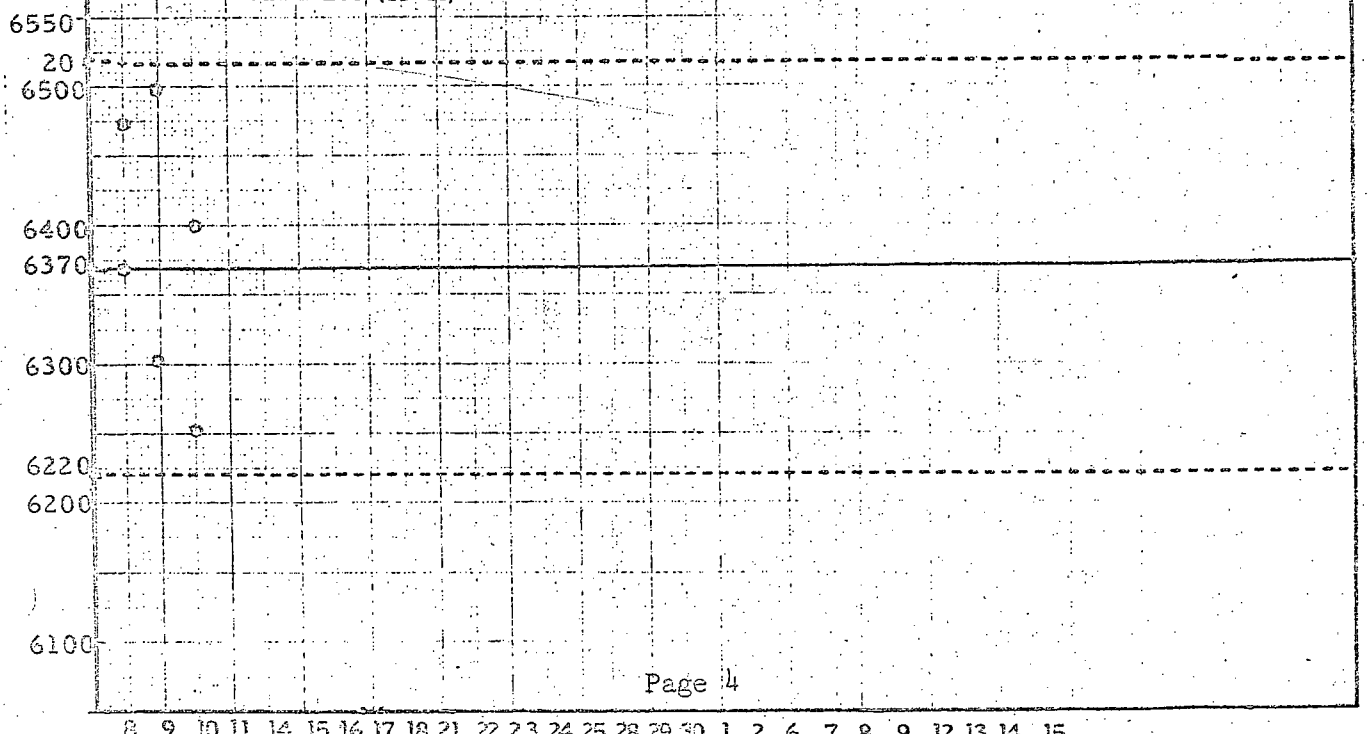
$\chi^2 = \frac{161,669}{6369} = 25.4$

$\sigma = \sqrt{\frac{161,669}{19}} = 92.2$ cpm

σ at 90% CL = (1.645)(92.2) = ± 151.7cpm

Limits of
Performance = 6369 ± 152 cpm

* NOTE: Some desk calculators are designed to perform the squaring and summing functions in one operation. This eliminates the need to tabulate $(X-\bar{X})^2$



points are within the dotted lines the counting system is performing satisfactorily. If the plotted points are not within the dotted lines the instrument control settings should be examined for correctness. Possible causes of malfunctions which can be readily checked are shifts in operating voltages or gain, detector damage, line noise, large background increases, or an erratic timer, scaling strip, or register. The standard itself should be examined for wearing of the protective covering or leakage, which could cause increased or decreased counting levels, respectively. If the fault cannot be corrected, the instrument should be removed from routine operation until repaired. The quality-control chart should be continuously examined for indications of trends toward unacceptable operation so that potential malfunction of the instrument system or other sources of faults can be corrected as quickly as possible. Gradually decreasing counting may be caused by subtle degradation of the photomultiplier tube in scintillation systems. Each incurred fault and its method of correction should be noted on the quality-control chart; this will assist in analytical data evaluations or in the diagnosis of instrument malfunction.

3. Counting Precision.

a. Standard Deviation.

(1) The process of radioactive decay is a random phenomenon, the events being counted from a random sequence in time. Therefore, counting for a finite period of time can only yield an estimate (r) of the true, average counting rate ($\bar{r}$). The degree or measure of precision is directly related to the standard deviation (σ) as shown by the following table:

TABLE II

T_S	C_S	R_S	σ	%E
.01	100	10,000	1,000	10.0%
1.00	10,000	10,000	100	1.0%
100.00	1,000,000	10,000	10	0.1%

Where: T_S = Sample Counting Time (minutes)

C_S = Net Sample Counts

R_S = Net Sample Counts per Minute

σ = Standard Deviation $\left(\sqrt{\frac{R_S}{T_S}}\right)$

%E = Percent Error $\left(\frac{100\sigma}{R_S}\right)$

(2) An examination of the table shows that in the first instance the sample was counted for a very short time but (let us assume) the count rate

was found to be 10,000 cpm. Now, examine the last entry; here the sample was counted for a long time but still the count rate was found to be 10,000 cpm. The difference between the two examples is that the first measurement must be reported as 10,000 cpm ± 10% @ 68% Confidence Level (CL) - relatively approximate estimation; while the last entry may be reported as 10,000 cpm ± 0.1% @ 68% CL - a fairly exact measurement.

(3) For health physics purposes a 25% counting error is usually sufficiently accurate. The percent error and the Confidence Level used must always be reported. The Confidence Level is the standard deviation multiplied by a factor, for example:

0.675σ = 50% Confidence Level (CL)

1.000σ = 68% Confidence Level (CL)

1.645σ = 90% Confidence Level (CL)

1.960σ = 95% Confidence Level (CL)-Normally rounded-off to 2.000

3.000σ = 99.7% Confidence Level (CL)

Counting at Health Physics is usually done at the 2σ or 95% Confidence Level. Therefore, the last example cited in 3a(2) above would be reported as:

$$C_s \pm \frac{2\sigma}{C_s}(100) \text{ @ 95\% CL}$$

$$\text{or } 10{,}000 \text{ NCPM} \pm \frac{2(10)}{10{,}000} \text{ @ 95\% CL}$$

$$= 10{,}000 \text{ NCPM} \pm 0.2\% \text{ @ 95\% CL}$$

b. Minimum Detectable Activity.

(1) The Minimum Detectable Activity (MDA) is a function of the sensitivity of the counting system, the background count rate, the length of time available for counting the sample, and the counting precision desired. For the normal health physics survey evaluation a Counting Error of ±25% is acceptable. The sensitivity of the counting system is determined by the distance of the sample from the sensitive volume of the detector, the mounting materials used, the energy of the emitted radiation, and the quantity and type of absorbing materials between the sample being counted and the detector.

(2) The MDA is calculated at 3σ (99.7% CL) as follows:

$$MDA = 3\sqrt{\frac{R_b}{T_b}}$$

Where R_b = Background Counting Rate

T_b = Length of Count

3 = 99.7% CL

e.g. BG = 400 counts in 10 minutes or 40 cpm

then MDA $= 3\sqrt{\frac{40}{10}} = 3\sqrt{4} = 3(2) = 6$ cpm

Therefore; the MDA is 6 NCPM, or we are 99.7% confident that 6 NCPM represent real activity and are not due to a statistical fluctuation of the background counting rate.

(3) The value thus calculated is valid only for a sample counting time equal to the background counting time and is dependent upon the ability of the counting system to reproduce the background obtained.

c. High Count Rate Corrections.

(1) Every counting system has a finite upper limit on its counting rate capacity. At high count rates errors are encountered from coincidence loss, dead time, and resolution limitations.

(2) Determination of Dead Time (the length of time a counting system requires to process a single pulse during which interval the system is insensitive to additional pulses).

(a) A simple way to evaluate Dead Time (t) is by the "Split Source" method. Four counting rates are required:

1 R_b = Background Counting Rate (cpm)

2 R_1 = First Beta Source (Gross cpm)

3 R_2 = Second Beta Source (Gross cpm)

4 R_{1+2} = First and second Beta Sources counted together (Gross cpm)

Calculation:

$$t = \frac{R_1 + R_2 - R_{1+2} - R_b}{(R_{1+2})^2-(R_1)^2-(R_2)^2} = \underline{\text{Minutes}}.$$

(b) Direct determination of the dead time by use of an oscilliscope is recommeded when the equipment is available.

(3) The dead time value may be used to determine the True Counting Rate using the following formula:

$$R_s = \frac{r}{1-rt}$$

Where R_s = True Net Count Rate (NCPM)

r = Observed Net Count Rate (NCPM)

t = System Dead Time (minutes)

4. Calibration of Counting Systems.

a. General. After it has been determined that a counting system is performing satisfactorily, it must be calibrated. By calibration we mean the establishment of a fixed and known relationship between the output of the counting system and the identity and quantity of the sample being analyzed. This relationship is generally based on the careful measurement of a "certified standard" which may be defined as a radioactive sample that has been assayed by a reputable scientific or commercial organization.

b. Selection of Counting Standards. Normally, the following standards will be used for comparison with unidentified, mixed samples:

α-emission - ^{238}Uranium

β-emission (unidentified laboratory samples) - ^{14}C

β-emission (unidentified reactor samples) - ^{204}Tl

γ-emission - ^{137}Cesium

Note: The 0.662 Mev Gamma-Ray from ^{137}Cesium and the 0.77 Mev (Emax) Beta-particle emission from ^{204}Thallium are considered to be suitable for Mixed Fission Product calibration.

c. Comparative Counting. Comparing a sample disintegration rate to that of a known standard is only accurate when the geometries are identical and the count rates are similar.

5. Evaluation of Samples.

a. Known Identity.

(1) If the identity of the radionuclide is established and the counting efficiency has been determined with a certified standard of that radionuclide, the activity is simply determined by preparing, mounting, and counting the sample. The dpm is then calculated using the following relationship:

$$dpm = \frac{NCPM}{Eff}$$

NCPM = Net Counts Per Minute

Eff = Counting Efficiency of the System

(2) If the identity of the radionuclide is known but the counting efficiency has not been determined with a certified standard of that radionuclide, then an estimation of the activity may be obtained by use of a plot of Energy vs Efficiency that has been prepared for a specific counting instrument and counting geometry using calibrated sources. See Figure 2. The counting efficiency for a predetermined energy is read from the graph and the activity is then calculated using the relationship in 5a(1) above.

b. Unknown Identity.

(1) When the identity of the radionuclide(s) is unknown and the health physics evaluation requires identification for the establishment of adequate control, the sample should be analyzed by either gamma spectrometry, chemical separation, half-life determination, Feather Analysis, or a combination of these methods. When the analyses have been accomplished and the identity of the radionuclide has been established, the activity should be determined in accordance with the previous instructions.

(2) If adequate control or evaluation does not depend on identification of the radionuclides, an estimation of the activity may be based on the radioisotopes listed in para 4b above.

c. Wipe Counting - Single Samples. Normally wipes are counted for only one minute each. This however is dependent upon the MDA of the system for the radionuclide(s) under consideration and the current contamination levels. It may, therefore, be necessary to lengthen the counting time on occasion in order to obtain suitable counting statistics (see para 3).

d. Efficient Distribution of Counting Time.

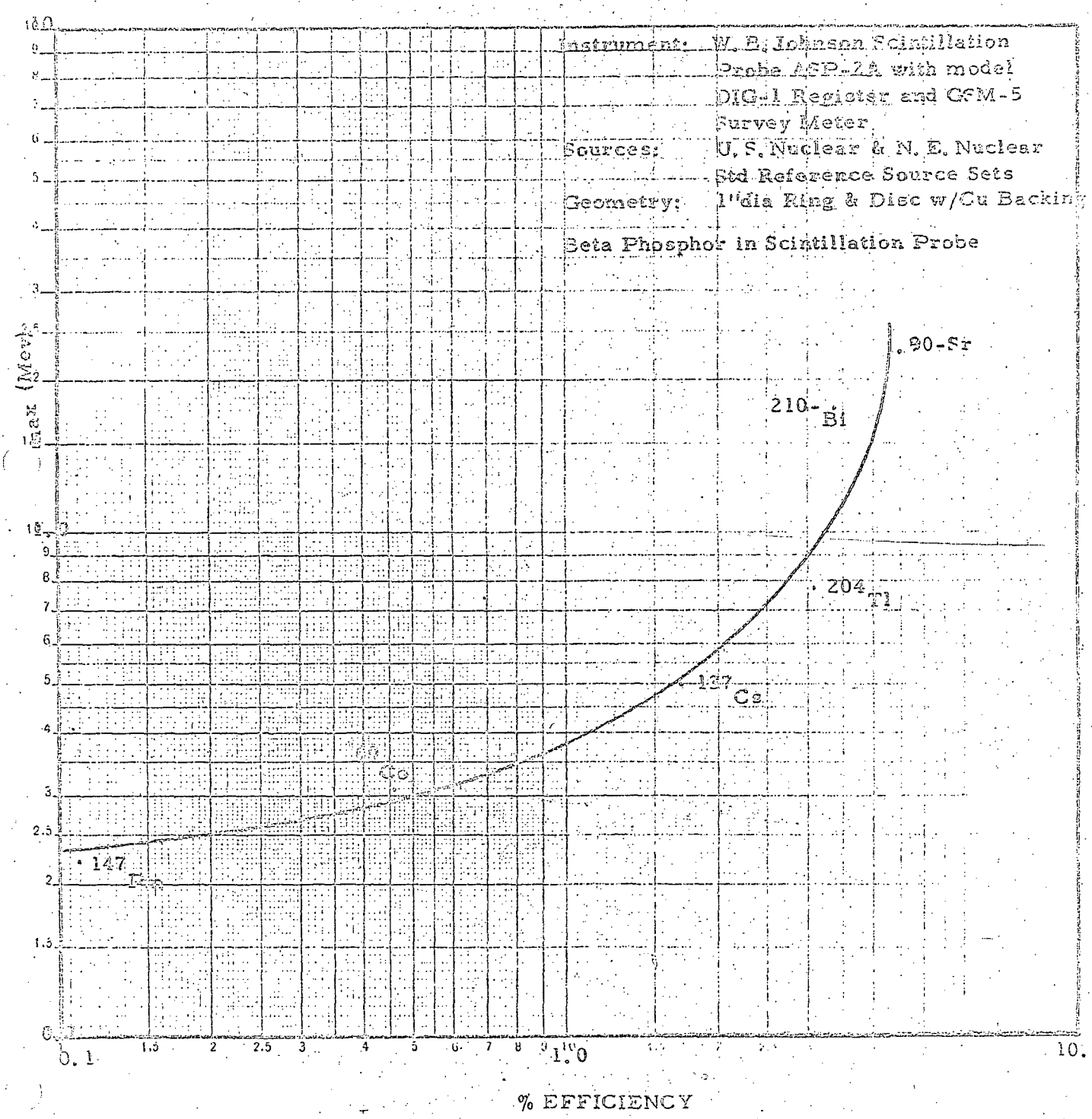
(1) When the activity of a sample is low compared to the background counting rate, it is advantageous to calculate the most efficient distribution of counting time between the sample activity and the background activity in order to minimize the counting error.

(2) It can be shown that for a particular time distribution, the counting error will be at a minimum. The time distribution is calculated as follows:

$$\frac{T_{b+s}}{T_b} = \sqrt{\frac{R_{b+s}}{R_b}}$$

Figure 2

MAXIMUM BETA ENERGY vs % EFFICIENCY



where T_{b+s} = Length of Sample plus Background Count in Minutes

T_b = Length of Background Count in Minutes

R_{b+s} = Gross Counting Rate of Sample plus Background

R_b = Background Counting Rate

e.g. Suppose a sample has an activity of 4,000 cpm and the background is 40 cpm; then

$$\frac{T_{s+b}}{T_b} = \sqrt{\frac{4000}{40}} = \sqrt{100} = 10$$

This means that for the most efficient distribution of counting time with minimum counting error for a given time, the sample should be counted for a time interval that is ten times that of the background determination.

6. Calculation of Activity. See the attached Appendix A for the methods and units employed to calculate the activity of samples analyzed by the Radioactivity Analysis Laboratory, Health Physics, WRAMC.

7. Statistical Analysis of Environmental Data.

a. All environmental sample data is subjected to standard statistical tests of significance. Chauvenet's Criterion is utilized to establish the acceptable deviation.

b. When the observed ratiation level of the environmental sample exceeds the base line environmental radiation level by more than the acceptable deviation as established by Chauvenet's Criterion, the sample is held for further evaluation and additional representative samples are obtained for analysis.

8. References.

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e. Chase and Rabinowitz, Principles of Radioisotope Methodology, 1964

f. Quimby and Feitelberg, Radioactive Isotopes in Medicine and Biology, 1963

g. NBS Handbook 80 - A Manual of Radioactivity Procedures, 1961

h. NBS Handbook 84 - Radiation Quantities and Units, 1962

i. NBS Handbook 86 - Radioactivity, 1963

j. PHS Publication 999-RH-15 - Quality Control of Radioactivity Counting Systems, 1965

k. NAS-NRC-Publication #573 - Measurements and Standards of Radioactivity, 1957

l. NBS-Circular-476 - Measurement of Radioactivity, 1949

APPENDIX A - Calculation Sheets

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APPENDIX A to
HP SOP 1-2 - Counting Procedures

10 June 1974

CALCULATION SHEETS

The mathematical symbols used in this Appendix are defined as follows:

SYMBOL	DEFINITION	UNITS
C	Activity Concentration	µCi/ml
R_s	Net Counting Rate of Sample	NCPM
R_b	Background Counting Rate of Counting System	cpm
R_{b+s}	Gross Counting Rate of Sample includes R_b	cpm
eff	Counting Efficiency for the Counting System	NCPM/dpm
V	Volume of Sample Counted	ml
t_{b+s}	Length of Gross Sample Count	min
t_b	Length of Background Count	min
Y	Chemical Recovery or Yield Factor	
%E	Percent Error	
σ	Standard Deviation	
dpm	Disintegrations per minute	
4.5×10^{-7}	Microcuries per Disintergration	µCi/dpm
µCi	Microcurie	10^{-6} Ci
2.22×10^{6}	Disintegrations per Microcurie	dpm/µCi
pCi	Picocuries	10^{-12} Ci
2.83×10^{4}	Cubic Centimeters per Cubic Foot	cc/ft^3
A	Sample Area in Square Meters	M^2
Nd	Interval of Exposure Time in Days	Days
Wt_s	Net Weight of Sample in Grams	g

SYMBOL	DEFINITION	UNITS
CL	Confidence Level	%
SA	Self Absorption Factor	
MDA	Minimum Detectable Activity	µCi or dpm

MEDEC-RS
SUBJECT: APP A to HP SOP 1-2

10 June 1974

Percent Error Calculation Sheet

$$* \quad \%\text{Error}(E) = \frac{2\sqrt{\frac{R_{b+s}}{t_{b+s}} + \frac{R_b}{t_b}}}{R_s} \times 100$$

Where:

$R_{b+s} = 3.08 \times 10^3$ cpm

$R_b = 7.65 \times 10^2$ cpm

$R_s = 2.32 \times 10^3$ NCPM

$t_{b+s} = 10$ minutes

$t_b = 10$ minutes

$$\therefore \%E = \frac{2\sqrt{\frac{3.08\times10^3}{10} + \frac{7.65\times10^2}{10}}}{2.32\times10^3} \times 100$$

$$= \frac{2(1.96\times10^1)}{2.32\times10^3} \times 100$$

$$= 1.69\% \text{ @ } 95\% \text{ CL (Confidence Level)}$$

* Note: Error is always calculated at the 95% Confidence Level (1.96 σ which is normally rounded-off to 2.000.)
Also, the expression $\sqrt{\frac{R_{b+s}}{t_{b+s}} + \frac{R_b}{t_b}}$ is another method of determining the Standard Deviation (σ), refer to 2d(2)(a) and 3a of the HP SOP 1-2.

Wipe Analysis for Removable Contamination

Calculation Sheet

$$dpm = \frac{NCPM}{eff}$$ for β and α samples

$$dpm = \frac{N\gamma PM}{eff}$$ for Integral γ Analysis of Samples - (Normally referenced to ^{137}Cs)

$$dpm = \frac{N\gamma PM_{PP}}{\gamma_q \, eff_\gamma}$$ for analysis of γ emitters whose identity has been determined

Where:

$N\gamma PM_{PP}$ ≡ Net Gamma Counts per Min Under photopeak area. (peak Channel ± 2 channels)

γ_q ≡ Gamma Abundance for the photopeak energy q being measured.

eff_γ ≡ Counting efficiency of the System for Counting the γ channel energy range of the subject photopeak.

Activity Concentration Reported:

dpm per wipe normally referenced to ^{14}C for β, ^{137}Cs for γ and ^{210}Po for α

Note: The relationships shown will be used in many other activity determinations.

Low Level Net β+α Activity Determinations in Waste Water

Calculation Sheet

$$C = \frac{R_s (4.5 \times 10^{-7})}{(eff)(V)(Y)(SA)}$$

Where:

R_s = 1.85 NCPM @ 1540 hrs 11 Jul 66
R_b = 1.31 cpm
R_{s+b} = 3.16 cpm
t_{s+b} = 60 min
t_b = 120 min
eff = 0.235 NCPM/dpm (^{204}Tl)
SA = 0.843
Y = 0.85
V = 1×10^3 ml

$$\therefore C = \frac{(1.85 \text{ NCPM})(4.5 \times 10^{-7} \mu Ci/dpm)}{(0.235 \frac{\text{NCPM}}{dpm})(1 \times 10^3 \text{ml})(0.843)(0.85)} = 4.92 \times 10^{-9} \mu Ci/ml$$

$$\%E = \frac{2\sqrt{\frac{3.16}{60} + \frac{1.31}{120}}}{1.85} \times 100 = 27.2\%$$

Activity Concentration Reported:

$4.92 \times 10^{-9} \mu Ci/ml \pm 27.2\%$ @ 95% C.L. @ 1540 hrs 11 Jul 66

Waste And DORF Pool Water for Gamma Analysis

Calculation Sheet

$$C = \frac{R_s (4.5 \times 10^{-7})}{(eff \times V)}$$

Where:

$R_s = 2.32 \times 10^3$ NCPM @ 1340 hrs 14 Jul 66
$R_{bks} = 3.08 \times 10^3$ cpm
$R_b = 7.65 \times 10^2$ cpm
$t_{bks} = 10$ min
$t_b = 10$ min
* eff = 0.14 NCPM / dpm (^{137}Cs)
$V = 2.5 \times 10^3$ ml

$$\therefore C = \frac{(2.32 \times 10^3 \text{ NCPM})(4.5 \times 10^{-7} \mu Ci/\text{dpm})}{(0.14 \text{ NCPM/dpm})(2.5 \times 10^3 \text{ ml})}$$

$$= 2.98 \times 10^{-6} \mu Ci/ml$$

$$\%E = \frac{2\sqrt{\frac{3.08 \times 10^3}{10} + \frac{7.65 \times 10^2}{10}}}{2.32 \times 10^3} \times 100$$

$$= \frac{2(1.96 \times 10^1)}{2.32 \times 10^3} \times 100 = 1.69\%$$

Activity Concentration Reported:

$2.98 \times 10^{-6} \mu Ci/ml \pm 1.69\%$ @ 95% CL @ 1340 hrs 14 Jul 66

*Note: The eff used is for ^{137}Cs in 2000 ml of H_2O Counted Integrally over 0-3.0 MeV in a Marinelli Type Beaker on the 4"x4" NaI Xtal.

Gamma Analysis Of Flora Samples

Calculation Sheet

$$pCi/gm = \frac{(R_s)(4.5\times10^{-1})}{(eff)(Wt_s)}$$

Where: R_s = 8571 NCPM @ 1520 25May66
R_{s+b} = 9365 cpm
R_b = 794 cpm
t_{s+b} = 10 min
t_b = 10 min
eff = 0.132 NCPM/dpm (^{137}Cs)
Wt_s = 2×10^3 gm

$$pCi/gm = \frac{(8.571\times10^3\ NCPM)(4.5\times10^{-1}\ pCi/dpm)}{(0.132\ NCPM/dpm)(2\times10^3\ gm)}$$

$$= 14.6\ pCi/gm$$

$$\%E = \frac{2\sqrt{\frac{9365}{10}+\frac{794}{10}}}{8571}\times100 = 0.75\%$$

Activity Concentration Reported:

14.6 pCi/gm ± 0.75% @ 95% CL @ 1520 hrs 25May66
Determined by Integral γ Analysis (0-3.0 MeV)

10 June 1974

Gamma Analysis Of Fallout-Washout Samples

Calculation Sheet

$$pCi/M^2/day = \frac{(R_s)(4.5\times10^{-1})}{(eff)(A)} \Big/ Nd$$

Where: R_s = 35.6 NCPM @ 1557 25 Jul 66
R_{s+b} = 777.8 cpm
R_b = 742.2 cpm
t_{s+b} = 10 min
t_b = 10 min.
eff = 0.142 NCPM/dpm (^{137}Cs)
A = 0.06 M^2
Nd = 7 days

$$\therefore pCi/M^2/day = \frac{(35.6\ NCPM)(4.5\times10^{-1}\ pCi/dpm)}{(0.142\ \frac{NCPM}{dpm})(0.06\ M^2)} \Big/ 7\ days$$

$$= \frac{188\ pCi/M^2}{7\ days} = 26.9\ pCi/M^2/day$$

$$\%E = \frac{2\sqrt{\frac{777.8}{10}+\frac{742.2}{10}}}{35.6}\times100 = 69\%$$

Activity Concentration Reported:

26.9 pCi/M^2/day ± 69% @ 95% C.L. @ 1557 hrs 25 Jul 66
Determined by Integral & Analysis (0-3.0 MeV)

Gamma Analysis Of Soil Samples

Calculation Sheet

$$pCi/gm = \frac{(R_s)(4.5\times10^{-1})}{(eff)(Wt_s)}$$

Where: R_s = 505 NCPM 21 Mar 66
R_{s+b} = 1280 cpm
R_b = 775 cpm
t_{s+b} = 900 min
t_b = 900 min
eff = 0.144 NCPM/dpm (^{137}Cs)
Wt_s = 240.8 gms

$$pCi/gm = \frac{(5.05\times10^{2}\ NCPM)(0.45\ pCi/dpm)}{(0.144\ NCPM/dpm)(2.408\times10^{2}\ gm)}$$

$$= 4.47\ pCi/gm$$

$$\%E = \frac{2\sqrt{\frac{1280}{900}+\frac{775}{900}}}{505} \times 100 = 0.6\%$$

Activity Concentration Reported:

4.47 pCi/gm ± 0.6% @ 95% CL @ 21 Mar 66
Determined by Integral γ Analysis (0-3.0 MeV)

10 June 1974

GAMMA Analysis of Air Particulate Monitor Samples

Calculation Sheet

Volume @ 2100 hrs 6 Jul 66 $= (12.92\ hrs)\left(\frac{60\ min}{hr}\right)(9.2\ ft^3/min)\left(2.83\times10^4\ \frac{cc}{ft^3}\right)$

$= 2.02\times10^8\ cc$

4.8×10^3 dpm @ 2100 hrs 6 Jul 66 (Mid-point of the Sampling Interval)

Where: Filter "ON" @ 0805 hrs 6 Jul 66
Elapsed time to 2100 hrs 6 Jul 66 = 12.92 hrs
Flow Rate = 9.2 cfm

Time & Date of Count	MDA	Observed dpm
1500 hrs 7 Jul 66	144 dpm	1384 dpm
1000 hrs 8 Jul 66	142 dpm	362 dpm

10^3 dpm

∴ Activity @ 2100 hrs 6 Jul 66 =

$(4.8\times10^3\ dpm)(4.5\times10^{-7}\ \mu Ci/dpm)\left(\frac{1}{2.02\times10^8\ cc}\right)$

$= 1.07\times10^{-11}\ \mu Ci/cc$ JaB

Activity Concentration Reported:

$= 1.07\times10^{-11}\ \mu Ci/cc$ @ 2100 hrs 6 Jul 66

Determined by Integral γ Analysis (0-3.0 MeV)

2100 hrs 6 Jul 66 | 2100 hrs 7 Jul 66 | 2100 hrs 8 Jul 66 | Elapsed Time

Apparent Age of Fission Products

Environmental Studies

Way-Wigner Formula

Calculation Sheet

$$t_1 = \frac{\Delta t_1}{\left\{\left(\frac{A_1}{A_2}\right)^{0.835} - 1\right\}}$$

Where:

t_1 = days ≡ Apparent Age at the Time of First Counting

Δt_1 = 6.72 days ≡ Time elapsed between 1st & 2nd Counts

A_1 = 8571 NCPM ≡ Activity at time of First Counting (Approximately 3 days after Collection.)

A_2 = 5662 NCPM ≡ Activity at time of Second Counting (Approximately 10 days after Collection.)

$$\text{Days} = \frac{6.72}{\left\{\left(\frac{8571}{5662}\right)^{0.835} - 1\right\}} = \frac{6.72}{1.413 - 1} = 16.3 \text{ days}$$

Time from first Count to detonation = 16.3 days

Time and date of First Count = 1520 hrs 25 May 66

Announced time of Chinese Test ≅ 9 May 66

Calculated time and date of Test ≅ 0800 9May66 (edt)

Fission-Product Activity at Time of Collection
Environmental Studies

Calculation Sheet

Collected: 1515 hrs 25 May 66
1st Count: 0830 hrs 1 Jun 66

$$A_c = A_1\left(\frac{t_1}{t_1 - \Delta t_2}\right)^{1.2}$$

Where:

$\Delta t_2 = 6.7$ days ≡ Time elapsed between Collection and first Counting

$A_1 = 9.65$ pCi/gm ≡ Activity at time of 1st Count

$t_1 = 23.0$ days ≡ Apparent Age of Fission-Products at time of 1st Counting (Way-Wigner)

$A_c =$ pCi/gm ≡ Activity at time of Collection

$$\frac{pCi}{gm}@\ \substack{1515\text{ hrs}\\25\text{ May 66}} = 9.65\left(\frac{23.0}{23.0-6.7}\right)^{1.2} = 9.65(1.51) = 14.6\ \frac{pCi}{gm}$$

$$\%E = \frac{2\sqrt{\frac{6456}{10}+\frac{794}{10}}}{5662} \times 100 = 0.95\%$$

Where: $R_s = 5662$ NCPM @ 0830 hrs 1 Jun 66

$R_{s+b} = 6456$ cpm $\quad t_{s+b} = 10$ min

$R_b = 794$ cpm $\quad t_b = 10$ min

Activity Concentration Reported:

14.6 pCi/gm ± 0.95% @ 95% C.L. @ 1515 hrs 25 May 66
Determined by Integral γ Analysis (0-3.0 MeV)

10 June 1974

Determination of Fission-Product Activity
Environmental Studies
(Koval Method)

Calculation Sheet

$$C_{LL} = \frac{C_2 - C_1 e^{-\lambda \Delta t}}{1 - e^{-\lambda \Delta t}}$$

Where:

C_{LL} = pCi ≡ Gross Long Lived Activity

C_1 = 2.02 pCi ≡ Activity Observed at time t (Approximately 4 hrs after Collection)

C_2 = 108 pCi ≡ Activity Observed at time t_2 (Approximately 24 hrs after C_1)

t = 1430 hrs 25 May 66 ≡ Date and time at which C_1 was measured

t_2 = 0900 hrs 26 May 66 ≡ Date and time at which C_2 was measured

Δt = 18.5 hrs ≡ Elapsed time between C_1 and C_2.

λ = 0.0654 ≡ Decay Constant for Thorium B (^{212}Pb) = 0.693/10.6 hrs

$$\therefore pCi = \frac{108 - 202e^{-(0.0654)(18.5)}}{1 - e^{-(0.0654)(18.5)}}$$

$$= \frac{1.08 - 202e^{-1.21}}{1 - e^{-1.21}} = \frac{47.8}{.702} = 68 \text{ pCi}$$

Volume of air collected = 167 M^3

∴ The Concentration of Long Lived Nuclides in Air at 1430 hrs 25 May 66 = 68 pCi/167 M^3 = 0.41 pCi/M^3

or 4.1×10^{-13} μCi/cc

Note: Determination of this activity was made by Integral γ Analysis (0-3.0 MeV). The activity is a result of the Chinese Test on 9 May 1966

HEALTH PHYSICS
WALTER REED ARMY MEDICAL CENTER
Washington, D.C. 20012

*
MEDEC-YHP
SOP
Number 2-2

10 June 1974

RADIOACTIVITY ANALYSIS LABORATORY

1. Purpose. To establish guidelines for the radioactivity analysis laboratory (R/A Lab), Health Physics (HP), Walter Reed Army Medical Center (WRAMC) in order to insure the orderly and continuous operation of the laboratory.

2. Mission. To assist the Chief, Nuclear Laboratory and Technical Service Branch (Ch, NL&TS Br), HP, WRAMC, in the successful fulfillment of the overall mission of the Branch by providing the necessary technical and administrative ability to determine the identity and quantity of radioactivity in environmental samples, wipe tests, reactor effluents, reactor pool water, and other special analyses as required.

3. Routine Duties.

a. General. Routinely the Ch, R/A Lab, will evaluate and report sample analyses directly to the requestor. However, when analyses indicate abnormal samples or contamination levels, he will consult with the Ch, NL&TS Br, prior to making a final report to the requestor.

b. Daily Calibration of Counting Equipment. All calibrations, background measurements, malfunctions and repairs will be entered into the Daily Performance Log. Calibration sources and backgrounds will be counted daily on routinely used equipment. All routinely used equipment will normally be left in the operating mode to insure its stability and reliability.

(1) NS 4096 Channel Analyzer. See manufacturer's literature for operating instructions.

(a) The integral gamma efficiencies for routine geometrics are arrived at from the 137-Cesium point source efficiency using an empirically determined correlation factor.

(b) Energy calibration - 0-2 MEV full range

(c) Performance check.

(2) Beckman Liquid Scintillation System. See manufacturer's literature for operating instructions.

*This SOP supersedes HP SOP Number 2-2, 10 September 1972.

(a) This instrument is normally calibrated by running a set of quenched standards and plotting the calculated efficiencies against the automatic quench correction (AQC) factor, (the decimal value following the χ on the printout).

(b) Efficiency for each sample is determined by going to the calibration curve for that type of sample and taking the efficiency as that point where the AQC factor intercepts the efficiency curve.

(3) Beckman WIDEBETA II, Beta Counting System. See literature for operating instructions.

(a) Net beta efficiency is calibrated from a 14-Carbon standard.

(b) Alpha efficiency is calculated from a 210-Polonium standard.

(4) 1600 Channel Multi-parameter Analyzer. See manufacturer's literature for operating instructions.

(a) This instrument will be interchanged between several different detector systems depending upon the laboratory's needs.

(b) Calibration of this instrument will be done at the time of sample counting. Calibration will be done with whatever isotopes are necessary to give the laboratory a reference as to the energy, activity, etc., of the sample under consideration.

(5) LCRM-22R Air Particulate Monitor. See manufacturer's literature for operating instructions.

(a) Change the filter paper each duty day at approximately 0900 hours. Prepare a WRAMC Form 708 (Health Physics Survey Work Copy) for the filter removed. Stamp the chart on the LCRM-22R and the WRAMC Form 708 with the rubber stamp provided and fill in the required data; time, date, weather, etc.

(b) Make a visual inspection of the indicators to assure proper operation.

(c) For calibration, see ANNEX B to this SOP.

c. Periodic Calibration (Determined by Chief, NL&TS Br)

(1) CHI Squared (χ^2) statistical evaluation of each laboratory instrument in daily use for nuclear counting purposes.

(2) Determination of the resolution of the 4x4" Sodium Iodide crystal and phototube assembly (4x4" NaI Xtal).

d. Voltage plateaus and χ^2 statistical evaluations will be performed as required, and after equipment repairs or component changes.

4. Laboratory Procedures and Work Load.

a. General.

(1) For convenience, 10 minute counting times are specified throughout these procedures; however, in cases where a low sample-to-background ratio exists and a small counting error is necessary, the counting time will be extended to insure statistical validity of the radioassay.

(2) Abnormal as used in these procedures is defined as any sample exceeding the radiation protection guidelines (RPG) and/or contamination levels or that has a gamma spectrum with a statistically significant photopeak(s) that has not been previously identified and whose origin has not been explained to the satisfaction of the Chief, NL&TS Br, HP, WRAMC.

b. Daily Samples.

(1) DORF Pool Water

(a) Action. Allow sample to decay for approximately 24 hours after collection to allow the 41-Argon to decay away, thus eliminating its interference in the detection of low levels of fission products.

1 Do a 10-minute integral gamma count on a Marinelli beaker with one empty plastic bag inserted to establish the background counting rate of the 4x4" NaI Xtal.

2 Do a 10-minute integral gamma count of 2500 ml aliquot of the sample.

3 Prepare an X-Y plot on all abnormal samples.

(b) Calculations - See HP SOP 1-2, Counting Procedures.

(c) Follow-up - Next day.

1 Do a 10-minute integral gamma count of the sample if required for decay purposes.

2 Prepare an X-Y plot of the gamma spectrum.

(d) Disposition of Sample - Discard the sample to the sewer

after the activity decays to approximately $10^{-6}\mu Ci/ml$, making the appropriate entries in the Waste Disposal Log.

(2) Air Particulate Monitor - Reactor Air Samples.

(a) Immediate Action

1 Do a 10-minute integral gamma count on the 4x4" NaI Xtal with the 1/4" lucite beta absorber in place to establish the background counting rate.

2 Do a 10-minute integral gamma count of each filter at least five (5) hours after sample cut-off (to allow for decay of short-lived Radon components).

3 Prepare an X-Y plot on all abnormal samples.

(b) Calculations - See HP SOP 1-2, Counting Procedures.

(c) Follow-up - Next day.

1 Do a 10-minute integral gamma count on the 4x4" NaI Xtal with the 1/4" lucite beta absorber in place to establish the background counting rate.

2 Do a 10-minute integral gamma count of each filter at least 24 hours after sample cut-off (to allow for decay of long-lived Thoron components).

3 Prepare X-Y plots only in cases where further analyses are indicated.

(d) Disposition of Samples

1 Routine Samples - Discard the samples after analysis.

2 Abnormal Samples - Discard the samples only after completion of analysis in accordance with current procedures.

(3) Air Particulate Monitor - LCRM-22R (2" Filter Disc).

(a) This sample is collected for use as a background comparison in the evaluation of reactor air samples.

(b) Procedure same as (2)(b) above with the exception that the 3/4"x4" diameter lead shield is placed on top of the flat filter disc for all counting.

(c) Calculations - See HP SOP 1-2, Counting Procedures.

(d) Disposition of Samples - Same as (2)(d) above.

(4) Wipes

(a) Immediate Action

1 Beta contamination suspected

a Select a calibration standard in the energy range of the suspect isotope and determine the counting efficiency (See HP SOP 1-2, Counting Procedures, para 4b).

b Set the wipes up for WIDEBETA II system. Initiate 10-minute counts on samples.

c If contamination is noted on any wipe, remove it from its planchet, place it in a paper envelope, and count it on the 4x4" NaI Xtal to determine the amount of gamma activity present and its identity if it is a gamma emitter. Wipes are counted with the 3/4"x4" diameter lead shield on top of the wipe.

2 Gamma contamination suspected - Proceed as in c above.

3 Alpha contamination suspected - Adjust the counting mode to Alpha Mode (WIDEBETA II).

(b) Calculations - See HP SOP 1-2, Counting Procedures.

(c) Follow up

1 Notify the requestor by telephone of any wipes found to be of greater activity than the contamination level, giving the activity (in dpm) and identity of the contaminating isotope, if known.

2 Prepare X-Y plots of the gamma spectrum only if a further analysis is indicated or if they have been requested on the WRAMC Form 708.

(d) Disposition of Sample

1 Discard all noncontaminated wipes.

2 Hold the contaminated wipes until a report is made to the requestor, then discard them in accordance with current procedures.

(5) Special Samples - From time to time, special samples will be received for evaluation. These will be treated in accordance with HP SOP 1-2, Counting Procedures, and with the priority determined by the Chief, NL&TS Br, HP, WRAMC.

c. Samples Collected

(1) Fallout-washout Samples (collected twice monthly,i.e., at intervals of not less than 13 days, but not to exceed 18 days).

(a) Immediate Action

1 Do a 10-minute integral gamma count on a fallout collector with one (1) liter of deionized water in a plastic bag to establish the background counting rate.

2 Counting will be performed and X-Y plots prepared in accordance with ANNEX C to this SOP.

(b) Calculations - See HP SOP 1-2, Counting Procedures.

(c) Follow-up. Samples with unusual spectra or those having activities above 600 dpm will be retained for detailed analysis and identification.

(d) Disposition of Samples

1 All normal samples will be discarded into the sanitary sewer system.

2 Abnormal samples will be discarded in accordance with current procedures upon completion of the analyses.

(2) Reactor Effluent Water Samples (collected as required for analysis prior to release to the unrestricted area).

(a) Immediate Action

1 Do a 10-minute integral gamma count on each sample. A Marinelli beaker with one plastic bag inserted will be counted for 10 minutes to establish the background counting rate on the 4x4" NaI Xtal. A background will be required for each sample analyzed.

2 Do a 10-minute integral gamma count of total sample minus one (1) liter (for reduction in accordance with ANNEX A to this SOP, an evaluation of the remaining volume is usually between 1500 and 1800 ml).

3 Prepare an X-Y plot on all abnormal samples.

4 Proceed with preparation of the one (1) liter aliquot of each sample for a net analysis (see ANNEX A to this SOP). Counting time should be sufficient to provide a counting error not greater than 25% at the 95% confidence level when assaying samples with an activity greater than 1 x 10 mCi/ml.

(b) Calculations - See HP SOP 1-2, Counting Procedures.

(c) Follow-up. Abnormal samples will be analyzed in detail for determination of the half-life and identification of the nuclides present.

(d) Disposition of Samples. Discard to sewer (liquid samples) or non-burnable waste (solid samples) when analysis is completed in accordance with current procedures.

(3) Gas Samples (collected as required by the Health Physics Officer, WRAMC, or the Physicist in Charge, DORF.

(a) Immediate Action

1 Do a 10-minute integral gamma count of an empty sample container to establish the background counting rate on the 4x4" NaI Xtal with the 1/4" lucite beta absorber in place.

2 Perform a 10-minute integral gamma count on each sample.

(b) Calculations - See HP SOP 1-2, Counting Procedures.

(c) Follow-up. Abnormal samples will be analyzed in detail for identification of all nuclides present.

(d) Disposition of Samples. As most samples of this type will be short-lived, samples will be held for decay.

(4) Soil Samples (collected twice annually).

(a) Immediate Action

1 Do a 10-minute integral gamma count of an empty sample container to establish the background counting rate on the 4x4" NaI Xtal with the 1/4" lucite beta absorber in place.

2 Perform a 10-minute integral gamma count on each sample.

3 Prepare an X-Y plot on each sample.

(b) Calculations - See HP SOP 1-2, Counting Procedures.

(c) Follow-up. Abnormal samples will be analyzed in detail for determination of the half-life and identification of the nuclides present.

(d) Disposition of Samples. Discard all samples to waste upon completion of analyses.

(5) Flora Samples - Grass Cuttings (collected as required by the Chief, NL&TS Br, HP, WRAMC).

(a) Immediate Action

1 Do a 10-minute integral gamma background count on the 4x4" NaI Xtal with the 1/4" lucite beta shield in place.

2 Do a 10-minute integral gamma count on each sample.

3 Prepare an X-Y plot of each sample.

(b) Calculations - See HP SOP 1-2, Counting Procedures.

(c) Follow-up. Abnormal samples will be analyzed in detail for determination of the half-life and identification of the nuclides present.

(d) Disposition of Samples. Discard all samples upon completion of analyses.

(6) Snow Samples (collected as required by the Chief, NL&TS Br, HP, WRAMC). Thaw and treat as in para 4c(1) above.

5. Radiochemistry The Chief, R/A Lab, will, as required

a. Prepare calibration standards for use in the laboratory.

b. Perform necessary radiochemical separations using appropriate technical and laboratory procedures on file at HP, WRAMC.

c. Continuously evaluate and improve the laboratory techniques in keeping with technical advances made in the field.

6. Maintenance of Supplies and Equipment. The Chief, R/A Lab, will

a. Order chemicals and laboratory equipment needed through HP Supply.

b. Coordinate equipment maintenance with the HP Instrument Shop. All radiation detection instruments require a quarterly maintenance check.

c. Perform the following preventive maintenance:

(1) LCRM-22R - Grease and check oil level monthly.

(2) Fume hood blower shaft - Grease as required.

(3) Air compressor - Maintain oil level.

(4) Vacuum pump - Maintain oil level.

(5) Change fume hood prefilter semiannually.

(6) Tally Tape and Tape Reader - Maintain proper oil level and lubricate as required by the respective maintenance manuals.

d. Maintain inventory of radiochemicals in the safe in HP Supply Room.

e. Maintain inventory of assigned equipment.

7. Records. The Chief, R/A Lab, will insure that the following records are properly maintained:

a. Logs

(1) Sample Data Log - All incoming samples will be recorded and assigned a number in sequence from this Log. A new series of numbers will be started at the beginning of each calendar year.

(2) Waste Disposal Log - Record the discharge of liquid radioactive materials to the sewer.

(3) Daily Performance Log - A record of daily check, calibration, voltage plateaus, maintenance and observations of malfunctions for the laboratory counting instrumentation will be kept.

b. Files

(1) Reports of Special Laboratory Analyses for Reference - Papers on specific projects which will be useful as reference sources will be kept.

(2) Technical Data - Books and papers pertaining to laboratory operations and assigned equipment will be kept.

(3) Manufacturer's Data - Instructional material on the use and maintenance of the laboratory equipment will be maintained.

(4) Environmental Monitoring Data

(a) Folder for completed WRAMC Forms 708 (Health Physics Survey Work Sheet) for Bldgs 188 and 149-A will be kept (COFF 1 yr).

(b) Folder for Background Air Activity - WRAMC Form 708 for the daily evaluation of the LCRM-22R filters will be kept (COFF 1 yr).

(c) Folder for Fallout Analysis - WRAMC Forms 708 for the Fallout-washout Sample evaluation.

(d) Folder for Special Analyses (COFF 1 yr).

(5) Maintaining Register - Data pertinent to the laboratory counting instrumentation that is not suitable for entry into the Daily Performance Log will be kept and maintained as a permanent history of the equipment.

(6) Calibration Source Data Sheets - Radiochemical Standards - Data pertaining to the preparation and use of radiochemicals will be kept but will be cut off when the isotope is depleted or discarded.

c. Chemical Inventory - 3"x5" Card File. Record receipt and use of chemical stores to maintain a constant inventory of these supplies.

8. Reports. The Chief, R/A Lab will insure that the Reports of Analysis (WRAMC Forms 708) are completed and forwarded to proper authorities without delay.

(1) Reports for non-routine analyses will be prepared and forwarded as directed by the Chief, NL&TS Br, HP, WRAMC.

(2) A sample number is assigned to each sample and appropriate entries are made into the Sample Data Log. This number will then accompany the sample throughout its evaluation in the laboratory. The time and date of sample receipt will be stamped on all copies of the Form 708.

Claude M. Wiblin

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ANNEX A to
HP SOP 2-2

10 June 1974

SAMPLE PREPARATION
NET β +α ACTIVITY IN WATER

1. Purpose. The purpose of this ANNEX is to provide a standard method for the preparation of water samples received at the R/A Lab, HPO, WRAMC, for Net β +α radioanalysis.

2. Responsibility. The Chief, R/A Lab will insure that all samples are processed for analysis without delay and provide a report of this analysis as quickly as possible to the requestor.

3. Water Samples - Net β +α Analysis Requested.

a. Agitate the sample and decant a one (1) liter aliquot from the total volume of the sample received.

b. Filter this aliquot through a strip of FINE quality filter paper on the "FILTER-FUGE" filtering apparatus; repeat as necessary to obtain a clear liquid.

c. Carefully remove the filter paper strip(s), place them into a porcelain crucible and allow to dry.

d. Carefully pour the clean filtrate into a clean water concentrator lightly greased with DOW-CORNING II silicon compound. Remove the paper tab from the planchet in the bottom of the concentrator before adding the sample.

e. Adjust the VARIAC for 85 volts, place the switch in the ON position and leave until the sample is evaporated.

f. When the sample is dried and cool, remove the planchet from the concentrator and place it in a 2"x 1/4" wall stainless steel planchet.

g. Place the crucible with the filter strip(s) in the fume hood, saturate the paper strip(s) with ACETONE, and IGNITE it (them). Repeat as necessary to completely reduce the paper strip(s) to an ash.

h. Using small amounts of Nitric Acid and deionized water, quantitatively transfer the ash to the planchet (f, above) and dry under a heat lamp or on a hot plate.

i. When the sample is dried and cool, it is ready for counting on the Beckman WIDEBETA II counting system.

ANNEX B to
HP SOP 2-2 10 June 1974

CALIBRATION OF LCRM-22R

1. Purpose. The purpose of this ANNEX is to provide a calibration procedure for the LCRM-22R Air Particulate Monitor.

2. Responsibility. The Chief, R/A Lab, HPO, WRAMC, will insure that the LCRM-22R is calibrated as required by the Chief, NL&TS Br, HPO, WRAMC.

3. Procedure.

a. A pulse generator with a pulse amplitude of 0 - 5.0 volts negative, a pulse width of 1.0 to 10.0 microseconds, and an accurate repetition rate is used in calibrating the LCRM-22R. Pulse width of the signal is not important as long as it remains within the above range. Both channels are driven simultaneously from the pulse generator through a 0.01 mfd capacitor to each signal injection point (green tip jack) on the LCRM-22Rchassis. Rotate both selector switches on the panel to the extreme counter-clockwise position (one position to the left of "test"). This is an unmarked position and disconnects the CRM inputs from any signal source except the green pin jacks.

b. Set the pulse generator for 50,000 CPM and 0.5 volts amplitude. Using an insulated screwdriver, adjust the sensitivity control of both channels for marginal triggering.

c. Reset pulse generator to 50 CPM and 4.0 volts amplitude. Set the LOW adjust pots on both channels until the recorder reads 53 CPM on both channels.

d. Set pulse generator to 50,000 CPM and leave the output amplitude at 4.0 volts for the remainder of the calibration procedure. Adjust the HIGH pots until the recorder reads 44,000 CPM on both channels.

e. Now, check the recorder readings of both channels at 5000 CPM and 500 CPM. Typical readings are 5200 CPM at 5000 CPM and 450 CPM at 500 CPM. The recorder and meter scales are logarithmic, but the electronic circuits are not truly logarithmic. In the interest of simple and reliable circuitry, this method was used in preference to the more complicated truly log circuit, since accuracy is not of prime importance, but reliability is important for monitoring applications. Thus, the circuit is adjusted as close as possible to the log scale of the recorder. After the initial calibration, minor adjustments usually have to be made again at the LOW and HIGH ends in order to obtain the best match between circuit and scale.

f. Remove the pulse generator leads from the green pin jacks and rotate both selector switches to "test". In this position of 60-Hz test, pulse is applied to the input of each CRM to give 3600 CPM. The actual recorder reading, under test signal conditions, will be somewhere between 3600 and 4000 CPM. If low counting or double counting is experienced in the "test" position, adjust the 8 - 50 mmfd trimmer capacitors, mounted on each selector switch, until the correct counting rate is obtained.

g. Plug signal generator leads, through 0.01 mfd capacitors, into the green pin jacks. Set the output pulse amplitude to 4.0 volts and 5000 CPM.

h. Allow enough time for the ratio circuit to come to equilibrium. Using an insulated screwdriver, adjust the LOW potentiometer until the recorder reads 1.0. This corresponds to the 1 K position on the chart paper.

i. Check the 1.0 reading at the 50,000 CPM, 50 CPM, and 500 CPM points. If a deviation in scale reading of more than 0.8 to 1.2 is found throughout the scale range, then additional steps in calibration must be taken to bring the deviation within the 0.8 to 1.2 tolerance allowed. On leaving the factory, the LCRM-22R is well within the above deviation, and need only be recalibrated for deviation, in the event that replacement of one or both 6005 tubes becomes necessary. These may vary somewhat in characteristics with the originals. This additional calibration is covered in para k, below.

j. Assuming that the 1:1 ratio is within tolerance, set the pulse generator for 50,000 CPM. Remove the test signal from channel 1 only, and rotate channel 1 selector switch to 3600 CPM or "test" position. Again, allow sufficient time for the ratio circuit to come to equilibrium. The ratio should show the actual ratio of channel 2 to channel 1 as indicated on the recorder. For example, if channel 2 shows 40,000 CPM and channel 1 shows 4,000 CPM, then the recorded ratio should indicate 10. The HIGH ratio adjust potentiometer is used to make this adjustment. Since the LOW and HIGH ratio adjustments are interactive to some extent, this procedure should be repeated at least twice to insure correct operation.

k. In the event that one or both 6005 tubes need to be replaced, it is quite possible that the ratio will not remain 1:1 when both channels are fed the same signal from 50 CPM to 50,000 CPM. This action results from the 6005 tube characteristics not being exactly the same. To correct this situation, perform the operations described in para a through i, above. If the ratio tends to increase in going from 50 CPM to 50,000 CPM, then the pulse width of the 5963 discriminator coupled to the 6005 of channel 2 is too wide, and needs to be decreased. If the ratio decreases, then this same pulse width is too narrow, and needs to be increased. The pulse width may be increased or decreased by adjusting a 5,000 ohm potentiometer located on the printed wiring side of the CRM card near each input end. There is one for each channel. Clockwise rotation increases the pulse width and counterclockwise rotation decreases the pulse width. This operation should be performed on only one channel at a time. If the desired effect cannot be made by adjusting channel 2, then the same procedure may be applied to channel 1. However, the pulse width adjustments on channel 1 produce the opposite effect on the ratio of the effects produced by pulse width adjustments made on channel 2.

l. After the pulse width adjustments have been finalized and the ratio stays within the prescribed limits, repeat para a - f and para j, above.

ANNEX C to
HP SOP 2-2

10 June 1974

COLLECTION AND EVALUATION OF ENVIRONMENTAL MONITORING SAMPLES

1. Purpose. The purpose of this ANNEX is to describe the methods used in collecting, handling, and evaluating environmental monitoring samples relative to operation of the DORF reactor facility.

2. Responsibility. The Chief, R/A Lab, will insure that the requirements of the WRAMC ENRADMON Plan are met with regard to proper collection, handling, and evaluation of environmental monitoring samples.

3. Location of Fallout-washout Collecting Stations:

Station #	Location
1	Forest Glen - Two meters outside DORF fence on the South side.
2	Forest Glen - 50 meters from DORF on the left side of the DORF access road.
3	Forest Glen - 25 meters North of the Northwest corner of Bldg 119.
4	Forest Glen - East front of Bldg 188 near Linden Lane.
5	Main Post - Roof of Out-patient Bldg, Southwest corner.

4. Collection Frequency. Twice monthly, with a period between successive collections of at least 13 days, but not more than 18 days.

5. Preparation of Collector. One liter of tap water is added to a plastic pan (12"x8"x4") for the purpose of providing a collecting surface. (NOTE: During the months when freezing weather is anticipated, a mixture of 1 part permanent antifreeze to 2 parts tap water will be used.) The pans are assembled by the HP vehicle operator in Bldg 188, covered, and placed in the carrier provided for that purpose.

6. Collection. The sample carrier is loaded onto the Health Physics truck and the newly-prepared sample collectors are set out by the driver as replacements for those in place. The samples being returned to the R/A Lab for evaluation will be poured into a plastic bag which is sealed and placed in the pan from which the sample was poured.

7. Sample Evaluation.

a. The sample will be allowed to decay and come to ambient temperature for at least one day prior to analysis.

b. A one (1) liter sample of deionized water is placed in a plastic bag in a sample collector pan. The pan is then placed into the pan positioner and a 10-minute integral gamma count is made to establish the background.

c. Each sample is counted for 10 minutes in the same geometry as that used in para b, above, and an X-Y plot is prepared for the sample which has the highest activity.

d. All samples with a gamma activity in excess of 600 dpm (referenced to 137-Cesium) will be retained for detailed analysis, and will be reported to the Chief, NL&TS Br, HPO, WRAMC.

e. 600 dpm is based upon the current definition of radioactive contamination levels (100 dpm/100 cm^2). The effective collecting area of the plastic pan is 600 cm^2, so

$$\frac{100 \text{ dpm}}{100 \text{ cm}^2} \quad \frac{600 \text{ dpm}}{600 \text{ cm}^2}$$

8. Records and Reports.

a. All records will be maintained in the R/A Lab on WRAMC Form 708, to which appropriate X-Y plots will be affixed.

b. All environmental monitoring records will be maintained as permanent records in accordance with AR 340-18-6 and the current WRAMC Form 110.

c. The Chief, R/A Lab, will report all non-routine analyses to the Chief, NL&TS Br, for necessary action and/or information.

d. Non-routine samples are those fallout samples with an integral gamma activity in excess of 600 dpm or any sample in which fission products are suspected to be present.

HEALTH PHYSICS
WALTER REED ARMY MEDICAL CENTER
Washington, D. C. 20012

MEMO
*Number 14

10 June 1974

GAS CHROMATOGRAPH OPERATING PROCEDURES

1. Purpose. To outline routine and emergency operating procedures for use with chromatography detectors equipped with radioactive sources.

2. Scope. This SOP applies to all persons occupying the area designated for use of gas chromatograph detectors.

3. Responsibilities.

a. The Gas Chromatograph detector shall be used only by, or under the supervision of the Principal User. The Principal User is responsible for:

(1) Control, safe operation, and security of the Gas Chromatograph Unit.

(2) Training selected individuals in its safe use and operation in accordance with the procedures outlined herein.

(3) Insuring that WRAMC Regulation 40-10 and other pertinent documents are available at all times and are complied with.

(4) Promptly reporting any accident that could result in an unsafe condition to the WRAMC Health Physics Officer (Ext. 5107).

b. WRAMC Health Physics is responsible for:

(1) Conducting routine radiation protection surveys, periodic inspections and leak tests.

(2) Providing personnel dosimetry for all personnel as needed.

(3) Providing routine bioassay studies as needed.

(4) Instructing operating personnel in the Health Physics aspects of gas chromatography.

c. Individual Operators are responsible for:

(1) Operating the unit in a safe manner at all times.

(2) Being familiar with the contents of these instructions, WRAMC Regulation 40-10, and other data as prescribed by the Principal User.

*This MEMO supersedes MEMO 14, dated 12 May 1971.

(3) Reporting all accidents or abnormal operating conditions that could result in an unsafe condition or exposure of personnel promptly to the Principal User.

4. Emergency Procedures.

a. In the event of an emergency, the following individuals will be notified after turning the power to the instrument off.

(1) The Principal User.

(2) Health Physics Officer, WRAMC (Ext. 5107).

(3) Charge of Quarters of appropriate building.

b. In the event of FIRE in the room the following will be done immediately:

(1) Notify the WRAMC Fire Department (Main Section-3317, F.G.S.-5317).

(2) Notify the Principal User.

(3) Notify the Health Physics Officer, WRAMC (Ext. 5107).

(4) Notify Charge of Quarters of appropriate building.

(5) The senior individual at the site should clear the area of personnel and attempt to turn off the power to the instrument.

c. Power Failure. In the event of a power failure no danger exists.

5. Gas Chromatograph Detectors. Some of the detectors presently used at WRAMC employ the use of a radioactive source as a supply of electrons to effect the detection of gasses according to their molecular weights and holdup times.

a. Tritium Foil. Tritium is usually bound to a copper or stainless steel foil as titanium tritide. The binding agent may begin to break down and allow liberation of tritium at temperatures as low as 150°C (See Addendum 1). The Gas Chromatograph units should have a built in thermocouple to shut the unit off at 220°C since the tritium would probably be entirely evolved at this temperature.

(1) Vented Detectors. Some of the detectors are equipped with exit ports for venting potentially contaminated gases. These detectors while in use shall be vented to a sink under running water or into an operating Health Physics approved fume hood.

MEDEC-HPO
MEMO
Number 14

(2) Non-vented Detectors. These detectors have no provision for control of potentially contaminated exhaust gases and should be used in an operating, Health Physics approved, fume hood. The gases in these detectors are forced through a rubber leak seal at the end of the cylinder. These detector cylinder caps become highly contaminated on the inside surface and shall not be displaced from their cylinders without Health Physics inspection and approval.

b. ^{226}Ra, ^{210}Pb, ^{90}Sr, and ^{63}Ni containing detectors. Temperatures below 500°C are not sufficient to break down the binding of these metallic isotopes to the detector foils. Therefore moderately high temperatures are not a consideration in their operation. These sources may, however, be partially exposed when dismantling the detector unit; accordingly detector units shall not be dismantled without Health Physics approval.

Claude M. Wiblin

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