# 40-Hour
# Advanced Radiation Protection and RSO Training for Research and Laboratory Facilities

## SYLLABUS

PRESENTED BY:
Applied Environmental Consulting, Inc.

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## COURSE OVERVIEW

History of Radiation
Fundamentals of Radiation
Radioactivity Measurements
Half-Life
Interaction with Matter and Biological Effects
Dose and Dose Risks
Radiation Protection Techniques
Radiation Detection and Instrumentation
Regulatory Authorities
Ensuring Compliance
Radiation Safety Officer Duties
Use and limitations of the Radiation Work Permit (RWP)

**MATH REVIEW**

How to use the Math Primer
Basic Math
Algebra Review
Scientific Notation
Exponents and Logarithms
Using Your Calculator
Radiation Math
Radioactivity
Half-Life
Time, Distance and Shielding
Radiation Work Permit (RWP)

**LESSON 1: HISTORY OF RADIATION DISCOVERY, HISTORICAL EVENTS & EMERGENCE OF REGULATORY AGENCIES**

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|---|---|
| TOPIC 1 | The Beginning |
| TOPIC 2 | Discovery of Radiation |
| | Henri Becquerel |
| | Wilhelm Roentgen |
| | Madam Curie |
| | (Plus others) |
| TOPIC 3 | Development of Nuclear Technology |
| | Manhattan Project |
| | Albert Einstein |
| | Enrique Fermi |
| | Development of the Nautilus |
| | Development of the Atomic Energy Act |

**LESSON 2: RADIATION FUNDAMENTALS**

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|---|---|
| TOPIC 1 | Energy Spectrum |
| | Ionization |
| | Non-Ionizing |
| TOPIC 2 | Atomic Structure |
| | Nuclear |
| | Proton |
| | Neutron: Extra-nuclear |
| | Electron: Classification |
| | Atomic Number |
| | Atomic Weight |
| TOPIC 3 | Unstable Atoms & Emissions |
| | Characteristics of Radioactive Materials |
| | Unstable |
| | Detectable |
| | Spontaneous Emission |
| | Emission from nucleus of atoms |
| | Photons: Gamma |

Particles: Alpha, Beta, Neutron
Emissions from outer shells of atoms
Photons: X-ray

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**LESSON 3: RADIOACTIVITY AND HALF-LIFE**

TOPIC 1 Units for Disintegrations
- Radioactivity
- Disintegration
- Disintegration per Unit Time (dps, dpm)
- Curie
- Becquerel
- Total Activity
- Specific Activity/Activity Concentration
- Background vs. Contamination

PRACTICAL EXERCISE: Problems

TOPIC 2 Half-Life
- Carbon-14 Dating
- Short/Long Half-Lives
- Half-life Formula

PRACTICAL EXERCISE: Problems

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**LESSON 4: INTERACTION OF RADIATION WITH MATTER**

TOPIC 1 Energy Disposition in Air
- Interactions
- Ionizations
- Excitation
- Energy Deposition in Air
- Roentgen
- Exposure Rates

TOPIC 2 Energy Disposition in Matter
- RAD
- Gray
- Relative Biological Effectiveness (RBE)
- Linear Energy Transfer (LET)

TOPIC 3 Energy Disposition in the Body

REM
Sievert
Dose rates

PRACTICAL EXERCISE: Problems

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**LESSON 5: RADIATION IN BIOLOGY**

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|---|---|
| TOPIC 1 | Sources of Dose |
| | External |
| | Internal |
| | Man-made and Natural |
| TOPIC 2 | Types of Dose |
| | Acute |
| | Fractionated |
| | Chronic |
| TOPIC 3 | Types of Dose Effects |
| | Somatic |
| | Genetic |
| | Teratogenic |
| TOPIC 4 | Variable in Dose Effects |
| | Amount of Dose |
| | Critical Organ |
| | Type of Radiation |
| | Individual Biological Variations |
| | Radio sensitivity and Radio resistance |
| TOPIC 5 | Types of biological effects in The Cell |
| | Types of Biological Variations |
| | Radio sensitivity and Radio resistance |
| TOPIC 6 | Types of Risks |
| | Definition |
| | Comparisons with other types of risks |
| TOPIC 7 | Causes of dose |
| | Stochastic |
| | Non-Stochastic |

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## LESSON 6: RADIATION PROTECTION

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|---|---|
| TOPIC 1 | Time |
| | Principles of Exposure Control |
| | Time |
| PRACTICAL EXERCISE: | Problems |
| TOPIC 2 | Distance (Inverse Square Law) |
| PRACTICAL EXERCISE: | Problems |
| TOPIC 3 | Shielding |
| | HVL and TVL |
| PRACTICAL EXERCISE: | Problems |
| TOPIC 4 | As Low As Reasonably Achievable (ALARA) |
| TOPIC 5 | Administrative Controls and Levels |
| | Administrative Controls |
| | Establishing administrative limits |
| | Engineering (Mechanical) Controls |
| | Signs, labels and postings |
| TOPIC 6 | Radiation Dose Limits |
| | Radiation Workers |
| | Members of the Public (MOP) study |
| TOPIC 7 | Monitoring External dose |
| | Personnel Monitoring Devices |
| | OSLDs/TLDs/Film Badges |
| | Pocket Dosimeters |
| TOPIC 8 | Monitoring Internal Dose |
| | Bioassays |
| | Direct and in vitro |
| TOPIC 9 | Active Monitors (reading real time) |
| | Pocket Ion Chamber |

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## LESSON 7: PORTABLE SURVEY METERS

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|---|---|
| TOPIC 1 | Types |
| | Geiger-Mueller (GM) |
| | Scintillator |
| | Comparing instrumentation for hazards: |
| | BIOLOGICAL, CHEMICAL and NUCLEAR |
| TOPIC 2 | Reading Results |

| | | |
|---|---|---|
| | | CPM vs. DPM |
| | | Scales and displays |
| | | Radiation Levels |
| TOPIC 3 | Efficiency and Calibration | |
| | | Efficiency |
| | | Calibration |
| TOPIC 4 | Operating a Survey Meter | |
| | | Battery check/Calibration check/Check source |
| | | Establish Background |
| | | cpm vs. mR/hour |
| | | High to Low scales |
| | | End window |
| | | LAG Time (GM) |
| | | Use & Care |

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**LESSON 8: IMPLEMENTING A RADIATION PROTECTION PROGRAM**

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|---|---|---|
| TOPIC 1 | Establish a Radiation Protection Manual (RPM) | |
| TOPIC 2 | Scope of Authorized Work | |
| TOPIC 3 | Role of Personnel | |
| | | Radiation Safety Officer (RSO) |
| | | Advanced Authorized User (40-hour) |
| | | Authorized User (less than 40-hour, usually 8-hour) |
| | | Ancillary workers |
| TOPIC 4 | ALARA philosophy emphasized | |
| | | Time, Distance and Shielding |
| TOPIC 5 | Contamination Control | |
| | | Fixed, Removable & Airborne |
| | | Friskers, glovebox & step-off pads |
| TOPIC 6 | Wearing of PPE & Personnel monitoring | |
| | | Protective clothing |
| | | Protective masks |
| TOPIC 7 | Performing Personnel Monitoring | |
| TOPIC 8 | Emergencies and Spills | |
| | | Major Spills |
| | | Minor Spills |
| TOPIC 9 | Storage/Disposition of radioactive wastes | |
| TOPIC 10 | Posting and Notification | |

TOPIC 11 Radiation Work Permit
- Tools for the RSO
- Documents task
- Can be used in lieu of personnel badges

TOPIC 12 Record Keeping

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## LESSON 9: REGULATORY AUTHORITY

TOPIC 1 Regulatory Agencies (Federal)
- USNRC
  - Types of radioactive materials regulated:
  - By-Product Material
  - Source Material (Source of SNM)
  - Depleted uranium
  - Special Nuclear Materials (SNM)
  - Fissionable
- USEPA
- OSHA
- FDA
- USDOE

TOPIC 2 Non-Federal Agencies
- Agreement States and Licensing States Regulate:
  - Naturally-Occurring Radioactive Materials (NORM) (to include TENORM)
  - Naturally-Occurring and Accelerator Produced Radioactive Materials (NARM)

TOPIC 3 The Radioactive Materials License
- Authorized Materials
- Authorized Use
- Authorized Users
- CONDITIONS
- Location
- Leak Testing
- Surveys
- Inventory
- Training
- Record keeping requirements

"Catch all" Condition

TOPIC 4 Role of Regulatory Agencies
- Issue licenses based on:
- ENGINEERING, TRAINING, PROCEDURES
- Inspections
- Amendments
- Termination
- REGUIDE
- Sealed Source and Device Registry

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## LESSON 10: ENSURING COMPLIANCE

TOPIC 1 Annual ALARA review

TOPIC 2 Delegation of Authority

TOPIC 3 Facilities Management
- Record Keeping (Maintaining LOGBOOK)
- Instrument calibration
- Inventory
- Surveys
- Transfer/shipment documents
- Leak tests (for sealed sources)

TOPIC 4 Training
- Training of new personnel and refresher

TOPIC 5 Set up a Personnel Monitoring Program

TOPIC 6 Radiation Work Permit (RWP)
- Pros & Cons

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## LESSON 11: TRANSPORTATION

TOPIC 1 Regulations

Items required to be trained in HAZMAT site specific to the facility to include: Type of packages: Type A, Type B, LSA, Strong-tight container

Definition of Package

Reportable Quantities

Bill of Lading

Labels, markings and placards

Exempt quantities

Receiving/Shipping radioactive materials
Opening packages
What to do for damaged items
Roles of RSO / Authorized Users

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**LESSON 12**: **RESEARCH and Laboratory**

Establish a Radiation Protection Program
Types of Radioactive Materials Used
Design and Safety of Laboratory
Setting up a Controlled Area
Elements of the Radiation Protection Program
Design and Safety of Administration for Outside Applications
Greenhouse
Operating and Emergency Procedures
Rules-of-thumb in the Laboratory
Survey Meters Used
Operation of Survey Meters
Survey and Contamination Control
How to Take a Swipe
Records Management
ALARA: Time, Distance, Shielding
Good House Keeping Practices
Emergency Procedures and Notifications
Managing Spills (Major and Minor)
Role of the RSO
Package Receipt and Opening
Radioactive Waste Management
Plan for Decommissioning
What Regulators are Looking For