

**MPR 1860.2  
REVISION C**

**EFFECTIVE DATE: November 5, 2019  
EXPIRATION DATE: November 5, 2024**

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# **MARSHALL PROCEDURAL REQUIREMENTS**

**AS01**

## **NONIONIZING RADIATION SAFETY**

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### DOCUMENT HISTORY LOG

Status (Baseline/ Revision/ Change/ Revalidation/ Canceled)	Document Revision/ Change	Effective Date	Description
Baseline		10/23/2008	[On 2-23-10, at the request of the OPRD and concurrence from AS01 DCB Members, administrative changes were made at P.2 b. to clarify MAF role, at 2.1.1 and throughout changing RSO to LSO and adding NILSO/NIRSO, in 4.0 and CH2.3.1.2 deleted MSFC Form 4503, at CH1.21 clarified, at CH2.4.5 clarified, at CH2.6.10.3 clarified, added CH2.7.8.8, added CH3.5.6.4, added reference in Appendix F Note, and made grammar and capitalization corrections throughout.]
Revision	A	9/18/2013	Revised to comply with new MPR template; updated authority and applicable documents, and applicability statement.
Revision	B	6/9/2015	Deleted requirement to have initial laser eye exam as ANSI Z136.1 and NPR 1800.1 no longer require it. Deleted requirement to use MSFC Form 4083-2. Corrected step numbers within step 3.5.7 and 3.5.8.
Change	1	9/15/2016	On 9/15/16, at the request of the OPRD, admin changes were made to correct inaccurate references in Steps 3.1.2, 3.2.1, 4.1.2, and 4.2.1, and in Section 3.3, P.4, and Appendix D to split Form 4505 into two forms, 4505 and 4505-1. Corrected P.6 Cancellation to MPR 1860.2A.
Revision	C	11/5/2019	Revised section 3.1.3 to reflect the new certification approval procedures. Deleted requirement to use and references to MSFC Form 4083.

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## PREFACE

### **P.1 PURPOSE**

To establish centralized control over the use of nonionizing radiation producing devices (NRPD) to ensure that exposure are adequately controlled to prevent adverse effects on the health and safety of employees and to enact the requirements set forth in the Federal, NASA, and Consensus standards referenced in P.3 “Authority.”

### **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. 21 CFR Part 1010, Performance Standards for Electronic Products: General
- b. 21 CFR Part 1040, Performance Standards for Light-Emitting Products
- c. 29 CFR Part 1910.97, Nonionizing Radiation
- d. 29 CFR Part 1926.54, Nonionizing Radiation
- e. 29 CFR Part 1926.102, Eye and Face Protection
- f. NPR 1800.1, NASA Occupational Health Program Procedures
- g. MPD 1860.2, Radiation Safety Program

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

- a. MPR 8715.1, Marshall Safety, Health, and Environmental (SHE) Program
- b. MPR 8730.5, Metrology and Calibration
- c. MWI 3410.1, Personnel Certification Program
- d. MWI 5100.1, Initiating Procurement Requisitions
- e. MWI 8715.15, Ground Operations Safety Assessment Program
- f. American Conference of Governmental Industrial Hygienists (ACGIH), "TLVs and BEIs - Based on the Documentation of Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices"
- g. ANSI Z136.1, American National Standard for Safe Use of Lasers
- h. IEEE Standard C95.1, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300 GHz
- i. IEEE C95.2, Radio-Frequency Energy and Current-Flow Symbols
- j. MSFC Form 4504, Optical Device Use Request/Authorization
- k. MSFC Form 4505, Class 3B and 4 Laser Use Request
- l. MSFC Form 4505-1, Class 3B and 4 Laser Authorization
- m. MSFC Form 4506, Radio Frequency/Microwave System Use Request/Authorization

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

None.

## **P.6 CANCELLATION**

MPR 1860.2B, Nonionizing Radiation Safety, dated June 9, 2015.

*Electronically approved by*

Jody Singer  
Director

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## **CHAPTER 1. RESPONSIBILITIES**

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

1.1.1 Designates a Laser Safety Officer (LSO) and alternate to coordinate the nonionizing radiation safety program. This individual also functions as the Nonionizing Radiation Safety Officer (NIRSO).

1.1.2 Provides for initial and annual medical examinations as required.

1.1.3 Provides for ophthalmologic eye examinations, as required.

### 1.2 LSO/NIRSO:

1.2.1 Surveys, evaluates, determines, and approves actions needed to control hazards associated with operations involving the use of NRPDs.

1.2.2 Maintains a current inventory of all Class 3B and 4 lasers or laser systems at MSFC as well as hazardous Radio frequency (RF), ultraviolet (UV), and infrared (IR) radiation-producing devices.

1.2.3 Reviews and approves/disapproves plans, specifications, and operating procedures for all operations using hazardous NRPDs and approves or disapproves requests for deviations from established requirements.

1.2.4 Reviews and approves/disapproves all purchase requests for hazardous NRPDs.

1.2.5 Coordinates with Safety and Mission Assurance (SMA) Directorate to allow for appropriate Safety Assessment and Hazardous Operating Procedures to be reviewed and approved per MWI 8715.15 and MPR 8715.1.

1.2.6 Provides or approves safety training for all hazardous NRPD users.

1.2.7 Provides an annual detailed nonionizing radiation safety program review to the Radiation Safety Committee (RSC).

1.3 Manager, Facilities Management Office is responsible for ensuring that plans for construction or modification of facilities and equipment involving storage or use of hazardous NRPDs are approved by the LSO/NIRSO prior to starting construction or modification work.

1.4 Director, MSFC SMA Directorate is responsible for assuring appropriate Safety Assessment and Hazardous Operating Procedures are reviewed and approved per MWI 8715.15 and MPR 8715.1.

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1.5 Directors/Managers/Office Leads/Team Leads ensure that:

1.5.1 Responsibility for every hazardous NRPD used for research and development is clearly assigned to a Responsible Person.

1.5.2 Each user is trained to understand their responsibilities and the hazards associated with any NRPD under their control and is certified, as required, per MWI 3410.1.

1.5.3 All laboratory personnel are adequately familiar with radiological hazards and regulations.

1.5.4 Facility Organizational Instructions clearly define operating and safety procedures for NRPDs as well as the performance and documentation of any required safety system checks for the facility.

1.5.5 All nonionizing radiation survey instruments are calibrated according to schedule and repaired when necessary per MPR 8730.5.

1.5.6 All radiation survey instruments deemed “not repairable” are replaced.

1.5.7 All hazardous NRPDs included in the design of their equipment are identified.

1.5.8 Each hazardous NRPD is reviewed to:

1.5.8.1 Establish its necessity.

1.5.8.2 Ensure that the design and procedures optimize safety.

1.6 Director, Office of Procurement ensures proper approval of procurement documents per MWI 5100.1 prior to the purchase of any hazardous NRPD.

1.7 Director, Engineering Directorate provides calibration of portable nonionizing radiation survey instruments for facilities review per MPR 8730.5.

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## **CHAPTER 2. GENERAL PROCEDURES**

2.1 The following general provisions are provided to assist users of NRPDs under the purview of the MSFC Radiation Protection Program. NRPDs may be exempted from some or all of the MSFC Radiation Protection Program control requirements if the NRPDs have been appropriately analyzed, evaluated, and determined to be non-hazardous. Questions of program applicability regarding an NRPD shall be determined by the LSO/NIRSO and/or RSC.

2.2 MSFC is committed to having an efficient, effective nonionizing radiation safety program. Therefore, MSFC is committed to not only follow applicable Federal regulations but to also follow as closely as possible the guidelines listed in:

2.2.1 ANSI Z136 series of Standards for laser safety.

2.2.2 IEEE C95 series of Standards for radio frequency safety.

2.2.3 ACGIH publication, "TLVs and BEIs - Based on the Documentation of Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices" for UV, IR, and optical radiation.

2.3 All proposals for procurement and use of hazardous NRPDs shall be submitted to the LSO/NIRSO and/or RSC for review and approval prior to procurement and use. Procurement of replacement parts for existing authorized devices does not require approval.

2.4 Personnel responsible for planning construction or modification of facilities and equipment involving storage or use of hazardous NRPDs shall assure that Facilities Management is made aware that the project involves hazardous NRPDs so that the LSO/NIRSO is able to review and approve the plans.

2.5 Supervision shall assure that their personnel who work with hazardous NRPDs are familiar with and follow the requirements of this Directive and applicable group procedures.

2.6 Approved MSFC Forms shall be utilized in submittals to the LSO/NIRSO/RSC.

2.7 All receipt, internal transfer, and shipment of hazardous NRPDs shall be coordinated with and approved in advance by the LSO/NIRSO.

2.8 Constraints imposed upon the use of hazardous NRPDs shall be those required by applicable regulatory authorities and standards, and can include any additional constraints deemed necessary by the LSO/NIRSO and/or RSC.

2.9 Authorization for possession or use of hazardous NRPDs requires review by and approval of the RSC and/or the LSO/NIRSO. To begin the authorization process, submittal of the appropriate Use Request/Authorization form(s), as outlined in Chapters 2 & 3, is required.

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These forms, in conjunction with any necessary supportive data, shall be submitted as soon as practicable.

2.10 Operations involving hazardous NRPDs shall require a procedure(s), reviewed and signed off by the LSO/NIRSO and SMA prior to the start of operations, detailing the use of the device(s) and all radiological safety provisions.

2.11 Prior to utilizing hazardous NRPDs, individuals shall possess pertinent experience and/or have received training covering at least the following topics:

2.11.1 General description of the applicable radiation type and associated biological effects.

2.11.2 Basic principles of radiation protection.

2.11.3 Radiation protection procedures relevant to intended use.

2.11.4 Provisions of this procedure and appropriate regulations and standards.

2.11.5 Emergency procedures, as required.

2.12 Personnel subject to certain nonionizing radiation hazards may be required to obtain additional training and medical certification as deemed necessary by the LSO/NIRSO or the RSC.

2.13 Responsible Persons shall ensure all users of hazardous NRPDs under their purview are trained and certified per MWI 3410.1 (if required) prior to using the NRPD.

2.14 The LSO/NIRSO shall evaluate each use request to assess the potential hazards associated with the possession and use of the hazardous NRPD. Additional information may be requested and site inspections or surveys utilized in the course of the analysis and evaluation. The survey can be prior to and/or in conjunction with initial use of the NRPD.

2.15 The LSO/NIRSO shall perform periodic surveys of hazardous NRPDs to ensure compliance with procedures and controls described by the provisions of this procedure. These surveys are performed once annually as a minimum.

2.16 Authorization for possession and use of hazardous NRPDs can be rescinded by the LSO/NIRSO/RSC at any time as a result of noncompliance with the provisions of the nonionizing radiation safety program.

2.17 Unattended hazardous NRPDs shall be secured against unauthorized operation as required by their specific Use Request/Authorization form.

2.18 Loss or theft of hazardous NRPDs shall be immediately reported to the LSO/NIRSO.

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2.19 In addition to any other required notifications, all real or suspected incidents, accidents, or emergencies involving hazardous NRPDs shall be immediately reported to the LSO/NIRSO and MSFC Medical Center, or by calling 911 as appropriate.

2.20 Changes to authorized use, location, or Responsible Person of hazardous NRPDs shall be coordinated with and approved in advance by the LSO/NIRSO and at the discretion of the LSO/NIRSO, a new Use Request/Authorization form is required.

2.21 Use Request/Authorization forms shall be reviewed annually by the Responsible Person and LSO/NIRSO.

2.22 Individual users and use organizations shall ensure accountability for their devices and coordinate this effort with the LSO/NIRSO.

2.23 The LSO/NIRSO shall maintain an inventory of all approved hazardous NRPDs at MSFC.

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## **CHAPTER 3. LASERS AND OPTICAL RADIATION DEVICES**

### **3.1 General Requirements**

3.1.1 Procurement, possession, and use of lasers and optical radiation devices under the purview of the MSFC Nonionizing Radiation Safety Program requires approval by and coordination with the MSFC LSO/NIRSO and RSC. Notwithstanding such approvals, the unique nature of certain laser or optical radiation devices may cause regulatory agencies outside MSFC to require authorization or registration of the intended use and/or location of such devices.

3.1.2 Any organization or individual functioning under MSFC jurisdiction proposing to procure, possess, use, store, transfer, or dispose of laser or optical radiation devices that are not specifically exempted from MSFC Nonionizing Radiation Safety Program requirements (refer to paragraph 3.4) shall request and obtain authorization to do so. The LSO/NIRSO is the contact point of the MSFC Nonionizing Radiation Safety Program for coordination of such authorizations.

3.1.3 To be certified to use lasers at MSFC, an individual shall have an initial and annual medical examination and complete initial and annual laser safety training. The employee's supervisor will assign and manage employee requirements in CERTRAK and submit for issuance the Laser Operator (>Class 3B and 4) laser safety certification by promoting the employee's completed proficiency requirements in CERTRAK. The certification is then automatically issued to the next approver. If the employee is a contractor, the next approver is the organizational approver followed by the LSO/NIRSO or Radiation Safety Officer (RSO). If the employee is a civil servant, the next approver is the LSO/NIRSO or RSO. Once the LSO/NIRSO or RSO has promoted the employee's certification, the certification is issued and the employee's profile in CERTRAK is automatically updated.

### **3.2 Device Use Authorization and Control**

3.2.1 Unless specifically exempted by the provisions of section 3.4 of this chapter or by MSFC LSO/NIRSO direct action, MSFC Use Authorization is required for:

3.2.1.1 Lasers and laser systems, designated ANSI Class 3B or 4 (see Appendices B and C).

3.2.1.2 Non-laser optical radiation devices operating in the ultraviolet, visible, or infrared wavelength range of the electromagnetic spectrum with TLVs in excess of those listed in current issue of the ACGIH, "TLVs and BEIs - Based on the Documentation of Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices."

3.2.2 Responsible Persons, individual users, and use organizations shall ensure accountability for their NRPDs and coordinate this effort with the LSO/NIRSO.

3.2.3 Radiation Controlled Areas and Exclusion Areas as designated by the LSO/NIRSO and applicable user procedures shall be posted and controlled by the user.

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3.2.4 Warning signs and labels described by this procedure or their equivalent shall be utilized in all area postings and be reviewed and approved by the LSO/NIRSO.

3.2.5 Any laser or optical radiation device improperly transported onto MSFC shall be subject to impoundment until either the irregularities are corrected and appropriate authorizations are obtained or removal of the device is arranged.

3.2.6 As determined by the RSC and LSO/NIRSO, noncompliance with MSFC Nonionizing Radiation Safety Program requirements relative to the use of lasers or optical radiation devices shall result in the revocation or suspension of authorization and impoundment of the NRPD(s).

### **3.3 Requesting Authorization**

3.3.1 To request authorization to use lasers and optical devices the proper form shall be used.

3.3.1.1 MSFC Form 4505, "Class 3B and 4 Laser Use Request," shall be completed and submitted for evaluation of all intended uses of lasers and laser systems; including laser diodes not associated with Optical Fiber Communication System (OFCS), and lasers incorporated in equipment, instrumentation, or other devices. In cases where applicability of program requirements is unclear to the user organization and cannot otherwise be determined, just Sections I and II are completed and submitted for review and preliminary evaluation by LSO/NIRSO. Based upon this review, additional data and information may be required by the LSO/NIRSO to complete the authorization process.

3.3.1.2 MSFC Form 4504, "Optical Device Use Request/Authorization," shall be completed and submitted for evaluation of all intended uses of non-laser optical radiation devices. In cases where applicability of program requirements is unclear to the user organization and cannot otherwise be determined, just Sections I and II are completed and submitted for review and preliminary evaluation by the LSO/NIRSO. Based upon this review, additional data and information may be required by the LSO/NIRSO to complete the authorization process.

3.3.2 Elements of a complete data submittal package include, but may not necessarily be limited to:

3.3.2.1 The appropriate form as described by paragraph 3.3.1.1 or 3.3.1.2.

3.3.2.2 Copies of all applicable procedures relating to possession and use of the NRPD(s) for which authorization is being requested.

3.3.2.3 Listing, by full name, of all proposed user/operator personnel.

3.3.2.4 Copies of all applicable nonionizing radiation training certificates for use/operator personnel.

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3.3.3 Upon review of the 4505 form the LSO/NIRSO shall complete a MSFC 4505-1, Class 3B and 4 Authorization form, sign it, and forward it to the Responsible Person for signature. The form is then returned to the LSO/NIRSO and a copy posted at the work location.

3.3.4 Upon review of the MSFC Form 4504, “Optical Device Use Request/Authorization,” the LSO/NIRSO shall add the specific radiological safety requirements and sign the form. The LSO/NIRSO’s signature on the form constitutes the authorization for the use of the NRPD(s). The LSO/NIRSO keeps the original, and a copy is posted at the NRPD location.

3.3.5 Any intended changes to applicable procedures, licenses or registrations, facilities, personnel, or equipment or materials described by the current use authorization shall require the submittal of a new Use Request/Authorization form prior to the implementation of the intended changes. At the discretion of the LSO/NIRSO, minor changes can be made without submittal of a new form.

### **3.4 Exempt Devices**

3.4.1 A variety of commercially-available consumer, business, and industrial application laser and optical radiation devices are exempted from the authorization requirements of the Nonionizing Radiation Safety Program because of their common usage and negligible potential for hazardous exposure under conditions of normal use. Individuals shall consult with the LSO/NIRSO if there is a question regarding applicability of program exemption to their particular situation or device.

3.4.2 The following devices are exempt from control:

3.4.2.1 Lasers and laser systems which are designated Class 1, 1M, 2, 2M, and 3R such as laser printers, laser copiers, CD/DVD players, bar code scanners, laser pointers, etc.

3.4.2.2 Equipment utilizing non-laser optical devices such as photographic strobe units and high intensity discharge lamps utilized for facility lighting.

3.4.2.3 Infrared devices with accessible irradiance less than  $10 \text{ mW/cm}^2$  for an exposure of  $>1000$  seconds.

3.4.2.4 Visible radiation devices with accessible luminance less than 1 candela per square centimeter ( $\text{cd/cm}^2$ ).

3.4.2.5 Ultraviolet radiation devices with accessible effective irradiance of  $1.0 \text{ J/cm}^2 < 1000$  seconds &  $1.0 \text{ mW/cm}^2 > 1000$  seconds.

3.4.3 Exemptions are valid for the general categories of equipment, instruments, and systems identified above provided that:

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3.4.3.1 The individual item is maintained in its original design configuration and utilized for its originally-intended use over the useful life of the item.

3.4.3.2 The design and manufacture of the item is in accordance with the specifications of the Federal Performance Standard for Light Emitting Products (21 CFR Part 1040).

3.4.3.3 The item is operated in accordance with the manufacturer's recommended operating procedures.

3.4.4 Maintenance, service, or repair activities which could expose personnel to accessible levels of radiation equal to or greater than the levels described or implied are performed only by appropriately-authorized and qualified personnel.

3.4.5 Exemption of radiation devices from the authorization requirements of the Nonionizing Radiation Protection Program shall not be construed to exempt the user from other safety or health requirements relating to potential hazards associated with operation of the item, such as electrical hazards, fire hazards, heat, chemical exposures, harmful noise, explosion/fragmentation of glass envelopes, etc.

3.4.6 Notwithstanding the negligible potential nonionizing radiation hazard characteristically represented by exempted sources, users should avoid:

3.4.6.1 Close or prolonged direct viewing of the devices.

3.4.6.2 Intra-beam viewing conditions of any duration.

3.4.6.3 Viewing of specularly (mirror-like) reflected emissions from exempted devices.

### **3.5 Radiation Protection Controls for Lasers and Laser Systems**

3.5.1 The following general considerations shall be given to lasers and laser systems set up:

3.5.1.1 Radiation protection controls shall be devised to reduce the possibility of exposure of the eye or skin to hazardous levels of laser radiation and to other hazards associated with the operation of laser devices during normal operation and maintenance.

3.5.1.2 For all uses of lasers and laser systems, the minimum level of laser radiation required for the application shall be utilized.

3.5.1.3 Where possible, the laser beam height shall be maintained at a level other than the normal position of the eye of a person in the standing or seated position.

3.5.1.4 Engineering control measures (items incorporated into the laser or laser system and/or laser installation by design) shall be given primary consideration for limiting access to laser radiation.

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3.5.1.5 If engineering controls are impractical or inadequate, administrative controls and protective equipment shall be used to limit access to laser radiation.

3.5.2 Required engineering control measures described in this procedure can, upon review and approval by the LSO/NIRSO, be replaced by administrative or alternate engineering controls which provide equivalent protection. The following are required engineering controls:

3.5.2.1 A protective housing shall be provided for all classes of lasers or laser systems.

3.5.2.2 Protective housings which enclose embedded Class 3B or Class 4 lasers or laser systems shall be provided with an interlock system which is activated when the protective housing is intended to be opened during operations and maintenance.

3.5.2.3 Fail-safe interlocks shall be provided for any portion of the protective housing which, by design, can be removed or displaced during normal operations and maintenance and thereby allowing access to radiation of an embedded Class 3B or Class 4 laser.

3.5.2.4 Portions of the protective housing which are intended to be removed only by service personnel and permit direct access to embedded Class 3B or Class 4 laser radiation shall:

- a. Either be interlocked or require a tool for removal.
- b. Have an appropriate warning label on the panel.
- c. If the interlock can be bypassed or defeated, have a warning label located on or near the interlock.

3.5.2.5 A Class 4 laser or laser system shall be provided with a master switch which is operated by a key or by coded access (computer code).

3.5.2.6 The master switch shall be disabled when the laser or laser system is not intended to be used.

3.5.2.7 If a key is used the key shall be removed from the laser. It is recommended that the same system be used on Class 3B lasers and laser systems.

3.5.2.8 All viewing portals and display screens included as an integral part of a Class 3B or Class 4 laser or laser system shall incorporate a suitable means (filters, interlocks, attenuators) to maintain the laser radiation at the viewing position at or below the applicable Maximum Permissible Exposure (MPE) for all conditions of operation and maintenance.

3.5.2.9 All collecting optics, such as lenses, telescopes, microscopes, endoscopes, etc., intended for viewing use with a Class 3B or Class 4 laser or laser system shall incorporate a suitable means (filters, interlocks, attenuators) to maintain the laser radiation at the viewing position at or below the applicable MPE for all conditions of operation and maintenance.

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3.5.2.10 A Class 4 laser or laser system shall be provided with a remote interlock connector such that when the terminals of the remote interlock connector are open circuited, the accessible radiation level does not exceed the appropriate MPE levels. It is recommended that the same system be used on Class 3B lasers and laser systems.

3.5.2.11 A Class 4 laser or laser system shall be provided with a permanently attached beam stop or attenuator which is capable of preventing access to laser radiation in excess of the appropriate MPE level when the laser or laser system output is not required. It is recommended that the same system be used on Class 3B lasers and laser systems.

3.5.2.12 An audible alarm, a warning light (visible through protective eyewear), or a verbal countdown command shall be used for Class 4 lasers or laser systems during activation or startup which is distinctive and clearly identifiable as being associated with the emission of laser radiation. It is recommended that the same system be used on Class 3B lasers and laser systems.

3.5.2.13 For Class 4 lasers or laser systems, the warning system shall be activated a sufficient time prior to emission of laser radiation to allow appropriate action to be taken to avoid exposure to the laser radiation.

3.5.2.14 Class 4 lasers and laser systems shall be monitored and activated from remote positions unless approved by the LSO/NIRSO. It is preferable for the remote console to also include a laser activation warning system.

3.5.3 Administrative controls are methods or instructions which specify rules or work practices, or both, which implement or supplement engineering controls and which may specify the use of personal protective equipment (PPE). The following are required administrative controls:

3.5.3.1 Written operating, maintenance, service, and emergency procedures shall be provided and maintained for reference by operator, maintenance, and service personnel.

3.5.3.2 The laser or laser system Responsible Person and users shall take such action as is necessary and approved by the LSO/NIRSO to reduce levels of accessible power or radiant energy to that which is commensurate with the required application.

3.5.3.3 Responsible Persons, users, maintenance, or service personnel shall have education and training commensurate with the level of potential hazard. All personnel working with Class 3B or Class 4 lasers are required to have initial and annual laser safety training.

3.5.3.4 Class 3B and Class 4 lasers or laser systems shall be operated, maintained, and serviced only by personnel certified per MWI 3410.1.

3.5.3.5 Alignment of optical systems for Class 3B or Class 4 lasers or laser systems shall be performed in such a manner that the primary beam, as well as any specular or diffuse reflection of the beam, does not expose the eye or skin to laser radiation levels above the applicable MPE.

3.5.4 Control of the laser beam path shall be accomplished as described in the following:

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3.5.4.1 In applications of Class 3B or Class 4 lasers or laser systems where the entire beam path is unenclosed, a laser radiation control area based upon the Nominal Ocular Hazard Distance (NOHD) and the Nominal Hazard Zone (NHZ) shall be established and appropriate control measures implemented based upon the classification associated with the maximum accessible level of laser radiation. Typically, the NHZ is the entire room housing the laser.

3.5.4.2 In applications of Class 3B or Class 4 lasers or laser systems where the beam path is confined by design to significantly limit the degree of accessibility of the open beam, a laser radiation control area based upon the magnitude and extent of the accessible level of laser radiation shall be established.

3.5.4.3 In applications of lasers and laser systems of all classes where the entire beam path is enclosed, and the enclosure meets the requirements of a protective housing, the requirements of Class 1 are fulfilled, and no further area controls are required.

3.5.5 All Class 3B laser radiation control areas shall be approved by the LSO/NIRSO and:

3.5.5.1 Be controlled to permit lasers and laser systems to be operated only by personnel who have been trained in laser safety and in the operation of the laser or laser system.

3.5.5.2 Be posted with appropriate LSO/NIRSO approved, laser warning signs.

3.5.5.3 Be operated in a manner such that the beam path is well defined.

3.5.5.4 Be well-defined and controlled if the laser beam extends outdoors and projects into a controlled airspace.

3.5.6 Depending on the situation and at the discretion of the LSO/NIRSO, Class 3B laser radiation control areas shall also require the following:

3.5.6.1 Be so located that access to the area by unauthorized personnel is limited and requires prior approval for entry;

3.5.6.2 Have any potentially hazardous beam terminated in a beam stop of an appropriate material.

3.5.6.3 Have only diffuse reflective materials in or near the beam path, where feasible.

3.5.6.4 Have personnel within the controlled area provided with appropriate eye protection.

3.5.6.5 Have the laser secured so the beam path is above or below eye level of personnel in standing or seated positions.

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3.5.6.6 Have all windows, doorways, open portals, etc., from an indoor facility be either covered or restricted in such a manner as to reduce the transmitted laser radiation to levels at or below the appropriate MPE.

3.5.6.7 Storage or disabling of the laser or laser system, when not in use, to prevent unauthorized access.

3.5.7 In addition to all the requirements for Class 3B laser radiation control areas listed in 3.5.5 and 3.5.6, Class 4 laser radiation control areas shall require the following:

3.5.7.1 All area/entryway safety controls shall be designed to allow rapid egress by personnel at all times and admittance to the area under emergency conditions.

3.5.7.2 For emergency conditions, a minimum of one clearly marked “Panic Button” shall be available for deactivating the laser or reducing the output to the appropriate MPE levels.

3.5.8 In addition to fulfilling all the requirements of 3.5.7, the Class 4 laser radiation control area shall incorporate one of the following alternatives:

3.5.8.1 Non-defeatable (non-override) area or entryway safety controls to deactivate the laser or reduce its output in the event of unexpected entry.

3.5.8.2 Defeatable area or entryway safety controls but only if it is clearly evident that there is no laser radiation hazard at the point of entry and that there are only authorized personnel with approved personal safety equipment allowed access.

3.5.8.3 Procedural area or entryway safety controls such as a barrier to block, screen, or attenuate laser radiation levels at the entryway, provided that only authorized personnel with approved personal safety equipment are allowed access, and a visible or audible signal at the entryway to indicate a Class 4 laser is energized.

3.5.9 All outdoor use of lasers or laser systems shall require a separate Laser Use Request/Authorization and the following controls apply:

3.5.9.1 The area shall be posted with appropriate LSO/NIRSO approved, laser warning signs.

3.5.9.2 All lasers and laser systems shall be operated only by personnel who have been trained in laser safety and in the operation of the laser or laser system.

3.5.9.3 Unprotected, untrained, and unauthorized personnel shall be excluded from the beam path at all points where the appropriate MPE is exceeded.

3.5.9.4 Appropriate combinations of physical barriers, screening, protective eye and body wear, or appropriate administrative controls shall be used if operator personnel are required to be in the NHZ.

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3.5.9.5 Directing the laser beam toward automobiles, aircraft, or other manned vehicles or structures shall be prohibited within the NHZ unless adequate training is provided to and used by all affected personnel, or as is authorized by the LSO/NIRSO.

3.5.9.6 Federal Aviation Administration approval shall be obtained prior to any use of a laser which might possibly affect aircraft.

3.5.9.7 The laser beam path shall not be maintained at or near eye level.

3.5.9.8 The beam path shall be confined and terminated where possible.

3.5.9.9 When the laser is not being used, it shall be disabled in such a manner to prevent unauthorized use.

3.5.10 In those conditions where removal of panels or protective housings, overriding of protective housing interlocks, or entry into the NHZ becomes necessary (such as for service), and the accessible laser radiation exceeds the applicable MPE, a temporary laser control area which, by its nature does not have the built in protective features as defined for a laser control area, shall be established and:

3.5.10.1 Shall provide all safety requirements for all personnel, both within and without the area.

3.5.10.2 Shall be posted with a notice sign(s) outside the temporary laser control area to warn of the potential hazard.

3.5.10.3 Personnel working inside the temporary laser control area shall maintain surveillance over the area to preclude unauthorized entry.

3.5.11 Protective eyewear shall be worn whenever operational conditions may result in a potential laser radiation eye hazard. All protective eyewear:

3.5.11.1 Shall be clearly labeled with the optical density and wavelength for which protection is afforded (color coding or other distinctive identification of laser protective eyewear is recommended in multilaser environments).

3.5.11.2 Shall be comfortable and prevent exposure to hazardous peripheral radiation.

3.5.11.3 Shall be periodically inspected.

3.5.12 Where personnel may be exposed to levels of laser radiation that clearly exceed the MPE for the skin, particularly in the ultraviolet wavelength range, protective clothing shall be utilized.

3.5.13 Laser warning signs and labels shall be utilized as described in ANSI Z136.1, American National Standard for Safe Use of Lasers and:

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3.5.13.1 The inclusion and choice of warning information or precautionary instructions shall follow the guidelines of ANSI Z136.1, unless otherwise specified by the Use Authorization.

3.5.13.2 All signs and labels shall be conspicuously displayed in locations where they will best serve to warn unauthorized personnel.

3.5.14 In some laser applications, other associated hazards require consideration. Associated hazards shall be evaluated and appropriate control measures taken by the laser user organization. Examples of some associated hazards are:

3.5.14.1 High-voltage sources and wiring.

3.5.14.2 X-ray radiation from high voltage equipment.

3.5.14.3 High-voltage equipment and intense beams of ultraviolet light producing hazardous concentrations of ozone requiring additional ventilation.

3.5.14.4 Toxic or combustible materials used with laser systems.

3.5.14.5 Cryogenic liquids.

3.5.14.6 Laser generated air contaminants.

### **3.6 Radiation Protection Controls for OFCS**

3.6.1 OFCS generally utilize Class 1 or Class 3B laser diodes, or Light-emitted Diode (LED) sources which generally emit incoherent energy at wavelengths greater than 700 nm and power levels significantly less than laser diode sources.

3.6.2 During normal system operation, OFCS are completely enclosed systems operating as Class 1 laser systems and there is no accessible emission. During service or installation activities, i.e., when connectors are removed or different connectors utilized for testing purposes, there is a risk of exposure.

3.6.3 There are several different categories of test sets in use with OFCS, e.g., optical loss test set (OLTS), optical time domain reflectometer (OTDR), and optical bandwidth test set. Although some OTDRs use Class 1 lasers, many OTDRs and OLTSs use Class 3B lasers. An OFCS test set is itself considered an OFCS.

3.6.4 The following controls shall be used for OFCS using Class 3B or higher lasers:

3.6.4.1 Only approved authorized personnel shall be permitted to install or perform service on OFCS.

3.6.4.2 Safety connectors shall be utilized in uncontrolled areas.

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3.6.4.3 When the laser classification for an OFCS has not been determined or verified, safety connectors should be used in all areas where the OFCS is subject to uncontrolled access, and the OFCS should be treated as using a Class 3B or 4 laser until the actual classification is determined.

3.6.4.4 For OFCS in uncontrolled areas, when the service group is known and cannot be changed to a higher service group anywhere within the OFCS and where safety connectors are not used, labels as described by paragraph 2.6.8 shall be used and placed in plain view on the equipment in the vicinity of the connectors, e.g., outlets, patch panels, patch cords.

3.6.5 Under some conditions of OFCS installation or service, e.g., splicing, removal of optical connectors, etc., there may be accessible emission. Under these disconnect conditions, the administrative and procedural controls described below shall be followed.

3.6.5.1 All personnel not approved and authorized by the LSO/NIRSO shall be excluded from the NHZ during installation and service when there is a possibility that these systems may become energized.

3.6.5.2 During installation or service, a broken optical fiber or un-terminated connector shall only be viewed with an indirect image converter or with a filtered optical instrument of optical density sufficient to reduce accessible emission to levels below the applicable MPE, unless it has been verified all optical transmitters have been turned off.

3.6.5.3 Laser diode or LED sources on a fiber shall be de-energized or viewing systems incorporating personal protection employed during all splicing operations that require viewing the end of a fiber of an OFCS.

3.6.5.4 Connectors which may emit hazardous levels of optical radiation shall have affixed a warning label as described by paragraph 2.6.8, unless a sign having the same wording is posted conspicuously nearby as for an area with a large number of connectors; e.g., an equipment bay or cable closet.

3.6.5.5 Eye protection devices which are specifically designed for protection against Class 3B or 4 lasers shall be procedurally required when engineering or other procedural control measures are inadequate to eliminate potential exposure in excess of the applicable MPE.

3.6.5.6 During service or installation of OFCS where access panels or doors are removed or opened and the critical viewing distance could exceed 100 centimeters, means shall be used to contain the beam to preclude exposure of nearby personnel.

3.6.5.7 Written operating, maintenance, service, and emergency procedures shall be provided for reference by installation, operator, maintenance, and service personnel.

3.6.6 Personnel working with OFCS incorporating Class 3B or 4 lasers shall be certified per MWI 3410.1.

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3.6.7 Protective eyewear shall be worn whenever operational conditions may result in a potential laser radiation eye hazard. All protective eyewear:

3.6.7.1 Shall be clearly labeled with the optical density and wavelength for which protection is afforded (color coding or other distinctive identification of laser protective eyewear is recommended in multilaser environments).

3.6.7.2 Shall be comfortable and prevent exposure to hazardous peripheral radiation.

3.6.7.3 Shall be periodically inspected.

3.6.8 Warning labels used with OFCS shall have wording as described below or equivalent:

3.6.8.1 For OFCS incorporating Class 3B or 4 lasers the label shall state:

“DANGER DISCONNECTED OPTICAL CONNECTORS MAY EMIT OPTICAL  
RADIATION - AVOID DIRECT EYE EXPOSURE TO THE BEAM.”

3.6.8.2 For all infrared systems, the words “INVISIBLE RADIATION” shall be used in place of “OPTICAL RADIATION.”

3.6.8.3 For all visible systems, the words “OPTICAL ENERGY” can be substituted for the words “OPTICAL RADIATION.”

3.6.9 All labels and signs shall comply with the following:

3.6.9.1 All signs and labels shall be conspicuously displayed in locations where they will best serve to warn unauthorized personnel.

3.6.9.2 Connectors which may emit Class 3B or 4 laser radiation shall have affixed a warning label, unless a sign having the same wording is posted conspicuously nearby.

3.6.9.3 In lieu of or in addition to warning labels, a sign shall be used in areas with a large number of connectors, e.g., equipment bay or cable closet.

3.6.9.4 Labels shall be placed in plain view on the equipment in the vicinity of the connectors, e.g., outlets, patch panels, patch cords.

3.6.10 In some OFCS applications, other associated hazards may require consideration. Associated hazards shall be evaluated and appropriate control measures taken by the user organization. Examples of associated hazards are:

3.6.10.1 Glass particles or shards from optical fibers imbedding in skin or clothing.

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3.6.10.2 Optical photocuring devices causing exposure to ultraviolet radiation and viewing of the light source.

3.6.10.3 Exposure to chemicals used for stripping, cleaning, and splicing operations.

### **3.7 Radiation Protection Controls for Non-laser Optical Radiation Sources**

3.7.1 Non-laser optical radiation sources include devices which emit non-coherent radiation in the wavelength range from 100 nm to 1 mm. Emissions from such devices may be relatively limited in spectral distribution, i.e., ultraviolet lamps, infrared heat lamps, or may radiate across the spectrum, emitting ultraviolet, visible, and infrared wavelengths simultaneously. Table 3.1 below provides a summary of potential exposure hazards for some typical optical radiation sources.

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Table 3.1  
Examples of Optical Radiation Sources

<b>Source Description</b>	<b>Principal Emission Range</b>	<b>Potential Effects of Overexposure</b>	<b>Potentially Exposed Population</b>
SUNLIGHT	Ultraviolet, Visible, and Near Infrared	Skin Cancer; Cataracts; Sunburn; Premature Skin Aging; Retinitis	Outdoor Workers; Sunbathers; General Population
ARC LAMPS	Ultraviolet, Visible, and Near Infrared	Photokeratitis; Erythema; Skin Cancer; Retinal Injury	Printing Plant Camera Operators; Optical Laboratory Workers; Entertainers
GERMICIDAL LAMPS	Ultraviolet	Erythema; Photokeratitis; Skin Cancer	Hospital Workers; Workers in Sterile Laboratories
CARBON ARC LAMPS	Ultraviolet, Blue Light	Photokeratitis; Erythema	Searchlight Operators; Certain Laboratory Workers
METAL HALIDE LAMPS	Ultraviolet, Visible	Cataracts; Photosensitive Skin Reactions; Retinal Injury	Printing Plant Maintenance Workers; IC Manufacturing Workers
SUNLAMPS	Ultraviolet, Blue Light	Photokeratitis; Erythema; Premature Skin Aging; Skin Cancer	Sun Tan Parlor Customers; Home Users
WELDING ARCS	Ultraviolet, Blue Light	Photokeratitis; Erythema; UV Cataract; Retinal Injury	Welders' Helpers, Welders
INDUSTRIAL INFRARED SOURCES	Infrared	Radiant Heat Stress; Infrared Cataract	Steel Mill Workers; Foundry Workers; Workers Using Infrared Drying Equipment

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3.7.2 The following general considerations shall be given to optical radiation device use:

3.7.2.1 Radiation protection controls shall be devised to reduce the possibility of exposure of the eye or skin to hazardous levels of optical radiation.

3.7.2.2 For all uses of optical radiation devices, it is recommended the minimum level of radiation required for the application be utilized.

3.7.2.3 Engineering control measures (items incorporated into the optical device or optical system by design) shall be given primary consideration for limiting access to optical radiation.

3.7.2.4 If engineering controls are impractical or inadequate, administrative and procedural controls and protective equipment shall be used to limit access to optical radiation.

3.7.3 Because of the varying nature of non-laser optical radiation devices, definition of engineering control requirements in the context of this procedure is limited to a listing of engineering control features which could be utilized, depending upon the specific device and the method of use. The following engineering controls are required where applicable:

3.7.3.1 Protective housings shall be used where practicable to limit accessibility to the device emission.

3.7.3.2 Protective housings which enclose optical devices or systems shall be provided with an interlock system which is activated when the protective housing is intended to be opened during operations and maintenance.

3.7.3.3 Viewing portals and display screens included as an integral part of an optical device shall incorporate a suitable means (filters, interlocks, attenuators) to maintain the optical emission at the viewing position at or below the applicable protection guide.

3.7.3.4 Collecting optics, such as lenses, telescopes, microscopes, endoscopes, etc., intended for viewing use shall incorporate suitable means (filters, interlocks, attenuators) to maintain optical emissions at or below the applicable protection guide for all conditions of operation and maintenance.

3.7.4 Administrative and procedural controls are methods or instructions which specify rules or work practices, or both, which implement or supplement engineering controls and which may specify the use of PPE. These controls can include, but are not limited to, access restrictions; eye protection; area controls; and education and training requirements for operators. The following are administrative controls:

3.7.4.1 Written operating, maintenance, service, and emergency procedures shall be provided and maintained with the optical device or system for reference by operator, maintenance, and service personnel.

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3.7.4.2 The device or system Responsible Person shall take such action as is necessary and approved by the LSO/NIRSO to reduce levels of accessible power or radiant energy to that which is commensurate with the required application.

3.7.4.3 Operators, maintenance, or service personnel shall have education and training commensurate with the level of potential hazard.

3.7.4.4 Optical devices and systems with accessible emission levels exceeding the appropriate protection guide shall be operated, maintained, and serviced only by authorized personnel.

3.7.4.5 Alignment of optical systems shall be performed in such a manner that the primary beam, or a specular or diffuse reflection of a beam, does not expose the eye or skin to optical radiation levels above the applicable protection guide.

3.7.5 Protective eyewear shall be worn whenever operational conditions may result in a potential radiation eye hazard. All protective eyewear:

3.7.5.1 Shall be clearly labeled with the optical density and wavelength for which protection is afforded.

3.7.5.2 Shall be comfortable and prevent exposure to hazardous peripheral radiation.

3.7.5.3 Shall be periodically inspected.

3.7.6 Where personnel may be exposed to levels of optical radiation that clearly exceed the MPE for the skin, particularly in the ultraviolet wavelength range, protective clothing shall be utilized. Where personnel may be subject to chronic skin exposure from scattered ultraviolet radiation, skin protection could be required even at levels below the applicable protection guide for skin exposure.

3.7.7 Areas containing hazardous optical radiation devices shall be posted with appropriate LSO/NIRSO approved warning signs.

3.7.8 In some applications, other associated hazards may require consideration. Associated hazards shall be evaluated and appropriate control measures taken by the user organization. The following are examples of associated hazards:

3.7.8.1 High-voltage sources and wiring.

3.7.8.2 High-voltage equipment may produce x-radiation.

3.7.8.3 High-voltage equipment and intense levels of ultraviolet light may produce hazardous concentrations of ozone.

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3.7.8.4 All electrical equipment properly grounded.

3.7.8.5 Flash lamps may explode.

3.7.8.6 Certain industrial lamps are manufactured with a quartz envelope to shield the ultraviolet portion of the lamp's emission. Failure of this envelope could result in an unexpected ultraviolet hazard, even if the lamp is of the 'self-extinguishing' variety.

3.7.8.7 Certain lamps are pressurized and may present an explosive hazard if improperly handled, especially with bare hands. The oil on the hands can degrade the integrity of the lamp and cause it to fail.

3.7.8.8 Exposure to chemicals associated with operations involving optical radiation producing devices.

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## **CHAPTER 4. RADIO FREQUENCY/MICROWAVE RADIATION DEVICES**

### **4.1 General Provisions**

4.1.1 Procurement, possession, and use of RF/microwave radiation devices under the purview of the MSFC Nonionizing Radiation Protection Program require approval by and coordination with the LSO/NIRSO and RSC. Notwithstanding such Radiation Protection Program approvals, the unique nature of certain RF/microwave radiation devices may cause regulatory agencies outside MSFC to require authorization or registration of the intended use and/or location of such devices. It is noted, however, that such outside authorization or registration is required in addition to and concurrently with MSFC Nonionizing Radiation Protection Program approval.

4.1.2 Any organization or individual functioning under MSFC jurisdiction proposing to procure, possess, use, store, transfer, or otherwise dispose of RF/microwave devices that are not specifically exempted from MSFC Nonionizing Radiation Protection Program requirements (refer to paragraph 4.4, Exempt Devices) shall request and obtain authorization to do so. The MSFC LSO/NIRSO is the contact point of the MSFC Nonionizing Radiation Protection Program for coordination of such authorizations.

4.1.3 To use RF/microwave devices at MSFC, operators, maintenance, or service personnel shall have education and training commensurate with the level of potential hazard. There are currently no routine medical surveillance requirements for users of radiofrequency/microwave radiation systems.

### **4.2 Device Use Authorization and Control**

4.2.1 Unless specifically exempted by the provisions of paragraph 4.4 or by the LSO/NIRSO/RSC, use authorization is required for any RF/microwave radiation device operating at frequencies between 3kHz and 300 GHz, including but not limited to:

4.2.1.1 Radar systems.

4.2.1.2 Communications systems.

4.2.1.3 Microwave generators.

4.2.1.4 RF generators.

4.2.2 Radiation-Controlled Areas and Exclusion Areas, as designated by the LSO/NIRSO and applicable user procedures, shall be posted and controlled by the user.

4.2.3 Warning signs and labels described by this procedure or their equivalent shall be utilized in all area postings and be reviewed and approved by the LSO/NIRSO.

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4.2.4 Any RF/microwave radiation device improperly transported onto MSFC shall be subject to impoundment until either the irregularities are corrected and appropriate authorizations are obtained or removal of the device is arranged.

4.2.5 Non-compliance with MSFC Nonionizing Radiation Protection Program requirements relative to the authorized use of RF/microwave radiation devices shall result in the revocation or suspension of such use authorization and impoundment of radiation devices.

### **4.3 Requesting Authorization**

4.3.1 MSFC Form 4506, Radio Frequency/Microwave System Use Request/Authorization, shall be completed and submitted for evaluation of all controlled sources, including radar units, communication systems, satellite earth stations, and RF/microwave generators. In cases where applicability of program requirements is unclear to the user organization and cannot otherwise be determined, just Sections I and II are submitted for review and preliminary evaluation by the LSO/NIRSO. Based upon this review, additional data and information may be required by the LSO/NIRSO to complete the authorization process.

4.3.2 Elements of a complete data submittal package for Use Authorization include, but may not necessarily be limited to, those described below:

4.3.2.1 MSFC Form 4506, Radio Frequency/Microwave System Use Request/Authorization.

4.3.2.2 Licenses or other appropriate registrations possessed by the user organization to own, maintain, and use the specific radiation device, if applicable.

4.3.2.3 All applicable operating, maintenance, and emergency procedures relating to possession and use of the radiation device(s) for which authorization is being requested.

4.3.2.4 A listing, by full name, of all proposed user/operator personnel.

4.3.2.5 Approximate dates of arrival and departure of the specified radiation device(s) to and from MSFC (if use is temporary).

### **4.4 Exempt Devices**

4.4.1 A variety of commercially-available consumer, business, and industrial application RF/microwave radiation devices are exempted from the authorization requirements of the Nonionizing Radiation Protection Program because of their common usage and negligible potential for hazardous exposure under conditions of normal use. However, such exemption is valid only when certain conditions are met. Individuals shall consult with the LSO/NIRSO if there is a question regarding applicability of program exemption to their particular situation or requirement.

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4.4.2 The following devices are exempt from controls:

4.4.2.1 Devices with transmitter power of 7 watts or less and an antenna gain of unity (“walkie-talkies,” cellular phones, etc.), at frequencies between 100 kHz and 450 MHz.

4.4.2.2 Speed monitoring devices (“radar-guns”).

4.4.2.3 Antennas designed to only receive and not transmit RF/microwave radiation.

4.4.2.4 Personal, break room, or cafeteria microwave ovens.

4.4.2.5 RF/microwave radiation devices designed for and operated in a completely enclosed configuration where no open air transmission is possible.

4.4.2.6 Devices or systems which have been shown by documented worst case analysis that they are incapable of emitting radiation levels greater than one half (50 percent) of current applicable maximum permissible exposures levels.

4.4.3 Exemptions are valid for the general categories of equipment, instruments, and systems identified by paragraph 4.4.2 provided that:

4.4.3.1 The individual item is maintained in its original design configuration and utilized for its originally-intended use over the useful life of the item.

4.4.3.2 The design and manufacture of the item is in accordance with the specifications of the Performance Standard for Electronic Products: General (21 CFR Part 1010).

4.4.3.3 The item is operated in accordance with the manufacturer's recommended operating procedures.

4.4.3.4 Maintenance, service, or repair activities which could expose personnel to accessible levels of radiation equal to or greater than the levels described or implied in paragraph 3.4.2 shall be performed only by appropriately authorized and qualified personnel.

4.4.4 Exemption of radiation devices from the authorization requirements of the MSFC Nonionizing Radiation Protection Program shall not be construed to exempt the user from other safety requirements relating to potential hazards.

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## **4.5 Radiation Protection Controls for Radio Frequency/Microwave Devices**

4.5.1 The following general considerations shall be given to radio frequency/microwave operations:

4.5.1.1 Radiation protection controls shall be devised to reduce the possibility of exposure of personnel to hazardous levels of RF/microwave radiation and to other hazards associated with the operation of RF/microwave devices during normal operation and maintenance.

4.5.1.2 For all uses of RF/microwave systems, the minimum level of RF/microwave radiation required for the application shall be utilized.

4.5.1.3 RF/microwave transmitter beam height shall be maintained at a level not to intercept occupied facilities/structures and/or personnel within the identified hazard distance.

4.5.1.4 Engineering control measures (items incorporated into the RF/microwave system installation by design) shall be given primary consideration for limiting access to RF radiation.

4.5.2 Engineering control measures may, upon review and approval by the MSFC LSO/NIRSO, be replaced by administrative controls, personnel protective equipment, or other engineering controls which provide equivalent protection. The following are required engineering controls:

4.5.2.1 Access panels to high voltage cabinets for RF/microwave systems which are intended to be opened only by service personnel and permit direct access to high voltage components shall be either interlocked or require a tool for removal and have an appropriate warning label on the panel.

4.5.2.2 If an interlock can be bypassed or defeated, a warning label shall be located on or near the interlock.

4.5.2.3 Mechanical and/or electrical antenna azimuth and elevation stops shall be utilized to inhibit movement of the transmitting antenna beyond established azimuth and elevation guidelines.

4.5.2.4 When required by the provisions of the applicable MSFC Use Authorization, a blue rotating light and a sign explaining the purpose for the light shall be installed near the antenna site and activated when the RF system is transmitting.

4.5.3 Administrative controls are methods or instructions which specify rules or work practices, or both, which implement or supplement engineering controls and which may specify the use of PPE. The following are required administrative controls:

4.5.3.1 Written operating, maintenance, service, and emergency procedures shall be provided and maintained with the RF/microwave system for reference by operator, maintenance, and service personnel.

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4.5.3.2 The RF/microwave system Responsible Person and operators shall take such action as is necessary and approved by the LSO/NIRSO to reduce levels of accessible power to that which is commensurate with the required application.

4.5.3.3 Operators, maintenance, or service personnel shall have education and training commensurate with the level of potential hazard.

4.5.3.4 RF/microwave systems with accessible emission levels exceeding the MPE published in IEEE Std C95.1 shall be operated, maintained, and serviced by qualified and trained personnel.

4.5.4 RF/microwave radiation control areas shall be approved by the LSO/NIRSO and:

4.5.4.1 Shall be posted with the appropriate warning sign(s) as described by paragraph CH4.5.5.

4.5.4.2 Shall be operated by and under the control of MSFC-approved operator personnel.

4.5.4.3 Shall have all untrained and unauthorized personnel excluded from the radiological controlled area at all points where the appropriate MPE is exceeded.

4.5.4.4 Shall not have radiating antennas or other RF/microwave generators positioned in such a manner as to intercept occupied facilities/structures and/or personnel within the identified hazard zone.

4.5.4.5 Shall not have the RF/microwave beam path exceed the established elevation and azimuth restrictions listed on the Use Request/Authorization.

4.5.4.6 Shall have the RF/microwave beam path terminated when possible.

4.5.4.7 Shall have the RF/microwave system locked or disabled in a manner to prevent unauthorized activation when not being used.

4.5.5 RF warning signs and labels shall be utilized as described in IEEE C95.2, Radio-Frequency Energy and Current-Flow Symbols and:

4.5.5.1 The inclusion and choice of warning information or precautionary instructions shall follow the guidelines of IEEE C95.2, unless otherwise specified by the Use Authorization.

4.5.5.2 All signs and labels shall be conspicuously displayed in locations where they will best serve to warn unauthorized personnel.

4.5.6 In some RF/microwave applications, other associated hazards require consideration. Associated hazards shall be evaluated and appropriate control measures taken by the RF user organization. Examples of associated hazards are:

4.5.6.1 Unshielded high-voltage sources and wiring.

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4.5.6.2 High-voltage equipment which produce x-radiation and require shielding.

4.5.6.3 Electrical equipment not properly grounded.

4.5.6.4 Exposure to chemicals, noise, or other hazards associated with processes involving RF/microwave producing devices.

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## APPENDIX A

### DEFINITIONS

Accessible Emission Limit (AEL). The maximum accessible emission level permitted for a particular laser hazard class.

Beam. A collection of light/photonic rays characterized by direction, diameter (or dimensions), and divergence (or convergence).

Beam Diameter. The distance between diametrically-opposed points in that cross section of a laser beam where the power per unit area is  $1/e$  (0.368) time that of the peak power per unit area.

Beam Divergence. The increase in the diameter of the laser beam with distance from the exit aperture, based on the full angle at the point where the irradiance (or radiant exposure for pulsed lasers) is  $1/e$  times the maximum value.

Class 1 Laser. Any laser or laser system that cannot emit accessible laser radiation levels in excess of the Class 1 AEL for the maximum possible duration inherent in the design or intended use of the laser or laser system during normal operation. Thus, these lasers or laser systems are exempt from all control measures or other form of surveillance with the exception of applicable requirements for embedded lasers. The exemption strictly applies to emitted laser radiation hazards and not to other potential hazards.

Class 1M Laser. Any laser or laser system that cannot emit accessible laser radiation levels in excess of the Class 1 AEL under the conditions of measurement for the unaided eye, but exceeds the Class 1 AEL for telescopic viewing and does not exceed the Class 3B AEL for any emission duration inherent in the design or intended use of the laser or laser system, is a Class 1M laser or laser system.

Class 2 Laser. Any visible (0.4 to 0.7  $\mu\text{m}$ ) laser or laser system which can emit accessible radiant energy exceeding the appropriate Class 1 AEL for the maximum possible duration inherent in the design or intended use of the laser or laser system during normal operation, but not exceeding the Class 1 AEL for any applicable pulse duration  $<0.25$  seconds and not exceeding an accessible radiant power of 1 mW.

Class 2M Laser. Any laser or laser system that cannot emit accessible laser radiation levels in excess of the Class 2 AEL under the conditions of measurement for the unaided eye, but exceeds the Class 2 AEL for telescopic viewing and does not exceed the Class 3B AEL for any emission duration inherent in the design or intended use of the laser or laser system is a Class 2M laser or laser system.

Class 3R Laser. Lasers and laser systems which have an accessible output between 1 and 5 times the Class 1 AEL for wavelengths shorter than 0.4  $\mu\text{m}$  or greater than 0.7  $\mu\text{m}$ , or less than 5 times the Class 2 AEL for wave lengths between 0.4 and 0.7  $\mu\text{m}$ .

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Class 3B Laser. ANSI Z136.1 states “Lasers and laser systems having wavelengths shorter than 0.4  $\mu\text{m}$  or greater than 0.7  $\mu\text{m}$  which can emit accessible radiant power in excess of Class 3R AEL for the maximum duration inherent in the design of the laser or laser system, but which (a) cannot emit an average radiant power in excess of 0.5 W for  $\geq 0.25$  seconds or (b) cannot produce a radiant energy greater than 0.125 J within an exposure time  $< 0.25$  s. Lasers and laser systems having wavelengths between 0.4 and 1.4  $\mu\text{m}$  which emit in excess of Class 3R AEL but which (a) cannot emit an average radiant power in excess of 0.5 W for  $\geq 0.25$  seconds and (b) cannot emit a radiant energy greater than 0.03  $C_A$  J per pulse.  $C_A$  being the correction factor which increases the MPE in the near infrared spectral band (0.7 to 1.4  $\mu\text{m}$ ) based upon reduced absorption properties of melanin pigment granules found in the skin and in the retinal pigment epithelium.”

Class 4 Laser. Lasers and laser systems that emit radiation that exceed Class 3B AEL.

Coherent. A beam of light characterized by a fixed phase relationship (spatial coherence) or single wavelength, i.e., monochromatic (temporal coherence).

Diffuse Reflection. Change of the spatial distribution of a beam of radiation when it is reflected in many directions by a surface or by a medium.

Hazardous NRPD. A device capable of producing nonionizing radiation of a type and of sufficient energy to cause biological harm in humans.

Infrared Radiation. Electromagnetic radiation having a wavelength from 0.75  $\mu\text{m}$  to 1 mm.

Laser. A device that produces radiant energy predominantly by stimulated emission. Laser radiation may be highly coherent temporally, spatially, or both.

Laser System. An assembly of electrical, mechanical, and optical components which includes a laser.

Microwave Radiation. A subset of radio frequency radiation having frequencies ranging from 300 MHz to 300GHz.

Maximum Permissible Exposure (MPE). That level of radiation to which an unprotected individual may be exposed without adverse biological effects.

Nominal Hazard Zone (NHZ). The space within which the level of direct, reflected, or scattered radiation exceeds the applicable MPE.

Nominal Ocular Hazard Distance (NOHD). The distance along the axis of the unobstructed beam from a laser, fiber end, or connector to the human eye beyond which the irradiance or radiant exposure does not exceed the applicable MPE.

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NRPD. Any device capable of producing radiation with a wavelength greater than 100nm, i.e., radiofrequency, microwave, infrared, visible, or ultraviolet radiation.

Optical Fiber Communication System (OFCS). A system consisting of one or more laser or light emitting diode (LED) transmitters, each of which is coupled to an individual optical fiber and which is used for the transmission of information, e.g., voice, or data.

Radio Frequency (RF). For the purposes of this Directive, electromagnetic radiation with a frequency between 3kHz and 300 GHz.

Responsible Person. That individual listed on the applicable Use Request/Authorization form that is responsible for the safe use of the NRPD(s).

Specular Reflection. A mirror-like reflection.

Survey. Inspection of an area or item to determine the presence and extent of any radiological hazard present.

Threshold Limit Value (TLV). That level of exposure to which individuals may be repeatedly exposed without adverse health effects.

Ultraviolet Radiation. Electromagnetic radiation having wavelengths ranging from 100 to 400 nm.

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## APPENDIX B

### ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
AEL	Accessible Emission Limit
ANSI	American National Standards Institute
BEI	Biological Exposure Index
C <sub>A</sub>	Correction factor
CD	Compact Disk
cd	candela
CFR	Code of Federal Regulations
cm <sup>2</sup>	square centimeters
DVD	Digital Video Disk
EEOH	Environmental Engineering and Occupational Health
GHz	Gigahertz
Hz	Hertz
IC	Integrated Circuit
IEEE	Institute of Electrical and Electronics Engineers
IR	Infrared
J	Joule
kHz	Kilohertz
Laser	Light Amplification by Stimulated Emission of Radiation
LED	Light Emitting Diode

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LSO	Laser Safety Officer
MHz	Megahertz
MPE	Maximum Permissible Exposure
MPR	Marshall Procedural Requirements
mm	Millimeter
mW	milliWatt
MWI	Marshall Work Instruction
NHZ	Nominal Hazard Zone
NIRSO	Nonionizing Radiation Safety Officer
NOHD	Nominal Ocular Hazard Distance
NRPD	Nonionizing Radiation Producing Devices
nm	Nanometer
OFCS	Optical Fiber Communication Systems
OLTS	Optical Loss Test Set
OTDR	Optical Time Domain Reflectometer
PPE	Personal Protective Equipment
RF	Radiofrequency
RSC	Radiation Safety Committee
RSO	Radiation Safety Officer
SMA	Safety and Mission Assurance
Std	Standard
TLV	Threshold Limit Value

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UV      Ultraviolet

W      Watt

e      Base e natural log (2.718281828)

μm      Class 3R laser (Appendix A)

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APPENDIX C

VERIFICATION MATRIX (Reserved)

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## APPENDIX D

### RECORDS

The following records are maintained according to the “List of AS10 Occupational Health Records” located at the following link: (<https://explornet.msfc.nasa.gov/community/msfc/office-of-center-operations/as10>).

D.1 MSFC Form 4504, Optical Device Use Request/Authorization

D.2 MSFC Form 4505, Class 3B & 4 Laser Use Request

D.3 MSFC Form 4505-1, Class 3B and 4 Laser Authorization

D.4 MSFC Form 4506, RF/Microwave System Use Request/Authorization

D.5 Surveys, audits, inventories, and reports

D.6 Civil service training records

D.7 Contractor training records

D.8 Medical Records