Radiation Protection Standards and Guidelines

Historical

- X-Rays Discovered by Roentgen – 1895
- Roentgen's Radiation Protection Standards
- X-Ray Injuries led to Protection Standards
- First Therapeutic Use of X-Rays – 2/1896

Historical

- Realization of Harmful Effects – 10/1896
- X-Ray Machines in Major U.S. Cities – 1897
- First Known Death From X-Rays – 1904
- First Radiation Exposure Guidelines - 1915

Significant Actions

- 1954 – Atomic Energy Act
- 1968 – Radiation Control Health & Safety Act
- Industrial & Medical Diagnostic X-Rays
- 1974 – Atomic Energy Commission Split:
  1. Nuclear Regulatory Commission (NRC)
  2. Energy Research & Development Administration (ERDA)

Significant Actions

- 1977 – ERDA Becomes the Department of Energy
- NRC Regulates Radiation Safety
- Agreement States Established

Advisory Organizations - History

- 1915 – Design Criteria for X-Ray Devices
- 1920-1921 – Operating Requirements Considered
- 1925 – 1st Exposure Level Recommended
- 1925 – ICRU Formed
- 1928 – Roentgen Used as Unit of Radiation Measurement

Advisory Organizations - History

- 1928 – ICRP Formed
- 1929 – Advisory Committee on X-Ray and Radiation Protection Formed in U.S.
- 1934 – ICRP First Dose Recommendation

  0.2 R/day (50 R/yr)
- 1946 – Advisory Council Becomes NCRP

Advisory Organizations - History

- 1947 – NCRP Lowers Dose
  a. 'Permissible Dose'–0.3 R/wk
  b. **A**s **L**ow **A**s **P**ractical-**ALAP**

- 1956 – Permissible Dose Reduced to 0.1 R/wk (5 R/yr)
- 1957 – IAEA Established by UN
- 1959 – Federal Radiation Council (FRC)

Advisory Organizations - History

- 1964 – NCRP Chartered by Congress
- 1966 – American National Standards Institute Established
- 1983 - Committee for Interagency Radiation Research and Policy Coordination Established in Office of Science & Technology

Radiation Protection Standards and Guidelines

- 10 CFR 20 governs Radiation Protection
- Awareness of the requirements necessary

Philosophy

- Risk based approach to radiation protection
  - Limits stochastic effects of radiation exposure
  - Avoids non-stochastic effects of radiation exposure
- Combines internal and external dose
- Annual dose limits only
- 5 (N-18) is N/A!

Risk Based Approach

- Stochastic risk is comparable to that for workers in other safe industries
  - Assumes ALARA program is effective
  - Cannot expose all workers to 5 Rem/year

- Non-stochastic risk is ZERO

Stochastic Effects

- No dose threshold
- Severity is NOT a function of dose
- Probability of occurrence is a function of dose
- Examples are:
  - Cancer
  - Genetic effects

ALARA

- **A**s **L**ow **A**s **R**easonably **A**chievable

  The Licensee shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are **A**s **L**ow **A**s **R**easonably **A**chievable (ALARA)

Non-stochastic Effects

- Well-defined dose threshold
- Severity ***is*** a function of dose
- Examples are:
  - Cataracts
  - Sterility
  - Skin reddening

Interrelationships

- License Condition – Specific Requirement
- NUREG – Supporting Information
- Recommendation - Suggestions
- Regulation – (CFR) - Legal Statement
- Regulatory Guide – Technical Aid
- Technical Specification – ‘Contract’

10 CFR 19
Notices, Instructions & Reports

- 19.11 - Posting of Notices to Workers
  1. 10 CFR 19 & 20 (Available)
  2. Operating License (Available)
  3. Operating Procedures (Available)
  4. Notice of Violations (Available)
  5. Form NRC-3 (Posted)

10 CFR 19
Notices, Instructions & Reports

- **19.12 – Instructions to Workers**

- **19.13 – Notices & Reports to Individuals**

10 CFR 20

Standards for Protection Against Radiation; Final Rule

10 CFR 20 Subpart A

- 20.1001 – Purpose:
- 20.1002 – Scope:
- 20.1003 – Definitions (Almost 100)

Important Terms

- ALARA
- ALI (Annual Limit on Intake)
- CDE (Committed Dose Equivalent)
- CEDE (Committed Effective Dose Equivalent)
- DDE – (Deep Dose Equivalent)
- DAC – (Derived Air Concentration)
- DAC Hour – (DAC Times Exposure Time)

Important Terms

- Declared Pregnant Woman
- Eye Dose Equivalent (LDE)
- Fetus/Embryo Dose
- Generally Applicable Environmental Radiation Standards (Issued by EPA)
- Nonstochastic Effect

Important Terms

- Planned Special Exposure (PSE)
- SDE (Shallow Dose Equivalent)
- Stochastic Effect
- TEDE (Total Effective Dose Equivalent)
  (DDE + CEDE)
- TODE (Total Organ Dose Equivalent)
  (DDE + CDE)

10 CFR 20 Subpart B

- Radiation Protection Programs Requirements

1. Radiation Protection Program
2. ALARA Program
3. Annual Review of Programs

10 CFR 20 Subpart C

- 20.1201 - Occupational Dose Limits
- 20.1202 – Sum Internal & External Doses
- 20.1203 – External Dose for Airborne
- 20.1204 – Determine Internal Exposure
- 20.1206 – Planned Special Exposures
- 20.1207 – Occupational Dose Limits for Minors
- 20.1208 – Dose to Embryo/Fetus/Worker

10 CFR 20

- Subpart D – Radiation Dose for Individual Members of the Public Limited to 100 mrem (1 mSv) per year.
- Subpart F – Surveys & Monitoring
- Subpart G – Control of Exposure External Sources in Restricted Areas
- Subpart L – Records
- Subpart M - Reports

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- Improper Posting
- Causes:
  - Inadequate Training
  - Inadequate Communications
- Error Prevention Tools:
  - Two Minute Rule
  - Effective Communications
  - Self-Checking
  - Questioning Attitude

10 CFR 20
Subpart L - Records

- 20.2102 – Radiation Protection Program
- 20.2104 – Prior Occupational Dose
- 20.2105 – Planned Special Exposures
- 20.2106 – Individual Monitoring Results (NRC Form 5)
- 20.2107 – Dose to Member of the Public

10 CFR 20
Subpart M - Reports

- 20.2202 – Immediate & 24-hour Notifications to NRC
- 20.2203 – Reports Documenting Exceeding Limits
- 20.2204 – Reports of Planned Special Exposures
- 20.2206 – Reports of Individual Monitoring (NRC Form 5)

Occupational Adult Dose Limits

Category	NRC Limit
TEDE (External + Internal)	5 rem/year
TODE (External + Organ)	50 rem/year
Skin or Extremities	50 rem/year
Lens of Eye	15 rem/year

Additional Dose Limits

Category	NRC Limit
Occupational Dose Limits	-10 % of Limit
For Minors	for adults
Declared Pregnant Worker	-500 mrem for Gestation
Lifetime	-No Limit
Member of Public	-100 mrem/ year

TVA's Administrative Dose Levels

- Up to 0.5 rem/year (5 mSv)
  1. Current Year Estimate
  2. No Authorization Required

- To Exceed 0.5 rem/year (5 mSv)
  1. Initiate Form 4
  2. Attempt to Verify Current Year Dose
  3. No Authorization Required

TVA's Administrative Dose Levels

- To Exceed 1.0 rem/year (1 cSv)
  1. Initiate Form 4
  2. Attempt to Verify Current Year Dose
  3. Approvals:

     Site RadCon Manager/RSO

TVA's Administrative Dose Levels

- To Exceed 5.0 rem/year (5 cSv)
  1. Initiate Form 4, Verify Information
  2. Initiate Planned Special Exposure
  3. Authorizations:
     a. Site RadCon Manager
     b. Plant Manager
     c. Site or Applicable VP
     d. VP, Nuclear Operations
     e. Senior VP, Nuclear Operations

TVA's Administrative Dose Levels

- To Exceed 1N (TEDE shall not exceed 1N rem, where N = Individual's age)

1. Form 4, Must be Verified
2. Authorizations:
    a. Site RadCon Manager
    b. Plant Manager
    c. Site VT
    d. VP, Nuclear Operations

EPA Guidance for Nuclear Incidents

EPA Dose Equivalent	Remarks
< 0.1 rem (< 0.1 cSv)	No Sheltering
1 rem (1 cSv)	Sheltering Initiated
1-5 rem (1-5 cSv)	Public Evacuation
25 rem (25 cSv)	Administer Stable Iodine
> 25 rem (> 25 cSv)	Save Lives/Protect Large Populations

Planned Special Exposures

1. Annual Limits:
   a. 10 rems TEDE (5 Routine & 5 PSE); or 100 rems to any organ (50 Routine and 50 PSE); and
   b. 30 rems LDE (15 Routine & 15 PSE); and
   c. 100 rems Skin or Extremity (50 Routine & 50 PSE)

Planned Special Exposures

2. Lifetime Dose Limits

   a. 25 rems TEDE or 250 rems to Organ or Tissue; and

   b. 75 rems to the Eye (LDE); and

   c. 250 rems to the Skin or Extremity

Conditions for PSEs

- An Exceptional Situation
- Written Authorization Before Exposure
- Individual Informed of Dose/Risk
- Instructed in ALARA Techniques
- Document all Prior Doses
- Special Records Maintained
- Limits: Annual – 5 rem; Lifetime – 25 rem

Voluntary Prenatal Exposure Program

- Training by RadCon to all Employees
- Minimize Risk to Embryo/Fetus
- Counseling Services Upon Request
- Strictly Voluntary – Written Records Kept
- Dose to Embryo/Fetus Should be:
  1. ALARA
  2. ≤ 50 mrem/mo. & 500 mrem/Gestation
  3. Excluded from PSE Activities

ALARA: Concepts

- Law – Balance Exposure & Economics
- Lead to Lower Dose Limits
- ALARA guidelines:
  1. Regulatory Guide 8.8
  2. Regulatory Guide 8.10
  3. Regulatory Guide 8.13
- Respiratory Protection – Reg Guide 8.15
- TVA's Radiation Exposure Tracking

ALARA: Bases

- Any Change in Body from Ionizing Radiation Potentially Detrimental
- Any Dose in Any Amount is Potentially Harmful
- Cells Part of Delicate, Balanced System, Easily Disrupted by Radiation

ALARA: Implementation

- Management Commitment & Support
- Careful Design of Facilities & Equipment
- Well Trained, Committed & Aware Workers

ALARA:
Organizational Responsibilities

- Plant RadCon Staff:
  - Implementation
  - Operation
  - Planning
  - Protection
  - Training
- Plant Supervision:
  - Procedures & Work Orders

ALARA: Individual Responsibilities

- Individual Employee - Most Important:
  - Reduce own Dose
  - Follow Procedures
  - Report Radiological Hazards

ALARA:
Program Elements

- ALARA Policy/Management Commitment
- Worker/Line Management Commitment
- Collective Dose Data Base System
- ALARA Job Reviews
- ALARA Design Reviews

ALARA:
Program Elements

- ALARA Coordinator
- Goals & Associated Tracking System
- Employee Incentives to Reduce Dose
- Management Incentives to Reduce Cost

Other Regulations - 1

- 10 CFR 21 – Reporting Noncompliance
- 10 CFR 30 – Byproduct Materials License
- 10 CFR 31 – General Licenses

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- Leak Test Not Performed
- Causes:
  - Inadequate Attention to Detail
  - Inadequate Communications
- Error Prevention Tools:
  - Effective Communications
  - Self-Checking
  - Peer-Checking
  - Questioning Attitude

Other Regulations - 2

- 10 CFR 34 – Radiography
- 10 CFR 50 – Power Production Facilities
- 10 CFR 61 – Radioactive Waste
- 10 CFR 71 – Transporting Rad Materials
- 49 CFR 100-199 – Transportation Regs

10 CFR 50

- 50.5 - Deliberate Misconduct Subject to fine
- 50.7 - Employee Protection "Whistleblower" protection
- 50.9 - Completeness and Accuracy Of Information (Provided to the NRC)
- 50.36- Technical Specifications

Completeness and Accuracy of Information

- Requirement – 10 CFR 50.9
  Information must be:
  1. ***Complete***
  2. ***Accurate***
- Implementation – TVAN Business Practice-213
- Interface – Nuclear Licensing
  1. Licensing Documents
  2. Meetings
  3. Conversations with NRC

Rule Violation

- The Requirement that all Information be Complete and Accurate may be Violated even though the Incorrect Information Submitted was:

1. Not in Writing
2. Not Under Oath
3. Not Intentional

Incomplete or Inaccurate Information

- False Statements
- Omission
- Inadequate Review
- Failure to Review
- Careless Disregard or Deliberateness
- Negligence not Careless Disregard
- Inadvertent Error
- Failure to Correct or Update

Responsibilities for Accurate Information

- Chief Nuclear Officer/Executive VP
  Receive Material from NRC & Assign
- Nuclear Licensing
  1. Log Correspondence
  2. Review Commitments
  3. Responsible Organization for each Commitment
- Responsible Organizations
  Evaluate Compliance with Commitments

Responsibilities for Accurate Information

- Organization Managers Assign Technical Lead
- Technical Lead
  1. Coordinate on Specific Input Data
  2. Monitor Performance vs. Schedule
  3. Provide Documentation
  4. Prepare Response; Submit to Licensing

Error Prevention Tools

- Pre-Task Briefings
- Research Bases and History
- Follow Procedures
- Verify Non-Routine Information
- Ensure Independent Technical Review
- Use Self-Checking or Peer-Checking

Responsibilities of All Employees

- TVAN Personnel

1. Document Commitments
2. Maintain Procedures
3. Coordinate NRC Contacts with Nuclear Licensing

Technical Specifications

- Safety Limits
- Limiting Conditions for Operation
- Surveillance Requirements
- Design Features
- Administrative Controls
- Decommissioning
- Initial Notification
- Written Reports

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- Improper Control of Sources in Transit
- Causes:
  - Inadequate Attention to Detail
  - Inadequate Communications
- Error Prevention Tools:
  - Effective Communications
  - Self-Checking
  - Peer-Checking
  - Questioning Attitude

TVA Documents

- Radiation Protection Plan
  1. Minimum Requirements and Management Controls for Radiation Protection
  2. Verbatim Compliance Not Required
- Plant RadCon Manuals
  1. Implement Radiation Protection Plan
  2. Verbatim Compliance Required

Summary

- Significant Advisory Organizations:
  1. ICRU
  2. ICRP
  3. NCRP
  4. FRC (EPA)
- Significant Regulatory Agencies:
  1. AEC
  2. ERDA
  3. NRC
  4. DOE

Questions

- *How much radiation is required to redden the skin (ESD)?*
- *Why is there a need for radiation dose limits and guidelines?*
- *What is the function of the NRC?*
- *What is meant by an "Agreement State?"*
- *What information is given in Title 10 Code of Federal Regulations Part 20, and what organization has the responsibility for regulating it?*
- *What does* **ALARA** *mean?*