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## **Kennedy NASA Procedural Requirements**

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# **KSC Nonionizing Radiation Protection Program**

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National Aeronautics and  
Space Administration

John F. Kennedy Space Center

## **TABLE OF CONTENTS**

### **PREFACE**

- P.1 Purpose
- P.2 Applicability
- P.3 Authority
- P.4 References
- P.5 Supersession

### **SECTION 1 GENERAL DESCRIPTION**

- 1.1 Organization

### **SECTION 2 RADIATION PROTECTION PROGRAM DEFINITIONS**

### **SECTION 3 PROGRAM RESPONSIBILITIES**

- 3.1 KSC Radiation Protection Committee
- 3.2 KSC Radiation Protection Officer
- 3.3 Joint Base Operations Support Contractor Element for Health Physics Services
- 3.4 Heads of Primary Organizations
- 3.5 Area Radiation Officers
- 3.6 Use Supervisor/Custodian
- 3.7 Each User
- 3.8 Directors, Safety, and Mission Assurance Organizations
- 3.9 Director, Center Operations
- 3.10 Director, Engineering Development
- 3.11 Director, Procurement Office
- 3.12 Director, External Relations and Business Development
- 3.13 Directors of Spacecraft Processing Operations
- 3.14 Contracting Officers

### **SECTION 4 ADMINISTRATIVE PROVISIONS FOR CONTROL OF NONIONIZING RADIATION SOURCES**

- 4.1 General Provisions
- 4.2 Procurement Authorization
- 4.3 Possession and Use Authorization
- 4.4 User Qualifications
- 4.5 Hazard Analysis and Evaluation
- 4.6 Radiation Protection Surveys
- 4.7 Assigned Controls
- 4.8 Scheduling and Notifications
- 4.9 Waivers, Deviations, and Suspensions
- 4.10 Loss or Theft of Nonionizing Radiation Devices
- 4.11 Unattended Nonionizing Radiation Devices
- 4.12 Incidents, Accidents, and Emergencies

- 4.13 Modification of Use Authorization
- 4.14 Annual Renewal

## **SECTION 5 CONTROL PROVISIONS FOR THE USE OF LASERS AND OPTICAL RADIATION SOURCES**

- 5.1 General
- 5.2 Registration
- 5.3 KSC Required Authorizations and Provisions
- 5.4 Program Exemptions
- 5.5 Radiation Protection Controls for Lasers and Laser Systems
- 5.6 Radiation Protection Controls for Optical Fiber Communication Systems
- 5.7 Radiation Protection Controls for Optical Radiation Devices
- 5.8 Laser Pointers

## **SECTION 6 CONTROL PROVISIONS FOR THE USE OF RADIOFREQUENCY (RF)/MICROWAVE EQUIPMENT**

- 6.1 General
- 6.2 Registration
- 6.3 KSC Required Authorizations and Provisions
- 6.4 Program Exemptions
- 6.5 Radiation Protection Controls for Radiofrequency/Microwave Systems

## **APPENDICES**

- A Radiation Incident Notifications
- B Medical Surveillance Requirements
- C Radiation Protection for Nonionizing Radiation
- D Glossary

## **PREFACE**

### **P.1 Purpose**

This KNPR describes KSC Radiation Protection Program provisions including requirements, and controls relating to the procurement, possession, and use of nonionizing radiation producing devices.

### **P.2 Applicability**

These provisions apply to all organizational and user elements under the jurisdiction or direction of NASA at the Kennedy Space Center (KSC), NASA/KSC facilities and personnel located on the U.S. Air Force Space Command, 45th Space Wing (45th SW) and the U.S. Air Force Space Command, 30th Space Wing, Vandenberg AFB, and other KSC work sites.

**P.3 Authority**

- a. KNPD 1860.1 KSC Radiation Protection Program.

**P.4 References**

- a. Air Force Occupational Safety and Health (AFOSH) Standard 48-9 (as revised), "Exposure to Radiofrequency Radiation"
- b. AFOSH Standard 48-10 (as revised), "Health Hazards Control for Laser Radiation"
- c. American Conference of Governmental Industrial Hygienists (ACGIH), "TLVs - Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes"
- d. American National Standards Institute (ANSI)/IEEE Standard C95.1 (as revised), "Safety Levels With Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz"
- e. ANSI Standard C95.3 (as revised), "Techniques and Instrumentation for the Measurement of Potentially Hazardous Electromagnetic Radiation at Microwave Frequencies"
- f. ANSI Standard C95.5 (as revised), "Recommended Practice for the Measurement of Hazardous Electromagnetic Fields-RF and Microwave"
- g. ANSI Standard Z136.1 (as revised), "Safe Use of Lasers"
- h. ANSI Standard Z136.2 (as revised), "Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources"
- i. ANSI Z136.6 (as revised) "American National Standard for the Use of Lasers Outdoors"
- j. ANSI Standard Z136.3 (as revised), "Safe Use of Lasers in Health Care Facilities"
- k. 45 SW Instruction 40-201, "Radiation Protection Program"
- l. 45 SW Instruction 127-1, "Range Safety Manual"
- m. KNPD 1800.1 (as revised), "Environmental Health Program"
- n. KNPD 1860.1 (as revised), "KSC Radiation Protection Program"
- o. State of Florida Administrative Code (FAC) Chapter 64E-5, "Control of Nonionizing Radiation Hazards"

- p. Title 21 Code of Federal Regulations Parts 1000-1040
- q. Title 29 Code of Federal Regulations Parts 1926.54 and 1910.97
- r. Title 47 Code of Federal Regulations Parts 15 and 300
- s. United States Army Environmental Hygiene Agency, Laser and Optical Hazards, February 1989
- t. United States Army Environmental Hygiene Agency, Radiofrequency/Ultrasound Hazards, April 1989
- u. Safety With Lasers and Other Optical Sources, A Comprehensive Handbook, Sliney and Wolbarsht, Plenum Press 1980
- v. DEPARTMENT OF HEALTH AND HUMAN SERVICES, Public Health Services, Food and Drug Administration, Center for Devices and Radiological Health.

#### **P.5 Supersession**

This KNPR cancels and supersedes the provisions and requirements of KHB 1860.2, Revision C.

Michael J. Benik  
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## SECTION 1 GENERAL DESCRIPTION

### 1.1 ORGANIZATION

Three major organizational elements make up the KSC Radiation Protection Program. Functions and responsibilities of these organizational elements are summarized below. Figure 1-1 describes the functional structure of the KSC Radiation Protection Program, including these three major elements.

a. KSC Radiation Protection Committee (RPC)

The Committee consists of four executive members, and not more than 12 primary members, including the KSC Radiation Protection Officer. The Committee develops policy and requirements to assure adequate facilities, equipment, training and operational and emergency controls are maintained for all operations utilizing nonionizing radiation-producing devices. The Committee approves or disapproves all uses of controlled radiation-producing devices.

b. KSC Radiation Protection Officer (RPO)

The KSC RPO is responsible for functional implementation and the administration of the Radiation Protection Program at KSC. Specifically, the RPO assures that operations involving nonionizing radiation producing devices are performed in accordance with applicable Federal, State, and local regulations, and other pertinent health and safety standards. The KSC RPO also serves as the KSC liaison for formal contact and coordination with other agencies regarding radiation protection matters.

c. Joint Base Operations Support Contractor Element Providing Health Physics Services (JBOSC HP)

The JBOSC HP, responsive to the Center Operations Directorate Aerospace Medicine and Occupational Health Branch, acts as the functional representative of the KSC RPO. Functional responsibilities of the JBOSC HP include technical review and evaluation of radiation sources and their use, consultations with users of nonionizing radiation producing devices, maintenance of the nonionizing radiation device inventory, and general surveillance, monitoring, and implementation of the KSC Nonionizing Radiation Protection Program.

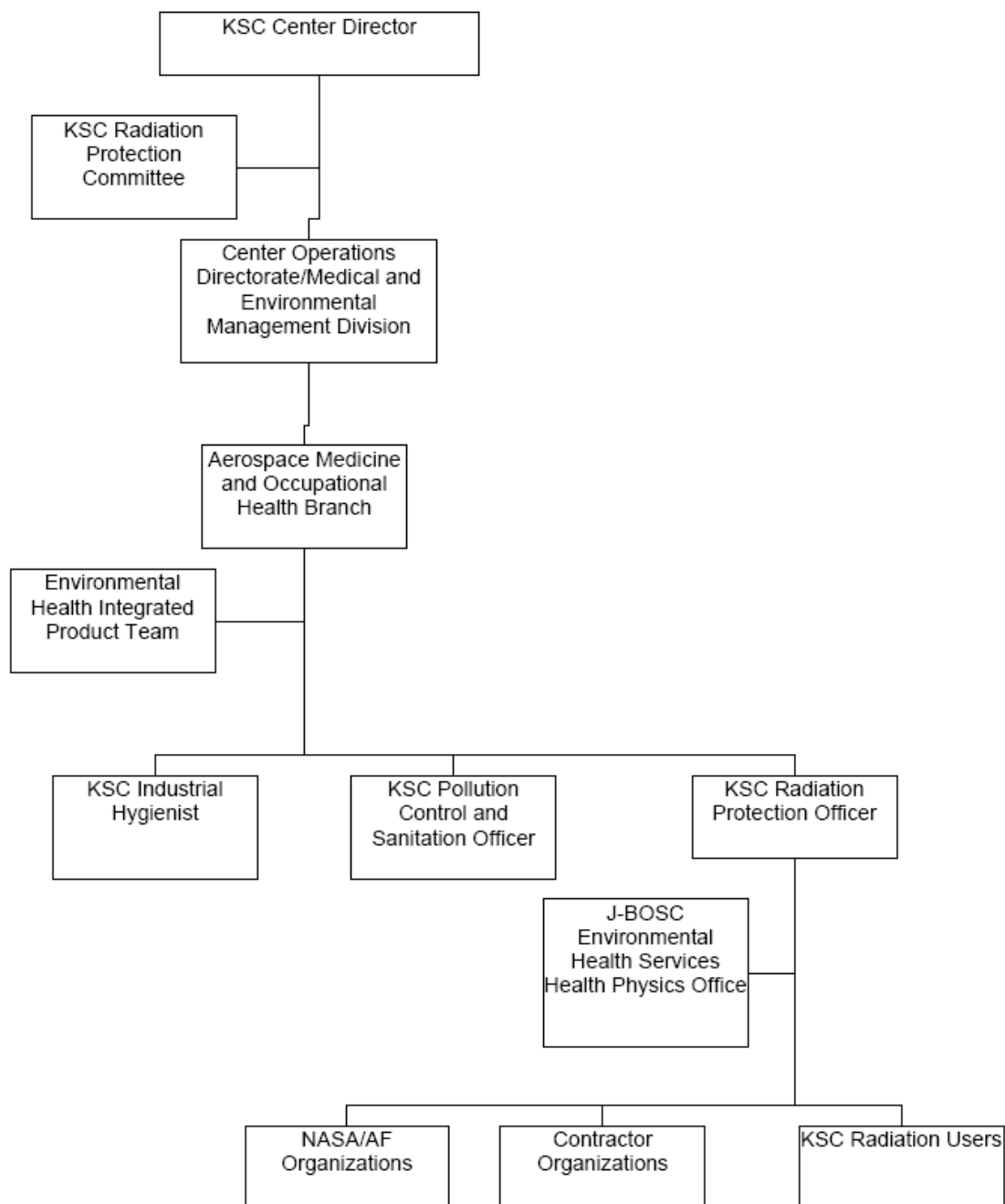


Figure 1-1  
Functional Structure of the KSC Radiation Protection Program

## SECTION 2 RADIATION PROTECTION PROGRAM DEFINITIONS

The definitions included in this Section are important to the proper description of program provisions and are provided here to promote user understanding of subsequent sections of this KNPR.

- 2.1 AREA RADIATION OFFICER (ARO) - The individual designated by the user organization's management as their representative for matters pertaining to the local control of authorized radiation sources.
- 2.2 AUTHORIZED PERSONNEL - Individuals approved by the RPO for activities occurring under the auspices of an approved Use Authorization.
- 2.3 HAZARD EVALUATION - A comprehensive technical review and theoretical analysis of formally submitted data and information related-to Use Authorization, Modification of Radiation Use Authorization, etc., in order to assess radiation hazard potentials and establish necessary controls.
- 2.4 HAZARD SURVEY - An onsite technical inspection or audit of material, systems, personnel, procedures, or devices covered by a Use Authorization. Such a survey may involve the physical measurement of radiation and the evaluation of precautionary control measures, as applicable.
- 2.5 HEALTH PHYSICS - The professional discipline dedicated to the protection of humans and their environment from unwarranted radiation exposure.
- 2.6 LASER - A device which produces an intense, coherent, and directional beam of radiation by stimulating electronic or molecular transitions to lower energy states.
- 2.7 LASER FACILITY - A facility which has one or more Class 2, 3, or 4 lasers. In the case of facilities possessing more than one laser class, the assigned facility classification shall be determined by the most hazardous class of laser contained therein.
- 2.8 LASER SYSTEM - An assembly of electrical, mechanical, and optical components which includes a laser.
- 2.9 MAINTENANCE - Performance of those adjustments or procedures specified in user information provided by the manufacturer with the nonionizing radiation device or system, which are to be performed by the user to ensure the intended performance of the device or system. Does not include 'operation' or 'service', as defined in this KNPR.
- 2.10 MICROWAVE RADIATION - Electromagnetic radiation with frequencies that lie within the range 300 MHz to 300 GHz.



2.11 NONIONIZING RADIATION -

- a. Electromagnetic radiation which is not capable of producing ionization when interacting with matter but is capable of producing thermal or other effects resulting in a personnel health hazard.
- b. That portion of the electromagnetic spectrum which includes the frequency and wavelength characteristics associated with ultraviolet, visible, and infrared radiation, radiofrequency, and microwaves.

2.12 NONIONIZING RADIATION PRODUCING DEVICE, NONIONIZING SOURCE - Any device capable of producing nonionizing radiation that has the potential for producing a health hazard to user personnel.

2.13 OPERATION/USE - The performance of a nonionizing radiation device or system over the full range of its intended function (normal operation/use). Does not include 'maintenance' or 'service' as defined in this KNPR.

2.14 OPTICAL FIBER COMMUNICATION SYSTEM (OFCS) - A system consisting of one or more laser or 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.

2.15 OPTICAL RADIATION - For the purposes of the Nonionizing Radiation Protection Program and this KNPR, optical radiation is used as a general term to describe nonlaser electromagnetic radiation including infrared, visible, and ultraviolet wavelengths.

2.16 RADIATION CONTROLLED AREA (RCA) - An area established where access to, occupancy of, and activities within, are controlled for the purpose of radiation protection.

2.17 RADIATION EXCLUSION AREA - An area established for the purpose of radiation protection to which entry and occupancy of personnel is prohibited.

2.18 RADIATION INCIDENT - Any unusual occurrence, accident, or emergency involving a radiation source(s).

2.19 RADIATION PROTECTION COMMITTEE (RPC) - At KSC, a committee composed of representatives from various directorates to assure adequate protection of personnel under KSC jurisdiction from the harmful effects of nonionizing radiation.

2.20 RADIATION PROTECTION OFFICER (RPO) - At KSC, the representative from the Spaceport Services Occupational Health Branch who is authorized to serve as an executive member of the RPC, and act for KSC on all matters related to nonionizing radiation protection.

2.21 RADIOFREQUENCY (RF) RADIATION - Electromagnetic radiation with frequencies that lie within the range 3 kHz to 300 GHz.

- 2.22 SCANNING LASER - A laser having a time-varying direction, origin, or pattern of propagation with respect to a stationary frame of reference.
- 2.23 SERVICE - The performance of those procedures or adjustments described in the manufacturer's service instructions which may affect any aspect of the performance of the nonionizing radiation device or system. Does not include 'maintenance' or 'operation' as defined in this KNPR.
- 2.24 SHALL - The word "shall" is to be understood as mandatory.
- 2.25 SHOULD - The word "should" is to be understood as advisory.
- 2.26 UNCONTROLLED AREA - Any area to which access is not controlled by the user for purposes of protection from radiation hazards.
- 2.27 USE AUTHORIZATION (UA) - An approval issued by the RPO, following review of the Use Request submittal, for the use of a specific radiation source by specified personnel, use location, and radiation protection control provisions.
- 2.28 USE REQUEST - A data package composed of appropriate KSC forms and attachments as described by Sections 5 and 6 of this KNPR. The Use Request is submitted to the KSC Radiation Protection Officer, through the JBOSC Health Physics Office (HPO), to obtain a Use Authorization for nonionizing radiation devices.
- 2.29 USER - Any NASA, contractor, or other personnel involved in the operation or use of nonionizing radiation producing devices under KSC jurisdiction.
- 2.30 USER ORGANIZATION - Any NASA, contractor, or other organization which has direct responsibility for the operational possession and use of nonionizing radiation producing devices.
- 2.31 USE SUPERVISOR/CUSTODIAN (US/C) - Designated onsite user who is authorized to act on behalf of the Area Radiation Officer during ARO absence.

### **SECTION 3 PROGRAM RESPONSIBILITIES**

**3.1 THE KSC RADIATION PROTECTION COMMITTEE (RPC) is responsible for:**

- a. Ensuring the development and maintenance of KSC Nonionizing Radiation Protection Program policies on behalf of the Center Director.
- b. Reviewing and approving uses of controlled nonionizing radiation devices.
- c. Advising the Radiation Protection Officer in the execution of duties as designated in KNPD 1860.1.
- d. Providing oversight of KSC radiological regulatory matters.

**3.2 THE KSC RADIATION PROTECTION OFFICER (RPO) is responsible for:**

- a. Providing general surveillance over users of radiation sources.
- b. Acting as liaison officer for the KSC Radiation Protection Program to ensure compliance with the applicable regulatory agencies' requirements relative to all nonionizing radiation related activities and regulatory matters for KSC.
- c. Acting as liaison officer between KSC and other nonregulatory agencies, parties, contractors, etc., relative to nonionizing radiation matters.
- d. Providing technical guidance to KSC organizations on nonionizing radiation related matters and acting as the functional representative of the RPC.
- e. Auditing the recordkeeping systems of the Nonionizing Radiation Protection Program for KSC pertinent to applicable requirements for licenses, registrations, and reports.
- f. Performs contract oversight role by participating in the Environmental Health Integrated Process Team, lead by the Joint Performance Office (JPMO), responsible for reviewing and accessing JBOSC contract indicators.
- g. Assuming technical control; initiating investigations; and directing corrective actions in nonionizing radiation incidents and emergencies for KSC and coordinating mishap reporting and investigation requirements with the appropriate KSC Safety and Mission Assurance Directorate, and/or KSC Protective Services Branch, as appropriate.
- h. Assuring proper disposition of nonionizing radiation records for all employees, both Government and contractor, upon their termination of employment or transfer from KSC.

- i. Representing the RPC and speaking and acting for KSC on matters of policy and procedures relating specifically to control of nonionizing radiation sources for KSC.
  - j. Making interim approvals for the Radiation Protection Committee, subject to subsequent RPC ratification.
- 3.3 THE KSC JOINT BASE OPERATIONS SUPPORT CONTRACTOR (JBOSC) ELEMENT FOR HEALTH PHYSICS SERVICES (HP), shall, to the extent provided by contract, provide services to include:
- a. Operational implementation of the Nonionizing Radiation Protection Program for KSC under the direction of the RPO.
  - b. Providing, in the RPOs absence and after formal notification by the RPO, an individual to act on behalf of the Radiation Protection Officer.
  - c. Maintenance of appropriate licenses and registrations with associated records and reports in compliance with applicable regulatory agencies' requirements.
  - d. Providing general surveillance functions for the KSC Nonionizing Radiation Protection Program.
  - e. Providing technical evaluation of proposed uses of nonionizing radiation, making recommendations, and providing other assistance to the RPO on matters concerning nonionizing radiation protection.
  - f. Acting as the field representative of the KSC Nonionizing Radiation Protection Program and as liaison between user organizations and the RPO on radiological matters.
  - g. Performing onsite surveillance, inspections, surveys, or monitoring of nonionizing radiation uses and users, as required.
  - h. Provide radiation protection training if needed for Use Authorization approval or if requested through the RPO. Such training shall be provided on a case by case basis and tailored to the intended Area Radiation Officer and users activities involving nonionizing radiation sources.
- 3.4 HEADS OF PRIMARY ORGANIZATIONS are responsible for:
- a. Ensuring all requests from their organizations for procurement, possession, use, transfer or other disposition of controlled nonionizing radiation devices are coordinated with and routed through the RPO to the RPC for approval prior to forwarding to the Procurement Officer, Transportation Officer, or other appropriate official.

- b. Ensuring the project leaders, technical representatives, and supervisors:
    - (1) familiarize themselves with all policies and procedures governing radiation sources/devices;
    - (2) ensure those personnel within their respective organizational responsibility are provided appropriate orientation and/or systems training; and
    - (3) review projects, plans, and procedures involving the use of nonionizing radiation sources and identify all controlled sources to the RPO for applicable use authorization approval.
  - c. Ensuring Procurement Requests and Statements of Work involving radiation sources (directly or indirectly):
    - (1) stipulate compliance with KSC Nonionizing Radiation Protection Program requirements; and
    - (2) require all contractor nonionizing radiation source user personnel who are terminating or transferring employment to be identified in accordance with the Use Authorization requirements.
  - d. Ensuring the designation of a user organization Area Radiation officer (ARO). The ARO shall have training and experience in radiation protection which is commensurate with the scope of proposed activities and is satisfactory to the RPO.
- 3.5 AREA RADIATION OFFICERS (AROs) are responsible for:
- a. Ensuring the safe use and accountability of the nonionizing radiation device(s) under their control in accordance with the provisions specified and approved by the applicable KSC Use Authorization.
  - b. Ensuring all sources of nonionizing radiation under their jurisdiction have been identified to and approved by the RPO.
  - c. Giving prior notification to the JBOSC Health Physics Office of movement of controlled nonionizing radiation devices, as required.
  - d. Ensuring all personnel utilizing sources of nonionizing radiation under their jurisdiction are properly trained in safe practices for the possession and use of such sources and oriented to the applicable regulatory and program requirements; ensuring the individual users have been approved through the KSC Radiation Protection Program.

- e. Providing immediate notification to the JBOSC Health Physics Office upon determination or suspicion of any accident or incident involving a potential overexposure of personnel.
  - f. Designating a "Use Supervisor/Custodian" (US/C) under the UA process to act as designated representative in their absence, or whenever they are unable to maintain direct supervision of the sources under their jurisdiction. The US/C shall have training and experience in radiation protection, which is commensurate with the scope of proposed activities.
- 3.6 THE USE SUPERVISOR/CUSTODIAN (US/C) as designated by the ARO is responsible for:
- a. Ensuring the operational implementation of control provisions and requirements levied by the applicable KSC approved Use Authorization.
  - b. Acting on behalf of the ARO in their absence.
- 3.7 EACH USER is responsible for:
- a. Ensuring proper personnel access controls at all identified Radiation Controlled Areas.
  - b. Observing applicable provisions of this KNPR and the specific control provisions and requirements as stated in the approved KSC Use Authorization.
  - c. Consulting with their ARO and supervision when deviation from approved procedures, equipment, personnel, or planned schedules would necessitate a modification of the approved KSC Use Authorization.
  - d. Immediately notifying the JBOSC Health Physics Office of any real or suspected accident or incident involving a potential overexposure of personnel.
- 3.8 DIRECTORS, SAFETY, AND MISSION ASSURANCE ORGANIZATIONS are responsible for:
- a. Coordinating provisions of the KSC Safety, Reliability, and Quality Assurance Program with KSC Nonionizing Radiation Protection Program provisions or with the KSC Radiation Protection Officer, as necessary.
  - b. Reviewing and monitoring procedures from a safety standpoint involving the use, movement, and transportation of nonionizing radiation devices, as required by KNPR 8715.3, or KHB 1700.7, as appropriate.

- c. Providing safety surveillance of all activities involving the use of nonionizing radiation devices.
- d. Coordinating with the RPO on emergency operations concerning nonionizing radiation devices.
- e. Supporting enforcement of radiological controls established by the KSC Nonionizing Radiation Protection Program and any applicable approved KSC Use Authorization.

3.9 DIRECTOR, CENTER OPERATIONS is responsible for ensuring that:

- a. Protective Services Branch will:
  - (1) Ensure that fire protection personnel are properly trained in personnel protective practices relative to fighting fires involving hazards associated with nonionizing radiation sources.
  - (2) Review and make final determination of requirements for the physical security of nonionizing radiation sources.
- b. Emergency Preparedness Office will:
  - (1) Coordinate with the RPO or designated representative on the development of emergency plans and procedures relative to major emergency situations involving nonionizing radiation devices which might significantly affect KSC operations or personnel safety.
  - (2) Coordinate KSC resources to support implementation of approved emergency plans and procedures as directed by the RPO relative to radiation sources.
- c. Property Disposal Office will:

Ensure identified controlled nonionizing radiation devices are not released from KSC without approval of the RPO or designated representative.
- d. Logistics Consultant will:
  - (1) Ensure shipments of controlled nonionizing radiation devices off KSC properties comply with applicable regulations and have been released for shipment by the RPO or designated representative.
  - (2) Ensure inbound shipments of controlled nonionizing radiation devices are identified to, and approvals are received from, the RPO or designated representative.

- 3.10 DIRECTOR, ENGINEERING DEVELOPMENT is responsible for ensuring that:
- a. Chief, Facilities Division will:  
  
Ensure that requests for construction, siting, and modifications of facilities and equipment involving nonionizing radiation hazards, have been reviewed and approved by the RPO.
- 3.11 DIRECTOR, PROCUREMENT OFFICE is responsible for:
- a. Ensuring procurement requests for equipment which incorporates controlled nonionizing radiation devices have been identified to the RPO prior to procurement.
  - b. Incorporating into all Requests for Proposal and Invitations for Bid (to include KSC form 7-49, "Request for Equipment/Materials") all nonionizing radiation protection requirements identified by the heads of primary organizations in their Purchase Requests or Statements of Work.
  - c. Ensuring contractor compliance with the requirements of the KSC Nonionizing Radiation Protection Program, to the extent delineated in their contract.
- 3.12 DIRECTOR, EXTERNAL RELATIONS AND BUSINESS DEVELOPMENT is responsible for coordinating public affairs activities involving announcements and releases concerning nonionizing radiation hazards under KSC jurisdiction with the RPC or RPO.
- 3.13 DIRECTORS OF SPACECRAFT PROCESSING OPERATIONS are responsible for assuring all payload organizations coordinate through proper channels with the RPO for compliance with KSC Nonionizing Radiation Protection Program requirements.
- 3.14 CONTRACTING OFFICERS are responsible for including in contracts, the requirement that all contractor personnel who have been associated with operations involving nonionizing radiation devices and are terminating or transferring employment be identified in accordance with Use Authorization requirements.



## **SECTION 4 ADMINISTRATIVE PROVISIONS FOR CONTROL OF NONIONIZING RADIATION SOURCES**

### **4.1 GENERAL PROVISIONS**

The following general provisions are provided to assist users of controlled nonionizing radiation devices under the purview of the KSC Radiation Protection Programs. Radiation source(s) may be exempted from some or all of the KSC Radiation Protection Program control requirements, if the specific source(s) have been appropriately analyzed and evaluated. Questions of program applicability regarding a specific source of nonionizing radiation which the user cannot otherwise determine may be addressed by submitting the appropriate form and information as described in Sections 5 and 6 of this KNPR.

- a. All proposals for procurement and use of controlled nonionizing radiation devices shall be submitted to the KSC RPC through the KSC RPO, or designee, for review and approval prior to procurement and use.
- b. Approved KSC Nonionizing Radiation Protection Program forms, as described by Sections 5 and 6 of this KNPR, shall be utilized in submittals to the KSC Radiation Protection Officer through the JBOSC HPO.
- c. All receipt, internal transfer, and shipment of controlled nonionizing radiation devices shall be coordinated with and approved in advance by the KSC RPO or designee. Responsible individuals designated in the approved Use Authorization (e.g., AROs, US/Cs) shall review plans and procedures to assure such coordination and approval.
- d. Constraints imposed upon the use of controlled nonionizing radiation devices shall be no less than those required by applicable regulatory authorities and shall include any additional constraints deemed necessary by the KSC RPC or the KSC RPO.
- e. Applicable records pertaining to the KSC Radiation Protection Program shall be maintained by the RPO, or designee. Such records may include, but not necessarily be limited to, records of procurement, receipt, use authorization, exemption, licensing or registration, inventory, surveys, dosimetry, shipments, and investigations.
- f. Controlled nonionizing radiation devices transferred to, or stored or used on, CCAFS by organizations under KSC purview must also be approved by the 45th SW RPO. This approval is accomplished by concurrence signature of the 45th SW RPO on the appropriate KSC Use Authorization form. This coordination is performed by the KSC RPO or designee and does not require separate submittals to the 45th SW RPO by the user organization.

#### 4.2 PROCUREMENT AUTHORIZATION

All procurement requests for controlled nonionizing radiation-producing devices, except as specifically exempted by the provisions of Sections 5 and 6 of this KNPR, must be accompanied by an explanatory statement or by the signature of approval from the KSC RPO.

#### 4.3 POSSESSION AND USE AUTHORIZATION

Authorization for possession or use of controlled nonionizing radiation devices requires review by and approval of the KSC RPC and the KSC RPO. To begin the authorization process, submittal of a completed Use Request as outlined in Section 5 or Section 6 (as applicable) of this KNPR is required. These forms, in conjunction with any necessary supportive data, shall be submitted as soon as practicable but in no case later than 90 days prior to the intended arrival of the source(s) at KSC.

##### a. Specific Use Authorization

A specific Use Authorization (UA) shall be issued subsequent to evaluation of information/data submitted on the appropriate KSC forms. Attachments to these forms should include all relevant data and information pertaining to the specified devices and use. Details of the type of information required are delineated in Sections 5 and 6 (as applicable) of this KNPR.

##### b. General Use Authorization

(1) A General Use Authorization (GUA) may be issued under certain circumstances subsequent to evaluation of information submitted on appropriate KSC forms. GUAs will usually pertain only to devices which represent a minimal hazard potential for personnel.

(2) Use of devices under General Use Authorizations may be subject to specific controls or restrictions.

(3) General Use Authorization will normally be issued for indefinite periods of time.

#### 4.4 USER QUALIFICATIONS

a. Prior to utilizing controlled nonionizing radiation devices, individuals must possess pertinent experience, an understanding of the limiting provisions of the Use Authorization, and have received training or orientation covering at least the following topics:

(1) General description of the applicable radiation type and associated biological effects.

(2) Basic principles of radiation protection.

- (3) Radiation protection procedures relevant to intended use.
- (4) Provisions of this KNPR and appropriate Federal, State, and local regulations.
- (5) Emergency procedures.
- b. Personnel subject to certain nonionizing radiation hazards may be required to obtain additional training and medical certification as deemed necessary by the KSC RPC or the KSC RPO.
- c. AROs shall ensure all potential users of nonionizing radiation devices under their purview supply the necessary information as delineated above on KSC Form 16-450, "Training and Experience Summary (Nonionizing Radiation Users)."

#### 4.5 HAZARD ANALYSIS AND EVALUATION

The KSC RPO or designee shall evaluate each Use Request to assess the potential hazards associated with the possession and use of the nonionizing radiation source. Additional information may be requested, and site inspections or surveys may be utilized in the course of analysis and evaluation.

#### 4.6 RADIATION PROTECTION SURVEYS

Surveys may be required to ensure compliance with procedures and controls described by the provisions of this KNPR. Also, based on the preliminary assessment of a Use Request, an initial survey may be required by the KSC RPO or designee, either prior to or in conjunction with initial use of the controlled nonionizing radiation device(s).

#### 4.7 ASSIGNED CONTROLS

In addition to compliance with applicable Federal, State, and local regulations, an individual Use Authorization may stipulate additional controls assigned by the KSC RPO as a result of unique source or operational characteristics.

#### 4.8 SCHEDULING AND NOTIFICATIONS

- a. Based upon the potential hazard represented by the use of certain nonionizing radiation devices, organizations responsible for use of such devices may be required to schedule use operations through the KSC Scheduling System or to provide other prior notification of operations to the JBOSC HP Office. Such requirements shall be specified in the Use Authorization, if required.

- b. The user organization shall ensure all KSC Nonionizing Radiation Protection Program support requirements for activities involving hazardous radiation sources, as stipulated in the approved KSC Use Authorization, are included in the appropriate KSC Scheduling System document sections.

#### 4.9 WAIVERS, DEVIATIONS, AND SUSPENSIONS

- a. Waivers of or deviations from the requirements described by this KNPR may be issued by the KSC RPO on an individual basis.
- b. Authorization for possession and use of nonionizing radiation devices may be rescinded at any time as a result of noncompliance with provisions of the applicable Use Authorization or other regulatory requirements.

#### 4.10 LOSS OR THEFT OF NONIONIZING RADIATION DEVICES

Loss or theft of controlled nonionizing radiation devices shall be immediately reported to the KSC RPO, or the JBOSC Health Physics Office. Refer to Appendix A of this KNPR for emergency notification telephone numbers.

#### 4.11 UNATTENDED NONIONIZING RADIATION DEVICES

Unattended controlled nonionizing radiation devices shall be secured against unauthorized access at all times.

#### 4.12 INCIDENTS, ACCIDENTS, AND EMERGENCIES.

All real or suspected incidents, accidents, or emergencies involving sources of nonionizing radiation shall be immediately reported to the KSC RPO or to the JBOSC Health Physics Office. Refer to Appendix A, paragraph A.3 for radiation incident notification requirements and telephone numbers. Mishaps shall also be reported.

#### 4.13 MODIFICATION OF USE AUTHORIZATION

- a. Changes to authorized use of nonionizing radiation devices shall be coordinated with, and approved in advance by, the KSC RPO. This coordination and approval process may be initiated by submittal of KSC Form 16-353, "Modification of Radiation Use Authorization," to the KSC RPO, or designee.
- b. Requests for modification should be submitted as soon as practicable but in no case later than 30 days prior to implementation of the planned change.
- c. Examples of changes requiring Modification of Use Authorization include, but are not limited to, changes in approved procedures, location of storage or use, device operating parameters, personnel, or other associated equipment.

#### 4.14 ANNUAL RENEWAL

- a. Specific Use Authorizations shall expire after one year from effective date if request for renewal is not made to the KSC RPO, through the JBOSC HPO, for extension of the use period. Such renewal requests shall be submitted by the user on KSC Form 16-353 "Modification of Radiation Use Authorization."
- b. Submittal of requests for extension of authorized period of use should be made as early as practicable, but not earlier than 90 days prior to the expiration of the Use Authorization. Requests for extension must be received by the RPO not later than 30 days prior to expiration to preclude expiration of the Use Authorization.

## **SECTION 5 CONTROL PROVISIONS FOR THE USE OF LASERS AND OPTICAL RADIATION DEVICES**

### **5.1 GENERAL**

Procurement, possession, and use of lasers and optical radiation devices under the purview of the KSC Nonionizing Radiation Protection Program require coordination with the KSC Radiation Protection Officer (RPO) and approval by the KSC Radiation Protection Committee (RPC). Notwithstanding such Radiation Protection Program approvals, the unique nature of certain laser or optical radiation devices may cause regulatory agencies outside NASA/KSC to require authorization or registration of the intended use and/or location of such devices. It must be noted, however, such outside authorization or registration shall be required in addition to and concurrently with KSC Nonionizing Radiation Protection Program approval. The provisions in this Section are provided to assist users in their effort to comply with NASA/KSC requirements as well as those of other regulatory agencies as they apply to NASA-directed operations at KSC/CCAFS.

### **5.2 REGISTRATION**

Certain controlled nonionizing radiation devices on pertinent areas of KSC/CCAFS may require specific registration by the State of Florida. Copies of all such registrations must be provided to the KSC RPO as part of the data submittal required for KSC Radiation Protection Program authorization of laser or optical radiation devices.

### **5.3 KSC REQUIRED AUTHORIZATIONS AND PROVISION**

#### **a. General Provisions**

Any organization or individual functioning under KSC jurisdiction proposing to procure, possess, use, store, transfer or otherwise dispose of laser or optical radiation devices that are not specifically exempted from KSC Nonionizing Radiation Protection Program requirements (refer to paragraph 5.4, Program Exemptions) must request and obtain authorization to do so. The KSC RPO is the focal point of the KSC Nonionizing Radiation Protection Program for coordination of such authorizations.

(1) Unless specifically exempted by the provisions of paragraph 5.4 of this Section or by KSC RPO direct action, KSC use authorization is required for:

- (a) lasers and laser systems, with ANSI Class IIIa or greater,
- (b) nonlaser optical radiation devices operating in the ultraviolet, visible, or infrared wavelength range of the electromagnetic spectrum,

- (c) laser diodes and laser diode arrays,
  - (d) optical fiber communication systems (OFCS) utilizing laser diodes and LEDs with ANSI Class SG IIIA, and
  - (e) laser pointers (greater than ANSI Class 2).
- (2) Prior written authorization to procure for use or to transport controlled laser or optical radiation devices on to KSC must be obtained from the KSC RPO or designated representative. KSC Nonionizing Radiation Protection Program authorization is also required for responsible individuals and for all documented instructions or procedures (and subsequent revisions) applicable to operations involving such radiation devices. This applies to requests and plans which involve the acquisition, possession, use, storage, and transfer or other disposition of these laser or optical radiation devices. No operation or modification to existing operation shall be initiated prior to issuance of KSC Nonionizing Radiation Protection Program authorization.
  - (3) KSC Nonionizing Radiation Protection Program authorization of storage and use areas and facilities shall be obtained prior to commencement of initial operations.
  - (4) Overall inventory control and administrative accountability of all authorized laser and optical radiation devices on KSC shall be maintained by the KSC Radiation Protection Program Office. Individual users and use organizations shall ensure accountability for their sources and coordinate this effort with the KSC RPO or designated representative.
  - (5) Radiation Controlled Areas and Exclusion Areas as described by the applicable Use Authorization shall be posted and controlled by the user. Warning signs and labels described by this KNPR or their equivalent shall be utilized in all area postings.
  - (6) All personnel exposure to laser or optical radiation devices on KSC/CCAFS shall be kept ALARA.
  - (7) Any laser or optical radiation device improperly transported on to KSC/CCAFS shall be subject to impoundment, until either the irregularities are corrected and appropriate KSC authorizations are obtained, or removal from KSC is arranged.
  - (8) Noncompliance with KSC Nonionizing Radiation Protection Program requirements relative to the authorized use of lasers or optical radiation devices shall result in the revocation or suspension of such use authorization, and impoundment of radiation devices.

b. Data submittals and approvals

KSC Nonionizing Radiation Protection Program authorization for the possession or use of laser or optical radiation devices requires submittal of the appropriate completed KSC Nonionizing Radiation Protection Program form(s) for the type of device(s), together with any supportive data required.

Submittals shall be made as soon as practicable, but in no case later than 90 days (unless otherwise specified) prior to the intended arrival of the radiation devices. Appropriate KSC forms required for laser and optical radiation devices and associated data submittal requirements for KSC Nonionizing Radiation Protection Program authorization are described in this section.

(1) Lasers and Laser Systems

KSC Form 16-447, "Laser Device Use Request/ Authorization," must be completed and submitted for evaluation of all intended uses of lasers and laser systems; including laser diodes, diode arrays, and LEDs not associated with 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, KSC Form 16-447 shall be submitted, with Sections I and III completed, for review and preliminary evaluation by the JBOSC HPO for the KSC RPO. Based upon this review, additional data and information may be required by the RPO to complete the authorization process.

(2) Nonlaser Optical Radiation Devices and OFCS

KSC Form 28-626, "Optical Device Use Request/ Authorization," must be completed and submitted for evaluation of all intended uses of nonlaser optical radiation devices, fiber optic systems, and OFCS, including equipment, instrumentation, or other items incorporating such devices. In cases where applicability of program requirements is unclear to the user organization and cannot otherwise be determined, KSC Form 28-626 shall be submitted, with Sections I (IA for optical devices, IB for fiber optic and OFCS) and III completed for review and preliminary evaluation by the JBOSC HPO for the KSC RPO. Based upon this review, additional data and information may be required by the RPO to complete the authorization process.

(3) User Personnel Identification

KSC Form 16-450, "Training and Experience Summary for Nonionizing Radiation Users," shall be completed and submitted with the appropriate Use Request/Authorization Form for each identified user/operator, the Area Radiation Officer (ARO), and the Use



Supervisor/Custodian (US/C) proposed for possession and use of the specified laser or optical radiation device.

(4) Modification of Approved Use Authorization

KSC Form 16-353, "Modification of Radiation Use Authorization," shall be completed and submitted for evaluation of any intended changes to applicable procedures, licenses or registrations, facilities, personnel, or equipment or materials described by the current KSC Use Authorization. Submittal of requests for modification of Use Authorization shall be submitted not later than 30 days prior to the implementation of the intended changes.

c. Specific Data Submittal Requirements

- (1) Certain information is required to be submitted in support of a request for use of lasers or optical radiation devices at KSC. All documentation for initial use requests should be submitted with an original and one copy of the submittal package.
- (2) Copies of appropriate Use Request/ Authorization forms for use of lasers or optical devices related to cargo or payloads should be included in any safety review documentation associated with the payload/cargo which is provided prior to arrival of sources.
- (3) Requests for use of lasers or optical devices at KSC/CCAFS shall be submitted to the KSC RPO through the JBOSC Health Physics Office as early as practicable, but in no case later than 90 days prior to projected receipt of the device(s) at KSC/CCAFS.
- (4) Elements of a complete data submittal package for Use Authorization include, but may not necessarily be limited to, those described below.
  - (a) The appropriate KSC Nonionizing Radiation Protection Program Use Request/Authorization form as described by paragraphs 5.3.b.(1) and 5.3.b.(2).
  - (b) Copies of licenses or other appropriate registrations possessed by the user organization to own, maintain, and use the specific radiation device.
  - (c) Copies of all applicable operating, maintenance, and emergency procedures relating to possession and use of the radiation device(s) for which authorization is being requested.
  - (d) Listing, by full name and badge number, of all proposed user/operator personnel, accompanied by a completed KSC Form 16-450 for each individual identified by such a list.

- (e) Completed KSC Form 16-450 for the designated ARO and US/C.
- (f) Approximate dates of arrival and departure of the specified radiation device(s) to and from KSC/CCAFS, and mission or payload designation.

#### 5.4 PROGRAM EXEMPTIONS

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 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. The following paragraphs describe currently exempted devices and the conditions necessary for their exemption. Individuals should consult with the KSC RPO or the JBOSC Health Physics Office if there is a question regarding applicability of Program exemption to their particular situation or requirement.

##### a. Exempted Item Categories

- (1) Equipment Utilizing Lasers and LEDs, including the following general categories of Class I and Class II laser devices, products, and systems:
  - (a) laser printers
  - (b) laser copiers
  - (c) image scanners
  - (d) CD ROM players
  - (e) bar code scanner, reader, and verifier units
  - (f) Class I and Class II laser devices and other Class I and Class II laser products, except for those that allow access to other classes of laser radiation during servicing operations, provided that the laser product is maintained as a Class I or Class II laser product through its useful life
  - (g) Service Group 1 (SG1) fiber optic devices/systems
  - (h) Laser Pointers (Class 2)
- (2) Equipment Utilizing Nonlaser Optical Devices, including the following general categories:

- (a) photographic strobe units
- (b) high intensity discharge (HID) lamps utilized for facility lighting
- (c) infrared radiation devices with accessible irradiance less than milliwatt per square centimeter ( $\text{mW}/\text{cm}^2$ )
- (d) visible radiation devices with accessible luminance less than 1 candela per square centimeter ( $\text{cd}/\text{cm}^2$ )
- (e) ultraviolet radiation devices with accessible effective irradiance of less than 0.1 microwatt per square centimeter ( $\text{mW}/\text{cm}$ )
- (f) SG1 or SG2 fiber optic devices/systems.

b. Basis for Exemption of Sources

Exemptions are valid for the general categories of equipment, instruments, and systems identified by paragraph 5.4.a of the Section provided that:

- (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;
- (2) the design and manufacture of the item is in accordance with the specifications of the Federal Performance Standard for Light Emitting Products (Title 21, CFR, Part 1040);
- (3) the item is operated in accordance with the manufacturer's recommended operating procedures; and
- (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 5.4.a shall be performed only by appropriately authorized and qualified personnel.

c. General Precautions for Exempted Items

(1) Associated hazards

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 requirements relating to potential hazards associated with operation of the item, such as: electrical hazards; fire hazards; heat; explosion/fragmentation of glass envelopes; etc.

(2) ALARA

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

- (a) close or prolonged direct viewing of the devices,
- (b) intrabeam viewing conditions of any duration, and
- (c) viewing of specularly (mirror-like) reflected emissions from exempted devices.

5.5 RADIATION PROTECTION CONTROLS FOR LASERS AND LASER SYSTEMS

a. General Considerations

- (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.
- (2) For all uses of lasers and laser systems, it is recommended the minimum level of laser radiation required for the application be utilized.
- (3) Laser beam height should be maintained at a level other than the normal position of the eye of a person in the standing or seated position.
- (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.
- (5) If engineering controls are impractical or inadequate, administrative and procedural controls and protective equipment shall be used to limit access to laser radiation.

b. Applicability of Control Measures

- (1) The purpose of control measures is to limit the possibility of exposure of the eye and skin to hazardous levels of laser radiation and to associated hazards.
- (2) Whenever the application of any one or more control measures reduce the possible exposure to a level at or below the applicable Maximum Permissible Exposure (MPE), the application of additional controls for the same purpose is not required.

- (3) Control measures described by this KNPR and the applicable KSC Use Authorization shall apply at all times when a laser or laser system is in its operational and maintenance modes.
- (4) If, during periods of service to a laser or laser system, the level of accessible laser radiation exceeds the applicable MPE, the applicable control measures shall be instituted on a temporary basis.

c. Substitution of Alternate Control Measures

Engineering control measures described by paragraph 5.5.d may, upon review and approval by the KSC RPO, be replaced by procedural, administrative, or other alternate engineering controls which provide equivalent protection.

d. Engineering Controls

(1) Protective Housings

- (a) A protective housing shall be provided for all classes of lasers or laser systems, except as provided by 5.5.d.(1)(b). The protective housing may require interlocks and labels.
- (b) In some circumstances, such as research and development and manufacture/assembly of lasers, operation of the laser or laser system without a protective cover may become necessary. In such cases, the KSC RPO shall determine the hazard and assure that controls are instituted appropriate to the class of maximum accessible emission to assure safe operation. These controls may include, but not be limited to:
  - 1. access restrictions,
  - 2. eye protection,
  - 3. area controls,
  - 4. barriers, beam stops, shrouds, etc.,
  - 5. administrative and procedural controls, and
  - 6. education and training.

(2) Interlocks on Removable Protective Housings

- (a) 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.

- (b) The interlock or interlock system shall be designed to prevent access to laser radiation above the applicable MPE; for instance, an interlock which is electrically or mechanically interfaced to a shutter which interrupts the beam when the protective housing is removed.
- (c) 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.
- (d) The protective housing interlock shall not be defeated or overridden during operation of the laser or laser system.
- (e) Adjustments or procedures during service on lasers or laser systems containing interlocks shall not cause the interlocks to be inoperative when the equipment is restored to its normal operational condition.

(3) Service Access Panels

- (a) 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 either:
  - 1. be interlocked, or
  - 2. require a tool for removal and shall have an appropriate warning label on the panel.
- (b) If the interlock can be bypassed or defeated, a warning label shall be located on or near the interlock.

(4) Master Switch

- (a) A Class 3b laser or laser system should be provided with a master switch.
- (b) A Class 4 laser or laser system shall be provided with a master switch.
- (c) The master switch shall be operated by a key, or by coded access (computer code).

- (d) The authority for access to the master switch shall be vested in the ARO for the laser or laser device.
- (e) The master switch shall be disabled when the laser or laser system is not intended to be used.

(5) Viewing Portals and Collecting Optics

(a) Viewing Portals and display screens

All viewing portals and display screens included as an integral part of a Class 2, Class 3a, 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.

(b) Collecting optics

1. 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.
2. Normal or prescription eyewear are not considered collecting optics.

(6) Remote interlock connector

- (a) A Class 3b laser or laser system should be provided with a remote interlock connector.
- (b) A Class 4 laser or laser system shall be provided with a remote interlock connector.
- (c) When the terminals of the remote interlock connector are open circuited, the accessible radiation level shall not exceed the appropriate MPE levels.

(7) Beam Stops or Attenuators

- (a) A Class 3b laser or laser system should be provided with a permanently attached beam stop or attenuator.

- (b) A Class 4 laser or laser system shall be provided with a permanently attached beam stop or attenuator.
- (c) The beam stop or attenuator shall be capable of preventing access to laser radiation in excess of the appropriate MPE level when the laser or laser system output is not required.

(8) Laser Activation Warning Systems

- (a) An audible alarm, a warning light (visible through protective eyewear), or a verbal countdown command should be used for Class 3b, and shall be used for Class 4 lasers or laser systems during activation or startup.
- (b) Audible warnings shall be distinctive and clearly identifiable sounds which are uniquely associated with the emission of laser radiation.

(9) Emission Delay

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.

(10) Remote Firing and Monitoring

- (a) Whenever possible, Class 4 lasers and laser systems should be monitored and fired from remote positions.
- (b) The remote console should also include a laser activation warning system.

e. Administrative and Procedural Controls

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 personal protective equipment (PPE).

(1) Written Procedures

Written operating, maintenance, service, and emergency procedures shall be provided and maintained with the laser equipment for reference by operator, maintenance, and service personnel.

(2) Output Emission Limitations



The laser or laser system ARO shall take such action as is necessary and approved by the RPO to reduce levels of accessible power or radiant energy to that which is commensurate with the required application.

(3) Education and Training

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

(4) Authorized Personnel

Lasers or laser systems with accessible emission levels exceeding the appropriate MPE shall be operated, maintained, and serviced only by KSC RPO-approved and authorized personnel.

(5) Alignment Procedures

Alignment of laser 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 laser radiation levels above the applicable MPE.

f. Laser Area Identification and control

(1) Beam Path Control

Control of the laser beam path shall be accomplished as described in the following subparagraphs.

(a) Totally unenclosed beam path

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 shall be implemented based upon the classification associated with the maximum accessible level of laser radiation.

(b) Limited open beam path

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.

(c) Enclosed beam path

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 described by paragraph 5.5.d.(l), the requirements of Class 1 are fulfilled, and no further area controls are required.

(2) Indoor Laser Radiation Control Area

(a) Indoor controlled laser radiation areas shall:

1. be posted with the appropriate warning sign(s), as described by paragraph 5.5.i of this Section,
2. be operated by and under the control of KSC RPO-approved operator personnel,
3. be operated in such a manner that the beam path is limited when the NHZ of the laser beam must exit an indoor controlled area, particularly to the outdoors under adverse atmospheric conditions,
4. be so located that access to the area by unauthorized personnel is limited and requires prior approval for entry,
5. have any potentially hazardous beam terminated in a beam stop of an appropriate material,
6. have only diffuse reflective materials in or near the beam path, where feasible,
7. have personnel within the controlled area provided with appropriate eye protection for the accessible emission levels,
8. have the laser secured so the beam path is above or below eye level of a person in a standing or seated position,
9. 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, and

10. require storage or disabling of the laser or laser system, when not in use, to prevent unauthorized access.

(b) Additional controls for Class 4 indoor laser radiation control areas include the following special requirements:

1. All area/entryway safety controls shall be designed to allow rapid egress by laser personnel at all times,
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, and
3. In addition to fulfilling all the requirements of paragraph 5.5.f(2)(a) of this section, the indoor Class 4 controlled laser radiation area shall incorporate one of the following alternatives:
  - a. nondefeatable (non override) area entryway safety controls; or
  - b. nondefeatable safety latches; entryway or area interlocks shall be used to deactivate the laser or reduce the output to the appropriate MPE levels for unexpected entry into the controlled area; or
  - c. procedural area/entryway safety controls; such as, a barrier to block, screen, or attenuate laser radiation levels at the entryway; or a visible or audible signal at the entryway to indicate the laser is energized.

(3) Outdoor Laser Radiation-Control Area

Outdoor laser radiation control areas shall meet the following requirements:

- (a) The area shall be posted with the appropriate warning sign(s) as described by paragraph 5.5.i of this Section.
- (b) The area shall be operated by and under the control of KSC approved operator personnel.

- (c) Unprotected, untrained, and unauthorized personnel shall be excluded from the beam path at all points where the appropriate MPE is exceeded.
- (d) 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.
- (e) Directing the laser beam toward automobiles, aircraft, or other manned vehicles or structures shall be prohibited within the NHZ.
- (f) The laser beam path shall not be maintained at or near eye level.
- (g) The beam path shall be terminated where possible.
- (h) When the laser is not being used, it shall be disabled in such a manner to prevent unauthorized use.

(4) Temporary Laser Control Area

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 shall be established.

- (a) Such a temporary area which by its nature shall not have the built in protective features as defined for a laser control area, shall provide all safety requirements for all personnel, both within and without the area.
- (b) A notice sign (refer to paragraph 5.5.i of this Section, and Figure 5-3) shall be posted outside the temporary laser control area to warn of the potential hazard.
- (c) A laser warning sign (refer to paragraph 5.5.i of this Section, and Figures 5-1 and 5-2) appropriate to the accessible hazard shall be posted inside the temporary laser control area.
- (d) Personnel working inside the temporary laser control area shall maintain surveillance over the area to preclude unauthorized entry.

g. Laser Demonstrations Involving the General Public

(1) General

- (a) The following special control measures shall be employed for those situations where lasers or laser systems are used for demonstration, artistic display, entertainment, or other related uses where the intended viewing group is the general public.
- (b) Such demonstrations can be, but are not limited to, trade show demonstrations, artistic light performances, planetarium laser shows, stage lighting effects, and similar special lighting effects that use lasers or laser systems emitting in the visible wavelength range (400 to 700 nm).

(2) Operational Requirements - General

- (a) Only Class 1 lasers or laser systems shall be used for general public demonstration, display, or entertainment in unsupervised areas without additional requirements.
- (b) The unsupervised use of Class 2 lasers or laser systems shall be limited to installations which prevent access to the direct or specularly reflected beams or where the accessible radiation is maintained at the distance requirements specified by paragraph 5.5.g(6) of this Section.
- (c) The use of Class 3 or Class 4 lasers or laser systems shall be permitted only under the following conditions:
  - 1. When the laser operation is under the control of a KSC RPO-authorized laser operator, or
  - 2. When the laser is operated in a supervised laser installation as described by paragraph 5.5.g(7), or
  - 3. When the laser is operated in an unsupervised laser installation provided a designated, authorized person, present at all times at the show or display, is responsible for the immediate termination of the laser equipment for equipment malfunction, audience unruliness, or other unsafe conditions.

(3) Invisible Laser Emission Limitations

The general public shall not be exposed or have access to laser radiation emissions at wavelengths outside the range 400 to 700 nm

at levels exceeding 10 percent of the applicable MPE levels under any possible conditions of operation.

(4) Operators and Performers

All operators, performers, and employees shall be able to perform their required functions without the need for exposure to laser radiation levels in excess of the applicable MPE level.

(5) Scanning Devices

Scanning devices, including rotating mirrored balls, shall incorporate a means to prevent laser emission if scan failure or other failure resulting in a change in either scan velocity or amplitude would result in failure to fulfill the criteria described in paragraphs 5.5.g(3) and 5.5.g(4) of this Section.

(6) Unsupervised Laser Installations

- (a) If a laser demonstration utilizing a Class 2, Class 3, or Class 4 laser does not operate at all times under the direct supervision of an authorized laser operator, the laser radiation levels to which access can be gained shall be limited by barriers, windows, or other means not to exceed the limits of the applicable MPE.
- (b) This limitation shall apply at any point less than 6 meters above any surface to which a person in the general public may have access during the performance or display.
- (c) Any laser installation not meeting the criteria described above shall be required to operate as a supervised laser installation, as described by paragraph 5.5.g(7) of this Section.

(7) Supervised Laser Installations

- (a) Supervised laser installations shall be operated at all times under the direct supervision and control of a KSC authorized laser operator who shall maintain constant surveillance of the laser display and who shall terminate the laser emission in equipment malfunction, audience unruliness, or other unsafe conditions.
- (b) The operator shall have full visual access to the entire area of concern at all times during the demonstration or performance.

- (c) If obstacles or size of the area preclude visual access by a single operator, then multiple observers shall be utilized, with a communications link to the laser operator.
- (d) In supervised laser installations, accessible laser radiation shall be limited by barriers, windows, or other means so as not to exceed the applicable MPE at any point, unless the following requirements are met:
  - 1. The accessible laser radiation is maintained a minimum of 3 meters above any surface to which a person in the general public may have access during the performance or display, and
  - 2. The accessible laser radiation is maintained at a minimum distance of 2.5 meters in lateral separation from any position where a person in the general public may have access during the performance or display.

(8) Beam Termination Requirements

- (a) All laser demonstration systems shall be provided with a means to effect immediate termination of the laser radiation.
- (b) If the demonstration does not require continuous supervision or operator control during its operation, there must be a designated, authorized individual at all times at the show or display who is responsible for immediate termination of the laser emission in equipment malfunction, audience unruliness, or other unsafe conditions.

(9) Maximum Power Limitations

The maximum output power of the laser shall be limited to the level required to produce the desired and intended effect.

h. Personal Protective Equipment (PPE)

(1) General

- (a) Enclosure of the laser equipment is the preferred method of control, since the enclosure shall isolate or minimize the laser radiation hazard.
- (b) When other control measures do not provide adequate means to prevent access to direct or reflected beams at levels above the MPE, PPE may be required.

(2) Protective Eyewear

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

(a) Identification of eyewear

All laser protective eyewear 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.

(b) Comfort and Fit

Laser protective eyewear shall be comfortable and prevent exposure to hazardous peripheral radiation.

(c) Periodic Inspection

Periodic inspection of protective eyewear shall be made by the ARO to ensure the maintenance of satisfactory condition. Inspections shall include:

1. examination of attenuation material for pitting, crazing, cracking, discoloration, etc.,
2. examination of the frame for mechanical integrity, and
3. examination for light leaks that would permit hazardous intrabeam viewing.

Eyewear in suspicious condition shall be tested for acceptability or discarded.

(3) Protective Clothing

(a) 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 as specified by the applicable Use Authorization shall be utilized.

(b) Where personnel may be subject to chronic skin exposure from scattered ultraviolet radiation, skin protection may be required even at levels below the applicable MPE for skin exposure.

(c) Consideration should also be given to the use of fire resistant materials when using Class 4 lasers or laser systems.



(4) Other PPE Considerations

Respirators and hearing protection may be required whenever engineering controls cannot provide protection from a harmful ancillary environment.

i. Warning Signs and Labels

(1) Design of Signs

Figures 5-1, 5-2, and 5-3 in this Section represent typical design and lettering placement for laser radiation warning signs.

(2) Symbols

The laser hazard symbol shall be a sunburst pattern consisting of two sets of radial spokes of different lengths, and one long spoke, radiating from a common center (refer to Figures 5-1, 5-2, and 5-3 of this Section).

(3) Signal Words

(a) The signal word "CAUTION" (Figure 5-1) shall be used with all signs and labels associated with:

1. Class 2 lasers and laser systems, and
2. All Class 3a lasers and laser systems that do not exceed the appropriate MPE for irradiance.

(b) The signal word "DANGER" (Figure 5-2) shall be used with all signs and labels associated with:

1. all other Class 3a lasers and laser systems,
2. all Class 3b lasers and laser systems, and
3. all Class 4 lasers and laser systems.

(c) A Class 2a laser or laser system shall have a label affixed which instructs: "AVOID LONG TERM VIEWING OF DIRECT LASER RADIATION." This label need not bear the warning symbol or signal words but must be clearly visible during laser operation and bear the designation "Class 2a Laser."

(d) The word "radiation" on signs may be replaced by the word "light" for lasers operating in the visible wavelength range.

- (e) For lasers operating outside the visible wavelength range the word "invisible" shall be placed prior to the word "radiation."

(4) Inclusion of Pertinent Information

Signs and labels shall conform to the following specifications.

- (a) The appropriate signal word shall be located in the upper panel (refer to Figures 5-1 and 5-2).
- (b) Adequate space shall be left on all signs and labels to allow the inclusion of pertinent information. Information may be included during the printing of the sign or label or may be entered by hand in a legible manner, and shall include the following:
  - 1. At position 1 above the tail of the starburst, standard precautionary actions required by the reader:
    - a. For Class 2 and Class 3a lasers and laser systems where the accessible irradiance does not exceed the appropriate MPE based upon a 0.25 second exposure duration, "LASER RADIATION - DO NOT STARE DIRECTLY INTO BEAM OR VIEW WITH OPTICAL INSTRUMENTS."
    - b. For all other Class 3a lasers and lasers systems, "LASER RADIATION - AVOID DIRECT EYE EXPOSURE."
    - c. For Class 3b lasers and laser systems, "LASER RADIATION - AVOID DIRECT EXPOSURE TO BEAM."
    - d. For Class 4 lasers and laser systems, "LASER RADIATION - AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION."
  - 2. At position 1 above the tail of the sunburst, any additional special instructions or protective actions such as: "Invisible Laser Radiation;" "Knock Before Entering," "Do Not Enter When Light is on," "Restricted Area," etc., should be added.

3. At position 2 below the tail of the sunburst:
  - a. type of laser or the emitted wavelength,
  - b. pulse duration, if applicable, and
  - c. maximum output of the laser.
4. At position 3, the class of the laser or laser system.

(5) Temporary Laser-Control Area

- (a) A notice sign (see figure 5-3) shall be posted outside a temporary laser control area established, for example, during periods of service.
- (b) When a temporary laser control area is created, the area outside the temporary area remains class 1, while the area within the temporary control area is posted with the appropriate warning sign.

(6) Display of Signs and Labels

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

j. Associated Hazards

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

- (1) High-voltage sources and wiring should be shielded.
- (2) High-voltage equipment may produce x-ray radiation and require shielding.
- (3) High-voltage equipment and intense beams of ultraviolet light may produce hazardous concentrations of ozone and may require additional ventilation.
- (4) All electrical equipment should be properly grounded.
- (5) Materials used with laser systems may be toxic or combustible. Procedures for handling such materials should be developed and followed.

- (6) Cryogenic liquids may cause burns. Examples are liquid nitrogen, liquid helium, and liquid hydrogen.
- (7) Flashlamps may explode and should be shielded. Also, the radiation from these lamps may constitute an ocular hazard.
- (8) Certain laser tubes produce ultraviolet radiation. If such a tube is constructed of materials transparent to this ultraviolet radiation, a shield should be placed around the tube.
- (9) The possible fragmentation of high-speed rotating devices used for switches and choppers may require special shielding.

k. Medical Surveillance Requirements

Medical surveillance requirements for lasers and laser systems are included in Appendix C to this KNPR.

5.6 RADIATION PROTECTION CONTROLS FOR OPTICAL FIBER COMMUNICATION SYSTEMS (OFCS)

a. General considerations

- (1) During normal system operation, OFCS are completely enclosed 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.

- (2) Service Group Classification

Since all OFCS are designed to normally operate as Class 1 laser systems, and the only risk for personnel exposure would occur during installation and service, OFCS are assigned one of four Service Group (SG) classifications, as defined in ANSI Z136.2, specifically: SG1, SG2, SG3a, or SG3b.

- (a) An OFCS is classified SG1 if the total output power is less than the Accessible Emission Limit (AEL) for Class 1, and there is no risk of exceeding the Maximum Permissible Irradiance (MPI) when viewing the end of a fiber with a microscope, an eye loupe, or with the unaided eye.
- (b) An OFCS is classified SG2 if it emits at wavelengths between 400 nm and 700 nm and if it is potentially hazardous when viewed for more than 0.25 second.

- (c) An OFCS is classified SG3a if it is hazardous when viewed with a microscope or an eye loupe but is not hazardous when viewed with the unaided eye.
- (d) An OFCS is classified SG3b if it meets none of the criteria above, provided that the total power is less than 0.5 watt.

(3) OFCS Utilizing Laser Diodes

OFCS that incorporate lasers generally utilize Class 1 or Class 3b laser diode transmitters. In normal operation, these systems are totally enclosed and fully shielded by protective devices.

(4) OFCS Utilizing LEDs

OFCS that utilize LED sources generally emit incoherent energy at wavelengths greater than 700 nm and power levels significantly less than laser diode sources.

(5) Optical Fiber Test Sets

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 (OBTS).

- (a) Although some OTDRs use Class 1 lasers, many OTDRs and OLTSs use Class 3b lasers.
- (b) An OFCS test set is itself considered an OFCS and, thus, all control measures described by paragraph 5.6.c of this Section apply to its use.

b. Applicability Of Control Measures

- (1) The purpose of control measures is to limit the possibility of exposure of the eye to hazardous levels of optical radiation and to associated hazards.
- (2) Whenever the application of any one or more control measures reduces the possible exposure to a level at or below the applicable MPI, the application of additional controls for the same purpose is not required.
- (3) Control measures described by paragraphs 5.6.d and 5.6.e of this Section shall apply at all times during OFCS installation and service.
- (4) If, during periods of OFCS installation or service, the level of accessible laser radiation exceeds the applicable MPI, the applicable

control measures for that Service Group shall be instituted on a temporary basis.

- (5) Engineering control measures (items incorporated into the OFCS installation by design) shall be given primary consideration for limiting access to optical radiation.
- (6) Connection or disconnection of fiber optic cables during normal operation shall take place in an appropriate laser control area, if the applicable MPE or MPI is exceeded.
- (7) Connection or disconnection of fiber optic cables during maintenance, service, modification, or repair shall take place in a temporary laser control area, if the applicable MPE or MPI is exceeded.
  - (a) When the connection or disconnection is made by means of a connector other than one within a secured enclosure, such a connector shall be disconnectable only by the use of a tool.
  - (b) When the connection or disconnection is made within a secured enclosure, no tool for connector disconnection shall be required, but a warning sign appropriate to the class of laser or laser system shall be visible when the enclosure is open.

c. Substitution of Alternate Control Measures

Engineering control measures may, upon review and approval by the KSC RPO, be replaced by procedural, administrative, or other alternate engineering controls which provide equivalent protection.

d. Control Measures for OFCS in Uncontrolled Areas

Under normal operating conditions, OFCS are completely enclosed. The following controls are required to minimize potentially hazardous exposure.

- (1) Safety connectors shall be utilized with all SG3b OFCS located in uncontrolled areas
- (2) When the service group 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 a SG3b until the actual service group is determined.
- (3) For OFCS where 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 5.6.h of this Section shall be used.

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

e. Control Measures for OFCS in controlled Areas

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

- (1) Only KSC RPO-approved authorized personnel shall be permitted to install or perform service on SG3b OFCS.
- (2) Only KSC RPO-approved authorized personnel shall be permitted to use SG3b test set equipment during installation or servicing of OFCS.
- (3) All personnel not approved and authorized by the KSC RPO shall be excluded from the NHZ of SG3b OFCS during installation and service when there is a possibility that these systems may become energized.
- (4) During installation or service, a broken optical fiber or unterminated 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 MPI, unless it has been verified all optical transmitters have been turned off.
- (5) During all splicing operations that require viewing the end of a fiber of an SG3b OFCS, laser diode or LED sources on the fiber involved shall be deenergized or viewing systems incorporating personal protection shall be employed.
- (6) Connectors which may emit SG3a or SG3b levels of optical radiation shall have affixed a warning label described by paragraph 5.6.h of this Section, unless a sign having the same wording is posted conspicuously nearby. A sign should be used in an area with a large number of connectors; e.g., an equipment bay or cable closet.
- (7) Eye protection devices which are specifically designed for protection against SG3b OFCS shall be procedurally required when engineering or other procedural control measures are inadequate to eliminate potential exposure in excess of the applicable MPI.
- (8) During service or installation of SG3b 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.

f. Administrative and Procedural Controls

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.

(1) Written Procedures

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

(2) Output Emission Limitations

OFCS personnel shall take such action as is reasonable, necessary, and approved by the RPO to reduce levels of accessible power or radiant energy to that which is commensurate with the required application.

(3) Education and Training

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

(4) Authorized Personnel

SG3b OFCS with accessible emission levels exceeding the appropriate MPI shall be installed, operated, maintained, and serviced only by KSC RPO approved and authorized personnel.

g. Personal Protective Equipment (PPE)

(1) General

(a) Enclosure of the OFCS equipment is the preferred method of control, since the enclosure shall isolate or minimize the laser radiation hazard.

(b) When other control measures do not provide adequate means to prevent access at emission levels above the MPE, PPE may be required.



(2) Protective Eyewear

Protective eyewear shall be worn whenever operational conditions may result in a potential eye hazard.

(a) Identification of Eyewear

All protective eyewear shall be clearly labeled with the optical density and wavelength for which protection is afforded. Color coding or other distinctive identification of protective eyewear is recommended in multiwavelength use environments.

(b) Comfort and Fit

Protective eyewear shall be comfortable and prevent exposure to hazardous peripheral radiation.

(c) Periodic Inspection

Periodic inspection of protective eyewear shall be made by user personnel to ensure the maintenance of satisfactory condition. Eyewear in suspicious condition shall be tested for acceptability or discarded. Inspections shall include:

1. examination of attenuation material for pitting, crazing, cracking, discoloration, etc.;
2. examination of the frame for mechanical integrity; and
3. examination for light leaks that would permit hazardous intrabeam viewing.

h. Warning Labels

(1) Label Wording

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

(a) For SG2 OFCS

“CAUTION DISCONNECTED OPTICAL CONNECTORS MAY EMIT OPTICAL RADIATION - DO NOT STARE INTO BEAM.”

(b) For SG3a OFCS

“CAUTION DISCONNECTED OPTICAL CONNECTORS MAY EMIT OPTICAL RADIATION - DO NOT VIEW BEAM

WITH OPTICAL INSTRUMENTS.”

(c) For SG3b OFCS

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

(d) For all infrared systems, the words "INVISIBLE RADIATION"  
should be used in place of "OPTICAL RADIATION.”

(e) For all visible systems, the words "OPTICAL ENERGY" may  
be substituted for the words "OPTICAL RADIATION.”

(2) Display of Signs and Labels

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

(b) Connectors which may emit SG3a or SG3b levels of optical  
radiation shall have affixed a warning label, unless a sign  
having the same wording is posted conspicuously nearby.

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

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

i. Associated Hazards

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 provided here for consideration.

(1) Glass Particle Hazards

(a) There is some risk of direct injury from small lengths or  
particles of fiber, particularly during splicing operations.

(b) The use of protective guards or shields should be considered  
during these types of operations.

- (c) Where practicable, discarded pieces of optical fiber should be collected in a suitable container to avoid subsequent embedding in clothing or skin.

(2) Photocuring Compounds

- (a) Optical photocuring devices should be operated with caution to preclude exposure to ultraviolet and viewing of the light source.
- (b) Protective filter lenses should be worn if direct viewing of the light source is necessary.

(3) Solvents and Chemicals

- (a) Solvents and chemicals used for stripping, cleaning, and splicing operations shall be used in adequately ventilated areas.
- (b) The least hazardous solvents needed for a task should be used.
- (c) Material Safety Data Sheets (MSDS) for each solvent or chemical should be consulted.
- (d) Service and installation personnel shall receive adequate safety instructions in the use of solvents and chemicals.

j. Medical Surveillance Requirements

Medical Surveillance requirements for OFCS are included in Appendix C to this KNPR.

5.7 RADIATION PROTECTION CONTROLS FOR OPTICAL RADIATION DEVICES

a. Nonlaser-Optical Radiation Sources

Nonlaser optical radiation sources include devices which emit noncoherent radiation in the wavelength range from 180 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 5-1 below provides a summary of potential exposure hazards for some typical optical radiation sources.

Table 5-1  
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

b. General Considerations

- (1) Radiation protection controls shall be devised to reduce the possibility of exposure of the eye or skin to hazardous levels of optical radiation.
- (2) For all uses of optical radiation devices, it is recommended the minimum level of radiation required for the application be utilized.
- (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.
- (4) If engineering controls are impractical or inadequate, administrative and procedural controls and protective equipment shall be used to limit access to optical radiation.

c. Applicability of Control Measures

- (1) The purpose of control measures is to limit the possibility of exposure of the eye and skin to hazardous levels of optical radiation and to associated hazards.
- (2) Whenever the application of any one or more control measures reduces the possible exposure to a level at or below the applicable protection guide, the application of additional controls for the same purpose is not required.
- (3) If, during periods of service to an optical device or system, the level of accessible radiation exceeds the applicable protection guide, the applicable control measures shall be instituted on a temporary basis.

d. Engineering Controls

Because of the varying nature of nonlaser optical radiation devices, definition of engineering control requirements in the context of this KNPR is limited to a listing of engineering control features which could be utilized, depending upon the specific device and the method of use.

(1) Protective Housings

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

(2) Interlocks on Removable Protective Housings

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) Viewing Portals and Collecting Optics

(a) Viewing portals and display screens

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.

(b) Collecting optics

1. Collecting optics, such as lenses, telescopes, microscopes, endoscopes, etc., intended for viewing use shall incorporate suitable means (filters, interlocks, attenuators) to maintain the optical emission at the viewing position at or below the applicable protection guide for all conditions of operation and maintenance.
2. Normal or prescription eyewear are not considered collecting optics.

e. Administrative and Procedural Controls

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 may include, but not be limited to: access restrictions; eye protection; area controls; and education and training requirements for operators.

(1) Written Procedures

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.

(2) Output Emission Limitations

The device or system ARO shall take such action as is necessary and approved by the RPO to reduce levels of accessible power or radiant energy to that which is commensurate with the required application.

(3) Education and Training

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

(4) Authorized Personnel

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

(5) Alignment Procedures

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.

f. Personal Protective Equipment (PPE)

(1) General

- (a) Enclosure of the optical device is the preferred method of control, since the enclosure will isolate or minimize the emission hazard.
- (b) When other control measures do not provide adequate means to prevent access emission levels above the protection guide, PPE may be required.

(2) Protective Eyewear

Protective eyewear shall be worn whenever operational conditions may result in a potential optical radiation eye hazard.

(a) Identification of Eyewear

All protective eyewear shall be clearly labeled with the optical density and wavelength or wavelength range for which protection is afforded, if applicable.

(b) Comfort and Fit

Protective eyewear shall be comfortable and prevent exposure to hazardous peripheral radiation.

(c) Periodic Inspection

Periodic inspection of protective eyewear shall be made by the ARO to ensure the maintenance of satisfactory condition. Eyewear in suspicious condition shall be tested for acceptability or discarded. Inspections shall include:

1. examination of attenuation material for pitting, crazing, cracking, discoloration, etc.;
2. examination of the frame for mechanical integrity; and
3. examination for light leaks that would permit hazardous viewing conditions.

(3) Protective Clothing

- (a) Where personnel may be exposed to levels of radiation that clearly exceed the protection guide for the skin, protective clothing as specified by the applicable Use Authorization shall be utilized.
- (b) Where personnel may be subject to chronic skin exposure from scattered ultraviolet radiation, skin protection may be required even at levels below the applicable protection guide for skin exposure.
- (c) Consideration should also be given to the fire resistance of materials used in protective clothing.

g. Warning Signs and Labels

(1) Design of Signs

Figure 5-4 in this Section represents the typical design and lettering placement for optical radiation warning signs.

(2) Symbol

The optical hazard symbol shall be a sunburst pattern consisting of two sets of radial spokes of different lengths, radiating from a common center (refer to Figure 5-4 of this Section).

(3) Signal Words

- (a) Position 1 (Figure 5-4) shall indicate the nature of the optical hazard.



1. The signal word "INFRARED" shall be used to indicate optical sources presenting a potential infrared radiation exposure hazard.
  2. The signal words "HIGH INTENSITY VISIBLE LIGHT" shall be used to indicate optical sources presenting a potential visible radiation exposure hazard.
  3. The signal word "ULTRAVIOLET" shall be used to indicate optical sources presenting a potential ultraviolet radiation exposure hazard.
- (b) Position 2 (Figure 5-4) shall be used to indicate any special precautions required to control exposure of personnel, such as:
1. eye protection requirements,
  2. skin protection requirements, or
  3. special access controls.

h. Associated Hazards

In some 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 provided here for consideration by the user organization.

- (1) High-voltage sources and wiring should be shielded.
- (2) High-voltage equipment may produce x-radiation and require shielding.
- (3) High-voltage equipment and intense levels of ultraviolet light may produce hazardous concentrations of ozone and may require additional ventilation.
- (4) All electrical equipment should be properly grounded,
- (5) Flashlamps may explode and should be shielded.
- (6) Certain industrial lamps are manufactured with a quartz envelope to shield the ultraviolet portion of the lamp's emission. Failure of this envelope may result in an unexpected ultraviolet hazard, even if the lamp is of the 'self-extinguishing' variety.

i. Medical Surveillance Requirements

Medical surveillance requirements for optical radiation devices and systems are included in Appendix C to this KNPR.

5.8 LASER POINTERS

a. General considerations

- (1) All class 2 lasers pointers are exempt from the controls specified in this document.
- (2) All class 2 laser pointers are approved under a "blanket" General use authorization which requires the user to prevent direct intra-beam viewing while in use.
- (3) All other laser pointers (class 3 and 4) require specific request for laser use authorization as specified in section 5.3 above.

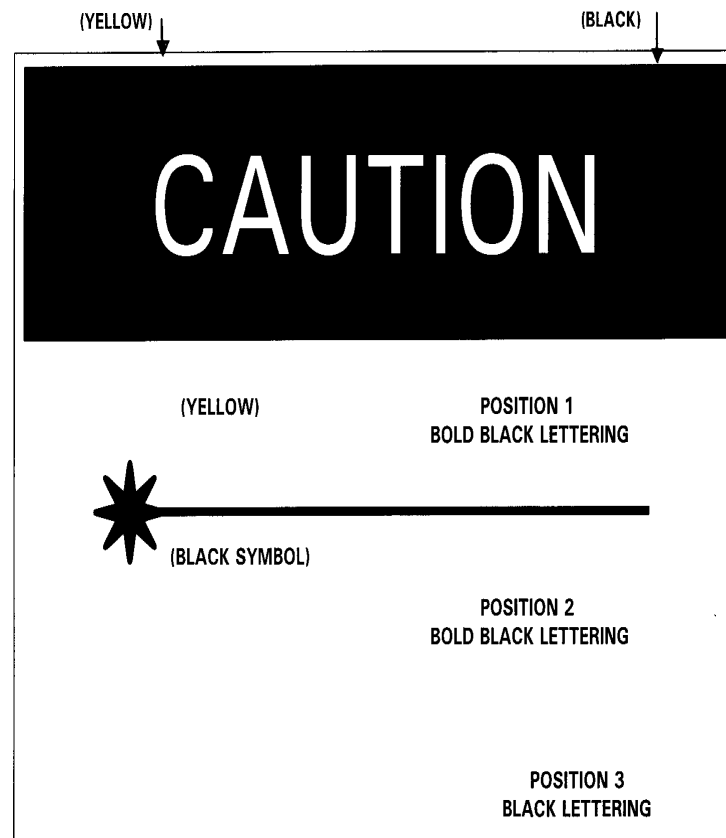


Figure 5 - 1  
Laser Caution Warning Sign

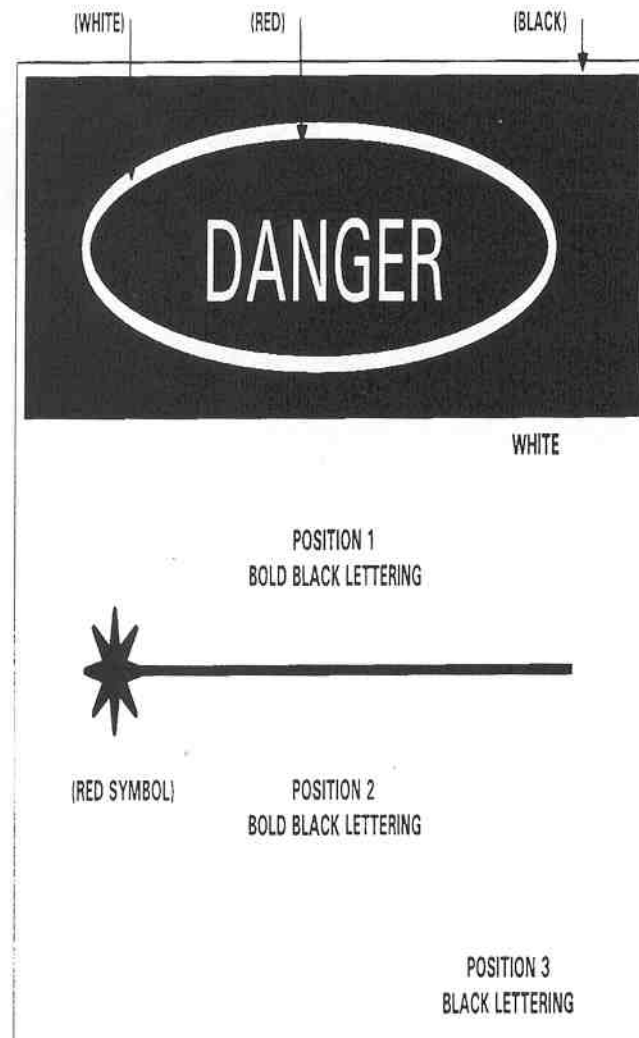


Figure 5 - 2  
Laser Danger Warning Sign

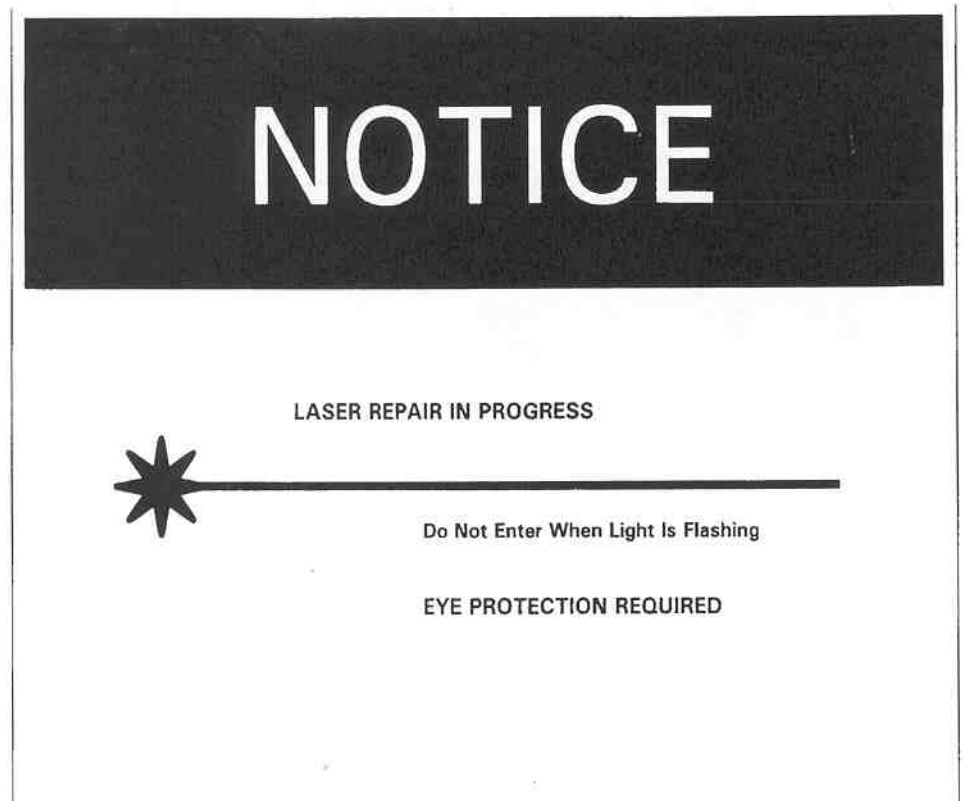


Figure 5 - 3  
Temporary Laser Control Area Warning Sign

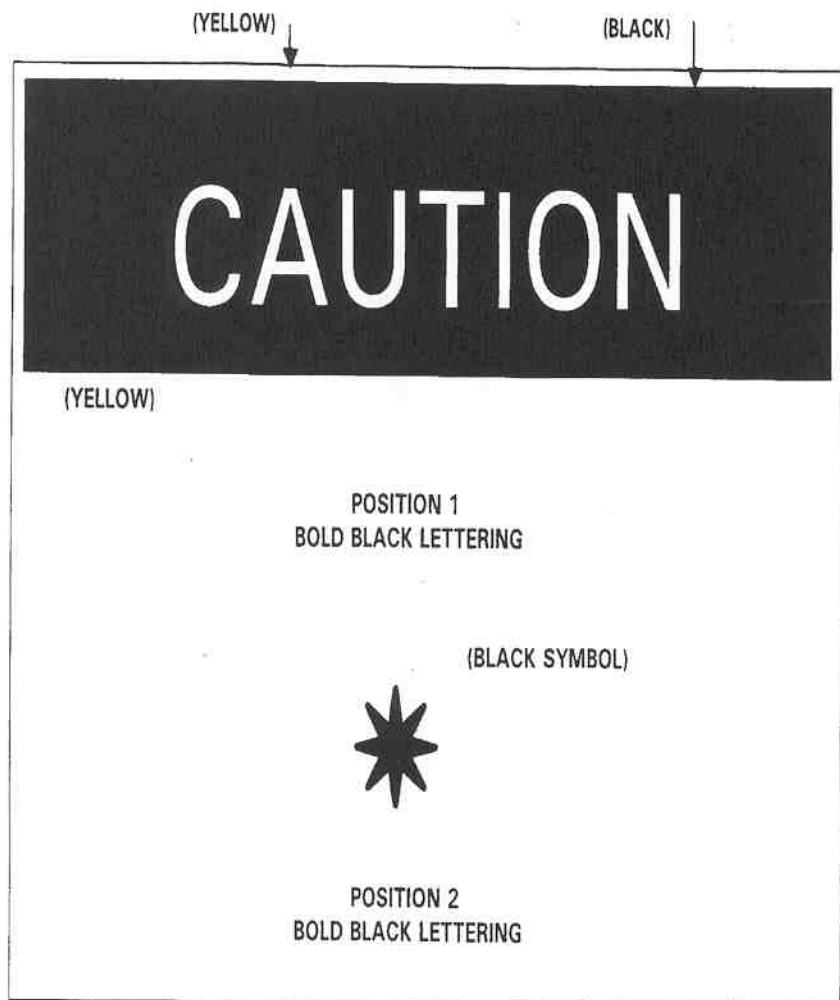


Figure 5 - 4  
Optical Radiation Warning Sign

## **SECTION 6 CONTROL PROVISIONS FOR THE USE OF RADIOFREQUENCY (RF)/MICROWAVE RADIATION DEVICES**

### **6.1 GENERAL**

Procurement, possession, and use of radiofrequency (RF)/microwave radiation devices under the purview of the KSC Nonionizing Radiation Protection Program require coordination with the KSC Radiation Protection Officer (RPO) and approval by the KSC Radiation Protection Committee (RPC). Notwithstanding such Radiation Protection Program approvals, the unique nature of certain RF/microwave radiation devices may cause regulatory agencies outside NASA/KSC to require authorization or registration of the intended use and/or location of such devices. It must be noted, however, that such outside authorization or registration will be required in addition to and concurrently with KSC Nonionizing Radiation Protection Program approval. The provisions in this Section are provided to assist users in their effort to comply with NASA/KSC requirements as well as those of other regulatory agencies as they apply to NASA-directed operations at KSC/CCAFS.

### **6.2 REGISTRATION**

Certain nonionizing radiation devices on pertinent areas of KSC/CCAFS may require specific registration by the State of Florida or other Federal agencies, such as the Federal Communications Commission (FCC). Copies of all such registrations must be provided to the KSC RPO as part of the data submittal required for KSC Radiation Protection Program authorization of RF/microwave radiation devices.

### **6.3 KSC REQUIRED AUTHORIZATIONS AND PROVISIONS**

#### **a. General Provisions**

Any organization or individual functioning under KSC jurisdiction proposing to procure, possess, use, store, transfer, or otherwise dispose of RF/microwave devices that are not specifically exempted from KSC Nonionizing Radiation Protection Program requirements (refer to paragraph 6.4, Program Exemptions) must request and obtain authorization to do so. The KSC RPO is the focal point of the KSC Nonionizing Radiation Protection Program for coordination of such authorizations.

(1) Unless specifically exempted by the provisions of paragraph 6.4 of this Section or by KSC RPO direct action, KSC use authorization is required for any RF/microwave radiation device operating at frequencies between 3kHz and 300 GHz, including but not limited to:

- (a) radar systems;
- (b) spacecraft and vehicle telemetry and communications systems;

- (c) earth stations;
  - (d) microwave diathermy units; and
  - (e) radiofrequency (RF) generators
- (2) Prior written authorization to procure for use or to transport RF/microwave radiation devices on to KSC must be obtained from the KSC RPO or designated representative. KSC Nonionizing Radiation Protection Program authorization is also required for responsible individuals and for all documented instructions or procedures (and subsequent revisions) applicable to operations involving such radiation devices. This applies to requests and plans which involve the acquisition, possession, use, storage, and transfer or other disposition of these RF/microwave radiation devices. No operation or modification to existing operation shall be initiated prior to issuance of KSC Nonionizing Radiation Protection Program authorization.
  - (3) KSC Nonionizing Radiation Protection Program authorization of storage and use areas and facilities shall be obtained prior to commencement of initial operations.
  - (4) Overall inventory control and administrative accountability of all authorized RF/microwave radiation devices on KSC shall be maintained by the KSC Radiation Protection Program office. Individual users and use organizations shall ensure accountability for their sources and coordinate this effort with the KSC RPO, or designated representative.
  - (5) Radiation Controlled Areas and Exclusion Areas, as described by the applicable Use Authorization, shall be posted and controlled by the user. Warning signs and labels described by this KNPR or their equivalent shall be utilized in all area postings.
  - (6) All personnel exposure to RF/microwave radiation devices on KSC/CCAFS shall be kept ALARA.
  - (7) Any RF/microwave radiation device improperly transported onto KSC/CCAFS shall be subject to impoundment, until, either the irregularities are corrected and appropriate KSC authorizations are obtained, or removal from KSC is arranged.
  - (8) Noncompliance with KSC Nonionizing Radiation Protection Program requirements relative to the authorized use of RF/microwave radiation devices will result in the revocation or suspension of such use authorization, and impoundment of radiation devices.



b. Data Submittals and Approvals

KSC Nonionizing Radiation Protection Program authorization for the possession or use of controlled RF/microwave radiation devices requires submittal of the appropriate completed KSC Nonionizing Radiation Protection Program form(s) for the device(s), together with any supportive data required. Submittals shall be made as soon as practicable, but in no case later than 90 days (unless otherwise specified) prior to the intended arrival of the radiation devices. Appropriate KSC forms required for RF/microwave radiation devices and associated data submittal requirements for KSC Nonionizing Radiation Protection Program authorization are described in this section.

(1) Radio Frequency and Microwave Systems

KSC Form 16-451, "Radio Frequency/Microwave Systems Use Request/Authorization," must be completed and submitted for evaluation of all controlled sources, including radar units, communication systems, satellite earth stations, radio frequency (RF) generators. In cases where applicability of program requirements is unclear to the user organization and cannot otherwise be determined, KSC Form 16-451 with completed Section I (IA through IE) shall be submitted for review and preliminary evaluation by the JBOSC HPO for the KSC RPO. Based upon this review, additional data and information may be required by the RPO to complete the authorization process.

(2) User Personnel Identification

KSC Form 16-450, "Training and Experience Summary for Nonionizing Radiation Users," shall be completed and submitted with the appropriate Use Request/Authorization form for each identified user/operator, the Area Radiation Officer (ARO), and the Use Supervisor/Custodian (US/C) proposed for possession and use of the specified RF/microwave radiation device.

(3) Modification of Approved Use Authorization

KSC Form 16-353, "Modification of Radiation Use Authorization," shall be completed and submitted for evaluation of any intended changes to applicable procedures, licenses or registrations, facilities, personnel, or equipment or materials described by the current KSC Use Authorization. Submittal of requests for modification of Use Authorization shall be submitted not later than 30 days prior to the implementation of the intended changes.

c. Specific Data Submittal Requirements

- (1) Certain information is required to be submitted in support of a request for use of radio frequency/microwave radiation devices at KSC. All documentation for initial use requests should be submitted as a single complete copy of the submittal package.
- (2) Copies of appropriate use Request/Authorization forms for use of RF/microwave radiation devices related to cargo or payloads should be included in any safety review documentation associated with the payload/cargo which is provided prior to arrival of sources.
- (3) Request for use of RF/microwave devices at KSC/CCAFS shall be submitted to the JBOSC HPO for the KSC RPO, as early as practicable, but in no case later than 90 days prior to projected receipt of the device(s) at KSC/CCAFS.
- (4) Elements of a complete data submittal package for Use Authorization include, but may not necessarily be limited to, those described below:
  - (a) the appropriate KSC Nonionizing Radiation Protection Program Use Request/Authorization form;
  - (b) licenses or other appropriate registrations possessed by the user organization to own, maintain, and use the specific radiation device;
  - (c) all applicable operating, maintenance, and emergency procedures relating to possession and use of the radiation device(s) for which authorization is being requested;
  - (d) a listing, by full name and badge number, of all proposed user/operator personnel, accompanied by a completed KSC Form 16-450 for each individual identified;
  - (e) a completed KSC Form 16-450 for the designated Area Radiation Officer (ARO) and Use Supervisor/Custodian (US/C); and
  - (f) approximate dates of arrival and departure of the specified radiation device(s) to and from KSC/CCAFS, and mission or payload designation.

#### 6.4 PROGRAM EXEMPTIONS

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. The conditions listed below must be met for exempted sources. Individuals should consult with the KSC RPO or the JBOSC Health Physics Office, if there is a question regarding applicability of program exemption to their particular situation or requirement.

a. Exempted Item Categories

The following general categories of radio frequency/microwave radiation devices are exempted:

- (1) devices with transmitter power of 7 watts or less and an antenna gain of unity ('walkie-talkies', car phones, cellular phones), at frequencies between 100 kHz and 450 MHz;
- (2) speed monitoring devices ('radar-guns');
- (3) automotive radar detectors;
- (4) RF/microwave radiation devices designed for and operated in a completely enclosed configuration where no open air transmission is possible;
- (5) RF/microwave radiation devices designed to operate in a hard-lined, closed loop configuration where no open air transmission is possible; and
- (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%) of current applicable maximum permissible exposures levels.

b. Basis for Exemption of Sources

Exemptions are valid for the general categories of equipment, instruments, and systems identified by paragraph 6.4.a of this Section provided that:

- (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;
- (2) the design and manufacture of the item is in accordance with the specifications of the Federal Performance Standard for Electronic Products (Title 21, CFR, Part 1010);
- (3) the item is operated in accordance with the manufacturer's recommended operating procedures; and

- (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 6.4.a shall be performed only by appropriately authorized and qualified personnel.

c. General Precautions for Exempted Items

(1) Associated hazards

Exemption of radiation devices from the authorization requirements of the KSC Nonionizing Radiation Protection Program shall not be construed to exempt the user from other safety requirements relating to potential hazards associated with operation of the item, such as, electrical hazards.

(2) ALARA

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

- (a) close or prolonged exposure to emissions of devices, and
- (b) intrabeam exposure conditions of any duration.

6.5 RADIATION PROTECTION CONTROLS FOR RADIOFREQUENCY (RF)/MICROWAVE SYSTEMS

a. General Considerations

- (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.
- (2) For all uses of RF/microwave systems, it is recommended the minimum level of RF/microwave radiation required for the application be utilized.
- (3) RF/microwave transmitter beam height should be maintained at a level not to intercept occupied facilities/structures and/or personnel within the identified hazard distance.
- (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.

- (5) If engineering controls are impractical or inadequate, administrative and procedural controls and protective equipment shall be used to limit access to RF radiation.

b. Applicability of Control Measures

- (1) The purpose of control measures is to limit the possibility of exposure of personnel to hazardous levels of RF/microwave radiation and to associated hazards.
- (2) Whenever the application of any one or more control measures reduces the possible exposure to a level at or below the applicable Protection Guide (PG), the application of additional controls for the same purpose is not required.
- (3) Control measures described by this KNPR and the applicable KSC Use Authorization shall apply at all times when an RF/microwave system is in its operational and maintenance modes.
- (4) If, during periods of service to a RF/microwave system, the level of accessible radiation exceeds the applicable PG, the applicable control measures shall be instituted on a temporary basis.

c. Substitution of Alternate Control Measures

Engineering control measures described by paragraph 6.5.d may, upon review and approval by the KSC RPO, be replaced by procedural, administrative, or other alternate engineering controls which provide equivalent protection.

d. Engineering Controls

(1) Service Access Panels

- (a) 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 either:
  1. interlocked, or
  2. require a tool for removal and shall have an appropriate warning label on the panel.
- (b) If the interlock can be bypassed or defeated, a warning label shall be located on or near the interlock.

(2) Antenna Stops

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.

(3) Antenna Activation Warning Systems

When required by the provisions of the applicable KSC Use Authorization, a blue rotating light shall be installed near the antenna site and activated when the RF system is transmitting. A sign explaining the purpose of the blue rotating light shall be posted adjacent to the light.

e. Administrative and Procedural Controls

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 personal protective equipment (PPE).

(1) Written Procedures

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.

(2) Output Emission Limitations

The RF/microwave system ARO shall take such action as is necessary and approved by the RPO to reduce levels of accessible power to that which is commensurate with the required application.

(3) Education and Training

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

(4) Authorized Personnel

RF/microwave systems with accessible emission levels exceeding the appropriate PG shall be operated, maintained, and serviced by qualified and trained personnel.

f. RF/Microwave Area Identification and Control

(1) RF/Microwave Radiation Control Area (RCA)

- (a) The area shall be posted with the appropriate warning sign(s) as described by paragraph 6.5.g of this Section.
- (b) The area shall be operated by and under the control of KSC approved operator personnel.
- (c) Untrained and unauthorized personnel shall be excluded from the RCA at all points where the appropriate PG is exceeded.
- (d) Radiating antennas shall never be positioned in such a manner as to intercept occupied facilities/structures and/or personnel within the identified hazard zone.
- (e) The RF/microwave beam path shall not exceed the established elevation and azimuth restrictions.
- (f) The RF/microwave beam path shall be terminated when possible.
- (g) When the RF/microwave system is not being used, it shall be disabled in a manner to prevent unauthorized use.

(2) Temporary RF/Microwave Control Area

In those conditions where entry into the hazard zone becomes necessary because of a contingency, and the accessible RF radiation exceeds the applicable PG, a temporary RF radiation control area shall be established.

- (a) Such a temporary area which by its nature will not have the built-in protective features as defined for an RF radiation control area, shall provide adequate safety requirements for all personnel, both within and without the area.
- (b) A notice sign (refer to paragraph 6.5.g of this Section) shall be posted outside the temporary RF radiation control area to warn of potential hazard.
- (c) Personnel working inside the temporary RF radiation control area shall maintain surveillance over the area to preclude unauthorized entry.

g. Warning Signs and Labels

(1) RF warning sign and Labels

RF warning signs and labels should be utilized as described in ANSI C95.2 "American National Standard Radio Frequency Radiation Hazard Warning Symbol."

(2) Inclusion of Pertinent Information

The inclusion and choice of warning information or precautionary instructions should follow the guidelines of ANSI C95.2, unless otherwise specified by the KSC Use Authorization.

(3) Display of Signs and Labels

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

h. Associated Hazards

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

(1) High-voltage sources and wiring should be shielded.

(2) High-voltage equipment may produce x-radiation and require shielding.

(3) All electrical equipment should be properly grounded.

i. Medical Surveillance Requirements

Medical surveillance requirements for RF/microwave systems are included in Appendix C to this KNPR.



## **APPENDIX A RADIATION INCIDENT NOTIFICATIONS**

### **A.1 GENERAL**

Nonionizing radiation incidents may result in exposure of personnel to nonionizing radiation. The resulting exposure is not assessable except by the use of specialized techniques and detection instrumentation.

### **A.2 BASIC EMERGENCY PROCEDURES**

#### **a. Eliminate Source of Radiation**

- (1) Remove power source to radiation producing device.
- (2) If unable to remove power to radiation source, evacuate personnel from radiation area.

#### **b. Notify Appropriate Response Elements**

- (1) Refer to Section A.3 for notification requirements and telephone numbers.
  - (a) Notify Emergency Response elements, (Fire, Medical, Security, etc.) as determined necessary.
  - (b) Notify KSC Radiation Protection Officer, or designated representative.
  - (c) Notify KSC Emergency Preparedness Officer as determined necessary.
- (2) Use Section A.4 to list local telephone notification numbers if different from A.3.

#### **c. Standby Activities for Affected Area Personnel**

- (1) Control unauthorized access to the area.
- (2) Inform response element(s) of the nature of the radiological hazard (i.e., type of nonionizing device).
- (3) Detain evacuated personnel in marshaling area until released by the RPO, or designated representative.

d. Personnel Conduct

- (1) Potentially exposed personnel shall be required to provide a detailed account of conditions/circumstances surrounding the exposure incident.
- (2) The written account shall be provided to the KSC RPO.
- (3) Survey efforts shall in all cases be conducted under the supervision of the KSC RPO, or designated representative.

A.3 RADIATION INCIDENT NOTIFICATION

a. Notification Requirements

- (1) Radiation incidents involving fire, explosion, personnel injury or facility damage requiring emergency response by medical, fire, and/or security elements should be reported by using the telephone number 911 (KSC). Caller must identify the radiation source and describe its involvement in the emergency. See paragraph A.3.b below for telephone numbers.
- (2) All other radiation incidents not requiring emergency notification must be immediately reported to the KSC RPO or designated representative. See paragraph A.3.b for telephone numbers.

b. Telephone Numbers

- (1) All Hours Emergency Response 911  
(Medical, Fire, Security)
- (2) Normal Duty Hours (0730-1630)  
  
KSC Radiation  
Protection Officer 321-867-6958  
  
JBOSC Health Physics 321-853-5688/5689  
  
KSC Emergency  
Preparedness Office 321-867-8723  
  
45th SW Radiation  
Protection Officer 321-494-5435

- c. Listings above are subject to change without notice or may not be applicable to your area. Consult your local installation telephone directory for current listings and for areas not listed.

A.4 LOCAL NOTIFICATION TELEPHONE NUMBERS/PROCEDURES

Use this Section to record other or additional telephone numbers and procedures for notifications, as required for your specific area.

FIRE\_\_\_\_\_

MEDICAL\_\_\_\_\_

SECURITY\_\_\_\_\_

RADIATION PROTECTION\_\_\_\_\_

NOTES:

## **APPENDIX B      MEDICAL SURVEILLANCE REQUIREMENTS**

### **B.1      GENERAL**

- a.      This Appendix provides user guidance relating to minimum acceptable medical surveillance requirements for users or operators of various types of nonionizing radiation devices.
- b.      Medical surveillance examinations may include assessment of physical fitness to safely perform assigned duties, biological monitoring of exposure to a specific agent, and early detection of biologic damage or effect.
- c.      Establishment of medical surveillance requirements shall be in accordance with the minimum requirements specified in this Appendix. Based upon review and assessment of specific proposed uses of nonionizing radiation devices, additional medical surveillance requirements may be levied by the KSC RPO, as deemed appropriate.

### **B.2      LASERS AND LASER SYSTEMS**

#### **a.      General Provisions**

- (1)      Medical surveillance is required for all approved users or operators of Class 3b or Class 4 lasers.
- (2)      Additional medical surveillance requirements may be established by the KSC RPO, based upon the specific proposed use of the laser or laser system, the personnel involved, or the area in which operations may occur.

#### **b.      Personnel Risk Categories**

Each individual's risk category shall be established by the KSC RPO relative to the type (Class) of laser to be used and the perceived involvement of the individual in the actual operation of the laser or laser system.

##### **(1)      Incidental Personnel**

Incidental personnel are those individuals whose work makes it possible (but unlikely) that they shall be exposed to laser energy of sufficient magnitude to damage eyes or skin, e.g., custodial, clerical, and supervisory personnel not directly involved in laser operations.

(2) Laser Personnel

Laser personnel are those who work routinely in laser environments. These individuals are ordinarily fully protected by engineering controls or administrative procedures, or both.

c. General Procedures

(1) Incidental Personnel

Incidental personnel shall have an eye examination for visual acuity for far and near vision.

(2) Laser Personnel

Laser personnel shall be subject to the following baseline eye examination:

- (a) ocular history, to include noting of current refraction prescription and date of most recent examination,
- (b) visual acuity for far and near vision with refraction corrections, if required,
- (c) macular function for distortions and scotomas,
- (d) contrast sensitivity, and
- (e) ocular fundus examination by ophthalmoscope, if results of any of the tests specified above are outside the normal range.
- (f) Wavelength specific tests

The following tests shall be required only when the proposed laser use involves the emission of radiation within the wavelength ranges noted below:

- 1. external ocular examination - for users of laser radiation or exposure to collateral radiation in the ultraviolet (less than 350 nm) or far infrared (greater than 1400 nm) wavelength regions;
- 2. slit lamp examination - for users of laser radiation or exposure to collateral radiation in the wavelength regions less than 420 nm or greater than 750 nm; or

3. skin examination - suggested for personnel with a history of photosensitivity or working with ultraviolet lasers.

(g) Other examinations

Further examinations should be done as deemed necessary by the examiner.

d. Frequency of Examinations

(1) Preplacement

For both incidental and laser personnel, required examinations shall be performed prior to participation in laser work.

(2) Suspected Injury

Following any suspected laser overexposure or injury, the pertinent tests shall be repeated, in addition to whatever other examinations may be desired by the attending physician.

(3) Periodic and Termination Examinations

Periodic and termination examinations are not required.

e. Records and Record Retention

- (1) Complete and accurate records of all routine medical examinations (including specific test results) should be retained at least 8 years.

- (2) Records of examinations for suspected exposures should be retained for at least 30 years.

B.3 OPTICAL FIBER COMMUNICATIONS SYSTEMS (OFCS)

a. General Provisions

- (1) Medical surveillance is required for all personnel assigned to work routinely on SG3b OFCS and whose job requires:
  - (a) disconnecting optical connectors,
  - (b) using SG3b optical test equipment, or
  - (c) performing splicing operations on SG3b OFCS.

- (2) Employees who work in the general vicinity of OFCS but who are not routinely within the control distance of an emitting optical fiber should not be included in the medical surveillance program.
- (3) Additional medical surveillance requirements may be established by the KSC RPO based upon the specific proposed use of the OFCS, the personnel involved, or the area in which operations may occur.

b. Personnel Risk Categories

Each individual's risk category shall be established by the KSC RPO relative to the OFCS Service Group (SG) to be used and the perceived involvement of the individual in the actual operation, maintenance, or servicing of the OFCS. The risk categories used for establishment of OFCS medical surveillance requirements are the same as those used for lasers and laser systems.

(1) Incidental Personnel

Incidental personnel are those individuals whose work makes it possible (but unlikely) that they shall be exposed to laser energy of sufficient magnitude to damage eyes or skin, e.g., custodial, clerical, and supervisory personnel not directly involved in laser operations.

(2) Laser Personnel

Laser personnel are those who work routinely with SG3b OFCS. These individuals are ordinarily fully protected by engineering controls or administrative procedures, or both.

c. General Procedures

(1) Incidental Personnel

Incidental personnel shall have an eye examination for visual acuity for far and near vision.

(2) Laser Personnel

Laser personnel shall be subject to the following baseline eye examination:

- (a) ocular history, to include noting of current refraction prescription and date of most recent examination,
- (b) visual acuity for far and near vision with refraction corrections, if required,

- (c) macular function for distortions and scotomas,
- (d) contrast sensitivity, and
- (e) ocular fundus examination by ophthalmoscope, if results of any of the tests specified above are outside the normal range.
- (f) Wavelength specific tests
  - 1. External ocular examination - for personnel exposed to radiation in the ultraviolet (less than 350 nm)  
  
or far infrared (greater than 1400 nm) wavelength regions
  - 2. Slit lamp examination - for personnel exposed to wavelength regions less than 420 nm or greater than 750 nm
- (g) Other examinations

Further examinations should be done as deemed necessary by the examiner.

d. Frequency of Examinations

(1) Preplacement

For both incidental and laser personnel, required examinations shall be performed prior to participation in OFCS work.

(2) Suspected Injury

Following any suspected OFCS overexposure or injury, or for specific eye complaints, the pertinent tests shall be repeated, in addition to whatever other examinations may be desired by the attending physician.

(3) Periodic and Termination Examinations

Periodic and termination examinations are not required.

e. Records and Record Retention

- (1) Complete and accurate records of all medical examinations (including specific test results) should be retained for at least 8 years.



- (2) Records of examination for suspected exposure should be retained for at least 30 years.

B.4 NONLASER OPTICAL RADIATION DEVICES

There are currently no routine medical surveillance requirements for users of nonlaser optical radiation devices.

B.5 RADIOFREQUENCY/MICROWAVE RADIATION SYSTEMS

There are currently no routine medical surveillance requirements for users of radiofrequency/microwave radiation systems.

## APPENDIX C RADIATION PROTECTION FOR NONIONIZING RADIATION

### C.1 GENERAL

- a. This Appendix describes current criteria for protection guides regarding personnel exposure to sources of nonionizing radiation.
- b. The information provided in this Appendix is for use by prospective users of nonionizing radiation devices at KSC/CCAFS.
- c. The information provided herein shall not be used to demarcate areas of safe and unsafe levels of nonionizing radiation.
- d. Specific Protection Guides (PGs) for controlled nonionizing radiation device usage shall be specified by the KSC RPO following receipt of the use request submittal package as described by Section 5 or 6 of this KNPR, as applicable.

### C.2 LASERS AND LASER SYSTEMS

#### a. Personnel Exposure Limits

Limits for personnel exposure to emissions from lasers and laser systems shall be derived from guidance provided by current standards, guides, and regulations applicable to personnel exposure to laser radiation.

#### b. Applicable Standards, Guides, and Regulations

Standards, guidance documents, and regulations applicable to establishment of exposure limits for laser radiation include, but are not necessarily limited to, the following:

- (1) Air Force Occupational Safety and Health (AFOSH) Standard 48-10, "Health Hazards Control for Laser Radiation"
- (2) American National Standards Institute (ANSI) Standard Z136.1, "Safe Use of Lasers"
- (3) ANSI Standard Z136.2, "Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources"
- (4) ANSI Standard Z136.3, "Safe Use of Lasers in Health Care Facilities"
- (5) 45SW Instruction 40-201, "Radiation Protection Program"
- (6) State of Florida Administrative Code (FAC) Chapter 64E-4, "Control of Nonionizing Radiation Hazards"

- (7) U.S. Code of Federal Regulations, Title 21, Part 1040
- (8) United States Army Environmental Hygiene Agency, "Laser and Optical Hazards," February 1989
- (9) "Safety With Lasers and Other Optical Sources, A Comprehensive Handbook," Sliney and Wolbarsht, Plenum Press 1980

### C.3 OPTICAL FIBER COMMUNICATIONS SYSTEMS (OFCS)

#### a. Personnel Exposure Limits

Limits for personnel exposure to emissions from OFCS shall be derived from guidance provided by current standards, guides, and regulations applicable to personnel exposure to OFCS.

#### b. Applicable Standards, and Regulations

Standards and regulations applicable to establishment of exposure limits for OFCS emissions include, but are not necessarily limited to, the following:

- (1) American National Standards Institute (ANSI) Standard Z136.1, "Safe Use of Lasers"
- (2) ANSI Standard Z136.2, "Safe Use of Optical Fiber Communication systems Utilizing Laser Diode and LED Sources"
- (3) 45SW Instruction 40-201, "Radiation Protection Program"
- (4) State of Florida Administrative Code (FAC) Chapter 10D-89, "Control of Nonionizing Radiation Hazards"
- (5) U.S. Code of Federal Regulations, Title 21, Part 1040
- (6) United States Army Environmental Hygiene Agency, "Laser and Optical Hazards," February 1989
- (7) "Safety With Lasers and Other Optical Sources, A Comprehensive Handbook," Sliney and Wolbarsht, Plenum Press 1980

### C.4 NONLASER OPTICAL RADIATION DEVICES

#### a. Personnel Exposure Limits

Limits for personnel exposure to emissions from nonlaser optical radiation (i.e., ultra violet (UV), infrared (IR) and high intensity visible (VIS) radiation) devices shall be derived from guidance provided by current standards,

guides, and regulations applicable to personnel exposure to nonlaser optical radiation devices.

b. Applicable Standards, Guides, and Regulations

Standards, guidance documents, and regulations applicable to establishment of exposure limits for nonlaser optical radiation emissions include, but are not necessarily limited to, the following:

- (1) American Conference of Governmental. Industrial Hygienists (ACGIH), "TLVs Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices." Visible and optical sources with luminance of not greater than  $1 \text{ cd/cm}^2$ , are generally exempt from controls.
- (2) Department of Health and Human Services, Public Health Service, Food and Drug Administration, Center for Devices and Radiological Health
- (3) United States Army Environmental Hygiene Agency, "Laser and Optical Hazards," February 1989
- (4) 45 SW Instruction 40-201 "Radiation Protection Program"
- (5) "Safety With Lasers and Other Optical Sources, A Comprehensive Handbook," Sliney and Wolbarsht, Plenum Press 1980

C.5 RADIOFREQUENCY/MICROWAVE RADIATION SYSTEMS

a. Personnel Exposure Limits

Limits for personnel exposure to emissions from radiofrequency (RF)/microwave radiation sources shall be derived from guidance provided by current standards, guides, and regulations applicable to personnel exposure to RF/microwave radiation.

b. Applicable Standards and Regulations

Standards and regulations applicable to establishment of exposure limits for RF/microwave emissions include, but are not necessarily limited to, the following:

- (1) Air Force Occupational Safety and Health (AFOSH) Standard 48-9, "Exposure to Radiofrequency Radiation"
- (2) American National Standards Institute (ANSI) /IEEE Standard C95.1, as revised, "Safety Levels With Respect to Human Exposure To Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz"

- (3) 45SW Instruction 40-201, "Radiation Protection Program"
- (4) U.S. Code of Federal Regulations, Title 21, Parts 1010 and 1030
- (5) U.S. Code of Federal Regulations, Title 29, Part 1910.97
- (6) United States Army Environmental Hygiene Agency, "Radiofrequency/  
Ultrasound Hazards," April 1989

## APPENDIX D GLOSSARY

**ABSORPTION** - Transformation of radiant energy to a different form of energy by interaction with matter.

**ACCESSIBLE EMISSION LIMIT (AEL)** - The maximum accessible emission level permitted within a particular laser classification.

**ACCOMMODATION** - The ability of the eye to change its focal length, thus focusing for objects at variable distances.

**ANTENNA** - An apparatus for radiating and/or receiving electromagnetic waves.

**ANTENNA ARRAY** - A system of antennas coupled together for the purpose of obtaining directional effects.

**ANTENNA, DIELECTRIC** - An antenna which employs dielectric as the major component in producing the required radiation.

**ANTENNA, DIPOLE** - A straight radiator, usually fed in the center producing a maximum of radiation in the plane normal to its axis. The length specified is the overall length.

**ANTENNA DIRECTIVITY** - The value of the directive gain in the direction of its maximum value.

**ANTENNA EFFECTIVE AREA** - In any specified direction, the square of the wavelength multiplied by the power gain in that direction and divided by 47.

### **ANTENNA EFFECTIVE HEIGHT -**

1. The height of the antenna center of radiation above the effective ground level.
2. In low-frequency applications, the term applied to loaded or non-loaded vertical antennas, and equal to the moment of the current distribution in the vertical section divided by the input current.

**ANTENNA, HORN** - An antenna having the shape of a tube whose cross-sectional area increases toward the open end and through which radio waves pass.

**ANTENNA, ISOTROPIC** - A hypothetical antenna radiating or receiving equally in all directions.

**ANTENNA, LENS** - In radio practice, a structure substantially transparent to radio waves but which inserts a phase delay over the cross section of an aperture so as to effect a convergence (or divergence) of radio wave.

**ANTENNA, PARABOLIC** - An antenna consisting of a parabolic reflector and a source at or near its focus.

**APERTURE** - An opening through which radiation can pass.

**ATHERMAL EFFECT** - Any effect of electromagnetic radiation absorption exclusive of the production of heat.

**ATTENUATION** - A general term used to denote a decrease in magnitude from one point to another.

**BEAM** - A collection of rays which may be parallel, divergent, or convergent.

**BEAM DIAMETER** - The distance between diametrically opposed points in that cross section of a beam where the power unit area is 1/e times that of the peak power per unit area.

**BEAM DIVERGENCE** - The full angle of the beam spread between diametrically opposed 1/e irradiance points; usually measured in milliradians (one milliradian = 3.4 minutes of arc).

**CARCINOGENIC** - Capable of causing cancer in a biological system.

**CLASS 1 LASER or LASER SYSTEM** - Class 1 lasers and laser system include any laser, or system containing a laser, that cannot emit accessible levels of laser radiation 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.

**CLASS 2 LASER OR LASER SYSTEM** - Class 2 (low power) lasers and laser systems include:

1. Visible (400 to 700 nm) continuous wave (cw) lasers and laser systems which can emit accessible radiant power exceeding the Class 1 AEL for the maximum possible exposure duration inherent in the design or intended use of the laser or lasers system, but not exceeding 1 milliwatt (MW).
2. Visible (400 to 700 nm) repetitively pulsed lasers and laser systems which can emit accessible radiant power exceeding the Class 1 AEL for the maximum possible exposure duration inherent in the design or use of the laser or laser system, but not exceeding the Class 1 AEL for a 0.25 second exposure duration.

**CLASS 2a LASER or LASER SYSTEM** - A visible (400 to 700 nm) laser or laser system intended for a specific use where the output is not intended to be viewed and the accessible radiant power does not exceed the Class 1 AEL for an exposure duration less than or equal to 1000 seconds.

**CLASS 3 LASER or LASER SYSTEM** - Class 3 (medium power) lasers and laser systems include:

1. Infrared (1400 nm to 1 mm) and ultraviolet (200 to 400 nm) lasers and laser systems which can emit accessible radiant power in excess of the Class 1 AEL for the maximum possible exposure 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 watts (W) for exposure durations equal to or greater than 0.25 seconds, or
  - b. cannot produce a radiant exposure of 10 joules per square centimeter ( $\text{J}/\text{cm}^2$ ) within an exposure duration less than 0.25 seconds.
2. Visible cw or repetitively pulsed lasers and laser systems which produce accessible radiant power in excess of the Class 1 AEL for a 0.25 second exposure duration, but which cannot emit an average radiant power greater than 0.5 W.
3. Visible and near-infrared (400 to 1400 nm) single pulse lasers which can emit accessible radiant energy in excess of the Class 1 AEL but which cannot produce a radiant exposure that exceeds  $10 \text{ J}/\text{cm}^2$ .
4. Near-infrared cw or pulsed lasers which can emit accessible radiant power in excess of the Class 1.

AEL for the maximum 'on-time' inherent in the design or intended use of the laser or laser system, but which cannot emit an average power of 0.5 W or greater for exposure periods equal to or greater than 0.25 seconds.

**CLASS 3a LASER or LASER SYSTEM** - Class 3 lasers or laser systems which have an accessible power output that is:

1. between 1 and 5 times the Class 1 AEL for wavelengths less than 400 nm or greater than 700 nm, or
2. between 1 and 5 times the Class 2 AEL for wavelengths between 400 and 700 nm, are designated as Class 3a lasers or laser systems.

**CLASS 3b LASER or LASER SYSTEM** - All Class 3 lasers which do not meet the requirements for Class 3a are designated as Class 3b lasers or laser systems.

**CLASS 4 LASER OR LASER SYSTEM** - Class 4 (high power) lasers and laser systems are those which:

1. emit an average accessible radiant power in excess of 0.5 W for exposure duration equal to or greater than 0.25 seconds, or
2. produce a radiant exposure of  $10 \text{ J}/\text{cm}^2$  for an exposure duration of less than 0.25 seconds.



**COHERENT** - A light beam is said to be coherent when the electric vector at any point in it is related to that at any other point by definite, continuous sinusoidal function.

**COLLIMATED BEAM** - Effectively, a "parallel" beam of light with very low divergence or convergence.

**COLLIMATOR** - An optical device for converting a diverging or converging beam of light into a collimated or 'parallel' one.

**CONTINUOUS WAVE (CW)** - A term used to describe any nonionizing radiation device operating with a continuous output for periods equal to or greater than 0.25 seconds.

**CONTROLLED AREA** - An area where the occupancy and activity of those within is subject to control and supervision.

**CONTROLLED SOURCE** - A source/device of nonionizing radiation not specifically exempted under the provisions of this KNPR.

**CORNEA** - The transparent outer coat of the human eye which covers the iris and the crystalline lens. It is the main refracting element of the eye.

**CRYOGENICS** - The branch of physics dealing with very low temperatures.

**DIFFUSE REFLECTION** - The change of the spatial distribution of a beam of radiation when it is reflected in many directions by a surface or by a medium.

**DUTY FACTOR** - Of a wave composed of pulses that recur at regular intervals, the product of the pulse duration and the pulse repetition frequency.

**ELECTROMAGNETIC RADIATION** - The flow of energy consisting of orthogonally vibrating electric and magnetic fields lying transverse to the direction of propagation. X-rays, ultraviolet, visible, infrared, and radio waves occupy various portions of the electromagnetic spectrum and differ only in frequency and wavelength.

**EMBEDDED LASER** - A laser with an assigned class number higher than the inherent capability of the laser system in which it is incorporated, where the systems lower classification is appropriate to the engineering features limiting accessible emission.

**ENERGY** - The capacity for doing work. Energy content is commonly used to characterize the output from pulsed lasers, and is generally expressed in joules.

**ERYTHEMA** - A redness of the skin due to congestion of the capillaries.

**EXPOSURE (LASER)** - The product of an irradiance and its duration.

**EXPOSURE (RF)** - Generally expressed in terms of power density ( $\text{mW}/\text{cm}^2$ ) or equivalent electric field strength ( $\text{V}/\text{m}$ ).

**FAILSAFE INTERLOCK** - An interlock where the failure of a single mechanism or electrical component of the interlock shall cause the system to go into or remain in, a safe mode.

**PAR-FIELD REGION** - That region of the field of an antenna where the angular field distribution is essentially independent of the distance from the antenna. For an antenna focused at infinity, the far-field region is sometimes referred to as the Fraunhofer region on the basis of analogy to optical terminology.

**FIBER OPTICS** - The branch of optical technology concerned with the transmission of radiant power through fibers made of transparent materials such as glass, fused silica, or plastic.

**GAIN** - General term used to denote an increase in signal power in transmission from one point to another. Gain is usually expressed in decibels (dB).

**HERTZ (Hz)** - The unit which expresses the frequency of a periodic oscillation in cycles per second.

**INFRARED (IR)** - Electromagnetic radiation with wavelengths which lie within the range 700 nanometers to 1 millimeter.

**INSERTION LOSS** - The loss resulting from the insertion of a transducer in a transmission system. It is the ratio of power delivered before the insertion to that part of the system following the transducer, to the power delivered to that same part after the insertion, usually expressed in decibels (dB)

**INSTALLATION (OFCS)** - Placement and connection of OFCS at the appropriate site to enable intended operation. Installation includes connection and disconnection of optical connectors.

**INTRABEAM VIEWING** - The viewing condition whereby the eye is exposed to all or part of a laser beam.

**IRRADIANCE** - Quotient of the radiant flux incident on an element of the surface containing the point, by the area of that element. Unit: Watt per square centimeter ( $\text{W}/\text{cm}^2$ ).

**JOULE (J)** - A unit of energy; 1 joule = 1 watt-second.

- LASER** -
1. A device which produces an intense, coherent, and directional beam of light by stimulating electronic or molecular transitions to lower energy states.
  2. An acronym for Light Amplification by Stimulated Emission of Radiation.

**LASER DIODE** - A laser employing a forward-biased semiconductor junction as the active medium. Also called injection laser, semiconductor laser.

**LASER FACILITY** - A facility which has one or more Class 2, Class 3, or Class 4 lasers. In the case of facilities possessing more than one laser class, the assigned facility classification is determined by the most hazardous class of laser contained therein.

**LASER SYSTEM** - An assembly of electrical, mechanical, and optical components which includes a laser.

**LASING MEDIUM** - A material emitting coherent radiation by virtue of stimulated electronic or molecular transitions to lower energy levels.

**LENS CONNECTOR** - A fiber optic connector which, by design, decreases the divergence inherent in the optical fiber. Because of the decreased divergence, the nominal hazard zone (NHZ) associated with lens connectors may be considerably greater than that of a conventional connector.

**LIGHT EMITTING - DIODE (LED)** - A p-n junction semiconductor device that emits incoherent optical radiation when biased in the forward direction.

**LIMITING APERTURE** - The maximum diameter of a circular area over which irradiance and radiant exposure can be averaged.

**LOBE** - A portion of directional pattern of an antenna bounded by one or two cones of nulls.

**MAXIMUM PERMISSIBLE EXPOSURE (MPE)** - The level of laser radiation to which a person may be exposed without hazardous effects or adverse biological changes in the skin or eye.

**MAXIMUM PERMISSIBLE IRRADIANCE (MPI)** - The level of laser or LED radiation, associated with OFCS, to which a person may be exposed without hazardous effect or adverse biological changes in the skin or eye.

**METER (m)** - A unit of length in the international system of units; currently defined as a fixed number of wavelength, in vacuum, of the orange-red line of the spectrum of Krypton-86. Typically, the meter is subdivided into the following units:

Centimeter =  $10^{-2}$  m (cm)  
Millimeter =  $10^{-3}$  m (mm)  
Micrometer =  $10^{-6}$  m (um)  
Nanometer =  $10^{-9}$  m (nm)

**MICROWAVE RADIATION** - Electromagnetic radiation with frequencies that lie within the range 300 MHz to 300 GHz.

**MODULATION** - The process, or result of the process, whereby some characteristic of one wave is varied in accordance with another wave or signal.

**NEAR-FIELD REGION RADIATING** - That region of the field of an antenna between the reactive near-field region and the far-field region wherein radiation fields predominate and wherein the angular field distribution is dependent upon distance from the antenna. For an antenna focused at infinity, the radiating near-field region is sometimes referred to as the Fresnel region.

**NEAR-FIELD REGION REACTIVE** - That region of the field immediately surrounding the antenna wherein the reactive field predominates.

**NOMINAL HAZARD ZONE (NHZ)** - The space within which the level of the direct, reflected, or scattered laser radiation during normal operation exceeds the applicable MPE. Exposure levels beyond the NHZ are below the appropriate MPE level.

**NOMINAL OCULAR HAZARD DISTANCE (NOHD)** - The distance along the axis of the unobstructed laser beam from the laser to the human eye beyond which the irradiance or radiant exposure during normal operation is not expected to exceed the appropriate MPE.

#### **NONIONIZING RADIATION**

1. Electromagnetic radiation which is not capable of producing ionization when interacting with matter but is capable of producing thermal or other effects resulting in a personnel health hazard.
2. That portion of the electromagnetic spectrum which includes the frequency and wavelength characteristics associated with ultraviolet, visible, and infrared radiation, radiofrequency, and microwaves.

**NUMERICAL APERTURE (NA)** - The sine of one half the vertex angle of the largest cone of meridional rays that can enter or leave an optical system or element, multiplied by the refractive index of the medium in which the vertex of the cone is located. Generally measured at the 5%-of-peak irradiance points.

**OPTICAL DENSITY** - Logarithm to the base ten of the reciprocal of the transmittance.

**OPTICAL FIBER** - Any filament or fiber, made of dielectric materials, that guides light, whether or not it is used to transmit signals.

**OPTICAL FIBER COMMUNICATION SYSTEM (OFCS)** - A system consisting of one or more laser or 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.

**OFCS SGI** - Any OFCS containing an LED or laser that cannot emit accessible levels of optical radiation in excess of the SG1 AEL for an emission duration of 100 seconds.

**OFCS SG2** - Any OFCS containing an LED or laser emitting in the visible wavelength range which can emit a total accessible radiant power exceeding the appropriate SG1 AEL for the maximum possible duration inherent in the design of the system, but not exceeding the SGI AEL for an exposure duration of 0.25 second or less.

**OFCS SG3a** - OFCS SG3a systems include:

1. Near infrared (700 to 1400 nm) CW or repetitively pulsed OFCS which can emit accessible radiant power in excess of the SG1 AEL for an emission duration of 100 seconds but which cannot emit an average radiant power in excess of the SG3a AEL.
2. Infrared (1400 nm to 1mm) CW or repetitively pulsed OFCS which can emit accessible radiant power in excess of the SG1 AEL for an emission duration of 10 seconds but which cannot emit an average radiant power in excess of the SG3a AEL.
3. Visible (400 to 700 nm) CW or repetitively pulsed OFCS which can emit accessible radiant power in excess of the SG2 AEL for an emission duration greater than 0.25 second but which cannot emit an average radiant power in excess of the SG3a AEL.

**OFCS SG3b** - OFCS SG3b systems include:

1. Near infrared (700 to 1400 nm) CW or repetitively pulsed OFCS which can emit accessible radiant power in excess of the SG3a AEL for an emission duration of 100 seconds but which cannot emit an average radiant power in excess of 0.5 watt.
2. Infrared (1400 nm to 1mm) CW or repetitively pulsed OFCS which can emit accessible radiant power in excess of the SG3a AEL for an emission duration of 10 seconds but which cannot emit an average radiant power in excess of 0.5 watt.
3. Visible (400 to 700 nm) CW or repetitively pulsed OFCS which can emit accessible radiant power in excess of the SG3a AEL for an emission duration of 100 seconds but which cannot emit an average radiant power in excess of 0.5 watt.

**OPTICAL RADIATION** - For the purposes of the Nonionizing Radiation Protection Program and this KNPR, optical radiation is used as a general term to describe nonlaser electromagnetic radiation including infrared, visible, and ultraviolet wavelengths.

**PARTIAL BODY IRRADIATION** - Pertains to the case in which part of the body is exposed to the incident electromagnetic energy.

**PEAK POWER OUTPUT** - In a modulated carrier system, the output power averaged over a carrier cycle, at the maximum amplitude which can occur with any combination of signals to be transmitted.

**POWER** - The time rate at which energy is emitted, transferred, or received; usually expressed in Watts (or Joules per second).

**POWER GAIN** - In a given direction, 4 times the ratio of the radiation intensity in that direction to the net power accepted by the antenna from the connected transmitter.

**POWER LEVEL** - At any point in a transmission system, the ratio of the power at the point to some arbitrary amount of power chosen as a reference. This ratio is usually expressed as decibels referred to 1 milliwatt (dBm) or decibels referred to 1 watt (dBw).

**PROTECTIVE HOUSING** - Any panel, partition, dividing wall, or similar device which prevents human access to laser or collateral radiation in excess of the prescribed accessible emission limit.

**PULSE DURATION** - The time duration of a laser or RF pulse; usually measured as the time interval between the half power points on the leading and trailing-edges of the pulse.

**PULSE REPETITION FREQUENCY (PRF)** - In a system using recurrent pulses, the number of pulses per unit of time.

**PULSED OPERATION** - A term used to describe any nonionizing radiation device which delivers its energy in the form of a single pulse or a train of pulses, with a single pulse duration of less than 0.25 seconds.

**PUPIL** - The variable aperture in the iris through which light travels toward the interior regions of the eye.

**RADIANCE** - Radiant flux or power output per unit solid angle - unit area ( $\text{W}/\text{sr}\cdot\text{cm}^2$ ).

**RADIANT EXPOSURE** - Surface density of the radiant energy received. Unit: Joules per square centimeter ( $\text{J}/\text{cm}^2$ ).

**RADIATION PROTECTION GUIDE (RPG)** - Recommended radiation exposure levels that shall not be exceeded without careful consideration of the reasons for doing so.

**RADIO BEAM** - A radio wave, most of whose energy is confined within a relatively small angle in at least one plane.

**RADIOFREQUENCY RADIATION (RF)** - Electromagnetic radiation with frequencies that lie within the range 10 kHz to 100 GHz.

**RETINA** - That sensory membrane which receives the incident image formed by the cornea and lens of the human eye. The retina lines the inside portion of the eye.

**SAFETY CONNECTOR** - A fiber optic connector which is designed to preclude, when removed, access to levels of radiant energy exceeding the appropriate MPI at any point in space.

**SAFETY INTERLOCK** - A device associated with the protective housing of a laser product, system or facility which prevents human access to laser or collateral radiation in excess of the prescribed accessible emission limit.

**SECURED ENCLOSURE** - An enclosure to which casual access is impeded by appropriate means, such as a door secured by lock, by latch, or by screws.

**SCANNING LASER** - A laser having a time-varying direction, origin, or pattern of propagation with respect to a stationary frame of reference.

**SERVICE GROUP (SG)** - The term used in classification of OFCS, equivalent in meaning to the term 'Class' as used for classification of lasers. OFCS classification levels are roughly correspondent to the laser classification levels and include OFCS SG1, SG2, SG3a, and SM. There is no corollary to the laser Class 4 category in OFCS.

**SOLID ANGLE** - The three dimensional angular spread at the vertex of a cone measured by the area intercepted by the cone on a unit sphere whose center is the vertex of the cone. It is expressed in steradians.

**SPECULAR REFLECTIONS** - Mirror-like reflections.

**STERADIAN** - The unit of measure for a solid angle. There are  $4\pi$  steradians about any point in space.

**ULTRAVIOLET (UV) RADIATION** - Electromagnetic radiation with wavelengths which lie within the range 200 nanometers to 400 nanometers.

**VISIBLE RADIATION** - Electromagnetic radiation with wavelengths which lie within the range 400 nanometers to 700 nanometers.

**WATT (W)** - The unit of power, or radiant flux. 1 watt = 1 Joule per second.

**WAVELENGTH** - The distance between two points in a periodic wave which have the same phase.

**WHOLE BODY IRRADIATION** - Pertains to the case in which the entire body is exposed to the incident electromagnetic energy or in which the cross section of the body is smaller than the cross section of the incident radiation beam.