Document Number:	GLM-QS-1800.1.13
Revision	Revision E
Effective Date:	3/20/2012
Expiration Date:	3/20/2017

Occupational Health Programs Manual – Chapter 13

Laser Safety Program w/Change 2 (9/30/2015)

Approved by: QS/Chief, Safety and Health Division

Distribution: BMS Library

NASA - Glenn Research Center
Cleveland, OH 44135

Change Record

Revision	Effective Date	Expiration Date	C-25, Change Request #	Description
1A	3/20/2012	3/20/2017	310	Reorganization changes, satisfy additional requirements in reference work instruction on chapter content. Added additional laser safety training category. Added verification elements (gray boxes in section 6).
Change 1	3/20/2012	3/20/2017	N/A	Administrative change to add front cover and change history log to comply with NPR 1400.1.
Change 2	9/30/2015	3/20/2017	N/A	Administrative change to remove hyperlinks.

***Include all information for each revision. Do not remove old revision data. Add new rows to table when space runs out by pressing the tab key in the last row, far right column.*

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Note: *The current version of this chapter is maintained and approved by the Safety and Health Division (SHeD). The last revision date of this chapter was March 2012. The current version is located on the Glenn Research Center intranet within the BMS Library. Approved by Chief of Safety and Health Division*

1.0 PURPOSE

This chapter provides requirements for the safe use of lasers and laser products at the GRC's Lewis Field and Plum Brook Station.

2.0 APPLICABILITY

This chapter is applicable to all civil servant and contractor employees assigned to GRC sites and to any NASA-controlled, Government-owned facilities associated with GRC. This document applies to the operation of lasers at wavelengths between 180 nanometer and 1 millimeter. Examples of lasers and laser systems that this document applies to may include

- commercially available lasers that are used as a part of an experiment or laser development
- commercially available lasers that have been modified, assembled, or incorporated into a device built by GRC personnel
- GRC designed or built lasers or laser systems
- commercially available devices utilizing high-power lasers for heat-dependent activities such as welding, parts prototyping, or laser cutting
- commercially available devices utilizing lower power lasers for analytical or construction-related activities

The evaluation of potential hazards associated with such lasers or laser systems is accomplished via the Center's safety permit process and construction health and safety plan review process.

This document does not apply to lasers incorporated into certain commercially available devices used by the general public, unless opened, serviced, modified, or incorporated into a device built by or for GRC, or as specifically addressed in this document. The laser safety officer (LSO) will determine which devices are to be covered by the Center's laser safety program. Although misuse of these lasers may pose a hazard, it is generally accepted that the risk of injury from these devices is minimal if used as intended by the manufacturer. Examples of these lasers and laser systems not covered by this document include compact disc players and laser printers.

Laser pointers, as defined by the Food and Drug Administration (FDA), are currently not subject to conditions within this chapter. Such FDA-compliant devices have very limited power output. The reader should be advised that many higher output "handheld" lasers are currently available in the market place, some at very low cost. These devices can pose a significant eye hazard and shall not be used as laser pointers. Those desiring to procure such devices for use in research activities should be aware that evaluations of such devices have shown that their actual output parameters may not match the specifications claimed by the manufacturer or distributor. Output power levels can vary (high or low) from those stated and the emission may include other wavelengths of laser energy, which can present an additional hazard. Questions about these high power handheld lasers should be addressed to the LSO.

3.0 BACKGROUND

A laser is a device that produces an intense, coherent directional beam of light energy. GRC personnel use many types of lasers, some posing little hazard to users and others that could cause significant harm if used improperly. The light characteristics of these lasers vary greatly. Wavelengths of emissions can range from the lower ultraviolet to the far infrared. Emissions can be continuous wave or pulsed. Power output can range from nanowatts to kilowatts.

As stated, using any laser involves exposure to varying degrees of hazards. Most lasers at GRC can injure the eyes of anyone who looks directly into the beam or its specular (i.e., mirrorlike) reflection. In addition, diffuse reflections created by some high-power laser beams can cause permanent eye damage. High-power laser beams can also burn exposed skin, ignite flammable materials, and heat materials so that they release hazardous fumes, gases, debris, or nonionizing radiation (i.e., plasma).

> ***Note:*** *The most common hazard when working with lasers is eye injury. To prevent such an injury, workers shall avoid looking directly into the laser beam or its specular reflections. This rule shall be followed regardless of the protective eyewear worn or the type of hazard classification of laser unless specifically authorized in support of research being conducted.*

The classification of lasers and laser systems is based on their ability to cause injury.

- Class 1 lasers (or laser systems) pose no hazard if used in their designed state.
- Class 1M lasers are considered not to pose a hazard to the eye during unaided viewing conditions but may pose an eye hazard over an extended period when collecting optics (e.g., eye loop, binoculars, or telescope) are in use.
- Class 2 and 3R (formerly 3a) lasers are considered low- to medium-hazard lasers and could cause eye damage if viewed directly and intentionally.
- Class 2M lasers are considered to pose low degree of hazard to the eye during unaided viewing conditions but may pose an eye hazard over a relatively short period when collecting optics (e.g., eye loop, binoculars, or telescope) are in use.
- Class 3b and 4 lasers are considered high-hazard lasers and require more stringent controls.

Equipment and optical apparatus required for producing and controlling laser energy also introduces other potential hazards, including high voltage, high pressure, cryogenics, noise, additional radiation, flammable materials, laser dyes and solvents, and toxic fluids and gases.

4.0 POLICY

This document describes the different types of lasers used at GRC, their classifications, and the required controls for each classification. It describes the responsibilities of personnel who work with lasers or supervise laser operations and identifies the training required for all GRC operations involving laser use. Unless specifically stated otherwise in this document, work standards for the safe operation of lasers and laser systems at GRC shall follow requirements of NPR 1800.1, "NASA Occupational Health Program Procedures," and the recommendations of the American National Standards Institute (ANSI) Z136.1–2007, American National Standard for Safe Use of Lasers, and ANSI Z136.6–2005, American National Standard for Safe Use of Lasers Outdoors, or their subsequent revisions. The Center's LSO is charged with establishing and maintaining adequate policies and procedures for the control of laser radiation hazards.

5.0 RESPONSIBILITIES

> ***Note***: *The LSO duties and responsibilities identified in Appendix A of the ANSI Z136.1 standard will be performed by either the GRC LSO or the Laser Safety Committee Chairperson (LSCC), as appropriate.*

5.1 Laser Safety Officer (LSO)

Shall ensure laser activities are conducted in accordance with NASA guidelines and recommendations made in the ANSI Z136.1 and Z136.6 standards for the safe use of lasers. The LSO is not necessarily the LSCC. If the LSO is not also the LSCC, then the LSO will serve as a member of the laser safety committee (LSC).

5.2 Laser Safety Committee Chairperson (LSCC)

Shall lead laser safety permit evaluations and provide guidance to the safety permit requester on how to satisfy permit conditions. The LSCC shall approve laser safety permits and has discretionary authority to waive permit requirements as conditions may dictate. In addition the LSSC shall, in accordance with the Center's current safety permit process, maintain the documentation package (paperwork, procedures, drawings, etc.) that was used in evaluating the permitted activity.

5.3 Laser Safety Committee (LSC) Members

Participate in or, if designated by the LSCC, lead laser safety permit evaluations and, as needed, provide guidance to the safety permit requester on conditions of safe laser use. LSC members will provide input to the committee chairperson regarding the acceptability of the proposed laser activity being evaluated.

5.4 Laser Safety Permit Requester

Shall follow the SHeD process for obtaining a safety permit and to work with the LSC in satisfying conditions for the permit.

5.5 Laser User (Operator)

Shall satisfy training and medical surveillance requirements of this chapter in addition to working in a safe manner in accordance with established procedures for their lab, area, room, or cell. Laser users should express their concerns or questions regarding potential laser safety issues to their management or to the LSO.

5.6 Laser User's (Operator's) Supervisor

Shall ensure laser users meet requirements specified in applicable laser safety permits or those for/by any laser facilities. Also, for Support Service Contractors (SSC), supervisors may be required to maintain medical surveillance and training records.

5.7 Laser Facility Supervisor

Shall ensure their facility satisfies conditions for safe laser use designated by the laser safety permit or local procedures and shall verify that laser users/operators are following applicable procedures and safety precautions for the area.

5.8 Construction Laser Operator

Shall obtain training to become qualified for construction laser use and shall operate such laser products in accordance with the manufacturers' specifications and following general safe use practices. The construction laser operator shall maintain proof of their qualification in their possession at all times during laser use.

5.9 Medical Director, Occupational Medicine Services

Shall maintain complete, accurate records of all laser medical examinations for personnel in the medical surveillance program. Records shall be retained for at least 30 years. Results of examinations shall be discussed with employees as needed. For SSC, such records may alternately be maintained by the employer. The Medical Director shall also be responsible for identifying examination elements following a laser exposure incident.

5.10 Human Capital Development Division Chief

Shall maintain records for employee completion of laser safety courses and any associated examinations.

5.11 Safety and Health Division Chief

Shall provide support to the LSO and LSCC in the performance of their duties. In addition, the SHeD Chief shall satisfy applicable safety permit process requirements identified in accordance with the Center's current safety permit program.

5.12 Support Service Contractor Supervision

If applicable, maintain records for employee completion of radiation safety courses and any associated examinations as well as records of any medical evaluations or examinations triggered because of potential exposure to ionizing radiation.

6.0 REQUIREMENTS

Note: *The use of construction lasers for sighting and surveying activities is addressed in Section 6.10.*

6.1 Training (*ANSI Z136.1*)

6.1.1 Laser Safety Instruction

Laser safety training at GRC is split into two training curriculums, one for those using higher (class 3B or 4) lasers and one for those using lower power (Class 2 or 3A/3R) lasers. As needed, the LSO can clarify questions regarding the need for laser safety training. Records of training completions shall be maintained by the Human Capital Development Division, or, in certain instances, by the SSC employer of a laser operator.

6.1.1.1 Laser Safety Training for Higher Power Lasers

Laser safety training shall be required for individuals who use Class 3B or 4 lasers or operate certain Class 1 laser systems that contain embedded Class 3b or 4 lasers. The source, content, and refresher periodicity of this training are specified by the GRC LSO. While this training is typically delivered via SATERN (System for Administration, Training and Educational Resources for NASA), it could alternatively consist of viewing training videos (from the Learning Center), classroom instruction, or other online or computer-based training. Periodic refresher training is required every 2 years (biennially).

6.1.1.1 - Employee completion of laser safety training is documented in SATERN, which is accessible by the reporting function of an administrative SATERN session.

6.1.1.2 Laser Awareness Training for Lower Power Lasers

The awareness level laser safety instruction was developed for those only working with lower power, Class 2 or 3R (formerly 3A), lasers. This laser awareness training shall be required for individuals who use or operate Class 2 or 3R/3A lasers that are covered by this document. The source, content, and refresher periodicity of this training are specified by the GRC LSO. The laser awareness training is typically provided via SATERN, although, an instructor-led course can be arranged with the LSO. Also, completion of the laser safety training for higher power lasers would satisfy this requirement. Periodic refresher training is required every 4 years.

6.1.1.2 - Employee completion of laser awareness training is documented in SATERN, which is accessible by the reporting function of an administrative SATERN session.

6.1.2 Laser Facility Instruction and Training

Laser users/operators shall also satisfy training and/or work experience requirements specified for the area, room, cell, or lab where the lasers are present. These requirements may be specified on the NASA C–580, "Qualified Operators List," associated with a laser safety permit, or in the local procedures for the area. Typically, users/operators will receive instruction on the specific hazards of the laser(s) used in the area, along with protection measures to ensure risks are minimized.

6.1.3 Other Training

The LSO may periodically coordinate more advanced laser safety training for GRC personnel.

6.2 Medical Surveillance (*ANSI Z136.1, NASA NPR 1800.1*)

6.2 – Any such medical records would be maintained by Occupational Medical Services. Alternately, such records may be maintained by supervisor for Support Service Contractors.

6.2.1 Eye Examination: Pre-Use

Operators of Class 3b through 4 lasers shall receive a baseline eye examination before laser use. This examination entails a review of ocular history, test of visual acuity and determination of associated manifest refraction (if applicable), test of macular function (e.g., Amsler Grid), test of color vision tests (e.g., Ishihara), and examination of ocular fundus as described by NASA Procedural Requirement (NPR) 1800.1, NASA Occupational Health Program Procedures.

An individual requiring an exam, or their supervisor, can contact the LSO or Occupational Medicine Services to receive directions on scheduling the examination. Arrangements with one or more local ophthalmologists or optometrist have been made for receiving the examination per NASA guidelines. Civil servants will receive their exam from one of these contracted physicians, the cost of which is paid by their organization. Contractor employees required to obtain a baseline exam may also use one of these contracted doctors.

The individual receiving the exam shall provide the ophthalmologist with the "LASER OPERATOR EYE EXAM CLEARANCE FORM" (included as Appendix B to this procedure and is available from the LSO or Occupational Medicine Services). The physician's office shall forward this form along with a copy of all examination results to GRC's Occupational Medicine Services who shall, in turn, forward a copy of the clearance form only to the LSO. The examinee should also retain the copy they receive for their records.

This examination policy also applies to students, interns, and other temporary laser research personnel. Exams costs for co-op students will be handled in the manner similar to civil servants. The GRC LSO and occupational health physician may approve of any exceptions to this policy according to the special circumstances of the case.

6.2.2 Skin Examination: Pre-Use

Examination of the skin is not required for pre-placement examinations of most laser workers; however, it is suggested for employees with history of photosensitivity who are working with ultraviolet lasers. Any previous dermatological abnormalities and family history are reviewed. Any current complaints concerned with the skin are noted as well as the history of medication usage, particularly concentrating on those drugs that are potentially photosensitizing.

6.2.3 Eye and/or Skin Examination: Postincident

Any employee with a known or suspected laser eye and/or skin injury shall contact GRC's Occupational Medicine Services to arrange for a post-exposure exam. This exam shall include those items listed above as deemed necessary by the facility occupational health physician.

6.3 Laser Incident/Accident Response (*GLM–QSA 1700.1*)

Notification, investigation, and documentation of incidents of actual or suspected exposure to potentially harmful laser radiation shall follow the process identified in Chapter 21 "Mishap and Close Call Reporting, Investigating, and Recordkeeping" of the Glenn Safety Manual.

6.4 Hazard Classification of Lasers (*ANSI Z136.1; (FDA) 21 Code of Federal Regulations (CFR) 1040.1*)

Classification of laser products is based upon the maximum output power or radiant energy available for the intended use. The LSO would normally rely on the manufacturer's information for most commercial laser products and not need to perform measurements of laser output. The LSO shall review the manufacturer's stated classification

or that indicated on product labels to verify accuracy as it is not uncommon for manufacturer's to "over classify" devices in order to simplify their labeling requirements for a family of similar lasers.

6.4 – Laser hazards are reviewed during the safety permit evaluation process. As needed, any updates to laser or laser system hazard classification will be made during this review.

6.5 Laser Signage (*ANSI Z136.1*)

Signs shall be posted in visible locations at/near access points to facilities where Class 2 and above lasers are used. General requirements for signs are below. "Caution" signs shall have black letters/sunburst on a yellow background while "Danger" signs shall have red (and some black) letters/sunburst on a white background. Also, verbiage can vary somewhat on signs to convey specific information that is pertinent to the laser in use, but, the LSO will review the wording on signs/labels in use or proposed for use. The LSO should be consulted when questions about postings, signs, or labeling exist; he/she will provide direction to the laser facility supervisor or laser safety permit requestor.

6.5 – Use of appropriate laser signage is reviewed during the safety permit evaluation process. As needed, any additional signs or changes to signs will be made prior to permit issuance.

6.5.1 Class Warning Signs.—Required for All Areas Where Class 2 and Above Lasers Are In Use

Note: *Legacy signs and labels based upon previous versions of the ANSI Z136.1 standard, including those posted and those in stock, are allowed to be used for laser hazard communication.*

6.5.1.1 Class 2 Warning Sign.—CAUTION (Figure 6.1)

- A Caution sign
- Verbiage above the sunburst: "Laser Radiation, Do Not Stare Into Beam"
- Verbiage below the sunburst shall include information about the laser…type, wavelength, power or energy/pulse rate
- "Class 2" in the lower right-hand corner of sign

6.5.1.2 Class 2M Warning Sign.—CAUTION (Figure 6.2)

- A Caution sign
- Verbiage above the sunburst: "Laser Radiation, Do Not Stare Into Beam or View Directly With Optical Instruments"
- Verbiage below the sunburst shall include information about the laser including type, wavelength, power, or energy/pulse rate
- "Class 2M" in the lower right-hand corner of sign

6.5.1.3 Class 3R Warning Sign.—DANGER (Formerly Class 3a) (Figure 6.3)

- A Danger sign
- Verbiage above the sunburst: "Laser Radiation, Avoid Direct Eye Exposure"
- Verbiage below the sunburst shall include information about the laser including type, wavelength, power, or energy/pulse rate
- "Class 3R" (or "Class 3a") in the lower right-hand corner of sign

Figure 6.1.—Class 2 Caution Sign.

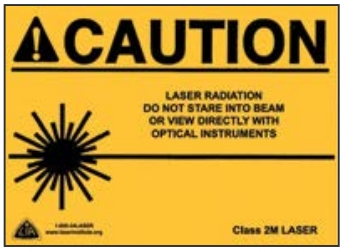

Figure 6.2.—Class 2M Caution Sign.

Figure 6.3.—Class 3R Danger Sign.

6.5.1.4 Class 3a Warning Sign.—CAUTION (Figure 6.4)

Note: *Under the pre-2007 classification scheme, CAUTION postings/labels were used with certain Class 3a lasers. Such lasers have been reclassified to 1M or 2M.*

- A Caution sign
- Verbiage above the sunburst: "Laser Radiation, Do Not Stare Into Beam or View with Optical Instruments"
- Verbiage below the sunburst shall include information about the laser including type, wavelength, power, or energy/pulse rate
- "Class 3a" in the lower right-hand corner of sign

6.5.1.5 Class 3b Warning Sign.—DANGER (Figure 6.5)

- A Danger sign
- Verbiage above the sunburst: "Laser Radiation, Avoid Direct Exposure to Beam"
- Verbiage below the sunburst shall include information about the laser including type, wavelength, power, or energy/pulse rate
- "Class 3b" in the lower right-hand corner of sign

6.5.1.6 Class 4 Warning Sign.—DANGER (Figure 6.6)

- A Danger sign
- Verbiage above the sunburst: "Visible and/or Visible Laser Radiation, Avoid Eye or Skin Exposure to Direct or Scattered Radiation"
- Verbiage below the sunburst shall include information about the laser including type, wavelength, power, or energy/pulse rate
- "Class 4" in the lower right-hand corner of sign

Figure 6.4.—Class 3a Caution Sign.

Figure 6.5.—Class 3b Danger Sign.

Figure 6.6.—Class 4 Danger Sign.

6.5.2 Other Signs

6.5.2.1 Specific Message Signs

Specific messages may be written on white/red and black Danger or yellow/black Caution signs with sunbursts. Examples of such pertinent precautionary instructions could include “Laser Alignment in Progress, Appropriate Eye Protection Required for Entry,” “Restricted Area,” “Do Not Enter When Light is ON,” or “When these Enclosure Panels are Removed, This Area is Within a Laser Hazard Zone.” Laser and class information may also be included on this sign, allowing it to satisfy the requirement for a Class warning sign.

6.5.2.2 Laser Controlled Area (Figure 6.7)

A yellow/black Caution sign with sunburst may be placed at the entrance to a room or area designated as being within the nominal hazard zone (NHZ) of a laser. One use example would be in a facility where there is no clear delineation for the laser area, such as in a high bay area that may house several different technical activities. This will alert incoming personnel that a laser may be in operation. The appropriate wording can be any instructions the reader will need to know upon entering the area. Wording may specify “Authorized Personnel ONLY.” A Laser Controlled Area sign would be in addition to the appropriate Class warning sign required above.

6.5.2.3 Temporary Controlled Area Signs (Figure 6.8)

A white/blue and black Notice sign with a sunburst may be used to denote temporary controlled laser areas during periods of servicing or maintenance. Verbiage on such a sign would be “Laser Controlled Area” or similar. The Notice sign is placed outside the controlled area while the appropriate danger warning (i.e., Class) sign is required within the controlled area.

6.5.2.4 Illuminated Signs (Figure 6.9)

Warning signs that are illuminated during laser activities provide an added safety measure since they reduce any potential complacency, which can develop when signs are continually posted. Such signs are highly recommended for existing Class 4 laser operations, especially those involving nonvisible wavelengths, and shall be required for any new Class 4 laser facilities. These lighted signs could be posted at the entrance to a laser controlled area to serve as a warning to individuals not to enter, or they could be posted within the controlled area as a reminder to operators that the laser is firing. Appropriate verbiage for these two scenarios could be “Laser On, Do Not Enter” and “Danger, Laser On,” respectively. In the situation where the warning sign/light is placed within the laser controlled area, the light should be visible through the operator’s laser protective eyewear. An alternative to an illuminated sign would be a similarly operated warning light/beacon that is immediately adjacent to a sign specifying the desired message or warning.

Figure 6.7.—Laser Controlled Area Caution Sign.

Figure 6.8.—Temporary Controlled Area Notice Sign.

Figure 6.9.—Illuminated Warning Sign.

6.5.3 Obtaining Signs

Many standard laser signs can be obtained from the LSO or their designee within SHeD. Those signs not available from SHeD shall be procured by the organization sponsoring the subject laser facility. When signs are no longer needed for an area, they should be returned to the LSO who can facilitate their re-use. The LSO also has “Laser On, Do Not Enter” warnings that are used to create illuminated signs; the lighted box itself is not provided by SHeD. Wording on signs can be varied somewhat using label-making machines or by other methods, but, the wording on signs/labels in use or proposed for use shall be reviewed by the LSO.

6.6 Labels for Lasers and Laser Systems (*ANSI Z136.1; FDA 21 CFR 1040.1*)

Note: *Legacy signs and labels based upon previous versions of the ANSI Z136.1 standard, including those posted and those in stock, are allowed to be used for laser hazard communication.*

The Food and Drug Administration (FDA) requires that laser products be labeled by the laser or laser product manufacturer. One exception to this requirement would be lasers provided to original equipment manufacturers (OEMs) as components for manufacturing a product/system containing the laser. If such a laser was purchased, it may not have been appropriately labeled and the individual purchasing this device shall contact the LSO to ensure the laser is appropriately labeled and classified. In addition, the LSO shall be contacted when alterations or modifications are planned for a laser device as these might affect the laser classification.

Also, it is worth noting that manufacturers may "over label" their laser devices. That is, provide a more hazardous label warning than is required. Manufacturers typically do this in an effort to simplify their labeling process by creating a generic label that works for a group of lasers. Manufacturers may also erroneously place a label on a laser with an erroneously lower class rating. Laser documentation should be consulted to confirm the exact class of the laser, or, such an inquiry can be addressed to the LSO. Again, the LSO should be consulted when questions about postings, signs, or labeling exist; they will provide direction to the laser facility supervisor.

6.6 – Use of appropriate laser labeling is reviewed during the safety permit evaluation process. As needed, any additional labels or changes to labels will be made prior to permit issuance.

6.6.1 Specific Laser Labeling Requirements

6.6.1.1 Class Warning Label – Class 2 and Above Lasers

Lasers shall be labeled with the appropriate Caution or Danger label, based on the laser's classification. The label specifications are identical to the class warning sign requirements specified above. If the laser is embedded within a device or housed in an enclosure, an appropriate label shall be placed on this outer surface to provide the needed warning.

6.6.1.2 Aperture Label

An aperture label (Figure 6.10) shall be required on a laser or laser device to identify the laser emission point. Typically, this is a small label and may include an arrow pointing to the location of the beam output.

Figure 6.10.—Aperture Label.

6.6.1.3 Non-Standard Configurations and Labels

Certain laser configurations do not lend themselves to the standard application of labels. Examples include small diode laser devices, inadvertent obscuring by a jig, or connections of optical fibers carrying laser energy. Recognizing the intent of this requirement, which is hazard communication, other labeling accommodations may be utilized such as tethering labels on fibers near connections, or, relocating a label to a more conspicuous location.

6.6.1.4 Other Labels

As with signs, labels can also be used to communicate specific messages about a laser product. For example, a danger label reading "Removal of this Panel Makes This System a Class 4 Laser Device" could be applied to a removable panel on a Class 1 system containing an embedded Class 4 laser.

6.7 Laser Standard Operating and Alignment Procedures (*ANSI Z136.1*)

Class 3b and 4 lasers shall have written standard operating and alignment procedures that are approved by the LSO. These procedures are typically provided to the LSCC during the safety permit request process. If the LSC is not also the LSO, LSC shall forward the procedures to the LSO for review and approval. The LSC shall keep record of the LSO's approval on file with the corresponding laser safety permit. If one person acts as both the LSO and LSCC, the LSCC's signature on the laser safety permit (NASA C–919) shall denote their approval of the attached procedures.

The written procedures shall include a description of the laser(s) being used as well as the specific steps followed to ensure the device is being used safely. These steps may include a checklist of precautions to be observed or followed prior to laser activity. Specifications for laser protective eyewear shall also be included in the procedures by indicating the required optical density (O.D.) for each wavelength of interest. Requesters can get this information from the LSO.

Laser alignment activities, in particular, can pose a significant ocular hazard to users and the procedures outlining the methodology of the task are critical to minimizing this hazard. Again, if there is potential exposure to laser radiation above the applicable maximum permissible exposure (MPE) level, then controls shall be followed. Approaches to performing alignments include

- Operating laser at lowest power setting that permits alignment
- Reducing laser power via other means (neutral density filter, and optical attenuator) during alignment
- Use of a coaxially oriented low-power alignment laser
- Use of burn paper, fluorescing paper/material, or other indicating medium to identify beam location
- Wearing protective eyewear when laser intensity (irradiance or radiant exposure) exceeds the applicable MPE
- Breaking down alignment activity into stages, the first being a "rough" alignment requiring various protective measures and the second being a "fine-tuning" alignment involving more procedural and work practice control measures
- Wearing skin protection (gloves and long sleeves) if aligning Class 4 lasers above the skin MPE
- Clearing area, room, lab, or cell of unnecessary personnel during alignment

Standard operating and alignment procedures do not need to reproduce detailed and complex laser operating procedures found in the manufacturer's instruction manuals. Rather, they can provide specific references to the procedures within such documents. As needed, the LSO or LSCC can provide some assistance in preparing the procedures.

6.7 – Written operating and alignment procedures are reviewed during the safety permit evaluation process and updated, as needed, prior to permit issuance.

6.8 Control Measures for Laser Activities (*ANSI Z136.1, 21 CFR 1040*)

6.8.1 General Discussion on Engineering and Administrative Controls

Aspects of the laser activity that influence the hazard evaluation and thereby, influence the application of control measures include (1) the laser or laser system's capability of injuring personnel or interfering with task performance, (2) the environment in which the laser is used, including access to the beam path (considering enclosures, baffle, beam, etc.), and (3) the personnel who may use or be exposed to laser radiation. Aspect (1) is fairly straightforward and is addressed by the ANSI laser safety standard. Aspects (2) and (3) can vary with each laser application and cannot be readily standardized. While the total hazard evaluation shall consider all aspects, typically aspect (1) has the greatest influence upon which control measures are applicable.

So, when the intensity of an accessible laser beam exceeds the applicable MPE level, appropriate controls shall be implemented to minimize the potential hazards to laser operators and bystanders. These measures include both engineering and administrative controls, with the former being the preferred course of action. "Accessible" laser beams are those that are not enclosed or contained, and are oriented such that the direct beam or inadvertently-

reflected beam could pose a potential eye or skin hazard. Beam accessibility is typically greater during laser alignment activities, necessitating greater controls.

Typical engineering controls include (but are not limited to) protective housings/enclosures, interlocked entryways or beam enclosures, key control, beam path enclosures, beam stops/dumps, beam attenuators to limit output level, and shades/curtains over windows. Common administrative controls include alignment and operating procedures, emission output limitations, the use of protective eyewear, the use of skin protection, education and training, and the use of temporary barriers and curtains. As mentioned, the use of engineering controls is typically favored over administrative controls since the latter relies on a human-dependent variable.

6.8.2 Entryway Controls

Because open-beam configurations are commonly found in research environments such as the GRC, entryway controls are an important part of our safe-use practices. There are three basic options for controlling entry to a laser controlled area. Entryway controls shall be required for most Class 3b and 4 laser activities and the LSO shall be responsible for specifying the type of control required for a laser facility. Individuals with questions about what entryway controls are required for a new facility can contact the LSO. The basic types are as follows:

6.8.2 – The use of engineering (e.g., interlocked access) and administrative (e.g., procedural) entryway controls is reviewed during the safety permit evaluation process. In addition, the proper operation of any interlocked safety features is verified.

6.8.2.1 Nondefeatable Controls

These utilize a built-in interlock switch that will "turn off" the laser beam (either secure power or close a shutter) when an entry door is opened. Nondefeatable entryway controls are to be used for long-term laser operation.

> *Note: Interlock features on enclosure access panels or facility/laboratory doors are to "Fail Safe," which means that the system goes into, and, remains in a safe mode. For example, a interlock system which has reacted to a door opening by securing the laser should not automatically re-enable the laser once the door has closed. Rather, a manual reset of the facility interlock system would be required.*

6.8.2.2 Defeatable Entryway Control

Similar to the "Nondefeatable Control" described above with the addition of a temporary (typically, 15- to 30-second) bypass, which will allow entry into an area without securing the beam. This type of control can be used if no laser beam hazard exists at the point of entry. Typically, there is also a procedural aspect to this type of control whereby the person entering or exiting the laser controlled area verifies that an individual who might be standing outside the door to the area will not be exposed to an emission hazard while the door is open. Defeatable entryway controls are to be used for long-term laser operation.

6.8.2.3 Procedural Entryway Controls

A door, blocking barrier, screens, curtains, etc., are used to block, screen, or attenuate the laser radiation at the entryway. The laser radiation at exterior of these devices shall not exceed the applicable MPE, nor shall any personnel experience any exposure above the MPE immediately upon entry. Procedural entryway controls are used only for temporary laser activities and only with the permission of the LSO. Sufficient warning signs are an important part of implementing these short-term measures.

6.8.3 Class-Based Control Measures

The control measures described below are general in nature for the specific class of laser being used. The LSO shall make a final determination of what control measures will be required for a facility and can modify these general requirements on a case-by-case basis. Note that laser classification during alignment activities may be higher than that during normal operation of some laser systems.

6.8.3 – Laser use controls and conditions are reviewed during the laser safety permit evaluation process and such requirements are specified on the laser safety permit (form C-919) and the written procedures. Requirements and

use conditions for Construction Contractor Use of lasers would be called out in the HASP for the subject activity.

6.8.3.1 Class 2 and Class 2M Laser Control Measures

- Training, signs, and labels (see above)

6.8.3.2 Class 3R (Formerly Class 3a) Laser Control Measures

- Class 2 laser control measures
- Protective eyewear (if accessible beam intensity exceeds MPE)

6.8.3.3 Class 3b Laser Control Measures

- Class 3R laser control measures
- Baseline eye examination (see above)
- Alignment and operating procedures (see above)
- Entryway controls and/or interlocked beam enclosures (see above)
- Key controls

  Note: *Key control features are provided on high power lasers for the intent of preventing the inadvertent startup of such lasers. This safety feature lends itself well to laser use in an industrial environment rather than such activities at a government research facility. Consequently, the discretionary authority of the LSO may allow for alternate means or measures to satisfy the spirit of this specified control.*

6.8.3.4 Class 4 Laser Control Measures

- Class 3b laser control measures
- Skin protection (if accessible beam intensity exceeds skin MPE)
- For FDA compliant lasers, Class 4 laser devices are to have a manual reset feature on the system itself which must be actuated if the laser is automatically secured for safety purposes. This would be in addition to resetting the room interlock system.

6.9 Laser Safety Permit Process (*GLM–QSA 1700.1*)

6.9 – Safety permit documentation is maintained by the chairperson of the committee issuing the permit.

6.9.1 Overview

All laser operations covered by this procedure (see "APPLICABILITY" section) require a laser safety permit; the safety permit program is described in Chapter 1A of the NASA Glenn Safety Manual. This process formalizes the hazard evaluation of laser activities and the resulting prescription of applicable control measures. The LSCC may waive the need for a safety permit if the conditions of use for the laser satisfy Class 1 criteria or if, based on their judgment, the circumstances of use offer sufficient protection for a temporary activity. In either case, that decision is up to the LSCC. When a safety permit is issued, the proposed laser operation is approved within the constraints listed on the safety permit, the corresponding qualified operators list, and the procedures and other documentation supporting the permit.

6.9.2 Details

6.9.2.1 Preparation and Request Submission

Requesters are encouraged to contact the LSCC directly early in the permit process if they have any questions regarding laser safety permits and the associated requirements/controls. As needed, LSC members or the LSCC will assist the requester in identifying specific controls to be implemented or actions to be conducted to satisfy typical conditions of a laser safety permit. The official permit paperwork and supporting documentation shall be submitted

to the SHeD administrative staff, who, in turn shall log the request and forward it to the responsible safety committee chair (in this case the LSCC). At a minimum, the paperwork shall include the permit request (NASA C–923) or permit renewal/change request (NASA C–590), a hazard analysis (NASA C–923a), and a qualified operators list (NASA C–580). Additional documentation provided with the request should include laser specifications and operating and alignment procedures.

6.9.2.2 Scheduling Reviews

Once the LSC chair receives the safety permit request (new or renewal/change), they will contact the "requester" designated on the permit to discuss the activity and arrange a time for the evaluation or possibly an informal pre-evaluation, which would be followed at a later time by the formal LSC evaluation. Typically, laser safety permit evaluations are conducted by the LSCC (or their designee) and at least one other member of the committee. At their discretion, the chair can limit the evaluation of a permit request to one reviewer. Candidate scenarios for a single reviewer could involve a simple permit request involving a low-hazard laser or the renewal of a permit involving a non-changing activity with good documentation on file.

6.9.2.3 Permit Evaluation

During the onsite evaluation of the proposed laser activity, the LSC shall meet with the safety permit requester and other pertinent staff to review the anticipated task and the specific use of laser radiation. Written operating and alignment activities shall also be assessed to determine their adequacy and accuracy. Being a center that conducts research activities, it is sometimes not possible to outline exactly how a laser will be used, so, in such cases the methodology and basic approaches to handling the laser radiation will be reviewed. During the laser permit review, the laser safety committee shall also verify the presence, adequacy, and functionality of any required interlock system(s), protective eyewear and other protective equipment, and any other safety features or control measures.

6.9.2.4 Scope of Laser Safety Permits

Like standard safety permits, laser safety permits are issued as a vehicle for assuring activities are conducted in a manner to minimize potential health and safety risks to employees. The scope of a laser safety permit is to address the eye and skin hazards associated with the use of the lasers. If an activity also involves nonlaser radiation hazards, then a second "standard" safety permit (issued by the appropriate "area" safety committee) might also be necessary, whether or not these hazards are directly associated with the laser. For example, excimer lasers consume toxic (health hazard) gas in generating the desired ultraviolet wavelength, or a microgravity experiment involving a pressurized (safety hazard) fuel (safety hazard) cylinder may use a high-power laser to visualize a combustion parameter. For each of these activities, both a standard safety permit and a laser safety permit would be required.

6.9.2.5 Safety Permit Expiration

Safety permits can be issued to cover time periods ranging from a day to several years. The periodicity of the permit renewal is left to the discretion of the LSCC, who signs/approves the permit. Safety permits and the associated qualified operators' list are to be posted outside the lab/room/cell where the activity is being conducted. Completed and expired permits shall be signed by the requestor and returned to the Safety and Health Division according to the procedures outlined in Chapter 1A of the Glenn Safety Manual.

6.9.2.6 Laser Safety Permit Documentation

The chair of the LSC shall, in accordance with the Center's current safety permit process, maintain the documentation package (paperwork, procedures, drawings, etc.) that was used in evaluating the permitted activity.

6.10 Requirements.—Construction Lasers ((*OSHA*) *29 CFR 1926.54; FAA Order 7400.2; Draft NASA Policy for Outdoor Laser Use; GLM–QSA–1700.1*)

6.10 – Laser use controls and conditions for devices used by Construction Contractors are reviewed during the HASP evaluation process.

6.10.1 Construction Laser Operator Training

Operators of construction lasers shall receive training on proper and safe use of the laser products they operate. This training should be offered or coordinated by their employer and should satisfy the OSHA construction standard for

"Nonionizing radiation." (29 CFR 1926.54) The employer for construction laser operators shall provide their operators with documentation of their laser use qualification. Per the OSHA standard, this proof of qualification shall be available and in the possession of the operator at all times during laser use.

6.10.2 Controls for Using Construction Lasers

Physical control measures for construction lasers are typically not required because of the lower powers involved with such lasers. Construction lasers, as described in this document, include commercially available products designed and intended for leveling/measuring activities with power emissions satisfying Class 3R (formerly Class 3a) limits for visible lasers and Class 1 for other wavelengths. Intentional misuse of low-power visible lasers, such as construction lasers, for the purpose of causing visual interference shall be prohibited. Visual interference with "critical tasks" (e.g., operating a vehicle or flying an aircraft) by Class 2 or 3R (formerly Class 3a) lasers is possible if they are intentionally used at dusk or night near airports or roads. Consequently, the use of visible construction lasers shall not be permitted during such time periods. This should have little impact on construction activities as such construction lasers are typically not used at night and would not be expected to create a direct or indirect hazard when operated by a "qualified" operator and when used as intended.

6.10.3 Procedures for Construction Lasers

6.10.3.1 Written Procedures for Safe Use of Construction Lasers

Contractors using construction lasers shall have established written procedures, which address, at a minimum, the following issues:

- use restriction to qualified persons
- methods undertaken to minimize direct eye potential (verifying beam path prior to firing, considering beam termination, not positioning at eye level, prohibiting intentional direct viewing, etc.)
- prohibited times of use (i.e., dusk or night)

6.10.3.2 Health and Safety Plan (HASP) for Construction Activity

The contractor's laser-use procedure/conditions shall be included in the HASP written for the involved construction task. The contractor should also provide the OSHA-required proof of qualification for their construction laser operator(s) with the proposed HASP. The SHeD staff member charged with reviewing and approving HASPs shall approve the laser use on behalf of the LSO. Any questions regarding this document review shall be addressed to the LSO.

6.11 Inventory of High Power Laser Devices *(NASA NPR 1800.1)*

A comprehensive inventory of hazardous laser soures shall be maintained by the Center and periodically verified. This listing includes only Class 3B and 4 lasers or laser systems and identifies specific information about the device (hazard class, manufacturer, model #, serial #, NASA ECN), its location and a point of contact. The inventory will be verified and updated on an on-going basis by the LSO, SHeD staff, and others.

6.11 – The inventory of Class 3B and 4 lasers is maintained electronically on the SHeD share drive

7.0 RECORDS

- Laser Safety Permit, NASA C–919, and supporting documentation—Maintained by the Laser Safety Committee Chairperson
- Training Records—Maintained by Human Capital Development Division. In the case of a Support Service Contractor, these records could be maintained by the employer.
- Medical Exam Records (Baseline and Others)—Maintained by Occupational Medicine Services. In the case of a Support Service Contractor, these records could be maintained by the employer.
- High Power Laser Device Inventory—Maintained by the Laser Safety Officer.

8.0 REFERENCES

Document Number	Document Name
21 CFR 1040	U.S. Food and Drug Administration, "Performance Standards for Light-Emitting Products," Section 1040.10—Laser products
29 CFR 1926.54	Occupational Safety and Health Administration, "Construction Health and Safety Standards," Section 1926.54—Nonionizing radiation
GLM–QSA–1700.1	NASA Glenn Safety Manual, Chapter 1A—Safety Permit System
GLM–QSA–1700.1	NASA Glenn Safety Manual, Chapter 17—Construction Safety
GLM–QSA–1700.1	NASA Glenn Safety Manual, Chapter 21—Mishap and Close Call Reporting, Investigating and Record Keeping
NPR 1800.1	NASA Procedural Requirement, "NASA Occupational Health Program Procedures"
Order JO 7400.2	U.S. Federal Aviation Administration, Part 6, Chapter 29—Procedures for Handling Airspace Matters, Outdoor Laser Operations
Unassigned	Draft NASA Policy on Outdoor Laser Use, 2004
Z–136.1	American National Standards Institute, "American National Standards Institute for Safe Use of Lasers: Z–136.1," Publisher: Laser Institute of America, Orlando, FL, 2007.
Z–136.6	American National Standards Institute, "American National Standards Institute for Safe Use of Lasers Outdoors," Z–136.6, Publisher: Laser Institute of America, Orlando, FL, 2005.

APPENDIX A.—DEFINITIONS AND ACRONYMS

American National Standards Institute (ANSI)

Code of Federal Regulations (CFR)

Construction laser.—Commercially available laser products used for construction tasks such as alignment, surveying, or positioning. These lasers are limited to Class 3R (formerly 3a) emission limits for visible lasers (0.4 to 0.7 μm) and Class 1 output for other lasers.

Construction laser operator.—Individual who has received appropriate training for safe use of construction lasers and is also qualified to operate such lasers by their employer per OSHA's 29 CFR 1926.54.

Continuous wave laser.—A laser that emits for more than 0.25 seconds.

Diffuse reflection.—When an incident laser beam is reflected over a wide range of angles.

Fail Safe Interlock.—An interlock where the failure of a single mechanical or electrical component of the interlock will cause the system to go into, or remain in, a safe mode.

Food and Drug Administration (FDA)

Glenn Research Center (GRC)

Health and Safety Plan (HASP)

Irradiance.—Radiant power incident per unit area upon a surface, expressed in watts-per-square-centimeter. It is used to characterize a CW laser. Synonym: Power density.

Laser.—Acronym for light amplification by stimulated emission of radiation; a source of intense, coherent, directional beam of optical radiation.

Laser controlled area.—An area containing one or more lasers where the activity of personnel is subject to control.

Laser device.—Either a laser or a laser system.

Laser Safety Officer (LSO)

Laser Safety Committee (LSC)

Laser Safety Committee Chairperson (LSCC)

Laser system.—An assembly of electrical, mechanical, and optical components that include a laser.

Laser User and Laser Operator.—Used interchangeably as a person who uses a laser or laser system.

Laser user requirements.—Actions, tools, and equipment deemed necessary for safety and to monitor biological effects of laser use.

Maximum permissible exposure (MPE).—The level of laser radiation to which a person may be exposed without hazardous effect or adverse biological changes in the eye or skin.

National Aeronautics and Space Administration (NASA)

Nominal Hazard Zone (NHZ).—The space within which the level of the direct, reflected, or scattered radiation during normal operation exceeds the applicable MPE. Exposure levels beyond the NHZ are below the appropriate MPE level.

NASA Procedural Requirement (NPR)

Occupational Safety and Health Administration (OSHA)

Optical density (O.D.).—Logarithmic expression for the attenuation produced by an eye protection filter.

Original equipment manufacturer (OEM)

Radiant exposure.—Surface density of the radiant energy received, expressed in units of joules-per-centimeter squared (J/cm^2). It is used to characterize a pulsed laser.

Safety and Health Division (SHeD)

Shall.—Indicates a requirement that is necessary to meet the standards of protection currently in effect.

Should.—Indicates a recommendation that can be applicable.

Specular reflection.—Reflections from shiny surfaces.

Ultraviolet (UV)

APPENDIX B.—LASER OPERATOR EYE EXAM CLEARANCE FORM

NASA John H. Glenn Research Center
Occupational Medicine Services

21000 Brookpark Road, Mailstop 15-5
Cleveland, Ohio 44135
216.433.5841(ph) 216.433.6529(fax)

LASER OPERATOR EYE EXAM CLEARANCE FORM

EMPLOYEE NAME: _____ D.O.B.:_____

SUPERVISOR NAME: _____

☐ **Civil Servant (including Co-Op Students)**

☐ **OTHER (Contractor, non-Co-Op Students)**
Company Name: _____

This patient will be working with high powered lasers at the NASA Glenn Research Center. The eye examination should include the following:

☐ *Ocular History*

☐ *Visual Acuity and Manifest Refraction (if needed)*

☐ *Macular Function (e.g., Amsler Grid)*

☐ *Color Vision (e.g., Ishihara)*

☐ *Dilated Fundus Exam*

☐ *Fundus Photo (if available)*

Results:

☐ *The exam was within normal limits and this patient is cleared for laser operation.*

☐ *Other (explain in "Comments")*

Comments: _____

_____

_____ _____ _____
Physician's Signature ***Date*** ***Physician's Office Stamp/Info***

☐ **Return this form <u>and a copy of all examination results</u> to NASA GRC's Office of Occupational Medicine Services at the above address**

_____ _____
Reviewed by: ***Date***
Occupational Medicine Services
Singleton Health Services, L.L.C.

cc: GRC Laser Safety Officer