

**MPR 1860.1**  
**REVISION G**  
**EFFECTIVE DATE: March 28, 2016**  
**EXPIRATION DATE: March 28, 2021**

---

# **MARSHALL PROCEDURAL REQUIREMENTS**

**AS01**

## **MSFC RADIATION SAFETY PROCEDURAL REQUIREMENTS**

**COMPLIANCE IS MANDATORY**  
DIRECTIVE IS UNCONTROLLED WHEN PRINTED  
Verify current version before use at <https://dml.msfc.nasa.gov/directives>

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 2 of 63</b>

## DOCUMENT HISTORY LOG

Status (Baseline/ Revision/ Change/ Canceled)	Document Revision/ Change	Effective Date	Description
Baseline		10/18/01	
Revision	A	10/28/2004	<p>Added equivalent to <math>3.7 \times 10^{10}</math> disintegrations per second to 1.13; changes "Initiators" to "Requisitioners" in P.4 ; replaced will with shall as applicable, changed MPG to MPR ; deleted specification are roentgens for x- or gamma rays, rads or equivalent roentgens for beta rays, and rems for neutrons in 1.14; deleted service is furnished in 1.29 replaced quarterly with annually in 2.16; replaced "exposed to excessive radiation" with who receive doses (overexposures) of radiation requiring medical attention"</p> <p>Deleted MSFC Form 4415, "Radiation Machine Use Authorization" from 4.0. Deleted 'RSO will maintain records of' from CH1.1.1; deleted CFR 20 requires that a" form CH6.2.1; changed CH 6.2.1.3 to read "Each individual, prior to entering a restricted area or any area where a dose in excess of 2 millirem/hr. or 100 millirem/yr is likely"; replaced "particles" with "radiation" in CH6.5; added "TLDs are capable of storing energy from ionizing radiation and releasing that energy in the form of visible light when heated. The amount of light is relative to the dose received" and "TLDs shall be worn on the trunk of the body, preferably at the chest level, representative of the dose to the whole body" to CH6.6; replaced "mass" with "Z or atomic" in CH9.1.2; added "They shall also complete OMEHS OT Form 101 "Quality Control Guidance for Field Radiography Operations at MSFC" in CH9.1.3; replaced 10 mrem/hr with 100 mrem/hr in CH9.8.8; deleted CH9.10.3-CH9.10.4; added "MSFC utilizes the State of Alabama Regulations for Protection Against Radiation as guidance for radiation safety when using radiation producing devices, such as analytical X-ray devices" to 10.1;added "and a warning light indicating the presence of X-rays shall be placed outside each door leading into the room which houses the system(s) to 10.5.1.4b; replaced "Organizational Work Instruction with <u>Operational Instructions (OI)</u> in CH9.7.</p>
Revision	B	12/19/2006	Updated organizational changes, added 4.2, corrected record retention schedules, and deleted unnecessary references in P.3.
Revision	C	9/17/2007	Updated definitions. Updated Chapters 1-8 and 12-15 to reflect current practices and regulations.
Revision	D	10/3/2008	Revised 2. Applicability statement to address the applicability of this directive to the Michoud Assembly Facility. Also reflects minor editorial changes.
Revision	E	2/19/2010	<p>Added requirements for tritium exit signs. Changed Applicability to reflect new template. Changed format to reflect new procedure layout requirements. Removed multiple "shall" statements per step. Moved definitions from CH9 to Section 1 and added definition for Responsible Person. Added 10 CFR 31 to Authority and deleted link to ADPH. Corrected title names in Authority. Added definitions of radiographer, radiographers assistant, radiography, and Responsible person. Added requirement for FMO to track tritium exit signs. Added requirement for RSO to send report to NRC when disposing of tritium exit signs and other generally licensed items. Reworded and added to the responsibilities of Directors/Managers/Office Leads/Team Leads/Contractors. Reworded and added to responsibilities of RSO. Changed record retention for dosimetry records and added reports to NRC to Records. Reworded and added/deleted requirements for CH1. Added requirements for disposal of Generally Licensed items to CH3. Minor wording changes to CH4. Minor grammatical changes to CH5 &amp; 6. Deleted references from CH8. Complete re-write of CH9 to clarify requirements and bring into line with current practices. Minor grammatical and requirement changes to 10, 11, 13, 14, &amp; 15. Moved References to Appendix B.</p> <p>[On <b>7/15/11</b>, at the request of the OPRD, administrative changes were made at P.1 to clarify and add authority citations, at P.3, P.4, and P.5 to remove citations not</p>

**DIRECTIVE IS UNCONTROLLED WHEN PRINTED**  
Verify current version before use at <https://dml.msfc.nasa.gov/directives>

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 3 of 63</b>

			used, at 1. Definitions to remove unused terms, at 2.2.20 to add text, at 4.1 to clarify, at CH6.4.4 to add MSFC Form 4414, at CH6.4.10 to add NRC Form 5, and throughout to edit.]
Revision	F	6/29/2015	Put MPR into new format and changed section references. Put in new P.2 Applicability statement. Added forms to P.4. Clarified that radiation surveys are performed by RSO. Added steps for Permit process and specified inspection/survey forms in CH2. Changed RSC membership and meeting frequency to be per RSC charter. Reworded and made grammatical changes to various sentences. Clarified that dose limits are a combination of internal and external exposure in CH6. Added provision in CH8 for leak tests to be counted in RSO counting equipment. Added provision in CH14 for group requesting an NRC license amendment to pay for the amendment. Added Responsible Persons in CH15.4. Added acronyms.
Revision	G	3/28/2016	Various grammatical changes, added "if known" to the list if items required in Step 2.2.1.5, added "Intended use" and "List of Users" to list of items required in Sections 2.2.1 and 2.2.2, added statement in Step 2.5 that any change in the items listed on a Permit will require a revised Permit, clarified type of radioactive material in Step 3.1.1, added definitions of "Unimportant Quantity of Source Material" and Non-exempt Byproduct Material. Added that items under the control of RSO do not need a Permit. Provided methodology to provide dosimeters to visitors and associated requirements in 7.7 – 7.10.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 4 of 63</b>

## TABLE OF CONTENTS

### PREFACE

- P.1 Purpose
- P.2 Applicability
- P.3 Authority
- P.4 Applicable Documents and Forms
- P.5 Measurement/Verification
- P.6 Cancellation

- CHAPTER 1. RESPONSIBILITIES
- CHAPTER 2. GENERAL PROCEDURES
- CHAPTER 3. PROCUREMENT OF RADIOACTIVE MATERIALS AND IONIZING RADIATION-PRODUCING DEVICES
- CHAPTER 4. DISPOSAL OF RADIOACTIVE MATERIAL
- CHAPTER 5. RECEIVING, SHIPPING, AND STORING OF RADIOACTIVE MATERIAL
- CHAPTER 6. PERSONNEL EXPOSURE
- CHAPTER 7. PERSONNEL MONITORING
- CHAPTER 8. LEAK TESTING SEALED SOURCES
- CHAPTER 9. EMERGENCY PROCEDURES FOR CONTROL OF RADIOACTIVE CONTAMINATION
- CHAPTER 10. INDUSTRIAL RADIOGRAPHY X-RAY REGULATIONS
- CHAPTER 11. ANALYTICAL X-RAY DEVICES
- CHAPTER 12. PARTICLE ACCELERATORS
- CHAPTER 13. RADIATION SAFETY TRAINING
- CHAPTER 14. NUCLEAR REGULATORY COMMISSION (NRC) LICENSING
- CHAPTER 15. MSFC AS LOW AS REASONABLY ACHIEVABLE (ALARA) PROGRAM
- CHAPTER 16. VIOLATIONS

- Appendix A. Definitions
- Appendix B. Acronyms
- Appendix C. Verification Matrix (Reserved)
- Appendix D. Records
- Appendix E. Maximum Surface Contamination Values

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 5 of 63</b>

## PREFACE

### P.1 PURPOSE

To establish Center-specific requirements for centralized control over the use of ionizing radiation sources to ensure that exposure is adequately controlled to prevent adverse effects on the health and safety of employees as mandated by 10 CFR Part 20, and MPD 1860.2, and implement Agency-level requirements per NPR 1800.1.

### P.2 APPLICABILITY

- a. This MPR applies to Center personnel, programs, projects, and activities, including contractors and resident agencies to the extent specified in their respective contracts or agreements. (“Contractors,” for purposes of this paragraph, include contractors, grantees, Cooperative Agreement recipients, Space Act Agreement partners, or other agreement parties.)
- b. This MPR does not apply to the Michoud Assembly Facility.
- c. This MPR applies the following: all mandatory actions (i.e., requirements) are denoted by statements containing the term “shall.” The terms: “may” or “can” denote discretionary privilege or permission, “should” denotes a good practice and is recommended, but not required, “will” denotes expected outcome, and “are/is” denotes descriptive material.
- d. This MPR applies the following: all document citations are assumed to be the latest version unless otherwise noted.

### P.3 AUTHORITY

- a. “Standards for Protection Against Radiation,” 10 CFR Part 20
- b. “Rules of General Applicability to Domestic Licensing of Byproduct Material,” 10 CFR Part 30
- c. “General Domestic Licenses for Byproduct Material,” 10 CFR Part 31
- d. “Domestic Licensing of Source Material,” 10 CFR Part 40
- e. “Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, Training Requirements, and Security Plans,” 49 CFR Part 172
- f. Subpart I – Class 7 (Radioactive) Materials, 49 CFR Part 173
- g. NPR 1800.1, “NASA Occupational Health Program Procedures”
- h. MPD 1860.2, “Radiation Safety Program”

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 6 of 63</b>

- i. International Air Transport Association (IATA) Dangerous Goods Regulations Manual
- j. Alabama Department of Public Health Rule 420-3-26, Radiation Control

#### **P.4 APPLICABLE DOCUMENTS AND FORMS**

- a. MWI 3410.1, “Personnel Certification Program”
- b. MWI 5100.1, “Initiating Procurement Requisitions”
- c. MWI 8621.1, “Mishap and Close Call Reporting and Investigation Program”
- d. MWI 8715.2, “Control of Hazardous Energy (Lockout/Tagout) Program”
- e. MSFC Form 4414, “Radiation Users Approval
- f. MSFC Form 4484, “Declaration of Pregnancy”
- g. MSFC Form 4485, “Radiological Survey.”
- h. MSFC Form 4486, “Radiological Survey Map.”
- i. MSFC Form 4493, “Quality Control Guidance for Contractor Field Radiography
- j. MSFC Form 4497 “Quality Control Guidance for MSFC Field Radiography Operations ”
- k. MSFC Form 4624, Radioactive Material Inspection Form
- l. MSFC Form 4625, Ionizing Radiation Producing Device Inspection Form
- m. MSFC Form 4645, “Radioactive Material Use Request/Permit”
- n. MSFC Form 4646, Ionizing Radiation Producing Device Use Request/Permit”
- o. NRC Form 4, “Cumulative Occupational Dose History”
- p. NRC Form 5, “Occupational Dose Record for a Monitoring Period”

#### **P.5 MEASUREMENT/VERIFICATION**

None.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 7 of 63</b>

## **P.6 CANCELLATION**

MPR 1860.1F, MSFC Radiation Safety Procedural Requirements, dated June 29, 2015.

*Original signed by*

Todd A. May  
Director

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 8 of 63</b>

## **CHAPTER 1**

### **RESPONSIBILITIES**

1.1 Environmental Engineering and Occupational Health Office (EEOH) shall:

1.1.1 Designate a Radiation Safety Officer (RSO) and an alternate to coordinate the Radiation Safety Program, serve as a member of the Radiation Safety Committee (RSC), and perform those functions outlined in this document. The name and qualifications of the RSO are part of the MSFC Nuclear Regulatory Commission (NRC) Materials License. The designation of an individual as the RSO requires the approval of the NRC, as well as an amendment to the license.

1.1.2 Conduct required medical examinations and advise individuals assigned to radiation work.

1.1.3 Arrange for treatment of personnel who receive doses (overexposures) of radiation requiring medical attention.

1.1.4 Provide for dosimetry service for measuring personnel exposure to radiation.

1.1.5 Maintain records of radiation exposure of each individual and monitor the accumulated exposure. Provide this information annually to all participants in the program.

1.1.6 Provide a physician as an advisory member to the RSC.

1.1.7 Coordinate the repair and calibration of portable radiation survey instruments at least every 6 months. If an instrument cannot be repaired, tag the instrument properly.

1.2 The RSO shall:

1.2.1 Train personnel in the safe use of radioactive materials and radiation-producing devices, both before initial approval of radiation work and annually.

1.2.2 Keep this radiation safety procedure document current.

1.2.3 Perform an annual audit of compliance with this document and with relevant state and/or Federal regulations.

1.2.4 Maintain all records pertaining to the Radiation Safety Program.

1.2.5 Serve as secretary of the RSC and keep the RSC informed of the status of the Radiation Safety Program.

1.2.6 Provide an annual detailed radiation safety program review to the RSC.



<b>Marshall Procedural Requirements</b>		
<b>AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 9 of 63</b>

1.2.7 Review and approve plans of proposed operations involving the use of radiation to ensure adequate protective measures are incorporated into the layouts and engineering drawings and consult with the RSC on these matters. New state-of-the-art activities may require consultation with independent experts.

1.2.8 Assist operating segments in developing operating procedures for radiological operations.

1.2.9 Perform special surveys of radioactive material areas and ionizing radiation producing devices or installations as required, and routine surveys at a minimum of once annually.

1.2.10 Perform leak tests on sealed sources.

1.2.11 Impound radioactive material and Ionizing Radiation Producing Devices (IRPDs), as appropriate, and stop unsafe practices as discussed in chapter 16 of this document.

1.2.12 Delineate, control access to, and oversee the decontamination of contaminated areas.

1.2.13 Require tests of potentially-contaminated personnel.

1.2.14 Approve all shipments of radioactive material and associated documentation.

1.2.15 Approve purchase requests for all IRPDs and radioactive materials.

1.2.16 Maintain an inventory of all licensed radioactive material onsite.

1.2.17 Within 30 days following transfer offsite, prepare and submit notification per 10 CFR Part 30.6 to the NRC detailing the date of transfer, manufacturer (or distributor), model number, serial number, and name, address, and license number of the party to which it is transferred for items containing byproduct material covered by 10 CFR Part 31.5.

1.2.18 Prepare all required renewal or amendment paperwork relating to the MSFC NRC Materials License and act as the point of contact between MSFC and the NRC for all matters relating to an initial, renewal, or amendment application.

1.2.19 Review and approve all site and group procedures relating to radioactive material and IRPD use.

1.2.20 Maintain the radiation safety program in accordance with the requirements of MPD 1860.2, 10 CFR Part 20, 10 CFR Part 30, 10 CFR Part 40, NPR 1800.1, and Alabama Department of Public Health Rule 420-3-26.

1.3 Manager, Facilities Management Office (FMO), shall:

1.3.1 Be responsible for ensuring plans for construction or modification of facilities and equipment involving storage or use of sources of ionizing radiation are approved by the RSC/RSO prior to starting construction or modification work.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 10 of 63</b>

1.3.2 Maintain an inventory of all tritium exit signs onsite detailing the sign's location, date of placement, manufacturer (or distributor), model number, and serial number.

1.3.3 Prior to transfer offsite, provide a list to the RSO of tritium exit signs to be transferred/disposed detailing each sign's proposed date of transfer, manufacturer (or distributor), model number, serial number, and name, address, and license number of the party to which it is transferred.

1.4 Directors/Managers/Office Leads/Team Leads/Contractors shall ensure:

1.4.1 Responsibility for all radioactive material used for research and development is clearly assigned to an "Authorized User" who is approved by the RSO and the NRC, as well as included in an amendment to the license.

1.4.2 Each Authorized User is trained to understand their responsibilities and the hazards associated with radioactive material under their control.

1.4.3 Each Responsible Person is trained to understand their responsibilities and the hazards associated with any IRPD under their control.

1.4.4 All laboratory personnel with radioactive material or IRPDs are adequately familiar with radiological hazards and regulations.

1.4.5 Organizational Instructions (OI) clearly define procedures for operating ionizing-radiation-producing equipment and for performing and documenting checks of the safety systems of the facility and have been reviewed and approved by the RSO.

1.4.6 OIs clearly define the line of radiation safety responsibility.

1.4.7 All radiation survey instruments are calibrated according to schedule and repaired when necessary.

1.4.8 All radiation survey instruments deemed "not repairable" are replaced.

1.4.9 All radioactive material sources and IRPDs included in the design of their equipment have been identified and are approved by the RSO prior to being purchased or otherwise being brought onsite.

1.4.10 Each radioactive material source and/or IRPD is reviewed to establish its necessity and ensure that the design and procedures optimize safety.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 11 of 63</b>

1.5 Director, MSFC Safety and Mission Assurance (SMA) Directorate, shall:

1.5.1 Be responsible for providing a representative to serve as a member of the RSC.

1.5.2 Assure review and approval of OIs involving ionizing radiation.

1.6 Director, Office of Procurement, shall:

1.6.1 Ensure contractors from whom radioactive materials are purchased are required to request shipping instructions from the MSFC RSO prior to shipment.

1.6.2 Ensure proper approval of procurement documents per MWI 5100.1 prior to the purchase of any radioactive materials and IRPDs.

1.7 Director, Engineering Directorate, shall:

1.7.1 Provide calibration of portable radiation survey instruments for facilities review.

1.7.2 Be responsible for providing a representative to serve as a member of the RSC.

1.8 The Radiation Safety Committee shall:

1.8.1 Approve the use of radioactive material and/or hazardous radiation-producing devices.

1.8.2 Ensure personnel qualifications, facilities, and user operating procedures are adequate for the use of radioactive material or radiation-producing devices.

1.8.3 Ensure users are aware the provisions of 10 CFR Part 20 are to be followed in all operations involving radiation, whether they are radioactive material or radiation-producing devices.

1.8.4 Maintain oversight of Center-wide radon monitoring status, radiation training efforts, and other activities associated with radiation protection.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 12 of 63</b>

## **CHAPTER 2**

### **GENERAL PROCEDURES**

2.1 The RSO and/or RSC shall approve the use of radioactive material and/or radiation-producing devices with the approval level being determined based on such information as: complexity of operation, state-of-the-art knowledge, and experience level of user group.

2.2 Requesting authorization to use radioactive material or IRPD's:

2.2.1 Requests for use of radioactive material shall be made by completing the following portions of MSFC Form 4645, "Radioactive Material Use Request/Permit," and submitting the form to the RSO for approval.

2.2.1.1 Building – building the material will be used/stored in.

2.2.1.2 Room(s) – room(s) the material will be used in.

2.2.1.3 Authorized User or Lead – the individual who will be responsible for the material.

2.2.1.4 Intended Use(s) – what the radioactive material will be used for.

2.2.1.5 List of Radioactive Materials – list the isotope, serial number (if known), original activity in microcuries, date of original activity (if known), and current activity (if known) in microcuries.

2.2.1.6 Procedure(s)/Manual(s) – list Organizational Issuances or other procedures used to control the use of the material.

2.2.1.7 List of Users – list the name, organization, and phone number of all users.

2.2.2 Requests for use of IRPD's shall be made by completing the following portions of MSFC Form 4646, Ionizing Radiation Producing Device Use Request/Permit, and submitting the form to the RSO for approval.

*NOTE: Scanning Electron Microscopes, Transmission Electron Microscopes, and devices less than 17 keV are exempt from this requirement.*

2.2.2.1 Building – building the IRPD(s) will be used/stored in.

2.2.2.2 Room(s) – room(s) the IRPD(s) will be used in.

2.2.2.3 Responsible Person – the individual who will be responsible for the IRPD.

2.2.2.4 Intended Use(s) – what the IRPD(s) will be used for.

<b>Marshall Procedural Requirements</b>		
<b>AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 13 of 63</b>

2.2.2.5 List of Ionizing Radiation Producing Device(s) – list the manufacturer, model number, maximum kVp, milliamps or watts, equipment control number (if known), and serial number (if known).

2.2.2.6 Procedure(s)/Manual(s) – list Organizational Issuances or other procedures/manuals used to control the use of the IRPD(s).

2.2.2.7 List of Users – list the name, organization, and phone number of all users.

2.3 For new or out-of-the-ordinary uses of radioactive material or IRPDs, the RSO shall require the requestor to formally present the request to the RSC and obtain their approval.

2.4 After the RSO and/or RSC review and approve the request, the RSO shall enter the Radiological Requirements, Permit Number and Date. After the RSO and Authorized User or Responsible Person sign the form, the Permit is in effect.

2.5 Radioactive material and IRPDs under the control of the RSO do not require a Use Request/Permit.

2.6 Any change to any of the items listed in Sections 2.2.1 or 2.2.2 will require a revised Permit.

2.7 Permits are good for one year and shall be renewed annually at which time the RSO will perform an inspection/survey to ensure provisions of radiation protection are still adequate and are being followed. The inspections/surveys will be documented on MSFC Form 4624, Radioactive Material Inspection Form, or MSFC Form 4625, Ionizing Radiation Producing Device Inspection Form, as applicable.

2.8 If a request is received for radioactive material in quantities, in types, or for uses that are not covered in the MSFC NRC Materials License, the RSO shall apply for an amendment to the existing license to allow a greater quantity, a different type, or a different use prior to the material being received or used at MSFC.

*NOTE: Amendments usually require at least a 90-day lead time.*

2.9 The RSO shall maintain oversight of Center-wide radon monitoring status, radiation training efforts, and other activities associated with radiation protection.

2.10 Membership and meeting frequency of the RSC shall be per the RSC Charter.

2.11 The RSC shall provide a timely response to requests for use. Small changes to approved uses or new uses involving low risk can be approved by the concurrence of the Chairman of the RSC and the RSO without being presented to the RSC. A Permit can be withdrawn at any time if safety violations occur or use of radioactive material or IRPDs is found not to be in compliance with conditions of the Permit.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 14 of 63</b>

## 2.12 MSFC Radiation Safety Program Document

2.12.1 The MSFC Radiation Safety Procedure document shall include, but not be limited to, the following subjects:

2.12.1.1 Special requirements and procedures for the acquisition, accountability, and control of radioactive material and IRPDs.

2.12.1.2 Functions and procedures of the RSC.

2.12.1.3 Radiological safety procedures and radiation monitoring.

2.12.1.4 Procedures for securing approval of work involving the use of ionizing radiation, including user requests, licenses from NRC, and special work permits.

## 2.13 Users

2.13.1 Authorized Users, Responsible Persons, and Users of any ionizing radiation source shall have adequate training and experience to receive, use, and have custody of specific regulated sources of ionizing radiation, as determined by the RSO and/or RSC.

2.13.2 Authorized Users, Responsible Persons, and Users shall be responsible for ensuring compliance with the provisions of this MPR.

## 2.14 Inventory of Radioactive Material

2.14.1 Per the MSFC NRC Materials License, the RSO shall maintain an inventory of all radioactive material covered by the license.

2.14.2 The RSO shall verify this inventory semiannually in conjunction with the leak tests specified in Chapter 8.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 15 of 63</b>

## CHAPTER 3

### PROCUREMENT OF RADIOACTIVE MATERIALS AND IONIZING RADIATION-PRODUCING DEVICES

#### 3.1 General

3.1.1 All personnel wishing to procure radioactive materials (nonexempt byproduct material, or greater than unimportant quantities of source material) or IRPDs (greater than 17 keV x-ray) shall first get approval from the RSC and RSO prior to initiating their purchase request.

3.1.2 Purchase requests for **ALL** radioactive material or ionizing radiation-producing devices shall be approved by the RSO regardless of whether they are generated in the System Applications and Products (SAP) program or are credit card purchases.

3.1.3 Purchase requests for **ALL** radioactive materials or ionizing radiation-producing devices generated in SAP shall be identified by selecting “NASA Hazardous PR” as the doc type. This assures the request is routed through the RSO for review and approval prior to final processing.

3.1.4 Personnel purchasing radioactive material or ionizing radiation-producing devices utilizing a credit card shall coordinate the purchase with the RSO prior to ordering.

#### 3.2 Radioactive Material Purchases

3.2.1 All purchase requests for radioactive material shall state the isotope, activity, and form of the material.

3.2.2 Purchase requests for sealed sources shall also list the manufacturer and model number of the source.

3.2.3 All purchase orders for radioactive material shall list the RSO as being the individual to whom the material is shipped.

3.2.4 All procurements shall cite the following clause for inclusion in all purchase orders and contracts for radioactive materials or service irradiation: “In addition to the labeling required by 49 CFR Part 172.403, all outside packaging shall be conspicuously identified as containing radioactive material.”

3.3 Purchase requests for ionizing radiation-producing devices shall state the type, manufacturer, model number, and operating parameters of the devices.

<b>Marshall Procedural Requirements</b>		
<b>AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 16 of 63</b>

## CHAPTER 4

### DISPOSAL OF RADIOACTIVE MATERIAL

4.1 This Chapter applies to all radioactive material or equipment containing radioactive material, including waste, requiring disposal regardless of whether the item is controlled by the MSFC NRC Material License or not. This includes such items as exempt quantity sources and items which contain sources that are under an NRC General License such as gas chromatographs, static meters, smoke detectors, and tritium exit signs.

#### 4.2 General Disposal

*NOTE: 4.2 does not apply to tritium exit signs.*

4.2.1 The Authorized User, or other cognizant person, shall notify the RSO for all radioactive material or items containing radioactive material requiring disposal and give the RSO, as a minimum, the following information about the material or item(s):

4.2.1.1 Brief description of the material or item(s).

4.2.1.2 Serial number(s) or lot number(s) (as applicable).

4.2.1.3 Isotope(s).

4.2.1.4 Activity(s).

4.2.2 The RSO shall use a licensed radioactive waste broker to dispose of all radioactive material going to a disposal site.

*NOTE: Some items containing small amounts of radioactive material have been specifically exempted by the NRC and are allowed to be disposed of along with non-radioactive waste. The RSO decides whether an item falls under this criteria.*

4.2.3 The broker shall be responsible for assuring the material is properly packaged, labeled, and all shipping/disposal paperwork is completed correctly per Department of Transportation (DOT) and NRC regulations.

4.2.4 For material or items being returned to the manufacturer for disposal, the RSO shall be responsible for the packaging of the material or item(s) and for completion of the shipping papers per DOT and NRC regulations. Only an individual specifically trained and certified to ship radioactive material is allowed to do so.

4.2.5 The RSO shall maintain copies of disposal and/or transfer paperwork per DOT and NRC regulations, and also delete the material from the radioactive material inventory if applicable.



<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 17 of 63</b>

#### 4.3 Special Requirements for the Return of Certain NRC General License Items to Manufacturer (or Distributor) for Disposal

4.3.1 For items covered by 10 CFR Part 31.5 (e.g., tritium exit signs, gas chromatographs, certain smoke detectors) being transferred to the manufacturer (or distributor) for disposal, the Authorized User, or responsible individual, shall also give the RSO, as a minimum, the following information about the items:

4.3.1.1 Original manufacturer (or distributor).

4.3.1.2 Model number.

4.3.1.3 Serial number.

4.3.1.4 Name, address, and NRC or Agreement State license number of the party to which it is transferred.

4.3.2 The RSO shall be the only one to make the determination as to whether or not an item is covered by 10 CFR Part 31.5.

4.3.3 The RSO shall determine the proper packaging and shipping requirements for the items.

4.3.4 Per 10 CFR Part 30.6, within 30 days of the transfer the RSO shall make a report containing the information in 4.3.1 to the NRC.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 18 of 63</b>

## **CHAPTER 5**

### **RECEIVING, SHIPPING, AND STORING OF RADIOACTIVE MATERIAL**

#### **5.1 General**

5.1.1 The receiving, packaging, shipping, and storing of radioactive material shall be coordinated and controlled to keep personnel exposure As Low As Reasonably Achievable (ALARA) and to assure all regulatory requirements are met.

5.1.2 All radioactive material received, transported, stored, or shipped at MSFC shall be appropriately packaged, shielded, and labeled.

5.1.3 The RSO shall maintain originals or copies of shipping records for all incoming and outgoing radioactive material shipments as well the radiological surveys performed on these shipments per NRC and DOT regulations.

#### **5.2 Receiving Radioactive Material**

5.2.1 Unless previously approved by the RSO, all receipt of incoming shipments of radioactive material shall be at the receiving warehouse, Building 4631, operated by the Transportation and Logistics Engineering Office.

5.2.2 Upon receipt, the material shall be segregated from other items in the receiving area and identified as containing radioactive material.

5.2.3 Transportation and Logistics Engineering shall immediately notify the RSO within 3 hours of receipt of the material, if receipt is during normal working hours and within 3 hours of the start of the next work day if receipt is after normal working hours, and give him all available information such as type of material, amount, size of package, and to whom addressed.

5.2.4 Upon notification, the RSO or alternate shall immediately proceed to the receiving area and:

5.2.4.1 Inspect/survey the shipment.

5.2.4.2 Take custody of small items and either store the material or deliver the material to the Authorized User.

5.2.4.3 For large items, assure the material is properly identified and stored until the Authorized User makes arrangements for delivery.

5.2.4.4 Document the survey of the package on MSFC Form 4485, "Radiological Survey," or MSFC Form 4486, "Radiological Survey Map."

5.2.5 All incoming shipments of radioactive materials shall be coordinated with the MSFC RSO to ensure proper licenses are valid and the users are authorized to receive the material.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 19 of 63</b>

### 5.3 Outgoing Shipments

5.3.1 The Authorized User or other cognizant person shall notify the RSO of the need for any offsite shipment of radioactive material.

5.3.2 The RSO shall assure the receiver is authorized and licensed to receive the radioactive material.

5.3.3 The RSO shall ensure the outgoing shipment is properly packaged by either personally packaging the material or directing and approving the packaging of the material.

5.3.4 Packaging, labeling, and marking of radioactive material shipments shall be in accordance with the requirements of DOT (49 CFR Part 172 and 49 CFR Part 173, Subpart I) and International Air Transport Association (IATA).

5.3.5 A final survey of the package shall be documented on MSFC Form 4485, "Radiological Survey," or MSFC Form 4486, "Radiological Survey Map," prior to shipment of the package.

5.3.6 The RSO shall provide technical advice or assistance as necessary in any phase of the preparation for shipment.

5.3.7 The RSO shall prepare and sign all radioactive material specific shipping documents, i.e., Shipper's Declaration For Dangerous Goods.

### 5.4 Intracenter Transportation

5.4.1 Approval by the RSO shall be required for movement of radioactive material to a different onsite location.

5.4.2 Movement of radioactive material shall be performed by the RSO or at the RSO's direction.

5.4.3 Radioactive material to be transported on the Center shall be packaged and shielded so that the radiation level on the outside of the package is maintained ALARA.

5.4.4 The package shall be sealed to prevent the release of radioactive material and be free of detectable radioactive contamination on the outside of the package.

5.4.5 Standard radiation warning postings required by 10 CFR Part 20 shall be used.

5.4.6 If the RSO is not actually moving the material, then the driver of the vehicle shall be apprised of the nature of his cargo and be accompanied by the Authorized User or someone designated by the Authorized User.

5.4.7 If there is a vehicle accident, the driver shall notify the Protective Services Control Center (PSCC) and the RSO immediately and ensure they know the exact nature of the cargo.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 20 of 63</b>

5.4.8 The uniformed security officers shall secure the accident area until the RSO or alternate has determined the area is safe.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 21 of 63</b>

## CHAPTER 6

### PERSONNEL EXPOSURE

#### 6.1 General

6.1.1 Personnel exposure shall be maintained ALARA. Personnel exposure is divided into two categories:

6.1.1.1 Internal exposure resulting from radioactive material taken into the body by ingestion, inhalation, or absorption through the skin or through wounds.

6.1.1.2 External exposure resulting from the body being exposed to radiation from radioactive materials and ionizing radiation produced by machines.

#### 6.2 Dose Limits

6.2.1 Dose limits are a combination of both internal and external exposures. The following limits shall apply to all personnel at MSFC:

Category	MSFC Administrative Limit mrem/year	MSFC Investigation Level (mrem)	NRC Limit mrem/year	Comments
<b>Total Effective Dose Equivalent (TEDE) Whole Body Dose</b>	500	100	5,000	Includes dose from both internal and external sources. The Whole Body limit applies to exposure of the torso and head when the radiation is penetrating enough to irradiate tissues at a depth of 1 cm.
<b>Lens Dose Equivalent (LDE) Lens of the Eye</b>	1500	300	15,000	The Lens of the Eye limit applies to exposure of the eye to radiation penetrating enough to irradiate the lens, at a depth of 0.3 cm.
<b>Shallow Dose Equivalent (SDE) Extremities &amp; Skin</b>	5000	1000	50,000	The extremities include the arm or leg below the elbow or knee. The skin is the skin of the whole body. The SDE limit applies to exposure of the extremities and skin when the radiation is penetrating enough to irradiate tissues at a depth of 0.07 cm.
<b>Declared Pregnant Woman (Embryo/Fetus)</b>	100/pregnancy	50	500/pregnancy	TEDE of the mother.
<b>Occupational Exposure of a Minor</b>	Occupational exposure of a minor is not permitted at MSFC.	N/A	10 percent of above limits	Applies to anyone under 18 years of age.
<b>Member of the General Public</b>	N/A	N/A	100	Applies to anyone not designated a radiation worker.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 22 of 63</b>

6.2.2 The receipt of a planned dose in excess of the MSFC administrative limit requires the written approval of the RSO and the RSC Chairman.

6.2.3 If any of the MSFC investigation levels are exceeded, the RSO shall conduct an investigation into the cause of the exposure and submit the results of the investigation as well as recommendations to prevent reoccurrence to the RSC.

6.2.4 In extraordinary circumstances and with the written approval of the Manager, EEOH, an individual shall be allowed per 10 CFR Part 20.1206 to receive a planned special exposure in excess of the NRC annual limits.

### 6.3 Declared Pregnant Woman

6.3.1 If a woman working with radiation becomes pregnant or decides to become pregnant, she is encouraged to declare her pregnancy using MSFC Form 4484, "Declaration of Pregnancy," and take advantage of the reduced dose limits provided to protect the embryo/fetus. The form shall be completed and given to the RSO and a copy of the form made available to the worker and her supervisor.

6.3.2 Per 10 CFR Part 20.1208, dose equivalent to an embryo/fetus, MSFC shall ensure the dose equivalent to the embryo/fetus during the entire pregnancy, due to occupational exposure of a **declared pregnant woman**, does not exceed 500 mrem. The exposure is to be kept as uniform as possible during the pregnancy.

6.3.3 If a woman who is pregnant or who has decided to become pregnant does not wish to declare her pregnancy, then the normal dose limits for a radiation worker shall apply.

6.3.4 The program is entirely voluntary, but the RSO shall be consulted by the woman in order for her to properly assess the radiological risk to her embryo/fetus.

### 6.4 Radiological Caution Signs, Labels, and Postings

6.4.1 Caution signs, labels, warnings, and postings shall be used in accordance with 10 CFR Part 20.

6.4.2 In addition to the above, it is permissible to use other warning devices as prescribed and approved by the RSO.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 23 of 63</b>

## CHAPTER 7

### PERSONNEL MONITORING

#### 7.1 General

7.1.1 Appropriate personnel monitoring equipment shall be applied to:

7.1.1.1 Each individual who is likely to receive a dose in excess of 10 percent of the NRC limits listed in 6.2.1 for whole body, lens of the eye, extremities, or skin.

7.1.1.2 Each individual, prior to entering a restricted area or any area where a dose in excess of 2 mrem in any 1 hour or 100 mrem in a year is likely.

7.1.2 In addition to these requirements, personnel monitoring shall be provided for all individuals entering a posted radiation area.

*NOTE: Visitors and personnel performing temporary work not involving radioactive material or IRPDs in areas where radioactive material or IRPDs are being used are not required to wear or be issued Thermoluminescence dosimeter (TLD) badges so long as the area is not posted as a "radiation area."*

7.1.3 MSFC EEOH shall be responsible for providing dosimetry service at MSFC and exchanging the TLDs quarterly.

7.1.4 The project manager of each activity in which there are projects dealing with radioactive materials or equipment capable of producing ionizing radiation shall enforce these requirements.

7.1.5 These requirements apply to all employees of MSFC, its contractors, and its consultants.

#### 7.2 Types of Dosimeters

7.2.1 The following dosimetry devices are in use at MSFC:

7.2.1.1 TLD badges.

7.2.1.2 TLD finger rings (badges).

7.2.2 TLD badges and finger rings are used to obtain a permanent record of the radiation dose to which the individual has been exposed.

7.2.3 TLD finger rings are worn by personnel utilizing devices, such as x-ray diffraction units, or high activity radioactive sources where a need for extremity (finger, hand) dosimetry is present.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 24 of 63</b>

7.2.4 TLD badges shall be worn on the front of the body between the waist and the collar, preferably at the chest level, with the beta window facing out. Readings from TLD badges are representative of the dose to the whole body.

7.3 General Precautions. The following precautions shall be taken:

7.3.1 Do not tamper with the TLD.

7.3.2 Do not expose the TLD to excessive heat or moisture.

7.3.3 Do not leave the TLD in a location where it is exposed to radiation except when worn by the employee.

7.3.4 Always wear the TLD when entering a restricted area, radiation area, high radiation area, or very high radiation area.

7.3.5 Do not take the TLD home. When TLD badges/finger rings are not being worn, they shall be kept in the designated location for that work area.

7.3.6 Exemptions to this policy shall be approved by the RSO.

7.3.7 Wear only your own TLD.

7.3.8 Report any suspected exposure the TLD did not record or any suspected over-exposure to the MSFC RSO.

7.3.9 Wear the TLD with the beta window facing outward on the front of the body between the waist and neck unless directed otherwise by the RSO. Wear the TLD finger ring with the chip facing the anticipated radiation beam/beam source unless directed otherwise by the RSO.

7.4 How to Obtain a TLD

7.4.1 The responsible supervisor, Authorized User, or Responsible Person shall, prior to using a radiation source, request a TLD from the RSO for each individual working with the source.

7.4.2 The information required, for persons assigned a TLD badge, is as follows: first name, middle initial, last name, social security number, type radiation used, building number, room number, date of birth, organization, sex (M/F), and supervisor's name.

7.4.3 The MSFC EEOH shall review each individual's medical record and conduct pre-assignment examinations as deemed necessary by the RSO, and notify the responsible supervisor if an individual assignment is inadvisable. Pre-assignment, annual, and termination physical examinations are only required if the individual is expected to receive or has received 500 mrem in one calendar year.



<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 25 of 63</b>

7.4.4 An NRC Form 4, “Lifetime Occupational Exposure History”, and an MSFC Form 4414, “Radiation Users Approval”, shall be completed and signed by the individual requesting dosimetry and given to the RSO.

7.4.5 The MSFC EEOH shall furnish a TLD for each individual. The TLDs are numbered by means of a code designator system to identify the individual user.

7.4.6 All personnel assigned dosimetry instruments shall attend annual approved MSFC radiation safety training.

7.4.7 The MSFC EEOH shall deliver the badges to the user.

7.4.8 At the end of the monitoring period, the MSFC EEOH shall promptly collect all badges.

7.4.9 If an individual has received an overexposure:

7.4.9.1 EEOH shall immediately notify the employee’s supervisor.

7.4.9.2 The employee shall be removed from further radiation exposure.

7.4.9.3 Personnel dosimetry and dose assessments shall be analyzed and evaluated by the RSO and EEOH.

7.4.9.4 EEOH and RSO shall assure the overexposed individual is monitored for any biological effects, ensure health and regulatory requirements are satisfied, and determine when the exposed individual is able to resume duties.

7.4.9.5 The NRC and the Occupational Health and Safety Administration (OSHA) shall be notified by the RSO within 24 hours following the determination of an overexposure.

7.4.10 NRC Form 5, “Occupational Dose Record for a Monitoring Period” or its equivalent, documenting each individual’s annual dose shall be made available for all radiation workers at MSFC.

7.4.11 The MSFC EEOH shall maintain cumulative dose records on each employee exposed to radiation.

## 7.5 Determination of Internal Exposure

In vitro and in vivo bioassays shall be performed as deemed necessary by the RSO to determine personnel exposure from internally deposited radioactive material. Other methods are able to be used for internal dose determination as given in 10 CFR Part 20.

7.5.1 Baseline and quarterly urine bioassays shall be required for individuals working with unsealed radioactive material as determined by the RSO.

<b>Marshall Procedural Requirements</b>		
<b>AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 26 of 63</b>

7.5.2 These bioassay samples shall be given at the MSFC Medical Center and analyzed by a qualified laboratory.

7.5.3 A bioassay sample shall be taken upon termination of use of unsealed radioactive material by the individuals identified above.

7.5.4 Emergency bioassays shall also be taken upon actual or suspected uptakes of unsealed radioactive material.

7.5.5 Follow-up bioassays shall be taken for as long as deemed necessary in the case of positive samples.

7.6 All personnel shall be advised no food or drink is to be consumed, used, or stored in an area where radioactive materials are in use.

7.7 Visitors shall be issued temporary dosimetry if:

7.7.1 The visitor will enter a Radiation Area, or,

7.7.2 The visitor is expected to receive an accrued dose higher than the amount allowed for the General Public, or,

7.7.3 For any reason the RSO decides it is necessary.

7.8 To receive a temporary dosimeter the visitor must either have MSFC radiation safety training or provide evidence of radiation safety training from their employer.

7.9 At the discretion of the RSO, visitors shall be issued a TLD or a digital alarming dosimeter.

7.10 A visitor's digital alarming dosimeter shall be zeroed after each day's use. Any reading above zero is to be reported to the RSO for documentation.

<b>Marshall Procedural Requirements</b>		
<b>AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 27 of 63</b>

## **CHAPTER 8**

### **LEAK TESTING SEALED SOURCES**

#### **8.1 Leak Test Requirements**

8.1.1 All sealed sources at MSFC shall be leak tested in accordance with the requirements of the MSFC NRC Materials License.

8.1.2 All sealed sources containing >100 uCi of beta and/or gamma emitting material shall be leak tested at intervals not to exceed 6 months.

8.1.3 All sealed sources containing >10 uCi of alpha emitting material shall be leak tested at intervals not to exceed 6 months unless it is designed to emit alpha particles in which case it is leak tested every 3 months.

8.1.4 All sealed sources meeting the above criteria shall be leak tested upon receipt regardless of whether the sealed source arrives with documentation showing it has been leak tested within the specified time interval.

8.1.5 Except for disposal shipments, all sources meeting the above criteria shall be leak tested prior to shipment to another licensee regardless of whether the sealed source has documentation showing it has been leak tested within the specified time interval.

8.1.6 The leak test shall be capable of detecting the presence of 0.005 uCi (185 Bq) or more of radioactive material on the sample.

8.1.7 Leak test results shall be kept in units of microcuries.

#### **8.2 Exceptions to Leak Test Requirements**

8.2.1 Sealed sources need not be leak tested if they contain only hydrogen-3 (tritium), contain only a radioactive gas, or the half-life of the isotope is 30 days or less.

8.2.2 Sealed sources need not be leak tested if they are in storage and are not being used. However, when they are removed from storage for use or transferred to another licensee and have not been tested within the required leak test interval, they shall be leak tested before use or transfer.

8.2.3 No sealed source shall be stored for a period of more than 10 years without being tested for leakage and/or contamination.

#### **8.3 Performing Leak Tests**

8.3.1 All leak tests shall be performed by the RSO or at the direction of the RSO.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 28 of 63</b>

8.3.2 All leak tests shall be performed in a manner such as to avoid the spread of contamination and to assure dose to personnel is ALARA.

8.3.3 Where practical, the surfaces of the source shall be rubbed with a water or alcohol moistened swab or wipe with care to avoid damage to the source.

8.3.4 Where the RSO determines it is not practical to touch the actual surfaces of the source due to high dose rates, source fragility, or being inside of equipment, then the travel path of the source or the surfaces of its container shall be checked for removable contamination instead of the actual source.

8.3.5 The swab or wipe shall be dried and initially checked with a count rate meter appropriate to the type of radiation emitted by the source. For beta/gamma emitting sources, a meter equipped with a “pancake” Geiger Muller probe is recommended. For alpha emitting sources, a meter equipped with a zinc sulfide scintillation detector is recommended.

8.3.6 If the leak test does not indicate the presence of removable contamination in excess of the contamination area limits in Appendix E, the swab or wipe shall be either counted in the RSO’s counters, or placed into a small individual plastic or paper container labeled with the source isotope, serial number, and date of the leak test and then sent to a qualified counting laboratory such as the U.S. Army Primary Standards Laboratory for analysis.

8.3.7 If the leak test indicates the presence of removable contamination in excess of the contamination area limits in Appendix E , then the source shall be removed immediately from service and decontaminated, repaired, or disposed of in accordance with NRC regulations.

8.3.8 If the leak test reveals the presence of 0.005 uCi (185 Bq) or more of removable contamination, a report shall be filed with the NRC in accordance with 10 CFR Part 30.50(c)(2).

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 29 of 63</b>

## **CHAPTER 9**

### **EMERGENCY PROCEDURES FOR CONTROL OF RADIOACTIVE CONTAMINATION**

#### 9.1 General

9.1.1 Radioactive contamination is easily spread during an emergency situation such as a fire, explosion, accidental breakage of a container, or spilling. Radioactive materials are spread very rapidly and easily by the air currents set up by a fire. They also find their way into air conditioning systems, or if spilled on the floor, are able to be tracked around by personnel. This contamination is undetectable except by the use of special radiation-detecting devices. Since it is extremely difficult to set up adequate detection controls in an emergency, this chapter has been prepared to present preplanned emergency procedures. Personnel whose work involves the use of radioactive materials shall familiarize themselves with these procedures.

9.1.2 Because of the potential for personnel injury, all incidents involving unplanned release or contamination shall be treated as mishaps per MWI 8621.1.

#### 9.2 Emergency with No Associated Injury to Personnel

9.2.1 Immediately after the occurrence of a spill, breakage of a container, or any accident resulting in the release of radioactive material, the involved person shall accomplish the following:

9.2.1.1 Inform all other personnel in the area an incident has occurred and prevent them from approaching the contaminated area or from attempting to deal with the spillage. Prevent personnel suspected of being contaminated from leaving the area and spreading contamination.

9.2.1.2 Notify the RSO by telephone, or by the most rapid method of communication, and follow the RSO's instructions or those of the RSO's authorized representative. Unless otherwise instructed by the RSO, close all windows and other openings such as ventilating grills and shut off air condition systems, and electric fans.

9.2.1.3 Survey all personnel suspected of being contaminated. Initiate decontamination procedures immediately for any contaminated personnel. No one who is found to be contaminated is to be allowed to leave the area until they are de-contaminated or directed to do so by the RSO.

9.2.1.4 Ensure no one (excluding fire fighters) enters the evacuated areas unless they are equipped with protective equipment.

9.2.2 After a spill, all personnel in the general area are affected by the rules listed below:

9.2.2.1 No person shall enter the area until the RSO has conducted radiological surveys and has pronounced the area safe for resumption of work.

9.2.2.2 Unauthorized personnel shall not attempt to make a survey or to clean up the spillage.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 30 of 63</b>

9.2.2.3 Decontamination procedures shall always be conducted under the supervision of the RSO or the RSO's authorized representative.

9.2.2.4 Personnel shall keep their movements in the contaminated area to a minimum to avoid spreading the contaminant by tracking.

### 9.3 Emergency with Associated Injury to Personnel

9.3.1 In the event of an emergency with associated injury to personnel, the following procedures apply:

9.3.1.1 The RSO and emergency personnel shall work together to decontaminate and treat all patients who can be adequately treated at the scene.

9.3.1.2 All injured persons who are suspected to be contaminated with radioactive material and who require more than on-the-spot first aid shall be taken from the scene by ambulance to an appropriate emergency medical care facility.

*NOTE: Huntsville Hospital and Decatur General are currently the only local hospitals set up to handle personnel contaminated with radioactive material.*

9.3.1.3 When calling 911, the emergency medical services dispatcher shall be told the injured person is possibly contaminated with radioactive material.

9.3.1.4 Emergency medical personnel shall determine whether the patient has a concomitant serious medical condition or injury that cannot be adequately treated at this location.

9.3.1.5 If there is a serious medical condition or injury that cannot be adequately treated at the location, emergency medical personnel or the RSO shall so inform other responding emergency services and applicable hospital so the procedure for handling radioactively-contaminated patients is instituted.

9.3.1.6 All preliminary decontamination of the patient, including removal of contaminated clothing, shall be accomplished as time and conditions permit.

9.3.1.7 The RSO shall notify emergency medical personnel and the hospital of the probable amount and type of contamination of patients being forwarded and of any special precautions required.

9.3.1.8 The RSO or the RSO's representative shall survey the exterior of the ambulance for contamination before allowing it to leave the scene to deliver the patient. The critical needs of the patient take priority over contamination control.

9.3.1.9 All equipment or material used on the patient or at the scene shall be considered as contaminated until it is checked by the RSO or the RSO's representative and cleared or decontaminated as necessary.

<b>Marshall Procedural Requirements</b>		
<b>AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 31 of 63</b>

9.3.1.10 The responding emergency medical services shall remain at the delivery site until the RSO or the RSO's representative surveys the ambulance for contamination and directs any necessary decontamination.

#### 9.4 Decontamination Procedures

9.4.1 Contamination of personnel, plant areas, or equipment areas sometimes presents emergency conditions following an accident. Prompt measures shall be taken to identify contaminated personnel and to perform required decontamination.

9.4.2 Only under life-saving emergency conditions shall a person contaminated with radioactive material leave the area until released by the RSO or the RSO's representative.

9.4.3 As soon after a contamination survey as possible, preplanned decontamination methods shall be applied to the contaminated plant areas and equipment.

9.4.4 Only the RSO or the RSO's authorized delegates shall decontaminate or supervise the decontamination of personnel or material.

#### 9.5 Procedure for Decontaminating Personnel

9.5.1 With care taken to prevent the spread of contamination to personnel or surrounding areas, all contaminated clothing or clothing suspected to be contaminated shall be removed and placed in suitable waste containers (a plastic bag within a plastic can or equivalent) for later disposal.

9.5.2 Initial decontamination shall be done utilizing a wet wipe.

9.5.3 If more aggressive decontamination methods are required such as scrubbing with a waterless cleanser or soap and water, care shall be taken to contain and collect all materials and fluids used.

9.5.4 All fluids, wipes, gloves, and other material used for decontamination shall be considered to be radioactive waste and marked, packaged, and handled accordingly.

9.5.5 Consideration shall be given to the chemistry of the contaminant, and an attempt made to find a suitable agent for dissolving it.

9.5.6 Prolonged decontamination often results in irritation of the skin and shall be avoided.

9.5.7 If internal contamination is suspected, the physician and emergency medical service personnel shall be notified so appropriate biological samples are collected.

9.5.8 Personnel engaged in contamination surveys and decontamination operations shall wear appropriate personal protective equipment such as gloves, respirators, coveralls, and shoe covers, as necessary.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 32 of 63</b>

## 9.6 Decontamination of Areas, Tools and Materials

9.6.1 Exercising care to prevent the contamination of personnel and surrounding areas and under the direction of the RSO, vacuum cleaners, mops, detergents, and wetting agents shall be employed on the contaminant.

9.6.2 All materials used for decontamination shall be considered to be radioactive waste and marked, packaged, and handled accordingly.

9.6.3 Vacuum cleaners shall have high-efficiency filtered exhausts.

9.6.4 The RSO shall perform or direct all surveys of personnel, areas, and equipment to determine if they are clean or whether further decontamination is needed.

9.6.5 Only the RSO or his designee shall clear personnel, areas, or equipment.

9.6.6 Areas and equipment shall be decontaminated to below the levels specified in Appendix E.

9.6.7 Personnel shall be decontaminated to as low a level as is possible.

9.6.8 The RSO shall document on MSFC Form 4485, "Radiological Survey," or MSFC Form 4486, "Radiological Survey Map" a survey of the initial contamination levels and a final survey showing personnel, areas, or equipment have been cleared.



<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 33 of 63</b>

## **CHAPTER 10**

### **INDUSTRIAL RADIOGRAPHY X-RAY REGULATIONS**

#### **10.1 General**

10.1.1 The principal method of protection from radiation at fixed installations shall be by shielding the tube/source and by enclosing the machine/source in a protective housing or high-density concrete and/or lead-lined room.

10.1.2 Other methods used in conjunction with shielding at fixed locations shall be: restricting the direction of the useful beam, limiting the workload, restricting the occupancy of adjacent areas, and using interlocks to shut off the beam when the doors or access covers are opened.

10.1.3 For non-fixed installations, the principal method of protection from radiation shall be by the establishment of a boundary beyond which the radiation level is below any regulatory limit.

10.1.4 All radiography shall be done under the direct supervision of a trained, licensed radiographer.

#### **10.2 New Fixed Installations**

10.2.1 Each new x-ray installation shall be designed to limit exposures to those outlined in Chapter 6 and the design criteria and drawings submitted to the RSO/RSC for review and approval.

10.2.2 After the installation is completed, the RSO shall be notified so a survey with radiation detection instruments is made prior to beginning operations to ensure adequate protection to operators and personnel occupying adjacent areas.

10.2.3 Only the RSO/RSC shall give final approval for a new facility to operate.

#### **10.3 Existing and New Fixed Installations**

10.3.1 All entrances into a radiographic cell or other high radiation area shall be provided with interlocks.

10.3.2 The switch on the radiography control panel shall be used to turn the x-ray generator on and off.

10.3.3 The safety interlock system shall not be used to turn off the x-ray generator, except in an emergency.

10.3.4 If the interlock system does turn off the x-ray generator, it shall not be possible to resume operation without resetting the system.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 34 of 63</b>

10.3.5 A scram button(s) or other emergency cutoff switch(s) shall be located and easily identifiable in all high radiation areas and include a manual reset so the generator cannot be restarted from the control panel without resetting the cutoff switch.

10.3.6 Electrical circuit diagrams of the generator and the associated interlock systems shall be kept current and on file at each facility.

10.3.7 All entrances to high radiation areas shall be equipped with easily-observable flashing or rotating red or magenta warning lights which operate automatically when, and only when, radiation is being produced.

10.3.8 All safety and warning devices, including interlocks, shall be checked at intervals not to exceed 1 month to ensure they are functioning properly and are appropriately serviced.

10.3.9 Appropriate portable radiation monitoring equipment, properly maintained and calibrated, shall be available at the radiographic facility and be sensitive to those radiation energies being produced.

10.3.10 Portable radiation monitoring equipment shall have a minimum range of 2 mrem/hour to 2000 mrem/hour, and be calibrated at least every 6 months.

10.3.11 An appropriate radiation monitor shall be used within a radiography control room. A good example is an area monitor with an easily-observable indicator which warns of radiation levels above a predetermined limit such as 2 mrem/hour. With RSO approval, an alarming rate dosimeter may be used in lieu of an area radiation monitor.

10.3.12 In addition, wherever possible, a personal alarming rate dosimeter shall be worn by personnel entering the cell and/or a portable survey instrument carried into the cell.

10.3.13 Personal alarming rate dosimeters shall be calibrated annually and have their alarms set as: 100 mrem/hour dose rate, 10 mrem dose accrued.

10.3.14 Personal radiation dosimeters that measure the expected radiations and that are of sufficient range to be useful under normal and accidental conditions shall be worn by all designated persons.

10.3.15 A radiation survey shall be made each quarter and after any maintenance or alteration has been performed on an x-ray unit, radioactive source, radiation shielding, and/or office locations of adjacent areas.

10.3.16 Records of all radiation surveys, inspections, and maintenance performed on the x-ray generator and related components shall be kept current and on file at each facility and be periodically (at least annually) reviewed by the RSO.

10.3.17 The RSO shall perform a radiation survey and installation inspection of fixed x-ray installations at least once annually.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 35 of 63</b>

#### 10.4 Field Radiography

10.4.1 All the requirements for portable radiation detection instruments and personal dosimetry in Section 10.3 shall apply.

10.4.2 During all radiography, the radiographer(s) and/or radiographer's assistant(s) shall maintain direct surveillance of the radiography boundary to assure there is no unauthorized entry of personnel into the radiography boundary.

10.4.3 All radiographers and radiographer's assistants shall have a dose rate meter with which to check the dose rates at the radiography boundary during radiography.

10.4.4 Except as directed by the RSO, all radiography boundaries shall be set such that the dose rate at any point on the boundary does not exceed 2 mrem in any one hour.

10.4.5 The RSO shall approve all radiography boundaries and, unless waived by the RSO, check the dose rates at the radiography boundary at the beginning of the radiography.

10.4.6 All groups/organizations/contractors wishing to have radiography performed for them at MSFC shall contact the RSO and provide him with all pertinent information concerning the radiography such as time/date, location, item(s) to be inspected, and who is to perform the radiography.

#### 10.5 All Outside Contract Radiographers

10.5.1 Shall report to the MSFC RSO, Building 4249, Room 116A, or call the RSO at 544-5738 prior to performing any work at MSFC.

10.5.2 Shall make available for RSO review and approval all documentation and required materials such as NRC or Agreement State Materials License, shipping papers, procedures, instrumentation, dosimetry, radiographer's license, records of training, and any other items deemed necessary by the RSO.

10.5.3 Shall obtain approval from the RSO prior to exposing a radioactive material source or energizing an x-ray source.

10.5.4 Shall complete MSFC Form 4493, "Quality Control Guidance for Contractor Field Radiography Operations at MSFC," for each job performed onsite and give it to the RSO upon completion of the job.

#### 10.6 NASA Radiographers

10.6.1 Shall contact the RSO prior to performing work.

<b>Marshall Procedural Requirements</b>		
<b>AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 36 of 63</b>

10.6.2 Shall make available for RSO review and approval all documentation and required materials such as procedures, instrumentation, dosimetry, radiographer's license, records of training, and any other items deemed necessary by the RSO.

10.6.3 Shall obtain approval from the RSO prior to energizing an x-ray source.

10.6.4 Shall complete MSFC Form 4497, "Quality Control Guidance for NASA X-Ray Field Radiography Operations at MSFC," for each job performed onsite and give it to the RSO upon completion of the job.

### 10.7 Organizational Instructions (OI)

10.7.1 As determined by the RSO/RSC, an adequate OI shall be required for the operation of all equipment producing x-rays.

10.7.2 The OI shall be submitted to the RSO/RSC for review and approval prior to commencing operations.

10.7.3 The OI shall include instructions for at least the following:

10.7.3.1 The handling and use of sources of x-radiation to be employed so no person is likely to be exposed to radiation doses in excess of the limits established in 10 CFR Part 20.

10.7.3.2 Methods and occasions for conducting radiation surveys.

10.7.3.3 Methods for controlling access to radiographic areas.

10.7.3.4 Methods and occasions for locking and securing sources of radiation.

10.7.3.5 Personnel monitoring and the use of personnel monitoring equipment.

10.7.3.6 Procedures for testing interlocks and other safety systems at regular intervals.

10.7.3.7 The procedures for notifying proper persons in the event of an accident.

10.7.3.8 The maintenance of records.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 37 of 63</b>

## **CHAPTER 11**

### **ANALYTICAL X-RAY DEVICES**

#### 11.1 General

MSFC uses the State of Alabama Regulations for Protection Against Radiation as guidance for radiation safety when using IRPDs, such as analytical x-ray devices.

#### 11.2 Responsibilities

11.2.1 For each operation using IRPDs, a person familiar with the basic principles of radiation protection and the particular hazards of the specific device under consideration shall be appointed to be the Responsible Person, with assistance and direction from the RSO, for the safe operation of the device(s). These responsibilities include:

11.2.1.1 Ensuring operational procedures required by the RSO/RSC pertaining to radiation safety are established and carried out so that the radiation exposure of each worker is kept at a minimum.

11.2.1.2 Providing instruction in the operation of the equipment and safety practices for all personnel who work with or near the equipment.

11.2.1.3 Arranging for the establishment of radiation control areas, including placement of appropriate radiation warning signs and/or devices.

11.2.1.4 Arranging for regular testing of safety features such as interlocks (monthly) and warning lights (daily), and for permanent record keeping.

11.2.1.5 Providing radiation safety inspections of the equipment and operations.

11.2.1.6 Reviewing modifications to x-ray apparatus, including shielding and safety interlocks.

11.2.1.7 Investigating any case of abnormal radiation exposure of personnel.

11.2.1.8 Closely coordinating all of the above with the RSO/RSC.

11.2.2 The Responsible Person shall further ensure:

11.2.2.1 Individuals who act as operators of analytical x-ray devices receive an acceptable amount of training in radiation safety (refer to Chapter 13 of this document).

11.2.2.2 Operators have demonstrated competence in the use of x-ray devices and radiation survey equipment.

11.2.2.3 Operators' radiation exposure records as derived from personnel-monitoring devices are kept at the EEOH.

<b>Marshall Procedural Requirements</b>		
<b>AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 38 of 63</b>

11.2.3 The operators of analytical x-ray equipment are responsible for all operations associated with the equipment they are operating, including radiation safety and shall:

11.2.3.1 Keep radiation exposure to self and to others at a minimum.

11.2.3.2 Be familiar with safety procedures as they apply to each machine.

11.2.3.3 Wear personnel-monitoring devices.

11.2.3.4 Notify their supervisor and the RSO/RSC of known or suspected abnormal radiation exposures to self or others.

### 11.3 Operating Procedures

11.3.1 For each operation involving analytical x-ray devices, operating procedures required by the RSO/RSC reflecting safety practices shall be prepared which reflect the following:

11.3.1.1 Personnel shall not expose any part of their body to the primary radiation beam.

11.3.1.2 Only trained personnel (assure requirements of MWI 8715.2 are met) shall be permitted to install, repair, or make other than routine modifications to the x-ray generating apparatus and the tube housing apparatus complex.

11.3.1.3 Procedures and apparatus used in beam alignment shall be designed to minimize radiation exposure to the operator.

11.3.1.4 Written emergency procedures pertaining to radiation safety shall be established and posted in a conspicuous location.

11.3.1.5 If for any reason it is necessary to alter safety devices temporarily such as by removing shielding or bypassing interlocks, such action shall be specified in writing, approved by the RSO, and posted near the x-ray tube housing so that other persons know the existing status of the machine.

11.3.1.6 Radiation exposure to individuals, either within the radiation-controlled area or its surroundings, shall be controlled so dose limits specified in 6.2.1 are not exceeded.

11.3.1.7 Personnel monitoring devices shall be worn by all personnel.

### 11.4 Area Monitoring

11.4.1 Area radiation surveys shall be made and maintained by the operator at frequent intervals to detect stray radiation.

11.4.2 During changes in operations, surveys shall be performed for proper placement of shielding or for the location of barriers that limit the entry of persons into the area.

<b>Marshall Procedural Requirements</b>		
<b>AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 39 of 63</b>

11.4.3 In addition to the above, it is possible for area monitoring locations to be established by the RSO using thermo luminescent dosimeters.

### 11.5 Radiation Protection Engineering Considerations

11.5.1 The following considerations apply to the design and construction of all analytical x-ray equipment. Any deviation from these standards shall be reviewed and approved by the RSO/RSC.

11.5.1.1 The tube housing leakage radiation, measured at a distance of 5 cm from the surface of the tube housing with beam ports blocked, shall not exceed 25 mrem (250  $\mu$ Sv) in 1 hour and 0.5 mrem (5  $\mu$ Sv) in 1 hour at every specific tube rating.

11.5.1.2 Radiation originating within the high-voltage power supply, i.e., transformer and rectifiers, shall not exceed 0.5 mrem (5  $\mu$ Sv) in 1 hour at every specific rating at a distance of 5 cm from the housing of the power supply.

11.5.1.3 For x-ray diffraction and spectrographic equipment in which the primary x-ray beam is completely enclosed, the stray radiation at a distance of 30 cm from the tube housing apparatus complex as measured with a monitor appropriate for the energy range monitored, shall be less than 2 mrem (20  $\mu$ Sv) in 1 hour at every specified tube rating.

11.5.1.4 For all analytical x-ray devices, the following precautions apply:

- a. A warning light which is visible from all directions shall be provided that turns on automatically when the x-ray tube and/or machine are activated.
- b. Normally, the operator shall be in immediate attendance at all times when the equipment is in operation.
- c. If this is not possible, for example, in extended periods of continuous operation, then access to the equipment shall be prevented for those other than the user.
- d. A warning light indicating the presence of x-rays shall be placed outside each door leading into the room which houses the system(s).
- e. When not in operation, the equipment shall be secured in such a way as to be accessible to, or operable by, authorized personnel only. Because the exposure rate at the beam port has the potential to be greater than 100,000 roentgens/minute, extreme cautions are necessary to prevent accidental exposure to the primary beam. For this reason, open beam techniques are to be used only after all other possibilities have been exhausted.

11.5.1.5 It is preferable for each tube housing apparatus complex to be so arranged as to prevent the entry of parts of the body into the primary radiation beam path or to cause the primary radiation beam to be shut off upon entry into its path.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 40 of 63</b>

11.5.1.6 A shutter status (open or closed) indicator shall be provided on or adjacent to the tube housing, which automatically indicates the position of each shutter in a readily discernible manner.

11.5.1.7 A black/yellow or magenta/yellow sign or label bearing the radiation symbol and the words CAUTION - RADIATION - THIS EQUIPMENT PRODUCES X-RADIATION WHEN ENERGIZED or words having similar intent shall be placed near any switch that energizes an x-ray tube.

11.5.1.8 A sign or label bearing the words CAUTION - HIGH INTENSITY X-RAY BEAM or words having similar intent shall be placed on or adjacent to each x-ray tube housing such that, if possible, it is clearly visible to any person working in proximity to the primary radiation beam.

11.5.1.9 A red or magenta warning light with the notation "X-Ray On," or equivalent shall be located on the control panel which lights only when the x-ray tube is activated.

11.5.1.10 A labeled x-ray tube status (on or off) indicator, preferably a red or magenta light, shall be provided on or near each tube housing so the tube status is readily discernible.

11.5.1.11 Machines that use an x-ray diffraction camera shall have appropriate ports of the x-ray tube housing arranged so either:

- a. The x-ray tube is energized only when the camera collimating system is in place.
- b. A shutter mechanism allows the primary radiation beam to pass only when the camera collimating system is in place.

11.5.1.12 The coupling between the x-ray tube and the collimator of the diffractometer, camera, or other accessory shall prevent stray x-rays from escaping the coupling.

11.5.1.13 Safety interlocks shall not be used to deactivate the x-ray beam, except in an emergency or during testing of the interlock system.

11.5.1.14 If the interlock system does turn off the x-ray beam, it shall not be possible to resume operation without resetting the beam "ON" switch at the control panel.

11.5.1.15 All safety devices (interlocks, shutters, warning lights) shall be tested prior to use and periodically to ensure their proper operation.

11.5.1.16 These tests shall be conducted at least once per month (follow specific OI for appropriate facility).

11.5.1.17 If a unit is used only rarely, the safety devices shall be checked prior to use and their status recorded.

11.5.1.18 All tube head ports that are not used shall be secured in the closed position in a manner that prevents casual opening.



<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 41 of 63</b>

11.5.1.19 Port covers shall offer the same degree of protection as is required of the tube housing.

11.5.1.20 Permanent shielding shall be used in preference to temporary shielding such as lead foil which is easily distorted and possibly permit radiation leaks.

11.5.1.21 X-ray diffraction and spectrographic equipment shall be placed in a room separate from other work area whenever possible.

11.5.1.22 Research projects sometimes involve frequent modifications of the analytical x-ray equipment, and there is often an assorted increase in potential radiation hazards. Special efforts are necessary to control the hazards from such machines:

- a. Radiation surveys shall be made routinely and after each modification of the apparatus.
- b. Equipment operators shall wear a TLD badge as a radiation-monitoring device.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 42 of 63</b>

## **CHAPTER 12**

### **PARTICLE ACCELERATORS**

#### **12.1 The Accelerator Safety Program**

12.1.1 A person familiar with the basic principles of radiation protection and the particular hazards of the specific device(s) under consideration for the particle accelerator facility shall be appointed as the Responsible Person.

12.1.2 The accelerator facility shall be under the guidance of the Responsible Person who, with guidance and direction from the RSO/RSC, is responsible for ensuring the devices are operated safely.

12.1.3 The operator of the accelerator shall be responsible for all operations connected with the accelerator, including radiation safety.

12.1.4 The Responsible Person and RSO shall have the authority to cease operations at the facility because of radiation safety considerations.

12.1.5 No individual shall be permitted to act as an operator of an accelerator until such person has:

- a. Received an acceptable amount of training in radiation safety as approved by the RSO:
- b. Demonstrated competence to use the accelerator, related equipment, and radiation survey instruments employed.
- c. Been approved by the Responsible Person.

12.1.6 Operators and other appropriate personnel shall be familiar with and be given a copy of the written operating and emergency procedures pertaining to radiation safety which are also posted near the accelerator control console.

12.1.7 Particle accelerators shall be secured to prevent unauthorized use when not in operation.

12.1.8 Meters and controls on the accelerator control console shall be clearly identified and easily discernible.

12.1.9 All entrances into a target room or other high radiation area shall be provided with interlocks.

12.1.10 Normally, only a switch on the accelerator control shall be used to turn the accelerator beam on and off.

12.1.11 The safety interlock system shall not be used to turn off the accelerator beam, except in an emergency or during testing of the interlock system.

<b>Marshall Procedural Requirements</b>		
<b>AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 43 of 63</b>

12.1.12 If the interlock system does turn off the accelerator, it shall not be possible to resume operation without resetting the accelerator “ON” switch at the control console.

12.1.13 All safety interlocks shall be dependent upon the operation of a single circuit.

12.1.14 An easily-identifiable scram button or other emergency cutoff switch which includes a manual reset such that the accelerator cannot be restarted from the accelerator control console without resetting the cutoff switch shall be located in all high radiation areas.

12.1.15 Electrical circuit diagrams of the accelerator and the associated interlock systems shall be kept current and on file at each accelerator facility.

12.1.16 All locations designated as high radiation areas and entrances to such locations shall be equipped with easily-observable flashing or rotating red or magenta warning lights that operate automatically when, and only when, radiation is being produced.

12.1.17 All safety and warning devices, including interlocks, shall be checked at intervals not to exceed 1 month to ensure that they are functioning properly and are appropriately serviced.

12.1.18 Appropriate, portable radiation monitoring equipment, properly maintained, calibrated, and sensitive to those radiation energies being produced shall be available at the accelerator facility.

12.1.19 An appropriate radiation monitor shall be used within an accelerator target room and other high radiation areas. Possibilities are an area monitor with an easily observable indicator that warns of radiation levels above a predetermined limit in accessible areas, a personal alarming rate dosimeter carried into the room, or a portable survey instrument carried into the room.

12.1.20 Personal radiation dosimeters that measure the expected radiations and that are of sufficient range to be useful under normal and accidental conditions shall be worn by all persons designated by the radiation protection supervisor.

12.1.21 Before a new installation is placed in routine operation, a radiation survey shall be made by the RSO.

12.1.22 A radiation survey shall be performed when changes have been made in shielding, operation, equipment, or occupancy of adjacent areas.

12.1.23 Annually the RSO will perform a radiation survey and inspection.

12.1.24 Records of all radiation surveys and inspections, and maintenance performed on the accelerator and related components shall be kept by the RSO.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 44 of 63</b>

## **CHAPTER 13**

### **RADIATION SAFETY TRAINING**

#### **13.1 General**

Assurance of proper training and certification by MWI 3410.1 shall be maintained through formalized training requirements for each employee whose regular job assignment involves work in areas involving radiation producing materials and/or equipment.

#### **13.2 Indoctrination**

13.2.1 Before an employee's assignment, the area supervisor shall acquaint the employee with general radiation protection rules and applicable procedures for the work involved.

13.2.2 Before an employee begins work and before a TLD badge is issued, the employee shall complete radiation safety training presented or approved by the RSO or other properly-qualified individual.

#### **13.3 Field Instruction**

Before an employee begins work, their supervisor shall familiarize them with specific procedural and engineering safeguards employed in their specific work area.

#### **13.4 Annual Radiation Safety Training**

13.4.1 Radiation safety training shall be renewed annually but is considered good until the end of the quarter in which it was taken the previous year.

13.4.2 Copies of training records shall be maintained by the RSO.

13.4.3 At the discretion of the RSO, computer-based training is allowed to be used in lieu of classroom training.

13.4.4 The RSO shall process Radiation personnel certification information into the Certification Tracking Database (CERTRAK)

#### **13.5 Radiation Training Outline**

13.5.1 Fundamentals of Radiation Safety:

13.5.1.1 Characteristics of alpha, beta, neutron, gamma and x-radiation, as appropriate.

13.5.1.2 Units of radiation dose (rem, sievert) and quantity of radioactivity (curie, Becquerel).

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 45 of 63</b>

13.5.1.3 Hazards of excessive exposure to radiation.

13.5.1.4 Levels of radiation from sources or machines.

13.5.1.5 Methods of controlling radiation dose:

- a. Working time.
- b. Working distances.
- c. Shielding.

13.5.2 Radiation detection instrumentation to be used.

13.5.2.1 Use of radiation survey instruments:

- a. Operation.
- b. Calibration.
- c. Limitations.

13.5.2.2 Survey techniques.

13.5.2.3 Use of personnel monitoring equipment: TLD badges.

13.5.3 The requirements of pertinent Federal regulations.

13.5.4 The user's written operating and emergency procedures.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 46 of 63</b>

## **CHAPTER 14**

### **NUCLEAR REGULATORY COMMISSION (NRC) LICENSING**

#### 14.1 NRC Licensing for MSFC

14.1.1 All operations involving radioactive material at MSFC are controlled by the NRC. The RSO and the EEOH are the official liaisons between the users, the NRC, and the RSC.

14.1.2 MSFC has an NRC Materials License. This license is very limited in scope and application and only authorizes the possession and use of those isotopes, materials, and sealed sources listed on the license.

14.1.3 An amendment to the license shall be obtained from the NRC any time an isotope or sealed source not listed on the license is required for work at MSFC.

*NOTE: This amendment is obtained prior to the material's arrival at MSFC. Only material authorized by the MSFC NRC Materials License is allowed at MSFC.*

14.1.4 Individuals or groups wishing to use material not authorized by the license shall first obtain approval of the RSO and the RSC to use the material.

14.1.5 The individual or group wishing to use material not authorized by the license shall be responsible for supplying the RSO with all information required to obtain a license amendment for the material.

14.1.6 The RSO shall prepare the amendment paperwork which is signed by the Manager, EEOH, and then sent to the NRC for their approval. The RSO is the point of contact between MSFC and the NRC for all matters relating to an amendment application.

14.1.7 The RSO shall contact the individual or group when the amendment is approved.

*NOTE: Allow 3 to 6 months for an amendment to be approved.*

14.1.8 Unless otherwise agreed upon, if the license amendment increases the annual cost of the license to MSFC, the group requesting the amendment shall be responsible for the extra cost of the license.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 47 of 63</b>

## **CHAPTER 15**

### **MSFC AS LOW AS REASONABLY ACHIEVABLE (ALARA) PROGRAM**

#### **15.1 Management Commitment**

15.1.1 The management of MSFC is committed to the program described herein for keeping individual and collective dose as low as reasonably achievable. MSFC hereby describes an administrative organization for radiation safety and shall develop the necessary written policy, procedures, and instructions to foster the ALARA concept within MSFC. The organization includes an RSC and RSO.

15.1.2 The RSO for MSFC shall perform a formal annual audit of the radiation safety program, including ALARA considerations, reviews of operating procedures, dose records, inspections, and consultations with the radiation safety staff or outside consultants and report the results of the audit to the RSC.

15.1.3 Modifications to operating and maintenance procedures and to equipment and facilities shall be made if they reduce exposures unless the cost is considered to be unjustified (per agreement between the local supervisor, the RSC, and the Facilities Engineering Department Director).

15.1.4 MSFC shall be able to demonstrate, as necessary, that improvements have been sought, that modifications have been considered, that they have been implemented when reasonable, and be prepared to defend any decision to not implement them.

15.1.5 In addition to maintaining doses to individuals as far below the limits as is reasonably achievable, the sum of the dose received by all exposed individuals shall also be maintained at the lowest practicable level. It is not desirable, for example, to hold the highest doses to individuals to some fraction of the applicable limit if this involved exposing additional persons and significantly increasing the sum of radiation doses received by all involved individuals.

#### **15.2 Radiation Safety Committee**

15.2.1 The RSC shall thoroughly review the qualifications of each applicant with respect to the types and quantities of materials and methods of use for which application has been made to ensure the applicant is able to take appropriate measures to maintain exposure ALARA.

15.2.2 When considering a new use of radioactive material, the RSC shall review the efforts of the applicant to maintain exposure ALARA.

15.2.3 The RSC shall ensure the users justify their procedures and individual and collective doses are ALARA.

15.2.4 The judicious delegation of RSC authority is essential to the implementation of a successful ALARA program.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 48 of 63</b>

15.2.5 The RSC shall delegate authority to the RSO for implementation of the ALARA concept.

15.2.6 The RSC shall support the RSO when it is necessary for the RSO to assert authority by the appropriate channels and, if the RSC has overruled the RSO, record the basis for its action in the minutes of their meetings.

15.2.7 The RSC shall encourage all users to review current procedures and develop new procedures as appropriate to implement the ALARA concept.

15.2.8 The RSC shall perform an annual review of occupational radiation exposure with particular attention to instances in which investigation levels are exceeded. The principal purpose of this review is to assess trends in occupational exposure as an index of the ALARA program quality and to decide if action is warranted when investigation levels are exceeded. See 6.2.1 for investigation levels.

15.2.9 The RSC shall evaluate MSFC's overall efforts for maintaining exposures ALARA on an annual basis with the review including the efforts of the RSO, Authorized Users, and workers as well as those of management.

### 15.3 RSO

15.3.1 The RSO shall perform an annual review of the radiation safety program for adherence to ALARA concepts.

15.3.2 The RSO shall review at least annually the external radiation exposures of Authorized Users and workers to determine their exposures are ALARA in accordance with the provisions of Table 1 of this program and prepare a summary report for the RSC.

15.3.3 The RSO shall review radiation levels in unrestricted and restricted areas to determine that they were at ALARA levels during the previous year and prepare a summary report for the RSC.

15.3.4 The RSO shall ensure Authorized Users, workers, and ancillary personnel exposed to radiation be instructed in the ALARA philosophy and informed that management, the RSC, and the RSO are committed to implementing the ALARA concept.

15.3.5 Radiation workers shall be given opportunities to participate in formulating the procedures they are required to follow.

15.3.6 The RSO shall be in close contact with all users and workers to develop ALARA procedures for working with radioactive materials.

15.3.7 The RSO shall evaluate the suggestions of individual workers for improving radiation protection and encourage the use of those procedures.



<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 49 of 63</b>

15.3.8 The RSO shall investigate all known instances of deviation from good ALARA practices and, if possible, determine the causes, and advise changes in the program to maintain exposures ALARA.

#### 15.4 Authorized Users and Responsible Persons

15.4.1 The Authorized User or Responsible Person shall consult with and receive the approval of the RSC during the planning stage before using radioactive materials for a new method of use.

15.4.2 The Authorized User or Responsible Person shall evaluate all methods of use before using radioactive materials to ensure exposures are kept ALARA.

15.4.3 The Authorized User or Responsible Person shall explain the ALARA concept and the need to maintain exposures ALARA to all supervised persons.

15.4.4 The Authorized User or Responsible Person shall ensure supervised persons who are subject to occupational radiation exposure are trained and educated in good health physics practices and in maintaining exposures ALARA.

#### 15.5 Persons Who Receive Occupational Radiation Exposure

15.5.1 Workers shall be instructed in the ALARA concept and its relationship to work procedures and work conditions.

15.5.2 Workers shall know what recourses are available if they feel that ALARA is not being promoted on the job.

#### 15.6 Establishment of Investigation Levels to Monitor Individual Occupational Radiation Exposure

15.6.1 MSFC hereby establishes investigation levels for occupational external radiation doses, which, if exceeded, shall initiate review or investigation by the RSC and/or the RSO. The investigation levels that have been adopted are listed in 6.2.1. These levels apply to the exposure of individual workers.

15.6.2 Except when deemed appropriate by the RSO, no further action shall be taken in those cases where an individual's dose is less than any investigation level.

15.6.3 The RSO shall review the dose of each person whose annual dose equals or exceeds any investigation level and report the results to the review at the first RSC meeting following the year when the dose was recorded.

15.6.4 The RSO shall review each such dose in comparison with those of others performing similar tasks as an index of ALARA program quality and record the review in the committee minutes.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 50 of 63</b>

## **CHAPTER 16**

### **VIOLATIONS**

#### 16.1 General

For the RSO to carry out the job effectively, the authority and means to prevent unsafe practices shall be granted. To assist in accomplishing this, the following chapters define: (a) different categories of actions to which the RSO responds, and (b) the appropriate action necessary from the RSO in response, with backup from the RSC as necessary. These are of necessity, guidelines only, as the perception of risk is highly subjective. Nevertheless, the RSO is trained to assess such situations and make the best judgment regarding the appropriate category. The appropriate action is detailed below:

#### 16.2 Minimum Risk

16.2.1 This category includes those actions that are nonhazardous violations of applicable regulations and procedures.

16.2.2 Verbal warning. If warning not heeded, then category is upgraded to medium.

#### 16.3 Medium Risk

16.3.1 This category includes those practices that are in violation of applicable regulations and, if continued, could eventually pose a health hazard or a moderate to serious regulatory concern. It also includes “Minimum Risk” category actions where the violator has ignored the RSO’s verbal warning.

16.3.2 The violation shall be documented by the RSO in a standard memorandum and copies are sent to the violator, their immediate supervisor, MSFC Occupational Health Officer, RSC Chairperson, EEOH Contracting Officer’s Representative (COR), and COR if violator is a contractor employee. The memorandum details the nature of the violation, the remedial action necessary with an appropriate timescale, and states the consequences of failure to comply. In most cases, failure to comply results in the RSO revoking radiation badge privileges and/or shutting down of the equipment or facility (see “Serious Risk” action below). The memorandum also gives the violator the opportunity to discuss matters with the chairperson of the RSC if they feel the action is unjustified or the timescale cannot be met. All findings are entered into the Safety, Health, and Environmental-Finding Tracking System (SHETrak) by the RSO and tracked.

#### 16.4 Serious Risk

16.4.1 This category includes those violations that are considered an immediate health risk and/or a serious regulatory violation.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 51 of 63</b>

16.4.2 In these cases the RSO shall:

16.4.2.1 Immediately shut down operations and revoke radiation privileges, as appropriate.

16.4.2.2 Document the violation in the standard memorandum that gives details of the nature of the violation and the remedial action necessary.

16.4.2.3 Send copies of the memorandum to the appropriate department manager and supervisors and personnel directly involved, as well as the RSC Chairperson, MSFC Occupational Health Officer, EEOH Contracting Officer's Representative (COR), and COR if violator is a contractor employee.

16.4.2.4 Convene an emergency session of the RSC to review the case and recommend at what point operations are allowed to continue.

16.4.2.5 Enter all findings into SHETrak and track compliance with RSC requirements.

16.4.3 The RSC shall authorize continuation and reinstatement of radiation privileges as necessary in the form of a memorandum when determined necessary requirements have been met.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 52 of 63</b>

## APPENDIX A

### DEFINITIONS

Absorbed Dose. The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest; the traditional unit of absorbed dose is the rad; one rad equals 100 ergs/gram. The Systeme International (SI) equivalent is the gray (Gy). One gray equals 100 rad.

As Low As Reasonably Achievable (ALARA). Means making every reasonable effort to maintain exposures to ionizing radiation as far below the dose limits as practical, consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.

Alpha. A positively-charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to a helium nucleus with 2 protons and 2 neutrons, has a mass number of 4, and an electrostatic charge of +2. It has low penetrating power and a short range (a few centimeters in air). The most energetic alpha particle will generally fail to penetrate the dead layers of cells covering the skin and are easily stopped by a sheet of paper. Alpha particles are hazardous when an alpha-emitting isotope is inside the body.

Beam. An approximately-unidirectional flow of electromagnetic or particulate radiation.

Beta. A charged particle emitted from a nucleus during radioactive decay, with a mass equal to 1/1837 of a proton. A negatively-charged beta particle is an electron. A positively-charged beta particle is called a positron. Exposure to large amounts of beta radiation from external sources might cause skin burns (erythema). Beta emitters are also harmful if they enter the body. Thin sheets of metal or plastic stop beta particles.

Byproduct Material. Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or utilizing special nuclear material.

Code Designator. A coding system identifying each separate dosimeter with a specific period of time, the user installation, and the individual wearing the dosimeter.

Collimator. A device for confining a beam of particles or rays within a defined cross section.

Contaminated Area. Any area where the removable or fixed radioactive contamination exceeds the values in Appendix E.

Controlled Area. Any area whose access is restricted by the user for the purpose of limiting radiation exposure.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 53 of 63</b>

Count (Measurement of Radiation). The external indication of a device designed to enumerate ionizing events; it might refer to a single detected event or to the total events registered in a given period of time; the term is loosely used to designate disintegration, an ionizing event, or a voltage pulse.

Curie. The conventional unit for the quantity of a radioactive nuclide equivalent to  $3.7 \times 10^{10}$  disintegrations per second. The SI unit is the Becquerel (Bq). One Bq is one disintegration per second.

Dose. A general term used to refer to the effect on a material that is exposed to radiation. It is used to refer either to the amount of energy absorbed by a material exposed to radiation (absorbed dose) or to the potential biological effect in tissue exposed to radiation (dose equivalent).

Dose Equivalent. The product of absorbed dose in tissue (rad) multiplied by a radiation weighting factor (quality factor) to account for the potential for a biological effect resulting from the absorbed dose. The traditional dose equivalent unit is the rem. The SI unit is the sievert (Sv). One sievert equals 100 rem.

Dose Rate. Radiation dose delivered per unit time.

Dose Rate Meter. Any instrument that measures radiation dose rate.

Dosimeter. A device used to detect and measure an accumulated dose of radiation [e.g., TLD badge, finger ring].

Dosimetry. The theory and application of the principles and techniques involved in the measurement and recording of ionizing radiation doses.

External Radiation. Exposure to ionizing radiation when the source is outside the body.

Gamma. High-energy, short wavelength, electromagnetic radiation emitted from the nucleus of an atom. Gamma radiation frequently accompanies the emission of alpha and beta.

Half-Life. The time in which one-half of the activity of a particular radioactive substance is lost due to radioactive decay. Measured half-lives vary from millionths of a second to billions of years. Also called physical or radiological half-life.

High Radiation Area. Any area with dose rates greater than 100 mrem (1 millisievert) in 1 hour, 30 cm from the source, or from any surface through which the ionizing radiation penetrates.

Interlock. A device, usually electrical and/or mechanical in nature, that prevents operation of a system until a preliminary condition has been met or prevents hazardous operations; its purpose usually is the safety of personnel or equipment. For example, an interlock might be provided to prevent operation of a radiographic system until all access doors have been closed.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 54 of 63</b>

**Ionizing Radiation.** Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.

**Ionizing Radiation Producing Device (IRPD).** A device capable of producing electromagnetic or particulate radiation of sufficient energy to cause ionization in human tissue. For the purposes of this procedure, this is a device capable of producing x-radiation of an energy greater than 17 keV.

**Licensed Material.** Source material, special nuclear material, or byproduct material that is authorized for use by the NRC.

**Millirad (mrad).** 0.001 rad.

**Millirem (mrem).** 0.001 rem.

**Monitoring.** Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in an occupied region as a safety measure for purposes of health protection.

**Monitoring Period.** The length of time during which a badge is worn by the person being monitored. Usually, TLD badges are exchanged each calendar quarter.

**Nonexempt Byproduct Material.** Radioactive material in a quantity in excess of those amounts listed in 10 CFR Part 30.71 Schedule B.

**Rad.** The unit of absorbed dose (100 ergs/gram); measure of energy imparted to matter by ionizing particles per unit of mass of irradiated material at the point of interest.

**Radiation.** The energy propagated through space or through a material medium as waves; for example, energy in the form of electromagnetic waves or elastic waves. The term radiation or radiant energy, when unqualified, usually refers to electromagnetic radiation; such radiation commonly is classified, according to frequency, as radio, infrared, visible (light), ultraviolet, x-ray, and gamma ray. By extension, particulate emission such as alpha and beta radiation, or rays of mixed or unknown type such as cosmic radiation.

**Radiation Area.** Any area with radiation levels greater than 5 mrem (0.05 millisievert) in 1 hour at 30 cm from the source or from any surface through which the radiation penetrates.

**Radioactive Contamination.** Radioactive material deposited in any undesired place and particularly any place where its presence is harmful.

**Radioactive Material.** Any material, whether or not under licensing control of the NRC, that emanates electromagnetic and/or particulate radiations capable of producing ionization in the absorbing medium; includes both naturally-occurring radioactive elements as well as byproduct, source, and special nuclear material.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 55 of 63</b>

Radiographer. Any individual who performs or who, in attendance at the site where sources of radiation are being used, personally supervises industrial radiographic operations and who is responsible for ensuring compliance with the requirements of all applicable regulations and all license conditions.

Radiographer's Assistant. Any individual, who, under the personal supervision of a radiographer, uses sources of radiation, related handling tools, or survey instruments in industrial radiography.

Radiography. The examination of the structure of materials by nondestructive methods using ionizing radiation.

Radiological Survey. Evaluation of the radiation hazards incident to the production, use, or existence of radioactive materials or other sources of radiation under a specific set of conditions; such evaluation customarily includes a physical survey of the disposition of materials and equipment, measurements of estimates of the levels of radiation that can be involved, and a sufficient knowledge of processes using or affecting these materials to predict hazards resulting from expected or possible changes in materials or equipment.

rem (Roentgen Equivalent Man). The acronym for roentgen equivalent man is a standard unit that measures the effects of ionizing radiation on humans. The dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor of the type of radiation.

Responsible Person. The individual designated to be responsible for the safe operation of an IRPD such as an analytical x-ray device.

Restricted Area. See Controlled Area (Appendix A).

Roentgen (R). A unit of exposure to ionizing radiation (x or gamma rays) and is named after the German physicist Wilhelm Roentgen. It is the amount of radiation required to liberate positive and negative charges of one electrostatic unit of charge in 1 cm<sup>3</sup> of air at standard temperature and pressure (STP). This corresponds to the generation of approximately  $2.08 \times 10^9$  ion pairs.

Sealed Source. Radioactive material that is permanently bonded or fixed in a capsule or matrix designed to prevent release and dispersal of the radioactive material under the most severe conditions which are likely to be encountered in normal use and handling.

Sievert (Sv). The SI unit for dose equivalent equal to 1 Joule/kilogram. 1 sievert = 100 rem. Named for physicist Rolf Sievert.

Source Material. Uranium or thorium or any combination of uranium or thorium in any physical or chemical form, or ores containing by weight 0.05 percent or more of uranium or thorium or any combination of uranium or thorium. *Source material* does not include *special nuclear material*.

<b>Marshall Procedural Requirements</b>		
<b>AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 56 of 63</b>

Special Nuclear Material. (a) Plutonium, uranium enriched in the isotope 233 or in the isotope 235, and any other material the NRC determines to be special nuclear material, not including source material; or (b) any material artificially enriched by any of the foregoing, not including source material.

Thermoluminescence Dosimeter (TLD) Badge. A pack of thermo luminescent material (typically sulphurs) capable of absorbing energy from ionizing radiation and releasing this energy in the form of visible light when heated. The amount of light released is a relative measurement of dose.

Unimportant Quantity of Source Material. That amount of source material meeting the criteria of 10 CFR Part 40.13.

Very High Radiation Area. Any area accessible to personnel, where the dose rate at 1 meter from the source or any surface from which it penetrates exceeds 500 Rad/hr.

X-ray. High-energy, short wavelength, electromagnetic radiation capable of ionization which is emitted from other than the nucleus of an atom. Identical to a gamma ray except in origin.

X-Ray Area. Any area where an x-radiation hazard exists.



<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 57 of 63</b>

## APPENDIX B

### ACRONYMS

ALARA	As Low As Reasonably Achievable
Bq	Becquerel
CERTRAK	Certification Tracking Database
cm	Centimeter
COR	Contracting Officer's Representative
Cpm	Counts per minute
DOT	Department of Transportation
Dpm	Disintegrations per minute
EEOH	Environmental Engineering and Occupational Health Office
FMO	Facilities Management Office
Gy	Gray
IATA	International Air Transport Association
IRPD	Ionizing Radiation Producing Devices
keV	Kilo electron volts
LDE	Lens Dose Equivalent
mrاد	millirad
mrem	millirem
NRC	Nuclear Regulatory Commission
OI	Organizational Instruction
OSHA	Occupational Safety and Health Administration

<b>Marshall Procedural Requirements</b>		
<b>AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 58 of 63</b>

PSCC	Protective Services Control Center
R	Roentgen
RSC	Radiation Safety Committee
RSO	Radiation Safety Officer
SHETrak	Safety, Health, and Environmental-Finding Tracking System
SMA	Safety and Mission Assurance
SAP	System Applications and Products
SDE	Skin Dose Equivalent
SI	Systeme Internacional
STP	Standard Temperature and Pressure
Sv	Sievert
TEDE	Total Effective Dose Equivalent
TLD	Thermoluminescent dosimeter
uCi	Microcurie
uSv	Microsievert

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 59 of 63</b>

## **APPENDIX C**

### **VERIFICATION MATRIX (Reserved)**

None.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 60 of 63</b>

## APPENDIX D

### RECORDS

1. The following records are maintained according to the “List of Occupational Health Records” located at the following link: (<https://explornet.msfc.nasa.gov/community/msfc/office-of-center-operations/as10>).
- a. MSFC Form 4414, “Radiation Users Approval.”
- b. NRC Form 4, “Cumulative Occupational Dose History,” or equivalent.
- c. Inventories of licensed radioactive material.
- d. Leak test results of sealed sources.
- e. Records of receipt, transfer, and disposal of licensed radioactive material.
- f. Radiation program review report.
- g. Radiological surveys pertaining to radioactive materials.
- h. Test results of safety features of ionizing radiation producing devices and facilities.
- i. Radiation surveys of ionizing radiation producing devices and facilities.
- j. MSFC Form 4485, “Radiological Survey.”
- k. MSFC Form 4486, “Radiological Survey Map.”
- l. MSFC Form 4493, “Quality Control Guidance for Contractor Field Radiography Operations at MSFC.”
- m. Reports to the NRC on transfer of NRC General License items to the manufacturer (or distributor).
- n. MSFC Form 4497 “Quality Control Guidance for NASA X-Ray Field Radiography Operations at MSFC.”
- o. RSC meeting minutes.
- p. Initial NRC Materials License applications.
- q. NRC Materials License amendment applications.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 61 of 63</b>

- r. NRC Materials License renewal applications.
  - s. Correspondence with the NRC concerning Materials License applications.
  - t. Personnel training records for civil service employees.
  - u. Personnel training records for contractor employees.
  - v. MSFC Form 4624, Radioactive Material Inspection Form
  - w. MSFC Form 4625, Ionizing Radiation Producing Device Inspection Form
  - x. MSFC Form 4645, "Radioactive Material Use Request/Permit"
  - y. MSFC Form 4646, Ionizing Radiation Producing Device Use Request/Permit"
2. Dosimetry records of personnel exposure are maintained as lifetime records by the MSFC dosimetry provider.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 62 of 63</b>

## APPENDIX E

### MAXIMUM SURFACE CONTAMINATION VALUES

Radionuclide <sup>1</sup>	Removable (dpm/100 cm <sup>2</sup> ) <sup>2</sup>	Total (fixed + removable) (dpm/100 cm <sup>2</sup> ) <sup>3, 4</sup>
U-natural, depleted-U, U-235, U-238, and associated decay products, Th-nat, Th-232, Ra-223, Ra-224, U-232	200 alpha	1,000 alpha
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129, and any unknown alpha emitter	20 alpha or beta-gamma	100 <sup>8</sup> alpha or beta-gamma
Sr-90, I-126, I-131, I-133	200 beta-gamma	1,000 beta-gamma
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above. Includes mixed fission products containing Sr-90 <sup>5, 6</sup>	1,000 beta-gamma	5,000 beta-gamma
Tritium and tritiated compounds <sup>7</sup>	10,000 beta-gamma	N/A

<sup>1</sup>The values in this table apply to radioactive contamination deposited on, but not incorporated into the interior of, the contaminated item. This table does not apply to personnel contamination. Where contamination by both alpha- and beta-gamma-emitting nuclides is present, the limits established for the alpha- and beta-gamma-emitting nuclides apply independently.

<sup>2</sup>The amount of removable radioactive material per 100 cm<sup>2</sup> of surface area is determined by swiping the area with dry filter or soft absorbent paper while applying moderate pressure and then assessing the amount of radioactive material on the swipe with an instrument of known efficiency. For objects with a surface area of less than 100 cm<sup>2</sup>, the entire surface is swiped, and the activity per unit area is based on the actual surface area. Using swiping techniques to measure removable contamination levels is not required if direct scan surveys indicate that the total residual contamination levels are below the values for removable contamination.

*NOTE: The use of dry material may not be appropriate for tritium.*

<sup>3</sup>The levels can be averaged over 1 square meter provided the maximum activity in any area of 100 cm<sup>2</sup> is less than three times the values in the table.

<sup>4</sup>As used in this table, disintegrations per minute (dpm) means the rate of emission by radioactive material as determined by correcting the counts per minute (cpm) observed by a detector for background, efficiency, and geometric factors associated with the instrumentation.

<b>Marshall Procedural Requirements AS01</b>		
<b>MSFC Radiation Safety Procedural Requirements</b>	<b>MPR 1860.1</b>	<b>Revision: G</b>
	<b>Date: March 28, 2016</b>	<b>Page 63 of 63</b>

<sup>5</sup>This category of radionuclides includes mixed fission products, including any Sr-90 that is present. It does not apply to Sr-90 that has been separated from the other fission products or mixtures in which the Sr-90 has been enriched.

<sup>6</sup>The limits for average and maximum dose rates associated with surface contamination resulting from beta/gamma emitters are 0.2 mrad/hr and 1.0 mrad/hr, respectively, at 1 cm.

<sup>7</sup>Tritium contamination can diffuse into the volume or matrix of materials; thus, any evaluation of surface contamination includes determining the extent to which such contamination might migrate to the surface to ensure the surface radioactivity value provided in this table is not exceeded. Once this contamination migrates to the surface, it might be removable, not fixed; therefore, a “total” value does not apply.

<sup>8</sup>When measuring fixed contamination during a survey, the active area of the probe used is taken into account. (For example, if the active area is 100 cm<sup>2</sup> and the nuclide is natural uranium, then the 1000-dpm alpha/100 cm<sup>2</sup> limit applies. For a 40-cm<sup>2</sup> probe, 400 dpm alpha would be the limit because of the reduced active area of the probe.)