**Revision History**

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| **Author** | **Description of Change** | **Revision Date** |
| K. Graden | Initial issue | November 2007 |
| K. Graden | Incorporated Peer Review of the Fermilab Radiological Control Program suggestions | January 2008  |
| K. Graden | Editorial changes | October 2009 |
| K. Graden | Editorial changes | November 2011 |
| K. Graden | Addition of revision history, formatting, and editorial changes | September, 2015 |
| K. Graden | Editorial changes. Update to ES&H Section procedure template. Addition of hourly credit for RCT support role in Radiological Worker Practical Factors training | December 2019 |

1. **Purpose**

The Fermilab Radiological Control Technician (RCT) Training Implementation Plan documents the implementation of RCT core academic, site-specific, and continuing RCT training. The Fermilab Radiological Control Manual (FRCM) describes training requirements as set forth in the Fermilab Radiation Protection Program (RPP).

1. **Review, Revision, and Change Control**

The Fermilab RCT Training Implementation Plan is reviewed and revised as necessary to reflect changes in the Fermilab RCT training program, Laboratory mission, applicable DOE Directives, or every five years. The Fermilab RCT Training Implementation Plan is subject to change control. Change control is identified by the revision date.

1. **Applicable DOE Regulations**

Title 10 Code of Federal Regulations Part 835, Occupational Radiation Protection, current revision, is applicable to the Fermilab RCT Training Implementation Plan.

**4. Responsibilities**

The ES&H Section is responsible for managing Radiological Control Technician Training. The ES&H Section reports to the Directorate. A member of the Fermilab Environment, Safety & Health (ES&H) Section Radiation Physics Operations Department is responsible for revising the Fermilab RCT Training Implementation Plan, maintaining site-specific training courses, implementing DOE Core academic training for RCTs, and implementing the Fermilab RCT continuing training program.

**5. Radiological Control Technician Training Program Description**

The Department of Energy (DOE) RCT core academic training materials are provided by the DOE and reflect the requirements identified in 10 CFR Part 835. In addition to core academics, RCTs receive site-specific training on subjects pertinent to the Fermilab radiological control program. These training qualification requirements are described in the Fermilab Radiological Control Manual (FRCM) Chapter 6, Part 3. RCT standards for physical condition and education are delineated in FRCM Article 632.4. Fermilab RCT site-specific training is designed such that RCTs will gain the knowledge and skills necessary to properly carry out radiological control program functions, duties, and responsibilities. RCT site-specific training includes participation in Radiological Worker Practical Factors training (FN000471) and on-the-job training. The level of site-specific training is commensurate with the technician’s specific job assignment. Additionally, RCT continuing training for requalification is designed to maintain and enhance Fermilab RCT proficiency and performance.

**6. Radiological Control Technician DOE Core Academic Training Requirements**

The Department of Energy Office of Environment, Health, Safety, and Security provides RCT core academic training materials and examinations. The most recent version of the DOE Standardized Core Academics (lesson plans and study guides) can be obtained by downloading them from the following website:

<http://energy.gov/search/site/Radiological%20Control%20Technician%20Training?gid=860906>

 A self-study program containing RCT core academic training materials is provided to individuals to work through at their own pace. The ES&H Section may periodically meet with the RCT candidate to review lesson materials and to administer lesson exams.

 RCTs who have prerequisite knowledge or related qualifications may take a comprehensive challenge exam to satisfy the requirements of the core academics portion of the training. If the RCT does not successfully pass the comprehensive challenge exam in the first attempt, the entire core academic training must be completed. The challenge exam does not exempt RCTs from site-specific training or on-the-job training. A passing score for RCT core academics challenge exam and core academic lesson exams is 80%.

The DOE core academic training topics are listed in the table below.

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| **DOE RCT Core Academic Training Lessons (FN000277/CR/01)** |
| **Topic** | **Description** |
| 1. Basic Mathematics and Algebra | * Fractions and Decimals
* Signed Numbers and Exponents
* Scientific Notations
* Order of Mathematical Operations
* Basic Algebra
* Common and/or Natural Logarithms
 |
| 2. Unit Analysis and Conversion | * Common Unit Systems and Basic Units
* Values and Abbreviations for SI prefixes
* Unit Conversions (with a table)
 |
| 3. Physical Sciences | * Definitions work, force, energy
* Describe forms of energy
* Law of Conservation of Energy
* Physical forms (solid, liquid, gas)
* Basic structure of an atom, including characteristics of subatomic particles (p, n, e)
* Definitions of atomic number, mass number, atomic mass, atomic weight
* notation
* Periodic Table of Elements
* Valence shell and valence electrons
 |
| 4. Nuclear Physics | * Definitions nucleon, nuclide, isotope
* Basic principles of mass-energy equivalence concept
* Definitions mass defect and binding energy
* Definitions fission, criticality, fusion
 |
| 5. Sources of Radiation | * Natural Background
	+ Terrestrial
	+ Cosmic
	+ Internal Emitters
	+ Inhaled Radionuclides
* Artificially-produced Radiation
	+ Nuclear fallout
	+ Medical exposures
	+ Consumer products
	+ Nuclear facilities
 |
| 6. Radioactivity and Nuclear Decay | * Neutron/proton ratio as it relates to nuclear stability
* Definitions radioactivity and radioactive decay
* Characteristics of  radiations
* Identify radioactive decay modes using equations
* alpha decay
* beta decay
* positron decay
* electron capture
* Differences artificial and natural radioactivity
* Naturally-occurring families
* Chart of the Nuclides
	+ atomic number
	+ atomic mass
	+ natural percent abundance
	+ stability
	+ half-life
	+ types and energies of radioactive emissions
	+ trace decay to stable product
* Units of Curie, Becquerel, Roentgen, Rad/Gray, Rem/Sievert
* Definition of specific activity and half-life
* Formula for radioactive decay
* Define exposure, absorbed dose, dose equivalent, quality factor
 |
| 7. Interaction of Radiation With Matter | * Define ionization, excitation, bremsstrahlung
* Define specific ionization, LET, stopping power, range, W-value
* Major mechanisms of energy transfer for radiations
* Categorization of neutrons (Kinetic energy)
* Neutron capture of slow neutrons
* Elastic and inelastic scattering for fast neutrons
* Shielding materials for each radiation
 |
| 8. Biological Effects of Radiation | * Cellular structure
* Effects of radiation on cell structure
* Law of Bergonie and Tribondeau
* Factors affecting radiosensitivity
* General categorization of cells by radiosensitivity
* Primary and Secondary reactions on cells
* Define and give examples of stochastic and non-stochastic effects
* LD50/30 for humans
* Acute radiation syndrome (exposure levels and symptoms)
* Risks to developing embryo/fetus
* Distinguish between somatic and heritable effects
 |
| 9. Radiation Protection Standards | * 10 CFR Part 835
* Role of advisory agencies (ICRP, NCRP, ICRU)
* Role of regulatory agencies (NRC, DOT, DOE)
 |
| 10. ALARA | * Philosophies with current ALARA recommendations
* ALARA philosophies for collective and individual exposure
* Scope of an effective ALARA program
* Purposes and reasons for pre-job and post-job reviews
* RCT responsibilities for implementing ALARA
 |
| 1. External Exposure Control
 | * Four basic methods for minimizing personnel exposure
	+ - Source reduction techniques
		- Time-saving techniques
		- Maximizing distance
		- Stay times
* 6CEN equation
* Point and line source equations
* Definitions mass attenuation coefficient and density thickness
* Calculate shielding thickness or exposure rates
 |
| 12. Internal Exposure Control | * Routes of entry
* ALI and DAC
* Reference Man
* Use DACs to minimize internal exposure potential
* Factors governing behavior of radioactive material in body
* Natural mechanisms to reduce quantities in body
* Relationship between physical, biological, effective half-lives
* Calculate effective half-life
* Methods (how and why effective) used to increase elimination rate
 |
| 13. Radiation Detector Theory | * Fundamental laws associated with electrical charges
* Definitions current, voltages, resistance
* Parameters affecting number ion pairs collected
* Identify regions gas amplification curve
* Characteristics of detectors operated in specific regions of gas amplification curve
* Define resolving time, dead time, recovery time
* Methods for discrimination
* Scintillation detectors and associated components
* Neutron detectors
* Principles of detection, advantages and disadvantages to GeLi and HPGe detectors
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**7. Radiological Control Technician Site-Specific Training Requirements**

Site-specific RCT training is based on identification of the knowledge and skills required to competently perform RCT functions at Fermilab.

On-the-job training is included as part of RCT site-specific training. Specific RCT tasks that are unique to specific ES&H Section departments are taught on-the-job. Fermilab RCT on-the-job training is recorded in TRAIN. Additionally, Radiological Control Technician On-the-Job Training Validation Form (R.P. Form # 104) may be used to document and record on-the-job training if there is special OJT activities that need to be documented in addition to training records.

RCTs provide a support role for Radiological Worker Practical Factors training (FN000471) as part of RCT continuing training. RCTs provide hands-on instruction during Practical Factors training which includes personnel frisking, frisking to identify radioactive materials, surveying and labeling radioactive materials, and practice zeroing pocket dosimeters.

A passing score for RCT site-specific exams is 80%. If the student fails to pass any examination, remediation will be conducted. The RCT will be remediated until the instructor is satisfied that the appropriate knowledge level has been reached.

The following table lists the Fermilab RCT site-specific training courses.

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| **Radiological Control Technician Site-Specific Training**  |
| **Course Description** | **TRAIN Course No.** |
| 1. Material Move Survey Training | FN0000125/CR/00 |
| 2. Radioactive Source Training | FN000048/CR/00 |
| 3. Overview of the Fermilab Price Anderson Amendments Act (PAAA) Program | FN000346/CR/01 |
| 4. Environmental Monitoring | FN000283/CR/01 |
| 5. Radiological Instrumentation | FN000288/CR/01  |
| 6. Nuclear Materials Control & Accountability Programs | FN000282/CR/02  |
| 7. Storage, Release, and Transportation of Radioactive Material | FN000286/CR/02  |
| 8. Radionuclide Analysis Facility Procedures and Counting Statistics | FN000279/CR/02 |
| 9. Dosimetry Program | FN000280/CR/01 |
| 10. ALARA Principles and Documentation | FN000284/CR/02 |
| 11. Fermilab Waste Management Procedures | FN000290/CR/01  |
| 12. Beam-On Radiation Fields at Fermilab and the Conduct of Beam-On Surveys | FN000289/CR/01 |
| 13. Setting Up Radiological Areas | FN000418/CR/01 |
| 14. Radiological Work Coverage | FN000285/CR/02 |
| 15. Contamination and Airborne Radioactivity Controls | FN000281/CR/02 |
| 16. Radiological Postings and Radioactive Material Labeling | FN000419/CR/01 |
| 17. Handling and Transportation of Radioactive Materials that Have Been Determined to Be Class 3 or Higher | FN000359/CR/01 |
| 18. Radiological Emergencies | FN000287/CR/01 |
| 19. Personnel Decontamination Training | FN000366/CR/01 |
| 20. Radiological Incidents and Lessons Learned | FN000420/CR/01 |
| 21. RCT Practical Factors/OJT & Requalification * Surveying and Labeling Radioactive Materials
* Radiological Postings
* Proper Survey Techniques
* Contamination Surveys
* Area Surveys
* Sampling Procedures
* Department Specific Procedures
 | FN000288/CR/01FN000285/CR/02FN000289/CR/01FN000359/CR/01FN000300/CR/01 |
| 22. Provide Hands-on instruction to workers during Radiological Worker Practical Factors training. Instruction includes personnel frisking, frisking to identity radioactive material, surveying and labeling radioactive material, and zeroing pocket dosimeters | Radiological Worker Practical Factors course FN000471/OJ/01 |

1. **Radiological Control Technician Continuing Training Requalification Requirements**

RCT continuing training for requalification is designed to review RCT knowledge and skills in order to enhance RCT competency level. RCT continuing training includes self-study and on-the-job training. Each training cycle, selected topics from the core academic training and/or site-specific training are included as part of continuing training. Periodically, policy changes, radiological incidents and lessons learned from Fermilab and other facilities will be reviewed. Continuing training is determined for each two-year cycle based the needs of division/section/center RCTs. In addition to the retraining program, the RCT shall demonstrate competence in those tasks deemed necessary by his/her supervisor.

RCT continuing training is conducted on a two-year training cycle. RCTs complete a minimum of 24 hours of continuing training over a two-year interval. Successful completion of examinations and/or a comprehensive examination with a passing score of 80% is required for RCT requalification.

 It should be noted that personnel who maintain qualifications as Radiological Control Technicians are considered to satisfy the requirements of Radiological Worker training.