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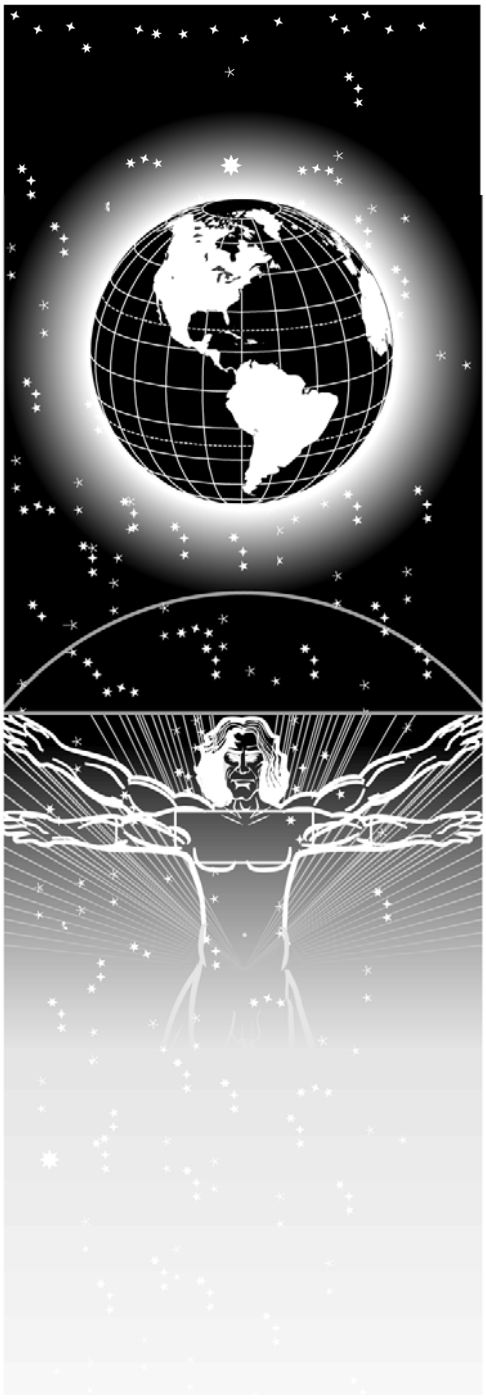

UNITED STATES AIR FORCE
SCHOOL OF AEROSPACE MEDICINE

United States Air Force School of Aerospace Medicine Laser Injury Guidebook

Patrick J. Clark, Lieutenant Colonel, USAF, BSC

John M. Gooch, Lieutenant Colonel, USAF, MC, SFS

Douglas J. Ivan, MD
Eagle Applied Sciences
200 Concord Plaza, Suite 430
San Antonio, TX 78216

Thomas J. Tredici, MD

Ronald C. Tutt, Major, USAF, OD, BSC

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Air Force Materiel Command
Air Force Research Laboratory
711th Human Performance Wing
USAF School of Aerospace Medicine
Aerospace Medicine Department
Aerospace Medicine Consultation Division
2507 Kennedy Circle
Brooks City-Base TX 78235-5116

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PATRICK J. CLARK, Lt Col, USAF, BSC	ROLLAND C. REYNOLDS, Col, USAF, MC, CFS
Chief, Aerospace Vision Section	Chief, Aerospace Medicine Consultation Division
USAF School of Aerospace Medicine	USAF School of Aerospace Medicine

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Clark, Patrick, J, Lieutenant Colonel, USAF, BSC
Gooch, John, M, Lieutenant Colonel, USAF, MC, SFS
*Ivan, Douglas, MD
Tredici, Thomas J., MD
Tutt, Ronald, C, Major, USAF, BSC

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*Eagle Applied Sciences
200 Concord Plaza, Suite 430
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14. ABSTRACT
The primary purpose of the laser injury guidebook is to provide guidelines and instructions for flight surgeons dealing with potential laser beam exposures in aircrew and ground personnel. The intent is to provide an evaluation and initial management process to assess and respond to laser beam exposures where ocular and ocular adnexal injury may have occurred. Subjects covered in detail include the laser beam exposure threat in the HR aviation environment, and the role of the flight surgeon in the management of laser beam exposures. Specifically, history, external examination, near visual acuity testing, far visual acuity testing, Amsler grid testing, pupils evaluation, streoposis evaluation, color vision, slit lamp, dilation fundoscopy and vitreoretinal hemorrhage are covered in detail. A point of contact list is provided as well as a suggest list of supplies and equipment. A laser beam incident questionnaire is included, as well as an Amsler grid test, laser injury brief and general flow chart.

15. SUBJECT TERMS
laser beam exposure, flight surgeon, aircrew, eye injury, corneal burn, retina

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TABLE OF CONTENTS

ATTACHMENTS

UNITED STATES AIR FORCE SCHOOL OF AEROSPACE MEDICINE
LASER INJURY GUIDEBOOK

CHAPTER 1

INTRODUCTION

1.1. Purpose. The primary purpose of this laser injury guidebook is to provide guidelines and instructions for flight surgeons dealing with potential laser beam exposures in aircrew and ground personnel. The intent is to provide an evaluation and initial management process to assess and respond to laser beam exposures where ocular and ocular adnexal injury may have occurred.

1.1.1. Points of Contact. Attachment 1 provides a reference for points of contact (POC) when working laser beam exposure incidents. Any laser beam exposure resulting in flash blindness, persistent visual symptoms or suspected eye injury should be reported to the Tri-Service Laser Hotline referenced in the attachment.

1.1.2. Recommended Equipment and Supplies. Attachment 2 lists suggested equipment that may help the flight surgeon assess a laser injury. Ideally the near and distant visual acuity letter charts and the Amsler Grid Test referenced in this guide should be ordered from an appropriate source. If needed substitute charts, tests and forms can be obtained via electronic mail from 711th HPW/USAFSAM/FECO and printed on a laser printer.

1.2. General

1.2.1. The Threat. Laser beams represent a potential threat to mission effectiveness and flight safety because of their ability to damage aircraft sensors and the eye. Laser based systems and devices are proliferating and pose a threat to the eye, both temporarily and permanently, from friendly and hostile sources. The frequency of laser beam exposures is likely to increase. Medical force protection and prevention in operational units should include training and awareness of the threat by direct flight surgeon involvement in flying safety and aircrew training programs. For example, awareness that many lasers, e.g. Class 2 and 3A pointers, although very bright, cause no more than momentary dazzle or temporary flash blindness effects may help reduce fear and anxiety associated with these events. On the other hand, more powerful lasers, to include laser pointers rated Class 3B or higher, are potentially dangerous, especially when the source is at close range. Laser beams can be invisible in the form of infrared (IR) and ultraviolet (UV) wavelengths. The risk of permanent ocular injury diminishes at increasing distances from the source. However, laser beam exposures may disrupt operations during critical phases of flight and have psychological effects at distances far beyond those associated with ocular damage. Aircrew should be knowledgeable as to the entire laser beam threat spectrum, including appropriate steps to be taken if exposed.

1.2.2. Flight Surgeon**.** The key to evaluating and managing any laser eye injury or suspected laser beam exposure is immediate involvement of the local flight surgeon. The flight surgeon is responsible for coordinating and determining the appropriate care and action to be taken. The flight surgeon should always approach a laser eye injury as a potentially serious ocular injury. The diagnosis of a laser eye injury may be difficult since the injury may not produce any visible signs to the examiner. Subjective complaints may exist in the absence of objective physical findings. Personnel exposed or suspected to have been exposed to a laser beam should always be evaluated and managed in accordance with related Air Force instructions and policies. Reference materials listed in this guidebook will provide additional knowledge and guidance. The Tri-Service Laser Hotline 1-800-473-3549 is available "24/7" to answer any questions and should always be called in any laser beam exposure incident suspected of causing injury. A consultation with a laser eye injury specialist is also available at 711th HPW/USAFSAM: (210) 536-3241/DSN 240-3241 and 711th HPW/RHDO (210) 536-4784/DSN 240-4784.

CHAPTER 2

FLIGHT SURGEON EVALUATION OF EXPOSED CREWMEMBERS

2.1. History. Obtain a detailed operational and medical history with respect to the nature and characteristics of the laser beam exposure. Important details include characteristics such as intensity, color, constant or flicker nature of the light source, duration of exposure, location, estimated beam diameter, range, tracking, source, location (airborne or ground), glare, pain, photophobia, and any immediate or delayed symptoms. It is important to note that some laser beams are invisible to the human eye (e.g., UV and IR) and may induce sudden visual symptoms. Be sure to note what types of personal protective equipment or viewing devices were being used. Past ocular and family eye histories should be included. Use of the Laser Beam Incident Questionnaire (Atch 3) will aid in both the medical assessment and intelligence aspects of the incident. The Laser Incident Questionnaire is meant to provide medical and laser experts with enough information to aid in initial treatment of exposed personnel. Involved personnel will undergo more extensive interviews by additional medical, operational, and military intelligence personnel.

Notifications as outlined in AFOSH Standard 48-139: paragraph 2.6., should be made as soon as possible. Field level notification should be made to the Deployed Medical Commander and the Air Expeditionary Wing Commander. The Tri-Service Laser Hotline 1-800-473-3549 should also be notified as soon as time and circumstances permit.

2.2. External Examination. Perform an external examination of the skin and adnexa looking for burns or any evidence of physical trauma. Remember an ultraviolet laser beam will be invisible to the naked eye but may result in visible external tissue damage. Photograph any abnormalities believed related to a laser beam exposure.

2.3. Near Visual Acuity Test. Near visual acuity should be tested at 14 inches using a standard Armed Forces Near Visual Acuity Chart card or equivalent. If available, this should be done with correction. Always record visual acuity test results in each eye separately and whether it was corrected or uncorrected

2.4. Far Visual Acuity Test. Distant vision should be tested using any standardized distant visual acuity tester. Ideally, this should be accomplished using correction, if required. Generally, near and far visual acuity will correlate, but there can be wide variation, especially if correction is not used. If far visual acuity test results are worse than 20/30, or if corrective eyewear is not available, then administer a pinhole acuity test to assess far visual acuity. Always record visual acuity test results in each eye separately and whether it was colleted corrected or uncorrected. If not done at the standard 20-foot distance, or in an approved vision test apparatus, record the test distance and how it was determined.

2.5. Amsler Grid Test. The Amsler grid test provides information on the condition of the macula and perimacular region of the retina. An Amsler grid test is provided as an attachment (Atch 4) should one be unavailable in the local environment. The Amsler grid test should be administered monocularly at 30 cm under proper illumination and with corrective eyewear if required. Have the crewmember sketch out any abnormalities directly on the Amsler grid recording sheet. A defect on Amsler testing indicates that the central 10 degrees of the visual field may have been affected. The Amsler grid is capable of detecting scotomas and lesions as small as 50 microns and may note retinal damage not visible to the examiner. Not all laser eye injuries have an associated visible retinal lesion, and some visible retinal injuries may still present a normal grid test result. It is critical to follow and document any changes related to a laser injury. In any suspected laser eye injury, the patient should be re-examined as clinically indicated, ideally in 24 hours, but at least within 72 hours.

2.6. Pupils. Examine the pupils for any change in shape, symmetry, reaction to light, or other abnormalities. Perform such examinations before dilating drops are administered.

2.7. Stereopsis. Perform the Optec Vision Tester (OVT) depth perception test. This testing should be performed with correction if required and before dilation. It is unlikely that stereopsis would be affected without other symptoms, but it should be checked before returning aircrew to flying duty.

2.8. Color Vision. Although it is unlikely that color vision will be affected in association with an acute event without other macular damage, it is possible that subtle affects may only be picked up with color vision testing. Color vision testing should be performed monocularly with an appropriate set of Pseudoisochromatic Plates, “aka” PIP plates. The standard PIP I plates (Dvorine or Ishihara) screen for congenital red/green deficits; however, screening for acquired deficiencies, including blue/yellow, with the PIP II (SPP2) plates is desirable if this test is available to the flight surgeon. Color tests should be administered under approved illumination called Illuminant C or equivalent if available.

2.9. Slit Lamp. If available, a slit lamp examination should be performed on the anterior segment, cornea, anterior chamber, iris and lens. Fluorescein should be used to examine for any corneal abrasions or burns. If a slit lamp is unavailable, then use a Woods lamp or blue light source to examine the anterior portion of the eye. Describe, photograph, and diagram any lesions identified.

2.10. Retinal Examination. Retinal evaluations should be accomplished under dilated conditions if clinical circumstances warrant. It is recommended that both eyes be dilated even if only monocular symptoms are present. Proparacaine, Tropicamide 1% and Phenylephrine 2.5% should be used as they last only 4-6 hours. Other dilating agents (such as Cyclogyl®, homatropine or atropine) will have much longer effects. Using a direct ophthalmoscope, carefully examine the macular and paramacular region in both eyes and describe any abnormal lesions. Retinal lesions should be photographed, if possible, and digitally sent to the consulting ophthalmologist for evaluation and recommendations.

2.10.1. Vitreoretinal Hemorrhage. The back of the eye should be evaluated for the presence of any hemorrhages. Such a hemorrhage may be localized or diffuse and may impair visualization of retinal details. The red reflex may be asymmetric and reduced in the affected eye. Such a scenario would be expected to be associated with a significant loss of visual acuity. Patients who are suspected of having vitreoretinal hemorrhage should be maintained at bed rest, with their head elevated to facilitate blood settling down and away from the macula. They should be evacuated to a referral ophthalmologist for more definitive care as soon as possible.

2.10.2 Chorioretinal Lesions. The classic hallmarks of significant laser eye injuries are chorioretinal burns and retinal hemorrhages. Chorioretinal burns can also be associated with inflammation throughout the eye. Usually this inflammation is not effectively treated with use of topical steroid drops because of poor penetration and access to retinal tissue. Therefore, oral or IV steroids are generally more effective in reducing intraocular inflammation, but should only be considered in those cases consistent with a significant laser beam related retinal injury threatening the macula. Periocular, retrobulbar, or subconjuntival injections should only be given by an ophthalmologist. The flight surgeon, after consultation with an ophthalmologist, may be advised to administer IV or oral steroids if preservation of vision is thought to benefit from such therapy. Note: The use of systemic steroids to facilitate preservation or recovery of vision should only be considered in confirmed or strongly suspected laser beam retinal injuries and only after consultation on a case-by-case with an ophthalmologist.

2.11. Optical Coherence Tomography (OCT). Use of OCT can be very beneficial to aid in the determination of subtle retinal effects from laser beam exposure. OCT allows for examination of the nerve fiber layer, retinal pigment epithelium and choriocapillaris. It has been used to demonstrate and document retinal injuries by lasers when no symptomatic changes have been present. It is unlikely the flight surgeon will have access to OCT outside an ophthalmic setting, but use of OCT imaging should be considered and requested if a laser beam injury is suspected.

CHAPTER 3

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

References

AFI 48-123, Medical Examination and Standards, 5 June 2006, Volume III

Air Force Occupational Safety and Health Standard 48-139, Laser Radiation Protection Program, 10 December 1999

Air Force Operational Test and Evaluation Center Supplement 1 to AFOSH 49-139, 1 December 2004

ASCC Air Standard 61/115/14A Initial Investigation and Intermediate Management of Laser Eye Damage in Aircrew

The Evaluation and Management of Laser Injuries NATO-AGARD AGARDOGRAPH AR-354

Headquarters, Dept. of the Army FM8-50, Prevention and Medical Management of Laser Injuries

USAFSAM-TR-88-21, Oct 1988, Medical Management of Combat Laser Eye Injuries

Document 9815, AN/447, *Manual on Laser Emitters and Flight Safety*, International Civil Aviation Organization, Quebec, Canada, 1st edition, 2003.

Abbreviations and Acronyms

AFOSH--Air Force Occupational Safety and Health

AFRL--Air Force Research Laboratory

ALEP--Aircrew Laser Eye Protection

IR--Infrared

OCT--Optical Coherence Tomography

OI--Operating Instruction

OVT--Optec Vision Tester

PIP--Pseudoisochromatic Plates

POC--Point of Contact

USAFSAM--United States School of Aerospace Medicine

UV—Ultraviolet

Attachment 1

Point of Contact (POC) Quick Reference

POC Information	Utilization
Tri-Service Laser Hotline 1-800-473-3549 DSN 240-4784 laser.safety@brooks.af.mil (no classified data or material via e-mail)	Contact after laser beam exposure incidents suspected of causing injury. Available "24/7" by phone for treatment guidance and coordination of laser injuries. **The Hotline can also be contacted at any time for information on laser training, safety issues, laser classification, etc.** For non-emergencies call from 0800-1600 US Central Time.
USAF School of Aerospace Medicine **Aerospace Ophthalmology Branch** (711 HPW/USAFSAM/FECO) 2507 Kennedy Circle, Bldg 100 Brooks City-Base TX 78235-5116 (210) 536-3241 DSN 240-3241	Provides ophthalmologic consultation. Assists in the coordination of evaluation and medical care of laser injuries. Broad base of medical expertise to include current evaluation techniques and treatment protocols. Provides training and support for AF Flight Surgeons, RAMS, Ophthalmologists, and Optometrists in aspects of laser evaluation and treatment. Responsible for the Laser Injury Guidebook. Can provide e-mailed evaluation charts, guidelines and forms by special request.
Air Force Research Laboratory/Optical Radiation Branch (711 HPW/RDHO) 2624 Louis Bauer Drive, Bldg 809 Brooks City-Base TX 78235-5128 (210) 536-4784 DSN 240-4784	Provides laser safety consultation on operational issues. Maintains the Tri-Service Laser Hotline and conducts hazard evaluations for operational lasers. Certifies personnel as Laser Safety Officers (LSOs) through USAFSAM. Publishes and distributes evaluation tools such as the Laser Hazard Assessment (LHAS) software. Develops and recommends LEP technologies. Essential resource for providing analysis of any AF laser beam exposure incident.
Air Force Medical Operations Agency Radiation Protection Division (AFMOA/SG3PR) 110 Luke Avenue, Room 405 Bolling AFB DC 20332 (202) 767-4309 DSN 297-4309	Primary policy and coordination agency for laser and optical radiation protection program. OPR for AFOSH 48-139. Provides guidance and policy to ensure effective implementation of the USAF health protection program for lasers and broadband optical radiation.

Attachment 2

Recommended Equipment and Supplies

Below is a suggested list of equipment and supplies that the flight surgeon should find useful in evaluating laser beam exposure. The base optometry clinic should be able to assist in procuring many of the items that the flight surgeon might not already have. It is recommended that you have at least one blue or UV light source to evaluate the corneal surface with fluorescein.

1. **Near and Far Visual Acuity Charts**
2. **Amsler Grid Tests**
3. **Sodium Fluorescein Strips**
4. **Artificial Tears**
5. **Sterile Eye Pads and Bandage Tape**
6. **Proparacaine 0.5%**
7. **Tropicamide 1%**
8. **Phenylephrine 2.5%**
9. **2% Homatropine**
10. **Topical Ophthalmic antibiotic drops or ointment**
11. **Pinhole Occluder**
12. **Penlight with detachable blue light filter**
13. **Direct Ophthalmoscope with blue light filter**
14. **Woods Lamp**
15. **Pseudoisochromatic Plates** (Armed Forces Color Plates, Ishihara, Dvorine, etc.)
16. **Optec Vision Tester** (OVT)

The following equipment is optional but would be very useful if a high number of laser beam exposure cases are anticipated.

17. **Digital Camera** (for documenting external burns, lesions, etc)
18. **Hand Held Tonopen®**
19. **Hand Held Retinal Camera**

Attachment 3

Laser Incident Questionnaire

The following questions are designed to gather information to assist medical, operational, and intelligence personnel in analysis of laser beam exposure incidents. It should be anticipated that further questions and information will be sought as time allows. Finally, remember to call the Tri-Service Hotline at 1-800-473-3549 or DSN 240-4784 as soon as possible.

1. Describe the light you saw.

a. What color(s) was the light(s)?

b. How bright was it?

c. How long was it on?

d. Was it uniform in appearance?

e. Did the intensity of the light change?

f. Was it constant or did it pulse or flicker? If so how fast did it pulse or flicker?

g. How wide (perhaps using finger widths at arms length) was the beam at origin?

h. How wide on exposure was the light? Did the light fill your cockpit or compartment?

i. Was the light emanating directly from a source or was it reflected off a surface?

j. Were there any other unusual light sources?

k. Have you seen this light(s) before?

2. Date, Location and Circumstances

a. Date and time (local & zulu using a 24-hour clock) that the exposure occurred?

local: DDMMYYYY hh:mm
zulu: DDMMYYYY hh:mm

b. Location of exposure (if non-classified). Describe location preferably using degrees decimal (DD), degrees-minutes-seconds (DMS), Universal Transverse Mercator (UTM) or Military Grid Reference System (MGRS)?

c. How far and in what direction was the light source? Was it airborne or surface based?

d. What was between the light source and your eyes?

e. What were the atmospheric conditions: clear, overcast, rainy, foggy, hazy, sunny?

f. Was any equipment such as windscreens, visors, NVGs, goggles or sensors affected by the light?

g. What evasive maneuvers did you attempt and did the beam follow you as you tried to move away?

3. Effects

a. How long did you look into the light beam?

b. Did you look straight into the light beam or off to the side?

c. What tasks were you doing when the exposure occurred? Did the light(s) hamper you from doing those tasks?

d. Were both eyes exposed? If not, describe the difference between the light exposure (for example, one eye was shielded or closed, or on the side away from the light beam). Describe any difference in the affect on either eye.

e. Was the light so bright that you had to blink or squint, close your eyes, or look away? Was the light painful? Describe the pain. For how long did the pain persist after the light exposure?

f. Was vision affected while the light was on? How much of your visual field was affected? What types of things could you see or not see? Did you notice the color of instruments or targets change? Did the changes to your vision remain constant or vary during the exposure? If the light source was mounted on a platform (e.g.: aircraft, ground vehicle or building), how much of the platform was obscured?

g. Did your vision remain affected after the light was extinguished? If so, for how long and how did you estimate the time? What types of things could you see or not see? Did you notice afterimages (“spots before you eyes”)? If so describe them.

h. Was there any lingering (i.e., hours or days) visual effects? If so, were the effects continuous or intermittent? Did you have problems reading or seeing in low-light conditions? How long until you were able to see normally again?

i. Did you notice any reddening, warming, or burns to your skin?

j. Describe the condition of your vision before the incident? Do you wear glasses?

k. Are you taking any medications?

LASER RADIATION ACCIDENT/INCIDENT REPORTING FORM

PLEASE COMPLETE ALL APPLICABLE SECTIONS

LASER SAFETY OFFICER INFORMATION

NAME: _____ RANK: _____

ORG: _____ BASE: _____

ADDRESS: _____

_____

TEL COM: - - TEL DSN: - -

EMAIL: _____

MEDICAL PROVIDER INFORMATION

NAME: _____ RANK: _____

ORG: _____ BASE: _____

ADDRESS: _____

_____

TEL COM: - - TEL DSN: - -

EMAIL: _____

LASER ACCIDENT/INCIDENT INFORMATION

LOCATION OF ACCIDENT/INCIDENT: _____ DATE: / / TIME: _____

BRIEF DESCRIPTION OF ACCIDENT/INCIDENT: _____

_____

_____

NAME/DESCRIPTION OF LASER: _____

EXPOSURE DISTANCE: (meters) EXPOSURE DURATION: (seconds)

TYPE OF EXPOSURE: ☐ INTRA-BEAM ☐ REFLECTION

WERE OPTICAL INSTRUMENTS USED: ☐ YES ☐ NO

LASER EYE PROTECTION WORN? ☐ YES ☐ NO TYPE: _____

DETAILS OF IMMEDIATE MEDICAL FINDINGS: _____

_____

_____

_____

_____

Every incident involving an alleged or suspected overexposure to laser radiation will be investigated and evidence of overexposure or injury (or absence thereof) documented (IAW AFOSH 48-139).

Whenever an alleged or suspected overexposure to laser radiation occurs, the following steps shall be taken:

1.1 The supervisor will make sure that each exposed individual is taken immediately to the emergency room of the medical facility and examined by a qualified ophthalmologist / optometrist.

1.2 The supervisor will notify the unit LSO and unit Commander within eight hours.

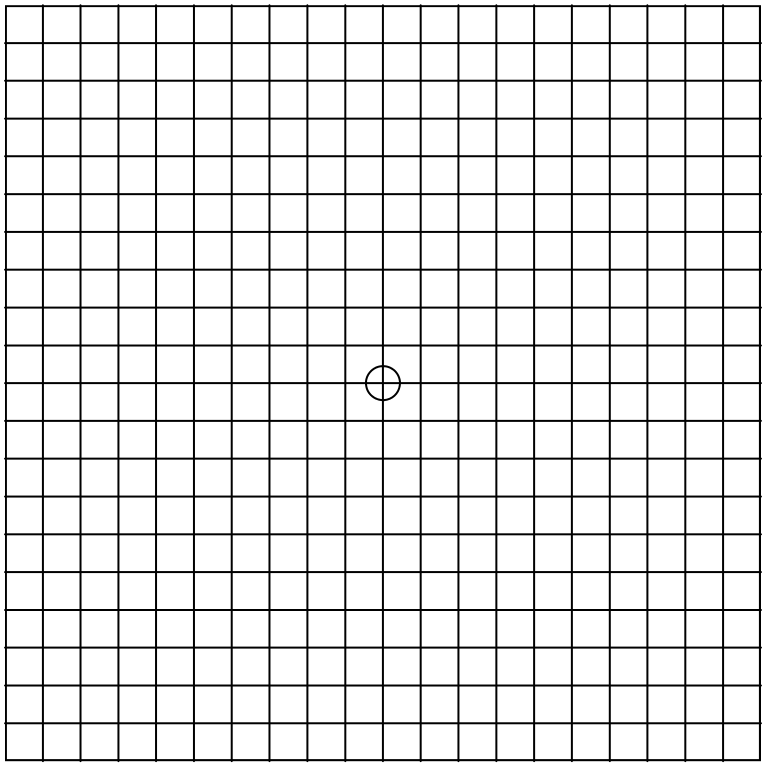
1.3 The LSO will immediately notify local Bioenvironmental Engineering Services (BES). BES is required to notify the Tri-Service Laser Injury Hotline (1-800-473-3549) within three duty days of any incidences.

1.4 LSO will complete the attached checklist with the assistance of the BES and forward it to:

711 HPW/RHDO
Tri-Service Laser Injury Hotline
2650 Louis Bauer
Brooks City-Base TX 78235
1-800-473-3549
Fax: 210-536-3903
laser.safety@brooks.af.mil

Attachment 4

Amsler Grid Test



Instructions

1. To test right eye, begin by covering left eye
2. Hold the sheet 30 cm from your eye (about 2 cm longer than this sheet length)
3. Focus on intersecton of the lines inside the center dot
4. While looking at the center, do you notice any dark, hazy, or missing areas on the grid?
5. While looking at the center, do you see all the horizontal lines? All the vertical lines?
6. Do all the lines appear straight?
7. Repeat test for left eye

If Airman wears glasses, then indicate what for and if glasses or contacts lenses were worn during the test.

Attachment 5

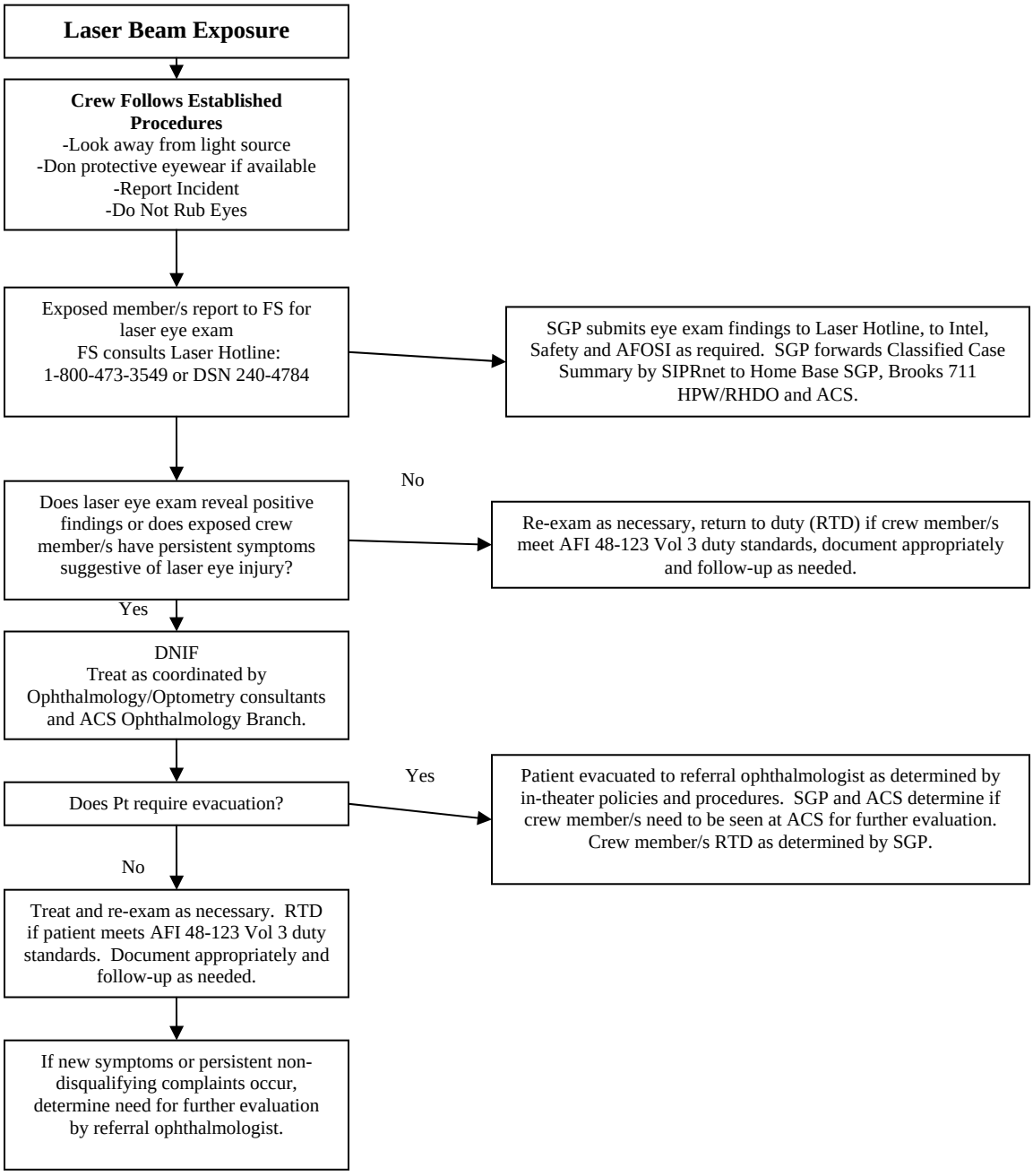
Laser Eye Injuries Brief

The following paragraph is meant to be act as a guide that the flight surgeon can read or relate to the aircrew member following a laser incident.

If you have been involved in a laser incident, then naturally you are concerned about what effect the laser might have had on your eyes and vision. If you can read 20/20 and there is no distortion on the Amsler grid test, then it is unlikely that the laser did any significant damage. In fact, it may have done none at all. Laser injuries can have a wide range of effects including flash blindness, dazzle, dark spots, hazy vision, floaters, burns, retinal bleeding, etc. Of special interest are the hazards posed by visible lasers from glare and flash blindness, and from very high energy lasers that could cause serious thermal injuries. Luckily, the part of the eye responsible for most of our central vision is about the size of a pinhead. It is possible, that this area could be damaged by a laser, but only if a person happened to be looking directly at the light. A laser injury even a few millimeters away from this area, will probably not significantly affect the central vision. The central vision is what you use to read, watch TV, and drive. Most people after encountering a laser incident quite naturally start to become overly conscious about how their eyes feel and sometimes begin to rub their eyes. This has caused some people to erroneously conclude that their eye was injured. Furthermore, rubbing of the eyes can produce small scratches on the cornea resulting in painful irritated eyes. The important point is that if your vision and eyes seem normal after direct laser beam exposure, then there is probably no significant damage to your eyes due to the laser beam.

Attachment 6

General Flow Chart



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711th HUMAN PERFORMANCE WING
USAF SCHOOL OF AEROSPACE MEDICINE/FEC
2507 KENNEDY CIRCLE
BROOKS CITY-BASE TX 78235-5116

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