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THAI - CANADIAN

NUCLEAR HUMAN RESOURCES DEVELOPMENT

LINKAGE PROJECT

TRAINING PROGRAM

RADIATION PROTECTION

REFERENCE TEXT

written by

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SPONSORED BY

ATOMIC ENERGY OF CANADA LIMITED
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FOREWORD

The objectives of our Radiation Protection Program are:

1. To prevent radiation fatalities;
2. To prevent radiation injuries;
3. To remain within legal radiation dose limits;
4. To keep radiation doses as low as reasonably achievable.

This book forms part of the Radiation Protection Training Course for the staff of the Point Lepreau CANDU-6 Generating Station. It is designed to give you an appreciation and understanding of the principles of radiation protection that you have to follow, so that we can meet the objectives listed above.

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NOTE (January 2005): The complete reference text for this course is available at the following URL:

<http://canteach.candu.org/catalog.html#NBPOWER>

Relevant portions of the reference text are copied here for convenient reference.

Dan Meneley

CONTENTS

*CHAPTER 1 - THE ATOM

ATOMIC STRUCTURE

The atom; protons, neutrons, electrons; atomic number; elements; mass number; atomic size.

ISOTOPES

Separation of isotopes; isotopes of hydrogen and uranium; nuclides.

*CHAPTER 2 - RADIATION THEORY

RADIOACTIVITY

Stable and radioactive nuclides; alpha, beta, gamma and neutron radiation; energy, electron volt.

IONIZATION

Ion pairs; ionization by alpha and beta particles; ionization by photoelectric effect, Compton scattering, pair production; ionization by neutrons.

PENETRATING ABILITY OF RADIATION

Comparison of alpha, beta, gamma and neutron range; beta ranges in various materials; bremsstrahlung; half-value layer; neutron range.

DECAY SCHEMES

Alpha, beta, positron and gamma decays; excited and ground states; decay series.

RATE OF DECAY

Activity; half-life; decay curve; becquerels.

NEUTRONS

Fast, slow, thermal neutrons; neutron sources; fission; elastic and inelastic scattering; neutron activation; radiative capture; neutron reactions in tissue.

RADIATION SOURCES IN A NUCLEAR PLANT

Activation, contamination; radiation from the core; fission products; fuel failure; activation products in moderator and PHT systems.

CHAPTER 3 - BIOLOGICAL EFFECTS OF RADIATION

IONIZATION AND RADIATION DOSE

Ionization and its effect on water molecules; direct and indirect damage; absorbed radiation dose; the gray; quality factors; equivalent dose; the sievert.

NATURAL BACKGROUND RADIATION

Cosmic rays; radioactivity in the earth's crust; radon daughters; external gamma radiation; natural radioactivity in the body; areas of high natural radiation; man-made radiation; medical exposures; fallout; occupational doses; nuclear power contribution.

HEREDITARY EFFECTS

Cell division; mutation; risk from radiation.

LONG-TERM SOMATIC EFFECTS

Cancer; human high exposure data; extrapolation to low doses; cancer risk.

SHORT-TERM SOMATIC EFFECTS

Acute and chronic exposures; effects on the cell; radiation sickness; radiosensitivity; lethal dose; treatment of radiation injury; effects of exposure to specific organs or tissues.

RADIATION EFFECTS DURING PREGNANCY

Effects of exposure to embryo or foetus, 10-day rule.

CHAPTER 4 - DOSE LIMITS AND RISK

DOSE EQUIVALENT LIMITS

The ICRP; ICRP-26 and ICRP-60; stochastic and non-stochastic effects; objectives of radiation protection; dose limits.

RISK

Acute and chronic risk; occupational radiation risk; hourly risk; lost life expectancy; comparison of various risks.

*CHAPTER 5 - INSTRUMENTS

GENERAL

Features of radiation instrumentation; identification of radiation type; measurements made with radiation instruments.

IONIZATION CHAMBERS

Principles of operation; ion chamber gamma survey meters; tritium-in-air monitors; DRD.

PROPORTIONAL AND GEIGER COUNTERS

Gas amplification; proportional counters for beta/gamma and alpha contamination and neutron measurements; Geiger counters as particle detectors and gamma survey meters.

PRACTICAL CONSIDERATIONS

Identification of radiation type; instrument design; special operating techniques; energy dependence; scalers and ratemeters; response time; efficiency; dead time; instrument checks.

SCINTILLATION COUNTERS

Functions of phosphor, phototube, amplifier and discriminator; alpha scintillation counter; pulse height analysis; whole-body counter; liquid scintillation counters (bioassay and portal monitor).

EXTERNAL DOSIMETRY

Description and performance of our TLD system; neutron response; operational procedures; TLD-DRD discrepancies.

CHAPTER 6 -PROTECTION FROM EXTERNAL RADIATION

TIME, DECAY AND DISTANCE

Methods using time, decay, distance; inverse square law; point, line and plane sources.

SHIELDING

Alpha, beta, gamma and neutron shielding; design of permanent shielding.

ACCESS CONTROL

Safety precedence sequence; access control system.

CHAPTER 7 - EXTERNAL RADIATION HAZARDS

RECOGNIZING HAZARDS

Hazards of major station systems; hazard assessment; typical gamma and neutron fields at Point Lepreau; anticipating changes in hazards.

RADIATION SURVEYS

Routine and job surveys; signposting; gamma, beta and neutron surveys.

ALARMING AREA GAMMA MONITORS

Fixed alarming area gamma monitors.

USING SUITABLE DOSIMETRY

Use of TLDs, DRDs, personal alarming dosimeters and neutron survey meters.

CHAPTER 8 - INTERNAL RADIATION HAZARDS

BEHAVIOUR OF INTERNAL SOURCES

Entry of radionuclides into the body; distribution in the body; target tissue; biological and effective half-lives; physical form of radionuclides.

ANNUAL LIMIT ON INTAKE, DERIVED AIR CONCENTRATION

Intake and uptake; Reference Man; ALI; DAC; internal exposure and committed dose.

TRITIUM

Production; physical form; behaviour in the body; exposure and committed dose; bioassay; dose calculations; infinity dose; Bioassay Update Reports; systems containing tritium.

RADIOIODINES 339

Important isotopes; sources; behaviour in the body; dose commitment; thyroid blocking.

PARTICULATES

Short-lived and long-lived; transportable and non-transportable; DAC for unidentified particulates; sources and locations of particulates, carbon-14.

BIOASSAY

Excretion analysis; whole body counting.

CHAPTER 9 - CONTAMINATION CONTROL

SURFACE CONTAMINATION

Sources; loose and fixed contamination; Contamination Control Limits (CCL); direct and indirect measurements; surveys.

AIRBORNE CONTAMINATION

Particulates; continuous air monitor; spot sampler; noble gases; radioiodine; tritium; tritium-in-air monitor; bubbler; airborne areas.

CONTAMINATION CONTROL DESIGN FEATURES

Zoning; Rubber Areas; Change Room; design and operation of ventilation systems; heavy water vapour recovery systems; local ventilation systems.

PROTECTIVE CLOTHING

Browns; disposable coveralls; gloves; footwear; plastic suit and hood; protection factors.

RESPIRATORS

Air purifying, air-supplied and self-contained respirators; protection factors; respiratory hazards; respirator fit testing; respirator maintenance.

DECONTAMINATION

Chemical and physical methods; general principles; Decontamination Centre; decontamination of equipment, work areas, heavy water spills, clothing, skin.

*CHAPTER 10 - DOSE RECORDS

External dose; internal dose; Monitoring Period Dose Report; Bioassay Update Report; Dose Check Point; Occupational Dose Report; mSv/MW-y performance.

*CHAPTER 11 - WASTE MANAGEMENT

SOLID WASTE

Types of solid waste; Solid Radioactive Waste Management Facility (SRWMF); waste handling.

DERIVED EMISSION LIMITS

Critical group; DELs for airborne emissions; DELs for liquid emissions; past performance.

LIQUID WASTE MANAGEMENT

Sources, storage, sampling, dispersal; liquid effluent monitoring; the LEM.

GASEOUS WASTE MANAGEMENT

Ventilation flows exhausting to the stack; gaseous effluent monitoring system; GEM and noble gas spectrometer; C-14 sampler.

ENVIRONMENTAL MONITORING

Objectives; atmospheric monitoring; terrestrial monitoring; ocean monitoring.

*CHAPTER 12 - WORK PLANNING

Work Control at Point Lepreau G.S., Job Safety Analysis; work process interfaces (the Safety Wheel); work planning specifics; work planning examples.

*CHAPTER 13 - EMERGENCY PLANNING

Point Lepreau G.S. Contingency Plan; Alert and Emergency alarms; Response Team; Off-Site Emergency Centre.

Note: * CHAPTERs marked with * are not included in this issue.