

Radiation Health Protection Manual



This edition supersedes the August 2001 edition.

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**RADIATION HEALTH PROTECTION MANUAL
NAVMED P-5055 (FEB 2011)**

Reviewed and approved 3 Feb 11
(Date)

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1-1. Purpose

1. This manual provides the radiation health requirements applicable to Navy and Marine Corps Radiation Protection Programs. A radiation protection program is the sum of all methods, plans, and procedures used to protect human health and the environment from exposure to sources of ionizing radiation. It includes the Radiation Health Program and Radiological Controls Program. The purpose of the Radiation Health Protection Program is to preserve and maintain the health of personnel while they accomplish necessary and purposeful work in or around areas contaminated with radioactive material, or in areas where they are exposed to ionizing radiation.

2. The interpretation of this manual requires knowledge of radiation biology and radiation safety to insure proper implementation of the content herein. Bureau of Medicine and Surgery (BUMED) Undersea Medicine is the final authority on the standards.

1-2. Scope

1. These regulations apply to all Navy and Marine Corps activities possessing or using sources of ionizing radiation which may affect the health of personnel.

2. These standards do not apply to the exposure of an individual to ionizing radiation when used for the diagnosis or treatment of medical or dental conditions of that individual. Personnel not employed by the Department of the Navy shall comply with these regulations when engaged in a Navy-sponsored program or operation.

3. It is recognized that these regulations may not be applicable to procedures initiated after an accident, incident, or attack in which a radiological or nuclear device is utilized; however, the provisions of these regulations, insofar as they are feasible, shall remain in effect after such an attack.

1-3. Policy

1. Exposure to personnel from ionizing radiation shall be reduced to levels as low as reasonably achievable (ALARA). Efforts will be made to fulfill this objective without compromising operational and training efforts.

2. Personnel engaged in work in which they may be exposed to ionizing radiation shall be trained in radiological controls and radiation safety practices and protective measures.

3. Supervisors of personnel working with radioactive materials or devices that produce ionizing radiation shall be aware of their responsibilities regarding the execution of safety and protective measures.

4. Proper protective equipment, and training in its use, shall be available to and utilized by all occupationally exposed personnel.

1-4. Responsibilities

1. **General.** Federal regulations for radiation protection are issued by the Nuclear Regulatory Commission (NRC), Department of Health and Human Services, Department of Labor, Department of Transportation, and the Environmental Protection Agency. Instructions, manuals, and work procedures are issued by the Department of Defense, Chief of Naval Operations (CNO), Theater and Fleet Commanders, Systems Commanders, Type Commanders, and commanders, commanding officers, and officers in charge.

2. **CNO and the Commandant of the Marine Corps (CMC).** The CNO and CMC shall exercise overall coordination and policy control of the radiation protection programs under their cognizance in the fields of organization, equipment, safety, personnel qualifications, assignments, and training.

3. **Deputy Chief of Naval Operations, Fleet Readiness & Logistics (N4).** The Deputy CNO (Fleet Readiness & Logistics) is responsible for:

a. Maintaining a NRC Specific License of Broad Scope (License) for NRC regulated sources utilized by the Navy and Marine Corps.

b. Chairing the Naval Radiation Safety Committee to issue Radioactive Material Permits to individual commands and activities for the use and possession of NRC regulated sources.

c. Enforcing compliance with NRC regulations relative to the use of NRC sources and management of the License.

4. **Chief, BUMED.** BUMED is responsible for approving and issuing requirements for the Radiation Health Protection Program applicable to all Navy and Marine Corps activities, and for management of the Medical Department's Radiation Health Program. BUMED is specifically responsible for:

- a. Defining the radiation medical exam surveillance standards.
- b. Applying established radiation protection standards and guidelines.
- c. Investigating physiological effects of radiation.
- d. Conducting radiation medical examinations and providing treatment of radiation casualties.
- e. Approving personnel dosimetry programs.
- f. Establishing training programs and qualification standards for Medical Department personnel involved in radiation health programs.
- g. Reviewing and approving radiation health programs.
- h. Conducting annual audits of the Naval Dosimetry Center's (NDC) dosimeter programs.

5. **Commander, Naval Sea Systems Command (NAVSEASYS-COM).** NAVSEASYS-COM is responsible for:

- a. Coordinating Systems Command functions related to the radiological controls programs in the areas of industrial (Radiological Affairs Support Program) and weapons (Nuclear Weapons Radiological Controls Program) applications.
- b. Developing procedures and providing technical support and training in the area of radiation safety as assigned in NAVSEAINST 5100.18 series.
- c. Developing and procuring instruments and systems, i.e., any equipment used to detect or measure ionizing radiation and specialized equipment used for test/calibration of Radiation Detection, Indication, and Computations (RADIAC) equipment. Equipment for nuclear reactor control and instrumentation is not included.
- d. Establishing procedures for possession, use, and disposal of radioactive material other than medical isotopes, weapons, and naval nuclear reactors and associated equipment.
- e. Managing the Navy Low Level Radioactive Waste Program. (See Chapter 7.)

6. **Director, Naval Nuclear Propulsion Program (NNPP).** The Director, Naval Nuclear Propulsion Program, per Presidential Executive Order 12344 and Public Laws 98-525 and 106-65 is responsible for:

- a. Control of radiation and radioactivity associated with Naval Nuclear Propulsion activities.
- b. Prescribing and enforcing standards and regulations for these areas as they affect the environment and the safety and health of workers, and the general public.

7. **Commanders, Commanding Officers, and Officers in Charge.** Commanders, commanding officers, and officers in charge having jurisdiction over installations and activities using radiation sources shall:

- a. Take such action as deemed necessary to establish uniform practices and procedures by subordinate commanders and to assure compliance with and implementation of Federal Regulations, Department of Defense directives, and Department of the Navy directives.
- b. Conduct periodic inspections to assure compliance with the applicable directives.
- c. For installations and activities using sources licensed by the NRC and permitted by the CNO ensure compliance with provisions of the Command's Naval Radioactive Material Permit and with Title 10, Code of Federal Regulations in the use of these sources.

8. **Commanders, Commanding Officers, and Officers in Charge.** Commanders, commanding officers, and officers in charge of Navy or Marine Corps activities where military and civilian personnel may be exposed to ionizing radiation as a result of their duties shall:

- a. Maintain a Radiation Health Protection Program. The Radiation Health Protection Program will be administered by the command's Medical Department and shall be supervised by a Radiation Health Officer or his/her assigned equivalent.
- b. Comply with Federal Regulations and Department of the Navy directives to ensure safety in the procurement, control, storage, handling, use, and disposal of radiation sources and radioactive material in the Command's custody. Ensure coordination between the radiation health and radiological controls aspects of the radiation protection program.
- c. Ensure that radiation workers have a radiation medical examination prior to being occupationally exposed to ionizing radiation, as required by Chapter 2 of this manual. If it is known that a visitor is to perform duties which require a radiation medical examination, ensure the individual is medically qualified for occupational exposure to ionizing radiation per the requirements of this manual.

d. Ensure that measures are established for controlling ionizing radiation sources such that the radiation exposure to individuals under his or her command or within his or her jurisdiction is as low as reasonably achievable and no greater than the limits prescribed herein.

(1) Provide and maintain an appropriate radiation monitoring capability to verify personnel do not exceed the prescribed exposure limits. Chapter 4 provides these limits. Chapter 6 describes environmental, area, and personnel monitoring requirements.

(2) Ensure appropriate protective clothing, respiratory protection, and decontamination facilities, as necessary, are provided for personnel handling unsealed radioactive material.

(3) Ensure that areas where radioactive materials are used or stored, radiation areas, high radiation areas, very high radiation areas, airborne radioactivity areas, and contaminated areas are posted per Federal regulations and Navy directives.

e. Ensure that all personnel monitoring results for exposures to ionizing radiation are recorded and reported following the requirements in Chapter 5.

f. Ensure the health record custodian enters all personnel monitoring results for occupational exposures to ionizing radiation in the health records, individual Health Record entries (DD Form 1141 or NAVMED 6470/10 and 6470/11), as well as all supporting records are correct, concise, and in agreement with instructions contained in Chapter 5.

g. Ensure accurate and timely submissions of Situational and Annual Reports to the NDC.

h. Ensure accurate, timely, and complete response to notifications issued by the NDC (official correspondence) or NNPP dosimeter processor of the need to investigate abnormal or unexpected dosimetry results.

i. At activities holding Radioactive Material Permits under the Navy's NRC license, ensure that a copy of the Radioactive Material Permit is maintained together with its amendments, related correspondence, and other records as necessary to meet the conditions of the Permit.

j. Ensure that personnel receive radiation protection training commensurate with their duties and per Federal regulations, Department of the Navy directives, program radiological controls manuals, and this manual.

9. *Naval Dosimetry Center (NDC)*. The Officer in Charge, NDC is responsible for:

a. Providing control of distribution, receipt, and processing for Thermoluminescent Dosimeters (TLD) (the DT-702/PD, DT-648/PD dosimeter, the DT-518/PD accident dosimeter, and LiF extremity dosimeters) and special purpose dosimeters. The NDC shall ensure the above mentioned dosimetric systems meet the appropriate calibration standards and shall maintain equipment, calibration sources, and a staff capable of evaluating the various types of dosimeters.

b. Providing technical assistance when requested on matters regarding personnel dosimetry.

c. Maintaining a repository of radiation exposure history information for Navy and Marine Corps personnel that allows retention and retrieval of reported radiation exposure data.

d. Notifying appropriate authorities of irregularities in exposure reports or indications of an exposure control problem at an activity. These actions include maintaining a tracking system to monitor the TLD exchange process.

e. Preparing summary reports of the exposure of Navy and Marine Corps personnel.

f. Tracking and reporting on participating command compliance with dosimeter receipt and utilization procedures and return shipping requirements listed in this manual. The NDC will notify Immediate Superior in Command (ISIC) commanders, and BUMED, of non-compliance upon its discovery.

g. Research, develop, and deploy dose algorithms in support of personnel dosimetry for the U.S. Navy and Marine Corps.

h. Conduct state of the art research in the development of new dosimetric devices for potential use by the U.S. Navy and Marine Corps.

i. Providing technical support and services in support of the DT-702/PD dosimetry program in the NNPP. Specifically, assisting in the set up of new reader systems, provide the dose algorithm for DT-702/PD processing, providing necessary documentation to support accreditation through the National Voluntary Laboratory Accreditation Program (NVLAP), calibrating dosimeters, assisting with resolution of processing problems related to NDC-provided services and software, and performing other functions as appropriate and agreed to by BUMED Undersea Medicine/Radiation Health and Naval Reactors.

10. **NNPP Dosimetry Providers.** The commander, commanding officer, officer in charge, or cognizant authority of the dosimetry providers is responsible for:

a. Providing control of distribution, receipt, and processing for TLDs (the DT-702/PD) and special purpose dosimeters. The provider shall ensure the above mentioned dosimetric systems meet appropriate calibration standards and shall maintain equipment, calibration sources, and a staff capable of evaluating the various types of dosimeters.

b. Providing technical assistance when requested on matters regarding personnel dosimetry. Consult with NDC on dosimetry issues related to BUMED, Radiological Affairs Support Program (RASP), and nuclear weapons personnel.

c. Notifying appropriate authorities of irregularities in exposure reports or indications of an exposure control problem at an activity. These actions include maintaining a tracking system to monitor TLD exchange process.

d. Processing TLDs for BUMED, RASP, and nuclear weapons workers on nuclear-powered ships and nuclear maintenance facilities following agreements with BUMED and NAVSEA-04.

11. **Individual.** Individuals assigned to duties as radiation workers are responsible for:

a. Reporting the following to their supervisor or medical department personnel in a timely manner:

(1) Any physical condition which they feel affects their qualification to receive occupational radiation exposure.

(2) Any radiation therapy treatment received.

(3) Any radiopharmaceutical received for diagnosis or treatment.

(4) Any occupational radiation exposure received from secondary or temporary employment.

(5) Any open wounds or lesions.

(6) Any personal history or diagnosis of cancer or neoplasia.

b. Wearing a personnel monitoring device at all times in any area where monitoring is required. The individual is responsible for loss or misuse of a dosimeter.

c. Knowing their current issue cycle and annual Total Effective Dose Equivalent. This information may be obtained from the Health Record Custodian or Radiation Health/Safety Officer.

1-5. Definitions

1. **Absorbed Dose.** The energy imparted by ionizing radiation per unit mass of irradiated material. The unit of absorbed dose is the rad.

2. **Activity.** The rate of disintegration (transformation) or decay of radioactive material. The unit of activity is the curie.

3. **Adult.** An adult is an individual 18 years of age or older.

4. **Airborne Radioactivity Area.** A room, enclosure or area in which airborne radioactive materials exist in concentrations in excess of the derived air concentrations (DACs) specified in Table I, Column 3 of Appendix B, Title 10, Part 20 of the Code of Federal Regulations, or concentrations such that an individual present in the area without respiratory protective equipment could exceed, during the hours the individual is present in a week, an intake of 0.6 percent of the annual limit on intake.

5. **Annual Limit on Intake (ALI).** The ALI for radioactive materials is the smaller amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year (40 hours per week for 50 weeks) that would result in: a committed effective dose equivalent of 5 rem (0.05 Sv) or a committed dose equivalent of 50 rem (0.5 Sv) to any individual organ or tissue. The ALI values are based on the intake rate and standards for "reference man" as defined in International Commission on Radiological Protection Report No. 23, 1975.

6. **Background Radiation.** Background radiation is radiation from cosmic sources; naturally occurring radioactive materials on the earth's surface including radon in concentrations or levels commonly found in structures or the environment; and global fallout as it commonly exists in the environment from the testing of nuclear explosive devices. Background radiation does not include radiation from source, byproduct, or special nuclear materials regulated by the NRC.

7. **Bioassay.** Synonymous with radiobioassay - see definition for radiobioassay.

8. **Calendar Quarter.** A calendar quarter is a period of time not less than 12 consecutive weeks nor more than 14 consecutive weeks. The first calendar quarter shall begin in January or begin with the dosimetry issue cycle closest to January. Subsequent calendar quarters shall begin within 12 to 14 weeks of that date so that no day is included in both quarters or omitted from either quarter.

9. **Cancer and other related terms.** (Definitions from the National Cancer Institute Web site at: <http://www.cancer.gov/dictionary>).

a. **Cancer.** A term for diseases in which abnormal cells divide without control and aggressively migrate or are transported to other organs in the host.

b. **Benign.** Not cancerous. Benign tumors may grow larger but do not spread to other parts of the body. They can cause damage and/or death for the host.

c. **Hyperplasia.** An abnormal increase in the number of cells in an organ or tissue.

d. **Malignant.** Cancerous. Malignant tumors can invade and destroy nearby tissue and spread to other parts of the body.

e. **Neoplasia.** Abnormal and uncontrolled cell growth that alters normal functions of host tissue, physiology, or function. A neoplasm may be benign or malignant (cancer).

f. **Tumor.** An abnormal mass of tissue that results when cells divide more than they should or do not die when they should. Tumors may be benign (not cancerous), or malignant (cancerous). Also called neoplasm.

10. **Committed Dose Equivalent ($H_{T,50}$).** The dose equivalent to an organ or tissue that will be received from an intake of radioactive material by an individual during the 50-year period following the intake, (i.e., total organ dose for 50 years from internal contamination).

11. **Committed Effective Dose Equivalent ($H_{E,50}$).** The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues. ($H_{E,50} = \sum w_T H_{T,50}$; see weighting factor table for w_T values).

12. **Controlled Area.** Controlled area is an area outside of a restricted area but inside the site boundary, access to which can be limited by the activity for any reason.

13. **Curie (Ci).** The unit of radioactivity. One curie equals 3.7×10^{10} nuclear disintegrations per second. (1 Ci = 3.7×10^{10} Becquerel).

14. **Declared Pregnant Woman.** A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception. The declaration remains in effect until the declared pregnant woman withdraws the declaration in writing or is no longer pregnant.

15. **Deep Dose Equivalent (H_d).** Applies to external whole-body exposure; the dose equivalent at a tissue depth of 1 cm (1000 mg/cm^2); establishes a standard depth for specifying the dose from whole body external exposure.

16. **DAC.** The concentration of a given radionuclide in air which, if breathed for a working year (40 hours per week for 50 weeks) under conditions of light work (inhalation rate 1.2 cubic meters of air per hour), results in an intake of one ALI.

17. **Direct Radiobioassay.** Synonymous with in vivo radiobioassay. See radiobioassay.

18. **Dose.** A generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent or total effective dose equivalent.

19. **Dose Equivalent (H_T).** The product of the absorbed dose (D) and the quality factor (Q), where $H_T = DQ$. Its purpose is to have a single unit, regardless of the type of radiation, describing the radiation effect on man. The dose equivalent has the unit "rem". The dose equivalent for each type and energy of ionizing radiation shall be determined by using the following quality factors or neutron fluences unless otherwise approved by BUMED.

- a. For x-ray, gamma or beta radiation, the quality factor will be equal to one.
- b. For neutrons of unknown energy and for protons, the quality factor will be equal to 10.
- c. For neutron fluences with known energy distributions, the dose equivalent will be determined using the table of Neutron Fluence per Unit Dose Equivalents in Title 10, Part 20 of the Code of Federal Regulations.
- d. For ionizing particles heavier than protons and with sufficient energy to reach the lens of the eye, the quality factor will be equal to 20.

20. **Effective Dose Equivalent (H_E).** The probability of a stochastic effect, e.g., cancer induction or heredity effect, in any tissue is proportional to the dose equivalent to that tissue. The value for the proportionality factors differs among the various tissues because of the differences in tissue sensitivity. If radiation dose is uniform throughout the body then the total risk factor is one. For non-uniform radiation, such as partial body exposure to an external radiation field, or from internal exposure where the isotope concentrates to different degrees in the various tissues, weighting factors which are based on the relative susceptibility of the tissues to stochastic effects may be used to calculate an effective dose equivalent. The effective dose equivalent is the sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the dose equivalent to these organs or tissues. ($H_E = \sum w_T H_T$), see weighting factor table under the definition of weighting factor for w_T values).

21. **Exposure.** Receipt of ionizing radiation, either by proximity to external sources of ionizing radiation or through intake of radioactive material into the body.

22. **External Personnel Contamination.** An area of the body is considered to be externally contaminated if it contains in excess of 450 picocuries of beta-gamma emitters by direct frisk or 50 picocuries of alpha emitters by direct frisk, i.e., 100 counts/minute above background of beta-gamma emitting contamination (Cobalt-60 equivalent) as measured under the area of a DT-304 probe, 8 counts/minute above background of alpha emitting contamination measured on an IM-265/PDQ with DT-681/PDQ alpha probe, or 50 counts/minute above background of alpha emitting contamination as measured on an AN/PDR-56 with small probe. Different limits may be approved by the Naval Radiation Safety Committee for radioactive material used under a Naval Radioactive Materials Permit (NRMP) or by Chief, BUMED for radioactive material not under a NRMP.

23. **Extremities.** Extremities are defined as hand, elbow, and arm below the elbow, foot, knee, or leg below the knee.

24. **Eye Dose Equivalent.** Applies to the external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 cm (300 mg/cm²).

25. **High Radiation Area.** Any radiation area accessible to a major portion of the whole body of personnel in which there exists ionizing radiation at levels such that an individual could receive in excess of 100 mrem (1 mSv) in 1 hour at 30 centimeters (approximately 1 foot) from the radiation source or from any surface that the radiation penetrates.

26. **Indirect Radiobioassay.** Synonymous with in vitro radiobioassay. See radiobioassay.

27. **In Vivo radiobioassay.** See radiobioassay.

28. **In Vitro radiobioassay.** See radiobioassay.

29. **Ionizing Radiation.** Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter. Ionizing radiation includes the following: gamma rays, x-rays, alpha particles, beta particles, neutrons, protons, and other particles and electromagnetic waves capable of producing ions.

30. **Ionizing Radiation Sources.** Any material, equipment, or device which emits or is capable of generating ionizing radiation. This includes naturally occurring and artificially induced radioactive material, special nuclear material, nuclear reactors, particle generators and accelerators, medical or dental x-ray or fluoroscopic equipment, industrial radiographic equipment, certain electromagnetic wave generators, and certain analytical instruments such as x-ray diffraction spectrometers, electron microscopes, nuclear moisture density meters, etc.

31. **Members of the Public.** Individuals who are not occupationally exposed to ionizing radiation shall be considered members of the public. Examples would include individuals who live and work outside the perimeter of a base or activity, family members of an employee or crew member who live on a base but are outside a controlled industrial area, and visitors who do not normally receive occupational exposure.

32. **Minimum Detectable Activity (MDA).** The amount of a radionuclide, if present in a sample, that would be detected with a 5-percent probability of non-detection, while accepting a 5-percent probability of erroneously detecting that radionuclide in an appropriate blank sample. MDA is the minimum amount of radioactivity that can be reliably detected at the 95-percent confidence level.

33. **Non-ionizing Radiation.** Any electromagnetic radiation, including ultraviolet, visible, or infrared light, radio or microwaves, or laser radiation, which generally does not produce ionizations in its interaction with matter.

34. **Non-stochastic Effect.** Non-stochastic effect means health effects for which the severity varies with the dose and for which a threshold normally exists. Radiation-induced cataract formation is an example of a non-stochastic effect.

35. **Non-radiation Workers.** Non-radiation workers are employees or crew members who may receive very low level radiation exposure incidental to their employment at a command or activity but not as an integral part of their skill, trade or work assignment.

36. **Occupationally Exposed Personnel.** Occupationally exposed personnel are individuals who receive exposure to ionizing radiation in the course of their employment or duties. Occupationally exposed personnel include radiation workers and non-radiation workers.

37. **Quality Factor (Q).** That factor which is multiplied by the absorbed dose (D) to obtain a quantity which equates to a common scale, the dose equivalent (H_T), of any type of ionizing radiation to which an individual is exposed ($H_T = DQ$).

38. **Rad.** The unit of absorbed dose (D) which is equal to the absorption of 100 ergs per gram.

39. **RADIAC.** RADIACs are instruments used for the detection and measurement of type, intensity, and exposure rate or dose of radiation.

40. **Radiation Area.** Any area to which access shall be limited as deemed necessary by the cognizant authority and in which appropriate precautionary measures are taken to protect personnel from exposure to radiation or radioactive material. A "radiation area" includes any area accessible to personnel in which there exists ionizing radiation at dose-rate levels such that an individual could receive a deep dose equivalent in excess of 5 mrem (0.05 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

41. **Radiation Health Officer.** A Medical Department officer or civilian who is qualified by virtue of education, training and/or professional experience, to supervise a Radiation Health Program. The officer will normally function within the Medical Department of a ship or station and will not normally be assigned responsibilities in radiological controls/radiation safety except within BUMED activities. On ships without Medical Service Corps or Medical Corps officers attached, the senior enlisted Medical Department Representative assigned radiation health duties shall be designated the Radiation Health Officer. The Radiation Health Officer shall plan, supervise, and administer the Radiation Health Program.

42. **Radiation Health Program.** A Medical Department responsibility comprising all methods and procedures designed to maintain and protect the health of personnel exposed to ionizing radiation or radioactive contamination. It includes, but is not limited to the following:

- a. Detecting and identifying radiation and contamination hazards.
- b. Determining, evaluating, and documenting personnel exposures (both internal and external).
- c. Performing medical qualification and surveillance examinations of radiation workers before, after, and during periods of employment involving occupational radiation exposure.
- d. Evaluating environmental monitoring and radiation control procedures related to radiation health.
- e. Reviewing training and qualification requirements of personnel handling radioactive material, or working in radiation areas, as applicable to radiation health.
- f. Conducting radiation health training for involved personnel as necessary.
- g. Ensuring compliance with BUMED and other relevant instructions in the area of radiation health.
- h. Submitting required reports and maintaining applicable records.
- i. Assisting, as required, in the radiation health aspects of nuclear accident preparedness, Chemical, Biological, and Radiological (CBR) Warfare Defense, and disaster control planning.
- j. Promoting a high state of awareness and compliance with radiation health precepts.

43. **Radiation Workers.** Radiation workers are people who receive exposure to ionizing radiation in the course of their employment or duties, and are identified by their command as being occupationally exposed. Normally, these individuals' routine duties require working directly with sources of ionizing radiation and have a significant potential for exposure. These individuals normally receive radiation medical examinations. These individuals also normally receive specialized training as part of a specific radiological controls program.

44. **Radioactive Contamination.** A radioactive substance dispersed in or on materials or places where it is undesirable. Unless a different limit is approved by the Naval Radiation Safety Committee for radioactive material used under a NRMP, or by the Chief, BUMED for radioactive material not under a NRMP, an object or area is considered to be contaminated when:

a. The loose surface radioactivity exceeds 450 picocuries (450 micromicrocuries or 16.6 becquerel) of beta-gamma activity as measured on a dry filter paper wiped over an area of approximately 100 square centimeters or by frisk.

b. The loose surface radioactivity exceeds 50 picocuries (50 micromicrocuries or 1.85 becquerel) of alpha activity as measured on a dry filter paper wiped over an area of approximately 100 square centimeters or by frisk.

45. **Radiobioassay (or bioassay).** (Definition from American National Standards Institute HPS N13.30-1996 Radiobioassay) Radiobioassay is the measurement of amount or concentration of radionuclide material in the body or in biological material excreted or removed from the body and analyzed for purposes of estimating the quantity of radionuclide in the body.

a. **Direct Radiobioassay** (synonymous with *in vivo* radiobioassay) is the measurement of radioactive material in the human body (such as lung or whole body counts) utilizing instrumentation that detects radiation emitted from the radioactive material in the body.

b. **Indirect Radiobioassay** (synonymous with *in vitro* radiobioassay) is the measurement to determine the presence of or to estimate the amount of radioactive material in the excreta (such as urine or feces) or in other biological materials removed from the body.

46. **Radiological Controls Program.** A command responsibility comprising all procedures and techniques which are used to control radiation sources and radioactive material to minimize exposure to personnel and the environment. It includes control of all ionizing radiation sources during receipt, storage, handling, use, shipping and disposal.

47. **Radiological Controls/Radiation Safety Officer.** An individual who shall be appointed by the unit commander to provide consultation and advice regarding the implementation of controls for the hazards associated with radiation sources and the effectiveness of these measures. The individual shall be responsible to the unit commander for promulgating and

supervising the radiological controls/radiation safety program. The individual is directly responsible for adequate and effective controls which prevent spread of contamination and exposure of personnel. This individual shall be technically qualified by virtue of education, training and/or professional experience to supervise the receipt, storage, issue, use and disposition of radioactive sources and shall have a thorough knowledge of applicable regulations pertaining to the control of radiation sources and radioactive material prior to appointment.

48. **Radiation Effects Advisory Board (REAB).** The REAB is composed of Navy medical experts with extensive scientific and medical knowledge on the effects of ionizing radiation and is BUMED's authority on determining an individual's fitness for work involving exposure to ionizing radiation. (See BUMEDINST 6470.21 series.)

49. **Rem.** The unit of dose equivalent (H_T) which is equal to the absorbed dose in rad multiplied by the quality factor. The rem shall be the unit of dose equivalent for record purposes unless otherwise specified by BUMED.

50. **Restricted Area.** Restricted Area means an area, access to which is limited by the command for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted Areas may not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a Restricted Area.

51. **Roentgen (R).** A unit of exposure to ionizing radiation. It is that amount of x-ray or gamma radiation ≤ 3 MeV which will produce in air 2.58×10^{-4} coulombs of charge per kilogram of air.

52. **Shallow Dose Equivalent (SDE) (H_S).** SDE, which applies to the external exposure of the skin or an extremity, is taken as the dose equivalent at a tissue depth of 0.007 centimeter (7 mg/cm^2) (average depth of the germinal cell layer of the skin) averaged over an area of 10 square centimeters.

53. **Stochastic Effects.** Stochastic effects means health effects that occur randomly and for which the probability of the effect occurring is assumed to be a linear function of dose without threshold. Neoplasia is an example of a stochastic effect.

54. **The System International (SI) of Units.** These units have been established by the International Commission on Radiation Units and Measurements (ICRU) and are used by many countries. As such, they may be encountered in the scientific literature. These units compare to the rem, rad and curie, referred to as "traditional units" in the following manner:

- a. One gray (Gy) = 100 rad
- b. One sievert (Sv) = 100 rem

- c. One becquerel (Bq) = 2.7×10^{-11} curie (Ci) = One disintegration/sec
- d. One rad = One centigray (cGy) = 1×10^{-2} gray (Gy)
- e. One rem = One centisievert (cSv) = 1×10^{-2} sievert (Sv)
- f. One curie = 3.7×10^{10} becquerel (Bq)

55. **Total Effective Dose Equivalent.** The sum of the deep dose equivalent (external dose) and the committed effective dose equivalent (internal dose).

56. **Unrestricted Areas.** Any area to which access is neither limited nor controlled by the activity and any area used for residential quarters.

57. **Very High Radiation Area.** Any area accessible to personnel in which there exists ionizing radiation at such levels that an individual could receive in excess of 500 rads (5 grays) in 1 hour at 1 meter from the radiation source or from any surface that the radiation penetrates.

Note: At very high doses received at high dose rates, units of absorbed dose (e.g., rad and gray) are appropriate, rather than units of dose equivalent (e.g., rem and sievert).

58. **Weighting Factors (w_T).** The weighting factor for an organ or tissue is the proportion of the risk of stochastic effects (random probability effects, e.g., cancer) resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. For calculating the effective dose equivalent, the values are:

Organ or Tissue	Tissue Weighting Factor, w_T
Gonads	0.25
Breast	0.15
Red Bone Marrow	0.12
Lung	0.12
Thyroid	0.03
Bone Surfaces	0.03
Remainder*	0.30
WHOLE BODY	1.00

* 0.30 results from 0.06 for each of the 5 “remainder” organs (excluding the skin and the lens of the eyes) that receive the highest doses. The individual sections of the gastrointestinal tract, i.e., stomach, small intestine, upper large intestine, and lower large intestine, are treated as individual organs.

59. **Whole Body.** Whole body means, for purposes of external exposure, head, trunk (including male gonads), arms above the elbow, and legs above the knee.

1-6. Radiation Health Program Evaluation

1. To ensure compliance with regulations and procedures specified in this manual, evaluations of the Radiation Health Program shall be conducted as follows:

a. For forces afloat and intermediate maintenance activities audited under Type Commander (TYCOM) directives, an audit shall be conducted at least annually by medical department personnel from Group, Squadron, or TYCOMs (e.g., Squadron Medical Officers, Squadron Hospital Corpsmen, Radiation Health Officers, etc.). For nuclear-powered ships, the ship's Executive Officer shall also be a member of the Audit Team. The Executive Officer's participation qualifies this audit as one of the semiannual radiation health audits required by OPNAVINST C9210.2 series.

b. For shore stations, two audits per year (conducted approximately 6 months apart) shall be conducted by personnel knowledgeable in radiation health, with at least one audit conducted by personnel who are as independent as possible of the local Radiation Health Program. For NNPP activities, one of these audits may be performed by the radiological auditing group and the other shall be conducted by the Radiation Health Division.

c. For Naval Shipyards with large Radiation Health Programs, Intermediate Maintenance Activities, Nuclear Naval Training Schools, and the NDC; the BUMED Director of Undersea Medicine and Radiation Health, performs periodic audits. These audits are in addition to the audits required by article 1-6.1b, and shall not be used to replace them.

2. When auditing the medical records during the Radiation Health Program audit, auditors should verify compliance with current Radiation Health Program standards. This includes a review of the radiation medical examination form (NAVMED 6470/13), other pertinent medical documents for findings and evaluations affecting continued qualification as a radiation worker, and individual exposure records (NAVMED 6470/10). The auditors should focus on completeness and clinical accuracy of the radiation medical examination and exposure records. Other findings that are only administrative in nature, such as date and name formatting errors should be identified to the command, but shall not be cited as radiation health record deficiencies.

3. A copy of the audit report shall be retained and be available for review for a period of 3 years.

1-7. Assistance for Audit Requirements. Commands and Medical Department activities requiring technical assistance related to either their radiation health programs or their medical NMRPs, to meet audit requirements, should consult the following resources (in the order presented):

1. The nearest Medical Department activity with a Radiation Health Officer/Radiation Specialist, subspecialty code 1825 or 1828.

2. The Radiation Health Team Leader, Navy and Marine Corps Public Health Center (NMCPHC), commercial (757) 953-0766 or DSN 377-0766.

3. The BUMED Head, Radiation Health Branch, commercial (202) 762-3444 or DSN 762-3444.

1-8. Implementation. Commands and Medical Department activities must fully implement the requirements of this manual within 90 days of its signature. Requests for extension must be submitted in writing to BUMED Head, Undersea Medicine and Radiation Health.

MEDICAL EXAMINATIONS

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2-1. Introduction

1. Occupational radiation exposure criteria are based upon the concept that there may be some degree of risk from any level of radiation exposure, although medical knowledge shows the risk from radiation exposure within limits to be small. No radiation injuries have been scientifically proven to be causally related in man to exposures which were compliant with existing radiation protection guidelines.

2. Radiation workers receive focused medical examinations to establish whether or not cancer is present which would medically disqualify a person from receiving occupational radiation exposure. In determining the scope of the radiation medical examination (RME), the primary determinants were clinical value as well as logistic feasibility. The RME is not intended to replace the routine health screening exams that may be recommended by a worker's primary care provider.

3. The medical standards are based on:

a. Guidelines established by the United States Preventive Services Task Force, American Cancer Society, and early cancer screening methods issued by the National Cancer Institute.

b. Stochastic (without a dose threshold, random) and deterministic radiation health effects.

4. Ionizing RMEs are documented on NAVMED 6470/13, Medical Record - Ionizing Radiation Medical. When performing multi-purpose examinations (i.e., submarine, nuclear field, and ionizing radiation work) the NAVMED 6470/13 is used only for RMEs and is independent

of other examination forms (i.e., DD Form 2807-1, Report of Medical History and DD Form 2808, Report of Medical Exam). The NAVMED 6470/13 is filed together with other examination documents, but not as an addendum. In these cases, the NAVMED 6470/13 should be filed on top of other examination documents.

2-2. Types of Ionizing Radiation Medical Examinations (RMEs)

1. *Preplacement Examination (PE)*

a. The following personnel require a PE:

(1) Individuals being considered for assignment as radiation workers prior to assignment or transfer to those duties.

(2) Individuals who have been radiation workers at one time or another, received a termination examination, and are now being considered for re-entry into the program.

b. The following personnel do not require a PE:

(1) Non-radiation workers and members of the general public.

(2) Visitors including messengers, service personnel, and delivery personnel.

(3) Personnel exposed sporadically such as emergency response personnel; dentists, dental technicians and other dental paraprofessionals; nurses and ward personnel; explosive ordinance disposal (EOD), SEALs, Navy Divers, and Marine Force Recon personnel; and personnel who receive less than 100 millirem of occupational ionizing radiation dose annually unless required by the appropriate radiological controls manuals for specific program requirements.

c. Individuals who are not required to have a PE but who exceed 500 mrem (5 mSv) exposure in a calendar year, must have a PE within one month of the date they exceed 500 mrem (5 mSv) or as soon thereafter as documented operational requirements permit.

2. *Reexamination (RE)*. Personnel who are to continue in routine duties as radiation workers must have an ionizing RME, defined as a RE, as follows: Periodicity between examinations will not exceed 5 years up to age 50. After age 50, periodicity will not exceed every 2 years, e.g., an individual examined at age 46 would be re-examined at 51, an individual examined at age 47, 48, 49, or 50 would be re-examined at age 52. Beginning at age 60 the examination is required annually. The exam may be performed earlier than the required frequency to distribute medical examination workload evenly, or to combine the RE with a

medical exam required for another purpose, or for any other reason. BUMED strongly encourages combining examinations whenever possible. The RE must be performed no later than the end of the month following the anniversary date (month and year) of the previous RME's physical examination date, i.e., for an exam performed on 15 February 2005, the reexamination must be completed by 31 March 2010. When constrained by ship operating schedules, the examination is to be performed at the earliest opportunity.

3. **Situational Examination (SE).** Any individual who has exceeded the radiation protection standards for radiation workers as stated in Chapter 4, or has ingested or inhaled a quantity of radioactive material exceeding 50 percent of an ALI, or whom an attending physician deems necessary must be given an ionizing RME, defined as an SE. ALIs are listed in International Commission on Radiological Protection, Publication Number 30 or in Appendix B of Title 10, Part 20, of the Code of Federal Regulations. ALIs for commonly used isotopes are reprinted for convenience in Appendix B of this manual. The medical history must contain summary statements which provide the basis for performing the examination.

4. **Termination Examination (TE).** Radiation workers will be given a TE as near as practical to, but no earlier than 6 months prior to satisfying one of the following conditions:

- a. Upon separation or termination of their active duty or employment if they received a PE, and have documented occupational radiation exposure (including personnel monitored for exposure but who received 00.000 rem).
- b. When permanently removed from duties as a radiation worker.

If a TE is not completed or not performed, e.g., due to lack of employee cooperation, etc., a NAVMED 6470/13 will be prepared and completed to the maximum extent practicable. The reasons why the form is incomplete will be recorded in the Summary of Abnormal Findings and Recommendations block of the NAVMED 6470/13.

5. **Other Examinations.** Medical examinations in the worker's medical record other than RMEs and results of consultations for individuals physically qualified as radiation workers will be reviewed by a physician or medical department representative for findings or evaluations affecting continued qualification as a radiation worker.

- a. Medical examinations performed outside the Department of Defense should not be requested for routine review. Individuals may submit medical information from their private physicians for consideration by the attending physician for specific criteria required for completion of the NAVMED 6470/13 as well as required information relating to diagnosis, treatment, and continued presence of cancer. In these cases, the Navy remains solely responsible for determining whether the medical information from the private physician will be accepted or rejected.

b. Outside examinations from private health care providers or specialty consultations and outside diagnostic studies required to complete evaluations listed in articles 2-3 and 2-4 must be tracked by the medical department administering the RMEs to ensure completion of the examination. This tracking should start with a face-to-face discussion with the worker concerning the need to complete the evaluation by the private resource within 45 days of the date the RME is started. Failure to comply will result in supervisor and worker notification that the worker may have his or her medical qualification suspended for ionizing radiation work. Medical staff should seek to assist the worker in completing this requirement by providing the worker with a written statement delineating the tests/medical evaluation required. In any case, the period for renewal of radiation worker medical qualification noted in article 2-2, paragraph 2 shall not be exceeded.

2-3. Scope of Examination. The RME will include:

1. **Medical History.** A *focused* medical history will include:

(a) History of accidental or occupational exposure to ionizing radiation above the Table 1 limits.

(b) History of cancer.

(c) History of anemia or Hematuria.

(d) History of radiation therapy.

(e) History of radiopharmaceuticals received for therapeutic purposes.

(f) History of work involving handling of unsealed sources.

(g) Significant illnesses or changes in medical history since the last ionizing RME that might be related to cancer. Positive results of the medical history blocks 3 through 10 shall be documented in the Summary of Abnormal Findings block of the NAVMED 6470/13.

2. **Physical Examination.** The examination will consist of the items described in the Physical Examination blocks of NAVMED 6470/13. *The date of the physical examination shall be the date of the Reviewing Physician's signature in Block 23 of NAVMED 6470/13.* The medical examination will place particular emphasis on determining the existence of cancer. All RMEs shall normally be performed by physicians, nurse practitioners or physician assistants who have received BUMED-approved radiation health training. Examinations performed by a physician assistant or nurse practitioner must be signed by a physician reviewer trained per above. The reviewing physician's signature also satisfies the counter-signature requirement.

3. *Special Studies.* The required documented special studies are:

a. White Blood Count (WBC) and Hematocrit (HCT) within 3 months prior to conduct of the physical examination.

b. Urinalysis. Urine will be tested for red blood cells using either dipstick or microscopic high-powered field within 3 months prior to conduct of the physical examination.

c. Breast examination (manual/clinical breast examination) is required for females age 40 and older. Civilian female workers may have this examination performed by their civilian provider and submit the documentation to the Navy examiner. Civilian female workers may also submit results of mammography examinations for consideration. Female pelvic examination is not required.

d. Digital Rectal Exam (DRE) is required for males age 40 and older. The DRE may be performed by the worker's private physician if so desired by the worker. Documentation of the results of the DRE must be provided if performed by a private physician. The DRE results shall be recorded on the NAVMED 6470/13.

e. In addition, the following special studies may apply:

(1) Occupational intake of radioactive material and assessment of the committed effective dose equivalent or committed dose equivalent shall be performed following Chapter 3 of this manual.

(2) When deemed necessary by the responsible physician, radiation health officer, or radiation health director, a radiobioassay may be performed on body tissues, secretions, and excretions to estimate an exposure from internal contaminants. If a command lacks the capability to perform the appropriate radiobioassay or to perform committed effective dose equivalent or committed dose equivalent calculations, a request for assistance shall be submitted to one of the support facilities designated in Chapter 3.

(3) Additional requirements to perform special exams due to specific work environments can be provided in the applicable program radiological controls manual with Chief, BUMED approval.

f. The periodicities for renewal of radiation worker medical qualification listed in article 2-2, paragraph 2 shall not be extended to accommodate outside physical examinations or special study results. Workers who do not complete outside private testing within the limits of article 2-2, paragraph 5b will be temporarily designated not physically qualified (NPQ), have their dosimeter issue privileges suspended, and where applicable, be placed on the command dosimetry issue not allowed (DINA) (disqualification) list. The worker's dosimeter issue privileges shall be reinstated when the RME is completed and the worker is found physically qualified.

2-4. Standards

1. These standards apply to all occupationally exposed personnel, regardless of classification.

2. Individuals found NPQ based upon these requirements may be reevaluated at a later date. Unless specified, the following will be cause for rejection or disqualification unless the condition is reviewed and the individual found qualified for radiation work by the BUMED REAB (see article 2-8). If a potentially disqualifying condition requiring further evaluation by or reports from a private health care provider or private/government specialist is found during a reexamination, the examining physician shall make a determination as to whether the individual's radiation medical qualification should be suspended pending receipt of the additional information.

a. History of cancer or of cancer therapy. Note: Adequately treated actinic keratosis (AK) or basal cell carcinoma (BCC) is not disqualifying. A medical provider may visually determine if AK has been adequately treated. However, any patient with BCC requiring surgical removal, including shave biopsy and Mohs microscopic surgery, will be considered not physically qualified for radiation work until pathology results of the surgery are obtained. If the pathology report reveals complete excision of the lesion, the BCC is adequately treated and is no longer disqualifying for radiation work. Colon polyps removed during a colonoscopy are not considered disqualifying, but a report from the physician/medical facility performing the colonoscopy is required. If prior treatment for BCC or colon polyps are noted during a reexamination, the individual may remain qualified pending receipt of the pathology report subject to the requirements of article 2-2, paragraph 5b above.

b. History of radiation therapy including radiopharmaceuticals administered for treatment of a disease. Radiopharmaceuticals administered for diagnostic reasons are excluded.

c. History of polycythemia vera.

d. History of leukemia.

e. Workers with open wounds or lesions (including lacerations, abrasions, and ulcerative, eruptive, or exfoliative lesions) that cannot be protected from contamination are subject to temporary disqualification from work in controlled surface contamination areas (CSCA) or handling radioactive material which is not hermetically sealed. Radiation workers with continuous generalized skin lesions noted above are subject to permanent disqualification from work in CSCAs or handling radioactive material which is not hermetically sealed, and require REAB review.

f. Abnormal HCT and WBC

(1) HCT or WBC values that are outside of laboratory normal ranges are considered disqualifying if the repeat HCT or WBC remains abnormal. In each case, the local or attending physician must perform further clinical evaluations to determine the reason for the abnormal HCT or WBC and record this reason. The physician's evaluation of the HCT or WBC and his or her requests for other studies or consultations must be directed toward ruling out cancer and/or bone marrow suppression. The repeat studies will be documented in the Summary of Abnormal Findings block. If a repeat study falls within the laboratory normal range, a comment will be made in the Summary of Abnormal Findings block with an annotation of not considered disqualifying (NCD). If it remains outside the laboratory normal range, the comment will include an annotation of considered disqualifying (CD) if due to cancer and/or bone marrow suppression. If the condition is chronic, has been evaluated during a previous physical examination and determined not to be due to cancer, and laboratory results do not indicate a change in patient status, the condition does not need to be reevaluated.

(2) If cancer or bone marrow suppression is determined, the case shall be submitted to the REAB. Otherwise, the responsible physician can medically qualify the individual for radiation work. The basis for a determination of CD or NCD must be given by the responsible physician as a comment in the Summary of Abnormal Findings block of NAVMED 6470/13.

(3) The laboratory normal values ranges for the HCT, and WBC must be transcribed on the NAVMED 6470/13.

g. Urinalysis. Urine will be tested for red blood cells using either a standard clinical dipstick method or by microscope. The result of the initial test will be written in block 12 of NAVMED 6470/13. The result from the laboratory report shall be transcribed verbatim.

(1) Red blood cells in the urine of 3 or more per high power field require repeat urine microscopy. If the dipstick method is used, a positive dipstick result must be followed by at least 2 microscopic exams to determine if hematuria of 3 or more red blood cells per high power field is present. Document repeat urinalysis results in the Summary of Abnormal Findings block. In each case, the local or attending physician must perform further clinical evaluations to determine the reason for the hematuria (if present) and record this reason. The physician's evaluation of the hematuria and his or her requests for other studies or consultations must be directed toward ruling out cancer. If the repeat study shows fewer than 3 RBCs per high power field, a comment will be made in the Summary of Abnormal Findings block with an annotation of NCD. If the repeat urinalysis shows 3 or more RBCs per high power field, a definitive evaluation by private or government physician will be performed. If definitive evaluation results in a finding of cancer, the Summary of Abnormal Findings comment will include an annotation of CD. If the hematuria is chronic, has been evaluated during a previous physical examination and determined not to be due to cancer, and laboratory results do not indicate a change in patient status, the condition is not disqualifying and does not need to be reevaluated.

(2) If cancer is the suspected cause of the hematuria, the case shall be submitted to the REAB. Otherwise, the responsible physician can medically qualify the individual for radiation work. The basis for a determination of CD or NCD must be given by the responsible physician as a comment in the Summary of Abnormal Findings and Recommendations block of NAVMED 6470/13.

h. If an individual has internally deposited radionuclides associated with an intake of 50 percent of an ALI or more in 1 year, the individual shall be disqualified from duties involving occupational radiation exposure pending REAB review. ALI values for some common isotopes are provided in Appendix B: Annual Limit on Intake.

2-5. Special Documentation Requirements

1. The following specific requirements will be adhered to when completing NAVMED 6470/13. Local reproduction of this form is authorized.

a. NAVMED 6470/13 should be placed at the top of other special duty exams and collected in this position for ready review and audit.

b. RMEs should be performed by physicians, nurse practitioners or physician assistants who have received BUMED approved radiation health training. Examinations performed by a physician assistant or nurse practitioner must be signed by a physician reviewer trained per above. The reviewing physician's signature also satisfies the countersignature requirement.

c. All RMEs must be reviewed to ensure that all components are complete, including special studies and other information to determine qualification. This review requires a credentialed physician's signature, printed name or stamp, and date of review in the reviewing physician block. The reviewing physician may be the same as the examiner, and must have completed BUMED approved radiation health training prior to reviewing radiation health medical examinations for NNPP radiation workers. All reviewing authority signatures need to identify their qualification with the pertinent designation, "UMO" for Undersea Medical Officers, "RAM" for Aerospace Medicine Specialist, and "RHI" for those trained at the Naval Undersea Medical Institute (NUMI) Radiation Health Indoctrination (RHI) course.

d. Any entry in the Summary of Abnormal Findings block of NAVMED 6470/13 concerning an abnormal finding will have an indication of "NCD" or "CD."

e. The examiner and/or the reviewing physician shall discuss the results of the ionizing RME with the examinee. Completion of this discussion shall be documented by the examinee's signature on NAVMED 6470/13.

f. Non-completion of a RME must be documented in the Summary of Abnormal Findings and Recommendation block of NAVMED 6470/13 with specific reasons for non-completion.

g. The physician or examiner will assess whether the individual is physically qualified (PQ) or NPQ for ionizing radiation work, and document the results of this assessment and the basis for CD/NCD findings in the Summary of Abnormal Findings block of NAVMED 6470/13. The basis for a finding of NPQ for ionizing radiation work shall also be documented in the Summary of Abnormal Findings block. If the examiner finds the individual NPQ, review and signature for review of the medical examination shall be performed after receipt of the response from the REAB with the final qualification determination.

h. The requirement for a termination RME will be entered on the front of the individual's health record jacket or employee medical file as "Termination Radiation Medical Examination Required."

2. Results of radiobioassay, internal monitoring, etc., which document monitoring for internally deposited radioactivity, will be documented as required in Chapter 5 of this manual.

3. Consultation reports from specialists for radiation health purposes shall be readily accessible in the patient's medical record for review and audit.

4. No RME report or portion thereof shall be removed from an individual's health record.

2-6. Correction of Deficient Examinations

1. RMEs are considered deficient in scope when clinical evaluations unique to the examinations are missing or incomplete.

a. If the examination is deficient in clinical scope, or found lacking on audit, the appropriate clinical studies and procedures will be performed which satisfy the missing requirements. This information will be added to the deficient examination in the Summary of Abnormal Findings block of the NAVMED 6470/13.

(1) Laboratory studies from previous examinations may be transcribed onto the NAVMED 6470/13 subject to the time limits stated in article 2-3.

(2) Once the examination is sufficient in clinical scope to meet the requirements of a RME, the additional tests or examination elements performed and interval history (e.g., "Member's thyroid exam normal this date, no significant interval history noted since the examination completed on DDMMYYYY. PQ for Ionizing Radiation Work.") will be entered in the notes block of the examination form and signed and dated by the reviewing physician.

(3) The date of the next required RME will be based on the date of the original uncorrected physical examination.

2. Administrative corrections for ionizing RMEs will be made by drawing a single line through the erroneous entry, initialing and dating the change, then adding the correct entry. Corrected entries may also be made in the Summary of Abnormal Findings block of NAVMED 6470/13.

3. Medical examination and health record entries will conform to the standards existing at the time of the examination. Clinically upgrading or administratively correcting an examination to meet current requirements in this manual that were implemented after conduct of the examination is not required.

4. A medical examination previously conducted for another purpose may not be upgraded to an ionizing RME. Laboratory studies from previous examinations may be transcribed onto the NAVMED 6470/13 subject to the time limits stated in article 2-3.

2-7. Radiation Effects Advisory Board (REAB). The REAB determines the effects of ionizing radiation on personnel as an authority established by Chief, BUMED. The Board may be consulted in an official capacity for reference opinions germane to the Department of the Navy (see BUMEDINST 6470.21 series).

2-8. Reporting Requirements for the REAB

1. The following medical examinations and supporting medical documents (see article 2-9) must be submitted to the BUMED, Director of Undersea Medicine and Radiation Health for review by the REAB.

- a. Any finding of cancer.
- b. Findings on a medical history or medical examination of:

(1) History of ionizing radiation exposure in excess of that allowed by article 4-3, paragraph 1a.

(2) History of, or ongoing cancer therapy.

(3) An intake in excess of 50 percent of an ALI of radioactive material not intentionally administered for medical diagnosis or treatment. A description of the analysis technique must be included with the submission.

c. Any medical examination or condition which the responsible physician, commander, commanding officer, or officer in charge recommends for Chief, BUMED review. Such request for review will not be denied by any member of the chain of command.

d. All SEs.

e. Allegations or claim by a Service member or employee that his or her physical condition was caused by exposure to ionizing radiation.

2. The board will perform a review and determine the individual's fitness for radiation work. The REAB letter must include the reason for submittal, total lifetime exposure of the individual, summary of the individual's duties, and if appropriate the current or disqualifying diagnosis. The REAB package should include a completed RME (if the individual is classified as a radiation worker or if a medical examination is required by a section of this manual), any applicable medical consultation results, and any supporting medical documents related to the individual's medical condition.

2-9. Documentation Requirements for the REAB

1. All cases submitted to the BUMED REAB for review must include a summary letter from the referring physician to the REAB outlining the key elements of the medical findings as well as a recommendation for a finding of PQ or NPQ and the basis for the finding. In addition, the package must include the individual's most recent RME and any supporting medical documentation directly related to the medical condition, including pathology reports and special studies results, consultation reports, and evaluations performed by the individual's private physician. Individual workers with medically disqualifying conditions who are not required to complete a RME need not complete a RME for the purpose of the REAB.

2. Cases submitted to the BUMED REAB for re-evaluation of an individual previously found NPQ by the BUMED REAB due to a diagnosis of cancer must include a current RME performed subsequent to the individual completing all prescribed treatment. Supporting medical documentation must include conclusions by the treating physician that the individual shows no evidence of residual cancer. A discussion of the medical procedures and pathology reports that support this conclusion should be provided. The treating physician's plan to ensure the worker remains cancer-free should also be provided. Finally, the submitting facility should address how the patient will be tracked to ensure the prescribed plan is followed.

3. The REAB letter from BUMED is to be filed on top of the RME which discovered the potentially disqualifying condition. The conclusion of the REAB letter is to be entered into Block 20a on the NAVMED 6470/13, with the notation of whether REAB found the member PQ or NPQ.

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SUPPORT FACILITIES

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3-3	Assistance with Radiobioassay and Internal Dose Calculations	3-2
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3-1. Introduction. This chapter provides requirements to monitor occupational radiation workers for the intake of radioactive material, and guidance for obtaining assistance with radiobioassay (direct/indirect) measurements and internal dose calculations when needed by an activity that lacks these capabilities. Assistance for the evaluation and treatment of irradiated or contaminated personnel is also discussed. Specific documentation requirements for recording results are contained in article 5-3 of this manual and in program radiological controls manuals. The monitoring requirements of this chapter do not apply to NNPP activities, which will follow the requirements found in the NNPP radiological controls manuals.

3-2. Requirements for Monitoring Internal Intake

1. Consistent with 10 Code of Federal Regulations (CFR) 20.1502, each activity (facility, ship, unit, or command) shall monitor the occupational intake of radioactive material and assess the committed effective dose equivalent, by either radiobioassay (direct or indirect) or by measuring the concentration of radioactive materials in the air inhaled and/or water ingested for:

a. Adults likely to receive, in 1 year, an intake in excess of 10 percent of the applicable ALI(s) as shown in table 1, Columns 1 and 2, of Appendix B to 10 CFR 20.

b. Minors likely to receive, in 1 year, a committed effective dose equivalent in excess of 0.1 rem (1 mSv).

c. Declared pregnant women likely to receive, during the entire pregnancy, a committed effective dose equivalent in excess of 0.1 rem (1 mSv).

d. Any person who potentially inhaled, ingested, absorbed, or injected a measurable quantity of radioactive material as a result of some mishap or incident in which it is likely that some intake of radioactive material occurred.

e. Any person, when deemed necessary by the cognizant medical officer, radiation health office, or radiation health director of an activity (facility, ship, unit, or command).

2. The monitoring of internal intake and evaluation for evidence of a partial body burden shall be performed before the assignment of duties in which internal intake is likely to exceed the levels described above, but not more than 3 months prior to the start date of those duties.

3. Additional or periodic monitoring of internal intake and assessment of the committed effective dose equivalent shall be conducted, as deemed necessary, by the responsible physician, radiation health officer, radiation health director, or applicable program radiological controls manuals with Chief, BUMED concurrence or as conditions of NRMPs.

4. A final monitoring of internal intake and assessment of the committed effective dose equivalent shall be performed at the completion of a tour involving these duties.

5. Internal dose calculations to determine the committed dose equivalent to an organ may be required when the committed dose equivalent to that organ is more limiting than the committed effective dose equivalent (e.g., thyroid monitoring for iodine uptake), or as deemed necessary by the responsible physician, radiation health officer, radiation health director, or applicable program radiological controls manuals with Chief, BUMED concurrence or as conditions of NRMPs.

3-3. Assistance with Radiobioassay and Internal Dose Calculations

1. Naval organizations lacking the capability to perform radiobioassay analyses or internal dose calculations may request assistance from the nearest BUMED-approved naval organization capable of providing these services and subject to that facility's agreement to provide assistance. BUMED approved facilities (organizations) include:

a. Naval Dosimetry Center, 8901 Wisconsin Ave., Bethesda, MD, 20889-5614. DSN 295-0142 or 295-5410 or commercial (301) 295-0142 or (301) 295-5410. The Naval Dosimetry Center's Plain Language Address for message traffic is NAVDOSCENTEN BETHESDA MD. Assistance can also be requested by e-mail at: HELP@NAVDOSCEN.med.navy.mil.

b. Shipyards, tenders, and naval bases which perform radioactive work associated with NNPP.

c. Nuclear-powered surface ships and Naval Reactors prototypes.

d. Naval Nuclear Power School, Goose Creek, SC 29445-6324, DSN 794-8000 or commercial 843-574-8000.

e. Other organizations specifically authorized by BUMED or required as a condition of an NRMP.

2. The request shall include a general description of the event or circumstance which produced the possible internal radioactive deposition, the probable radioisotopes present, the results of previous radiochemical analysis, and any other pertinent information.

3. Upon request, the NDC will supply urine and/or fecal collection kits for indirect (in vitro) radiobioassay evaluation. These kits include everything necessary for the collection and shipment of the samples including instructions, containers, and pre-addressed shipping labels.

3-4. Assistance for Evaluation and Treatment of Irradiated or Contaminated Personnel. Specific guidance for evaluation, monitoring, care, and decontamination of personnel is available in BUMEDINST 6470.10. Advice on the significance of abnormal findings and assistance in the evaluation of personnel suspected of exceeding radiation exposure limits due to external or internal radiation exposure is to be obtained by contacting the BUMED Director of Undersea Medicine and Radiation Health at DSN 762-3444 or commercial (202) 762-3444; after working hours telephone DSN 762-3211 or commercial (202) 762-3211.

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RADIATION PROTECTION STANDARDS

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4-1. Introduction

1. **General.** Every effort shall be made to maintain personnel radiation exposures as far below Navy radiation protection standards as practicable. Current Navy radiation protection standards are consistent with or more stringent than those of the Environmental Protection Agency, NRC and the Occupational Safety and Health Administration.

2. **Scope.** The standards prescribed herein are adopted for the control of ionizing radiation exposure to personnel within the naval establishment during peacetime and noncombatant operations, and do not include radiation exposure of an individual incident to medical or dental diagnostic or therapeutic procedures or to exposure from background radiation. These standards do not apply after an attack in which nuclear weapons are utilized, for combat operations, or during war; however, the provisions of these regulations insofar as they are feasible, shall remain in effect. Specifically, these standards do apply to medical personnel, such as radiologists and radiology technicians, in the performance of their medical duties when deployed to a combat theater. All exceptions to the following standards must be approved by the Chief, BUMED.

4-2. Members of the Public

1. Radioactive material and other sources of radiation shall not be used, maintained, or transferred in such a manner as to cause:

a. The dose in any unrestricted area, from external sources, to exceed 2 mrem (0.02 mSv) in any one hour.

b. An individual member of the public to receive a total effective dose equivalent in excess of 100 mrem (1 mSv) in a calendar year, exclusive of *background radiation*.

2. Exposure limits for members of the public shall continue to apply if the member enters a controlled area.
3. Exposure limits for members of the public apply to unrestricted areas and berthing spaces.
4. It must be locally documented, by measurement, calculation or both, that due to limited occupancy or transient situations:
 - a. The maximum exposed individual's total effective dose equivalent from occupancy in unrestricted areas would not be expected to exceed 100 mrem (1 mSv) per calendar year.
 - b. The annual average concentrations of radioactive material released in gaseous and liquid effluents at the boundary of the unrestricted area do not exceed the values specified in Table 2 of Appendix B to Title 10, Part 20 of the Code of Federal Regulations and, if an individual were continually present in an unrestricted area, the dose from external sources would not exceed 2 mrem (0.02 mSv) in an hour and 50 mrem (0.5 mSv) in a year.

4-3. Occupational Exposures

1. *Radiation Workers*

- a. Radioactive material and/or other sources of radiation shall not be used in such a manner as to cause an adult to receive in excess of the more restrictive of the radiation doses specified in Table I.

Total Effective Dose Equivalent (Whole Body)	3.000 rem/qtr
Total Effective Dose Equivalent (Whole Body)	5.000 rem/year
Shallow Dose Equivalent (Extremities)	50.000 rem/year
Shallow Dose Equivalent (Skin)	50.000 rem/year
Eye Dose Equivalent (Eyes)	15.000 rem/year
Sum of Deep Dose Equivalent and Committed Dose Equivalent for any organ or tissue other than the lens of the eye (Organ Dose)	50.000 rem/year

- b. For radiation workers whose prior or current year exposure is unknown, the annual limits shall be reduced by one-quarter for each quarter of the current year for which records of exposure are unavailable or incomplete. For example, if new employees are hired in June and state that they were exposed at their previous job earlier in the year but records are unavailable,

then the annual exposure limits for the new employees must be reduced by one-quarter for the first and second quarters of the year, i.e., reduced from 5 rem (0.05 Sv) to 2.5 rem (0.025 Sv), from 50 rem (0.5 Sv) to 25 rem (0.25 Sv) for shallow dose, 15 rem (0.15 Sv) to 7.5 rem (0.075 Sv) for eye dose and from 50 rem (0.5 Sv) to 25 rem (0.25 Sv) for the sum of deep dose equivalent and committed dose equivalent for any organ or tissue other than the lens of the eye.

2. **Non-radiation Workers.** Radioactive material and/or other sources of ionizing radiation exposure shall not be used in such a manner as to cause any non-radiation worker to exceed a total effective dose equivalent of 500 mrem (5 mSv) per year considering occupancy factors and source usage. It must be locally documented that due to limited source usage, occupancy or transient situations the individual's total effective dose equivalent is not expected to exceed 500 mrem (5 mSv) per year.

4-4. Embryo/Fetus. Once a woman monitored for occupational exposure notifies her command in writing of her pregnancy and the estimated date of conception, exposure to the embryo/fetus shall not exceed 500 mrem (5 mSv) for the term of the pregnancy and should not exceed 50 mrem (0.5 mSv) per month in any month for the remainder of the pregnancy.

1. The dose to the embryo/fetus shall be taken as the sum of the deep dose equivalent to the declared pregnant woman and the dose to the embryo/fetus from radionuclides in the embryo/fetus and declared pregnant woman.

2. If the dose to the embryo/fetus is found to have exceeded 500 mrem (5 mSv) or is within 50 mrem (0.5 mSv) of this dose by the time the woman declares the pregnancy, the activity shall be deemed to be in compliance with the limit if the additional dose to embryo/fetus does not exceed 50 mrem (0.5 mSv) during the remainder of the pregnancy.

3. Reporting requirements are listed in Section 5.10 of this manual.

4-5. Minors. No individual under 18 years of age shall receive an occupational exposure to ionizing radiation in excess of 10 percent of the annual total effective dose equivalent limit for radiation workers.

4-6. Emergency Exposure

1. In an emergency it may be necessary for emergency workers to exceed occupational dose limits in Table I to save life or valuable property. In such situations, the probable risk of high exposure to the rescuer must be weighed against the expected benefits. In emergency situations:

a. That require personnel to search for and remove injured personnel or that require entry to prevent conditions that would probably injure numbers of people, reasoned judgment is permitted; no upper dose limit is specified. In all cases, exposures should be kept as low as

practicable by using rotation of workers and other standard methods to minimize exposure. Workers used in such activities should be limited to non-pregnant volunteers who are aware of the risks associated with the projected dose.

b. Where it is desirable to enter a hazardous area to protect facilities, eliminate further escape of contamination, or to control fires, the planned total effective dose equivalent should not exceed 10 rem (0.1 Sv). Workers used in such activities should be limited to non-pregnant volunteers.

2. This emergency exposure guidance is consistent with criteria set forth in National Council on Radiation Protection and Measurements Report 116. When an individual has been exposed to more than 3 rem (0.03 Sv) during the calendar quarter, or 5 rem (0.05 Sv) in a calendar year as a result of an emergency, the individual shall be restricted from any additional occupational exposure pending BUMED review, and the individual's dose shall be reported as an overexposure following the requirements of Chapter 5.

4-7. Radiation Protection Guidance for Internal Emitters

1. If radioactive material is inhaled, ingested, or absorbed through the skin, it may be deposited in various organs or systems of the body. It then acts as a radiation source within the body and will continue to irradiate the cells of the body until it has been eliminated by biological processes and/or by radioactive decay. The amount of radioactive material retained in the body is limited by controlling the rate of intake of such material. This is accomplished primarily by limiting the concentration of radioactive materials on surfaces, in the air, and in water within the occupational environment. Risk of internal exposure is reduced by good housekeeping procedures, e.g., cleanliness, containment, protective clothing, and appropriate exhaust ventilation.

2. Intake of an ALI or exposure at the level of the DAC for 40 hours per week for a 50-week year could result in a committed effective dose equivalent of 5 rem (0.05 Sv) or a committed dose equivalent of 50 rem (0.5 Sv) to an organ or tissue, whichever is the more limiting. Appendix B lists ALI and DAC values which will result in an intake equal to an ALI for some of the isotopes used in the Navy. Tables of the ALI and DAC values for other radionuclides are published in Table I of Appendix B, Title 10, Part 20 of the Code of Federal Regulations.

3. Personal protective measures may be accomplished by:

a. *Avoiding Inhalation*

(1) Personnel shall not work in an environment whenever 10 percent of an ALI of radioactivity is likely to be exceeded without some action being taken to minimize the intake. Personnel shall not routinely work (2,000 hours expected) in an environment whenever 10 percent of a DAC is likely to be exceeded without some action being taken to minimize the

intake. Actions may include process or engineering controls, such as containments or ventilation, to minimize the concentration in the air or other controls, such as respirators, access control, limitation of exposure times, etc., to control and minimize the exposure of personnel.

(2) The commander, commanding officer, or officer in charge may authorize work without respiratory protection in environments where 10 percent of a DAC may be exceeded for short periods of time, provided the exposure time during any 7 consecutive days is decreased proportionately from the 40-hour time limit. For example, if work is for 8 hours, the concentration levels may be 5 times 10 percent of the DAC values listed in Appendix B of this manual or Table I of Appendix B, Title 10, Part 20 of the Code of Federal Regulations. Conversely, if a worker works more than 40 hours during any 7 consecutive-day period and the number of hours of exposure is more than 40, the air concentration limits (DACs) shall be lowered proportionately. For example, if work is for 48 hours the air concentration values for work without respiratory protection are 5/6 of 10 percent of those listed in Appendix B or Table I of Appendix B, Title 10, Part 20 of the Code of Federal Regulations.

(3) Personnel may work in an environment where 10 percent of the DAC is expected to be exceeded provided the workers use respiratory equipment and protective clothing as appropriate; or, if the particle size and chemical or physical state of the radionuclide is such that it is unlikely that the workers will exceed 10 percent of an ALI; or, if containments, glove bags, ventilation hoods, or barriers are used such that 10 percent of a DAC in the breathing zone is not likely to be exceeded.

(4) Respiratory protection from inhalation of radioisotopes is not required during decontamination or showering of a contaminated person unless it is expected that the individual or the attendants will exceed 50 percent of an ALI. Resuspension and redistribution factors may be used to calculate levels of activity necessary to pose a risk of exceeding 50 percent of an ALI. (For cobalt 60, approximately 100 mCi would need to be present. This amount would give an external exposure rate of approximately 100 mrem (1 mSv) per hour at one meter from the contaminated person.)

b. *Avoiding ingestion.* No edible material of any kind including chewing gum, candy, food, and beverages, or tobacco products shall be allowed in a contaminated area or stored in an area containing liquid or unsealed radioactive sources. Surface contamination levels will be minimized to preclude hand to mouth transfer of activity. Upon leaving a contaminated area, personnel should not be permitted to handle edible materials until they have been carefully monitored and decontaminated if necessary.

c. *Avoiding absorption.* Personnel should be provided, trained in the use of, and required to wear appropriate protective clothing in a contaminated area. Work surfaces (bench tops) where liquid radioactive material is used should be covered with absorbent paper or other material to minimize the potential for hand contact with any spilled liquid.

4. If an individual receives an internal deposition or uptake of radionuclides determined by internal monitoring or radiobioassay as a result of his duties (occupational exposure), the committed effective dose equivalent will be calculated by a BUMED-approved facility. (See Chapters 3 and 5.)

4-8. Radiation Protection Guidance for External Exposure. When the source of ionizing radiation is located outside the body, the following methods of control are applicable:

1. **Time.** Reducing the working time in a radiation field is the simplest way to limit exposure. Since the amount of radiation exposure received is equal to the dose rate multiplied by time of exposure, decreasing exposure time results in a proportional decrease in total exposure.

2. **Distance.** Radiation intensity varies inversely as the square of the distance from a point source (i.e., a source concentrated in a small volume). Therefore, if a worker doubles the distance between self and the source, the exposure is reduced to one-fourth; increasing the distance threefold reduces the exposure to one-ninth. Remote handling devices use this principle to reduce exposure.

3. **Shielding.** Shielding materials absorb a part or all of the energy of the various types of radiation. Interposing a shield between the individual and the radiation source reduces the amount of radiation exposure.

4. **Radioactive Decay.** All radioactive materials decay exponentially at a fixed time rate. The time required for a radioactive substance to decrease to one-half its original activity is called the half-life of that particular substance. Thus, allowing the radioactive material to decay for a period of time will reduce the amount of exposure received when the material is handled.

EXPOSURE RECORDS

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5-1. Introduction

1. All personnel monitoring for occupational exposure to ionizing radiation must be documented to establish individual radiation exposure histories. These histories have medical, epidemiological, and legal significance since they record the amounts of exposure as well as dates and locations at which exposures were received. Additionally, they serve as evidence that occupational exposure limits were or were not exceeded. This chapter contains the recording and reporting procedures the Chief, BUMED considers necessary and adequate for radiation exposure documentation. Reporting requirements contained herein have been approved by the CNO.

2. Monitored exposure to ionizing radiation is normally recorded on NAVMED 6470/10, Record of Occupational Exposure to Ionizing Radiation and NAVMED 6470/11, Record of Occupational Exposure to Ionizing Radiation from Internally Deposited Radionuclides. The predecessor to these forms was the DD Form 1141, Record of Occupational Exposure to Ionizing Radiation. NAVMED 6470/10, NAVMED 6470/11, and DD Form 1141 are to be filed and maintained in the health record.

3. For activities holding NRMPs, the NAVMED 6470/10 and NAVMED 6470/11 shall be used in lieu of NRC Form 4, Occupational External Radiation History and NRC Form 5, Current Occupational External Radiation Exposure.

5-2. Computerized Exposure Record Systems

1. **Computerized Exposure Record Systems.** Computerized exposure record systems are required. Request for exceptions to this requirement will be forwarded to the BUMED Head of the Ionizing Radiation Branch. Computer programs other than those provided by the Naval Dosimetry Center, for the automation of exposure reports, may be used if approved by Chief, BUMED. The NNPP Automated Radiological Controls Management Information System (ARCMIS) and the Shipboard Non-tactical ADP Program (SNAP) Automated Medical System (SAMS) are approved programs. Radiation Health Assistant (RHA) is no longer supported.

a. Personnel exposure information will be entered in the computerized database at least once a quarter.

b. The computer generated NAVMED 6470/10 and NAVMED 6470/11 printouts are to be verified and filed at least annually in the individual's medical record.

c. A back-up copy (separate disk, CD ROM, or magnetic tape) of the exposure information database must be made at least quarterly and retained for two quarters. If computer backups are made more frequently, at least two recent backups should be retained. For example, if backups are made daily, the last 2 days must be kept. If backups are made weekly, the last 2 weeks must be kept.

d. Requests for exceptions to the requirement to maintain computerized exposure record systems will be forwarded to Head of the Ionizing Radiation Branch, Bureau of Medicine and Surgery, explaining the reason why records must be maintained manually.

2. **Navy Automated Radiation Exposure Registry (NARER).** The NARER was established in 1947 by Deputy Chief of Naval Operations to provide a centralized location for the records of U.S. Navy personnel exposures to ionizing radiation. Today it also meets the requirements set forth by the NRC for those activities associated with the Navy's Master Materials License. NDC develops and maintains the NARER and ensures all reports forwarded

by commands are incorporated into the database system. The NARER is dependent on customer commands to provide exposures in compliance with current instructions and regulations. However, the official record for exposure to ionizing radiation remains in the individual's official medical record.

5-3. NAVMED 6470/10, Record of Occupational Exposure to Ionizing Radiation

1. **General.** The custodian of the individual's medical record is responsible for maintaining a NAVMED 6470/10 in the individual's medical record.

2. **Initial Determination.** For the initial preparation of NAVMED 6470/10 a reasonable effort should be made to obtain complete reports of all previous exposures based upon recorded personnel dosimetry. This shall be accomplished by individual interview, and correspondence with previous commands and employers. If, after reasonable effort has been expended and further information is needed, a formal request via command letterhead, naval message, or online request should be forwarded to NDC to provide the individual's Navy exposure for a period of interest or the individual's entire history. The request shall contain the individual's complete name, any alias, individual's social security number (SSN), service number (SN) (if different than SSN), date of birth, and command history.

a. For each period in which the individual was monitored for occupational exposure to ionizing radiation and no record or an incomplete record of the exposure during the period can be obtained, an entry will be made indicating exposure data was incomplete or not available. An estimate of prior lifetime total effective dose equivalent may be made based on partial records, exposure of others performing similar work, and statements from the individual. If an estimate is made, the basis for the estimate will be explained in the remarks section.

b. When an individual was previously exposed at more than one facility, the exposure from each facility shall be recorded separately in columns 5 through 14 of the NAVMED 6470/10, as appropriate.

c. If an individual has been occupationally exposed at any activity possessing a NRC license, and his or her exposures have been recorded on NRC-4 and NRC-5 forms, the cumulative exposure obtained from those forms shall be recorded on the NAVMED 6470/10 in items 5 through 14, as appropriate, and a statement regarding the source of that information shall be entered in the Remarks section of the NAVMED 6470/10.

d. If during generation of the initial record the command notes a discrepancy in the individual's Navy exposure history, the command shall forward a copy of exposure records found in the individual's official medical record or other applicable exposure records to the NDC, which will enable NDC to correct any discrepancy between individual's medical record and the NARER records.

3. **Current Record.** Appropriate entries on each individual's NAVMED 6470/10 or an update of the individual's computerized exposure database which can generate this form shall be made at least quarterly or within 30 days post-deployment for those personnel monitored for exposure.

a. Entries on the NAVMED 6470/10 are to be completed following the guidance provided below and the instructions on the back of the form. The method of monitoring is presumed to be by TLD after 1 October 1989 and no entry explaining the type of dosimeter is required in the Remarks section unless the method of monitoring is not a TLD.

b. All previous copies of NAVMED 6470/10 and DD Form 1141, Record of Occupational Exposure to Ionizing Radiation, filed in the individual's medical record shall be retained in the individual's medical records.

c. The instructions for the NAVMED 6470/10, items 7 and 8 require entering the period of exposure (beginning and end). Items 9 through 13 require entering the radiation dose received for the period of exposure. For TLDs used by forces afloat, the period of exposure and the radiation dose for the period entered on the NAVMED 6470/10 shall be the same as the issue period (beginning and end). Multiple entries on the NAVMED 6470/10, to document periods of leave etc., which occur routinely during any given issue period/period of exposure are not necessary.

d. Personnel exposure data shall be obtained and properly recorded on the NAVMED 6470/10. Entries should identify the dates of the exposure and either the installation where the individual is permanently assigned or if exposed while on temporary duty assignment, the activity where the exposure was received. Use of hull numbers for identification is considered appropriate for afloat commands.

e. When an individual is monitored for exposure to ionizing radiation at a naval installation or activity other than where his medical records are maintained, the commander, commanding officer, or officer in charge of that installation or activity shall ensure that the occupational dose information is furnished to the custodian of the individual's medical record. This occupational dose information shall be forwarded to the health record custodian at least quarterly or within 30 days of receipt of final personnel occupational dose information.

f. Exposures received by visiting or temporary duty personnel whose occupational doses are not reported annually by their parent activities, shall be submitted to the Naval Dosimetry Center, Navy Environmental Health Center Detachment, 8901 Wisconsin Avenue, Bethesda, MD 20889-5614 on a Situational Report, NAVMED 6470/1, Exposure to Ionizing Radiation, by the command where the exposure occurred within 30 days of receipt of the individual's final dose information.

g. When an individual is monitored for exposure to ionizing radiation at an installation outside the jurisdiction of the Department of the Navy, the individual shall ensure that the occupational dose data is furnished to the custodian of his medical record for entry on the NAVMED 6470/10, and submission on a NAVMED 6470/1, Annual or Situational Report.

h. Annual verification of the lifetime total effective dose equivalent (column 14 of the NAVMED 6470/10) is required if the entries are prepared manually. If the NAVMED 6470/10 is generated using an approved computer program, annual verification of the total effective dose equivalent is not required.

5-4. NAVMED 6470/11, Record of Occupational Exposure to Ionizing Radiation from Internally Deposited Radionuclides

1. Results of all internal monitoring including baseline measurements shall be recorded on a NAVMED 6470/11 and the results reported in the committed effective dose equivalent column of the NAVMED 6470/10 and NAVMED 6470/1, Annual or Situational Report of Exposure to Ionizing Radiation. Instructions are provided on the back of the forms. The results of internal monitoring shall include the following information:

- a. Date of monitoring.
- b. The system's MDA.
- c. The isotope(s) for which monitoring was performed.
- d. Activity (in units of nanocuries) present.
- e. The anatomical locations, organs, or samples monitored.

f. Additionally, the equipment type and serial number will be recorded in those cases where an individual has been exposed to airborne radioactivity above the limits of the applicable program radiological controls manual, or greater than MDA is identified during internal monitoring.

2. If a series of monitoring measurements is performed within one week following an occupational exposure which resulted in internal contamination, then the time as well as the date of each monitoring shall also be recorded. In this case, the committed effective dose equivalent is calculated based on intake and retention determined from the series of measurements, and a single entry is made in Column 12 of the NAVMED 6470/11 for the series of measurements.

3. Only one committed effective dose equivalent entry will be made per internal contamination. If non-naturally occurring, or abnormal amounts of radioisotopes not related to an occupational exposure are detected, e.g., isotopes administered for medical purposes, cesium-137 from consuming venison, etc., the detection shall be noted in the remarks section of the NAVMED 6470/11.

4. If internal monitoring is performed on an individual during an issue period when the individual is monitored for deep dose equivalent (photon or neutron), the committed effective dose equivalent entry in Column 12 of the NAVMED 6470/11 will be transcribed to Column 12 of the NAVMED 6470/10 for that issue period. For example, if the external monitoring period is 1 February 2009 to 28 February 2009 and the internal monitoring is performed on 5 February 2009 then a committed effective dose equivalent entry would be made for the 1 February 2009 to 28 February 2009 monitoring period. If internal monitoring is completed and the individual is not being monitored for deep dose equivalent, then the committed effective dose entry on the NAVMED 6470/11 will be transcribed to the NAVMED 6470/10 and the issue period ("From" and "To") will be the date the internal monitoring was performed.

5. The committed effective dose equivalent will be determined for all internal monitoring results.

a. Monitoring results that are less than the MDA for the counting system shall be recorded as such in Column 11 of NAVMED 6470/11 (i.e., < MDA) and a committed effective dose equivalent of 00.000 rem shall be recorded on Column 12 of NAVMED 6470/11 (and NAVMED 6470/10, if applicable).

b. Monitoring results that are in excess of the MDA for the counting system shall result in the calculation of the committed effective dose calculation and/or the committed dose equivalent (if appropriate) by the responsible qualified physician/medical provider, radiation health officer, or radiation health director, and be forwarded to NDC for confirmation of the calculation. Per Chapter 3, if the individuals at the activity where the monitoring was done lack the capabilities or experience to perform internal dose calculations, then they shall request assistance from one of the BUMED-approved facilities (organizations) listed in article 3-3 of this manual. The activity shall still forward the result to the NDC for confirmation of the calculation. Once internal dose calculations and values have been confirmed by the NDC, a confirmation letter will be sent to the submitting activity approving the dose for incorporation into the individual's health record.

(1) Naval shipyards are authorized to calculate the committed effective dose equivalent from monitoring results without consultation or confirmation from the NDC.

(2) Other facilities may request similar authorization from the BUMED Director of Radiation Health and Undersea Medicine. All such requests shall be made in writing and include proposed procedures.

(3) Unless deviations are specifically authorized by BUMED, committed effective dose equivalent determinations based on one or more bioassay measurements shall be made using:

(a) The intake retention functions from NUREG CR/4884 (Interpretation of Bioassay Measurements) and the dose conversion functions contained in Federal Guidance Report No. 13 (ALIs, DACs, and Dose Conversion Factors).

(b) The methodology recommended by the International Commission on Radiological Protection.

3. A committed effective dose equivalent may be estimated from air sampling data by determining the number of DAC-hours of exposure.

Example: A worker is exposed to an atmosphere containing an average concentration of 1×10^{-10} $\mu\text{Ci/mL}$ of insoluble Co-60 particles (1 μm AMAD) for an 8 hour shift. The DAC for insoluble Co-60 is 1×10^{-8} $\mu\text{Ci/mL}$ (Appendix B). The exposure in this case is: $(1 \times 10^{-10} \mu\text{Ci/mL}) / (1 \times 10^{-8} \mu\text{Ci/mL-DAC}) * 8 \text{ hours} = 0.08 \text{ DAC-hours}$. The committed effective dose equivalent in this case is: $(0.08 \text{ DAC-hours}) * (2.5 \text{ mrem/DAC-hour}) = 0.2 \text{ mrem}$.

4. For internal monitoring of organs where the committed dose equivalent to that organ is more limiting than the committed effective dose equivalent (e.g., thyroid monitoring for iodine uptake), a separate NAVMED 6470/11 shall be prepared and maintained. The name of the organ shall be written at the top and bottom of the form. For example, for thyroid monitoring the words "Thyroid Monitoring" will be written or typed at the top and bottom of the form. The word "Effective" in the heading for column 12 will be lined out so that the heading reads "Committed Dose Equivalent." The committed dose equivalent shall be documented per article 5-4, paragraph 2.

5-5. Cross Checks and Verifications

1. To ensure accurate transcription and recording of dosimetry information, a random sampling of the exposure data in the data base, or on printed computer formatted NAVMED 6470/10 and NAVMED 6470/11, or on manually prepared NAVMED 6470/10 and NAVMED 6470/11 shall be cross checked against appropriate records (e.g., exposure record cards, NAVMED 6470/3, Radiation Exposure Report, dosimeter processing records, comparable records).

a. This cross check shall be performed semiannually on 1 percent of the individual records in the computerized database or no less than 5 of the individual records. If errors are found, a plan of action shall be drafted which specifies the number of additional records to be reviewed and the schedule for reviewing the records.

b. The cross check shall be noted by making an entry in the remarks section of the data base for the audited NAVMED 6470/10 and NAVMED 6470/11 or by signing and dating a statement in the Remarks Section of the printed NAVMED 6470/10 and NAVMED 6470/11 that entries have been verified.

2. Manually prepared NAVMED 6470/10 and NAVMED 6470/11 shall be individually verified on an annual basis normally in conjunction with preparation of the annual report. This verification will consist of an audit of the past year's exposure entries to verify correct addition. If the NAVMED 6470/10 and NAVMED 6470/11 are generated using an approved computer program that has not been modified since approval, annual verification is not required.

3. If erroneous entries have been made on manually prepared NAVMED 6470/10 or NAVMED 6470/11, they shall not be stricken out. A new entry which corrects the error(s) shall be made. An explanation of the error and the correction shall be briefly documented by a dated entry in the remarks section. An asterisk (*) or footnote number shall be neatly entered in the block containing the erroneous entry. This procedure for correcting erroneous entries on the NAVMED 6470/10 and NAVMED 6470/11 supersedes previous requirements.

5-6. Dose Investigations and Dose Estimates. For convenience throughout this section the term dose will be used to imply a shallow, deep, and/or neutron dose equivalent.

1. **Preface.** As discussed in detail below, dose investigations are required any time a dosimeter measurement is in question (e.g., bad glow curve as determined by processing facility), or unavailable (e.g., a lost dosimeter), or not representative of the dose received by the person (e.g., the dosimeter was worn in the wrong body location). Some dose investigations will result in the need to perform a dose estimate, while others will not. For example, if a dose investigation is conducted due to a suspect reading and the investigation concludes that the dosimeter reading is valid, then the dosimeter reading shall be assigned to the person without a dose estimate. When required, a dose estimate becomes a vital component of a member's exposure history. It is imperative that dose investigation/estimate reports be easily readable, scientifically based, technically accurate, thoroughly documented, and retained indefinitely.

2. **Initiation of Dose Investigations.** A dose investigation shall be performed under the following circumstances. Whenever a dose investigation is initiated, the Medical Officer, Radiation Health Officer/Director, or Medical Department Representative, as applicable, shall be notified.

- a. When the primary dosimetric device (e.g., a TLD) is lost, destroyed, or damaged to the extent that a valid measurement cannot be obtained.
- b. When unmonitored personnel enter areas where personnel dosimetric devices are required to be worn as defined in applicable radiological controls manuals and directives.
- c. When a primary dosimeter assigned to an individual is worn by another individual.
- d. The dose recorded by a primary dosimetric device is not consistent with the individual's work history and known radiation levels in the area(s) entered.
- e. A technical, electronic, software, or mechanical problem is noted during dosimeter processing that potentially affects the accuracy or the validity of a personnel dose recorded by a primary dosimetric device. However, if the processing facility using approved evaluation procedures determines a valid reading can be obtained from the dosimeter (e.g., a broken TLD chip reads correctly or the dose can be assigned from another chip in a multichip TLD), the condition is documented, and the documentation is permanently retained, a separate dose investigation is not required and the dose is assigned.
- f. The primary dosimetric device was not worn on the correct location on the body for the radiation fields encountered during work. Criteria for dosimeter location are specified in the applicable radiological controls manuals.
- g. In an operational condition that prevents evaluation of the primary dosimeter in a timely manner, and the dose recorded by a secondary dosimetric device is not consistent with the defined occupational work environment and known radiation levels in the area(s) entered.
- h. The measurement of gamma/deep photon dose by the whole body primary dosimetric device differs significantly from the recorded measurement by the whole body secondary dosimetric device (e.g., a pocket or electronic dosimeter) and both devices have been worn together at the same body location. Criteria for significant differences are as below. These criteria are not applicable to primary and secondary measurements when the primary dosimeter is worn for extended periods (e.g., during normal shipboard issue cycles) and a majority of an individual's dose is received while not wearing a secondary dosimeter.
 - (1) Primary and secondary measurements differ by 30 millirem or more and the primary dosimetric device measurement is less than or equal to 100 millirem.
 - (2) Primary and secondary measurements differ by 30 percent or more and the primary dosimetric device measurement is greater than 100 millirem.

(3) Primary and secondary measurements differ by 100 millirem or more and the secondary dosimetric device is an intermediate range (0 to 1000 millirem) or high range self indicating ion chamber pocket dosimeter.

i. The measurement of whole body shallow or neutron radiation dose by the primary dosimetric device differs significantly from the expected dose. Criteria for significant differences are:

(1) Primary and expected doses differ by 100 percent or more and the primary dosimetric device measurement is less than or equal to 30 millirem shallow or neutron dose.

(2) Primary and expected doses differ by 30 percent or more and the primary dosimetric device measurement is greater than 30 millirem of shallow or neutron dose.

j. The measurement of extremity dose by the primary dosimetric device differs significantly from the expected dose or secondary measurement. Criteria for significant differences shall be established by the facility performing the monitoring prior to monitoring if not specified in the applicable technical manual for nonstandard secondary dosimetric devices (e.g., Recruitment Assistance Division, Student Training and Academic Recruitment (RADSTAR)).

3. ***Interview and Statement.*** The individual for whom the investigation is performed shall be interviewed, unless the problem is unrelated to the individual's actions, such as a dosimeter processing problem. The interview shall not be used to assign fault or for punitive purposes but rather as a process to obtain the necessary information to perform the investigation. A statement shall be written documenting the individual's account of what happened. It shall describe all of the individual's activities during the monitoring period relative to the receipt of radiation exposure. When possible, the individual shall indicate on a survey map the areas frequented, the amount of time spent in each area, and if relevant, their body position in a high gradient field. The interview should also address any exposure to radiation sources not associated with the radiological controls program under which the individual is being monitored, any abnormal dosimeter storage conditions, or abnormal TLD body location that may affect the evaluation/estimate. The interview should also determine if other monitored personnel were present with the individual or if the individual previously performed similar work. The individual interviewed need not write the statement, but must sign and date the statement indicating they understand and agree with the content of the statement. The individual's statement shall become part of the dose investigation/estimate report.

4. ***Methods to Estimate Dose.*** The three most common ways to estimate a personnel dose is by; (a) using secondary dosimeter measurements, (b) using doses from similar work performed, and (c) performing an exposure time and dose rate study. If data is available, all of

the first three methods below shall be used and the results compared for consistency except as noted below. If one method yields results inconsistent from the others, then the methods shall be further examined and differences explained. Results from different estimation methods may need to be combined to arrive at a final estimate (e.g., combining a dose rate and time calculation result for radiation area work with secondary dosimeter readings for work in a high radiation area). Ultimately the dose assigned (shallow, deep, and/or neutron when necessary) shall be the “best estimate” of the dose received as opposed to “worst case” or “most conservative” estimate.

a. ***Exposure Time and Dose Rate Study.*** For this method, a dose rate and length of time for each place a person traveled or worked during the monitoring period is needed. The dose is estimated by summing the product of dose rate and time for each area in which the individual worked as determined from the interview. Dose rates are most often obtained from radiation area surveys that have already been performed or by ordering new surveys. For an accurate dose estimate, the data on the surveys should be representative of the conditions during the time in question. Differences can occur for a variety of reasons, such as changes in the radiation source or shielding. This type of study is not normally feasible for long issue periods (e.g., for a month or more) when an individual is in radiation areas for extended exposure periods. In such cases, a note should be entered in the dose investigation record as to why this method was not used. (If a majority of the dose was received in a high radiation area, this method should still be used for the high radiation area work and combined with the dose for the extended period of time in radiation areas derived by other methods.) However, for investigation of higher than expected dose readings, a review of applicable routine survey records should be performed and a statement should be made in the report that there were no unusual radiation levels that would explain the elevated TLD reading, unless elevated (atypical) readings are noted in the individual’s work area and then this method should be used to address how the radiation levels may have affected the TLD reading.

b. ***Similar Work.*** For this method, doses received by other personnel performing similar work, or the individual's previously recorded dose while performing similar work, are used to estimate the person’s dose for the period in question. Similar work implies similar durations, rates, person locations/positions, source configurations, and shielding conditions. The more that any of these differ, the less accurate the dose estimate will be. Differences in exposure time can be compensated for by calculation. Specifically, the dose from previous similar work is divided by the total exposure time and multiplied by the exposure time of the person for which the estimate is being done. If no data is available to employ this method, this should be stated in the investigation report.

c. ***Secondary Dose Measurements.*** This method is available if the person was wearing a secondary dosimeter and both devices were worn together at the same body location. Secondary dosimeters are often used for real time dose control as they normally have the ability to read out continuously. The most common example is a radiation worker entering a high

radiation area wearing both a TLD and a self-indicating pocket dosimeter (PD) (ion chamber or electronic personal dosimeter). If the TLD measurement is unavailable, a dose estimate can be made by using the PD measurement. There can be several secondary measurements to each primary measurement because the requirements to read and record secondary and primary measurements differ. For example, a single TLD could have been issued for the week but several high radiation area entries can be made during the week, each with its own PD reading. In this case an estimate of the dose to the person from the week can be obtained by summing up all the individual PD measurements for the week and validating that no other or negligible occupational dose was received outside of the high radiation areas for the week. If no secondary dosimeter was worn, this should be stated in the investigation report.

d. *Other Methods.* Other methods of dose estimation may be employed if technically appropriate. For example, a TLD with a valid reading but worn at an incorrect body location may be corrected by the ratio of measured dose rates at the body locations. The method shall be explained in the investigation report. For cases where estimation of shallow dose is required and the individual was only exposed to higher energy gamma radiation (e.g., during normal propulsion plant operations and maintenance on a nuclear-powered ship), the deep dose value is assigned as the estimate for shallow dose. For cases where an individual lost the primary dosimeter after issue but did not enter any areas requiring monitoring or handle radioactive material, the investigation shall so state and no estimate of occupational dose is required.

5. *Dose Investigation/Estimate Reporting Requirements*

a. Dose investigations/estimates shall contain the following elements (not necessarily in the order listed).

(1) The reason(s) why the investigation was performed, including how the dosimetric device was lost, damaged, or destroyed if applicable. The narrative should be written in a manner that can be understood by individuals unfamiliar with the systems involved, technical requirements associated with those systems, or location(s) of the exposure(s).

(2) The individual's signed and dated statement discussed in article 5-6, paragraph 3, which includes the details of the work performed by the individual.

(3) The shallow, deep, and/or neutron dose equivalents assigned (as applicable), and the period covered by the assignments.

(4) All applicable supporting documentation such as any calculations performed, copies of radiation survey records, the results of any evaluations performed by the processing facility of the dosimetric device(s) involved, and results for each estimating procedure (time/dose rate, similar work, secondary measurements, other) used to validate a measured dose or to determine a dose for an estimate.

(5) The report shall be prepared in an unclassified manner. A second copy of the report shall be separately filed along with necessary supporting survey records that may contain classified information or unclassified Naval Nuclear Propulsion information (if applicable).

b. The Medical Officer, Radiation Health Officer, or equivalent Radiation Health Director shall approve the dose investigation/estimate report in writing. For commands/facilities not having a Medical Officer, Radiation Health Officer, or equivalent Radiation Health Director, the Medical Department Representative and Executive Officer shall approve the dose investigation/estimate report.

c. The individual for whom the dose investigation/estimate shall be informed of the final results (but is not required to sign the estimate).

d. The dose investigation/estimate report *shall not* be entered in the individual's health record.

e. The dose investigation/estimate report shall be retained indefinitely.

f. The following items shall be recorded in the "Remarks" section of the NAVMED 6470/10 or on an addendum to the NAVMED 6470/10. The entry must be concise and will normally be limited to a few summary statements. If the entry is made on an addendum to NAVMED 6470/10, the entry shall not exceed one page in length. Summary statements of less than 600 spaces for a dose estimate shall be transcribed to the NAVMED 6470/1 upon submission of the Annual or Situational Report of Personnel Exposure to Ionizing Radiation or as a footnote if submitted in computer format.

(1) The reason why the dose estimate was performed.

(2) The shallow, deep, and/or neutron dose equivalents assigned.

(3) The period covered by an estimate.

(4) The basis for the dose estimate.

Note: For a lost, damaged, or destroyed dosimeter, a description of how it was lost, damaged, or destroyed *shall not be recorded* on the NAVMED 6470/10 or on an addendum to NAVMED 6470/10.

5-7. External Contamination

1. Results of all cases of external personnel contamination shall be recorded in the remarks section of the individual's NAVMED 6470/10, Record of Exposure to Ionizing Radiation, and reported in the remarks section of a Situational Report or on the Annual Report, NAVMED 6470/1.

a. The results shall include the following minimum information: date of monitoring, isotope(s) monitored, activity (in units of microcuries or nanocuries) present, and the anatomical location of the contamination.

b. A form covering this information may be marked as "Addendum to NAVMED 6470/10" and incorporated with the NAVMED 6470/10 in the health record.

c. If a dose to the skin is estimated for the occurrence, record the dose in Column 9, Shallow Dose. Columns 10 through 14 will be left blank

5-8. Extremity Exposure. For individuals who are monitored for exposure to the extremities, as defined in Chapter 1, a separate NAVMED 6470/10 for extremity exposure shall be maintained. The words "Extremity Monitoring" will be written or typed at the top and bottom of the NAVMED 6470/10. The highest measured dose will be recorded as the extremity exposure when multiple extremities are monitored. Extremity dose will be recorded in Column 9, Shallow Dose. Columns 10 through 14 will be left blank. Do not transfer this entry to Column 9 of the whole body NAVMED 6470/10. The record of SDE to the extremities shall be maintained separately, and shall be reported to the NDC in either the Remarks section or on a separate page or pages of the Annual or Situational Report of Personnel Exposure to Ionizing Radiation, NAVMED 6470/1. The reported doses shall be clearly annotated as extremity doses.

5-9. Eye Exposure. For individuals who are monitored for exposure to the eyes, a separate NAVMED 6470/10 for SDE to the eye shall be maintained. The words "Eye Monitoring" will be written or typed at the top and bottom of the NAVMED 6470/10. The word "Shallow" in Column 9 will be lined out and replaced with the word "Eye." SDE to the eye will be recorded in Column 9. Columns 10 through 14 will be left blank. Do not transfer this entry to Column 9 of the whole body NAVMED 6470/10.

5-10. Embryo/Fetus Exposure

1. **Declared Pregnancy Statement.** In order for the embryo/fetus dose limits of Chapter 4 to apply, a woman monitored for radiation exposure must inform her command, in writing, of her pregnancy and the estimated date of conception. The declaration remains in effect until the declared pregnant woman withdraws the declaration in writing or is no longer pregnant. To

ensure its documentation and retention, the written declaration shall be made on a Standard Form 600, Chronological Record of Medical Care (SF-600), and placed in the woman's health record. The following SF-600 entry shall be completed, signed, and dated by the woman and witnessed, signed, and dated by a representative of the medical department:

"I hereby make notification that I am pregnant. My estimated date of conception is DD MMM YYYY. I understand that by declaring my pregnancy, my occupational exposure to ionizing radiation will be controlled such that the dose to my unborn child does not exceed the limits prescribed in Chapter 4 of NAVMED P-5055, the Navy Radiation Health Protection Manual."

Note: Throughout this section DD represents a 2-digit day of the month, MMM is a three letter abbreviation of a month, and YYYY is a 4-digit year for the date implied by the statement.

2. **Recording Initial Embryo/Fetus Dose.** When the woman declares her pregnancy, any total effective dose equivalent to the embryo/fetus from the estimated date of conception to the date she declares in writing will be calculated and recorded on a SF 600 in the mother's medical record as follows.

a. If the declared pregnant worker **did not receive** occupational exposure from the estimated conception date to the declaration date, then the following statement shall be recorded, signed, and dated by the qualified physician/medical department representative:

"The worker was not monitored for occupational exposure to ionizing radiation from the estimated date of conception to the declared pregnancy date. Total effective dose equivalent to the fetus is not applicable."

b. If the declared pregnant worker **did receive** occupational exposure from estimated conception date to the declaration date, then the following statement shall be recorded, signed, and dated by the qualified physician/medical department representative:

"The total effective dose equivalent to the fetus from the estimated date of conception to the declared pregnancy date is estimated to be XX.XXX rem."

3. **Termination of Exposure to Embryo/Fetus**

a. If a declared pregnant worker transfers to another Navy command or terminates her employment during her declared pregnancy, then the total effective dose equivalent to the embryo/fetus shall be calculated after the last potential exposure and prior to transferring or termination of employment.

b. For a declared pregnant worker who is transferring, the medical department representative shall ensure an updated NAVMED 6470/10 is filed in the medical record with one of the two following statements, dependent on whether occupational exposure was received from the estimated conception date to the current date, entered in the “Remarks” section.

“The worker was not monitored for occupational exposure to ionizing radiation from the estimated date of conception to DD MMM YYYY. The worker is [transferring/ending employment] and will receive no further exposure at her present place of employment. Assignment of a total effective dose equivalent for the fetus is not applicable.”

“The total effective dose equivalent to the fetus from the estimated date of conception to DD MMM YYYY is estimated to be XX.XXX rem. The worker is [transferring/ending employment] and will receive no further exposure at her present place of employment.”

c. If the declared pregnant worker transfers to another Navy activity and is employed in a job with occupational exposure to ionizing radiation, then the gaining Navy activity must resume tracking of the embryo/fetus dose and fulfill the requirements for declared pregnant workers in this manual.

d. At the conclusion of her pregnancy, the declared pregnant worker shall notify her command that the pregnancy ended and provide substantiating documentation. The declared pregnant worker shall sign and date the following statement on a SF 600 in her medical record.

“My pregnancy ended on DD MMM YYYY.”

e. The total effective dose equivalent to the embryo/fetus shall be calculated for the entire pregnancy. The medical department representative shall ensure the NAVMED 6470/10 is updated with one the two following statements, dependent on whether occupational exposure was received from the estimated conception date to the end of the pregnancy, in the “Remarks” section.

“The worker was not occupationally exposed to ionizing radiation from the estimated date of conception to the date of conclusion of her pregnancy. The total effective dose equivalent to the fetus is not applicable.”

“The total effective dose equivalent to the fetus from the estimated date of conception to the date of the conclusion of her pregnancy is estimated to be XX.XXX rem.”

f. Once the pregnancy is ended, the worker's dose control level can be modified back to her prior whole body control level.

g. The dose to the embryo/fetus at the time of declaration is based on proration of the measured dose by dosimeter, which is collected at the time of declaration. Another dosimeter is issued for monitoring during the remainder of the issue period. The dosimeter collected at the time of declaration may be processed immediately or held with control dosimeters in a low background area until the command batch is forwarded to the processing facility. Dose during the pregnancy would be measured by dosimeter per normal procedures. At the termination of the pregnancy, the dosimeter in use is turned in for processing. Processing may happen immediately or the dosimeter held with control dosimeters in a low background area until the command batch is forwarded to the processing facility. If the individual transfers during the pregnancy and dosimeter results are not available, a statement should be added to the exposure statement above that the dose was estimated using a specific method (e.g., past doses while performing is similar work) and a final dose will be forwarded when dosimeter measurement results are received. In such cases, the final dose prior to transfer shall be forwarded within 30 days of the receipt of the dosimeter processing results.

4. *Exceeding Embryo/Fetus Limits.* The qualified physician/medical department representative shall immediately administratively disqualify a declared pregnant worker from receiving further radiation exposure if the limits of Chapter 4 of this manual have been exceeded at any time during her pregnancy and shall follow the reporting requirements of article 5-12 of this manual. The qualified physician/medical department representative shall follow BUMED guidance on further actions required and shall modify statements in the Standard Form (SF) 600 accordingly.

5-11. Termination Letters

1. If radiation workers are released, retired or terminate employment and request a copy of their exposure information, they shall be provided with a statement of their total occupational radiation exposure received during their period of employment or service with the Navy or Marine Corps. The termination letter shall be submitted within 30 days of the receipt of the individual's final exposure information or final determination that the individual will no longer be monitored for exposure to ionizing radiation. The termination letter shall include:

a. Name, last four digits of the social security number (XXX-XX-1234), and date of birth of the individual.

b. Occupational dose information from all NAVMED 6470/10s and DD Form 1141s shall be extracted and summarized for all categories of monitored exposure. The current year's exposure shall be listed by quarter year. For prior years, the exposures shall be listed by

command and location or hull number, period monitored at that command, and cumulative Navy exposure during that time period. The period monitored shall be in day, month, year format from the date first monitored to the date last monitored at the command, inclusive. Exposures received prior to January 1992 may be listed as whole body exposures with internal monitoring listed separately as listed on the DD Form 1141 or may be converted to effective dose equivalents. To convert prior DD Form 1141 exposures to the appropriate dose quantity:

(1) SDE. If monitored for skin exposure, Shallow Dose will be entered as equal to the numeric value of the skin dose (Column 9), of the DD Form 1141 for the periods monitored. If not monitored, leave this column blank.

(2) Deep dose equivalent, photon will be entered as equal to the value of the gamma and x-ray dose (Column 10) of DD Form 1141.

(3) Deep dose equivalent, neutron will be entered as equal to the value of the neutron dose (Column 11) of the DD Form 1141.

(4) Committed effective dose equivalent. If internal monitoring was conducted and the results indicated a positive uptake, the committed effective dose equivalent shall be calculated by a BUMED approved facility (see article 5-4, paragraph 2b). Internal monitoring results less than the system's MDA shall be recorded as 00.000 rem in the committed effective dose equivalent column. If no internal monitoring was performed, leave this column blank.

(5) Total effective dose equivalent will be entered as the sum of deep dose equivalent-photon, deep dose equivalent-neutron and committed effective dose equivalent.

c. The following statements shall be included on the form or letter provided to the individual:

(1) "This report is provided per NAVMED P-5055, Radiation Health Protection Manual."

(2) "You should preserve this report for future reference. If you should seek future employment involving occupational exposure to ionizing radiation, your employer will want this information. To put your exposure into perspective, the average dose to a member of the United States population is approximately 310 mrem (3.1 mSv) per year from natural background radiation. The Federal dose limit for workers who receive occupational exposure to ionizing radiation is 5 rem (0.05 Sv) per year, total effective dose equivalent. No adverse effect is expected from exposure at levels below the Federal limit."

5-12. Required Reports

1. The currently approved computerized exposure record systems (ARCMIS and SAMS) have a report preparation function which will generate the hard copy and electronic media in the format required by the NDC for uploading data into the NARER. Therefore, all reports described in this article shall be prepared using one of these computerized exposure record systems. In the event that exigent circumstances preclude use of one of these systems, authorization to submit the affected report(s) in manual format must be requested in advance from the officer in charge of the NDC with justification for the request for manual submission. Instructions on manual preparation of NAVMED 6470/1 will be provided by the NDC only after approval of a request for manual submission.

2. With each annual or situational report submitted, point of contact information shall be provided including a person's name, telephone numbers, and an e-mail address.

3. *Annual Report of Personnel Exposure to Ionizing Radiation to the Individual.* Annually, every installation, activity, ship, or unit at which personnel are monitored for exposure to ionizing radiation, shall provide all monitored individuals currently onboard a written report of their dose for the previous calendar year. This annual report shall be provided prior to 1 April each year. If valid operational commitments (e.g., extended overseas deployment) delay receipt of final personnel exposure information for the previous year until after 1 March, the report shall be provided within 30 days of the date of receipt of final personnel exposure information.

4. *Annual Reports of Personnel Exposure to Ionizing Radiation*

a. Annually, every installation, activity, ship, or unit at which personnel are monitored for exposure to sources of ionizing radiation, shall submit an Annual Report of Personnel Exposure to Ionizing Radiation on NAVMED 6470/1, Report of Personnel Exposure to Ionizing Radiation, in electronic media format to the NDC. Acceptable submission will be on 3.5 inch diskettes, CD ROM, or electronic transmission and will include a printed copy of the tabulated report. Data submitted on removal media shall be encrypted using a method supported by the NDC. Data transmitted electronically shall be by secure transmission such as a web browser secure socket or Navy secure network. This annual report shall be submitted so that it will arrive at the NDC prior to 1 April each year. If valid operational commitments (e.g., extended overseas deployment) delay receipt of final exposure information for the previous year until after 1 March, the annual report shall be submitted within 30 days of the date of receipt of final personnel exposure information. These reports shall be submitted to:

Officer in Charge
Naval Dosimetry Center
8901 Wisconsin Avenue, Bldg 4/6
Bethesda, MD 20889-5614

b. This report shall include those personnel on board 31 December who have been monitored for exposure to ionizing radiation during the previous calendar year while assigned to the reporting activity. Dosimeter readings of 00.000 rem are required to be reported. If the individual was not monitored for a given type of radiation or if the individual did not receive monitoring for internal contamination leave the appropriate column(s) blank.

c. For dosimeter issue periods that span 1 January, the year in which the mid-point of the issue period occurs shall be the year in which the entire exposure for that period is reported.

5. *Situational Report of Personnel Exposure to Ionizing Radiation*

a. If a monitored individual is transferred, retires or terminates employment, prior to 31 December, a Situational Report of Personnel Exposure to Ionizing Radiation shall be submitted on NAVMED 6470/1 in electronic media format by the individual's activity to the NDC within 30 days of detachment of the individual from the command, or within 30 days of receipt of the individual's final exposure information, whichever is later. Acceptable submission will be on 3.5 inch diskettes, CD ROM, or electronic transmission and will include a printed copy of the tabulated report. Data submitted on removal media shall be encrypted using a method supported by the NDC. Data transmitted electronically shall be by secure transmission such as a web browser secure socket or Navy secure network.

b. If a visitor at a naval facility or an individual on temporary duty from an activity which does not submit Annual or Situational Reports of Personnel Exposure to Ionizing Radiation, is monitored for exposure to ionizing radiation, a Situational Report of Personnel Exposure to Ionizing Radiation, submitted in magnetic media format, shall be prepared and forwarded to the NDC by the activity at which the exposure was incurred, within 30 days of departure of the individual from the command or receipt of the individual's dose information.

c. The dose reported on a Situational Report of Personnel Exposure to Ionizing Radiation for an individual terminating or transferring shall be only that dose for the year in which transfer or termination occurs. Do not summarize the individual's complete exposure history on a Situational report.

6. ***Situational Report of Personnel Exceeding Radiation Exposure Limits.*** This report shall be submitted to the BUMED Director of Undersea Medicine and Radiation Health, as follows:

a. If any individual (adult radiation worker, non-radiation worker, minor, declared pregnant woman, or member of the general public) receives a total effective dose equivalent in excess of the limits specified in Chapter 4, this report shall be forwarded on NAVMED 6470/1

within 30 days from the determination of such exposure. Details explaining how the exposure was received will be entered in the remarks section of the form or as an attachment to the report. The report shall include:

- (1) The individual's dose.
- (2) The levels of radiation and concentrations of radioactive material involved.
- (3) The cause of the elevated exposures, dose rates, or concentrations.
- (4) The corrective actions taken or planned to preclude a recurrence.

b. If any individual receives a total effective dose equivalent of more than 5 rem (0.05 Sv), eye dose equivalent exceeding 15 rem (0.15 Sv), or a SDE of 50 rem (0.5 Sv) *in a single incident*, the BUMED Director of Undersea Medicine and Radiation Health shall be notified immediately by telephone and/or "IMMEDIATE" message. During "MINIMIZE," electrical transmission by priority message is authorized. A follow-up written report shall be forwarded on NAVMED 6470/1 within 24 hours from the determination of such exposure.

c. If an individual receives a total effective dose equivalent of more than 25 rem (0.25 Sv) or an eye dose equivalent of 75 rem (0.75 Sv), or a SDE of 250 rad (2.5 Gy) *in a single event*, the BUMED Director of Undersea Medicine and Radiation Health shall be notified immediately by telephone and/or "IMMEDIATE" message. During "MINIMIZE," electrical transmission by priority message is authorized. A detailed Situational Report of Personnel Exceeding Radiation Exposure Limits furnishing all information available on the exposure, the reason for such exposure, the general status of health and physical condition of the individual and a summary of treatment rendered or recommended, shall be submitted to the BUMED Director of Undersea Medicine and Radiation Health at the earliest practicable time following the exposure. In any event, this amplifying report must be submitted within 15 days after exposure. A copy of this report shall be placed in the individual's health record as an addendum to the NAVMED 6470/10.

7. ***NARER Summary Report.*** By the end of the third quarter of each year the NDC shall prepare a summary report of the exposures received from Navy and Marine Corps sources and forward the report to the BUMED Director of Undersea Medicine and Radiation Health. The report shall include the total person-rem, dose profiles in 100 mrem increments (number of people exposed per exposure increment), and a dose equivalent trend analysis for Navy as a whole and by occupational code. The report shall also include the total number of people reported to have received occupational exposure to ionizing radiation, the total number of activities reporting occupational exposure to ionizing radiation and a narrative summary of any exposures exceeding the exposure limits.

5-13. Retention, Disposition, and Release of Information

1. The DD Form 1141, NAVMED 6470/10, and NAVMED 6470/11 are permanent components of the individual's health record and should be safeguarded as such; however, commanders, commanding officers, officers in charge, authorized inspecting officials, and supervisors of persons occupationally exposed to ionizing radiation or the individual concerned may review the DD Form 1141s, NAVMED 6470/10, and NAVMED 6470/11 with the Medical Records Custodian upon request. The Medical Records Custodian may exchange dose data with installations outside the jurisdiction of the Department of the Navy for any persons occupationally exposed at the installation upon written request, provided a release authorization signed by the exposed individual is forwarded with the request.

2. When a civilian employee is not included in a Federal civilian employee health care service, DD Form 1141, NAVMED 6470/10, and NAVMED 6470/11 shall be maintained as a permanent document in the employee's official personnel folder. NAVMED 6470/10 and NAVMED 6470/11 for Federal contract workers shall be provided to the point of contact specified in the workers' contract.

3. All available dosimetry results shall be entered on NAVMED 6470/10 and 6470/11 as appropriate prior to transfer of military personnel. Dosimetry results not recorded as of the date of transfer shall be forwarded to the individual's next duty station within 30 days of receipt of final personnel exposure information.

4. The DD Form 1141, NAVMED 6470/10, and NAVMED 6470/11 shall be permanently retained in the retired medical records of a Service member who has been monitored for exposure to ionizing radiation during his or her service. When a member is released from active duty or retires prior to his or her exposure information being entered in his or her health record, a dose transmittal with instructions to enter the information in the medical record shall be forwarded for incorporation in the member's health record. For Navy and Marine Corps personnel, the dose transmittal should be forwarded to:

Department of Veterans Affairs
VARMC
P.O. Box 5020
St. Louis, MO 63115-8950
Tel: (314) 538-4500

5. Electronic or hard copies of completed NAVMED 6470/1, Situational and Annual Reports of Personnel Exposure to Ionizing Radiation shall be retained indefinitely by the originating command.

6. Exposure investigation and dose estimate reports shall be retained indefinitely by the originating command.

7. Copies of Termination Letters shall be retained for 5 years.
8. Copies of NAVMED 6470/3 shall be retained for 5 years.
9. Retain and dispose of other radiation health program documents per SECNAV INST 5212.5 (series) and applicable radiological controls program manuals.

5-14. Working copy of NAVMED 6470/1, Exposure to Ionizing Radiation. To maintain accurate NAVMED 6470/10s and to submit accurate NAVMED 6470/1s, a reliable record system is essential. It is suggested that each activity's record system contain a working copy of NAVMED 6470/1 on which is transcribed all required data from DD Form 1141 or NAVMED 6470/10 on any persons transferred, terminated, or retired during the month. Computer generated records are satisfactory provided either the source documents or a back-up copy exists. This data shall be updated when the personnel dosimetry is processed and used to prepare the Situational Report. The working copy of the NAVMED 6470/1 should be destroyed when the required Situational Report is submitted.

5-15. Control of Radiation Exposure Information for Nuclear Powered Warships and Operational Prototypes

1. Selected forms and reports containing aggregated (more than one individual) radiation exposure for crews of nuclear powered warships or operational prototypes generated on or after 1 January 1999 must be marked as not releasable to foreign nationals (NOFORN) and handled as unclassified naval nuclear propulsion information (NNPI) per NAVSEAINST C5511.32. Reports included under this requirement are the Situational Report (NAVMED 6470/1), Annual Report (NAVMED 6470/1), and Radiation Exposure Report (NAVMED 6470/3 and NAVMED 6470/15, Radiation Exposure Report (Extremity)) when completed with exposure information.
 - a. For Submersible Ship Nuclear (SSN)/Strategic Submarine Ballistic Nuclear (SSBN) platforms, all forms and reports containing aggregated radiation exposure information shall be handled as unclassified NNPI and labeled as NOFORN.
 - b. For Carrier Vessel Nuclear (CVN) platforms only, reports containing aggregated radiation exposure information for crewmembers directly involved in propulsion plant operations shall be handled as unclassified NNPI and labeled as NOFORN. Forms and reports for crewmembers not involved in propulsion plant operations (e.g., medical and radiography personnel) remain unclassified and are not to be controlled as NOFORN. Commands are not authorized to create two separate reports for controlled and uncontrolled personnel for submission to the NDC.
2. Applicable forms and reports, including disk labels when forwarding electronic copies, shall be marked and handled per NAVSEAINST C5511.32. Data stored on removal media shall be encrypted using a method supported by the NDC.

3. Corrective action to mark hard copies of forms and reports accumulated prior to 1 January 1999 is not required. However, this material should be otherwise safeguarded as NOFORN per NAVSEAINST C5511.32 series.

4. Forms and reports for specific individuals only (NAVMED 6470/10 and NAVMED 6470/11 forms in medical records and termination letters to individuals), reports from non-nuclear powered ships (including tenders), non-ship and non-prototype activities (e.g., shipyards and fleet maintenance activities (FMAs)), and reports that provide a compilation of exposure data without ship-specific identifiers, remain unclassified and are not to be controlled as NOFORN.

5-16. Occupational Codes

1. Where applicable, the 2-digit occupation code provides a means to identify the occupation which provides the majority of the exposure to the worker or it identifies a particular category of employee. The occupational codes currently authorized are:

- 00: Dosimeter (Control)
- 01: Dosimeter (Posted)
- 02: Dosimeter (Area Monitor, e.g. NAM-1 or NAM-5)
- 03: Dosimeter (Unused)
- 10: Nuclear Propulsion (Radiation Worker)
- 11: Nuclear Propulsion (Non-Radiation Worker)
- 12: Nuclear Propulsion (Visitor, not included in other Nuclear Propulsion Programs)
- 20: Nuclear Weapons (Radiation Worker)
- 21: Nuclear Weapons (Non-Radiation Worker)
- 22: Nuclear Weapons (Visitor)
- 30: Medical (Diagnostic Radiology)
- 31: Medical (Dental)
- 32: Medical (Nuclear Medicine)
- 33: Medical (Radiation Oncology)
- 34: Medical (Visitor)
- 35: Medical (General, not associated with aforementioned categories in Medical)
- 36: Medical (Non-Radiation Worker)
- 39: Medical (Radiation Worker, multiple dosimeters)
- 40: Industrial (Gamma Radiography)
- 41: Industrial (X-ray Radiography and Accelerators of energies less than 10 MeV)
- 42: Industrial (Accelerators of energies greater than 10 MeV)
- 43: Industrial (RADIAC Calibration)
- 44: Industrial (General Sources i.e., moisture density meters, analytical x-ray sources, depleted uranium, electron microscopes, backscatter devices/units)

5-16. Occupational Codes (Continued)

- 45: Industrial (Visitor)
- 46: Industrial (Non-Radiation Worker)
- 50: Research
- 51: Research (Radioisotope)
- 52: Research (Visitor)
- 53: Research (Non-Radiation Worker)
- 90: Other

5-17. Radiation Types. Where applicable, radiation types identify the numeric code to indicate the type of radiation exposure to be reported by the processing facility for each dosimeter:

1. Whole Body (Deep Dose Equivalent (DDE) - Deep Photon)
2. Whole Body (DDE - Deep Neutron)
3. Whole Body (DDE - Deep Photon, Deep Neutron)
4. Whole Body (SDE) - Shallow Photon and/or Beta)
5. Whole Body (SDE - Shallow Photon and/or Beta, Deep Photon)
6. Whole Body (SDE - Shallow Photon and/or Beta, Deep Photon, Deep Neutron)
7. Discontinued Extremity
8. Discontinued Extremity
9. Discontinued Extremity
- A. Extremity (Photon fields, average energy ≥ 20 keV (X-ray techniques ≥ 30 kVp, Nuclides: Numerous).
- B. Extremity (Beta fields, maximum energy 70-999 keV, nuclides: C-14, S-35, Pm-147, P-33, Kr-85, Tl-204, Beta particles of energy less than < 70 keV (e.g. H-3) have a range less than 7mg/cm^2 , and therefore do not have enough energy to reach the target cells of the skin).
- C. Extremity (Beta fields, maximum energy $\geq 1,000$ keV, Nuclides: Sr-89, P-32, Sr/Y-90).
- D. Extremity (Other; use "Remarks" section where applicable to specify isotope and energy of radiation(s), after having consulted with NDC.)

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PERSONNEL DOSIMETRY

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6-1. Introduction. The principal means for assessing absorbed dose or dose equivalent (shallow and deep) from external radiation exposure is by direct measurement using devices known as personal dosimeters. The systems and procedures used to produce the final doses of record from these devices have significant medical, legal and epidemiological implications; therefore, strict adherence to the policies and procedures contained herein regarding issuing and processing dosimeters is essential. In addition, proper administration of a local dosimetry program is necessary to provide management with critical information to assess whether practices and procedures that result in exposure to ionizing radiation are sufficiently controlled so that doses are as low as reasonably achievable.

6-2. Monitoring

1. **Personnel Monitoring.** Personnel monitoring devices shall be worn by:

a. All adult personnel who could potentially receive from sources external to the body a dose in excess of:

Total Effective Dose Equivalent (Whole Body)	00.500 rem/yr
Shallow Dose Equivalent (Extremities)	05.000 rem/yr
Shallow Dose Equivalent (Skin)	05.000 rem/yr
Eye Dose Equivalent (Eyes)	01.500 rem/yr

If the dose to the eye is expected to be less than or approximately equal to the deep dose equivalent, then whole body monitoring may be used in lieu of a special device for monitoring the eye dose. For example, in fluoroscopy, a device worn at the collar to monitor deep dose equivalent will suffice to assess the eye dose equivalent.

- b. All personnel entering a high radiation area as defined in article 1-5.
- c. Declared pregnant women who could potentially receive, from sources external to the body, a dose equivalent in excess of 50 mrem (0.5 mSv) to the embryo/fetus during the entire pregnancy.
- d. Minors who could potentially receive a dose equivalent in excess of 50 mrem (0.5 mSv) in 1 year from sources external to the body.
- e. Radiographers and radiographers' assistants as defined in 10 CFR 34 (in addition to a self indicating and alarming dosimeter).
- f. Any other personnel required to be monitored per the applicable radiological controls manual or deemed necessary by cognizant Radiation Health personnel.

2. **Internal Monitoring.** Internal monitoring shall be performed on the following personnel:

- a. Adults whose duties could reasonably be expected to result in an intake of radionuclide(s) of 10 percent or more of an ALI for the given radionuclide(s).
- b. Minors whose duties are expected to result in a committed effective dose equivalent of 50 mrem (0.5 mSv) or more in 1 year.
- c. Declared pregnant women whose duties are expected to result in a committed effective dose equivalent of 50 mrem (0.5 mSv) or more to the embryo/fetus during the course of the pregnancy.

3. **Environmental Monitoring.** Article 6-7 of this manual describes the devices approved for gamma/beta and neutron environmental monitoring. Environmental monitoring shall be performed in areas accessible to the general public to verify members of the general public are not likely to exceed a total effective dose equivalent of 100 mrem (1 mSv) per year and the dose equivalent in any unrestricted area from external sources does not exceed 2 mrem (0.02 mSv) in one hour.

4. **Area Monitoring.** Area monitoring shall be performed in areas accessible to non-radiation workers, defined in article 1-5, paragraph 29, to ensure that the dose equivalent to non-radiation workers does not exceed 500 mrem (5 mSv) per year considering occupancy factors and source usage. Non radiation workers are different from members of the public.

6-3. Dosimetric Devices

1. **Acceptable Dosimetric Devices.** The type of dosimetric device or devices used to measure personnel exposure shall be specified by the commander, commanding officer, or officer in charge and approved by the Chief, BUMED. Unless other types of dosimetry are approved by Chief, BUMED, the dosimetry program shall be based on dosimetry as described in this chapter, and its use shall be under the cognizance of the radiation health/radiation safety officer or designated senior medical representative. Acceptable dosimetric devices include:

- a. PDs (DT-526/PD or DT-702/PD).
- b. Wrist badges (DT-526/PD or DT-702/PD or DXTRAD wrist dosimeter).
- c. DXTRAD finger ring dosimeter; single lithium fluoride (LiF) element.
- d. PD, IM Series/PD or electronic dosimeter (e.g., electronic personal dosimeters (EPDs), Alcoa Mydose).
- e. Environmental and area monitoring dosimeters (DT-526/PD, DT-702/PD, or DT-702/PD TLD cards in a Neutron Area Monitor (NAM)).
- f. Accident dosimeters, DT-518/PD, DT-526/PD (end cap), DT-702/PD, and IM-270/PD.
- g. Battlefield dosimeters, DT-60/PD, DT-648/PD, DT-236/PD, and IM-270/PD.

2. **Personnel Dosimeters (PDs).** PDs are used to monitor DDE and SDE. The dosimetric devices listed in article 6-3, paragraphs 1a through 1c are known as primary personnel dosimeters. Personnel dosimeters provide very sensitive, accurate, and dependable indications of the dose equivalent to an individual. The personnel dosimeters approved for use, and the facilities that process these TLDs, have been accredited by the NVLAP, as required by 10 CFR 20.1501. Specific instructions for wearing the DT-702/PD are given in article 6-5, paragraph 7.

3. **Wrist Badges and/or Finger Rings** are used to monitor dose equivalent to the extremities in special situations where a relatively high local exposure is expected (e.g., working with radionuclides that emit primarily energetic beta particles).

4. **PDs/Electronic Dosimeters.** Pocket and electronic dosimeters are self-indicating devices used to monitor exposure to gamma or x-ray radiation in situations where an immediate indication of the exposure is desirable. PDs are pencil shaped devices containing a small ionization chamber. These devices are susceptible to shock, moisture, and other environmental factors which may produce a false over-response. Consequently, they are used as secondary dosimetric devices and are worn in addition to the primary dosimetry device. An alternative to the PD is the

electronic dosimeter, which is normally battery powered, has a digital display of integrated dose, and can be set to alarm at a preset dose or dose rate. Electronic dosimeters are also used as secondary dosimetric devices.

5. **Environmental and Area Monitoring Dosimeters.** Environmental and area monitoring dosimeters are used at the perimeter of radiation areas or in uncontrolled spaces used (in conjunction with occupancy factors) to verify doses to members of the general public and non-radiation workers are not in excess of the limits established in Chapter 4. They are not to be posted in known high radiation areas or any other restricted area. Specific program requirements are published in program radiological controls manuals.

6. **Accident Dosimeters.** Accident dosimeters are used to monitor areas or personnel in situations where very high doses may occur as the result of an accident. These dosimeters are less accurate than personnel dosimeters but have a much higher range. These dosimeters may be worn by individuals in addition to personnel dosimeters or they may be posted in areas to facilitate dose reconstruction.

7. **Battlefield Dosimeters.** Battlefield dosimeters provide an estimate of personnel exposure to high levels of ionizing radiation that can be used to aid in medical triage of affected individuals. These dosimeters are less accurate than personnel dosimeters but have a much higher range.

8. **Special Purpose Dosimetry.** Special purpose dosimetry is used to measure the dose from unique or special sources, e.g., low energy x-rays, high energy protons, high energy heavy particles, very low or high intensity sources, etc., or to measure special radiation fields in unique or special settings, e.g., research and patient dosimetry. BUMED approval is required prior to use of special purpose dosimetry, or use of dosimetry in a manner other than prescribed in article 6.2. Requests for such approval shall be submitted to the BUMED Ionizing Radiation Branch, via NDC and include sufficient detail and procedures to clearly describe the special purpose being requested. Upon approval, guidance for use of appropriate special purpose dosimetry shall be provided by NDC.

9. **Contact Information.** For further information or clarification, technical or administrative, concerning naval personnel dosimetry contact the NDC by telephone, letter, or e-mail:

Telephone	Voice: (301) 295-0142 (DSN: 295) FAX: (301) 295-5981 (DSN: 295)
Mailing Address	Officer in Charge Naval Dosimetry Center Navy Environmental Health Center Detachment 8901 Wisconsin Avenue Bldg 4/6 Bethesda, MD, 20889-5614
Plain Language Address	NAVENVIRHLTHCEN DET BETHESDA MD
E-mail	helpnavdoscen@med.navy.mil
URL	https://navymedicine.med.navy.mil/ndc/

6-4. Lithium Fluoride Thermoluminescent Dosimetry (LiF TLD)

1. **General.** TLD is the technique of measuring dose equivalent from ionizing radiation using a crystalline substance sensitive to radiation, that when heated, produces light output that is proportional to the amount of radiation absorbed.

2. **LiF Dosimeters.** The LiF TLD is capable of detecting beta, gamma, x-ray, and neutron radiation. LiF is extremely sensitive to low level radiation exposure, including background radiation.

6-5. DT-702/PD Dosimeter

1. **General**

a. The DT-702/PD LiF TLD is designed to measure beta, gamma, x-ray, and neutron radiation. This system has four LiF TLD elements on a card and is used with a black card holder. The following paragraphs describe the use of the DT-702/PD for monitoring personnel and areas for ionizing radiation. The DT-702/PD is authorized for monitoring gamma, x-ray, beta, and neutron radiation. For neutron radiation monitoring with the DT-702/PD, a default energy correction factor provides a conservative dosimetric value and should normally be applied. For situations where refined dosimetry values are needed, specific neutron energy correction factors can be determined by the NDC as described in article 6-7, paragraph 3 (or by approved procedure with an AN/PDR-70). Requirements for use of neutron energy correction factors (NECF) may also be found in applicable radiological controls manuals.

b. Requests for application of specific neutron energy correction factors shall be submitted to BUMED Ionizing Radiation Branch for approval via the cognizant radio-logical controls program manager.

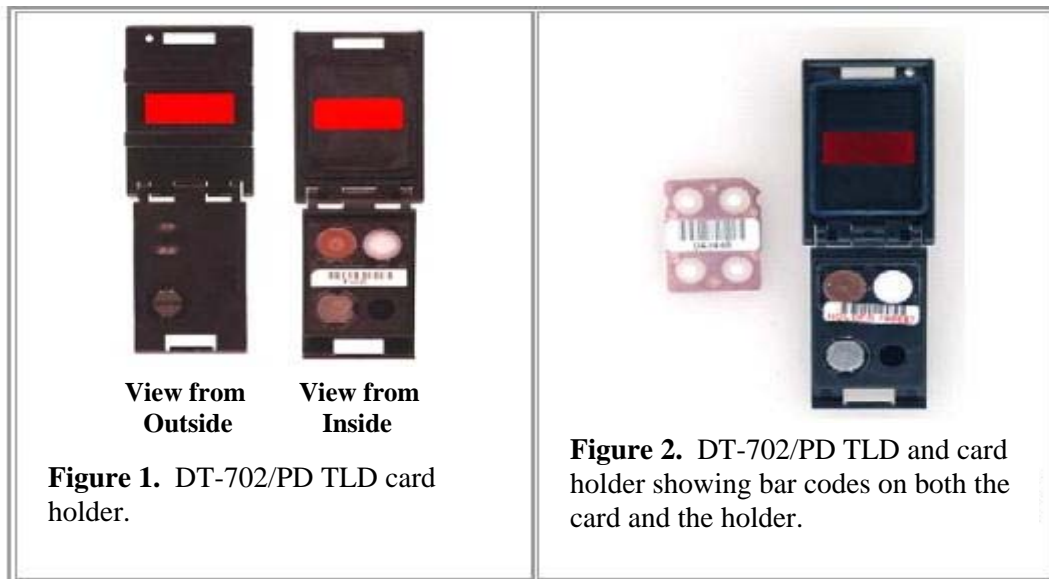
c. The DT-702/PD dosimeter has replaced the DT-648/PD because it has improved capabilities, and can meet more stringent accreditation requirements. The DT-702/PD dosimeter utilizes a new copper doped LiF TLD material, a redesigned holder, and a more robust dose calculation algorithm.

2. **Initiation.** To initiate personnel dosimetry services, submit a written request to the NDC stating the number of individuals and/or areas to be monitored, the source(s) and type(s) of radiation to be monitored, the activity's unit identification code (UIC), a desired starting date for dosimetry services, a complete mailing address, an e-mail address, and point of contact name and telephone number. Shore activities and non-nuclear powered ships shall send requests via their chains of command. Forces afloat associated with NNPP shall submit their requests via the cognizant nuclear-capable shipyard/facility and their immediate chain of command. Upon receipt of the request and approval, the NDC and/or cognizant nuclear-capable shipyard/processing facility will forward a package containing the necessary equipment for initiating the program.

3. **Implementation and Use.** Following approval of the request by NDC, the TLD processing facility will provide the following to the activity:

- ✓ A set of TLDs (quantity specified by the activity's RADIAC allowance)
- ✓ Twice the number of card holders as TLDs (one set to wear, and one set to work with when changing out TLDs)
- ✓ Card holder openers
- ✓ Identification stickers for the card holders (optional)
- ✓ Card holder clips (optional)
- ✓ External warning labels for TLD card shipment containers (if applicable)
- ✓ Return Address Label (if applicable)
- ✓ A shipping list (paper and electronic form)

4. **Component Description.** The DT-702/PD TLD card consists of four LiF:Mg, Cu, P thermoluminescent (TL) elements of different thicknesses and compositions mounted between two Teflon sheets on an aluminum substrate. The TLD card holder covers each TL element with a filter providing different radiation absorption thicknesses to allow evaluation of deep and SDEs. Elements 1, 2, and 3 are Li-7, which is sensitive to photon and beta radiation. Element 4 is Li-6, which is sensitive to photon, beta, and neutron radiation. The card has a bar code identification label across the face and must be used only in the black card holder provided specifically for this dosimeter card; no other holder is authorized. The card holder itself has a bar code located on the inside surface of the front cover. The DT-702/PD card holder is hinged and contains a window to allow verification that a TLD card is inserted. The holder is notched to prevent use of any other TLD card in the DT-702/PD holder. See Figures 1 and 2.



5. *Factors affecting accuracy.* The LiF TLD is not overly sensitive to environmental extremes, and does not require cold storage. However, to achieve the most accurate results, the following factors must be considered:

a. LiF TLD cards should be kept clean. Spurious dose readings can result if the card is soiled or chemically stained. Each TLD card shall be carefully inspected upon collection, and soiled cards cleaned prior to their return for processing. Cards may be cleaned locally using a q-tip or small soft sponge made damp with water or isopropyl alcohol. Do not use chemical solvents or cleaning fluids on LiF TLD cards. **DO NOT MARK, WRITE, OR PUT TAPE ON EITHER SIDE OF THE CARD.** Do not submerge in liquid and do not damage bar code label when cleaning. Ensure surfaces upon which the TLD cards are placed are free of chemical solvents or cleaning fluids.

b. Damaged cards (e.g., bent, broken, missing components, permanently soiled or stained) should be noted by a comment in the remarks section of the NAVMED 6470/3, Radiation Exposure Report – Whole Body. The TLD processing facility can repair most types of damage and accurately evaluate the TLD provided the damage is recognized before the card is processed.

c. Sunlight and intense artificially produced light can, after prolonged exposure, result in signal fade greater than the acceptable limit if the TLD card is exposed for several hours while removed from the holder. Thus, bare LiF TLD cards should be stored in the dark when not in use. If a bare TLD card(s) is so exposed, after being used as a personnel dosimeter, the amount of signal fade is not predictable, and therefore, a dose estimate will be required.

d. Static electricity or electrical discharge has been reported to have caused spurious dose readings on LiF TLD cards. This occurs only if the bare cards are subject to such treatment while removed from the holder. If TLD card exposure to static electricity or electrical exposure is suspected, include a comment in the remarks section of the NAVMED 6470/3.

e. The integrity of the card holder is critical to ensuring an accurate measurement. If a holder is damaged in a way that compromises its ability to protect the TLD card (for example, if the Mylar window is torn), it can allow the TLD card inside to be damaged, exposed to light, or collect dirt. Each TLD holder shall be carefully inspected prior to issue and upon collection. A defective or damaged holder shall not be used. If a holder is discovered upon TLD collection with damage that could have affected its ability to protect the TLD card, it shall be reported in the remarks section of the NAVMED 6470/3, indicating which TLD card number corresponds to the damaged holder, and the nature of the damage. If the silver Mylar window (or other components) of the DT-702/PD badge holder are damaged, the holder must be sent back to the processing facility for replacement since the window is sonically welded into place with a plastic set ring. Damage to the window does not require a subsequent dose estimate to be performed if the reading is consistent with historical data.

f. The accuracy of neutron measurements by the DT-702/PD is dependent upon the area of the body on which the dosimeter is worn. The waist provides adequate neutron moderation and reflection of thermal neutrons into the neutron-sensitive element. Proper wearing of the DT-702/PD is described in Article 6-5.7.

6. *Card Holder and Opener*

a. The DT-702/PD card has a concave cut-out on each of the two long sides of the card and is notched in one corner for proper alignment in the molded TLD card holder. With proper orientation of the TLD card, the holder snaps easily. If the holder does not close easily, check for mis-orientation of the front and back of the holder, or for some other obstruction. After snapping the holder shut, verify that the TLD card is oriented correctly by checking that the card serial number can be read upright through the red viewing window on the back of the holder when held with the hinge on the top.

b. To open the DT-702/PD holder, place the opener in the slot at the end of the holder via the back, with the thumb depressor of the opener oriented toward the opposite end of the holder, and press the opener to open the holder. Do not torque the opener in the slot of the card holder. Improper orientation will make opening impossible and could result in damage to the holder or opening tool. See Figure 3 for proper opener orientation.

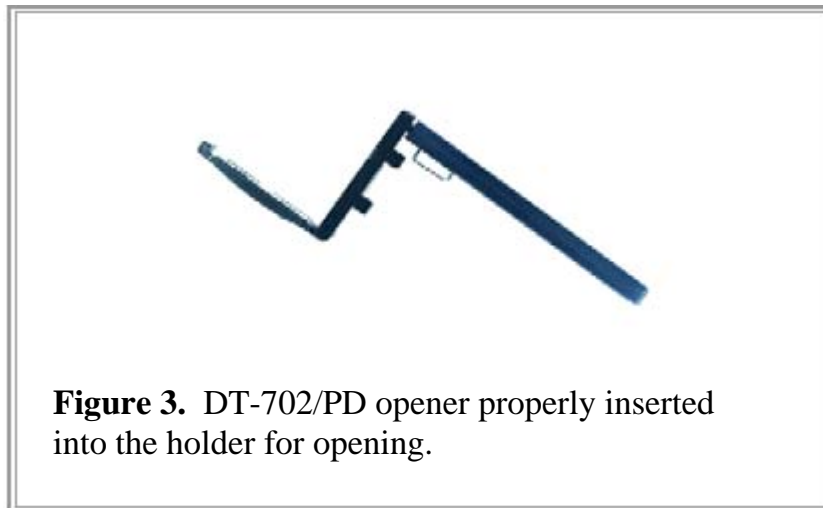


Figure 3. DT-702/PD opener properly inserted into the holder for opening.

7. *Wearing the DT-702/PD*

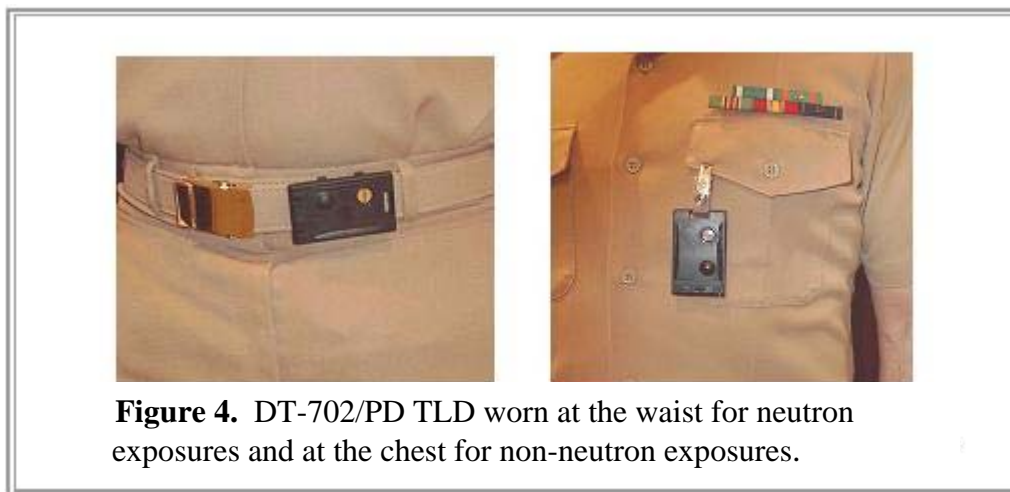
a. For photon and beta monitoring, the holder with the card enclosed should normally be worn on the front of the trunk of the body (waist or chest) when the source of radiation is likely to be isotropic or from the front of the wearer. It may be worn on the back of the waist or chest when appropriate. In unique situations, additional DT-702/PD TLDs worn in areas other than the waist or chest provide an accurate measure of beta and photon dose, but not neutron

exposure, as noted below. Additional requirements for wearing of dosimeters may be specified in the applicable radiological controls manuals. Attachment to the body is normally accomplished by one of two methods (shown in Figure 4):

(1) The belt loops on the back of the card holder can be used to place it on a belt; for neutron monitoring, this is the only method authorized;

(2) An attachable strap can be used to attach it to a pocket flap or lapel. Additional TLDs worn in unique situations may be held in place by tape, elastic or cloth bands, clips, or in plastic/cloth pouches. Regardless of the method of attachment, the badge holder must be positioned so the front of the holder is facing away from the body.

b. For neutron monitoring, the DT-702/PD must be worn at the waist for the entire issue period. The DT-702/PD may be relocated to the chest only when needed in rare situations. However, BUMED approval must be given to relocate the DT-702/PD, due to the differences in neutron correction factors at each body location. If not worn on the waist, the location shall be noted in the remarks section of NAVMED 6470/3.



8. *Issuing TLDs*

a. TLDs provided by the Naval Dosimetry Center shall be issued (a new issue period begun) within 14 working days of receipt, but no later than the expiration date printed on the TLD box and shipping list (data acquisition sheet). The expiration date determines the date when TLDs must be initially issued or returned to the processing facility. TLDs provided by a processing facility to Naval Nuclear Propulsion Program activities, tenders, and nuclear-powered ships shall be issued per requirements in the applicable radiological controls manuals. A batch is a set of TLDs which have originated from the same shipping list sharing a single expiration date. TLD batches shall not be mixed and all TLDs used during an issue period should be from the same batch. TLDs shall be inspected upon receipt to ensure the serial numbers match those on

the enclosed shipping list, and no damage has occurred in transit. If damage and/or shipping abnormality is identified, annotate conditions of receipt and/or abnormality on the NAVMED 6470/3 comment section upon the return of the batch.

(1) For situations where an intermediate command receives TLDs for a subordinate end-user, the boxes shall be issued such that the initial issue, from the batch, is prior to the expiration date. The intermediate command shall also provide accountability documentation for delivery to subordinate end-user.

(2) Information required on NAVMED 6470/3 shall be entered according to instructions on the reverse side of the form or instructions in this manual, whichever are the more current (activities using a BUMED approved computer program shall follow the instructions provided in the program). End-users shall ensure that the names and social security numbers of the individuals receiving the dosimeters are properly recorded, and the correct radiation type codes and occupational codes are properly assigned (see back of NAVMED 6470/3) to ensure proper processing and dose assignment.

b. TLDs shall be issued for a maximum period of no more than 95 days (approximately 3 months) unless alternate issue periods are specified by the applicable radiological controls manual. The following exceptions apply:

(1) Most personnel are issued LiF TLDs for the entire issue period, to include absences from the command during the issue period (for example, leave). For persons issued a TLD after the start of the issue period, or who turn in a TLD before the end of the issue period (for example, due to transfer or termination), the issue and collection dates should reflect the actual period of issue. For persons that are issued a LiF TLD for a particular job of less than the regular issue, the issue period should be for the length of time the TLD is actually issued to the individual for the job. A LiF TLD collected before the end of the issue period shall be kept with the rest of the batch until ready for submission to the processing facility.

(2) The maximum issue period for workers whose total effective dose equivalent is expected to exceed 500 mrem in a year shall be 1 month (i.e., 35 days). This worker population will be identified by radiation health personnel, based on historical dosimetry information or occupational dose projections for equipment use or procedures. Examples of such workers include nuclear medicine technologists, physicians performing angiographic and other fluoroscopic procedures, and radiographers. TLDs for these workers may be shipped to the Naval Dosimetry Center under separate cover from the batch they were originally shipped with to allow for early processing. Two unissued TLD cards from the same batch shall be enclosed with TLDs forwarded to the processing facility for early processing to provide control data.

(3) The maximum issue period for declared pregnant workers and minors who are likely to receive greater than 50 mrem in a month shall be no more than 35 days (approximately 1 month). These TLDs may also be shipped to the Naval Dosimetry Center under separate cover

from the batch they were originally shipped with to allow for early processing. Two unissued TLD cards from the same batch shall be enclosed with TLDs forwarded to the processing facility for early processing to provide control data.

(4) Personnel suspected of having exceeded an occupational dose limit shall have their LiF TLDs and two control TLDs from the same batch submitted for evaluation as soon as practicable after discovery. Submission of the TLDs should be coordinated with the processing facility to ensure receipt and prompt processing.

(5) TLDs issued at Naval Nuclear Propulsion Program activities, on tenders, and on nuclear-powered ships shall be for the periods specified in the applicable radiological controls manuals.

c. The issue periods for posted environmental or area dosimeters shall be the same as those used for personnel unless otherwise specified by the applicable radiological controls manual.

d. If replacement dosimeters are not available at the end of the normal issue period, the activity will notify the processing facility or Naval Dosimetry Center and BUMED by message or official correspondence. If a submitting activity is afloat or deployed, the issue period may be extended until the activity returns to home port or its parent command. However, if an extension of the normal issue period is necessary, the activity shall obtain authorization to extend the issue period from the processing facility by message or official correspondence.

e. LiF TLDs shall be collected and returned to the processing facility for processing within 5 working days of the end of the issue period, or as specified in the applicable radiological controls manual.

9. *Control LiF TLDs*

a. The purpose of submitting control dosimeters with each group of TLDs to be evaluated is to determine the amount of radiation dose that has accumulated on the TLDs from background or other non-occupational sources while they are in transit or being stored. It is essential to account for this background signal when processing dosimeters so that the final dose reflects the radiation exposure environment in which monitoring is being performed. As such, control TLDs should be stored with the unused cards in a low background area, away from any existing man-made radiation sources.

b. At least two LiF TLD cards from the same batch as the issued TLDs shall be included and designated as control cards in Block 4 and as Occupation Code 00 in Block 10 of NAVMED 6470/3 with each submission for evaluation, including those TLDs submitted for early or accelerated processing. If a batch is to be separated into multiple sets, additional control cards shall be designated to ensure that at least two control cards accompany each shipped set.

c. Any unused card retained in the same location and condition as the designated controls cards can be utilized as batch controls.

10. *Collecting and Submitting TLDs for Processing*

a. At the end of the issue period, all personnel and posted/area dosimeter TLDs shall be collected, the cards removed from their holders and placed in the shipping container in the same numerical order as they appear on the report form, NAVMED 6470/3. Each personnel TLD number shall be independently verified with the person's name and social security number.

b. When removing the LiF TLD card from its holder, observe any change in orientation from the designed orientation and if the TLD card has been rotated or put in upside down, note the change in orientation in the remarks section of the NAVMED 6470/3. Record any damage to the TLD card, damage to the holder that affects its ability to protect the TLD card, or any unusual occurrence associated with the TLD card during the issue period in the Remarks section of the NAVMED 6470/3. Handle cards with care; ensure hands are clean and dry. Clean dirty cards per article 6-5, paragraph 5a.

c. TLD cards shall be packed in the shipping container to maintain order. Cards may be secured in the shipping container by filling voids with packing material. Do not wrap the cards or use adhesive tape or rubber bands that contact the cards.

d. Forward an original dosimetry report, NAVMED 6470/3 with each group of TLD cards. Ensure that Blocks 1 through 10, 15 (as necessary), and 16 of the NAVMED 6470/3 are completed prior to submission. Failure to provide the data in these Blocks will result in an unnecessary and undesirable delay in dosimeter processing.

(1) The cards shall be submitted to the processing facility by traceable means (if being shipped), within 5 days after the last day of the issue period unless otherwise approved by BUMED.

(2) Each shipment of TLDs sent from the processing facility will contain a printed list of card serial numbers in that shipment. This list shall be returned with the shipment when sent to the processing facility for evaluation. If an entire shipment is being returned to the processing facility unused, the shipment shall be accompanied with a memorandum indicating the TLDs were unused.

(3) The processing facility shall record receipt of each received TLD batch in an electronic log and acknowledge receipt of the batch.

e. If a DT-702/PD dosimeter is used for research or other purposes such that it received a dose greater than five rem, it shall be segregated from the personnel monitoring TLDs and marked for special processing. This precaution is to preclude high dosed TLDs being

mistaken for personnel monitoring dosimeters. Cases where dosimeters have been dosed to in excess of 100 rads should also be indicated. Processing DT-702/PD dosimeters dosed in excess of 500 rads requires special dosimeter reader adjustments to prevent equipment damage and loss of glow curve information.

11. *Storage of LiF TLDs*

a. When issued personnel dosimeters are not being worn, they shall be stored in a low background area, i.e., an area where the dosimeters are not being exposed to radiation sources. Likewise, control and un-issued LiF TLD cards shall be stored in an area removed from radiation sources, but not in a shielded container. Unused cards may be used as control cards to improve statistical process control and therefore must be treated the same as control cards.

b. Do not stockpile batches of TLDs. Maintaining more than two sets of TLD cards is not authorized. Issue all TLDs received as replacements within 5 working days of receipt, unless delay is authorized by ISIC for deployed or afloat activities.

12. *Dosimetry Report Forms.* The form used with the DT-702/PD dosimeter is the Radiation Exposure Report, NAVMED 6470/3. The reverse side of the form has detailed instructions on how to prepare the report for submission. After the LiF cards are evaluated, a NAVMED 6470/3 will be completed by the processing facility and returned to the submitting activity.

13. *Program Changes.* Changes to the local dosimetry program shall be communicated to the processing facility by letter or official correspondence. Examples of change types that should be communicated include:

- a. Large changes in the number of personnel monitored.
- b. Problems that affect your program.
- c. Temporary or permanent termination of the requirement for dosimetry services.
- d. Address or UIC change.

14. *Identification Stickers.* The optional identification sticker may be placed only on the flat portion of the front of the black card holder. The use of different color stickers per issue period can assist in collection and distribution of the dosimeters. The identification label must never be placed directly onto the LiF card. Adhesive residue will alter the signal produced by the LiF elements when heated, producing an erroneous reading. In addition, do not write any information (e.g., the wearer's name) on the LiF card.

15. **Suspension of Dosimetry Program.** Commands may temporarily suspend personnel dosimetry during upkeep or overhaul periods as deemed operationally appropriate. Indicate the projected date of program suspension to the processing facility by official correspondence. Reactivation of the personnel dosimetry program will require official correspondence approval by the processing facility.

16. **Termination of Dosimetry Program.** To permanently terminate an existing personnel dosimetry program, submit official correspondence requesting permission to terminate dosimetry services to the Naval Dosimetry Center and cognizant processing facility, if applicable, stating the command name, UIC, projected termination date and reason for termination. Include all unused/recovered TLDs, TLD holders, holder clips, and openers with the submission of the final issue of personnel dosimetry devices. Upon receipt of the final exposure information, forward a Situational Report of Occupational Exposure, NAVMED 6470/1, with remarks in Block 17 indicating the program has been discontinued.

17. **Decommissioned Vessels and Commands.** Dispose of personnel radiation exposure records including annual and situational reports, exposure investigations, worksheets, charts, calibration results and statistical summaries as prescribed by SECNAV M-5210 (series). Documents shall NOT be forwarded to processing facilities for storage.

6-6. EPD Mk2 Electronic Personal Dosimeter

1. **General.** Recent advances in solid state detector technology and electronics have produced a new generation of electronic dosimeters that are relatively insensitive to the vulnerabilities of their ion chamber based predecessors (i.e. sensitivity to shock, electric fields, and need for dosimeter charger or reader). This lends the EPDs to effective use as secondary dosimeters in support of nuclear work, industrial radiography, fluoroscopy, nuclear medicine, radiation oncology, and other settings where immediate indication of exposure is desirable.



2. *Properties*

a. Electronic device that uses multiple radiation sensitive silicon diode detectors that produce voltage potentials proportional to the quantity of deposited radiation. The detector array is contained in a plastic case with a digital liquid crystal display (LCD), function control button, liquid emitting diode (LED) indicator and mounting clip assembly. EPD has an operating range of 0-1600 rads and is capable of detecting beta, gamma, x-ray and neutron. Navy has preinstalled configurations that will determine final usage alarms and detection capability.

3. *Use.* EPDs are used as directed by cognizant radiological controls program instructions and Navy Radioactive Material Permit conditions.

6-7. Environmental and Area Monitoring

1. *Introduction.* Environmental and area monitoring is required to demonstrate compliance with the provisions of Article 6-2 of this manual or applicable radiological controls manual. The DT-702/PD TLD may be employed to assist in meeting these requirements.

2. *Monitoring ambient photon/beta radiation:*

a. The DT-702/PD card, placed in its black holder, and posted in accessible areas immediately adjacent to restricted areas, serves as an effective monitor for ambient photon and/or beta radiation. No special mounting or phantom is required; however, the device shall be oriented so the front of the card holder faces the radiation source, if known. If the direction of the radiation source is unknown or isotropic, the orientation of the posted TLD is not important.

b. DT-702/PDs used to monitor ambient photon and/or beta radiation shall be listed as "Posted" in Block 4 of the NAVMED 6470/3. Block 5 should be left blank and occupation code 01 should be listed in Block 10 for each posted TLD.

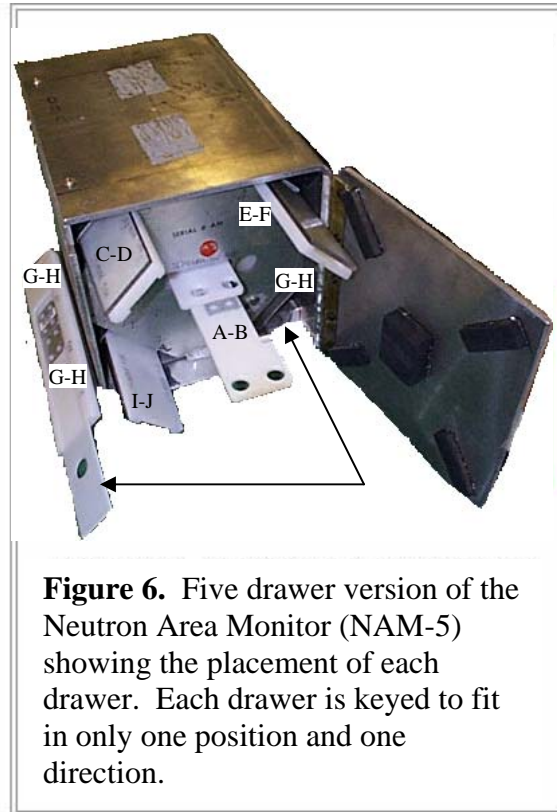
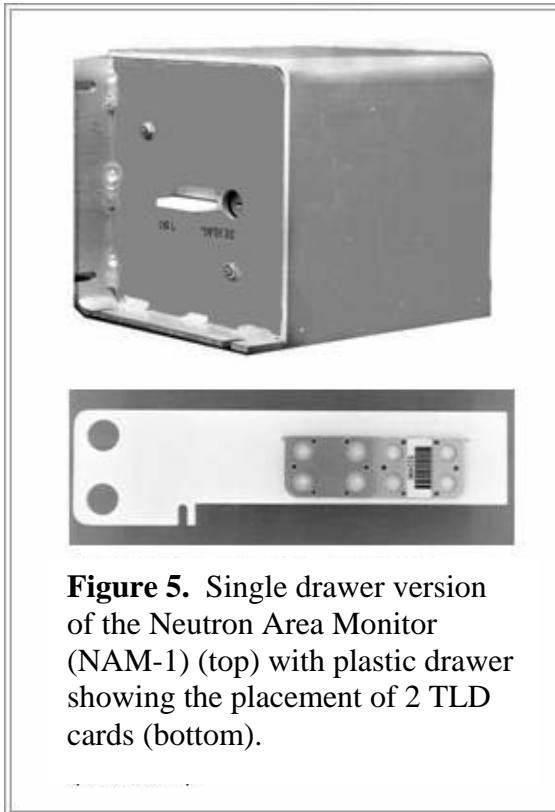
3. *Monitoring ambient neutron radiation:*

a. The DT-702/PD card placed in a polyethylene cylinder that is essentially the same size and internal design as an AN/PDR-70 and mounted in accessible areas immediately adjacent to restricted areas constitutes the only device authorized for neutron area and environmental monitoring.

b. This area and environmental monitor, designated as the Neutron Area Monitor (NAM) is available in two forms; a single drawer version (NAM-1, Figure 5) and a five drawer version (NAM-5, Figure 6). Both versions are totally encased in an aluminum box for mounting and protection.

(1) The polyethylene cylinder with a center drawer that holds two cards constitutes the single drawer version. It may be used in areas where the neutron energy spectrum is not known since it is relatively energy independent.

(2) The five drawer version is the same basic design as the single drawer version with the exception of having four additional drawers located on the perimeter. The additional perimeter TLD cards in the 5 drawer NAM allow for determination (by the NDC) of a specific NECF for DT-702/PD dosimeters in the particular NAM.



c. The NAM should be mounted, either by bolting or gluing, so one of the four larger surfaces faces the neutron source. Neither the NAM nor the DT-702/PD bare card were designed to be weatherproof. Therefore, they shall be maintained in a location such that they are protected from the weather. Two of the four surfaces are provided with mounting holes for vertical or horizontal surfaces. Mount the device so that the center drawer is in the horizontal plane with the TLDs facing upward in the drawer. This will keep them from falling out when the drawer is removed. The outer drawers have individual covers to retain the TLDs in any position. The center drawer is manually removed when unlocked and two LiF TLD cards are inserted so the notched corners of the cards align with the positioning guide in the drawer. When correctly

inserted, one card will have the I.D. number side down, and the other the I.D. number side up with the six-digit serial number visible (see Figure 5). The purpose of this design is to bring the neutron sensitive elements on each card as close together as possible for better consistency between those measurements. The perimeter drawers in the NAM work in a similar fashion, except that individual covers for these drawers need to be removed to change the TLD cards and replaced once the new cards have been inserted into position. After positioning the cards, slowly slide the drawer into the phantom, close and lock.

d. Each NAM is uniquely identified with a serial number. Each NAM drawers holds two TLD cards, the positions of which are identified with capital letters. The two cards in the middle drawer are located at positions A and B. It is unimportant which TLD position is listed as A or B for calculation purposes as both are treated equally. Similarly, each perimeter drawer in the NAM is labeled with two unique position locations (C/D, E/F, G/H, I/J) in order to record the placement of the cards located there. As with the middle drawer, the letter pairs on each perimeter drawer are interchangeable as they are treated equally in the calculations. For example, position C and D are interchangeable, as are E and F, etc. There are a total of 10 card positions (two in the middle and two in each of the four corners) in the NAM-5.

e. Allow at least two control cards for each NAM submission. Multiple NAM-5 configurations require separate NAVMED 6470/3 submissions which will entail individual electronic files, electronic media and submission of multiple batches. Units shall coordinate with processing facility prior to assigning NECF calculated by the processing facility for individual dosimeters. For each TLD card used in a NAM, list the serial number on the device followed by the one letter position code located on each drawer position in the device in Block 4 of the NAVMED 6470/3 (i.e., for the card used in position A of NAM 001, the Block 4 entry should be NAM 001A, followed on the next line by NAM 001B on the next line). Use occupation code 02 for Neutron Area Monitor dosimeters, and leave Block 5 blank.

f. The post-processing Radiation Exposure Report (NAVMED 6470/3) forwarded to commands will contain the average deep dose equivalent values for TLD cards used in position A and B only. The results from the other positions are used by the Naval Dosimetry Center to calculate the NECF. The NECF used to determine average deep dose equivalent values for each NAM will be listed in the Remarks section of NAVMED 6470/3. The TLDs used in NAMs (and associated control TLDs) must not be exposed to any other neutron source or the NECF measurement will be invalid. Although the NAM was designed primarily to monitor deep dose equivalent (neutron), the average deep dose equivalent (photon) listed on the NAVMED 6470/3 for the TLD cards used in positions A and B will adequately demonstrate compliance with the provisions of Article 6-2 for the photon component of the total effective dose equivalent unless the photon component of the ambient radiation field is of extraordinarily low energy (i.e., <100 keV). If this is the case, then it is recommended that both a NAM and a posted TLD be employed to evaluate that field for compliance with the provisions of Article 6-2.

g. A command must have an allowance, as prescribed in the RADIAC Policies and Procedures Manual (SE700-AA-MAN-100/RADIAC) to obtain a NAM. If an allowance does not exist, or the current allowance isn't sufficient, an allowance change request should be submitted as prescribed in that manual. Questions regarding the procurement of NAM equipment should be directed to the RADIAC Field Manager listed in SE700-AA-MAN-100/RADIAC.

h. Questions regarding neutron measurements, NECFs, or protocols should be referred to the NDC.

6-8. Extremity Monitoring

1. A limited number of personnel, particularly those in nuclear medicine, radiation therapy, research and some industrial applications are required to wear extremity dosimeters. Typically, individuals working with more than 1 mCi of an unshielded (with respect to their hands) source of high energy beta (e.g. P-32), photon emitter (e.g. I-125), or x-ray diffraction unit wear finger rings containing at least one TL element. To assure appropriate radiation protection practices are followed and to evaluate exposure to extremities, the NDC (or other authorized facility) provides and evaluates the DXTRAD finger ring dosimeter (Figure 7).

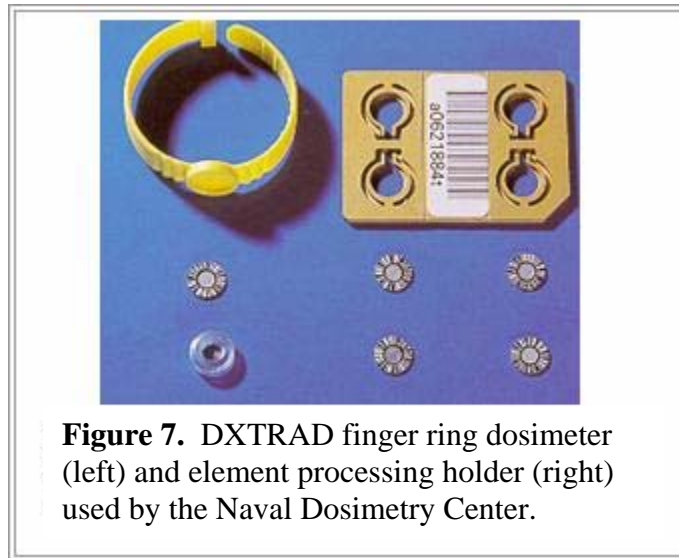


Figure 7. DXTRAD finger ring dosimeter (left) and element processing holder (right) used by the Naval Dosimetry Center.

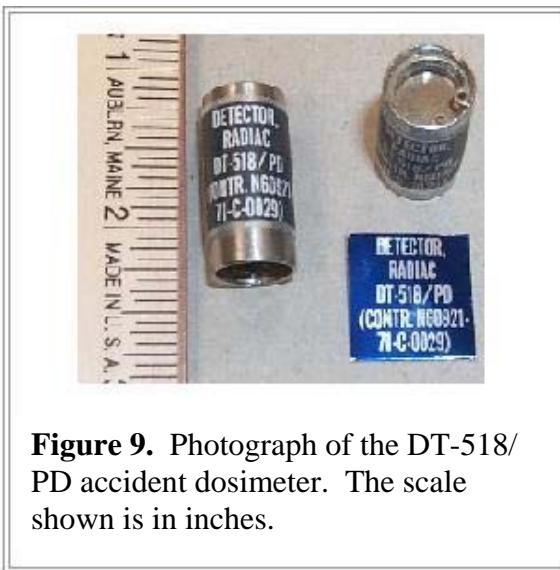
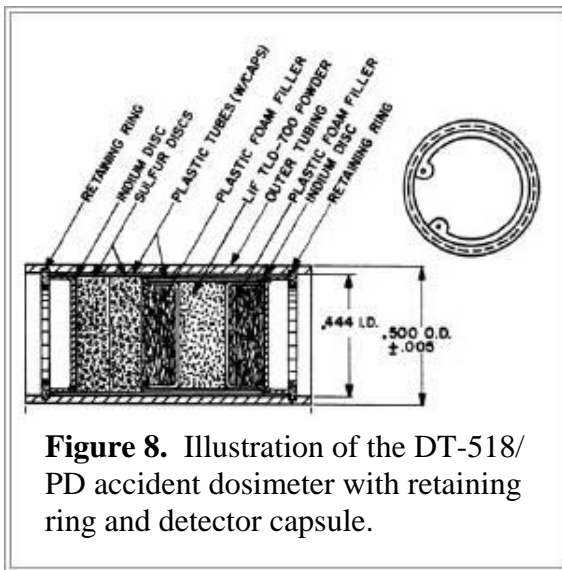
2. Finger ring service may be obtained upon request to the Naval Dosimetry Center, stating the requirement, number of personnel to be monitored, location of the dosimeter on the individual, radioactive materials being handled, and other pertinent information. The Naval Dosimetry Center provides instructions for handling and use of the DXTRAD are provided to the customer upon approval of program implementation. The NAVMED 6470/15, Radiation Exposure Report (Extremity) is used when submitting DXTRAD dosimeters for evaluation. Ensure that Blocks 1 through 10, 15 (as needed) and 16 are complete and accurate prior to submission of dosimeters for processing. DXTRAD finger ring dosimeters are shipped to the

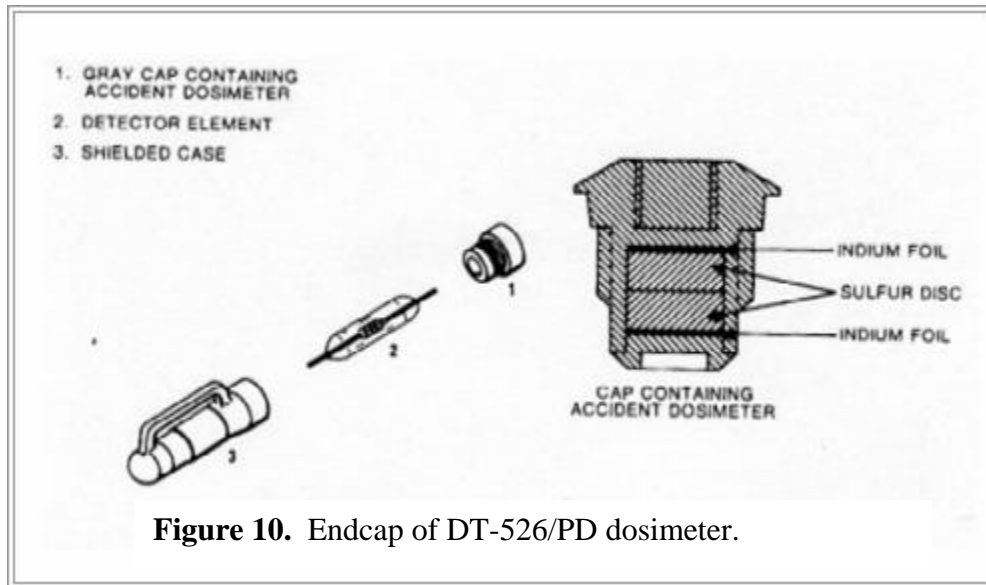
requestor ready for use. The dosimeter is shipped with a LiF TL element already installed requiring no adjustment. The DXTRAD should be returned to the NDC in the same material condition (unopened) as received.

6-9. Accident Dosimeters

1. The DT-518/PD accident dosimeter (Figures 8 and 9) is a passive dosimeter which is mounted on secondary shielding surrounding naval nuclear propulsion plants.

2. The DT-518/PD contains sulfur pellets, indium foils, and thermoluminescent powder. The indium foils may be used for field evaluation of the approximate neutron dose. The sulfur pellets (for definitive neutron dose determination; 10-50,000 rads) and the thermoluminescent powder (for gamma dose determination; 1 - 10,000 rads) are evaluated by the Naval Dosimetry Center post-exposure. Similar sulfur pellets and indium foils are also contained in the end cap of the DT-526/PD (Figure 10).





3. In the event of a suspected high dose (accident dose) to an individual wearing the DT-526/PD, refer to BUMEDINST 6470.10 series, Enclosure 5, and “Neutron Exposure.”

4. In the event of a suspected high dose (accident dose) to the posted DT-518/PD:

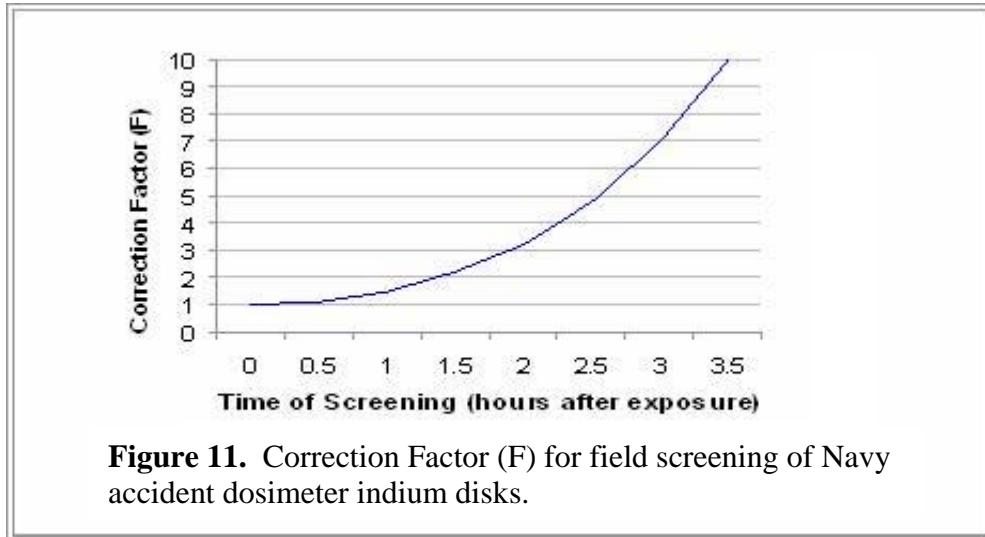
a. Record the time at which the accident is believed to have occurred. Promptly obtain a properly functioning gamma-ray sensitive RADIAC (e.g., IM-265/PDQ multi-function RADIAC). Read and record the meter indication as the background reading.

b. Place the accident dosimeter against and parallel to the most sensitive gamma probe (normally largest in size). The beta shield should be closed (if applicable). Observe the meter reading as the accident dosimeter is moved along the length of the probe. Record the highest reading observed as the gross reading. The gross-reading time shall be recorded.

c. Subtract the background reading from the gross reading. This difference is the net reading (nr). An estimated neutron accident dose ($\pm 25\%$) can be calculated for the point where the accident dosimeter was located at the moment of the accident as follows:

$$\text{Neutron Accident Dose (rads)} = \text{nr (mR/h)} \times 8 \times (F)$$

where the Correction Factor (F) is obtained from Figure 11 using the time of screening (hours after exposure) which is calculated as the time interval between the gross reading and the presumed time of the accident.



d. Finally, the accident dosimeter shall be sent to the NDC for definitive evaluation.

6-10. Battlefield Dosimeters

1. *DT-60 Navy battlefield dosimeter* (Figure 12).



a. Passive dosimeter that uses a silver phosphate glass that darkens with exposure to high-energy gamma and thermal neutron irradiation. The dosimeter is housed in a black plastic case sealed with a rubber gasket.

- b. The DT-60 is read in the CP-95/PD Reader.
 - (1) The CP-95/PD runs on 110V, 60 Hz AC power.
 - (2) This reader is calibrated for Co-60 gamma exposure.
 - (3) The CP-95 Reader has two scales that readout in roentgen (R) or rads (0 - 200 and 0 - 600).
- c. The lower limit of detection for the DT-60 dosimeter is 10 rads.

2. *DT-236 Marine Corps battlefield dosimeter (Figure 13)*

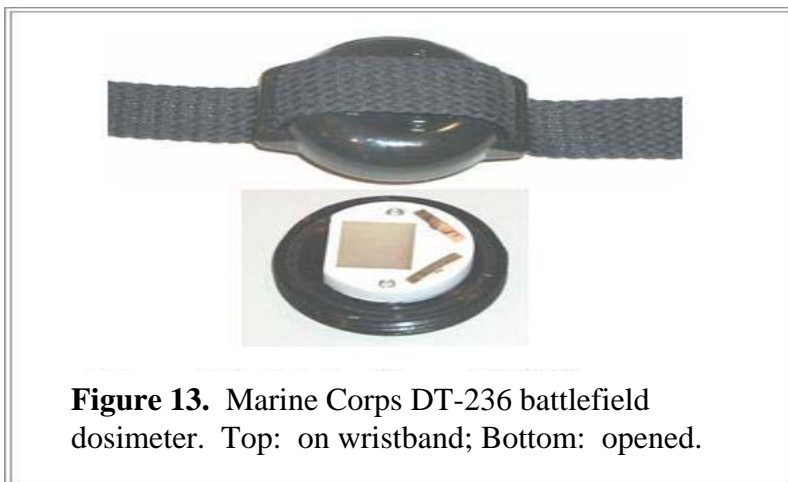


Figure 13. Marine Corps DT-236 battlefield dosimeter. Top: on wristband; Bottom: opened.

- a. Designed to measure short duration, high intensity neutron and prompt gamma radiation.
- b. Uses a silicon junction diode to measure neutron radiation and a silver activated phosphate glass to measure gamma radiation.
- c. The elements are encased in a tamper resistant locket worn on the wrist.
- d. The DT-236 can be used over a wide temperature range (-32° C to +52° C) and withstands all military environmental requirements e.g. shock, vibration, nuclear hardness and decontamination.
- e. The DT-236 is read with the AN/PDR-75 RADIAC set powered by a 24 Volt DC source and uses a single digital readout to display the combined gamma and neutron dose ranging from 0 to 1000 rads. The reader takes non-destructive readings as often as desired. The lower limit of detection for these devices is 5 rads neutron and 5 rads gamma.

3. *IM-270/PD Personnel Accident Dosimeter.* The IM-270/PD dosimeter is a personnel accident dosimeter that uses metal oxide semiconductor field effect transistor (MOSFET) technology. It is designed to detect x-ray and gamma rays. It has a dynamic range of 10-1000 rad in 1 rad increments which will initiate after an initial exposure of 10 rads. The IM-270/PD has a battery life expectancy of 10 years.



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RADIOLOGICAL CONTROLS

Article	Title	Page
7-1	Introduction	7-1
7-2	Radiological Control Program Requirements	7-1
7-3	Dental Commands	7-2

7-1. Introduction. Effective radiological controls are essential for the safe and beneficial use of ionizing radiation in the practice of the healing arts and to ensure compliance with all applicable regulations. The underlying principle for these controls is that the storage, handling, transportation and disposal of radioactive material and use of devices that generate ionizing radiation will be controlled so that personnel will not be exposed to radiation unnecessarily and that any exposures received will be maintained ALARA.

7-2. Radiological Control Program Requirements

1. The Navy has a specific license of broad scope for use and control of NRC-licensed radioactive materials at Navy and Marine Corps commands where the NRC has regulatory jurisdiction. The Naval Radiation Safety Committee (NRSC), as defined in OPNAVINST 6470.3 series, controls all NRC-licensed radioactive materials used in the Navy and Marine Corps (except nuclear propulsion, nuclear weapons, and certain components of weapons delivery systems). The NRSC issues NRMP to individual commands authorizing the use of such materials, as well as naturally occurring, and accelerator-produced material within the constraints provided by all applicable laws and regulations. The NMCPHC, Norfolk is the technical support center charged with coordination of the NRMP program for naval Medical Department activities. BUMED provides management oversight of NMCPHC.

2. Navy Medical Department radiological systems (e.g., x-ray units) must be evaluated on a periodic basis to ensure safe and proper operations and to demonstrate compliance with Federal regulations and accreditation standards. BUMEDINST 6470.22 series established the Navy Radiological Systems Performance Evaluation Program to meet these goals.

3. The Director, NNPP is responsible for all aspects of the Navy's nuclear propulsion, including research, design, construction, testing, operation, maintenance, and ultimate disposition of naval nuclear propulsion plants per Presidential Executive Order 12344 and Public Laws 98-525 and 106-65. The Program's responsibilities include all related facilities, radiological controls, environmental safety, and health matters, as well as selection, training, and assignment of personnel. Naval nuclear propulsion activities shall follow the requirements of the applicable NAVSEA Radiological Controls Manual.

4. The Commander, Naval Sea Systems Command is responsible for prescribing and enforcing standards and requirements for control of radiation and radioactivity associated with the nuclear weapons program. Navy nuclear weapons activities shall follow the applicable requirements of NAVSEA TW120-AA-PRO-010 (Nuclear Weapons Radiological Controls Program Manual).

5. The RASP issues radiological control requirements for all sources of ionizing radiation within the Navy and Marine Corps except nuclear propulsion, nuclear weapons, and medical-dental support. These requirements are contained in NAVSEA S0420-AA-RAD-010 (RASP Manual). The Radiological Affairs Support Office (RASO), Yorktown, is the technical center charged with coordination of the NRMP program for non-medical department activities.

7-3. Dental Commands

1. Policy

a. In 1993, BUMED informed naval commands that personal radiation monitoring in dental spaces is not required. In addition, these personnel are not required to receive radiation physicals. Under unusual circumstances, the commanding officer may require personnel monitoring to address unique radiation exposure situations.

b. National Council on Radiation Protection and Measurements (NCRP) Report 145 recommends that personnel dosimeters for external exposure measurement should be considered for workers who are likely to receive an annual effective dose in excess of 1mSv (0.100 rem). Further, it suggests that personal dosimeters should be provided for known pregnant occupationally-exposed personnel. BUMED reviewed the radiation exposure for all reporting dental clinics that operate intraoral, panoramic, and/or cephalometric dental x-ray units and found the average exposure to dental personnel was 0.004 rem (0.04 mSv) (based on year 2001 data).

c. NCRP Report 145 concludes that the use of a leaded apron is not required, although it is a good practice. However, Navy policy requires a minimum of 0.25 mm lead equivalent apron to be used for all radiographic applications to maintain all exposures ALARA. The Navy requirement is for an annual visual inspection with x-ray evaluation of suspicious areas. In summary, it is the Navy's policy to use lead aprons, specifically a minimum of 0.25 mm lead equivalent, for all radiographic applications.

2. Requirements

a. Dental spaces which operate intraoral, panoramic, and/or cephalometric x-ray equipment are not required to issue personal dosimeters. Dental environmental and area monitoring is not required for the previously mentioned spaces.

b. Dental repair technicians who service radiology equipment shall wear personal dosimeters due to the remote possibility of an accidental exposure.

c. Due to the unknown radiation levels produced by new radiation producing technologies (i.e., cone-beam dental CT), personnel who operate these technologies should receive radiation physicals and spaces monitored as appropriate following Chapter 2. Further guidance will be published as these new technologies are evaluated.

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ACRONYMS

AK	Actinic Keratosis
ALARA	As Low as Reasonably Achievable
ALI	Annual Limit on Intake
ARCMIS	Automated Radiological Controls Management Information System
BCC	Basal Cell Carcinoma
BUMED	Bureau of Medicine and Surgery
CBR	Chemical, Biological, and Radiological
CD	Considered Disqualifying
CFR	Code of Federal Regulations
CNO	Chief of Naval Operations
CMC	Commandant of the Marine Corps
CSCA	Controlled Surface Contamination Areas
DAC	Derived Air Concentration
DDE	Deep Dose Equivalent
DINA	Dosimetry Issue Not Allowed
DRE	Digital Rectal Exam
EOD	Explosive Ordnance Disposal
EPD	Electronic Personal Dosimeter
FMA _s	Fleet Maintenance Activities
HCT	Hematocrit
ICRU	International Commission on Radiation Units and Measurements
ISIC	Immediate Superior in Command
LiF	Lithium Fluoride
MDA	Minimum Detectable Activity
NAM	Neutron Area Monitor
NARER	Navy Automated Radiation Exposure Registry
NAVSEASYSKOM	Naval Sea Systems Command
NCD	Not Considered Disqualifying
NCRP	National Council on Radiation Protection and Measurements
NDC	Naval Dosimetry Center
NECF	Neutron Energy Correction Factors
NMCPHC	Navy and Marine Corps Public Health Center
NNPI	Naval Nuclear Propulsion Information
NNPP	Naval Nuclear Propulsion Program
NOFORN	Not Releasable to Foreign Nationals
NPQ	Not Physically Qualified
NRC	Nuclear Regulatory Commission
NRMP	Naval Radioactive Materials Permit
NRSC	Naval Radiation Safety Committee
NUMI	Naval Undersea Medical Institute
NVLAP	National Voluntary Laboratory Accreditation Program

PD	Pocket Dosimeter
PE	Preplacement Examination
PQ	Physically Qualified
RADIAC	Radiation Detection, Indication, and Computations
RADSTAR	Recruitment Assistance Division, Student Training and Academic Recruitment
RASO	Radiological Affairs Support Office
RASP	Radiological Affairs Support Program
RE	Reexamination
REAB	Radiation Effects Advisory Board
REM	Roentgen Equivalent Man
RHA	Radiation Health Assistant
RHI	Radiation Health Indoctrination
RME	Radiation Medical Examination
SAMS	SNAP Automated Medical System
SDE	Shallow Dose Equivalent
SE	Situational Examination
SI	System International
SN	Service Number
SNAP	Shipboard Non-tactical ADP Program
SSN	Social Security Number
TE	Termination Examination
TLD	Thermoluminescent Dosimeters
TYCOM	Type Commander
UMO	Undersea Medical Officer
WBC	White Blood Count

1. Forms. The following Navy Medicine (NAVMED) Forms are available electronically at: <https://navalforms.daps.dla.mil/web/public/home>.

Form No.	Form Title
6470/1 (Rev. 04-2010)	Exposure to Ionizing Radiation
6470/3 (Rev. 04-2010)	Radiation Exposure Report – Whole Body
6470/10 (Rev. 04-2010)	Record of Occupational Exposure to Ionizing Radiation
6470/11 (Rev. 04-2010)	Record of Occupational Exposure to Ionizing Radiation From Internally-Deposited Radionuclides
6470/13 (Rev. 04-2010)	Ionizing Radiation Medical Examination
6470/15 (04-2010)	Radiation Exposure Report (Extremity)

2. Reports. The reporting requirements for this manual are exempt from reports control per SECNAV M-5214.1 of December 2005, paragraphs 7g and 7p.

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ANNUAL LIMIT ON INTAKE

The annual limit on intake (ALI) and derived air concentrations (DAC) of some common isotopes as listed in Appendix B, Title 10 CFR 20 are provided below:.

Isotope	ALI (μCi) *		DAC * ($\mu\text{Ci}/\text{ml}$)
	<i>Ingestion</i>	<i>Inhalation</i>	
Americium-241	0.8	0.006	3×10^{-12}
Carbon-14	2000	2,000	1×10^{-6}
Cesium-137	100	200	6×10^{-8}
Chromium-51	40,000	20,000	8×10^{-6}
Cobalt-60	200	30	1×10^{-8}
Iodine-123	3,000	6,000	3×10^{-6}
Iodine-125	40	60	3×10^{-8}
Iodine-131	30	50	2×10^{-8}
Iridium-192	900	200	9×10^{-8}
Phosphorous-32	600	900	4×10^{-7}
Plutonium-239	0.8	0.006	3×10^{-12}
Radium-226	2	0.6	3×10^{-10}
Strontium-90	30	4	2×10^{-9}
Technetium-99m	80,000	200,000	6×10^{-5}
Thallium-201	20,000	20,000	9×10^{-6}
Thorium-232	0.7	0.001	5×10^{-13}
Tritium (H-3)	80,000	80,000	2×10^{-5}

* ALI and DAC values listed assume the most conservative class. If the chemical form is known, a more appropriate class may be used.

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