ALL AGREEMENT STATES
OHIO, OKLAHOMA, PENNSYLVANIA

JUN 14 1997

TRANSMITTAL OF STATE AGREEMENTS PROGRAM INFORMATION (SP-97-045)

Your attention is invited to the attached correspondence which contains:

INCIDENT AND EVENT INFORMATION.....

PROGRAM MANAGEMENT INFORMATION...

TRAINING COURSE INFORMATION.....XX ACCEPTANCE TO THE INTRODUCTORY HEALTH PHYSICS COURSE (H-117)

TECHNICAL INFORMATION.....

OTHER.....

Supplementary Information: Enclosure 1 is the list of students from the States selected to attend the July 14 - 18, 1997, Introductory Health Physics course (H-117). Please provide the list of students and the travel instructions (Enclosure 2) to each individual from your program that is on the list. Those traveling at State expense should be encouraged to follow the instructions and make the appropriate travel and lodging arrangements as soon as possible. Those traveling at NRC expense should follow the specific additional instructions in Enclosure 2. Please refer to the All Agreement States Letter (SP-95-006) "Timeliness of Travel Orders" for further information on timing and travel arrangements for attendance at training courses.

If you have any questions regarding this correspondence, please contact me or the individual named below.

POINT OF CONTACT: Dennis M. Sollenberger
TELEPHONE: (301) 415-2819
FAX: (301) 415-3502
INTERNET: DMS4@NRC.GOV

Original Signed By:
PAUL H. LOHAUS

Paul H. Lohaus, Deputy Director
Office of State Programs

Enclosures:
As stated

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

June 14, 1997

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Paul H. Lohaus, Deputy Director
Office of State Programs

Enclosures:
As stated

AGREEMENT STATE STUDENT LIST FOR THE
INTRODUCTORY HEALTH PHYSICS COURSE (H-117)
JULY 14-18, 1997

MARYLAND

P.L. Eisgruber (Traveling at State Expense)
Maryland Department of the Environment
Radiological Health Program
2500 Broening Highway
Baltimore, MD 21224

Howard Perry III (Traveling at State Expense)
Maryland Department of the Environment
Radiological Health Program
2500 Broening Highway
Baltimore, MD 21224

OKLAHOMA

Steven K. Fernandez (Traveling at State Expense)
Oklahoma Department of Environmental Quality
Waste Management Division/Radiation Management
1000 N.E. 10th Street
Oklahoma City, OK 73117-1212

Earlon Shirley (Traveling at State Expense)
Oklahoma Department of Environmental Quality
Waste Management Division/Radiation Management
1000 N.E. 10th Street
Oklahoma City, OK 73117-1212

TEXAS - TNRCC

George FitzGerald (Traveling at NRC Expense)
TX Natural Resource Conservation Commission
UIC, Uranium and Radioactive Waste Section - MC 131
P.O. Box 13087
Austin, TX 78711-3087

Alice Hamilton Rogers (Traveling at NRC Expense)
TX Natural Resource Conservation Commission
UIC, Uranium and Radioactive Waste Section - MC 131
P.O. Box 13087
Austin, TX 78711-3087

Kathleen Vail (Traveling at NRC Expense)
TX Natural Resource Conservation Commission
UIC, Uranium and Radioactive Waste Section - MC 131
P.O. Box 13087
Austin, TX 78711-3087

ENCLOSURE 1

INSTRUCTIONS TO STUDENTS

ACCEPTANCE: This is to advise you that those individuals in Enclosure 1 have been accepted for participation in the training course (H-117), "Introductory Health Physics." This course is scheduled to be presented July 14 - 18, 1997 at the Professional Training Center on the third floor of the Two White Flint North Building, 11545 Rockville Pike, Rockville, MD. The NRC buildings are across the street from the White Flint Metro station.

COURSE: The course starts at 8:30 a.m. on Monday, July 14, 1997, and will begin at 8:00 a.m. on all other days. The class will end at approximately 4:00 p.m. each day except for Friday, July 18, 1997, which will end at approximately 12:00 noon. Attached are the course outline and Chapters 11 and 12 of the course manual that we recommend you read prior to coming to the course. The material in Chapters 11 and 12 will not be covered specifically in the course but will enhance your understanding of the other material.

LODGING AND TRAVEL: The following hotels are listed for your use. Participants must make their own lodging arrangements. Individuals should request a State or government employee rate at the hotels. The Ramada or Doubletree are recommended based on their location near the Twinbrook Metro station. For those participants that fly to the area, taxi or metro service is available to take you to the hotel.

Ramada Inn at Congressional Park	Doubletree Hotel
1775 Rockville Pike	1750 Rockville Pike
Rockville, MD	Rockville, MD
(301) 881-2300	(301) 230-6729
1-800-255-1775	1-800-222-TREE

TRAVEL AND EXPENSES FOR STUDENTS TRAVELING AT NRC EXPENSE:

For those States that have requested that NRC continue funding their travel to training and have received notice in writing that NRC will continue to fund reasonable training and travel expenses for fiscal year 1997, they should follow the instructions below for Federal travel orders:

TRAVEL: If you travel by air, you must call Carlson Wagonlit Travel, (202) 554-1850, to make your flight reservations. You must use Carlson or you may not be reimbursed for your plane ticket. Your tickets will be mailed to you about a week before the course begins. If you travel by car, you will be reimbursed at a rate of $0.31 per mile, with the total payment not to exceed the minimum government airfare. For those participants that fly to the area, taxi or metro service is available to take you to the hotel.

The Nuclear Regulatory Commission has received approval from the General Services Administration to allow State employees who are able to obtain a special discount (i.e., a lower fare than is available from Carlson Wagonlit Travel) through their State travel agency to purchase airline tickets themselves and be reimbursed via their travel voucher. In order to use your own State travel agency, it must be confirmed that Carlson Wagonlit Travel is not able to obtain that same class ticket for the same price. Before purchasing your own

ticket, please contact Brenda Usilton at (301) 415-2348 in order to assure the proper procedures are followed.

EXPENSES: State participants traveling on Federal orders will be reimbursed for expenses in accordance with Federal travel regulations. A voucher will be provided to you at the course. Receipts are necessary to claim any expenses of $75.00 or more. Telephone calls will not be reimbursed by NRC. The per diem rate for the Rockville, MD area is $124.00 for lodging and $42.00 for meals and miscellaneous expenses, not to exceed $166.00 per day.

Any questions about, or changes in, travel should be directed to Ms. Brenda Usilton at (301) 415-2348. Any questions on the course should be made to Dennis Sollenberger at (301) 415-2819.

Please FAX the following information to
Brenda Usilton at (301) 415-3502
by 5 pm (EDT) June 27, 1997

Course or Workshop: Introductory Health Physics (H-117)

Dates: July 14 - 18, 1997

Travel: July 13 - 18, 1997

Location: NRC Professional Training Center, Room T-3B-39
Third Floor, Two White Flint North
11545 Rockville Pike
Rockville, MD

NAME: _____

BUSINESS ADDRESS: _____

_____

_____

WORK PHONE NUMBER: _____

SS#: ___-__-____

Departure City (airport): _____

Date of Departure (if not Jul 13): _____
Please provide reason: _____

Date of Return (if not Jul 18): _____
Please provide reason: _____

Cost of Airfare (from Carlson Travel): _____

If you are driving indicate roundtrip miles: _____

Lodging Arrangements Made: (Yes) (No) _____

ENCLOSURE 2

CHAPTER 1 INTRODUCTION

CHAPTER 2 FUNDAMENTAL HEALTH PHYSICS CONCEPTS

CHAPTER 3 INTERACTION OF RADIATION WITH MATTER

CHAPTER 4 RADIATION QUANTITIES AND UNITS

CHAPTER 9 ENVIRONMENTAL RADIOLOGICAL MONITORING

CHAPTER 10 OPERATIONAL ASPECTS OF HEALTH PHYSICS

CHAPTER 11 RADIATION PROTECTION STANDARDS AND REGULATIONS

CHAPTER 12 RADIATION PROTECTION PLANS AND PROCEDURES

CHAPTER 13 COURSE SUMMARY

LIST OF TABLES

LIST OF FIGURES

INTRODUCTORY HEALTH PHYSICS

CHAPTER 11
RADIATION PROTECTION STANDARDS AND REGULATIONS

This chapter provides the course participants with an overview of:

- The history of protective standards for ionizing radiation.
- The historical dose limits and their bases.
- The regulating agencies in relation to NRC licensees.
- The role of agreement states, EPA, and OSHA in relation to licensee regulation.
- The fundamental components of 10 CFR Part 20.

LEARNING OBJECTIVES

Upon completion of this chapter, the student should be able to successfully:

- Describe the historical origins of radiation protection standards:
  - Early observations of radiation injury
  - Standards based on prevention of clinical injury to radiation workers
  - Standards based on prevention of stochastic injury to populations
  - Standards based on assumed risk-benefit and ALARA assessment.
- Identify the regulatory agencies that regulate NRC licensees.
- Describe the roles of EPA and OSHA in regulating NRC licensees.
- Describe and define the regulatory dose equivalent limits.
- Describe the fundamental components of 10 CFR Part 20.

11.0 RADIATION PROTECTION STANDARDS AND REGULATIONS

11.1 History of Protective Standards

With the discovery x-rays in 1895 by Roentgen, mankind started using radiation for beneficial purposes. However, there was soon to be discovered a Pandora's Box that was associated with this new wonder. In 1896, injuries caused from exposure to Roentgen rays (x-rays) were being reported. Scientists began to study the reported injuries and other effects on animals when exposed to x-rays. By 1915, the users of x-ray machines in Britain (i.e., the British Roentgen Society) were urging the adoption of rules for the operators of x-ray equipment.

Early efforts at control were hampered by a lack of quantitative methods. There were no units by which one could assess the amount of radiation. As a result of the use of radiation by doctors in treating patients, a unit called the erythema dose came into use. This was a highly qualitative unit; defined in terms of the amount of radiation which would produce a well-defined reddening of the skin. It soon became apparent that this dose unit was not at all satisfactory. It varied not only with the type of radiation and the dose rate, but also with the response of different parts of the body. Thus, two people could receive the same supposed fraction of an erythema dose, yet one might show skin effects and the other none. This lack of a certain value for this unit made protection work more or less of a trial-and-error process.

Around 1914, radiation began to be used in industry. The radium dial-painting process came into being, and x-rays were found useful for showing up flaws in materials. Larger numbers of people were then being exposed. No longer could the vague notion of erythema does serve the purpose of a protection standard. Yet progress toward better standards still lagged because of lack of knowledge of the many complex factors which enter into radiation effects.

The following summarizes the keystone developments in radiation protection.

Evolution of Radiation Protection

The history of radiation protection is traced from the discovery of x-rays by Roentgen in 1895 up to the present time. The chronological summary of the development of radiation protection standards and of the promulgating organizations up to 1971 is taken largely from Taylor's book, Radiation Protection Standards, published by the CRC Press, 1971.

Early Observations of Radiation Injury (Pre-WW I)

In 1896, the earliest x-ray injury on record appears to have been observed in January of 1896 by Grubbé. In March 1896, Edison reported severe smarting of the eyes after several exposures to a "discharge tube". Skin dermatitis was reported by several observers before the end of 1896.

In 1901, Kollins reported that x-rays could cause injury at depth within the bodies of animals as well as to the skin.

In 1902, Rollins proposed a radiation tolerance dose based on lack of fogging of a photographic plate after 7 minutes of exposure.

In 1915, a resolution was introduced at a meeting of the British Roentgen Society urging the universal adoption of stringent rules for the protection of operators conducting Roentgen ray examination. The resolution was unanimously adopted, but due to the interruption caused by World War I, no significant action was taken prior to 1920.

Standards Based on Prevention of Clinical Injury to Radiation Workers (WW I - WW II)

In 1920, the first standing radiation protection committee was formed by the American Roentgen Ray Society.

In 1921, the first general set of radiation protection recommendations were published in the Journal of Roentgen Society.

By the end of 1922, many countries had adopted standards for radiation protection.

The year 1925 was one of the landmark years in the evolution of radiation protection. The first International Congress of Radiology was held in London and formed an Ad Hoc group to study the problem of radiation units; this was the forerunner of the International Commission on Radiological Units and Measurements (ICRU). Efforts to establish a "tolerance dose" were being made independently in several countries. Mutscheller recommended a tolerance dose of 1/100 of a threshold erythema dose (TED, also called the skin erythema dose [SED]) per month or approximately 1/10 TED per year. Sievert arrived independently at the same value, i.e., 1/10 of the threshold erythema dose per year. Although there began to be some general acceptance of Mutscheller's method of defining the tolerance dose, the actual value of the TED was not well established.

In 1927, Kustner conducted an elaborate survey to determine the value of the TED. Reported values ranged from 400 to 650 roentgens, with an average value of 550 roentgens. (It should be noted that during this time, the concept of the roentgen as a unit of air exposure was being developed, but that it was not quantitatively defined nor adopted by any official committee until 1928).

In 1928, the International X-ray and Radium Protection Committee [forerunner of the International Commission on Radiological Protection (ICRP)] was established by the second International Congress of Radiology. The committee held its initial meeting in 1928 and adopted interim regulations based upon the 1921 recommendations of the British X-ray and Radium Protection Committee. These protection standards were directed primarily to the shielding of x-ray tubes operated at various voltages and for radium sources. The committee also adopted the definition of the roentgen (1 electron spin unit/cm^3 air at standard temperature and pressure).

In 1929, the Advisory Committee on X-ray and Radium Protection [forerunner of the National Committee on Radiation Protection and Measurements (NCRP)] was organized in the United States. The work of this body was coordinated by the National Bureau of Standards. The early recommendations of the Committee appeared in the National Bureau of Standards Handbooks. The NCRP recommendations as outlined in Handbooks 20 and 23, which have been superseded by later reports, served as the basis for protection practices during the days of the project developing the atomic bomb during the Manhattan project. Many members of the NCRP were engaged in this program and were helpful in seeing that protection standards prevailed.

In 1931, the first x-ray protection rules produced by the NCRP were published as Bureau of Standards Handbook 15. (It should be noted that up until this time, protection standards were expressed in terms of working hours, x-ray shielding, electrical precautions, radium shielding, etc. and not in terms of exposure or dose limits).

In 1934 and 1935, ICRP adopted a permissible dose limit of 0.2 R/day (72 R/year). NCRP adopted an exposure limit of 0.1 R/day (36

R/year). Both of these limits were based on the earlier recommendations related to the TED (i.e., 0.1 TED per year, or approximately 55 ± 20 R/year). The NCRP was more cautious in establishing a dose limit because of growing suspicions that radiation might induce more subtle and delayed injuries. The possibility of genetic effect was also under consideration during this time period.

In 1941, the Advisory Committee on X-ray and Radium Protection recommended a permissible body burden for radium of 0.1 μCi. This standard was based on an intensive study of radium patients and dial painters.

The Manhattan District (WW II)

In the 1940's, the intensive wartime effort to develop fission reactors and nuclear weapons introduced radiation protection problems on a scale never before anticipated. For example, the entire world supply of radioactive materials prior to 1940 consisted of approximately 1 kg (1000 Ci) Ra-226; in contrast, millions of curies of a wide variety of radionuclides were produced in the first reactors of the Manhattan District and in the early detonations of nuclear weapons. Also, prior to 1940, the most intense sources of external radiation were x-ray machines, cyclotrons, or other high-voltage accelerators; the external radiation intensities from a nuclear reactor core are orders of magnitude larger.

Large scale animal experiments on the biological effects of radiation, both internal and external, were initiated at the National Cancer Institute, the University of Chicago, the University of Rochester, and at Oak Ridge. The radiobiology programs started during World War II have since been greatly expanded and collectively represent the largest single source of radiation effects data in the world.

Because of the rapid expansion of the use of radiation by industrial organizations, the American Standards Association organized Committee Z-54 to develop radiation protection standards for use in industry. Also, the rapid increase in shipments of radioactive materials prompted the Interstate Commerce Commission (ICC) to develop special tariffs pertaining to radioactive materials. This tariff was actually developed by the Bureau of Explosives of the Association of American Railroads, but was adopted and enforced by the ICC. The development of operational standards by associations of commercial or industrial organizations based on the recommendations of scientific committees is a pattern that has been continued in the field of radiation protection.

The three organizations, ICRU, ICRP, and NCRP, have figured prominently in the development of present day radiation protection practices. Although these bodies act as advisory boards only, much of the radiation protection philosophy which has evolved and which has been adopted by various regulatory agencies throughout the world, had its origins in the recommendations of these organizations.

11.2 Dose Limits

The changes in acceptable dose limits followed and continues to follow the growth of scientific data and recommendations by the ICRU, ICRP, and NCRP. The following summarizes the changes in dose limits that took place between 1948 and 1977.

11.2.1 Standards Based on Prevention of Stochastic Injury to Populations (the AEC and FRC years)

In 1948 and 1949, the NCRP lowered the maximum permissible dose for radiation workers to 0.3 R/week (15 R/year); this standard was still based primarily on the absence of detectable injury to individuals.

The NCRP also introduced the risk-benefit philosophy and considered population and genetic effects of radiation (NBS Handbook 59).

In 1950, the ICRU and ICRP were reorganized and adopted the same standards as the NCRP for external radiation. The ICRU expanded the definition of the curie to include all radioactive materials, not just radium.

In 1952, the ICRP and ICRU held the first Conference on Genetic Effects and reached conclusions essentially as subsequently recommended in 1956.

In 1953, the NCRP listed maximum permissible concentrations and maximum permissible body burdens for 100 isotopes. (NBS Handbook 52) The ICRP adopted these NCRP recommendations and also recommended for members of the general public a dose limit 1/10 of that for radiation workers. The ICRU introduced the concept of absorbed dose and adopted the rad as its unit.

In 1956, the ICRP introduced the concept of cumulative dose for both occupational and population exposures and recommended a dose limit of 5 rem/yr for radiation workers. The ICRU introduced the concepts of relative biological effectiveness (RBE) and the RBE dose and adopted the rem as the unit of dose equivalent. The National Academy of Sciences published the first of a series of reports on the biological effects of atomic radiation (BEAR Committee, forerunner of the Biological Effects of Ionizing Radiation [BEIR] Committee). The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) held its first two meetings and submitted a yearly progress report to the General Assembly of the United Nations at its 11th Session. The Committee has subsequently become a most valuable source of radiation exposure and protection data that are used in support of radiation standards.

In 1957, the NCRP formulated the age prorated occupational dose limit and also adopted the population dose concept of ICRP (0.5 rem/yr to any individual or 0.17 rem/yr to a population at large).

In 1959, the ICRP recommended a genetically significant dose limit of 5 rems in 30 years for the general population. The Federal Radiation Council (FRC) was formed in 1959 (Public Law 86-373) to "advise the president with respect to radiation matters directly or indirectly affecting health including guidance for all federal agencies in the formulation of radiation standards and in the establishment and execution of programs of cooperation with states..."

In 1960, the FRC issued its first report "Background Material for the Development of Radiation Protection Standards". The report introduced the terms radiation protection guide (RPG) and radioactivity concentration guide (RCG) to replace the terms maximum permissible dose and maximum permissible concentration as used by the NCRP and ICRP. These recommendations were made in the recognition of the linear non-threshold assumptions of the dose-effect relationship.

In 1964, the FRC introduced the concept of protective action guides (FRC Report No. 5).

In 1967, the increasing concern over the excessive lung cancer deaths among uranium miners lead to Congressional Hearings (JCAE 1967) and to the last report issued by the FRC (FRC 1967).

In 1968, the Radiation Control for Health and Safety Act (PL 90-603) was passed. This act gave the federal government, for the first time, the authority to regulate electronic product radiations. This category includes ionizing and

non-ionizing electromagnetic or particulate radiation, and sonic, infrasonic or ultrasonic waves emitted from electronic products. Prior to this act, regulation of such devices was a state responsibility. The act directed the Secretary of the Department of Health, Education and Welfare (DHEW) to establish performance standards for electronic products and to regulate the manufacturing and distribution of such products, but only to "study" the control of uses and users.

The research supported by the AEC, and the coordination provided by the FRC, motivated much of the development effort on standards during the 1950's and 1960's, even though AEC regulations remained relatively static during that time.

11.2.2 Standards Based on Assumed Risk-Benefit and ALARA Assessments (Adversary Era)

Three events occurred in rapid succession, producing a significant change in public attitudes toward radiation standards and in the standards-setting process, if not in the numerical values of the standards themselves. These events were all instigated by a public mood of the late 1960's; this mood could best be described as anti-establishment and distrustful political leaders.

In 1969, Drs. John W. Gofman and Arthur R. Tamplin presented a paper before the Institute for Electrical and Electronic Engineers (San Francisco, October 29), challenging the Atomic Energy Commission (AEC) and FRC standards and demanding an immediate reduction of the dose limit for members of the general public by at least one order of magnitude. In response to Gofman and Tamplin, the FRC requested a review of radiation standards by the National Academy of Sciences. The BEIR Committee held its first meeting on March 25, 1970.

The National Environmental Policy Act (PL 91-190) was passed in 1969 also.

In 1970, the U.S. Environmental Protection Agency (EPA) was formed by Reorganization Plan No. 3 of 1970. The FRC was abolished and its responsibilities for providing guidance to all federal agencies on matters of radiation protection were given to the EPA.

In 1972, the BEIR Committee released its report, The Effects on Populations of Exposures to Low Levels of Ionizing Radiation. The UNSCEAR report, Ionizing Radiation: Levels and Effects, was published. Both committees used the same database and arrived at comparable estimates of somatic and genetic effects from radiation exposures of large populations. UNSCEAR did not extrapolate to individual risk from low doses, as did BEIR.

In 1974, the Energy Reorganization Act (PL 93-438) split the AEC and also abolished the Joint Committee on Atomic Energy. The regulatory functions of the AEC were given to the U.S. Nuclear Regulatory Commission (NRC) and the development and promotional functions of the AEC were given to the Energy Research and Development Administration (ERDA).

Several noteworthy events took place in 1975 and 1977:

1975 The NRC issued Appendix I to 10 CFR 50, Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low as Practicable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents (40 FR 19439, May 5, 1975).

The EPA published its proposed standards (40 CFR Part 190), Environmental Radiation Protection for Nuclear Power Operations (40 FR 23420, May 29, 1975).

The NCRP reaffirmed its existing standards, i.e., individual dose limits, but strongly reiterated its emphasis on the ALARA principle. A summary of NCRP standards and NRC and EPA dose limits for members of the general public are shown in Table 11-1.

1977 UNSCEAR released a comprehensive report on Sources and Effects of Ionizing Radiation (UN Publ. No. E. 77. IX.1). This report is an expansion and update of the 1972 report.

The BEIR Committee issued a report on Considerations of Health Benefit-Cost Analysis for Activities Involving Ionizing Radiation Exposure and Alternatives (EPA 520/4-77-003). This report, also called the BEIR-II report, represents an attempt to develop benefit-cost analysis methods and apply them to specific applications, i.e., energy production and medical diagnosis.

The ICRP published a newly revised version of its recommendations (ICRP Publ. 26). Although the terminology and wording are substantially different from previous ICRP publications, the underlying concepts and philosophy of radiation protection are consistent with all earlier ICRP recommendations.

The ICRP believes that, for stochastic effects, the dose equivalent limit may be based on the total risk of all irradiated tissues. So, the system sets a single limit for uniform irradiation of the whole body and a weighing system to ensure that the total risk from partial body irradiation does not exceed the risk from uniform whole body irradiation. In addition, no single tissue should receive more than the dose limit to prevent nonstochastic damage.

The ICRP recommendations are intended to limit somatic effects in the individual, hereditary effects in the individual's immediate offspring, and somatic and hereditary effects in the population as a whole. For any organ, the dose limitation refers to the sum of the annual dose equivalents from external sources and the committed dose equivalents from internal sources during that year.

The NRC's occupational dose limits have been adjusted to agree with ICRP 26. Currently, the NRC believes that nonstochastic effects will be prevented by applying a dose equivalent limit of 0.5 Sv (50 rem) in a year to all tissues except the lens of the eye, for which the recommendation is 0.15 Sv (15 rem) in a year. In addition, the limits apply whether the tissues are exposed singly or in combination with other organs.

For stochastic effects, the annual dose equivalent limit for uniform irradiation of the whole body is 50 mSv (5 rem). If the irradiation is non-uniform, the system is based upon the premise that the risk should not exceed that for uniform whole body irradiation. This obtains if:

$$H_{WB,L} \geq \Sigma_T w_T H_T \qquad (11\text{-}1)$$

where

$H_{WB,L}$ is the annual whole body limit (50 mSv)

H_T is the annual dose equivalent in a given tissue T, and

w_T is a weighing factor.

This weighing factor expresses the ratio of the stochastic risk in tissue T to that in the total body. Values of w_T are given in Table 11-2. The summation on the right side of equation

11-1 is called the effective dose equivalent, H_E.

The weighing factor w_T, is 0.06 for each of the five organs of the remainder receiving the highest dose equivalents, and the remaining tissues can be neglected.

The NRC does not intend that the hands and forearms, the feet and ankles, the skin and the lens of the eye be included in the determination of the remainder in Table 11-2.

The NRC dose limit in 10 CFR Part 20 for members of the public is 0.1 rem (100 mrem) per year total effective dose equivalent. This is a stochastic limit. There are no non-stochastic limits for members of the public since it is assumed that non-stochastic effects will not occur at dose levels at or below the stochastic limit for the public.

Although the ICRP functions only as an advisory body, their recommendations have generally been adopted and applied as the basis for the radiation protection standards in use throughout the world. The NCRP has also endorsed these recommendations.

11.3 Regulating Agencies

So far, our attention has been directed to those groups which supply recommendations for exposure levels and safe practices and to the dose limits. The rest of this section will be concerned with the organizations which are charged with developing regulations. Of prime interest are those groups which regulate radiation matters in this country.

Under the Atomic Energy Act of 1954, the United States Atomic Energy Commission (AEC) was given the responsibility of regulating the atomic-energy industry. The Act authorized the AEC to set up a licensing program to be augmented by whatever rules or regulations are deemed appropriate. The bases for these rules are: to protect the public health and safety, and provide for national defense and security. Under this mandate, the AEC was concerned with the development of regulatory safety standards.

The Energy Reorganization Act of 1974 abolished the AEC and established two agencies to perform the functions of the AEC. The U.S. Nuclear Regulatory Commission (NRC) has taken over the licensing and regulatory functions. Licensed material under the control of the NRC includes source material (uranium and thorium or ores containing .05% of these materials), special nuclear material (plutonium, U-233, U enriched in U-233 or U-235), and by-product material (radioactive material resulting from producing or utilizing special nuclear material). The regulations of the NRC are set forth in the Code of Federal Regulations, Title 10. Part 20, Standards for Protection Against Radiation, deals specifically with the regulations for control of radiation hazards by the licensee. Other parts of Title 10 deal with licensing and regulatory requirements associated with the use of source, special nuclear material and by-product material.

As part of its duties, the NRC is charged with the task of seeing that these measures prevail. This aspect requires inspection and review in order to assure this. This function is carried out by NRC personnel (inspectors) at regular intervals. Their job is to make the inspections and report their findings. In the event that a failure to comply is noted, the licensee is required to correct this.

Many of the states have taken up the task of setting up their own safety standards. The NRC has been directed to assist the states to assure that the state and Commission programs are compatible. These states are referred to as Agreement States.

An Agreement State is any state using legislation known as the Radiation Control Act to provide regulation of radioactive materials and radiation producing machines and whose purpose is to protect the health and safety of the public. The governor of an Agreement State signs an agreement with the NRC or its predecessor, the Atomic Energy Commission. As part of this agreement, the State maintains a radioactive materials regulatory program that is sufficient to protect the health and safety of the public and that meets or exceeds that of the NRC.

The U.S. Department of Energy (DOE) has taken over the remaining functions of the AEC. These activities related to energy research and development and involved activities carried out by the Commission or by its contractors. The DOE has issued regulations which pertain to its own activities as well as to those of its contractors, not subject to licensing. These regulations appear in the DOE Orders, which replaced the Manual Chapters of the AEC. The standards which apply specifically to radiation protection are contained in DOE Order 5480.11. These standards are based upon the recommendations of the ICRP, NCRP, and the guidance of the EPA. Similar to the NRC, the DOE is charged with the inspection of its contractors to see that they are in compliance with the DOE Orders.

Safety in the shipment of radioactive substances is principally the responsibility of the U.S. Department of Transportation (DOT). Title 49-Transportation, of the Code of Federal Regulations, deals with hazardous shipments including radioactive materials. See Section 16.K for a discussion of these regulations.

From time-to-time, changes are made in various regulations. The Code of Federal Regulations is revised through submission of changes proposed by an agency and the Federal Government to other governmental and private agencies and to the general public. Hearings are held, if necessary, to discuss amending the proposals. Subsequently, the amended proposals are published in the Federal Register. If no adverse action is taken, the changes or additions become part of the Code of Federal Regulations and have the effect of law. Other agencies of the Federal Government having an interest in the regulations for the shipment of radioactive substances are: Interstate Commerce Commission, Coast Guard, Federal Aviation Agency, Postal Service, DOE and the NRC. The Department of Transportation has made an effort to make its labeling system conform with the regulations of the International Atomic Energy Agency.

This concludes the brief outline of the main groups whose function is to regulate. From the dynamic nature of the field of atomic energy, one can expect that many new problems will arise. for this reason, no attempt has been made to discuss any of the present regulations in detail. As new problems arise, new rules must be worked out. Thus, as in the case of exposure limits, changes will occur. To keep up on current changes, it is necessary to periodically review the Federal Register.

11.4 Agreement State

An Agreement State is any state using legislation known as the Radiation Control Act to provide regulation of radioactive materials and radiation producing machines and whose purpose is to protect the health and safety of the public. The governor of an Agreement State has signed an agreement with the NRC or its predecessor, the Atomic Energy Commission. As part of this agreement, the State maintains a radioactive materials regulatory program that is sufficient to protect the health and safety of the public and that meets or exceeds that of the NRC.

11.5 40 CFR Overview

Section 40 of the Code of Federal Regulations primarily sets limits on the activities and effects of radioactive materials dispelled beyond the boundaries of the facility. A brief outline of some specific parts are listed below:

40CFR 61	air pollutant limits including radon and other radionuclides
40CFR 141	public drinking water limits including Ra-226 and Ra-228
40CFR 190	nuclear power plant operation and uranium fuel cycle operation limits
40CFR 191	release limits for disposal of spent nuclear fuel, high-level, and transuranic wastes
40CFR 192	standards for remedial actions at inactive uranium processing sites
40CFR 220-229	ocean/marine dumping limits
40CFR 440	effluent limits from ore mining.

11.6 Role of OSHA - 29 CFR

The Occupational Safety and Health Administration is charged with improvement of safety to workers in the United States. Their rules are codified in 29 CFR 1910 "Occupational Safety and Health Standards" and 1926 "Construction" for operational facilities and construction respectively. These rules cover most aspects of worker safety and are applicable to any company that has more than ten employees. The Commission has a memorandum of understanding with the OSHA which allows NRC Inspectors to report/review safety compliance status by a licensee, thus becoming additional OSHA "eyes." However, due to the complexity of the OSHA regulations it is not required that the NRC Inspectors become proficient with the regulations, but only that they report situations that appear to be unsafe, or known violations based on the Inspector's knowledge.

11.7 Summary of 10 CFR 20

The new 10 CFR Part 20, Standards for Protection Against Radiation, represents the most significant change in radiation protection regulations in over 35 years. The new rule became effective on June 20, 1991 and compliance was mandatory for all NRC licensees on January 1, 1994. The new Part 20 is a risk-based system of radiation protection which implements the recommendations of the ICRP (1977) and the NCRP (1977) and Presidential Guidance to Federal Agencies issued in 1987. The new regulation updates dose/risk models and parameters, particularly with regard to internally deposited radioactivity. The format of the new regulations has also been changed to consolidate certain portions and improve its organization.

Major changes to Part 20 include: new dose limits for workers and members of the public; introduction of the concept of effective dose equivalent; summation of external and internal dose; use of Annual Limit on Intake (ALI) and Derived Air Concentration (DAC); dose limitation to the embryo/fetus of a declared pregnant woman; planned special exposure (PSE); the new respirator rule requiring total effective dose equivalent to be maintained ALARA; changes in dose recordkeeping and reporting (NRC Forms 4 and 5); and new effluent concentration limits for releases of radioactivity to air and water.

A series of regulatory guides have been issued to provide additional guidance on the new Part 20. Also, an extensive series (seven sets to date) of questions and answers (Q & A's) have been issued to reflect NRC staff decisions and

technical opinions on specific aspects of new Part 20 regulatory requirements.

A summary of the subparts of 10 CFR 20 is presented below:

Subpart A discusses the general provisions of the regulations including purpose, scope, definitions, and units of dose and radioactivity. Further it defines the proper mechanism for interpretations of these regulations, and lists the proper directions for communication and provides implementation guidance.

Subpart B states the requirements for licensees to develop, document, and implement a radiation protection program.

Subpart C provides the requirements for occupational dose limits. This subpart includes requirements for summing internal and external dose, determining dose due to internal exposure, the use of planned special exposure, and dose limits for minors and an embryo/fetus.

Subpart D provides the requirements for dose limits for members of the public and includes compliance with 40 CFR 190.

Subpart E is reserved.

Subpart F provides the requirements for the making of surveys and monitoring of personnel for external and internal occupational dose.

Subpart G provides the requirements for the control of exposure from external sources in restricted areas and includes access to high and very high radiation areas for both normal licensees and irradiators.

Subpart H provides the requirements for respiratory protection and controls to restrict internal exposure in restricted areas.

Subpart I provides the requirements for the storage and control of licensed material.

Subpart J provides the requirements for precautionary procedures including posting of areas and materials, and the receiving and opening of packages.

Subpart K provides the requirements for radioactive waste disposal.

Subpart L provides the requirements for records generated in support the radiation protection program. These records consist of such things as survey and monitoring reports, dose reports, planned special exposure documents, member of the public dose, and waste disposal.

Subpart M provides the requirements for reports to the Commission and include such things as theft or loss of licensed material, incidents, events where radiation levels, exposures, or concentrations of radioactive materials exceed limits, planned special exposures, and individual dose monitoring.

Subpart N provides exemptions to these regulations as well as other additional requirements.

Subpart O provides the requirements for enforcement of these regulations.

Appendix A provides the allowed protection factors for respirators.

Appendix B provides radionuclide specific values for the annual limits on intake and derived air concentrations for occupational exposure, effluent concentrations, and sewerage releases.

Appendix C provides radionuclide specific values for quantities of licensed material that requires labeling.

Appendix D lists the addresses and phone numbers for each of the four NRC Regions and the California Field Office.

Appendix E is reserved.

Appendix F lists the requirements for low-level-waste transfer for disposal at land disposal facilities and manifests.

Chapter 11 Study Questions

1. What are four of the subparts of 10 CFR Part 20?
2. What gives agreement states jurisdiction/power to regulate NRC licensees?
3. What gives the EPA jurisdiction/power to regulate NRC licensees?
4. What gives the DOT jurisdiction/power to regulate NRC licensees?
5. What gives the OSHA jurisdiction/power to regulate NRC licensees?
6. What are the radiation dose equivalent limits specified by the NRC for licensee workers and members of the public? Where can these limits be found?
7. Prior to the adoption of dose limits, how did the early radiation workers limit their exposure to ionizing radiation?
8. What agencies have guided the evolution of dose limits the most?

Table 11-1. Non-Occupational Radiation Standards (NCRP) and Dose Limits (NRC, EPA)

NCRP (Reports 39, 1971 and 40, 1975)	
To individual members of the public:	50 mrem/yr
Average to population groups:	170 mrem/yr
NRC (10 CFR 50, Appendix I), LWR Design Criteria	
From liquid effluents:	
All pathways - Total body:	3 mrem/yr
- Individual organs:	10 mrem/yr
From airborne effluents:	
Air dose - gamma radiation:	10 mrad/yr
- beta radiation:	20 mrad/yr
External dose to individual:	
Total body:	5 mrem/yr
Skin:	15 mrem/hr
Internal dose to any organ:	15 mrem/yr
NRC (10 CFR 20) Radiation Protection Regulations	
From all pathways, total effective dose equivalent to member of the public:	100 mrem/yr
EPA (40 CFR 61) Clean Air Regulations (except nuclear power plants	
From all air pathways, effective dose equivalent to member of the public:	10 mrem/yr
From airborne radioiodine:	≤3 mrem/yr
EPA (40 CFR 190), Nuclear Fuel Cycle	
From all sources except radon and short-lived progeny:	
To any individual - Total body:	25 mrem/yr
- Thyroid:	75 mrem/yr
- Other organs	25 mrem/yr
Release limits for total fuel cycle (effective 1983):	
Per gigawatt-year of power production:	
- krypton-85:	50 kCi
- iodine-129:	5 mCi
- transuranics:	0.5 mCi

Table 11-1. Non-Occupational Radiation Standards (NCRP) and Dose Limits (NRC, EPA)

(Continued)

EPA (40 CFR 141), Safe Drinking Water Act Regulations	
From man-made radionuclides in drinking water	4 mrem/yr

Table 11-2. Weighing Factors for Stochastic Risk

Tissue	w_T
Gonads	0.25
Breast	0.15
Red bone marrow	0.12
Lung	0.12
Thyroid	0.03
Bone surfaces	0.03
Remainder	0.30

INTRODUCTORY HEALTH PHYSICS

CHAPTER 12
RADIATION PROTECTION PLANS AND PROCEDURES

This chapter provides the course participants with an overview of:

- The components of a radiation protection plan.
- The occupational ALARA program.
- The operational radiation protection procedures.
- The dosimetry program.
- The keeping of occupational radiation protection records.
- The quality assurance aspects of the radiation protection plan.
- The integration of health and safety plans.

LEARNING OBJECTIVES

Upon completion of this chapter, the student should be able to successfully:

- Describe the fundamentals of operational radiation protection procedures on:
  - instrumentation programs
  - dosimetry programs and dose limitation
  - surveying and monitoring
  - posting and labeling.
- Identify the training, recordkeeping, and reporting requirements in a radiation protection plan.

12.0 RADIATION PROTECTION PLANS AND PROCEDURES

12.1 Introduction

A Radiation Protection Plan (RPP) is one part of every NRC license for radioactive materials or special nuclear materials. This requirement serves the purpose of directing activities of the licensee such that exposures to the licensee's employees and the public are kept as low as reasonably achievable. A RPP is a multifaceted program which entails all aspects of radiation protection, ranging from administration, to facility assessment, to training, to dose evaluation and control. Each of the many components of the RPP supports the philosophy of ALARA.

There is no specified outline for an RPP because facilities have various designs, functions, and needs. However, the dominant concepts include:

- Administration
- Occupational ALARA programs
- Radiation protection program surveys and monitoring
- Posting and labeling for radiological control
- Workplace air monitoring
- Instrument calibration for fixed and portable instruments
- Internal dosimetry program
- External dosimetry program
- Evaluation and control of fetal exposure
- Radiation safety training
- Sealed radioactive source accountability and control
- Occupational radiation protection record-keeping and reporting
- Quality assurance, and
- Emergency response.

Emphasis may differ among facilities and some facilities may include additional concepts, but this list comprises the core of the RPP. One topic that is general to all areas of an RPP is documentation and records retention. Every area to be discussed requires that sufficient documentation be retained to show that the program is being operated correctly and that worker doses are ALARA and within regulatory limits. Some records are to be maintained until the license is terminated while others need to be retained for 75 years. Therefore it is important that a licensee have a good document control system to support the RPP.

12.2 Administration

Within the arena of administration lies the requirement for an ALARA commitment from the upper level facility management down to the mid-level managers. Without this commitment there cannot be an active and progressive radiation protection program. The administration must support the health physics programs with the resources (personnel, equipment, space, etc.) needed to fulfill the task of radiation protection of the work force and the public. Failure to support health physics will ultimately lead to facility conditions that are not conducive to the principals of ALARA.

More close to home is the need to have a well trained Health Physics administrator to ensure all aspects of a good health physics program are instituted at a level commensurate with the potential for exposure to radiation and radioactive materials in the workplace and the environment. Levels of administration that report to the Health Physics administrator will be dependant on the complexity of the program. For instance a nuclear power generating station will have a far more complex (both in terms of personnel and resources) program than might be found at a facility that has a sealed source only license.

12.3 Occupational ALARA Programs

Occupational ALARA programs vary widely dependant on the potential for exposure to radiation and radioactive materials. The basic tenant to which these programs operate is that there should be a net benefit to justify the exposure to radiation or radioactive materials. The size of the facility and the types of tasks performed at the facility will affect the size of the ALARA program. In the most basic of programs should be a review of the current program to identify opportunities for reducing total man-rem expended in performing the facilities task.

ALARA programs should first target engineered controls, then administrative controls, and lastly personal protective equipment. Engineered controls consist of modification of new and existing facility design that reduces the exposure of personnel to radiation and radioactive materials. Examples of engineered systems are:

- use of heavy shield walls and labyrinths
- use of remote handling, use of robotics
- use of local ventilation exhaust
- use of local shielding and facility layout to ensure radiation sources are remote from office areas and other locations where personnel tend to congregate.

Administrative controls are "soft fixes" that result in programs for the reduction of worker exposure. Examples of administrative controls are:

- locking access to high radiation areas
- implementing ALARA review boards for all scheduled maintenance
- pre-job mockup maintenance training
- setting of ALARA man-rem goals
- purchasing control systems that ensure materials brought into the facility are compatible with the system components
- implementing a strong contamination control program
- posting and identification of radiation areas and radioactive materials
- use of administrative dose limits for personnel.

The last part of the ALARA program is the use of protective clothing to minimize worker exposure to direct radiation (e.g., alpha radiation), contamination and airborne radioactive materials. Clothing can range from simple lab coats and gloves to full anticontamination attire, including respiratory protection. What type of clothing is used and how much is required is dependant on the potential for exposure to radioactive materials.

12.4 Operational Radiation Protection Procedures

12.4.1 Radiation Protection Program Surveys and Monitoring

Every radiation protection program, from very simple to complex, requires that surveys and monitoring be performed in a facility to establish the exposure to radiation and radioactive materials on surfaces and in the air. A good program will utilize survey frequencies that are commensurate with the potential for radiation fields to change and for radioactive materials to be found in the workplace. For example in areas where little to no radioactive materials are allowed and radiation fields are near background there is little need to spend valuable personnel and instrument resources in monitoring activities. In this situation monthly surveys may be sufficient. However, in facility areas where contamination probability is high and known loose contamination levels are routinely elevated, there is good reason to implement monitoring programs that require frequent air samples, and loose contamination surveys. In facilities where radiation fields change daily it is important to perform radiation surveys

daily. Types of surveys and monitoring techniques must be tailored for the radionuclides of concern at the facility.

Although the primary focus of most survey and monitoring programs deals with the facilities it is important to not overlook the need to survey personnel and equipment as they come out of radiologically controlled areas, especially from areas containing loose or fixed radioactive contamination. All personnel leaving these type of areas should perform a frisk to detect the presence of contamination on their person or personal articles they may be carrying out of the area. The extent of the frisk, whole or partial body, should be driven by the potential for exposure. This is true also for equipment leaving the area. However, all equipment should be monitored by a health physics technician or a fixed monitoring device to ensure contamination control is affected.

12.4.2 Posting and Labeling for Radiological Control

A facility possessing radioactive materials is required to identify the locations of such materials and the resultant dose rate or effect on contamination levels due to the radioactive materials. All postings must bear the internationally accepted symbol of radioactivity, the trefoil in the appropriate colors of magenta, purple, or black on yellow background. Types of signs and their associated definitions, as defined in 10 CFR 20, are listed below:

CAUTION, RADIATION AREA

A radiation area is an area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem in 1 hour at 30 cm from the radiation source or from any surface that the radiation penetrates.

CAUTION, HIGH RADIATION AREA

High radiation area is an area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.1 rem in 1 hour at 30 cm from the radiation source or from any surface that the radiation penetrates.

GRAVE DANGER, VERY HIGH RADIATION AREA

A very high radiation area is an area, accessible to individuals receiving an absorbed dose in excess of 500 rads in 1 hour at 1 meter from the radiation source or from any surface that the radiation penetrates.

CAUTION, AIRBORNE RADIOACTIVITY AREA

An airborne radioactivity area is a room, enclosure, or area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations: (1) in excess of the derived air concentrations (DACs) specified in Appendix B of 10 CFR 20, or (2) to such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

CAUTION, RADIOACTIVE MATERIAL

A radioactive materials area is an area where amounts of stored material are $\geq$10 times Appendix C values in 10 CFR 20.

CAUTION, RADIOACTIVE MATERIALS

A radioactive materials area is an area where any such material whether or not subject to licensing control by the NRC is located.

Although these postings cover most situations for exposure control from direct radiation there is still the possibility of encountering loose contamination in a facility. Although not defined in 10 CFR Part 20, other appropriate postings may be as follows:

CAUTION, CONTAMINATION AREA

A contamination area is an area where contamination >1 time but ≤ 100 times Reg. Guide 1.86 Table 1 values.

DANGER, HIGH CONTAMINATION AREA

A high contamination area is an area where contamination >100 times Reg. Guide 1.86 Table 1 values.

12.4.3 Work Place Air Monitoring

Monitoring of internal dose to workers is required by 10 CFR Part 20 where the potential exists for a worker to exceed 10% of an ALI during the course of a year. To meet this requirement, most licensees perform air monitoring either continuously or on an intermittent schedule. Due to the large variety of contaminants that are handled by licensees in the United States there is no one way to obtain air samples. Typically air sampling can be subdivided into four categories: particulate, noble gas, radioiodines, and other.

Particulate radioactivity is normally associated with small dust particles that are made up of, or have attached to them, radioactive material. These materials are solid and can be collected as air is passed through a filter material.

Noble gases are kryptons and xenons, fission products that are inert and therefore do not attach to filters or quantitatively collect on absorbers. The normal method for sampling is the use of grab samples, where container volumes are liters or larger.

Radioiodine can either be a particulate or take many chemical forms such as organic, I_2, or HOI. Therefore sampling should be conducted by pulling air through a particulate filter followed by a charcoal cartridge. This combination of filters helps to assure that a representative sample will be collected.

In the category of "other" lies all of the odd ball radionuclides such as tritium and C-14. Also included in this category may be specialty radionuclides in specific chemical forms that have specific uses by a licensee. Types of sample collection devices must be tailored to the nuclide and chemical form. For example tritium can be found as hydrogen gas, water vapor, or organic vapors. Each form will require a different technique to adequately collect a representative air sample.

12.4.4 Instrument Calibration

Instruments used for the detection of contamination and radiation vary widely within the nuclear industry. However, there is one thing that doesn't vary and that is the need to properly maintain and calibrate the instruments to assure proper operation. Normally instruments are calibrated every six months to one year depending on the license requirements. At these times the instrument should also be checked for damage and repaired if needed. Every instrument should be returned into the workplace with a sticker attached that gives the date of calibration or next due date, and any specific information required by the licensee such as efficiency factors, initials of calibrator, serial number of meter and probe if two separate units.

Prior to each use the tag should be reviewed to ensure the instrument is still within calibration. The instrument should be inspected and the response checked with a source. Any instrument that is not in calibration or does not pass inspection should

be tagged out-of-service and sent for calibration and/or repair.

12.4.5 Sealed Radioactive Source Control

Proper control of and accountability for sealed radioactive sources used in a facility or by a licensee in field or mobile equipment is very important, and must be addressed within an RPP. There have been many instances where sources have been lost and later found by members of the public which resulted in death of individuals, severe radiation injury of individuals, and extensive contamination of cities and the environs.

Sources are used by licensees for many purposes such as instrument calibration, reactor startup, thickness gauges, level gauges, well logging, weld inspections, tumor irradiation, food irradiation, and many other ways. Sources used by licensees can range from small sources on the order of micro curies to very high activity sources having thousands of curies. The smaller sources represent significantly less hazard to an individual than the high activity sources, but their control is still important.

A well functioning source control program will allow for total accountability and control of all sources. Documentation of use and custody of sources is required to ensure sources do not end up in the hands of a member of the public. It is easier to accomplish this at a fixed facility than with sources that are being used in the field for well logging, weld inspection, and other remote site uses.

12.4.6 Management and Disposal of Radioactive Waste

Operations at licensee facilities generate radioactive wastes that must be handled and ultimately disposed. All aspects of waste generation, handling, storage, and waste disposal should be addressed in the facility radiation protection plan because failure to do so results in increased radiation exposure to workers and potentially even to the public.

The point of waste generation affords the best opportunity to control radiation exposures from radioactive waste. The best way to reduce exposures from radioactive waste is to avoid generating the waste in the first place. The RPP should include a mechanism for health physics review and oversight of all operations that generate radioactive waste so that means to reduce the quantities of waste can be evaluated. For example, raw materials that become contaminated might be recycled through a process operation (e.g. water, residual or scrap intermediate product), processing operations might be consolidated spatially to limit the area requiring decontamination, processes might be modified to involve fewer personnel and pieces of equipment that handle radioactive materials.

Simple measures can be taken to establish procedures for handling, storage, and disposal of radioactive waste that minimize doses, providing for greater worker protection and reduced doses to the public. Dose control measures can include double lining radioactive trash disposal bins to reduce the potential for breakage and contamination, short-to-medium term storage of radioactive wastes containing short-lived radionuclides, automation of waste handling operations and use of remote handling tools and equipment for higher dose rate wastes if personnel must be involved. Radioactive wastes must always be kept containerized to avoid potential releases of radioactive material and consideration should be given to waste storage location and the need for shielding to keep doses under control. Radioactive waste disposal should be performed in a timely manner to eliminate sources of radiation exposure, unless waste is being stored for decay of short-lived radionuclides.

12.4.7 Emergency Response

As with several other portions of the RPP, emergency response varies with the needs of the facility. The appropriate responses for the following incidents or emergencies as they pertain to the safe use of radioactive material are described in the facility emergency plan:

- Electrical power failures
- Minor spills (liquid or dry)
- Accidents involving radioactive dusts, mists, fumes, vapors, or gases
- Injuries to personnel involving radioactive contamination
- Fires or other emergencies.

In addition, radiological incidents may include lost or damaged TLDs or accidental overexposures. Such a loss or overexposure must be reported to the proper authority, usually the RSO. The emergency response section provides methods for those responding to other radiological emergencies.

A second side of emergency response involves handling of emergencies that result in off site release of effluents (gaseous or liquids) that potentially will impact members of the public. Response to these type of emergencies requires a different and more complex program than that used for on site emergencies. It may be prudent to not handle these emergencies within an RPP but handle within a separate group.

12.5 Dosimetry Programs

12.5.1 Internal Dosimetry Program

It is important to maintain the capability to monitor workers for the presence of internally deposited radionuclides where there is the possibility for internal deposition. Internal dosimetry programs are as varied as NRC licensees. However, there are two main ways for quantifying the amount of internally deposited radionuclides in that body of workers; in-vivo body counts and sample bioassay. In-vivo counting involves the detection of gamma-ray emitting radionuclides using detectors that are positioned over the body or specific organ. These detectors are described more fully in Chapter 8.

Bioassay sampling involves the collection of urine, feces, blood, saliva, etc. from a worker to identify the presence of a radionuclide and quantify the rate of excretion from the affected individual. More information on detection and sampling methods is presented in Chapter 8.

The internal dosimetry program must rely on the analytical results to estimate the dose to an organ and the effective dose equivalent to the whole body that a worker is committed to receive. This involves having the staff and computational software to perform these calculations.

12.5.2 External Dosimetry Program

Any radiation protection program requires the assessment of dose to workers from external sources of radiation in the workplace. This program requires that all affected workers be monitored both on a routine basis, and in certain instances on a special basis, to ensure dose limits are not exceeded. Depending on the size of the work force this program may be very extensive. At a nuclear power reactor this program represents a total organizational structure to ensure that dosimetry is properly issued, collected, read, and results recorded and doses assigned. Typically the dosimetry program involves the use of monthly issue of dosimetry. During outages daily or job task badges may be issued to ensure proper accounting of worker dose.

Not only does a dosimetry program rely on dosimeters such as TLDs or film badges, but self reading dosimeters are frequently used.

These dosimeters allow the worker to asses their dose on a real-time basis as they are performing their work. Typically the workers are allowed to work in an area until the self reading dosimeter is at some fraction of the task allowed dose. For instance if the worker is authorized a dose of 200 mrem for disassembly of a contaminated pump, he may have to stop work and leave the area when the self reading dosimeter reads 175 mrem. The cushion used depends on the experience the health physics department has with the self reading dosimeters giving dependable dose measurements.

12.5.3 Radiation Dose to the Embryo/Fetus

10 CFR Part 20.1208 requires that each licensee ensure that the dose to an embryo/fetus during the entire pregnancy, from occupational exposure of a declared pregnant woman, does not exceed 0.5 rem. The licensee is also required to make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman that would satisfy the 0.5 rem limit. This corresponds to roughly 50 mrem per month. This is to prevent all of the 0.5 rem dose being given at a time when the embryo/fetus is at a particularly radiosensitive stage of development.

The woman must declare her pregnancy in writing but medical confirmation of pregnancy is not required nor can it be required. If at the time of declaration, the embryo/fetus has already received 0.5 rem or more, the embryo/fetus is allowed to receive another 50 mrem for operational flexibility. The ALARA principle is to be applied in the case of a declared pregnant woman. The declared pregnant woman can withdraw her declaration at any time.

If a woman is pregnant but chooses not to declare her pregnancy, the routine occupational dose limits and ALARA apply as for any other worker.

Dose records for the embryo/fetus should be kept with those of the declared pregnant woman, who is still classified as a worker receiving occupational exposure. The dose records for the embryo/fetus are submitted to the NRC only in the case of an overexposure of the embryo/fetus.

All workers should receive training on NRC Regulatory Guide 8.13, "Instructions Concerning Prenatal Radiation Exposure".

12.6 Radiation Safety Training

All personnel who are going to either work with or work in areas containing radioactive materials or radiation fields must be trained in radiation protection. The amount of training required depends largely on the potential for exposure and the types of material of concern. Two levels of training that may be applicable are casual workers and radiation workers.

Casual workers may be personnel who are not routinely exposed or do not routinely work with radioactive material. Their level of training may be directed to a general understanding of radioactivity and the methods used at their facility to control exposure to radioactive materials and radiation. This would include information on postings, radiation alarms, reporting, and personal frisking. Certainly the information taught can be less than that required for a radiation worker.

A radiation worker requires more knowledge about the types of radiations and the methods used to protect them from these radiations than a casual worker. The course outline for a radiation worker could include such things as:

- defining radioactivity and contamination
- understanding the affects of time, distance, and shielding on worker dose
- explaining postings and worker responsibility for compliance with postings
- types of and use of respiratory protection
- understanding the use and proper donning and doffing of protective clothing
- understanding and proper use of personnel dosimetry
- forms used to document job tasks involving radiation or radioactivity and workers performing the tasks, etc.

The training should be performance based using an exam to test worker understanding of concepts. Each training course should involve a donning and doffing and mock work exercise to verify that the worker understands the proper methods for the use of protective clothing and proper techniques for keeping dose ALARA.

12.7 Occupational Radiation Protection Record-Keeping and Reporting

The regulations are replete with requirements for record keeping and reporting. These requirements are applicable for all areas covered by an RPP. Ensuring that records are maintained and reports are generated and transmitted on time requires a dedicated staff and space. The number and variety of report forms used to document activities covered under the RPP can easily outpace the ability of a small staff to sort, catalog, copy, and file. Not to mention retrieving data to support the generation of reports. In addition the data retention requirements within the regulations further exacerbate the situation involving records.

12.8 Quality Assurance

This vital section of the RPP describes all aspects of the quality assurance program and how they are implemented in connection with the facility. Some aspects of this program may be the type and location of training records for all authorized users, frequency and types of audits, and/or frequency of review for safety procedures. This part of the program should rely on both internal reviews and external audits to assure staff and program compliance with the RPP requirements. Quality assurance activities should be conducted by staff that is independent of any of the licensee's operational organizations in order to be effective.

12.9 Other Health and Safety Plans

There are three other areas of safety concern at every licensee's facility that do not deal with radiation safety. These are industrial safety, fire safety, and hazardous material worker right to know.

Rules governing industrial safety within an operating facility are found within 29 CFR 1910. These rules are broad in scope covering virtually all aspects of work place safety. There are specific training and safety plan requirements within 29 CFR 1910 depending on the physical and chemical hazards that exist within the work place. Personnel at a facility who deal with the industrial operational aspects are either industrial hygienists and/or industrial safety professionals. These individuals have been trained in the recognition of hazards and hazard abatement. Depending on the size of the facility and its complexity the safety department may consist of one person or many. These safety professionals implement procedures, perform work place evaluations, and inform workers of good safety practices.

Fire protection at a facility is guided by 29 CFR 1910 Subpart L and by industry code setting organizations such as the National Fire Protection Association. These standards guide design aspects for a facility as well as establish specific requirements for operations. Facilities are to have fire protection systems designed into them so that automatic systems will initiate if a fire occurs. Sufficient exits and emergency lighting is to be in place to facilitate worker evacuation. Fire extinguishers are placed strategically within a facility to allow easy access by workers to fight small local fires. Fire evacuation signals are to be used at large facilities to alert workers to the need to evacuate buildings. Training is to be provided to all workers so that they understand what their actions are to be in case of a fire. If the facility allows personnel to use fire extinguishers then there are specific training requirements. By implementing a comprehensive fire protection program at a facility, workers have little risk associated with fire.

Within the area of hazardous materials there are two components. First is what is generally called the "worker right to know" requirements found in 29 CFR 1910.1200. These regulations require that all personnel be informed about the chemical hazards that exist at a facility. Within these regulations are the requirements for having material safety data sheets (MSDSs) on any hazardous material or chemical that is used on site, and for the MSDSs to be kept on file and readily accessible to the work force. There are requirements for labeling of chemicals and other hazardous substances.

The second component for hazardous materials are the regulations governing the storage and disposal of hazardous waste materials within a facility. These regulations are found in 40 CFR 264 and 265. These requirements are very specific and contain holding times for wastes in either satellite accumulation areas and temporary storage areas. Implementation of these requirements drives a facility to have program plans and to train all employees to the plan.

If the licensee's site contains outside areas that have been contaminated by hazardous materials the site cleanup may be driven by the requirements of 29 CFR 1910.120. These requirements address specific training and health and safety plan requirements that must be complied with for personnel working at the cleanup site.

12.10 Summary

The Radiation Protection Program is designed to ensure that all operations at a facility using radioactive material and radiation-producing equipment are conducted within the scope of the Radioactive Material License and equipment registrations and in accordance with company policy, and local, state, and federal regulations. The program is also designed to ensure that exposures to personnel and the environment are maintained below the applicable standards and to a point that is as low as reasonably achievable (ALARA).

Chapter 12 Study Questions

1. What are the basic components of a radiation protection plan?

2. Define the criteria that require each of the following posting labels:

   - RADIATION AREA
   - HIGH RADIATION AREA
   - AIRBORNE RADIOACTIVITY AREA
   - CONTAMINATION AREA

< TRANSACTION REPORT >

06-17-1997(TUE) 13:14

[TRANSMIT]

NO.	DATE	TIME	DESTINATION STATION	PG.	DURATION	MODE	RESULT
32763	6-17	12:49	405 271 8425 Oklahoma	41	0°24'59"	NORM.E	OK
				41	0°24'59"		

Note: Destinations that did receive this were mailed copies - the entire package was mailed to All A/S, OH, OK, PA. 6/18/97

< TRANSACTION REPORT >

06-17-1997(TUE) 12:16

[BROADCAST]

NO.	DATE	TIME	DESTINATION STATION	PG.	DURATION	MODE	RESULT
32742	6-17	04:17	919 571 4148	41	0°24'53"	NORM.E	OK
32743		04:42	701 328 5200	41	0°24'49"	NORM.E	OK
32744		05:08	503 731 4081	41	0°24'49"	NORM.E	OK
32745		05:33	401 277 2456	41	0°47'17"	NORM.E	OK
32746		06:20	8037377412	19	0°15'21"	NORM.E	U010
32747		06:36	615 532 7938	41	0°24'54"	NORM.E	OK
32748		07:01	5128346708 Texas	41	0°26'52"	NORM.E	OK
32749		07:28	801 533 4097	18	0°12'33"	NORM.E	U010
32750		07:41	360 753 1496	41	0°24'51"	NORM.E	OK
32751		08:06	518 457 2225	41	0°24'55"	NORM.E	OK
32752		08:32	518 457 5545	13	0°06'56"	NORM.E	U010
32753		08:39	NEW YORK CITY	41	0°25'11"	NORM.E	OK
32754		09:04	502 227 7862	41	0°26'06"	NORMAL	OK
32755		09:31	AECB (613) 995-5086	41	0°25'42"	NORMAL	OK
32756		09:57	WASHINGTON DC	41	0°24'48"	NORM.E	OK
32757		10:22	7996726	41	0°25'21"	NORM.E	OK
32758		10:48	217 782 1328	41	0°28'07"	NORM.E	OK
32759		11:16	512 239 6362	41	0°25'00"	NORM.E	OK
32760		11:42	4024714840	41	0°29'50"	NORMAL	OK
32761		12:12	912 262 3143	4	0°03'47"	NORMAL	U008
			ERROR PAGE:04				
				710	7°52'05"		

Oklahoma
405-271-8425

< TRANSACTION REPORT >

06-17-1997(TUE) 04:16

[BROADCAST]

NO.	DATE	TIME	DESTINATION STATION	PG.	DURATION	MODE	RESULT
32717	6-16	18:15	610 337 5324	41	0°25'07"	NORM.E	OK
32718		18:40	404 562 4955	41	0°24'57"	NORM.E	OK
32719		19:05	7085151096	26	0°32'25"	NORM.E	U010
32720		19:38	817 860 8122	14	0°09'13"	NORM.E	U010
32721		19:48	5109750381	41	0°25'08"	NORM.E	OK
32722		20:13	334 613 5387	18	0°20'45"	NORM.E	U010
32723		20:34	6024370705	41	0°30'35"	NORMAL	OK
32724		21:05	5016612468	41	0°26'45"	NORM.E	OK
32725		21:32	0111916 3243610	41	0°24'52"	NORM.E	OK
32726		21:57	303 343 3697	27	0°17'29"	NORM.E	U010
32727		22:15	904 487 0435	41	0°26'02"	NORM.E	OK
32728		22:42	404 362 2653	31	0°19'27"	NORM.E	U010
32729		23:01	217 524 4724	41	0°24'54"	NORM.E	OK
32730		23:27	515 242 6284	41	0°25'09"	NORM.E	OK
32731		23:52	913 296 0984	41	0°26'21"	NORM.E	OK
32732	6-17	00:19	502 564 6533	41	0°24'53"	NORM.E	OK
32733		00:44	LOUISIANA	13	0°06'54"	NORM.E	U010
32734		00:51	MAINE	41	0°29'48"	NORMAL	OK
32735		01:21	410 631 3198	41	0°25'43"	NORMAL	OK
32736		01:47	601+354+6167	41	0°31'02"	NORMAL	OK
32737		02:19	402 471 9449	41	0°24'48"	NORM.E	OK
32738		02:44	7026875751	12	0°07'44"	NORMAL	U008
			ERROR PAGE:12				
32739		02:52	603 225 2325	38	0°25'23"	NORM.E	U010
32740		03:18	5058271544	41	0°29'47"	NORMAL	CK
32741		03:48	518 458 6434	41	0°28'38"	NORM.E	OK
				876	9°53'49"		