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Principles and Practices for Keeping Occupational Radiation Exposures at Medical Institutions As Low As Reasonably Achievable

J.S. Nuclear Regulatory Commission

Office of Nuclear Regulatory Research

A. Brodsky

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PREFACE

This report is a companion document to Regulatory Guide 8.18, "Information Relevant to Ensuring that Occupational Radiation Exposures at Medical Institutions Will Be As Low As Reasonably Achievable." Both this document and Regulatory Guide 8.18 have been revised to incorporate many good suggestions received after the original documents were published for comment.

The regulatory guide sets forth some of the major considerations in establishing management policies, staff, facilities and equipment, and operational procedures to promote radiation safety in medical or hospital care programs using radioactive materials licensed by the U.S. Nuclear Regulatory Commission (NRC). This report is a compendium of good practices and helpful information derived from the experience of the radiological and health physics professions and is not to be construed in any way as additional regulatory requirements of the Nuclear Regulatory Commission. In fact, many of the suggestions made in this report are based on accepted health protection practices not specifically addressed in NRC regulations. The information presented is intended to aid the NRC licensee in fulfilling the philosophy of maintaining radiation exposures of employees, patients, visitors, and the public as low as reasonably achievable (ALARA).

Sections of this report are numbered in the same sequence as sections of Regulatory Guide 8.18 for the convenience of the reader in examining specific topics of interest, except that Sections A, B, and C of the guide correspond to Chapters 1, 2, and 3, respectively, of this report. Thus Section 3.3.2 of this report addresses the same topic as Regulatory Position C.3.2 in the guide. Also, while efforts have been made to eliminate redundancy, each subsection of this report is designed to include the major radiation safety considerations of interest to the specific type of activity. Consequently, the busy doctor, administrator, or health professional will usually, by referring to the table of contents, need to read only a few pages of this document at any one time to obtain the information he or she needs. Additionally, in smaller institutions or private practice offices where many of the medical activities discussed in this report are not conducted, the physician or his or her staff may not need to read certain sections or subsections at all.

Any principles and practices contained in this document that involve reporting and recordkeeping are related to information collection requirements previously approved by OMB under the Paperwork Reduction Act, OMB Clearances 3150-0010, 3150-0014 and 3150-0015.

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CHAPTER 1. INTRODUCTION

Paragraph 20.1(c) of Title 10, Part 20 of the Code of Federal Regulations (10 CFR Part 20) states that NRC licensees should make every effort to maintain exposures to radiation, as well as releases of radioactive material to unrestricted areas, as low as is reasonably achievable (Ref. 1). Regulatory Guide 8.10, "Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable" (Ref. 2), sets forth the philosophy and general management policies and programs for achieving this objective of maintaining radiation exposures to employees "as low as reasonably achievable" (ALARA). This report provides information to assist the medical licensee in the design and construction of patient care or laboratory installations and in the planning and supervision of procedures using radioactive materials so as to achieve the objective of keeping radiation exposures within medical institutions ALARA. Detailed examples of radiation safety practices and procedures that are acceptable to the NRC licensing staff are now given in Regulatory Guide 10.8, "Guide for the Preparation of Applications for Medical Programs." More detailed guidance on radiation surveys is given in Regulatory Guide 8.23, "Radiation Safety Surveys at Medical Institutions." These two guides provide specific guidance on practices and procedures that supplement the general outline of principles and practices contained in this report and in Regulatory Guide 8.18.

Since the concept of keeping exposures ALARA is not new in the field of radiation protection, a number of excellent documents that give detailed methods for protecting employees and the public have already been prepared by national and international organizations. (See Bibliography section of this report.) A list of some of these organizations and their addresses is provided at the end of the Bibliography section. Practically all of the recommendations in these documents, some of them specific to activities in medical institutions, would help to achieve the ALARA objective. Many of the larger established medical institutions have, of course, been following these standard guides for some time and are already familiar with the ALARA concept. Indeed, some of these guidelines have originated from the experience gained in the more established and pioneering institutions.

This report and its associated guide deal only with radioactive materials subject to licensing by the Nuclear Regulatory Commission. The regulations and recommendations of other agencies, including Agreement States, should be consulted in regard to controlling radiation exposures from radiation-producing machines and materials not licensed by NRC. (A list of Agreement States and contact addresses is given in Appendix A.)

Design and planning considerations for ensuring that exposures will be ALARA within restricted areas in medical institutions often cannot be separated from considerations of public exposure or exposure to employees, patients, and

visitors in unrestricted areas.* Thus, many of the suggestions in this report provide methods of achieving exposures ALARA in restricted areas while at the same time ensuring that exposures will be ALARA in unrestricted areas.

*Restricted and unrestricted areas are defined in 10 CFR Part 20. "Restricted area" means any area access to which is controlled by the licensee for purposes of protecting individuals from exposure to radiation and radioactive material. A restricted area may not include any areas used as residential quarters, although a separate room or rooms in a residential building may be set apart as a restricted area.

CHAPTER 2. BACKGROUND

The principle of maintaining occupational radiation exposures (as well as public exposures) "as low as is reasonably achievable" (ALARA) is an extension of an original recommendation of the National Committee on Radiation Protection (now the National Council on Radiation Protection and Measurements (NCRP)) in its 1949 report (published in 1954 as Report No. 17 (Ref. 3)). In this early report, the NCRP introduced the philosophy of adopting the conservative assumption that any radiation exposure may carry some risk and recommended that radiation exposure be kept at a level "as low as practicable" (currently referred to as "ALARA") below the recommended maximum permissible dose (MPD) equivalent.

Similar recommendations to keep exposures ALARA have been included in NCRP reports (Ref. 4), as well as in recommendations of the National Academy of Sciences--National Research Council (Ref. 5), the Federal Radiation Council (Ref. 6), and other independent scientific and professional organizations.

Since the inception of Federal programs for licensing and regulating radioactive byproducts of atomic (nuclear) energy, regulations have been written and guidance provided by Federal agencies with the aim of complying with these recommendations of independent scientific and professional organizations. Statements of Consideration published with various regulations have affirmed the prudence of maintaining radiation exposures as far below the regulatory limits as practicable.

The principle of ALARA is now codified as an integral part of the Commission's regulations in 10 CFR Part 20, "Standards for Protection Against Radiation." Paragraph 20.1(c) states that persons engaged in licensed activities should make every reasonable effort to maintain radiation exposures, and releases of radioactive materials in effluents to unrestricted areas, as far below the limits specified in this part as practicable.

Paragraph 20.1(c) also states: "The term 'as low as is reasonably achievable' means as low as is reasonably achievable taking into account the state of technology, and the economics of improvements in relation to benefits to the public health and safety and other societal and socioeconomic considerations, and in relation to the utilization of atomic energy in the public interest." Also, in 10 CFR Part 51, "Licensing and Regulatory Policy and Procedures for Environmental Protection," applicants for licenses to construct or operate production or utilization facilities are required to include in their environmental reports a cost-benefit analysis that considers and balances the environmental effects of the facility and the alternatives available for reducing or avoiding adverse environmental effects, as well as the environmental, economic, technical, and other benefits of the facility. Specific cost-benefit analyses have not been required in the licensing of medical institutions in the belief that such a requirement would be an unreasonable interference with medical practice. However, in the licensing of medical institutions, NRC staff practice has been to review applications to ensure that reasonable radiation safety facilities, equipment, and procedures would be

provided to maintain exposures to employees and the public at the lowest practicable levels consistent with the provision of good medical care.

Despite the history of independent recommendations and regulatory provisions for maintaining exposures ALARA and the initiatives of most industrial, medical, and academic licensee institutions in maintaining average employee exposures well below regulatory limits, NRC inspections and professional reports in the literature have indicated that, in many cases, exposures could be further reduced by reasonable efforts and the adoption of good radiation safety practices (Refs. 7-9). Further, for both private and university-affiliated medical institutions, an adequate radiation safety program can be shown to reduce costs and improve the effectiveness of medical and research programs (Ref. 10), in addition to maintaining radiation exposures ALARA.

To assist in the administration of the ALARA philosophy in institutions licensed or applying for a license by NRC, the staff issued Regulatory Guide 8.10 (Ref. 2), which lists for all specific licensees the types of management commitments and radiation protection programs that would help to achieve the objective of maintaining occupational exposures ALARA.

Since there is evidence that a review of radiation safety practices for medical institutions would be helpful in achieving ALARA exposures (Refs. 7, 11), this report was developed. In writing this document, the author has relied heavily on the comments and suggestions of affected licensees and has endeavored to ensure that due consideration is given to the beneficial products and services of the licensees.

One general point should be reiterated regarding the concept of ALARA in relation to medical institutions. Regulatory Guide 8.10 points out that, as a consequence of the linear, no-threshold dose-effect relationship recommended by the National Academy of Sciences/National Research Council Committee on the Biological Effects of Ionizing Radiation (BEIR) (Ref. 5) for prudence in establishing radiation protection programs, the reduction of occupational exposures to individuals by exposing a larger number of employees to the same procedure involving radiation sources may not truly accomplish the objectives of ALARA. Although the assumption of a linear dose-effect relationship is currently believed to overestimate effects at low doses and dose rates, the distribution of the same number of person-rems among a larger number of persons could (under the linearity hypothesis) still result in the same total probability of health effects (Ref. 5, p. 88). Further, an even more adverse effect might be expected if, in the process of attempting to reduce the average and maximum individual exposures, procedures were adopted that exposed a larger number of persons to an even larger number of person-rems. There are some circumstances within medical institutions in which the principle of reducing the collective dose in person-rems as well as the average dose in rems per person should be considered in carrying out the programs and methods suggested in this report.

On the other hand, the 1972 BEIR committee report also states: "The public must be protected from radiation but not to the extent that the degree of protection provided results in the substitution of a worse hazard for the radiation avoided. Additionally, there should not be attempted the reduction

of small risks even further at the cost of large sums of money that spent otherwise would clearly produce greater benefits." (Ref. 5) This consideration is also taken into account in the concept of ALARA, and would still be applicable under 1980 BEIR committee findings.

Taking into account the above considerations, Chapter 3 of this report discusses some of the main considerations and methods for achieving exposures that are ALARA in medical institutions. The licensee could also use the references provided and additional literature cited as appropriate to the nature and extent of procedures involving radioactive materials.

CHAPTER 3. METHODS FOR MAINTAINING EXPOSURES ALARA

The methods and considerations presented in this section are intended to assist the medical institutions in conducting radiation safety programs that will keep exposures ALARA.

3.1 MANAGEMENT PHILOSOPHY AND ORGANIZATION

The management* of a medical institution has the following radiation protection responsibilities:

1. Keep exposures ALARA for employees, visitors, students, and patients who are not under medical supervision for the administration of radiation or radioactive materials for therapeutic or diagnostic purposes.

2. Avoid significant increases in environmental radioactivity.

Regulatory Guide 8.10 lists a number of actions that the licensee institution can take to carry out these responsibilities. Implementation of these actions may be tailored to the size of the institution and the nature and extent of its uses of radioactive material. The management actions include:

1. Information and policy statements to medical and hospital staff personnel regarding management's commitment to maintain exposures ALARA;

2. Periodic management audit of efforts to maintain exposures ALARA;

3. Continuing management evaluation of radiation safety staffing and program requirements to achieve ALARA exposures as well as compliance with other regulatory requirements;

4. Management programs to ensure that all hospital staff and employees receive appropriate briefings and continuing education and training in radiation safety and in the ALARA concept;

5. Delegation of sufficient authority to the Radiation Safety Officer** (RSO) to develop radiation protection procedures and to enforce regulations and administrative policies regarding radiation safety; and

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* "Management" is defined as those persons authorized by the charter of the medical institution to make its policies and direct its activities.

** The term "Radiation Safety Officer" is used by many licensees and will be used in this guide to designate the qualified individual who is responsible for carrying out the institution's radiation safety program and who is listed as the "Radiation Safety Officer" on the institution's "Application for Materials License--Medical," Form NRC-313M. Other titles for this individual, such as "radiation protection officer," are equally acceptable.

6. Administrative direction to ensure that any new construction or modifications to hospital facilities or equipment that may affect the radiation protection of employees, patients, visitors, students, or the public will be made in consultation with the RSO or the qualified individual listed in the license application who is responsible for carrying out the institution's radiation safety program.

Regulatory Guides 8.10 and 10.8 provide further discussions of items 1 through 6.

3.2 RADIATION SAFETY OFFICE FUNCTIONS

The term "Radiation Safety Office" is used here only to indicate an entity established in the organization to direct and coordinate administrative aspects of the radiation safety program (e.g., supervision, emergency calls, requests for assistance, required records and reports, training and briefings, radiation safety equipment, and supplies). This entity can be maintained most effectively in a specific office under the direct or overall supervision of the Radiation Safety Officer (RSO).

3.2.1 STAFFING AND ORGANIZATIONAL REQUIREMENTS

The staffing and organizational requirements for a medical institution's radiation safety program can vary widely depending on:

1. The nature and extent of uses of radioactive material or radiation sources;

2. The quantity, relative radiotoxicities, and radiation intensities of the sources;

3. The availability of qualified personnel in the various departments; and

4. The existing organizational and budgetary structure of the institution.

Institutions using only limited amounts of low-radiotoxicity byproduct materials in standard clinical assay or laboratory experiments may be able to carry out the Radiation Safety Office functions and the responsibilities of the RSO with existing medical staff and hospital personnel. Institutions using large or potentially more hazardous amounts of radioactive material, however, may require full-time professional staff and technician assistants devoted just to carrying out the requirements of the NRC license and regulations and complying with the ALARA exposure philosophy and recommendations for good radiation safety practice.

In these larger medical institutions with more extensive uses of radioactive material, experience has shown that probably the most important factor in maintaining good radiation protection practices and compliance with regulatory requirements and the ALARA philosophy is the provision of adequate staff, organization, and administrative authority for the Radiation Safety Office. There are numerous tasks and duties implied by NRC licenses and

regulations for the larger institutions, and these tasks and duties should be carried out under qualified professional supervision with adequate technical and clerical assistance. In addition, the RSO or individual delegated by the RSO to carry out the duties of the Radiation Safety Office can function most effectively if located in the organization in such a way and with sufficient authority that other hospital duties and responsibilities will not be allowed to infringe on his or her full devotion to the radiation safety program.

A sample outline of the various tasks of a typical Radiation Safety Office is presented in Appendix B. The extent of time and effort required for each task varies with the size of the hospital and the nature and extent of radioactive material usage. It is important that management review periodically the staffing requirements for each of these tasks and provide the necessary personnel to establish radiation safety program requirements. Management evaluation of program performance at least once per year is also important for providing proper direction and support.

Table 1 shows estimated minimum radiation safety staffing needs for various categories of medical institutions. The categories were selected according to the nature and extent of the medical institution's procedures with radioactive sources and radioactive materials. More specific estimates may be made by the management of each specific institution according to the time required for the tasks indicated in Appendix B.

The minimum time estimates of Table 1 take into account only the effort needed to comply with NRC regulatory requirements and the ALARA philosophy. They do not take into account all of the professional time requirements of larger hospitals for carrying out such radiological physics or medical physics and engineering functions as calibration of radiation therapy sources, planning of radiation therapy treatments, checks of nuclear medicine instrumentation, maintenance and repair of a variety of hospital electronic and scientific equipment, design and selection of general medical equipment, or other hospital engineering functions required in the planning and efficient utilization of hospital facilities.

3.2.2 RADIATION SAFETY PERSONNEL QUALIFICATIONS

For the same reasons that staffing requirements vary widely between different medical institutions, the qualifications of those supervising or carrying out the radiation safety program will also vary. In Category I hospitals (as indicated in Table 1), radiation safety surveillance and record-keeping requirements may be assigned as a part-time function to one of the radiology technicians who has had training in the principles of radiation protection in hospitals. This technician could then serve as the radiation safety technician under the supervision of the RSO, who may be a member of the full-time medical staff of the Nuclear Medicine Department or the Department of Radiology. Other arrangements may also be appropriate for a hospital using limited quantities of the less radiotoxic materials.

As indicated in Table 1, larger institutions may require either part-time or full-time professional staff trained and experienced in radiation protection theory and practice. Larger institutions should consider the need for at least one full-time professional health physicist (or radiological physicist) with at

least two years of experience in a hospital radiation safety program in addition to an education in one of the basic sciences or engineering sciences related to radiation protection. The larger programs may also require personnel with advanced training in radiation health or health physics at the graduate level.

Whatever the organizational structure and staffing provided for the radiation safety program, it is important that management ensure that personnel training and qualifications are adequate for the program and for the effort and expertise required to carry out the tasks in Appendix B. The qualifications of radiation safety personnel are reviewed by the NRC Material Licensing Branch upon receipt of a new or renewal application or when there is a change in radiation safety personnel.

3.2.3 SPACE AND EQUIPMENT

The Radiation Safety Office should have adequate equipment and space provided in appropriate locations to carry out the following functions:

1. Receive, process, and file regulations and licensing correspondence.

2. Prepare reports and records of surveys and personnel monitoring as required by 10 CFR Part 20.

3. Conduct radiometric measurement of smear tests from contamination surveys and source leak tests.

4. Instruct and brief personnel as required by 10 CFR Part 19.

5. Calibrate electronically, maintain, and repair radiation safety equipment.

6. Stock radiation safety supplies for labeling, surveying, decontamination, and personnel protection and monitoring.

7. Process orders for licensed materials and receive and distribute such materials (or as a minimum, receive radioactive materials during work hours).

8. Store radioactive wastes and sources not in use.

9. Calibrate in radiation fields the radiation safety and survey equipment, expose personnel dosimeters for regular quality control of personnel monitoring services, and check the calibrations of other hospital radiation sources (or ascertain that they have been properly checked by other medical physics staff).

10. Decontaminate personnel, clothing, and equipment.

In addition, the tasks listed in Appendix B should be examined for other activities that may require specific space allocations in the larger hospitals.

In planning and providing facilities, publications of professional and scientific organizations already referenced should be consulted for detailed

considerations. The RSO also can work with competent architects, engineers, and hospital administrators to ensure that the following considerations are emphasized:

1. Adequate shielding is necessary for source and waste storage areas to maintain limits of radiation exposure rates for unrestricted areas (10 CFR Part 20). It is good practice to locate storage areas as far away as possible from the usual location of employees and other areas frequented by persons both inside and outside the hospital.

2. Waste and source storage areas (including locations where Tc-99m generators are stored) require adequate ventilation to protect employees against the routine or accidental buildup of air concentrations of radioactive material when activity levels and processes are such that significant buildup of air concentrations is possible (Ref. 12).

3. Office space for administration of radiation protection programs is needed as far away as practicable from areas where radiation sources are used. Ideally, such space would be located to reduce ambient external radiation levels to levels approaching natural background, while considering at the same time the need for accessibility of facilities to radiation safety staff and the need for surveillance of certain areas by the staff.

4. Ventilation of offices and other areas occupied by personnel is required to minimize the possibility of radiation exposure resulting from airborne concentrations of radioactive materials. Good ventilation design principles (Ref. 13) are necessary even though radioactive materials would not generally be stored in close proximity to areas frequently occupied by personnel.

5. Adequate space is needed to avoid unnecessary exposure to personnel during counter calibration or instrument repair. Separate areas may be required for instrument or source calibrations at the higher radiation levels and for low-level radioactivity counting and evaluation.

A minimum amount of radiation safety equipment will also be needed for any medical institution licensed to possess or use byproduct, source, or special nuclear material. Appropriate planning and budgeting for this type of equipment can best be done with the advice of a professional health physicist, since an understanding of instrument specifications is required to determine instrument needs for the tasks presented in Appendix B. Available commercial instrumentation is always in a state of rapid technological change; therefore, specific equipment requirements are beyond the scope of this report. NRC licensing guides will indicate to the applicant what information should be included in the application regarding radiation safety equipment. The information submitted will be reviewed by the Material Licensing Branch to ascertain its adequacy in meeting regulatory and license requirements for the scope of activities proposed by the institution.

3.2.4 TASKS AND PROCEDURES

As noted earlier, a list of the tasks carried out by a Radiation Safety Office in order to provide good radiation safety surveillance and meet

regulatory and license conditions is presented in Appendix B. The RSO and the radiation safety staff should conduct surveillance programs and investigations to ensure that occupational exposures are as far below the specified limits as is reasonably achievable. Additionally, they should be vigilant in searching out new and better ways to perform all radiation jobs with less exposure. The Radiation Safety Office should be familiar with (1) the origins of all radiation exposure in the hospital by location, type of procedure, and job categories and (2) trends in exposures, as well as new practices and procedures. This awareness will help the office devise reasonable ways of influencing these trends toward lower (ALARA) exposure levels.

In seeking to reduce exposures, the radiation safety staff should:

1. Investigate unusual exposures and determine the causes.

2. Take steps to reduce the likelihood of similar occurrences.

3. Record the results of such investigations and conclusions or corrective actions.

4. Periodically review written procedures affecting radiation safety.

5. Periodically survey all procedures and areas involving possible occupational radiation exposures as required by 10 CFR Part 20 and survey all incoming shipments of radioactive materials as outlined in Regulatory Guide 10.8.

6. Ensure that indicated changes are properly implemented.

7. Encourage all users of radioactive materials and their employees to maintain their own daily surveillance of all activities involving radioactive material and provide procedures for receiving and evaluating employees' suggestions for improving radiation protection practices.

8. Provide briefings and training sessions to inform employees of radiation protection practices, as well as to receive their current ideas and suggestions.

9. Provide an adequate inventory of radiation monitoring equipment and supplies for the Radiation Safety Office's own surveillance activities, as well as for personnel monitoring and daily surveillance to be carried out by the users and employees.

10. Maintain monitoring instruments in good working order and calibration.

11. Ensure that users and employees understand the proper methods of care and operation of equipment assigned to them for their routine use in surveying their own activities.

3.2.5 ADMINISTRATIVE AUTHORITY

The Radiation Safety Office, supervised by the RSO, should be delegated in writing by responsible management the administrative authority to develop and enforce rules and procedures pertaining to the institution's radiation safety program as prescribed by management, as well as the responsibility of carrying out the tasks listed in Appendix B. The administrative authority provided to the Radiation Safety Office should provide for the need to temporarily suspend certain activities involving licensed radioactive materials when they are deemed unsafe, provided the suspension does not interfere with life-saving medical procedures that may warrant overriding priority before the radiation safety problems can be alleviated.

3.2.6 RADIATION SAFETY COMMITTEE

Section 35.11 of 10 CFR Part 35 requires that a radiation safety committee be appointed to supervise the institution's radiation safety program. Typical functions and responsibilities of the committee are given in Regulatory Guide 10.8. The RSO, who is required to be a member of the committee, may either serve as chairman or assist the chairman in preparing for and conducting meetings and maintaining committee records.

Meetings of the committee should be held at least quarterly. Every member of the committee should be invited to each meeting.

The purposes of the meetings should include:

1. Approving the acquisition and use of radioactive materials;

2. Discussing any radiation safety problems requiring a general solution;

3. Reviewing with the Radiation Safety Officer whether current procedures are maintaining exposures ALARA; and

4. Auditing the radiation safety program to ensure that it meets all the goals and requirements presented in Sections 3.2.1 to 3.2.5 above. This should include a review of reports submitted to the administration by the RSO.

The need for a management audit of the radiation safety program is discussed in Section 3.5 of this report.

All radiation safety committee meetings should be documented by a record of minutes approved by committee members and filed as part of the radiation safety record system within 60 days following a meeting. All records of the committee should be signed and dated. Regulatory Guide 10.8 provides further guidance on the composition and functions of the radiation safety committee.

3.3 FACILITY AND EQUIPMENT DESIGN

3.3.1 GENERAL CONSIDERATIONS

One of the first considerations in keeping radiation exposures ALARA is proper planning of the hospital facilities and equipment required for the medical uses of radioactive material (Ref. 14, page 227). Since the methodology for planning and designing such facilities extends over several fields of science and engineering, optimum design for keeping radiation exposures ALARA as well as for efficient delivery of medical care requires a joint effort between the hospital administration, personnel working in these areas, health physicists, architect-engineers, ventilation design engineers, and other engineering disciplines.

Health physics input is needed for the design of areas where radioactive materials are handled, where radiation-producing equipment is operated, and where radioactive materials and equipment are stored, shipped, repaired, or discarded to the environment. These places are in addition to the Radiation Safety Office facilities and equipment discussed in Section 3.2.

The design of facilities and equipment will depend not only on hospital and medical care considerations, but also on the nature and quantity of radioactive materials involved (Refs. 12, 14) and the relative potential for external and internal radiation exposure. Some of the major aspects of planning and design that should be considered are given in the following sections.

3.3.1.1 Space Layout

Important space layout considerations include:

1. The need for access to radiation or radioactive materials areas by medical staff, employees, patients, visitors, and others, while at the same time providing optimum separation between workers' "sit down" areas (frequently occupied areas) and sources of radiation or potential radioactive contamination.

2. Ventilation requirements;

3. Floor loading in the case of heavily shielded sources;

4. Receipt and shipment of radioactive materials, including radiation and contamination surveys;

5. Outpatient parking for some radiation therapy and nuclear medicine patients; and

6. The need to protect supplies of stored diagnostic films from radiation exposure.

In general, facility layout should keep employee exposures ALARA while at the same time ensuring that exposure is not thereby increased to other persons.

In cases where the potential for inhalation or ingestion of radioactive materials is significant or where radioactive gases are used, the placement of facilities will be influenced by the availability of ventilation ductwork that can lead from the facilities without carrying radioactive materials to other areas where they might contribute to internal exposure to unsuspecting persons.

3.3.1.2 Shielding

Permanent shielding may be needed in some cases for walls, floors, and ceilings to provide protection against radiation from radioactive materials currently housed in the institution, as well as radioactive materials that might be introduced into the area by future medical care requirements. Teletherapy installations always require permanent shielding. Occupancy and use factors should be taken into account as recommended in NCRP handbooks (Refs. 15, 16), but such factors should be chosen with the principle of ALARA in mind. The NRC Material Licensing Branch should also be consulted during the planning and design stage to obtain specific guidance for obtaining a license for the particular quantities and uses of radioactive material involved.

3.3.1.3 Caution Signs and Interlocks

In accordance with good radiation safety practice and in compliance with § 20.203 of 10 CFR Part 20, access to certain areas should be controlled or restricted by the use of prescribed caution signs, signals, and interlocks. The requirements for and the proper location of such caution signs, signals, and interlocks should be carefully considered to ensure that employees and others do not spend more time than necessary in certain areas, do not in any case exceed regulatory limits of exposure, and do not enter specified high-radiation or radioactive materials areas except under prescribed circumstances (Refs. 1, 16, 17).

3.3.1.4 Ventilation

Ventilation requirements should be considered for areas where radioactive gases (e.g., xenon-133) are stored or used or where other unsealed radioactive materials may enter the work environment in volatile or aerosol forms (e.g., some I-131 componds). The levels of such materials may necessitate special hoods or gloveboxes (Ref. 12). The recommendations of health physicists and engineers should be sought in this regard. Design of any necessary local exhaust hoods or fume hoods and their flow rates should be coordinated with the overall design of the general office or clinical air requirements. (Ref. 13).

In designing ventilation to guard against inhalation or ingestion of radioactive materials in work areas, the medical institution should also consider the need to prevent exhaust air or effluents from exposing persons in unrestricted areas. For example, a nuclear medicine department using Xe-133 and carrying out its own radiopharmaceutical operations may want to consider a location in the corner of a top floor to save the costs as well as engineering difficulties of transporting contaminated air through long ductwork. The exhaust vent should be located to provide meteorological diffusion and dilution adequate to meet the requirements of § 20.106 of 10 CFR Part 20 for effluents to unrestricted areas as well as ALARA exposure considerations for the public. In some cases it may also be advisable to include specific types of filters or

air cleaners for the exhaust air. In general, the release point of exhaust air from ventilation systems should be at least 10 meters from any window, air intake system, or point of occupancy by members of the public in order to provide meteorological dilution by a factor of 10^{-4} or more. The release point should also be selected to avoid recirculating contaminated exhaust air back into the building.

In any work area where radioactive gases or aerosols are used outside of a glovebox or fume hood, adequate ventilation should be provided to meet the requirements of § 20.103 of 10 CFR Part 20 for exposure to individuals to concentrations of radioactive material in restricted areas. Such areas should be under negative pressure as required to ensure that contaminated air is not carried to unrestricted areas.

3.3.1.5 Fire Control

The need for personnel exit and for closing the facility to prevent the spread of radioactive materials should be considered for areas where laboratory procedures could result in the dispersal of radioactive materials in case of a fire. Provision should be made for local showers where necessary. Chemical fire extinguishers should be conveniently placed for employees who may be able to provide early fire and contamination control. However, for the vast majority of medical institutions, emergency procedures and training should include immediate fire control as a priority item without interference because of radioactive contamination considerations.

3.3.1.6 Special Laboratory Design Features

There are many sources of guidance and information on design of laboratories for handling radioactive materials (Ref. 12). Consideration should be given to providing laboratory surfaces that may be easily cleaned and decontaminated daily to maintain minimal contamination levels and radiation exposures. In laboratories where radioactive contamination may frequently reach lab surfaces and be picked up or inhaled by employees, a fixed radiation monitor should be provided for employees to monitor their hands, feet, or clothing routinely before leaving the laboratory. This monitor should be in a very low-background area in or near the laboratory. Another monitor may be used to maintain a general awareness of the ambient radiation levels in the work area. Additional portable Geiger counters or other radiation monitoring equipment may also be desirable.

In general, there is no need (in hospitals) for any procedures that use quantities of radioactive material sufficiently radiotoxic that potential air concentrations may reach levels near or at the limits of 10 CFR Part 20. Thus, there is generally no need for additional respiratory protection such as face masks or supplied air hoods. Ventilation and contamination control should be designed to maintain air concentrations and contamination levels ALARA.

Nuclear medicine departments that perform xenon-133 studies may require special apparatus for dispensing and collecting the xenon-133. A number of collecting systems are commercially available, but those that collect the xenon-133 and hold it for decay are preferable to those that merely collect it for later release to the environment. Specific guidance for the use of

xenon-133 in nuclear medicine is available from the NRC Material Licensing Branch or in Regulatory Guide 10.8.

Other considerations are:

1. Designated sinks may be needed for rinsing and disposal to sewage systems of trace amounts of radioactive material from laboratory equipment. (Part 20 specifies the limits for such disposal and requires that a record be maintained of effluent dilution by the volume of sewage effluent from the institution.)

2. Design of plumbing and sewage systems should take into account the need to avoid buildup of radioactive contamination in areas where persons may be exposed to external radiation from these materials and to avoid the possibility of these materials finding their way to intakes of drinking water or water supply sources.

3. Temporary storage in appropriate containers placed in remote or shielded areas may be needed for the bulk of radioactive wastes of short half-life to allow for decay of the radioactive material.

4. Equipment or apparatus should be provided for storing long-lived liquid radioactive wastes that may be sent to a commercial disposal firm.

3.3.1.7 Storage, Source Control, and Inventory

Institutions that order a number and variety of sources of radioactive material may find it easier, less costly, and more secure to provide a centralized storage room for radioactive materials not in use or used only occasionally. Such a storage facility would normally be located in a remote ground-level area where a common storage vault can be constructed with minimum construction, space, and materials costs.

A central storage facility is helpful in keeping exposures ALARA, since it may result in a decrease in the amount of radioactive material stored in laboratories occupied by personnel. It can also minimize the loss or inadvertent misplacement of radiation sources.

Additional shielding may be needed in the walls of the central storage area to protect persons in unrestricted areas. Design considerations include:

1. Vault and shield design that will protect employees entering the area as well as those in adjacent unrestricted areas;

2. Provision for some ventilation of the area if volatile or gaseous radioactive materials escape into the room air;

3. Provision for monitoring the room air and effluents to unrestricted areas;

4. The possible need for a fixed gamma alarm or signal to warn employees of radiation levels at places where employees frequenting the area could receive appreciable radiation exposures;

5. Surface or strippable coatings that can be decontaminated easily;

6. Adequate floor loading requirements to support the required shielding materials; and

7. An adequate lock-and-key system for controlling the area.

Where space is limited, some calibration facilities may be included in the storage area. If so, a shielded area should be provided for the person carrying out the calibrations, and provision should be made for remote operation of the source exposure shutter (or raising and lowering the source remotely) and placing instruments to be calibrated in various positions without unnecessary or significant exposure of the operator. The source should be exposed only when instrument calibration is being carried out under the supervision of a member of the radiation safety staff.

3.3.1.8 Shipping and Receiving

In some medical institutions, unnecessary exposure of personnel has resulted from the need to transport packages of radioactive material long distances from the receiving area to the user. Medical institutions should therefore:

1. Plan specific radioactive material storage areas for day, night, and weekend deliveries so that such deliveries may be received at any time and placed in a secure location where they will not cause unnecessary exposure to personnel while awaiting survey by the Radiation Safety Office or the user.

2. When packages may expose couriers to measurable radiation, make available a cart or carrier that will maintain an adequate distance between the person transporting the material and the package to keep exposures ALARA.

3. Set aside some space in the receiving area for an initial survey and wipe test of each package unless other means are used to avoid transporting a contaminated package through unrestricted areas of the hospital.

4. Locate shipping and receiving areas and the access to them away from areas where radioactive materials are used so as to

   a. Minimize the time required for transporting radioactive material to areas where it is to be used and

   b. Avoid the need to transport radioactive material through crowded areas or areas occupied by personnel, patients, or visitors.

3.3.1.9 Equipment Considerations

General features that should be considered for equipment that will be used for handling, containing, or contacting radioactive materials are:

1. Surfaces should be easily cleaned and decontaminated in case unsealed radioactive material is released.

2. Equipment should be designed to optimize the ease of carrying out procedures where personnel are exposed to radiation, thereby minimizing working times, and to maximize distances of personnel from the radioactive materials with which they are working to an extent consistent with the purposes of the procedure.

3. Equipment should operate in such a fashion that it does not damage radiation sources and release radioactive materials if it fails.

4. Adequate shielding should be provided as part of the equipment where feasible.

5. Appropriate caution signs, symbols, signals, and alarms should be provided as part of the equipment to meet the requirements of § 20.203 and recommended standards of the medical physics profession (Refs. 15, 16).

In general, equipment to be used with radioactive materials or radiation sources should be selected or designed in consultation with the RSO, using health and safety principles and engineering data already developed by the health physics and nuclear engineering professions. A brief checklist of the more important radiation safety considerations in hospital facility and equipment design is given in Appendix C.

3.3.2 RADIATION THERAPY EQUIPMENT AND FACILITIES

Specific licensing guides are provided for licensed radiation therapy programs (Ref. 18), and the NRC Material Licensing Branch reviews the safety aspects of facilities and equipment before issuing a license. Therefore, the planning and design of radiation therapy facilities should consider licensing guidance from the Material Licensing Branch as well as recommendations of scientific and professional organizations and requirements of NRC (or State) regulations (Refs. 1, 15, 16). In designing shielding for teletherapy treatment rooms, medical institutions should consult NCRP Handbooks 33 and 49 (Refs. 15, 16) for recommended design details, specifications, methods of shielding against direct, scattered, and leakage radiation, and general principles of radiation safety design. Particular attention should be given to shielding the direct beam in installations of equipment having no built-in beam interceptor. Although occupancy and use factors recommended by NCRP may be taken into account in therapy facility design, experience has shown it is often reasonable to set a design objective of reducing occupational exposures to 10 percent or less of the limits of 10 CFR Part 20.

In addition, the institution should:

1. Protect each teletherapy treatment room from inadvertent entry by the following means:

a. Provide a door interlock that allows a "Beam On" condition only when the door is closed.

b. Provide independent backup caution lights on the console, above the door, and inside the treatment room to indicate the "Beam On" condition to

radiotherapy technologists and other staff members. Independent audible signals also provide added safety in the event lights fail.

c. Establish a procedure for checking whether everyone except the patient is out of the area before the door is closed and the beam is turned on.

d. Install independent caution lights or a visible radiation monitor near the entry inside teletherapy treatment rooms to provide a warning to the therapy technologist or others entering the room in case the door interlock system fails while the beam is in the "on" condition. Nonflashing lights have been found to be acceptable to patients for this purpose. When these warning lights are activated by an independent gamma ray-sensing radiation detector they can also be used to check the general operation of teletherapy equipment by viewing the condition of the warning light through the viewing window or closed-circuit television. Audible signals of a type that are not objectionable to patients provide added safety. Also, an emergency shutdown button and audio communication with the control console should be provided inside the treatment room.

2. Consider leakage through the teletherapy head with the source in the "on" position when designing shielding. Data provided by the manufacturer of the teletherapy machine or NCRP recommendations should be used for this purpose. Ordinarily, it will be possible with modern equipment to shield this leakage radiation with the shielding provided to protect against scattered radiation. However, this should be examined specifically because the leakage radiation may be more penetrating than the scattered. In installations where an existing teletherapy unit is being replaced by a newer one of higher intensity, actual radiation survey data for the existing unit should be used in addition to design data in the literature in order to provide an optimum design of the renovated facility. (License applications for teletherapy usually require specific shield and facility design details, and license conditions require a survey of an installed teletherapy unit prior to use.)

3. Design areas adjacent to the treatment room so as to maintain exposures ALARA to personnel, patients, or visitors who are not associated with the radiation therapy department. Reduction of occupational exposures to radiation therapy personnel should not be achieved by design provisions, procedures, or planning beam orientations that would increase exposure to persons in unrestricted areas. Beam orientations should always be preferentially planned toward unoccupied or low occupancy areas. In no case should it be necessary to design for instantaneous rates greater than 10 mrad/week in restricted or unrestricted areas adjacent to teletherapy treatment rooms.

Additional recommendations regarding the maintenance of safety provisions and calibrations of teletherapy devices are available from other independent standards organizations (Refs. 17, 19, 20). In general, a professional physicist should be consulted to efficiently apply these various recommendations to individual installations.

3.3.3 NUCLEAR MEDICINE FACILITIES

Nuclear medicine facilities and equipment should also be planned and provided in coordination with medical health physics and engineering staff,

using the latest recommendations of professional organizations and requirements of the NRC Material Licensing Branch. In addition to the considerations listed in Section 3.3.1, emphasis by the medical health physicists and engineers on the following space and equipment considerations will help to ensure that exposures are ALARA:

1. Allow sufficient space for personnel operating nuclear medicine equipment to be at least one meter, and preferably two meters, from any patient undergoing the scanning procedure in the vicinity (Refs. 11, 21, 22) whenever the condition of the patient and other work conditions permit.

2. Allow adequate space for stretcher patients awaiting scans, as well as for outpatients. Dosed patients awaiting scans may cause radiation levels of 10 mR/hr or more near the edge of the stretcher. They may need to be segregated from the general waiting area to reduce radiation exposure to employees, patients, and other persons passing through the area.

3. Locate physicians' offices and other areas occupied by personnel within easy access of the laboratory where radiopharmaceuticals are stored and prepared, but far enough away (several meters is usually sufficient) to minimize exposures from radiopharmaceuticals in storage and radioactive wastes.

4. Provide adequate shielding in the laboratory for stored radiopharmaceuticals. Partial body shielding should also be provided for employees when they are preparing radiopharmaceuticals from reagent kits or preparing dosages for patients. Portable or movable shields may be necessary within the diagnostic areas to shield employees while they are operating equipment or waiting for patients or results. Shielding should also protect any radiation-sensitive dose calibrating equipment or other nuclear medicine counting or imaging equipment.

5. Provide an adequate supply of syringe shields, bottle shields, tongs, and forceps near the place of dosage preparation to minimize hand and body exposures of nuclear medicine personnel.

6. Provide additional exhaust ventilation (Ref. 13) in the laboratory near the radiopharmaceutical storage and dose preparation area to protect against buildup of air concentrations of radioactive material from gases or from accidental release or spills of radiopharmaceuticals. In departments handling potentially hazardous quantities of radioactive material (Ref. 12) where release of radiopharmaceuticals is possible or in departments where preparation of radiopharmaceuticals from basic reagents is carried out, this additional ventilation should be provided through a hood in the laboratory that is maintained at a linear face velocity of about 100 feet per minute. This additional flow rate should act as a sink for air from the rest of the room (and perhaps the department) and can be used to rapidly reduce any air concentrations from accidental spills or breakage of vessels containing such volatile or gaseous materials as xenon-133. In general, the architectural layout should consider the need for air to flow from areas of lower radioactivity toward areas of higher radioactivity unless each space can be separately ventilated. Regulatory Guides 10.8 and 8.23 contain further information on planning and designing exhaust ventilation.

When a hood is provided, the Nuclear Medicine Office or Radiation Safety Office should maintain a calibrated velometer or other air flow meter to check hood flow rates at survey frequencies suggested in Regulatory Guide 8.23.

Exhausts from the hood should be vented above the hospital roof, where possible, or at a point outside the hospital that is removed by at least 10 meters from any source of intake air, open windows, or persons in parking lots or unrestricted areas.

7. Provide a special waste receptacle for used syringes and other radioactive wastes in the nuclear medicine laboratory near the dosage preparation area. This waste receptacle should be large enough to contain at least a one-week supply of waste without overflow. It should have a removable pail with a special cover that can be used while the pail is being carried. The pail should be shielded by at least the equivalent of a 1-mm thickness of lead to protect employees carrying the pail to the waste storage area. This shielding will protect at least against the Tc-99m gamma radiation. The shielding may also protect persons working in the laboratory from a substantial portion of potential occupational exposure.

An additional receptacle should be provided in the nuclear medicine laboratory for nonradioactive wastes so that radioactive waste volumes will be minimized.

8. Locate a permanently fixed GM counter and rate meter near the entrance to the nuclear medicine preparation laboratory so that employees can check for hand contamination when leaving the laboratory or the nuclear medicine department. This fixed monitor should preferably have a removable probe that can extend low enough to monitor shoes.

Although contamination levels up to 10,000 disintegrations per minute per 100 square centimeters will not necessarily indicate a serious ingestion or inhalation hazard for the radionuclides used in nuclear medicine, contamination levels should be minimized, and any loose contamination found on laboratory surfaces or clothing should be cleaned up immediately in order to minimize external radiation exposure and prevent gradually increasing interference with the background levels of calibrators and nuclear medicine equipment. In medical institutions, ALARA contamination levels for routine operations can generally be maintained well below the action levels given in Regulatory Guide 8.23.

The fixed GM counter and monitor will also serve to provide nuclear medicine personnel with an added awareness of ambient radiation levels and the continuing need to keep them ALARA. Records should be kept of the daily ambient levels so that any long-term, as well as short-term, increases in background radiation levels will be noted, investigated, and corrected where feasible.

9. Design all floors and surfaces according to good laboratory design practice for handling radioactive materials and for easy decontamination as described in References 12 and 23.

10. Provide individual labeled lockers for laboratory coats that may be contaminated. Clean change rooms should also be available. Stations where personnel monitoring devices are left at the end of each day should be remote from any radioactive material.

11. Provide finger badges or dosimeters and body dosimeters for monitoring occupational exposure of personnel whose hands may receive more than 10 percent of their permissible occupational dose. These dosimeters should be left at a station accessible to the Radiation Safety Office for prompt collection at appropriate intervals as designated by the RSO. A place for a control dosimeter should be maintained at the station where personnel monitoring devices are turned in.

3.3.4 IN VITRO CLINICAL AND RESEARCH LABORATORIES

Many of the radionuclides used in experimental or clinical work emit very little or no gamma radiation per disintegration. Clinical or research laboratories in medical institutions should therefore be able to maintain occupational radiation exposures to the average employee well below 10 percent of the permissible levels of 10 CFR Part 20. This is true also of internal dose commitments from inhaling or ingesting radioactive material.

Facilities in these laboratories will be evaluated by the NRC Material Licensing Branch for design features that ensure ALARA exposures as well as compliance with regulatory requirements according to types, forms, and quantities of radioactive material to be possessed and used. Recommendations for good laboratory design can be found in a number of references (see Refs. 12-16, 22-26). Some of the more important considerations* are:

1. Provide smooth, easily decontaminated laboratory surfaces for benches, sinks, walls, and floors.

2. Provide easily discarded bench paper that is absorbent on the top surface only for catching and disposing of small amounts of contamination that may drip or be removed from laboratory apparatus and glassware.

3. Design laboratories with a minimum of sharp corners or cracks where radioactive material can lodge.

4. Design plumbing, traps, and ductwork so that radioactive contamination will not build up and create sources of external radiation exposure or cross-contaminate drinking water or air-supply lines.

5. Provide separate lockers for hanging laboratory coats, and consider providing special laboratory shoes if floors are likely to be contaminated. Uncontaminated street clothes should be worn when leaving the laboratory for

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* This checklist of design considerations summarizes recommendations for good safety practice. Professional judgment and the other operational safety procedures in effect will determine which, if not all, of the listed design aspects are important in a given installation.

lunch periods or for any other reason. Appropriate change areas should be provided so that radioactively clean clothing may be separated from contaminated clothing. Showers should also be located in the change areas so that employees can minimize transport of radioactive contamination outside the nuclear medicine facilities.

6. Provide special locations in an area of normal background radiation for personnel to deposit body and finger dosimeters when leaving the radiation area.

7. Provide specially labeled radioactive waste cans for radioactive laboratory wastes. These cans should be shielded as necessary to avoid a buildup of external radiation exposure levels in the laboratory. The cans should be placed near the area where the radioactive waste will be generated, but as far away as possible from positions frequently occupied by personnel.

8. Designate special sinks to receive any small amounts of radioactive washings or effluents. Keep records of the estimated amount of radioactive waste disposed of in these sinks and the total sewage effluent into the connecting sewer in order to ensure compliance with the limits of § 20.303 of 10 CFR Part 20. These sinks should be connected directly to the main pipe; connections to open channels or any unnecessary devices that may accumulate radioactivity should be avoided. Sink taps should be designed where possible for operation by a foot, knee, or elbow rather than by hand whenever possible.

9. Reduce laboratory furniture to a minimum and be sure that it is easily washable. Dust-collecting items should be minimized and laboratory surfaces should be maintained as dust-free as possible, since dustiness tends to increase the spread of radioactive contamination.

10. Provide adequate lighting for laboratory work areas to help ensure safe handling of radioactive materials.

11. Provide adequate ventilation, including hoods for processing certain quantities (Refs. 12, 13, 23) of radionuclides, or closed gloveboxes for experiments or analytical work involving larger quantities of the more radiotoxic materials.

12. When possible, design laboratory ventilation to be under the control of laboratory supervisors so they can monitor and control the total air flow into and out of the laboratory. Fume hoods should maintain a linear face velocity of 100 feet per minute and should be designed to avoid eddy currents that would disperse radioactive materials outside the hood area.

Consideration should be given to providing adequate filtration of both intake air and air exhausted from the fume hoods or general laboratory area to avoid increasing environmental exposures. The ventilation system should be designed and checked during and after construction with the assistance of an industrial hygienist or health physicist (Ref. 13).

Provision should be made for shutting down the ventilation system in the event of accidents if necessary to contain radioactivity.

Consideration should also be given to the influence of opening doors or windows and adjusting the degree of opening of hood doors. Exhaust fans used in hoods should be placed only on the exit side of the exhaust filters, and preferably at the discharge point. In some new designs, hoods and glove-boxes are provided with exhaust fans pulling air downward rather than upward, thus providing additional protection against resuspension of particulates. Gas, water, and electrical appliances should be operable from outside the fume hood to minimize air flow disturbances.

Internal surfaces of hoods and exhaust ducts should be as easy to clean as possible. Before cleaning, any ducts or facilities that may have built up contamination should first be checked by the Radiation Safety Office staff. Exhaust filter design should consider contamination buildup, possible need for filter shielding, and ease of filter removal to minimize exposure during filter change.

13. Provide suitable easily cleaned drip trays for carrying out manipulations of radioactive materials where spills may occur. These drip trays may also be covered with absorbent plastic-backed (or similar) material to soak up minor spills. The absorbent materials should be changed when measurable radioactivity has built up or when they are unsuitable for further work; these materials should be treated as radioactive wastes.

14. Provide protective clothing, including disposable plastic or rubber gloves, for persons working with radioactive materials. (Disposable gloves should be changed frequently.) Also provide equipment for monitoring clothing before laundering. Radioactive laundry and radioactive wastes should be turned over to the Radiation Safety Office for further disposition when surveys indicate contamination levels may exceed 10^{-5} $\mu Ci/cm^2$. Again, the available reference material on design of laboratories for handling radioactive materials should be consulted (Refs. 13, 17, 27-29). Also, additional recommendations are available for carrying out in vivo experiments with animals (Ref. 4).

If proper containment or ventilation is provided to prevent or reduce internal exposures ALARA, external exposure should easily be made ALARA. However, there may be locations in some laboratories of medical institutions where additional shielding against beta radiation or gamma radiation is required. The references cited and professional health physicists should be consulted to plan these requirements when necessary, including adequate floor and bench loading strengths.

3.4 SAFE WORK PRACTICES AND PROCEDURES

3.4.1 GENERAL PRINCIPLES

References 12, 15-17, 21-26, and 30-34 suggest work practices and procedures that will help to ensure that exposures are ALARA. In addition, applicants should contact the NRC Material Licensing Branch regarding the specific items and radiation safety requirements to be addressed in the application for a particular institution. Practices that are particularly important in keeping exposures ALARA are discussed below.

3.4.1.1 Periodic Inventory and Control of All Radiation Sources

Many of the more serious occupational exposures, as well as patient exposures, have resulted from loss of radioactive material, which then may inadvertently expose unsuspecting persons or be subject to improper usage by unauthorized persons (Ref. 14). The following procedures can be used to guard against these problems:

1. A periodic (at least quarterly) inventory should be made of all radioactive sources. The inventory should be combined with an inspection to ensure proper labeling (see § 20.203 of 10 CFR Part 20).

2. Sources should be secured within locked rooms or storage areas when authorized users or their responsible employees are not present. Special shielded vaults should be provided in the storage area for sealed sources, and small brachytherapy sources should be maintained within separately identifiable holes or slots within the shielded vaults or containers. Each slot should be identified as to quantity and type of radioactive material, and a coding and control system should be devised to prevent errors in retrieving or replacing individual sources. All sealed sources should be stored and secured immediately after use. Unsealed sources should also be stored and secured, with appropriate shielding and proper ventilation in situations where significant quantities of environmental contamination are possible.

3. A station log should be placed near the exit to each source storage area. Each source removed from the area should be signed out on the log and signed back in upon its return to the proper vault location. Temporary storage locations during source cleaning or testing should also be noted. All entries in each station log should be signed with time, date, source identification, and activity. The source log should be checked regularly by the Radiation Safety Office.

4. The Radiation Safety Office should maintain a central inventory of all sources in the institution and should keep records to show that the institution has not exceeded any possession limits of its license.

5. Source storage areas should be surveyed frequently by users, who must be authorized according to license conditions.

6. Doors to source storage areas should be properly locked and posted as required by § 20.203 of 10 CFR Part 20.

7. Areas surrounding source storage areas should be surveyed frequently and ambient intensities in the vicinity of storage locations should be posted if they exceed 0.2 mrem/hour in any area frequented by personnel.

8. Procedures should ensure that the RSO will be alerted promptly if all sources are not returned within a specified time in order to avoid sending patients home with brachytherapy devices still in place.

3.4.1.2 Shielding

All radioactive material not in use should be shielded so that exposures in any area that may be occupied by personnel will be well below (ALARA) the exposures that would be received in unrestricted areas under provisions of 10 CFR Part 20. Radioactive materials that are in use should be unshielded only in the direction necessary for the use and to the extent that accessibility to the source is necessary. Sources should be in an unshielded state only when under the direct supervision of an authorized user or his or her responsible employees.

3.4.1.3 Control of Contamination

Radioactive materials in unsealed form or undergoing chemical or physical processing should be handled only in properly designed facilities (as described in Section 3.3) and with proper procedures to avoid the likelihood of transfer of radioactive material to the air or to surfaces where subsequent inhalation or ingestion of the material by personnel is possible. Furthermore, sealed sources of radioactive material should not be sterilized by heat if this would cause rupture of the source and the spread of contamination.

When necessary to ensure that exposures are ALARA, simulated tests of procedures should be carried out with simulated radioactive or nonradioactive materials or colored liquids to check provisions for containment, handling, and ventilation. The Radiation Safety Office staff may make preliminary job exposure estimates using tracer levels of radioactive material in the preliminary tests.

Trays and absorbent materials should be used to catch and limit the spread of radioactive contamination whenever there is a possibility that planned procedures will fail to contain the radioactive material.

Protective clothing appropriate to the type and quantity of radioactive material being processed should be worn whenever escape of radioactive contamination is possible.

3.4.1.4 Proper Work Habits

In general, all persons handling radioactive materials should be trained to be aware of the importance of using available shielding materials, maintaining as much distance as possible from radiation sources within reasonable limits of efficient operation, and minimizing the time of exposure to radiation sources to only the time necessary to carry out the required task or clinical procedure.

The following good work habits are particularly important in ensuring ALARA exposures:

1. Sealed (other than very-low-level check sources designed for manual use) or unsealed sources should be handled only with tongs or tweezers appropriate to the operation, never with the fingers. Adequate training in the use of proper tongs or forceps should precede manipulations with the actual radioactive material to be used. Whenever possible, syringes that are shielded

or made of high-density glass should be used for injecting radiopharmaceuticals into patients, except that pure high-energy beta emitters should be administered with syringes made of low-Z material to avoid increased bremsstrahlung radiation. If a conventional disposable plastic syringe is used, a syringe shield should also be used.

2. Finger dosimeters* as well as body dosimeters should be worn by personnel who are handling or manipulating unsealed or unshielded sources with tongs or forceps or who are holding partially shielded sources or containers of radioactive material with their hands. However, these dosimeters are not needed for personnel handling only the types of sources used for tracer-level in vitro studies or where dose rates are less than 5 mrem per hour at 1 cm.

3. When working with unencapsulated radioactive materials, personnel should wear rubber gloves and other special clothing to protect against contamination of their persons or regular street clothing. Recommendations of References 17, 25, and 28 should be followed in regard to the appropriate types of protective clothing for various types and levels of radioactive material.

4. Care should be taken to avoid contamination of objects such as telephones, light switches, taps, or doorknobs. When items other than those normally contaminated must be touched during a given procedure, some uncontaminated and easily disposed of material such as paper or plastic should be interposed between a contaminated protective glove and the object to be maintained free of contamination. When working within a hood containing a sink designated for radioactive washings, personnel should wash contaminated gloves before they are taken from the hood if possible, remove them, and discard. Gloves should be removed in a manner that avoids the spread of glove contamination to hands or other clean surfaces.

5. Radioactive solutions should never be pipetted by mouth. Various pipetting devices are available. Even a long rubber tube connected to the pipette does <u>not</u> make pipetting by mouth acceptable.

6. Special precautions should be taken to avoid the possibility of any radioactive material entering cuts.

7. Eating, smoking, drinking, and application of cosmetics should be prohibited in laboratories where radioactive materials are handled.

8. The use of containers or glassware with sharp edges should be avoided. Care should be taken in working with contaminated animals to avoid bites or scratches.

9. Food and drink should not be stored in the same place (e.g., refrigerator) as radioactive materials.

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* With some finger dosimeters, labels may wash off or the badge may rip protective gloves. In these cases, wrist badges may be preferable. In any case, the user should be aware of the fact that neither of these dosimeters will adequately measure very high finger contact doses, so handling unshielded syringes or bottles with the fingers should be absolutely avoided (Ref. 8).

3.4.1.5 Radiation or Radioactivity Monitoring

The independent radiation surveys, inspections, inventories, and smear tests carried out by the Radiation Safety Office staff and the importance of centralized records of these activities were discussed in Section 3.2. In addition, each user of radioactive materials should survey radiation and radioactivity levels within his or her own operations to help maintain exposures ALARA. A simple logbook of daily readings of radiation or contamination levels maintained by the user in specified areas will help the user maintain an awareness of any changes in radiation or radioactivity levels that may indicate a need for changes in procedures to meet ALARA radiation exposure objectives. Regulatory Guide 8.23 gives further guidance on radiation surveys in medical institutions (including nuclear pharmacies).

In hospital situations where higher exposure rates occur (e.g., in teletherapy rooms, where the limits of 10 CFR Part 20 could be approached before an indication is provided by ordinary personnel monitoring devices), self-reading devices that are read at least daily and warning devices worn on the body may be helpful in maintaining exposures ALARA as well as within the permissible limits. Further, personnel monitoring should also be provided to employees at levels well below those required by § 20.202 of 10 CFR Part 20 when such monitoring will further awareness of measurable exposures and reduce them ALARA.

3.4.1.6 Training

Training should be given to any employee who works in or frequents the vicinity of a restricted area. The regulations in § 19.12 of 10 CFR Part 19 require such training. In medical institutions, training sessions with persons handling licensed materials are often necessary on at least an annual basis. They should include instructions regarding the ALARA exposure philosophy as well as specific instructions pertinent to the procedures to be conducted. New employees should receive appropriate training before they are assigned work in restricted areas.

Employees should be made aware of the ALARA provisions of § 20.1 of 10 CFR Part 20 as well as those of Regulatory Guide 8.10. Employees should also be instructed in the philosophy and provisions of Regulatory Guide 8.13, "Instructions Concerning Prenatal Radiation Exposure" (Ref. 35), whenever there is a possibility that pregnant women may be exposed to radiation.

Each employee should be acquainted with the institution's own procedures for handling radioactive sources and radioactive materials and with NRC licenses and their radiation safety provisions (including license conditions incorporated from license applications and correspondence). Copies of these procedures, licenses, and related correspondence should be made available to the employees as part of their orientation to radiation safety requirements.

In order to place all of these procedures and requirements in proper perspective for the employee, it is preferable that instruction on these matters be presented by a member of the radiation safety staff with appropriate background and experience in the science and philosophy of radiation protection standards. An example of a handout sheet that may accompany briefings of the

nursing staff is presented in Appendix D. Similar handouts may be designed for other hospital employees.

Professional education and development should be encouraged to ensure that persons responsible for radiation safety are up to date on methods of radiation safety and efficient management of radiation safety programs.

3.4.2 RADIATION THERAPY

This section summarizes recommendations for maintaining exposures ALARA in three subdivisions of radiation therapy.

1. Teletherapy--the treatment of patients with high-energy beams from shielded irradiators containing sources of high gamma ray emission rate.

2. Brachytherapy--the treatment of patients by insertion of sealed sources such as needles or tubes for interstitial or intracavitary irradiation, or by surface application.

3. Radiopharmaceutical therapy--the injection or oral administration of solutions or colloids of radioactive pharmaceuticals that tend to concentrate in and irradiate the organs in which they are dispersed or absorbed.

3.4.2.1 Teletherapy

Primary reliance for radiation protection in teletherapy is based on the adequacy of facilities and equipment, since very intense radiation levels are generated.

Basic operating principles for maintaining occupational exposures ALARA can be summarized as follows:

1. With the aid of the maintenance and operating manuals provided by the manufacturer of the teletherapy unit, procedures should be established for routine maintenance of the teletherapy unit by hospital maintenance personnel under the surveillance of the radiation safety staff. This maintenance should ensure that all safety-related devices remain functional and that the machine remains safe for both patient and operator.

However, reference should be made to the institution's license regarding specific maintenance requirements; a standard condition in NRC teletherapy licenses requires that any maintenance or repair operation on a teletherapy unit involving work on the source drawer, the shutter, or other mechanism that could expose the source, reduce the shielding around the source, or compromise the safety of the unit and result in increased radiation levels must be performed by persons specifically authorized by the Commission or an Agreement State to perform such services.

2. A daily morning checkout procedure should be established and posted. It should require the therapy technologist to carry out simple operational checks of indicator lights, caution lights and signs, key and door interlocks, gamma radiation level indicators, and timer operation and interlock function. These checks can be made within a few minutes of the startup of the teletherapy

unit and before use on patients. They serve to maintain an awareness of the warning and interlock devices by the technologist in addition to ensuring their proper operation.

3. A general safety check, including a spot or point radiation output check and a check of beam alignment and confining devices, should be made and recorded at least monthly by the qualified physics staff. All records of the monthly output and safety check, as well as the daily morning checkouts, should be signed and dated by the persons carrying out the tests. Other checks should be conducted as recommended in ANSI standards (Refs. 19, 20). The RSO should at least be cognizant that these checks are carried out according to schedule.

4. During operation of the teletherapy unit for patient treatment or for calibration or maintenance procedures, care should be taken to follow written instructions and use installed safety devices to ensure that no person except the patient to be exposed is in the teletherapy treatment room during the "Beam On" condition. These procedures are also important when personnel carry out test procedures with phantoms on the treatment table.

5. During "Beam On" operation, the operator at the console should remain in the position of lowest radiation intensity consistent with vigilance over the console and patient during treatment, as advised by the Radiation Safety Office staff using the post-installation radiation survey. It is necessary that the operator be in a position to observe the patient at all times. In a well-designed facility, the shielding provides a very high degree of protection at the location of the console. However, all persons not required to remain near the console should remain or work in areas of lower radiation intensity while the teletherapy unit is in operation. The console area should not be used for routine office work by persons not required for the operation of the teletherapy unit. During "Beam Off" conditions, treatment setup should be done with minimum occupancy and exposure to source leakage radiation.

6. Emergency procedures established under NRC license conditions should be tested by regular familiarization sessions or by staging mock emergencies for the training of personnel. Staff personnel supervising the teletherapy operation should be prepared to carry out emergency procedures and repairs with minimal radiation exposure (usually less than 100 mR). However, the first step in any emergency must be the removal of the patient from the beam when treatment can not be terminated normally.

3.4.2.2 Brachytherapy

Detailed recommendations for reducing radiation exposures in brachytherapy are given in NCRP Reports No. 40 and 48 (Refs. 22, 36). Additional recommendations pertinent to brachytherapy, as well as radiopharmaceutical therapy, are contained in NCRP Report No. 37 (Ref. 25). The most important practices for maintaining exposures ALARA in brachytherapy may be summarized as follows:

1. Modern afterloading devices should be used wherever medically acceptable. Remote afterloading is particularly effective in reducing exposures ALARA. Much of the occupational exposure in brachytherapy is received by the nursing and radiology staff while brachytherapy sources are in the patient. However, considerable exposure may also be received in the

operating and recovery rooms, in diagnostic radiology, and while transporting patients to their rooms when intracavitary devices are inserted in the operating room. The latest medical literature and manufacturers' information may be consulted for available types of afterloading devices.

2. Jigs should be prepared when manual afterloading is used so that sources may be easily loaded into afterloading devices--ready for the physician's use in the patient's room. The jigs and setups should be tested by manipulating the loading of nonradioactive tubes simulating the brachytherapy sources.

3. The jigs for loading the afterloaders should be set up behind shields with lead glass viewing windows. Auxiliary lead brick shielding should be provided to shield the arms of the personnel loading the afterloaders for as much of the duration of the procedure as possible.

4. When afterloading sleeves or ovoids are loaded, they should be placed in adequately shielded carts for final liquid sterilization or for transport to the patient's room when the physician is ready to insert the afterloaders. These carts should be properly tagged and should at all times be under the supervision of the radiation safety or radiotherapy staff.

5. Similar protection should be provided for use in threading radioactive needles for implant therapy.

6. While they are manipulating sources, loading the afterloaders, and threading needles, personnel should be provided with tongs and surgical clamps to keep their fingers about 30 centimeters or more from the sources. Data for estimating hand exposures may be found in Reference 25, page 10. Thicknesses of lead for providing additional shielding may be found in Reference 25, pages 41-44.

7. Finger dosimeters as well as body dosimeters should be worn by personnel when they are loading or preparing sources for insertion. Also, the Radiation Safety Office staff should periodically survey the loading procedures and provide job-time-exposure information to help employees keep exposures ALARA. Use of a gamma-alarm type of monitor in the storage/loading area will indicate when radiation sources are outside of their shields and help avoid inadvertent exposure due to lost or misplaced sources.

8. A continuing list of removals and returns of individual sources from the storage containers should be maintained to help ensure against inadvertent loss and exposure of sources.

9. Sources maintained in a fixed position for a constancy check on the operation of any intracavitary ion chambers should be kept within shielded wells in constant geometry so they can be used for a rapid and safe check of ion chamber operation before the treatment of each patient.

10. Time and exposure studies should be carried out by the radiation protection staff on typical surgical implants and typical insertions of radioactive sources either in the operating room or by afterloading in the patient's room. The studies can be carried out without interference in the surgical or

gynecological procedures by using survey meter readings at a distance from the patient and, where possible, by the wearing of special finger dosimeters by the operating physician. Estimates of radiation exposure by the attending nursing staff should also be made, and results should be permanently recorded in the Radiation Safety Office files. Personnel involved should be informed of the results and of any recommendations for further reducing exposures.

11. Transport of a patient containing radioactive material to areas outside of the operating room and to his or her room should be directly supervised by the Radiation Safety Office or radiotherapy staff. The radiation safety or radiation therapy staff should also check and supervise the transport of afterloading sources and supplies for insertion of applicators, lead bedside shields for nurses, and any other supplies and equipment required for expediting an efficient afterloading procedure. Radiation surveys of these procedures should be carried out on a sample basis and recorded to maintain an awareness of radiation exposures resulting from the procedures.

12. Some of the major recommendations of NCRP Report No. 37 (Ref. 25) that will help keep exposures ALARA in the patient's room and nearby areas and nursing stations are:

a. It is desirable to conduct a preliminary background survey or maintain an awareness of background radiation levels in the patient's room or surrounding areas.

b. Before the radiation-emitting patient or the afterloaders with radiation sources are brought to a patient's room, the nursing staff should be briefed, the patient's chart should be tagged with a radiation symbol and sign, the bed and door tags should be in place, and any portable lead shields for protection of the nursing or housekeeping staff should be available. Radiation tags and caution signs should give the patient's exposure rate at one meter, the type and quantity of radioactive material, and the telephone number of the person to be contacted in emergencies.

c. The lead cart for transporting afterloading sources or for receiving interstitial or intracavitary sources after they are removed should be left in a corner of the patient's room. The nursing staff should be instructed:

(1) To use tongs to place in this cart any sources that are accidentally removed from the implant or applicator during treatment,

(2) To contact the RSO or the physician in charge of the patient if a loose source is found (all linens and wastes should be surveyed before removal from the room), and

(3) To record the time at which the source was estimated to have been removed from the treatment volume. Patients should be instructed to guard against inadvertent removal of any sources from the treatment volume and to immediately notify the head nurse in the event of such removal.

d. As far as possible, insertion of radiation sources should be carried out with at least partial body protection from the movable bedside

shield and with sufficient assistance to the physician so that physician and staff exposures are minimized. Normally, insertion of afterloaders should result in less than 100 mR exposure to the physician's hand (per patient) and less than 10 mR exposure to any other part of the physician's body. Attending personnel should ordinarily receive less than 20 percent of the exposures received by the physician.

e. During the patient treatment period, nursing and other hospital staff should minimize time spent in the room and near the patient, consistent with providing all necessary care. It should be possible to provide necessary care without any nurse or attendant receiving more than 10 mR per shift to any part of the body if the nursing staff is adequately briefed. Generally, the nursing staff should maintain a distance of more than 1 meter from the center of the volume of radiation sources in the patient. The nursing staff, together with the housekeeping staff, should also be able to provide patient care in less than a fraction of an hour per person per shift.

Visitors and special duty nurses should be seated as far from the patient as possible. Usually a distance of more than 3 meters is adequate, with the additional use of a lead bedside shield to reduce direct exposure where possible.

Visitors and private duty nurses should also be briefed on the concepts related to keeping exposures ALARA. The amount of time that should be permitted for each visitor depends on the type and quantity of radioactive material in the patient, as well as the degree of shielding afforded and the arrangement of the patient's room.

Recommended limits of exposure for visitors, nursing staff, employees, and patients in other rooms are presented in NCRP Reports Numbers 40 and 37 (Refs. 22, 25). These limits should be established by the radiation safety or radiation physics staff. The limits for each patient's room should be recorded on the patient's door and given to the nursing supervisor and entered in the patient's chart.

f. Members of the regular nursing staff who are likely to receive the larger exposures and any nurses likely to receive more than 25 percent of the permissible quarterly limits of § 20.101(a) of 10 CFR Part 20 should wear personnel monitoring devices. These devices should be returned to the Radiation Safety Office at the end of the regular wearing period. Private duty nurses attending inpatients who have been administered radioactive materials for either diagnostic or therapeutic purposes should be provided with personnel monitoring devices that are collected or returned at the end of the patient's treatment. In general, current reports recommend that it is preferable to limit exposure of pregnant women or fertile women who may become pregnant. This may require a special effort in regard to staff attending patients undergoing brachytherapy (Refs. 21, 22, 25). Regulatory Guide 8.13 presents the NRC staff position on this subject (Ref. 35).

g. When a treatment is completed, a member of the radiation safety or radiation physics staff should:

(1) Assist in a survey for removal of all radiation sources from the patient.

(2) Remove the cart containing the sources from the room.

(3) Assist the physician in recording the details of the procedures in radiation safety records.

(4) Remove all radiation signs and labels.

(5) Carry out a final radiation safety survey of the room.

(6) Assure the patient, the nursing staff, and any visitors that no further radiation exposure from these sources will be incurred.

(7) Ensure that all radiation sources and associated supplies are returned to the source storage area, cleaned, inventoried, and replaced in their secured positions in the shielded vault.

(8) Record radiation survey information and certify source return.

The above recommendations should be supplemented by the considerations presented in the references cited, as well as by any licensing conditions or applicable regulations.

3.4.2.3 Radiopharmaceutical Therapy (Nuclear Medicine Therapy with Unsealed Radioactive Materials)

Preparation of the basic radiopharmaceutical dosage forms for therapy should be carried out only in nuclear medicine departments that are staffed and equipped for this function. Institutions that desire to establish their own facilities for compounding and preparing radiopharmaceutical dosage forms should employ a professional radiopharmacist to plan such activities and assist in the design of separate laboratory facilities for these activities (Ref. 21, pp. 65-66). (Food and Drug Administration requirements for the pharmaceutical quality and efficacy of these preparations should be consulted in addition to NRC radiation safety requirements.) The physicochemical processing of radiopharmaceuticals that involve higher activity levels of more radiotoxic materials than the ordinary nuclear medicine diagnostic procedures will require special facilities and procedures for safe handling (Ref. 12). The adequacy of such materials and facilities for radiopharmaceutical preparation in medical institutions will be judged, for NRC-licensed materials, by the NRC Material Licensing Branch according to requirements similar to those for radiopharmaceutical manufacturers.

If appropriate and in the best interests of the patient, oral or intravenous administration of millicurie quantities of the types of radioactive drugs used for therapy of specific diseases may be carried out in a specific area or a room separate from other nuclear medicine or radiotherapy operations. A separate small room removed from areas occupied by personnel not associated with the administration of radioactive materials will help to minimize exposure to other personnel and reduce the risk of contaminating other areas and sensitive equipment used for other radiological or nuclear medicine procedures.

However, this special area or room should be in the general vicinity of the laboratory where the radiopharmaceuticals are stored to minimize the need for transporting these materials over long distances through other areas of the institution.

When the radioactive material is transported to a patient's room for administration, a member of the radiation safety staff (or a technologist or therapist who is directly responsible to the RSO or radiotherapy department for radiation safety aspects of the procedure) should monitor and assist in the preparation of the materials and supplies for administration, the transport of these materials to the patient's room, and the administration of the radioactive drugs.

Unsealed radioactive materials that are administered for radiotherapy may be obtained in final dosage form and may require only a calibration check of the material using a dose calibrator or other appropriate instrument. Vials containing I-131 in liquid form for oral use should be opened only in a properly ventilated fume hood (Ref. 13) to avoid inhalation of free iodine that may be released. During preparation and administration of an already-prepared drug, the general principles of safe work practices given in Section 3.4.1 (including the use of drip trays, absorbent paper, tongs for handling the radioactive drug containers, bottle shields, and gloves and protective clothing), along with monitoring assistance by a member of the radiation safety staff, will be important in helping to achieve ALARA exposures. A member of the radiation safety staff may also scan the patient with a portable radiation detector of small dimension and good spatial resolution, as well as a wide intensity response range, to help ensure that a satisfactory administration of the radioactive drug has been accomplished. This procedure will also help to minimize the possibility that the patient will contaminate hospital rooms and facilities.

In supervising the administration of radiopharmaceuticals to patients, the physician in charge and the radiation safety staff may use many of the principles given for brachytherapy in Section 3.4.2.2, as well as the principles of Section 3.4.1. Many of these principles are presented in more detail in NCRP Report 37 (Ref. 25), which is particularly helpful as a reference of acceptable radiation safety practices in the therapeutic administration of unsealed radionuclides. The use of NCRP Report 37 in planning procedures for the administration of therapeutic radiopharmaceuticals will help to ensure that exposures are ALARA not only during the administration of the dosage to the patient, but also during any hospital care of the patient, during and after discharge of the patient, and in the event of any later surgery, autopsy, or burial of the patient.

During the administration of a therapeutic radiopharmaceutical to a patient and the subsequent hospital care of inpatients, all of the principles given for brachytherapy in Section 3.4.2.2 regarding surveillance of the administration in the patient's room, tagging of the patient's chart and room, instructions to hospital staff and visitors, and provisions for emergency notification are also applicable to the patient receiving millicurie quantities of radioactive drugs. The following additional precautions are also particularly important in achieving ALARA exposures in the case of unsealed therapeutic radiopharmaceuticals (Ref. 25):

1. Control of Contamination in the Patient's Room. Patients hospitalized for radiopharmaceutical therapy should be placed in separate private rooms with enough space for the hospital staff to attend the patient while maintaining a reasonable distance from the patient and from radioactive waste stored in the room. Contamination control may include the following procedures:

a. Cover floors, furniture, and other surfaces likely to be contaminated by the patient, using absorbent paper backed by waterproof material, with the waterproofed side against the surface to be protected.

b. Protect the bed mattress with a waterproof covering.

c. Protect items likely to be touched by the patient with thin plastic bags. Use plastic bags to protect telephone handsets from contamination.

d. Cover door handles and other items frequently touched by the patient.

e. Instruct attending personnel to prevent the tracking of radioactive contamination outside the patient's room. Where there is a serious likelihood of spreading such contamination, booties or shoe covers should be put on and removed at the entrance to avoid contaminating hallways and other areas outside the patient's room.

f. Use disposable dishes and cups.

2. Patient Identification. A wristband should be given to the patient and tags should be attached to the patient's chart and bed to provide information recommended in NCRP Report 37 (Ref. 25, p. 9). This information includes:

a. The radionuclide administered and the activity in millicuries at time of administration;

b. The exposure rate at 1 meter, the time of measurement, and the person who performed the measurement; and

c. The date when precautions cease to be required and when the tag may be removed, i.e., the date when the maximum integrated exposure to any other individual would not exceed 0.5 R in one year.

3. Collection and Removal of Radioactive Contamination in Patient Excreta. Provisions should be made either to (a) completely collect, with the assistance of the patient where possible, any saliva, vomitus, urine, or other excreta in a manner that will contain the radioactive material temporarily until picked up by the radiation safety staff or (b) dispose of these materials in designated toilet facilities, preferably adjacent to the patient's room. Special attention should be given to training and monitoring regular nursing staff and private duty nurses who may handle these materials.

To ensure proper practices, the radiation safety staff should see that an adequate supply of waterproof containers is available at the bedside and that widemouth plastic bottles with sealable lids are available to the ambulatory patient in the toilet area.

An adequate supply of plastic bags should also be available. These bags should be large enough to be tied and to be held with the radioactive materials at a distance of at least 6 inches from the hand or body when they are picked up for disposal.

When the rate of excretion of the radioactive material is of interest in the medical treatment of the patient, samples taken over given periods of time should be transported under the supervision or cognizance of the radiation safety staff to radiochemical hoods or properly ventilated areas where aliquots or measurements of radioactivity may be taken using general laboratory practices for maintaining exposures ALARA, as summarized in Section 3.4.1.

4. Collection of Radioactive Wastes. The coverings and plastic bags used for contamination control will generate a large volume of radioactive waste, generally of low contamination level. A large plastic trash or garbage can with lid placed in a corner of the room opposite the entrance will allow temporary storage of these low-level wastes. The wastes should be monitored by the radiation safety staff daily and removed to the radioactive waste storage area.

Bed sheets and linens that come into contact with the patient should be temporarily stored in separate containers for daily monitoring by the radiation safety staff. The radiation safety staff should check these linens for the possibility of significant external radiation levels or potential for the spread of contamination before sorting and checking them further to determine whether (a) they may be laundered with ordinary hospital laundry, (b) they should be temporarily stored for decay, or (c) they should be permanently discarded with the radioactive wastes. (See Regulatory Guide 8.23 for appropriate action levels for contamination.)

A radiation safety staff member should control all procedures for collection and disposal of radioactive wastes and laundry and for decontamination since a familiarity with exposure limits, good radiation safety practices, and radiation safety evaluation is necessary for achieving exposures that are ALARA during these procedures. Radioactive wastes removed from the room should be transported as rapidly and directly as possible by cart to the radioactive waste storage area. These procedures should also be monitored, and estimates of radiation exposures to personnel should be computed out and written in the Radiation Safety Office record.

The radiation safety staff should resurvey the patient's room as necessary after each decontamination procedure to ensure that hospital regulations and license conditions regarding exposure and contamination limits in unrestricted areas are met.

5. Storage for Decay or Disposal. Radioactive waste in sealed bags or bottles should be separated for decay or disposal in the waste storage area by radiation safety personnel, and the bags of waste to be disposed of with the

radioactive waste shipments should immediately be placed in the radioactive waste drums.

To save waste disposal costs and to keep exposure to the public ALARA, a shielded area should be provided in a corner of the radioactive waste storage area to allow for decay of radioactive contaminants that have a half-life of less than 10 days. Allowing for decay of these wastes to undetectable levels will reduce radioactive waste disposal costs considerably. However, the wastes should be so stored that personnel entering the waste storage area to deposit other radioactive wastes will not be exposed to the sometimes higher-level wastes stored for decay.

6. Advice to Patient and Staff at Discharge. The radiation safety staff should survey the patient's room immediately before the patient's discharge and should monitor final removal of waste and contamination before any other room cleanup by hospital staff. During this final radiation safety staff visit with the patient, ALARA exposure philosophy should be explained to the patient in a straightforward, simple, and nonalarming way. These discussions may be carried out by the physician attending the patient in some institutions, but in any case the RSO and staff should be consulted.

7. Final Room Survey, Removal of Tags, and Records. After discharge of the patient and final decontamination and cleanup procedures, a final room survey should be carried out by the radiation safety staff to ensure that radiation and contamination levels meet regulatory requirements. At this time, after the room is approved for release for normal use, all radiation caution signs and tags should be removed by the radiation safety staff, and the tags should be removed from the patient's chart. A record of the results of all surveys and recommendations for any improved procedures for reducing radiation exposures should be kept in the Radiation Safety Office.

8. Personnel Monitoring and Bioassay Evaluation. Any temporary dosimeters provided for personnel monitoring should be evaluated and the results recorded by the radiation safety staff. Routinely worn personnel monitoring devices should be collected at appropriate intervals, and exposure reports should be reviewed by the radiation safety staff to ascertain that regulatory requirements were met and exposures were ALARA.

The need for bioassay sampling of some of the personnel involved in administration of the radiopharmaceuticals or care of the patient should be evaluated by the radiation safety staff according to the type of radioactive pharmaceutical (Ref. 31) and the potential (Ref. 12) for appreciable inhalation or ingestion by personnel. For many of the radionuclides used in these procedures, the possibility of significant internal exposure can be checked in in vivo counting of the lung, thyroid, or other organs appropriate to the radiopharmaceutical administered, using the ordinary nuclear medicine scanning or camera equipment. If many I-131 therapy cases are treated in the same location over a short period of time, the RSO may consider air sampling evaluations and thyroid checks of the nursing staff.

Professional health physics consultation with the assistance of the nuclear medicine staff will be needed to determine the appropriate methods of bioassay and evaluation of potential internal radiation exposure of personnel.

The latest edition of Reference 31 will provide summary data on some of the nuclides and dosage forms used on patients. These data may be useful in determining possible exposure to personnel with allowance for the different modes of intake. References 32 and 37-46 also provide data that may be useful in converting dose information in References 31 and 32 into exposure evaluations of personnel in various exposure situations.

There are also important radiation protection considerations presented in NCRP Report Number 37 for protecting medical, nursing, or undertaker personnel during surgery, autopsy, embalming, or burial of patients who have been administered radioactive pharmaceuticals (Ref. 25). Procedures should be established to ensure that wristbands are provided to patients or other means are made available to readily identify any radioactive patients undergoing surgery or post mortem procedures. Even after discharge from the hospital, most patients will still have some radioactivity concentrated within certain organs or in some cases will have needle implants, consisting of short-lived isotopes contained within a confined volume of tissue. Within these irradiated tissue volumes, remaining dose rates at close range can be as high as 10 rads per hour or more. Thus, these surgical and post mortem operations should also be monitored by a member of the radiation safety staff, or very specific procedures should be established for radiation protection.

In surgical or autopsy cases, the tissue volume containing all the radioactivity may be removable; when this is the case, this tissue volume should be removed and placed in a safe container and location before further surgical or autopsy procedures are carried out. When the surgeon or pathologist must operate on a radioactive patient or cadaver, the hands should generally be maintained at a distance of five centimeters from tissues containing radioactive material to avoid beta ray doses. For patients containing unsealed radioactive materials, blood and other tissues discarded from the operation should be treated as radioactive waste. These wastes should be held for decay before disposal, when practicable, particularly for nuclides having half-lives of less than 10 days.

Patients who have received therapeutic radiopharmaceuticals should also be monitored prior to discharge to ensure that their remaining radioactivity is below license requirements (see also the ICRP recommendations, Reference 26). NRC license conditions prohibit the discharge of patients containing more than 30 mCi of I-131 or Au-198. Also, before any radioactive cadavers are turned over to undertakers, the radiation safety staff should be called to obtain a radiation survey and recommendations for ALARA procedures to be carried out by the undertakers. Where the undertaker staff could possibly be exposed to levels that might exceed 25 percent of the limits of 10 CFR Part 20 for persons in unrestricted areas, consideration should be given to providing assistance or advice to the undertaker regarding personnel monitoring. In carrying out all of these procedures for the protection of the medical staff and employees, consideration should be given to the proper briefing of family or friends who may be concerned about the radioactive nature of the patient or the deceased. Proper planning and coordination between the radiation safety office and medical staff will ensure that family and friends will not be unduly alarmed as a result of radiation protection procedures.

3.4.3 DIAGNOSTIC NUCLEAR MEDICINE

A summary of some of the more important considerations in maintaining occupational exposures ALARA in diagnostic nuclear medicine is given below.*

1. Radionuclide Generators. These should be set up in an area separate from other nuclear medicine operations or in an area of the nuclear medicine laboratory or pharmacy adequately distant from other areas occupied by personnel. They should have adequate ventilation and additional shielding as necessary to reduce external as well as internal exposure to personnel during elution. An auxiliary generator shield should be provided for molybdenum-99 and technetium-99m generators as delivered from radiopharmaceutical companies since the shielding of these generators when delivered is not necessarily designed to be adequate to protect nuclear medicine personnel after the generator is removed from the shipping carton.

2. Assay of Tc-99m. After elution of a batch of Tc-99m, either the eluate should be calibrated in a shielded geometry or an appropriate sample should be placed in a separate shielded bottle for checking the assay of the eluate in the nuclear medicine dose calibrator or other suitable assay system. This procedure permits calibration with a smaller quantity of radioactive material. All patient dosages should be assayed prior to administration. Regulatory Guide 10.8 provides guidance on acceptable methods of ensuring delivery of properly checked and calibrated dosages to patients (Ref. 47).

3. Use of Fume Hoods. The use of fume hoods and good contamination control principles when preparing dosages of radiopharmaceuticals that have potential volatility will help to ensure ALARA internal exposures of personnel.

4. Hand Protection During Dosage Administration. Maximum use of syringe shields during administration of dosages can be a major factor in maintaining exposures ALARA (Refs. 7, 8, 11). This may require special training. Unshielded bottles should never be touched or carried directly with the fingers. Syringe shields should be routinely used for preparation and administration of patient dosages, except in rare circumstances where their use would compromise the patient's well-being. Tongs should be used when bottles must be removed from shields or to hold unshielded syringes containing radioactive material for transfer during dosage preparation. Because of the large skin doses possible from hand contamination (perhaps 5 rad/μCi per cm^2), gloves should be worn at all times during dosage injection (Ref. 8).

5. Storage of Vials. Unshielded vials should never be stored behind bench shields that are routinely used for manipulating radiopharmaceuticals. Vials of radiopharmaceuticals should be placed back in their shielded lead containers immediately after use and stored in a shielded section of the laboratory that is properly labeled, as required by § 20.203 of 10 CFR Part 20.

6. Dosimeters and Badges. Finger dosimeters as well as body badges or dosimeters should be worn by all nuclear medicine personnel who will prepare

* A recent report by the Bureau of Radiological Health, Reference 46, provides useful information for the safe operation of a nuclear medicine laboratory.

and administer radiopharmaceuticals, and records should be kept in the Radiation Safety Office of the cumulative exposure during each calendar year of each monitored employee's finger exposures, as well as the cumulative whole-body exposure as evaluated from the whole-body badge. Lead aprons can be used as an additional means of keeping exposures ALARA if they do not interfere with medical procedures. In nuclear medicine operations where lead aprons are worn to protect against technetium-99m gamma exposure, the whole-body badge should be worn outside the apron in order to monitor parts of the body that have the same exposure limits as the whole body according to 10 CFR Part 20. Nursing staff, including private duty nurses, who regularly attend patients who have been administered radiopharmaceuticals for diagnostic purposes should also be monitored and should be provided regular personnel monitoring service when warranted.

7. Waste. Shielded radioactive waste cans containing used syringes and other radioactive wastes should be kept at an adequate distance from the laboratory areas most frequently occupied by personnel, while still remaining convenient for use and rapid disposal of radioactive wastes, since gamma emitters with the more penetrating photons may build up temporarily higher external radiation levels in the laboratory.

The radioactive waste cans should be lined with plastic bags that are large enough and strong enough to keep them from breaking when the waste is ultimately discarded into the waste drums in the radioactive waste area. All syringes, needles, and pipettes (including Pasteur-type) should be appropriately capped to prevent puncture of the radioactive waste bags in the waste containers and to prevent internal contamination to nuclear medicine personnel handling the waste.

Radioactive waste cans should have a plastic liner and they should be emptied often enough to prevent unnecessary occupational exposure to nuclear medicine employees. In some busy departments, it may be desirable to have an extra radioactive waste can to prevent overflow. The inner plastic liner should not be overfilled, so the liner can be easily closed and sealed. The plastic bags of radioactive waste should be placed in a shielded pail and transported on an appropriate cart to the radioactive waste storage drums in the waste disposal room for storage.

8. Camera Procedures. During scanning or camera procedures, technologists should be aware of the advantages of keeping a reasonable distance away from patients containing radioactive materials, while at the same time avoiding any impression of fear of the very low risks that are being incurred when exposures are ALARA. If they do not interfere with the diagnostic tests, protective lead screens can be very helpful in achieving exposures that are ALARA for procedures using Tc-99m or other low-energy gamma emitters.

9. Xenon-133. In lung perfusion or ventilation studies with xenon-133, additional lead shielding 1.6 mm thick (or appropriate thicknesses for other radioactive gases) around the absorber canister, oxygen bag, and waste receptacle can reduce occupational exposures to some degree when frequent xenon procedures are carried out. An added shield of 3.2 mm of lead interposed between the xenon dispensing-collecting apparatus and the gamma camera may help

to ensure better diagnostic information, which may avoid the necessity for repeat procedures.

Better diagnostic information may also be achieved by keeping an adequate distance from the xenon waste absorber or waste storage bag. Immediately after a procedure using xenon-133, the waste xenon should be removed for decay or disposal to a remote area to minimize exposures to external or internal radiation from the xenon-133.

10. Contamination Control. Contamination spills during work hours that may produce appreciable occupational exposure or interference with nuclear medicine procedures should be immediately cleaned up using appropriate measures for contamination control and waste disposal as suggested in Section 3.4.1 and Section 3.4.2.3. At the end of each day, nuclear medicine departments should be monitored for external radiation levels and possible areas of contamination that should be cleaned up according to the institution's radiation safety procedures. However, when cleanup of larger amounts of short-lived nuclides such as Tc-99m may entail additional occupational exposure, consideration should be given to containing the spill or contamination by means of absorbent covers to allow overnight decay of the contamination before early morning cleanup the next day.

All surfaces likely to be contacted by personnel such as telephones, door knobs, desks, handles, and instrument knobs should be periodically checked for contamination by the nuclear medicine staff, as well as by the Radiation Safety Office staff during its regular surveys. Special attention should also be given to areas where vials with rubber septums are in use and to possible contamination on incoming as well as outgoing shields and vials.

Records of all contamination surveys should be maintained with dates and signatures. Further guidance on survey records is given in Regulatory Guide 8.23.

11. Bioassay Programs. Bioassay programs judged applicable by the Radiation Safety Officer or required by the radioisotope license are an important part of ALARA exposure programs in nuclear medicine. References 31-33, 37-45, 48, and 49 give information on providing appropriate bioassay evaluations.

3.4.4 LOW-LEVEL CLINICAL OR MEDICAL RESEARCH LABORATORY ACTIVITIES

Laboratories in medical institutions that use tracer amounts of the less radiotoxic nuclides may keep exposures ALARA by using the recommendations given in Section 3.4.1 and some of the recommendations of References 12, 14, 15, 23, 30, and 47-50. Many of the radionuclides used for in vitro clinical tests such as radioimmunoassay and other low-level in vitro or animal studies involve pure beta emitters or weak gamma emitters, with only microcurie or submicrocurie quantities handled and processed by individual personnel at any one time. External and internal radiation exposures to personnel in such laboratories should ordinarily be maintained well below 10 percent of the permissible occupational exposure limits of 10 CFR Part 20 through careful initial planning of laboratory facilities, equipment, and procedures by the laboratory supervisor, in conjunction with qualified health physics personnel, using the references cited.

3.5 MANAGEMENT AUDIT AND INSPECTION OF THE RADIATION SAFETY PROGRAM

Ultimate responsibility for the establishment and continuation of an adequate radiation safety program in a medical institution has been placed with the governing body of the hospital (Ref. 2; Ref. 30, p. 45). The administrator reporting to this governing body should be sufficiently informed at all times to be sure that all regulations are faithfully adhered to and that the use and safe handling of radioisotopes are properly carried out to achieve ALARA exposure objectives.

Hospital administration may find it helpful to carry out an annual audit of the radiation safety program in cooperation with members of the Radioisotope Committee and the Radiation Safety Office. The results of this audit may then be discussed at an annual radiation safety committee meeting to ensure that all users and responsible staff are aware of current policies and procedures and methods for their improvement. An inspection checklist (Ref. 51) is included in Appendix E to illustrate items that may be inspected by the administration during this annual audit in order to (1) ensure that regulatory requirements and license conditions are being met and (2) obtain a current familiarity with the overall effectiveness of the radiation safety program of the medical institution and possible ways of improving radiation safety practices. A report of the results of the audit should be maintained by the Radiation Safety Office for possible use in expediting any inspections by regulatory or accrediting agencies, as well as for reference in future auditing and improving the ALARA program.

A recent review (Ref. 52) of radiation safety procedures used in hospitals and data on the relative exposure potentials of various types of hospital procedures may be helpful to management in establishing priorities for implementing radiation safety programs and policies.

REFERENCES

1. Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, D.C.

2. U.S. Nuclear Regulatory Commission, "Operating Philosophy for Maintaining Occupational Radiation Exposures as Low as is Reasonably Achievable," Regulatory Guide 8.10, Washington, D.C.

3. National Bureau of Standards, "Permissible Dose from External Sources of Ionizing Radiation," Handbook 59, Recommendations of the National Council on Radiation Protection (National Council on Radiation Protection and Measurements Report No. 17), Washington, D.C., September 24, 1954.

4. National Council on Radiation Protection and Measurements, "Review of the Current State of Radiation Protection Philosophy," NCRP Report No. 43, Washington, D.C., January 15, 1975.

5. National Academy of Sciences--National Research Council, Committee on Biological Effects of Ionizing Radiation (BEIR), "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1972," Washington, D.C.; see also the more recent independent review of the same title, sometimes called, "The BEIR Report," 1980.

6. Federal Radiation Council, "Background Material for the Development of Radiation Protection Standards," Report No. 1, Washington, D.C., 1960.

7. R. Barrall, L. H. Lanzl, and J. W. Hilbert, "A Survey of Personnel Exposure in Nuclear Medicine," American Association of Physicists in Medicine, New York, N.Y., 1975; also R. C. Barrall and S. I. Smith, "Personnel Exposure and Protection from ^{99m}Tc Radiations," submitted Oct. 4, 1978 with comments on Regulatory Guide 8.18, Public Document Room, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

8. J. Howley, "Finger Tip Radiation Exposure in Nuclear Medicine," available from Radiation Safety Office, National Institutes of Health, Bethesda, Maryland 20014; see also N. L. McElroy, "Efficacy of Various Syringe Shields for ^{99m}Tc," Health Physics, Vol. 41, pp. 535-542, 1981.

9. American Association of Physicists in Medicine (AAPM) Monograph No. 1, "Biophysical Aspects of the Medical Use of Technetium-99m," J. G. Kereiakes and Karen R. Corey, Editors (available from American Institute of Physics, 335 East 45th Street, New York, NY 10017, or Dr. James G. Kereiakes, E555 Medical Sciences Building, University of Cincinnati, Cincinnati, Ohio 45267), 1976.

10. R. Ice, "Establishment of a University Radiation Safety Office," Health Physics, Vol. 20, pp. 444-446, 1971.

11. The following articles from DHEW Pub. No. 73-8029:

J. St. Germain, "Operational Health Physics in Diagnosis"; R. J. Cloutier and E. E. Watson, "Radiation Doses from Nuclear Medicine Procedures"; F. Dobrowolski, "Health Physics in Radiotherapy"; M. G. Mayes, R. L. Douglas, M. W. Carter, T. M. Grady, and E. van der Smissen, "Study of Radiation Exposures from Technetium Generators at Three Hospitals"; M. H. Lombardi, W. L. Beck, and R. J. Cloutier, "Survey of Radiopharmaceutical Use and Safety in Sixty-Nine Hospitals."

12. Y. Wang, Editor, "Handbook of Radioactive Nuclides," CRC Press, Cleveland, Ohio, 1969.

13. Committee on Industrial Ventilation, American Conference of Governmental Industrial Hygienists, "Industrial Ventilation," Lansing, Mich., 1975.

14. H. Blatz, "Introduction to Radiological Health," McGraw-Hill, New York, N.Y., 1964.

15. National Council on Radiation Protection and Measurements, "Medical X-Ray and Gamma-Ray Protection for Energies up to 10 Mev--Equipment Design and Use," NCRP Report No. 33, Washington, D.C., 1968.

16. National Council on Radiation Protection and Measurements, "Medical X-Ray and Gamma-Ray Protection for Energies up to 10 Mev--Structural Shielding Design and Evaluation," NCRP Report No. 34, Washington, D.C., 1970. Reissued as NCRP Report No. 49, "Structural Shielding Design and Evaluation for Medical Use of X-Rays and Gamma Rays of Energies Up to 10 MeV," September 1976.

17. International Commission on Radiological Protection (ICRP), "Report of Committee Five on the Handling and Disposal of Radioactive Materials in Hospitals and Medical Research Establishments," ICRP Report 5, Pergamon Press, Elmsford, N.Y., 1965.

18. U.S. Nuclear Regulatory Commission, "Draft Licensing Guide for Teletherapy Programs," NUREG-0339, Office of Nuclear Material Safety and Safeguards, USNRC, Washington, D.C. 20555. March 1979.

19. American National Standards Institute, "Guidelines for Maintaining Cobalt-60 and Cesium-137 Teletherapy Equipment," ANSI N449-1974, New York, N.Y., December 1973.

20. American National Standards Institute, "Procedures for Periodic Inspection of Cobalt-60 and Cesium-137 Teletherapy Equipment," ANSI N449.1-1978, New York, N.Y., 1978.

21. C. B. Braestrup and K. J. Vikterlof, "Manual on Radiation Protection in Hospitals and General Practice," Vol. 1, "Basic Protection Requirements," World Health Organization, Geneva, Switzerland, 1974.

22. National Council on Radiation Protection and Measurements, "Protection Against Radiation from Brachytherapy Sources," NCRP Report No. 40, Washington, D.C., 1972.

23. H. Blatz, Editor, "Radiation Hygiene Handbook," McGraw-Hill, New York, N.Y., 1959.

24. National Council on Radiation Protection and Measurements, "Safe Handling of Radioactive Materials," NCRP Report No. 30, Washington, D.C., 1964.

25. National Council on Radiation Protection and Measurements, "Precautions in the Management of Patients Who Have Received Therapeutic Amounts of Radionuclides," NCRP Report No. 37, Washington, D.C., 1970.

26. International Commission on Radiological Protection, "Protection of the Patient in Radionuclide Investigations," ICRP Publication No. 17, Pergamon Press, Elmsford, N.Y., 1969.

27. Department of Health, Education and Welfare, "Status and Future Manpower Needs of Physicists in Medicine in the United States," Publication No. (FDA) 74-8014, report of The Joint Committee on Manpower Needs in Medical Physics of The American College of Radiology and The American Association of Physicists in Medicine, sponsored by the Bureau of Radiological Health, Washington, D.C., November 1973.

28. International Atomic Energy Agency, "Safe Handling of Radionuclides," IAEA Safety Series No. 6, Vienna, Austria, 1973.

29. B. Branson, P. A. Feller, and V. J. Sodd, "Personnel Exposure from an Unshielded Pulmonary Ventilation System," Nuclear Medicine Lab., Cincinnati General Hospital, Cincinnati, Ohio, 1976.

30. R. D. Vanderwarker, Ed., "Use of Radioisotopes in Hospitals," American Hospital Association, Chicago, Ill., 1967.

31. L. M. Freeman and M. D. Blaufox, editorial consultants, "Physicians' Desk Reference for Radiology and Nuclear Medicine," Medical Economics Co., Oradel, N.J., 1975/76.

32. L. T. Dillman, "Radionuclide Decay Schemes and Nuclear Parameters for Use in Radiation-Dose Estimation," MIRD Pamphlet 4, Supplement No. 2 of the Journal of Nuclear Medicine, New York, N.Y., March 1969.

33. National Council on Radiation Protection and Measurements, "Basic Radiation Protection Criteria," NCRP Report No. 39, Washington, D.C., 1971.

34. International Commission on Radiological Protection, "Protection Against Ionizing Radiation from External Sources," ICRP Report No. 15, Pergamon Press, Elmsford, N.Y., 1973.

35. U.S. Nuclear Regulatory Commission, "Instruction Concerning Prenatal Radiation Exposure," Regulatory Guide 8.13, Washington, D.C.

36. National Council on Radiation Protection and Measurements, "Radiation Protection for Medical and Allied Health Personnel," NCRP Report No. 48, Washington, D.C., 1976.

37. U.S. Nuclear Regulatory Commission, "Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program," Regulatory Guide 8.9, Washington, D.C.

38. International Commission on Radiological Protection, "Report of ICRP Committee II on Permissible Dose for Internal Radiation (1959), with Bibliography for Biological, Mathematical, and Physical Data," ICRP Publication 2, Pergamon Press, Elmsford, N.Y., 1960.

39. International Commission on Radiological Protection, "Recommendations of the ICRP, 1962, Supplement to ICRP Publication 2," ICRP Publication 6, Pergamon Press, Elmsford, N.Y., 1964.

40. International Commission on Radiological Protection, "Recommendations of the International Commission on Radiological Protection," ICRP Publication 9, Pergamon Press, Elmsford, N.Y., 1966.

41. International Commission on Radiological Protection, "Evaluation of Radiation Doses to Body Tissues from Internal Contamination Due to Occupational Exposure," ICRP Publication 10, Pergamon Press, Elmsford, N.Y., 1968.

42. International Commission on Radiological Protection, "Assessment of Internal Contamination Resulting from Recurrent or Prolonged Uptakes," ICRP Publication 10A, Pergamon Press, Elmsford, N.Y., 1971.

43. International Commission on Radiological Protection, "General Principles of Monitoring for Radiation Protection of Workers," ICRP Publication 12, Pergamon Press, Elmsford, N.Y., 1969.

44. International Commission on Radiological Protection, "Reference Man," ICRP Publication 23, Pergamon Press, Elmsford, N.Y., 1975.

45. W. S. Snyder, Mary R. Ford, G. G. Warner, and Sarah B. Watson, "A Tabulation of Dose Equivalent per Microcurie-Day for Source and Target Organs of an Adult for Various Radionuclides," ORNL-5000, National Technical Information Service, Springfield, Va., 1974.

46. V. J. Sodd, "Radiation Safety in Nuclear Medicine: A Practical Guide," Bureau of Radiological Health, Department of Health and Human Services, HHS Publication FDA 82-8180, Rockville, Md., 1981.

47. U.S. Nuclear Regulatory Commission, "Guide for the Preparation of Applications for Medical Programs," Regulatory Guide 10.8, Washington, D.C.

48. U.S. Nuclear Regulatory Commission, "Applications of Bioassay for I-125 and I-131," Regulatory Guide 8.20, Washington, D.C.

49. U.S. Nuclear Regulatory Commission, "Applications of Bioassay for Fission and Activation Products," Regulatory Guide 8.26, Washington, D.C.

50. U.S. Nuclear Regulatory Commission, "Radiation Safety Surveys of Medical Institutions," Regulatory Guide 8.23, Washington, D.C.

51. S. M. Brahmavar, S. M. Zubi, and J. P. Sullivan, "Compliance Tests and Radiation Safety Procedures for Broad and Specific Medical Byproduct Material Licenses," in Proceedings of the 22nd Annual Meeting of the Society of Nuclear Medicine, 1975. (Available from Dr. S. M. Brahmavar, Department of Pathology, Medical Center of Western Massachusetts, Springfield, Mass.)

52. T. G. Martin and K. W. Price, Editors, Medical Health Physics, Proceedings of the Health Physics Society Fourteenth Mid-Year Topical Symposium, December 8-12, 1980 (available from Training Resources, 9150 Rumsey Center, Columbia, Md. 21045).

BIBLIOGRAPHY

American College of Radiology, "Planning Guides for Radiologic Installations," Washington, D.C., 1966.

American National Standards Institute, "Leakage Tests on Packages for Shipment of Radioactive Materials," ANSI N14.5-1977, New York, N.Y.

American National Standards Institute, "Calibration and Usage of Dose Calibrator Ionization Chambers for the Assay of Radionuclides," ANSI N42.13-1978, New York, N.Y.

American National Standards Institute, "Leak Testing Radioactive Brachytherapy Sources," ANSI N44.2-1979, New York, N.Y.

Barrall, R. C., and S. I. Smith, "Personnel Radiation Exposure and Protection from ^{99m}Tc Radiations," submitted October 4, 1978 with comments on Regulatory Guide 8.18, Public Document Room, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

Bushong, Stewart C., Radiologic Science for Technologists: Physics, Biology and Protection, 2nd Ed., The C. V. Mosby Co., St. Louis, Mo., 1980.

Cember, Herman, Introduction to Health Physics, Pergamon Press, New York, N.Y., 1969.

Department of Health, Education and Welfare, "Health Physics in the Healing Arts," Publication No. (FDA) 73-8029, Proceedings of the Seventh Mid-year Symposium of the Health Physics Society, San Juan, Puerto Rico, December 1972.

Frost, D., and H. Jammet, "Manual on Radiation Protection in Hospitals and General Practice. Volume 2: Unsealed Sources," World Health Organization, Geneva, Switzerland, 1975. (Available from WHO Publications Centre, 49 Sheridan Avenue, Albany, N.Y. 12210.)

International Atomic Energy Agency, "Radiopharmaceuticals from Generator-Produced Radionuclides," Panel Proceedings Series, STI/PUB/294, Vienna, Austria, 1971 (available from UNIPUB, Inc., 345 Park Avenue South, New York, N.Y. 10010).

International Commission on Radiological Protection, "Implications of Commission Recommendations that Doses Be Kept As Low As Readily Achievable," Report No. 22, Pergamon Press, Elmsford, N.Y., 1974.

International Commission on Radiological Protection, "The Handling, Storage, Use and Disposal of Unsealed Radionuclides in Hospitals and Medical Research Establishments," ICRP Publication No. 25, Pergamon Press, Elmsford, N.Y., 1977.

International Commission on Radiological Protection, "Limits for Intake of Radionuclides by Workers," Parts 1-3 and supplements, ICRP Publication 30, Pergamon Press, Elmsford, N.Y., 1980.

Kereiakes, J. G., and K. R. Corey, Editors, "Biophysical Aspects of the Medical Use of Technetium-99m," American Association of Physicists in Medicine, New York, N.Y., 1976.

Leahy, Irene M., Jean M. St. Germain, and Claudette G. Varricchio, The Nurse and Radiotherapy, A Manual for Daily Care, C. V. Mosby Co., St. Louis, Mo., 1979.

National Council on Radiation Protection and Measurements, "Specification of Gamma-Ray Brachytherapy Sources," NCRP Report No. 41, Washington, D.C., 1974.

National Council on Radiation Protection and Measurements, "Review of NCRP Radiation Dose Limit for Embryo and Fetus in Occupationally-Exposed Women," NCRP Report No. 53, Washington, D.C., 1977.

National Council on Radiation Protection and Measurements, "Medical Radiation Exposure of Pregnant and Potentially Pregnant Women," NCRP Report No. 54, 1977.

National Council on Radiation Protection and Measurements, "Protection of the Thyroid Gland in the Event of Releases of Radioiodine," NCRP Report No. 55, Washington, D.C., 1977.

National Council on Radiation Protection and Measurements, "Instrumentation and Monitoring Methods for Radiation Protection," NCRP Report No. 57, Washington, D.C., 1978.

National Council on Radiation Protection and Measurements, "A Handbook of Radioactivity Measurements Procedures," NCRP Report No. 58, Washington, D.C., 1978.

National Council on Radiation Protection and Measurements, "Operational Radiation Safety Program," NCRP Report No. 59, Washington, D.C., 1978.

National Council on Radiation Protection and Measurements, "Tritium and Other Radionuclide Labeled Organic Compounds Incorporated in Genetic Material," NCRP Report No. 63, Washington, D.C., 1979.

National Council on Radiation Protection and Measurements, "Influence of Dose and Its Distribution in Time on Dose-Response Relationships for Low-LET Radiations," NCRP Report No. 64, Washington, D.C., 1980.

National Council on Radiation Protection and Measurements, "Management of Persons Accidentally Contaminated with Radionuclides," NCRP Report No. 65, Washington, D.C., 1980.

National Fire Protection Association, "Facilities Handling Radioactive Materials," American National Standard ANSI N693, NFPA Pamphlet 801, 470 Atlantic Ave., Boston, Mass., 1975.

Sinclair, Warren K., and staff of M. D. Anderson Hospital and Tumor Institute, "Handbook of Rules for Administration of Radioactive Materials to Patients," available from Squibb Company, Box 4000, Princeton, N.J. 08540.

Title 10, Code of Federal Regulations, Part 51, "Licensing and Regulatory Policy and Procedures for Environmental Protection," U.S. Government Printing Office, Washington, D.C.

World Health Organization, "Use of Ionizing Radiation and Radionuclides on Human Beings for Medical Research, Training, and Nonmedical Purposes," Technical Report Series 611, 1977. (Available from WHO Publications Centre, 49 Sheridan Avenue, Albany, N.Y. 12210.)

ORGANIZATIONS INVOLVED IN RADIATION PROTECTION

In addition to the references listed above, there are a number of national and international organizations that have published recommendations and guidance providing detailed methods, data, and scientific information for use in establishing radiation protection programs aimed at maintaining radiation exposures as low as reasonably achievable. The organizations and their addresses are listed below:

American Association of Physicists in Medicine (AAPM)
Radiation Protection Committee
335 East 45th Street
New York, N.Y. 10017

The AAPM Radiation Protection Committee has developed guidance for radiation protection and reducing exposures ALARA in the various types of procedures in medical institutions using radioactive materials.

American College of Radiology
6900 Wisconsin Avenue
Chevy Chase, Md. 20815

American Conference of Governmental Industrial Hygienists
Committee on Industrial Ventilation
P.O. Box 453
Lansing, Mich. 48902

This committee regularly updates its "Industrial Ventilation" manual, which provides engineering data and methods equally applicable to the design of medical facilities handling radioactive materials.

American Industrial Hygiene Association (AIHA)
66 S. Miller Road
Akron, Ohio 44313

The AIHA has established a laboratory for accreditation of laboratories carrying out analyses related to the health and safety of employees and is proposing to extend this program to bioassay of radioactive materials for internal dose estimation. They may be contacted, as well as the Health Physics Society, for expert assistance on planning bioassay services or for ventilation design and general laboratory safety considerations.

American National Standards Institute, Inc. (ANSI)
345 East 47th Street
New York, New York 10017

Bureau of Radiological Health (BRH)
Food and Drug Administration
Public Health Service
U.S. Department of Health, Education, and Welfare
Rockville, Md. 20852

U.S. Department of Energy
Washington, D.C. 20585

Federal Radiation Council (FRC)

Functions of the Federal Radiation Council have now been transferred to the Environmental Protection Agency; documents are available from U.S. Government Printing Office, Washington, D.C. 20402.

International Atomic Energy Agency (IAEA)
Wagramerstrasse 5
P.O. Box 100
A-1400 Vienna, Austria

Publication orders from the U.S.A. should be addressed to UNIPUB, Inc., 345 Park Avenue South, New York, N.Y. 10010.

International Commission on Radiation Units and Measurements (ICRU)
7910 Woodmont Avenue
Bethesda, Md. 20814

Order publications from ICRU Publications, same address.

International Commission on Radiological Protection (ICRP)

Order publications from Pergamon Press, Inc., Fairview Park, Elmsford, N.Y. 10523, or through bookstores in the United States.

International Labour Office (ILO)
Geneva, Switzerland

Most publications of ILO useful in medical institutions are available from other agencies as joint publications.

Joint Commission on Accreditation of Hospitals (JCAH)
875 N. Michigan Avenue
Chicago, Ill. 60611
Attention: Publications

The JCAH has published a manual of standards, including environmental aspects of radiation safety, that contains the basis for their hospital inspection program for accreditation. These standards will be issued in revised form as available.

Medical Internal Radiation Dose Committee (MIRD)
Society of Nuclear Medicine
475 Park Avenue South
New York, N.Y. 10016

The MIRD committee has in recent years issued a number of excellent compilations of data and methods for calculating doses to humans from radionuclides used in medicine. These same data and methods are useful in monitoring and estimating both internal and external occupational exposures to hospital employees.

National Academy of Sciences--National Research Council (NAS-NRC)
2101 Constitution Avenue, N.W.
Washington, D.C.

National Council on Radiation Protection and Measurements (NCRP)
7910 Woodmont Avenue
Bethesda, Md. 20814

Order publications from NCRP Publications, same address.

National Institute for Occupational Safety and Health (NIOSH) and
National Institute for Environmental Health Sciences (NIEHS)
Department of Health and Human Services
Washington, D.C.

Publications are available from the National Technical Information Service, Springfield, Va. 22151.

Standards Committee
Health Physics Society (HPS)
4720 Montgomery Lane
Bethesda, Md. 20814

World Health Organization (WHO)
Distribution and Sales Service
1211 Geneva 27, Switzerland

APPENDIX A

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Carson City, NV 98710

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New Mexico 505-827-5271, Ext. 279

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P.O. Box 968
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2 Rockefeller Plaza
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Department of Social and Health
Services
Mail Stop LD-11
Olympia, WA 98504

APPENDIX B

RADIATION SAFETY TASKS INVOLVED IN KEEPING OCCUPATIONAL EXPOSURES ALARA

1. Surveys of the following radioactivity areas:

   a. Nuclear medicine
   b. Radiation therapy
   c. Oncology
   d. Pathology
   e. Cardiology
   f. Pediatrics
   g. Radioactive waste disposal and storage
   h. Other research and clinical laboratories using radioactive materials

2. Surveys of diagnostic and therapeutic machines and generators, including:

   a. Teletherapy sources and machines
   b. Computerized axial tomography scanners
   c. Interlock and safety checks
   d. Calibrations
   e. Fluoroscopes
   f. Radiographic x-ray

3. Personnel monitoring:

   a. Review of personnel exposure data and reports
   b. Preparation of reports required by regulations
   c. Filing, collecting, and mailing personnel monitoring devices (including late and lost)
   d. Special investigations of exposure and notifications to regulatory agencies as appropriate
   e. Calibration of personnel monitoring dosimeters, including commercially supplied film badge service

4. Radiation safety instrument calibration and maintenance:

   a. Calibration
   b. Battery replacement and adjustment
   c. Pocket chamber and TLD calibration
   d. Minor repair (electronic)
   e. Instrument selection and distribution
   f. Check-source calibration

5. Decontamination and waste disposal:

   a. Collection and packaging
   b. Surveying
   c. Recording
   d. Shipping arrangements
   e. Placarding
   f. Decontamination of surgical instruments, rooms, and laboratories

6. Leak-testing radioactive sources using the following techniques:

   a. Wiping
   b. Counting
   c. Calculation
   d. Recording
   e. Counter calibration

7. Evaluation of internal exposure by means of:

   a. Collection of samples, including air sampling when applicable
   b. Radiochemical or scintillation bioassay analysis
   c. Counter calibration
   d. In vivo counting
   e. Computer analysis of results

8. Special surveys of patients and rooms for implant, intracavitary, or unsealed radiopharmaceutical therapy, including:

   a. Room preparation and protective covering
   b. Labeling (bed, chart, door)
   c. Nursing staff and housekeeping staff briefings
   d. Background surveys
   e. Source insertion and afterloading surveys
   f. Surveys of patients in operating room and recovery room
   g. Placing of lead barriers
   h. Recovery of sources and wastes
   i. Survey of room cleanup and decontamination
   j. Instructions to patient and to family of patient as appropriate
   k. Measurement of radiation from cadavers and briefings to pathology staff and funeral directors as appropriate

9. Administration and consultation, including:

   a. Approval of facilities, equipment, and procedures used in areas where radioactive materials are handled
   b. Preparation of license applications and amendments
   c. Preparation of hazard evaluation reports for licensing
   d. Programming of routine required surveys
   e. Supervision of routine radiation safety operations
   f. Revisions to radiation safety manual
   g. Periodic radiation safety instruction for hospital staff and administration

h. Training of residents and medical staff
i. Conferences with physicians and other safety staff
j. Coordination of radiation safety committee meetings and minutes
k. Inspections and discussions with government regulatory agency representatives
l. Professional meetings
m. Selecting and ordering equipment and supplies
n. Planning and budgeting
o. Facility and shield design and meetings with architects
p. Record maintenance and related computer programming
q. Planning prompt effective response to incidents and emergencies involving radiation
r. Providing instructional direction for outside persons (for example, firemen) who would respond to an emergency situation involving or potentially involving radiation
s. Preparation of Radiation Safety Office reports to administration

APPENDIX C

SUMMARY CHECKLIST OF RADIATION SAFETY CONSIDERATIONS IN HOSPITAL FACILITY AND EQUIPMENT DESIGN

1. Adequate office space to carry out pertinent tasks of Appendix B. In the larger hospitals, 1,000 square feet or more should be provided for:

   a. Receipt, processing, and filing of regulations and licensing correspondence.
   b. Preparation of survey and personnel monitoring reports/records.
   c. Counting wipes from contamination surveys and leak tests.
   d. Providing instructions and briefings to personnel.
   e. Calibration, maintenance, and repair of radiation safety equipment.
   f. Stocking supplies for labeling, surveying, decontamination, and personnel monitoring.
   g. Processing of orders for and receipt, inspection, and distribution of radioactive materials.
   h. Storage for sources not in use and for radioactive wastes.
   i. Decontaminating personnel, clothing, and equipment.

2. Adequate space in all areas where radioactive materials are used or handled so that personnel may maintain appropriate distances from sources when they must be unshielded.

3. Adequate floor loading capacity in areas where heavy shielding (permanent or temporary) may be required.

4. Adequate shielding and ventilation in all areas in which radioactive materials are used.

5. Permanent shielding when needed, particularly for teletherapy.

6. Surfaces that are easily decontaminated in all areas where contamination by unsealed radioactive materials is possible.

7. Caution signs, symbols, caution lights, interlocks, keylocks, and independent gamma-sensing alarms at appropriate operating stations and entrances.

8. Adequate supply of radiation safety monitoring instruments as necessary for particular radioactive materials, quantities handled, and types of operation.

APPENDIX D

INFORMATION USEFUL FOR MAINTAINING RADIATION EXPOSURES ALARA

SAMPLE RADIATION SAFETY HANDOUT INFORMATION FOR BRIEFING NURSING STAFF*

1. Definitions (simplified)

Roentgen (R)	a unit of the amount of x- or gamma radiation, measured by the amount of electric charge produced in the air near the point of measurement (1 esu/cc at standard temperature and pressure, also 2.58×10^{-4}C/kg). (About 400 roentgens to the whole body in a short time (less than one day) would be lethal to about half of those exposed.)
Milliroentgen (mR)	1/1000th of a roentgen. Note: Averaging less than 100 milliroentgens (mR) per week is within safe limits, but exposures should be kept "as low as reasonably achievable" (ALARA).
Rad	100 ergs of energy absorbed per gram. This is about the rate of energy absorbed from 1 roentgen of x- or gamma rays near the surface of the body.
Rem	the amount of any kind of radiation that is equivalent in biological damage to one roentgen of x- or gamma rays.
Curie (Ci)	an amount of radioactivity equal to 37 billion atoms transforming or disintegrating per second. It does not by itself determine the hazard unless the type of radioactive material, how many gamma rays are emitted for each disintegrating atom, etc., are known.
Half-Life	the time for the number of radioactive atoms and the radiation intensity to decrease by 1/2.

*Be sure to include this information in necessary briefings to licensed practical nurses (LPNs), private duty nurses, housekeeping personnel, and others who may attend patients who have been administered radioactive materials for either diagnostic or therapeutic purposes.

2. Maximum Permissible Levels for Occupationally Exposed Individuals: (Simplified Summary)

Ordinary Employment:

a. 5 roentgens (R) per year
b. 5,000 milliroentgens (mR) per year
c. 100 mR per week (for 50 workweeks per year)

Pregnant Nurses:

Maximum of 500 mR during 9 months of pregnancy.*

(Refer to NRC Regulatory Guide 8.13, which should be available through the Radiation Safety Office.)

General Principle:

No unnecessary exposure. Although exposure to naturally occurring radiation cannot be avoided (for example, the radiation dose due to natural background may vary from 100 to 200 mrad in one year depending on geographical location), all occupational exposure is considered to carry some risk, and unnecessary exposure should be avoided. Maintain exposures ALARA, but do not fear reasonable exposures within limits. The risk is small compared to other risks of daily life when safe practices are followed (as described in the hospital radiation safety manual).

3. Radiation Safety Precautions (Routine)

a. Minimize unnecessary time near patients, but provide necessary care.

b. If possible, stay within time posted on door or on patient's chart, but provide patient's needs. If time must be exceeded during one case, keep average exposure well within limits for all cases in a 3-month period.

c. Stand behind lead shield as much as possible when shield is provided for patient containing radioactive material.

d. Limit visitors to exposures of no more than 10 mR. If possible, have them sit at least 6 feet from the patient. Do not allow visitors or employees to use toilets that may be contaminated by the patients.

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* See NCRP Report 54, "Medical Radiation Exposure of Pregnant and Potentially Pregnant Women," July 15, 1977, for a more detailed discussion on the advisability of limiting exposure during pregnancy. This report is available from the National Council on Radiation Protection and Measurements, P.O. Box 4867, Washington, D.C. 20008.

e. If patients have been injected or treated with radioisotopes in a form other than sealed sources such as radium or cesium implants, their clothing or bodies may be slightly contaminated. Minimize contact with such patients, but provide necessary care and then wash hands after contact. Have Radiation Safety Office make surveys and check clothing and bed clothes before removal. Inform any personnel who may need to draw blood samples about proper procedures.

f. Wear film badges or other personnel monitoring devices when provided by Radiation Safety Office for work near radioactive materials.

4. Radiation Emergencies, Incidents, or Further Information

a. If you suspect that an object is a radioactive source that may have been inadvertently removed from a patient or find a small needle or tube that you suspect may be radioactive, take long forceps (do not use fingers) and remove the unidentified object to the corner of the room farthest from personnel. Place the object in a lead shield, if one is available.

b. Limit access to the room and call the Radiation Safety Office immediately:

(1) _____, Extension _____ (Home: ___-___)
Radiation Safety Assistant, or

(2) _____, Extension _____ (Home: ___-___)
Radiological Physicist, or

(3) _____, Extension _____ (Home: ___-___)
Chairman, Radiation Safety Committee, or

(4) _____, Extension _____ (Home: ___-___)
Radiation Therapist, or

(5) _____, Extension _____ (Home: ___-___)
Director, Nuclear Medicine Department

c. If the spread of radioactive contamination is suspected (this kind of event would be extremely unlikely), keep all persons who entered the room in a nearby hall until they can be checked by someone from the Radiation Safety Office. If this is not possible, have persons who must leave the area wash exposed skin and change clothing, leaving suspected clothing in plastic bags for checking. Wash hands if

potentially contaminated materials were touched. Wear shoe covers or take other precautions against spreading contamination, when advised to do so by the Radiation Safety Office.

5. Recommended Reading

a. The hospital's radiation safety handbook.

b. "Precautions in the Management of Patients Who Have Received Therapeutic Amounts of Radionuclides," NCRP Report No. 37, National Council on Radiation Protection and Measurements (NCRP), Publication Department, 7910 Woodmont Avenue, Bethesda, MD, 20814 (Oct. 1, 1970). (Every nurse should order a personal copy of this excellent report, read it, and keep it for reference.)

c. "Radiation Protection for Medical and Allied Health Personnel," NCRP Report No. 48, August 1, 1976 (order from NCRP, address above).

6. Hospital Routine And Nursing Care For Radioactive Patients

The following pages, reprinted with the permission of NCRP, contain recommendations from NCRP Report 37 that are particularly useful in maintaining exposures ALARA by the nursing staff. The entire report should be read for further details.

3.4 General Considerations for Nursing Care

The length of time that attendants may spend in caring for patients *should* be limited by the exposure they may receive. Accordingly, as soon as the radionuclide has been administered and the exposure rate determined, the responsible person (Radiation Protection Supervisor or radiotherapist) *shall* attach the radioactivity labels and issue any special nursing instructions and limitations on visitors.

In Table 3 are given approximate times for exposure of 100 mR from 100 mCi of several radionuclides at two specified distances. These values have been calculated from the data of Table 1, and are accordingly conservative. If the administered activity was more or less than 100 mCi, the times *should* be modified proportionately.

Decisions as to whether or not attendants caring for radioactive patients are to be classified as radiation workers are to be made by the Radiation Protection Supervisor. To minimize exposure of hospital personnel, it is recommended that radioactive patients not be concentrated in one area, but dispersed. However, in some large centers, where there are many such patients, dispersal may be undesirable and it may be preferable to concentrate them in designated rooms or wards under care of specially trained personnel. This is a matter of institutional policy. Pregnant nurses *should not* be responsible for the routine care of

TABLE 3—*Approximate times for exposure of 100 milliroentgens from 100 mCi of various radionuclides, at specified distances*

Radionuclides	Approximate Time for 100 mR per 100 mCi	
	At 2 Feet (0.61 Meter)	At 6 Feet (1.83 Meters)
	hours	hours
Cesium-137	1	10
Chromium-51	25	230
Cobalt-60	⅓	3
Gold-198	1½	15
Iodine-125[a]	12	115
Iodine-131	1½	15
Iridium-192	¾	7
Radium or Radon[b]	½	5
Tantalum-182	½	5

[a] These values are based on the maximum values quoted in Table 1. Exposure rates below these maximum values will increase the amount of time necessary to accumulate 100 mR.

[b] Either of these in equilibrium with short-lived daughters and filtered by 0.5 mm Pt.

patients with appreciable radioactive burdens, especially those patients receiving therapy for gynecological cancer.

Unless a patient requires extensive care, one attendant can usually perform all the routine duties in the time allowed. When there is a possibility that an attendant may receive in excess of 25 percent of the 3 rems permitted in a 3-month period or fraction thereof, personnel monitoring *shall* be established.

A special duty nurse *should not* be assigned to care for more than one radioactive patient per month unless an exception is approved by the Radiation Protection Supervisor.

3.5 Precautions with Various Types of Therapeutic Procedures

Therapeutic procedures to be considered here can be divided into two classes: (1) treatment with encapsulated sources, permanent or removable, which are mechanically inserted; (2) treatment with solutions, colloidal suspensions or microspheres.

For patients being treated with encapsulated sources, the only radiation risks to attendants relate to exposure to radiations emitted by the radioactive material while in the patient or during movement of the source at the time of insertion and removal. Exposure may be controlled by limiting the duration of attendance, as outlined in the following sections.

In treatment with solutions, colloidal suspensions or microspheres, exposure times are also important because of the existence of a radiation field, and, in addition, there is a possibility of accidental contamination of attendants by contact with the patients or their excreta or vomitus. In dealing with these patients it is necessary to practice the "good housekeeping" habits recommended for all individuals working with radioactive materials [4]. Rubber or plastic gloves *shall* be worn wherever contamination is possible. The gloves *should* be washed thoroughly while still on the hands. After removal of the gloves, the hands *should* immediately be washed thoroughly, particular attention being given to the fingernails. If contamination is suspected, the hands *shall* be monitored to make sure that no contamination remains. Eating or smoking when there is a possibility of hand contamination *shall* be prohibited.

Small disposable tissues that may be slightly contaminated may be flushed down the toilet. They *should not* go into the regular wastebasket. For larger amounts of material, including contaminated linen,

a suitable waterproof, pedal-operated waste can or disposable plastic bag *should* be provided. These *shall* be turned over to the Radiation Protection Supervisor for disposal.

Special precautions regarding the use of individual radioactive nuclides will be considered in pertinent sections below.

3.5.1 *Removable Sources Used Internally.* With sealed sources, there is no danger of radioactive contamination except by damage to, or loss of, a source. No special precautions need be taken with regard to food utensils, bedding, or excreta, except to be sure that no source is lost via these routes by accidental premature removal. The problem to be considered is the amount of time the attendant should be allowed to spend in various activities connected with patient care; this depends on the radiation exposure rates at various positions. Determination of exposure rates has been discussed in Section 3.2.

During interstitial and intracavitary radiotherapy, surgical bandages and dressings *should* be changed only by the physician in charge or another individual designated by him and trained in techniques applicable to such cases. For gynecological patients perineal care is not ordinarily given during the treatment, but the perineal pad may be changed when necessary. In this case care must be taken to ensure that radioactive sources or source containers are not disturbed or loosened. If a source should get free, it *shall* immediately be picked up with forceps and placed in a container which is to be left in the patient's room until the arrival of the physician or the Radiation Protection Supervisor, both of whom *shall* be notified at once.

Patients who are disoriented (due to the influence of medication or for other reasons) and are not fully aware of the nature of their treatment, may have to be restrained in order to prevent loss or malposition of a source.

As an example of the radiation protection problem in intracavitary therapy, consider a patient with 80 mg of radium in an intrauterine applicator, which is to remain in place for 40 hours. The nurse caring for such patients *should* be classified and instructed as a radiation worker, with a maximum permissible dose equivalent of 100 mrem per week. At a distance of 2 feet, a dose of about 100 mrem can be anticipated in about half an hour. Accordingly, during the two-day treatment period, the nurse *should* spend less than a quarter hour each day within two feet of this patient. Making the bed and performing the associated tasks, during which the attendant might be close to the patient, should not take more than 10 minutes. A bed bath may be omitted during these two days. At greater distances from the patient, longer times are permitted; e.g., at 6 feet the permissible time during

the two days is a total of 5 hours. (These five hours are not in addition to the half hour at 2 feet.)

3.5.2 *Permanent Implants.* Sources in this class which represent potential radiation hazards are radon, chromium-51, iodine-125, gold-198, tantalum-182, and iridium-192. The radon and gold decay rapidly, so that permissible time increases from day to day. A satisfactory approximation for these two nuclides is to double the permissible time after three days and again at the end of the first week.

For example, consider a patient with 40 mCi of radon implanted in a neck node. He may be able to care for himself, but food trays and medicines *should* be brought to him. During the first 3 days, at a distance of 2 feet, a dose of about 100 mrem may be received in about an hour. However, it is probable that an attendant need spend no more than 5 minutes a day at this short distance. At a distance of 6 feet, a dose of 100 mrem would be accumulated in about 10 hours. After 3 days, times to accumulate 100 mrem at any particular distance are doubled.

Permanent implants of beta-emitters, such as yttrium-90, do not normally present significant hazards.

3.5.3 *Solutions, Colloidal Suspensions, and Microspheres.* Radionuclides presently of importance in this category include phosphorus-32, yttrium-90, iodine-131 and gold-198. Yttrium and phosphorus are pure beta-emitters and do not give rise to significant external irradiation. (The bremsstrahlung is measurable, but the dose from it is insignificant.) Phosphorus-32 and gold-198 in colloidal suspension may be injected directly into localized malignant growths and these colloids are also frequently used in body cavities. Iodine-131 is generally administered in iodide solution in treatment of thyroid diseases. Half the iodine may be excreted within the first day or two. The gold is not eliminated, but its half-life is short (2.7 days). Accordingly, the approximate rules mentioned in connection with gold and radon in sealed sources may be used here, namely, double all tabulated times after 3 days, and double them again at the end of the first week. However, if iodine is administered in chemical forms other than the iodide, the first doubling *should* be after one week and the second after two weeks. Certain special precautions may need to be observed with iodine-131. The patient who has received a therapeutic administration of iodine-131 may contaminate his food dishes and utensils with salivary excretion. Hence he *should* have his own tableware, kept separate for a few days, or use disposable articles. Also in his case, a large amount of the radionuclide is excreted in the urine. He *should* be permitted to use the regular toilet facilities, but whenever it is desirable to collect the urine for assay, special containers *should* be provided. Such a patient is usu-

ally ambulatory and *should* be instructed to collect his own urine. If the attendant must perform this duty, he *should* wear rubber gloves. The gloves *should* be washed thoroughly while still on the hands. Then the gloves *should* be removed and the hands washed thoroughly. A separate bedpan or urinal *should* be kept for the patient until he is discharged. Then the bedpan or urinal *should* be scrubbed thoroughly with soap and water and monitored for contamination before being returned to stock. If the patient treated with radioactive iodine vomits or is incontinent within the first 48 hours after administration of the radionuclide, or if he perspires excessively, there may be contamination of the bed linen or even of the floor. In any such emergency, or if the urine is spilled during collection, the Radiation Protection Supervisor *shall* be summoned immediately to supervise the decontamination. However, certain precautionary procedures *should* be instituted at once. (See Section 3.6.)

No special precautions regarding vomitus, urine, or sputum are necessary for patients treated with colloidal radioactive gold or phosphorus. The only hazard is leakage from the puncture wound made during the injection of the colloidal material. Surgical dressings and bandages *should* be changed only as directed by the physician in charge. Bandages or dressings which become stained *should* be monitored for contamination. (The gold colloid will stain linen pink, red or purple.) If at any time the dressing becomes damp, stained, or bloody, the physician in charge of the case and the Radiation Protection Supervisor *shall* be notified immediately. If there is no drainage from the wound after the first few days, dressings may be handled in the usual manner.

3.6 Procedures for Minimizing Radiation Hazards Associated with Accidental Contamination

If there is any suspicion that accidental contamination has resulted from the patient's excreta or vomitus, from spillage, from rupture of sealed sources, or from other causes, the Radiation Protection Supervisor *shall* be notified immediately. While awaiting his arrival, immediate steps *should* be taken to prevent the spread of the contamination. An area containing the entire region of potential contamination *should* be marked off. No person *should* be permitted to walk through this area. Any person who enters this area *should not* leave it without being monitored. Precautions *shall* be taken to prevent the spread of contamination to other areas.

If there is an appreciable amount of liquid, paper towels *should* be dropped upon it and left until the Radiation Protection Supervisor arrives. If there is contamination of the patient or of other persons, clothing *should* be removed and stored within the marked area. Contaminated skin *should* be scrubbed, using a washroom in this area, or wash basins brought to the area for this purpose. Contamination *shall not* be removed from the area or further cleanup attempted before arrival of the Radiation Protection Supervisor. However, the following actions *should* be carried out as rapidly as possible, even before the arrival of the Radiation Protection Supervisor:

1. If the radioactive contamination arises from a pure beta-emitter, such as P-32, the immediate concern is only to prevent spread of contamination. If possible, the region of the spill *should* be covered with a plastic bed sheet and then with the equivalent of ½ inch of soft absorbent material such as 2 thick blankets. This will protect personnel within the region from radiation exposure and *should* be left in place until the arrival of the Radiation Protection Supervisor.
2. If the contamination arises from a mixed beta-gamma emitter of medium energy such as I-131, protection against the beta radiation may be effected as described above. If personnel remain at least 6 feet from the covered spill, further immediate protection against the gamma radiation is not required.
3. If the contamination is due to breakage of a radium needle, it is possible that radioactive particles will become airborne. In this case the room *should* be evacuated, the door and all windows and ventilators *should* be closed if possible, and a region immediately outside the room marked off as a radiation hazard area. All persons evacuated from the room *shall* remain within this designated area until monitored by the Radiation Protection Supervisor.

3.7 Protection of Other Patients and Visitors from Radiation

The maximum permissible dose equivalent for persons not occupationally exposed is 500 mrem per year, and planning *shall* be based on the objective that this level will not be exceeded for other patients or for visitors exposed to radiation from a patient containing radioactive material.

As far as visitors are concerned, there is little likelihood of their exceeding this dose, even if they make repeated visits, if they remain about 6 feet or more from the patient, except for a brief period to shake hands, deliver mail, etc. Pregnant women and children *should not*, in

APPENDIX E

INSPECTION BY RADIATION SAFETY OFFICER*
(Preferably conducted in conjunction with hospital administrator)

I. Licensee: _____

II. Address: _____

III. License No.: _____ Expiration Date: _____

IV. Date of Inspection: _____

V. Inspection Findings:

The inspection was an examination of the activities conducted under the above license as they relate to radiation safety and to compliance with the Nuclear Regulatory Commission's rules and regulations and the conditions of the above license. The inspection consisted of selective examinations of procedures and representative records, interviews with personnel, and observations by the Radiation Safety Officer. The following findings resulted from this inspection:

A. Posting of Notices and Signs:

1. Rooms or areas were properly posted to indicate the presence of a RADIATION AREA. (10 CFR Part 20, paragraph 20.203(b))

   Yes _____ No _____ N/A _____

2. Rooms or areas were properly posted to indicate the presence of a HIGH RADIATION AREA. (10 CFR Part 20, paragraph 20.203(c))

   Yes _____ No _____ N/A _____

3. Rooms or areas were properly posted to indicate the presence of an AIRBORNE RADIOACTIVITY AREA. (10 CFR Part 20, paragraph 20.203(d))

   Yes _____ No _____ N/A _____

*Modified from S. M. Brahmavar, S. M. Zubi, J. P. Sullivan, "Compliance Tests and Radiation Safety Procedures for Broad and Specific Medical Byproduct Material Licenses," in Proceedings of the 22nd Annual Meeting of the Society of Nuclear Medicine, 1975. (Available from Dr. S. M. Brahmavar, Department of Pathology, Medical Center of Western Massachusetts, Springfield, Mass.)

4. Rooms or areas were properly posted to indicate the presence of RADIOACTIVE MATERIAL. (10 CFR Part 20, paragraph 20.203(e))

Yes _____ No _____ N/A _____

5. Containers were properly labeled to indicate the presence of RADIOACTIVE MATERIAL. (10 CFR Part 20, paragraph 20.203(f)(1) or (f)(2))

Yes _____ No _____ N/A _____

6. A copy of the regulation, "Notices, Instructions and Reports to Workers, Inspections," was properly posted for use by individuals participating in the licensed activities. (10 CFR Part 19, paragraph 19.11(a)(1))

Yes _____ No _____ N/A _____

7. A copy of the regulation, "Standards for Protection Against Radiation," was properly posted for use by the individuals participating in the licensed activities. (10 CFR Part 20; 10 CFR Part 19, paragraph 19.11(a)(1))

Yes _____ No _____ N/A _____

8. Copies of the current license, license conditions, and amendments thereto were properly posted. (10 CFR Part 19, paragraph 19.11(a)(2))

Yes _____ No _____ N/A _____

9. Copies of the documents incorporated into the current license by reference were properly posted. (10 CFR Part 19, paragraph 19.11(a)(2))

Yes _____ No _____ N/A _____

10. A copy of the operating procedures applicable to licensed activities was properly posted. (10 CFR Part 19, paragraph 19.11(a)(3))

Yes _____ No _____ N/A _____

11. Posting of documents specified in 10 CFR Part 19, paragraph 19.11(a)(1,2,3) was not practicable; therefore the licensee posted notice that describes the documents and states where they may be examined. (10 CFR Part 19, paragraph 19.11(b))

Yes _____ No _____ N/A _____

12. Form NRC-3, "Notice to Employees," was posted in a sufficient number of places for use by the individuals who work in or frequent any portion of the restricted areas. (10 CFR Part 19, paragraph 19.11(c))

Yes _____ No _____ N/A _____

13. A copy of any notice of violation involving radiological working conditions, proposed imposition of civil penalty, or order issued pursuant to Subpart B of 10 CFR Part 2 was posted within 2 working days after the receipt of notice. (10 CFR Part 19, paragraph 19.11(a)(4),(e))

Yes _____ No _____ N/A _____

14. A copy of the licensee's response, if any, to a notice of violation, etc. (10 CFR Part 19, paragraph 19.11(a)(4)) was posted within 2 working days after the dispatch of response by the licensee. (10 CFR Part 19, paragraph 19.11(a)(4),(e))

Yes _____ No _____ N/A _____

15. The documents posted in compliance with 10 CFR Part 19, paragraph 19.11(a)(4) and (e) remained posted for a minimum of 5 working days or until action correcting the violation was completed, whichever was later. (10 CFR Part 19, paragraph 19.11(e))

Yes _____ No _____ N/A _____

Date of Receipt of Violation: _____

Date of Dispatch of Response: _____

Date of Corrective Action: _____

Date on Which Documents Were Posted: _____

Date on Which Documents Were Removed: _____

B. Records and Reports:

1. Records of current occupational radiation exposures of individuals were properly maintained on Form NRC-5. (10 CFR Part 20, § 20.401)

Yes _____ No _____ N/A _____

2. Records of individual accumulated occupational dose were maintained for each radiation worker on Form NRC-4. (10 CFR Part 20, § 20.102)

Yes _____ No _____ N/A _____

3. Records of radiation surveys of all the working areas where the licensed material is used were maintained. (10 CFR Part 20, paragraph 20.201(b) or 30.43(d))

Yes _____ No _____ N/A _____

Frequency of Survey: _____

Date of Last Survey: _____

4. Records of disposal of licensed radioactive material were properly maintained. (10 CFR Part 20, §§ 20.301, 20.302, 20.303)

Yes _____ No _____ N/A _____

Frequency of Disposal: _____

Date of Last Disposal: _____

5. Records of receipt, transfer, and disposal of licensed material were properly maintained. (10 CFR Part 30, § 30.51; Part 40, § 40.61)

Yes _____ No _____ N/A _____

6. Records of leak tests were maintained as prescribed in the license. (10 CFR Part 34, paragraph 34.25(c))

Yes _____ No _____ N/A _____

Frequency of Leak Test: _____

Date of Last Leak Test: _____

7. Records of isotope inventories were properly maintained to comply with item #8 of byproduct material license. (10 CFR Part 30, paragraphs 30.51(b) and (d))

Yes _____ No _____ N/A _____

Frequency of Isotope Inventory: _____

Date of Last Inventory: _____

8. Utilization logs of each isotope received were properly maintained. (10 CFR Part 34, § 34.27)

Yes _____ No _____ N/A _____

9. Records of calibration of radiation survey instruments as required by the conditions of license were properly maintained. (10 CFR Part 30, paragraphs 30.51(b) and (d))

Yes _____ No _____ N/A _____

Frequency of Calibration: _____

Date of Last Calibration: _____

10. Records of bioassay tests were maintained on all individuals per requirements of license. (10 CFR Part 20, § 20.108)

Yes _____ No _____ N/A _____

Frequency of Bioassay Test: _____

Date of Last Bioassay Test: _____

11. Records of the wipe-test data and results on determination of concentrations of radioactive material present in the working areas were properly maintained. (10 CFR Part 20, paragraph 20.201(a))

Yes _____ No _____ N/A _____

Frequency of Wipe Test: _____

Date of Last Wipe Test: _____

C. Operating Procedures and Manuals:

1. The institutional radiation safety instruction program for all radiation workers and hospital employees is operational and effective. (10 CFR Part 19, § 19.12)

Yes _____ No _____ N/A _____

Frequency of Radiation Safety Instruction: _____

Date of Last Instruction Program: _____

2. A radiation safety procedures manual is written and copies are made available for the use of all the radiation workers, personnel involved in patient care and others who may handle radioactive material. (10 CFR Part 19, § 19.12)

Yes _____ No _____ N/A _____

3. Procedures for picking up, receiving, and opening the packages containing radioactive material are available and are in routine use. (10 CFR Part 20, § 20.205)

Yes _____ No _____ N/A _____

4. The Radiation Safety Committee meetings are held at periodic intervals to review the medical isotope program at the institution.

   Yes _____ No _____ N/A _____

5. The local fire and police officials are informed of the location and nature of radioactive materials in the institution.

   Yes _____ No _____ N/A _____

   Frequency of Familiarization by Fire and Police Officials: _____

   Date of Last Visit: _____

D. Administrative Actions:

1. No items of noncompliance or unsafe conditions were found.

   Radiation Safety Officer: _____

   Signature and Date: _____

2. The following items of noncompliance related to each of the above sections were found.

   Section A: _____

   Section B: _____

   Section C: _____

   Radiation Safety Officer: _____

   Signature and Date: _____

3. The Radiation Safety Officer has explained and I understand the items of noncompliance listed in Item 2 of this section. The items of noncompliance will be corrected within the next __ days.

   Chairman, Radiation Safety Committee: _____

   Signature and Date: _____

Reviewed by:

_____ Date _____

Hospital Administrator

Table 1

RECOMMENDED MINIMUM RADIATION SAFETY STAFFING FOR VARIOUS CATEGORIES OF MEDICAL INSTITUTIONS*

Category	Radiation Sources	Technician Time	Professional (Health Physics) Time
I	Low-level clinical and research laboratories** handling microcurie quantities of I-131, I-125, Cr-51, C-14, and H-3, plus radiographic units and fluoroscopes	6 man-hours per month	4 man-days/yr (plus daily supervision by full-time qualified staff radiologist or other health professional)
II	Category I plus nuclear medicine	1 full-time radiation safety technician (possibly doing some minor part-time electronics maintenance)	1/2 time of health physicist (possibly including calibration of diagnostic x-ray units)
III	Category II plus teletherapy, radionuclide therapy, or brachytherapy	1 full-time radiation safety technician***	1 full-time health or radiological physicist (possibly performing some diagnostic calibrations)
IV	Category III plus multi-megavolt therapy	2 full-time technicians - radiation safety and electronics***	1 full-time health physicist and 1 or more full-time radiological physicists with some radiation safety responsibilities

* All personnel are in addition to clinical radiological physics requirements. Also, for categories II-IV, the person serving as Radiation Safety Officer (RSO) should be a full-time member of the hospital staff.

** Major medical centers having larger research complexes may require larger radiation safety staffs just to meet survey requirements for the research laboratory areas. In some cases, medical research laboratories are serviced by university radiation safety offices when they are located in university medical complexes. Since situations vary, experience with the programs and organization of each institution is often needed to judge staffing requirements for surveying medical research uses of licensed radioactive materials (see Regulatory Guides 8.23 and 10.8).

*** Plus proportionate secretarial-clerical assistance for correspondence and recordkeeping requirements.

Table 2

CONVERSION FACTORS FROM OLD TO NEW RADIATION UNITS

Quantity	Old Unit	Symbol	New Unit	Symbol	Conversion Factor
Activity	curie	Ci	becquerel	Bq	1 Ci = 3.7×10^{10} Bq
Absorbed dose	rad	rad	gray	Gy	1 rad = 1cGy = 10^{-2} Gy = 10^{-2} J/kg
Dose Equivalent	rem	rem	sievert	Sv	1 rem = 1cSv = 10^{-2} Sv
Exposure	roentgen	R	-	-	1 R = 2.58×10^{-4} C/kg

NRC FORM 335 (11-81) U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

1. REPORT NUMBER *(Assigned by DDC)*
NUREG-0267
Revision 1

4. TITLE AND SUBTITLE *(Add Volume No., if appropriate)*
Principles and Practices for Keeping Occupational Radiation Exposures at Medical Institutions As Low As Reasonably Achievable

2. *(Leave blank)*

3. RECIPIENT'S ACCESSION NO.

7. AUTHOR(S)
Allen Brodsky

5. DATE REPORT COMPLETED
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This report is a companion document to Regulatory Guide 8.18, "Information Relevant to Ensuring that Occupational Radiation Exposures at Medical Institutions Will Be As Low As Reasonably Achievable." Both documents have now been revised to incorporate many good suggestions received after the original documents were published for comment. This report is a compendium of good practices and helpful information derived from the experience of the radiological and health physics professions and is not to be construed in any way as additional regulatory requirements of the Nuclear Regulatory Commission. The information presented, including comprehensive checklists of facilities, equipment, and procedures that should be considered for working with NRC-licensed materials in all types of hospital activities, is intended to aid the NRC licensee in fulfilling the philosophy of maintaining radiation exposures of employees, patients, visitors, and the public as low as reasonably achievable (ALARA). Each subsection of this report is designed to include the major radiation safety considerations pertaining to the respective hospital function. Thus, the busy health professional will need to read only a few pages of this document at any one time to obtain the information needed.

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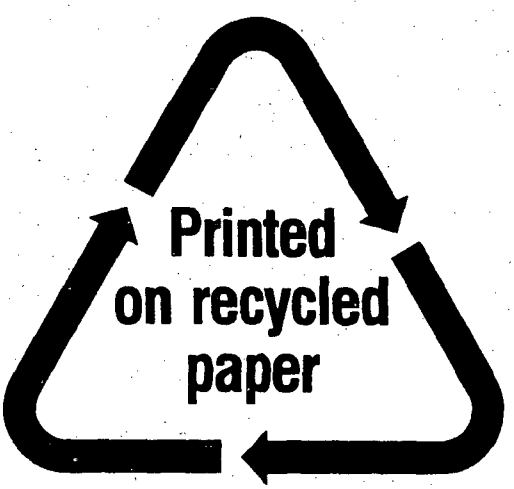

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