

APPENDIX A

RADIOGRAPHIC SAFETY

Appendix A: Radiographic Safety Operations and Emergency Instructions Course

Note: This outline provides radiation safety subject matter that applies to multiple types of penetrating radiation. Instructors should consider the applicable type of radiation source and delivery system to be covered and tailor their use of these subjects accordingly.

1.0 Personnel Safety and Radiation Protection

- 1.1 Hazards of excessive exposure
 - 1.1.1 General: alpha-, beta-, gamma, neutron, and X-radiation
 - 1.1.1.1 Alpha particles
 - 1.1.1.2 Beta particles
 - 1.1.1.3 X-radiation
 - 1.1.1.4 Gamma radiation
 - 1.1.2 Specific neutron hazards
 - 1.1.2.1 Relative biological effectiveness
 - 1.1.2.2 Neutron activation
- 1.2 Methods of controlling radiation dose
 - 1.2.1 Time
 - 1.2.2 Distance
 - 1.2.3 Shielding
 - 1.2.3.1 Half-value layers
 - 1.2.3.2 Tenth-value layers
 - 1.2.4 Exposure shields and/or exposure rooms
 - 1.2.4.1 Operation
 - 1.2.4.2 Alarms
- 1.3 Personnel monitoring
 - 1.3.1 Difference between dose and dose rate
 - 1.3.1.1 Coulomb per kilogram (C/kg)
 - 1.3.1.2 Gray (Gy)
 - 1.3.1.3 Sievert (Sv)
 - 1.3.2 Wearing of monitoring badges
 - 1.3.2.1 Pocket dosimeters
 - 1.3.2.1.1 Neutron monitoring dosimeters
 - 1.3.2.1.2 Gamma and X-ray dosimeters
 - 1.3.2.2 Film badges
 - 1.3.2.3 Thermoluminescent detectors (TLDs)
 - 1.3.3 Reading of pocket dosimeters
 - 1.3.4 Recording of daily dosimeter readings
 - 1.3.5 "Off-scale" dosimeter – required activity
 - 1.3.6 Permissible exposure limits
 - 1.3.7 As low as reasonably achievable (ALARA) concept

2.0 Radiation Survey Instruments

- 2.1 Types of radiation instruments
 - 2.1.1 Geiger-Müller tube
 - 2.1.2 Ionization chambers
 - 2.1.3 Scintillation chambers, counters
- 2.2 Neutron radiation survey equipment
- 2.3 Reading and interpreting meter indications
- 2.4 Calibration frequency
- 2.5 Calibration expiration – action to be taken
- 2.6 Battery check – importance

3.0 Radiation-Area Surveys

- 3.1 Type and quantity of radiation
- 3.2 Establishment of restricted areas
- 3.3 Posting and surveillance of restricted areas
 - 3.3.1 Radiation areas
 - 3.3.2 High radiation areas
- 3.4 Use of time, distance, and shielding to reduce personnel radiation exposure
- 3.5 Applicable regulatory requirements for surveys, posting, control of radiation, and high radiation areas
- 3.6 Establishment of time limits

4.0 Radiation Survey Reports

- 4.1 Requirements for completion
- 4.2 Description of report format

5.0 Neutron Radiographic (NR) Work Practices

- 5.1 Radioactive contamination
 - 5.1.1 Clothing requirements
 - 5.1.2 Contamination control
 - 5.1.3 Contamination cleanup
- 5.2 Operation and emergency procedures
- 5.3 Specific procedures

6.0 NR Explosive-Device Safety**

- 6.1 Static electricity
- 6.2 Grounding devices
- 6.3 Clothing requirements
- 6.4 Handling and storage requirements and procedures
- 6.5 Shipping and receiving procedures
- 6.6 State and federal explosive-licensing requirements

7.0 Safety and Health

- 7.1 Radiation hazards
 - 7.1.1 Exposure hazards
 - 7.1.2 Methods of controlling radiation exposure
 - 7.1.3 Operation and emergency procedures

8.0 Biological Effects of Radiation

- 8.1 "Natural" background radiation
- 8.2 Unit of radiation dose – sievert (Sv)
- 8.3 Difference between radiation and contamination
- 8.4 Radiation damage – repair concept
- 8.5 Symptoms of radiation injury
- 8.6 Acute radiation exposure and somatic injury
- 8.7 Personnel monitoring for tracking exposure
- 8.8 Organ radiosensitivity

9.0 Exposure Devices

- 9.1 Daily inspection and maintenance
- 9.2* Radiation exposure limits for gamma ray exposure devices
- 9.3 Labeling
- 9.4 Use
- 9.5 Use of collimators to reduce personnel exposure
- 9.6* Use of source changers for gamma ray sources

10.0 Emergency Procedures

- 10.1* Vehicle accidents with radioactive sealed sources
- 10.2* Fire involving sealed sources
- 10.3* "Source out" – failure to return to safe shielded conditions
- 10.4* Emergency call list

11.0 Storage and Shipment of Exposed Devices and Sources

- 11.1* Vehicle storage
- 11.2* Storage vault – permanent
- 11.3* Shipping instructions – sources
- 11.4* Receiving instructions – radioactive material

12.0 State and Federal Regulations

- 12.1 NRC and Agreement States – authority
- 12.2 License reciprocity
- 12.3* Radioactive materials license requirements for industrial radiography
- 12.4 Occupational Safety and Health Administration (OSHA)
- 12.5 Qualification requirements for radiography personnel
- 12.6 Regulations for the control of radiation (state or NRC as applicable)
- 12.7* Department of Transportation regulations for radiographic source shipment
- 12.8 Regulatory requirements for X-ray machines (state and federal as applicable)

RADIOGRAPHIC SAFETY OPERATIONS TRAINING REFERENCES

- ASNT. 2001. *Gamma Radiation Safety Study Guide*. 2nd ed. Columbus, OH: American Society for Nondestructive Testing Inc.
- ASNT. 2018. *Radiographic Testing Classroom Training Book (PTP Series)*. Columbus, OH: American Society for Nondestructive Testing Inc.
- ASNT. 2019. *Radiographic Testing, 4th ed. vol. 3. Nondestructive Testing Handbook*. Columbus, OH: American Society for Nondestructive Testing Inc.
- ASNT. 2022. *ASNT Study Guide: Industrial Radiography Radiation Safety*. 2nd ed. Columbus, OH: American Society for Nondestructive Testing Inc.
- CRCRD, 1999. *Suggested State Regulations for Control of Radiation (SSRCR)*, Part E, "Radiation Safety Requirements for Industrial Radiographic Operations," Sec. E.17, Training.
- McGuire, S.A., and C.A. Peabody. 2004. *Working Safely in Radiography*. Columbus, OH: American Society for Nondestructive Testing Inc.
- NRC. Code of Federal Regulations, Title 10, Energy, Part 34. *Licenses for Industrial Radiography and Radiation Safety Requirements for Industrial Radiographic Operations*, Sub-Part 43, Training, US Nuclear Regulatory Commission.

* Available from The American Society for Nondestructive Testing Inc., Columbus, OH.

* Topics may be deleted if the radiography is limited to X-ray exposure devices.

** Required only by those personnel who will be involved in neutron radiography of explosive devices.