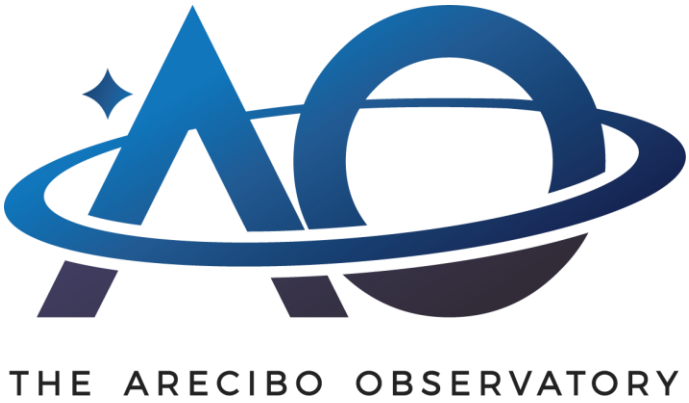
YANG ENTERPRISES INC.



AOMT

AO-EHS-11
YAG LASER USAGE

AUGUST 30, 2019

The Arecibo Observatory, Emergency Health & Safety Plans (EHS) pertain to all AOMT members UCF, YEI, and UAGM employees.

DOCUMENT REVISION RECORD

The current version of this document is maintained on-line at the Yang Enterprises Inc. (YEI) Arecibo Observatory (AO) Configuration Management file server to support management and operations for all AO Management Team (AOMT) members.

Obsolete versions shall be removed from the server. Printed copies are uncontrolled and will not be used without first verifying that they are up to date.

The following revisions have been applied to this document:

Document Number	Change Description	Date
AO-EHS-38	Original Release	5/1/2018
AO-EHS-38	First Revision	8/30/2019
AO-EHS-11	SOPs revised, new number assigned	9/25/2020

Version 1: Initial draft.

Revision A: Initial release under change control

Ver	Process Owner	Department	Training Required?	
1	Wilson Arias	EH&S	☒ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

APPROVALS CHANGE CONTROL

Rev.	Process Owner	Title	Signature	Date
1	Wilson Arias	EH&S		8/30/2019

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ACRONYMS LIST

Acronym	Description
AO	Arecibo Observatory
AOMT	Arecibo Observatory Management Team
cm	Centimeter (a unit of measurement)
EH&S	Environmental Health and Safety
LSO	Laser Safety Officer
m	Meter
MPE	Maximum Permissible Exposure
mW	milliWatts
NE	North east
nm	Nanometers
NHZ	nominal hazard zones
SOP	Standard Operating Procedures
µJ	Nano-joules
UCF	University of Central Florida
UAGM	Universidad Ana G. Mendez
V	volts
W	watts
YEI	Yang Enterprises, Inc.

GLOSSARY OF TERMS

AO-EHS-11	Naming convention of the AO document: AO – stands for Arecibo Observatory EHS – stands for Environmental Health and Safety The number at the end is the program identifier for the YAG Laser SOP.

PREFACE

The contents of this YAG Laser SOP are presented as a matter of information only. The procedures herein are established to increase understanding, eliminate the need for personal decisions on matters of company-wide policy, and to assure uniformity throughout our organization. It is the responsibility of each and every member of management to administer these policies in a consistent and impartial manner.

The AOMT, reserves the right to modify, revoke, suspend, terminate, or change any or all such policies, or procedures, in whole or in part, at any time, with or without notice. The language used in this manual is subject to modification as we must remain in compliance with all local, state, and federal laws and regulations.

Personnel performing outside of their respective AOMT corporate office, whether they are working at a customer site or working on a contract at another location, must also follow all policies and procedures set forth at that respective location.

SCOPE

All individuals at the Arecibo Observatory (AO) working with lasers and laser systems are responsible for knowing and adhering to all applicable requirements of the Laser Safety Manual. All Class 3b and Class 4 lasers must have a Standard Operating Procedure (SOP) approved by the Laser Safety Officer (LSO). Generally, an SOP is required for each laser. However, if several lasers in the same location are supervised by the same Laser Supervisor and have similar characteristics, hazards, and controls, a combined SOP may be used.

1.0 LASER DESCRIPTION

Repeat this section for each laser included in this SOP.

Laser ID	Alexandrite	**Manufacturer**	Light Age, Inc.
Laser hazard class	IV	**Model**	PAL-PRO
Lasing medium	Cr^{4+}-Alexandrite	**Serial number**	0004
Continuous wave or pulsed	Pulsed	**Wavelength(s)**	770 nm (720–800 nm)
Max power (W)	4	**Max energy per pulse (J)**	0.13
Beam diameter at 1/e power points (cm)	0.11	**Pulse duration (sec) if multiple are possible include range**	1.5e-7
Beam divergence (milliradians)	0.65	**Pulse frequency (Hz) if multiple are possible include range**	25
Briefly describe the intended use and location	Lidar remote sensing measurements of MLT-region potassium (K) and temperature. Located in the lidar laboratory at the Arecibo Observatory.		

2.0 LASER CONTROLLED AREA

Describe the laser controlled area and any nominal hazard zones (NHZ). The NHZ is the space within which the level of direct, reflected, or scattered laser radiation exceeds the Maximum Permissible Exposure (MPE). Describe entryway controls to prevent unauthorized entry into the laser controlled area during laser operation. Describe controls to prevent laser radiation exceeding the MPE from escaping the laser controlled area.

This laser is located on an optical bench in the central part of the south hall of the lidar lab. The beam exits the laser in a northerly direction and is vertically polarized. It is ~15

cm above the table. The main power of the beam reflects from 3 mirrors on the table before being transmitted vertically to the sky. The vertical beam is fully contained in a 20 cm diameter beam tube. The gap between the bottom of the tube and the final mirror is about 15 cm. At the roof, approximately 2.5 m above the laser bench, the beam is turned horizontally towards the northeast at a height of about 30 cm above the roof. It travels ~5 m to the NE telescope where another mirror turns it towards the sky. This 5 m stretch and the vertical beam along the telescope are currently in the open. However, there is a 5-m beam tube for the horizontal beam that was used until one of its supports was misplaced. (This should be corrected before our next operations.) The vertical beam is ~15 cm from the telescope structure.

Additionally, there are low power beams from the alexandrite on the optical bench that result from the small (~0.1%) transmission through the dielectric mirrors. These are ~3 mW average power, or 500 W peak power in 100 µJ, 150 ns pulses. These are generally contained in beam tubes through most of the regions they travel. One is intercepted by a photodiode. Another is further split into two beams which are heavily attenuated in neutral density filters and used for monitoring purposes.

3.0 NON-BEAM HAZARDS

Describe any non-beam hazards (such as: high voltage/current, ignition of combustible materials, laser dyes, compressed gasses, and any others) and the control measures for these non-beam hazards.

The laser is a flashlamp-pumped, q-switched solid state laser. Thus, there is high voltage (1.9kV) over the flashlamps and (2.5 kV) over the Q-switch. There is also a piezo electric device that can have as much as 500V. The Q-switch and piezo are low-current devices. The flashlamps draw under 3 A. These are covered by insulated connectors, which, to the best of my knowledge, comply with all legal and regulatory requirements. All control measures are those provided by the laser manufacturer.

3.1 PERSONAL PROTECTIVE EQUIPMENT

Laser Eyewear				
For This Laser Wear		This Eyewear		
Laser ID	Under These Conditions	Designation/ Manufacturer	Wavelengths Attenuated	Optical Density
Alexandrite	Whenever working in an area where the beam is in an “uncontrolled” space, such as on the roof.	Thorlabs model LG9	730–1090	7+

3.2 OTHER PROTECTIVE EQUIPMENT

Item	Use Under These Conditions
Laser Curtains	Always
Barriers and beam tubes	Whenever they do not interfere with operations, maintenance, adjustments.

4.0 PROCEDURES

Describe the procedures for setup and beam alignment.

Initial alignment is done with the beam at low power (~0.1 W) and not q-switched (long pulsed, ~20 μs). We placed the three turning mirrors with the beam roughly centered. Once positioned with the centered beams, the first two of these mirrors are no longer adjusted. A beam expander telescope is placed in the beam just before the third mirror, and it is positioned so that the beam is as nearly as possible down the center. The third mirror is adjusted until the beam is centered on the 4th mirror (first roof mirror). From this mirror, the beam is adjusted to the center of the 5th and final mirror at the base of the telescope. Sky alignment is initially done from this 5th mirror. However, all fine tuning and subsequent mirror adjustments are done from mirror 3, in the laboratory. Sky alignment is a question of adjusting the beam direction so that it overlaps the field-of-view of the telescope at the highest altitude possible.

Describe the procedures for routine start-up and operation.

Startup begins by turning on both the external and internal water circulators. The internal water system has two circulators, each of which is stabilized at a different temperature. These take about 15 minutes to complete, and during this time, the laser does not operate. After the warmup, the laser lamps are started up. The internal shutter is left closed, and the q-switch is off. The operator has to be sure at this point that the laser power meter is in place. This not only helps in adjusting the laser, but it blocks the beam from exiting the laboratory to the sky. After another 15 minutes, the laser shutter can be opened and any optical adjustments that may be required are completed. Then the shutter is opened and the q-switch is turned on. When the laser is functioning correctly, and the skies are clear of weather and air traffic, the internal shutter is closed, the power meter is removed, and the shutter is re-opened for data acquisition.

Describe the procedures for normal shut-down.

1. Close the internal shutter.
2. Turn off the Q-switch and lamps.
3. Turn off remaining laser electronics.
4. Shut off the internal water circulation system.

5. Shut off the external water circulator.

Describe the procedures for emergency shut-down.

There is a large red button on the control panel of the laser for emergency shut down.

If necessary describe any special procedures not listed above.

1. Just to reiterate: the beam is not transmitted onto the sky unless there are no clouds overhead nor aircraft in the vicinity.
2. The alexandrite laser is injection seeded by a low power (15 mW) CW external-cavity diode laser. It is turned on and off in the startup and shut down procedures. The beam is completely contained in a modular box, and it is transmitted to the alexandrite via an optical fiber.

5.0 PERSONNEL

Refer to Appendix A for the Approved laser User Personnel Log. This section to be completed after the SOP has been approved by the Laser Safety Officer.

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APPENDIX A - APPROVED LASER USER PERSONNEL LOG

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APPROVED LASER USER PERSONNEL LOG

Laser User Statement:	**I have read and understand this procedure. I agree to follow this procedure each time I use the laser or laser system.**			
Laser User Print Name	Laser User Signature	Entrance Laser Eye Exam Date	General Laser Safety Training Date	SOP Training Date

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APPROVED LASER USER PERSONNEL LOG

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REGISTRO DE PERSONAL DE USUARIO DE LÁSER APROBADO

Declaración del usuario del láser:	**He leído y entiendo este procedimiento. Acepto seguir este procedimiento cada vez que utilice el láser o el sistema láser.**			
Nombre del usuario del laser en letra de molde:	Firma del usuario láser	Fecha del examen de la vista con láser de entrada	Fecha de capacitación general sobre seguridad láser	Fecha de entrenamiento de SOP

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REGISTRO DE PERSONAL DE USUARIO DE LÁSER APROBADO

Declaración del usuario del láser:	**He leído y entiendo este procedimiento. Acepto seguir este procedimiento cada vez que utilice el láser o el sistema láser.**			
Nombre del usuario del laser en letra de molde:	Firma del usuario láser	Fecha del examen de la vista con láser de entrada	Fecha de capacitación general sobre seguridad láser	Fecha de entrenamiento de SOP

REFERENCE DOCUMENTS

THE FOLLOWING DOCUMENTS ARE REFERENCED IN THIS PLAN:

DOCUMENT NUMBER	TITLE
	SRI International Laser Safety Manual 2002
	American National Standard for the Safe Use of Lasers: ANSI Z136.1-2007
	Manufacturer website: http://www.lightage.com

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