



# ETA<sup>®</sup> International

## Photonics Technician - Operator (PTO)

### Competency Requirements

Photonics technicians work in jobs where they assemble, measure, test, and repair optical components such as lenses, mirrors, filters and optical sources such as lasers and light-emitting diodes (LEDs).

**Operator Level:** These technicians typically work in applications where photonics is an “enabling technology” such as manufacturing/materials processing, internet/communications, biomedical equipment, and defense/homeland security systems development/integration. They set up, calibrate, operate, monitor, maintain, and sometimes repair equipment containing lasers, optics, fiber-optics and/or electro-optic or other photonics devices that are being used in their organization.

Certification requires competence in the following **knowledge** areas:

- 1) Applied mathematics
- 2) Principles of Optics: nature of light, geometrical optics, wave optics
- 3) Basics of laser physics and devices
- 4) Safety

The required knowledge competence can be demonstrated via a passing score of 75% or better on each of the Photonics Technician Operator Certification exam sections. These exam sections will be required of all applicants, regardless of formal education training or work experience

Certification requires competence in the following **hands-on** competency areas:

- 1) Laser device & systems skills
- 2) Photonic/optical component & system skills
- 3) Electronics skills
- 4) Basic technical skills

The required hands-on competence can be demonstrated via one or more of the following:

- 1) If employed currently, or previously employed, a letter from the employer, preferably a supervisor who has been certified, certifying that the person has demonstrated the competencies listed.
- 2) Transcript showing passing grade of C or better in the subject matter from an accredited college or university or technical school.

**Knowledge Competencies – Certification as a “Photonics Technician Operator” requires evidence of understanding and competence in all of the following areas.**

### **I. Applied Mathematics**

- 1) Understand and utilize basic math skills:
  - a) Apply the scientific method to general problem solving, to the design and collection of data, and to the analysis and effective presentation of results and conclusions
  - b) Work with fractions, decimals, percents, exponents, real & imaginary numbers, symbolically and graphically.
  - c) Know basic units of measurements for distance/length, weight, volume, angle, energy, power, amplitude/attenuation (dB & dBm), and radiometric, irradiance, and luminous measurements in English and Metric units and be able to convert between English and Metric units.
  - d) Know the meaning of various unit measurement abbreviations such as micro, nano, pico, atto, and be able to convert one unit to another.
  - e) Estimate answers to problems, round off numbers, and understand approximations such as  $\sin(\theta) \approx \theta$  for small  $\theta$ .
  - f) Understand precision, accuracy, and tolerance in measurements
  - g) Understand basic statistics and statistical methods
- 2) Understand and utilize basic algebra skills:
  - a) How to utilize formulas and to arrange equations to solve for specified unknowns
  - b) Ratio and proportion
  - c) Perform calculations using powers, roots, basic trig functions (sine, cosine, tangent), scientific and engineering notation, logarithms, decibels
  - d) Quadratic equations
- 3) Understand graphs: includes bar graphs, pie charts, and line graphs (linear, semi-log, log)
- 4) Read scale drawings

### **II. Principles of Optics**

- 1) Basic Nature of Light
  - a) Light described as a ray
  - b) Light described as a wave
  - c) Characteristics of light waves—amplitude, frequency, period, wavelength, wavefronts, electromagnetic spectra and propagation direction
  - d) Reflection, scattering, and absorption of light in various media and at various interfaces
- 2) Geometric Optics
  - a) Law of reflection
  - b) Law of refraction (Snell's law)
  - c) Index of refraction/speed of light
  - d) Critical angle and total internal reflection
  - e) Refraction of light by prisms

- f) Basic optical aberrations such as defocus, astigmatism, dispersion
  - g) Optical and geometrical characteristics of concave, convex, and aspheric lenses and mirrors, including effects of decenter and tilt of single and multiple elements
  - h) Use of thin-lens formulas to locate images
  - i) f-number of a lens or mirror: meaning, use, and how to calculate it
  - j) Aperture and field stops and their effect on light propagation
- 3) Wave Optics
- a) Characteristics of electromagnetic spectra
  - b) Principle of superposition and interference of light waves
  - c) Standing waves (nodes and antinodes)
  - d) Formation of interference fringes
  - e) Diffraction of light waves through small openings and around sharp edges
  - f) Single-slit and double-slit diffraction patterns
  - g) Diffraction with gratings
  - h) Diffraction-limited optics
  - i) Characteristics of randomly polarized, plane polarized, circularly polarized, and elliptically polarized light
  - j) Producing polarized light, including unintentional production by stress and some coatings
  - k) Detecting polarized light

### III. Basics of Laser Physics and Devices

- 1) Characteristics of laser (coherent) light vs. incoherent light
- 2) Light generation/emission, stimulated emission, light amplification
- 3) Basic laser design: media, mirrors, resonators
- 4) Characteristics of different types of lasers: gas, ion, solid-state, dye, excimer, diode
- 5) Use of optical mounts and laser structures: kinematic mounts, stress-induced by mounts, degrees of freedom.
- 6) Basic principles and applications of optical fibers

### IV. Safety

Basic laser safety as defined in ANSI Z136.1-2007 American National Standard for Safe Use of Lasers

- 1) Laser safety concepts
  - a) Biological effects of laser radiation on the eye and skin with all wavelength from 180nm to 1mm
  - b) Understand the significance of specular and diffuse reflections
  - c) Understand the non-beam hazards
  - d) Understand laser classification
  - e) Maximum Permissible Exposure (MPE), Normal Hazard Zone (NHZ)
  - f) Familiarity of the US code of federal regulation 1040.10, Federal Laser Product Performance Standard. Be able to identify if a laser or laser system complies with the code.

- 2) Knowledge of other basic safety procedures that are likely in most photonics applications:
  - a) Electrical
  - b) Chemical (e.g., optics cleaning using acetone - flammability & explosion potential)
  - c) Materials (e.g., MSDS – Material Data Safety Sheets)

**Hands-On Competencies – Certification as a “Photonics Technician Operator” requires evidence of training and/or experience and competence in all of the following areas.**

**I. Laser device & systems skills**

- 1) Operate at least 2 types of laser devices (e.g., gas, ion, solid-state, dye, excimer, diode)
- 2) Measure output power of laser or other light source
- 3) Optimize laser system parameters
- 4) Perform preventive laser maintenance per device specifications
- 5) Clean laser optics to appropriate technical specification level including understanding of cleaning issues with hard and soft coatings, effect of static charge and its control/elimination, and use of different solvents with different materials.
- 6) Determine (measure) required spatial and temporal laser beam characteristics for specified applications
- 7) Verify laser, optical, and imaging devices and instrumentation performs according to manufacturer’s specifications and regulation standards
- 8) Determine (measure) focused beam spot size and location
- 9) Align and clean laser beam delivery system according to required operating procedures, including understanding of cleaning issues with hard and soft coatings, effect of static charge and its control/elimination, and use of different solvents with different materials.
- 10) Conduct laser safety checks and follow laser safety practices in working area per ANSI standards
- 11) Identify and comply with established regulatory codes and safety practices, in particular laser safety practices in working area per ANSI standards including ANSI Z136.1-2007 “American National Standard for Safe Use of Lasers”

**II. Photonic/optical component & system skills**

- 1) Install appropriate light sources (e.g., laser, laser diode, VCSEL diode array, or a nonlaser light source) for system assembly
- 2) Clean optics to appropriate technical specification level including understanding of cleaning issues with hard and soft coatings, effect of static charge and its control/elimination, and use of different solvents with different materials.

- 3) Set up and align single and multiple laser, optical, and opto-mechanical components using appropriate alignment and mounting techniques for device, application, or characterization per technical specifications. Know a variety of methods for providing angle and/or displacement adjustments (e.g. wedges, kinematic mounts).
- 4) Understand the use and purpose of basic optical instruments: autocollimator, interferometer, alignment scope, spectrophotometer, energy/power meter, pulsewidth detector
- 5) Use a variety of optical instruments such as comparator, optical alignment scope, theodolite, autocollimator, alignment scope, spectrophotometer, energy/power meter, pulsewidth detector, ratiometer, beam analysis camera.
- 6) Perform radiometric and photometric measurements
- 7) Measure, analyze, and evaluate interferometric diffraction fringe patterns
- 8) Set up and utilize autocollimation methods
- 9) Determine depth of focus

### III. Electronics skills

- 1) Analyze digital circuits using at least 3 of the following: probes, pulsers, logic analyzers, oscilloscopes, counters, digital multimeters
- 2) Set up and operate a variety of instruments, including assuring accurate and calibrated measurement, such as digital and analog oscilloscopes, power supplies, measurement instruments, signal generators, multifunction digital meters, recording devices, etc.
- 3) Use a variety of basic tools such as soldering tools and materials in accordance with IPC standards
- 4) Read and interpret digital and analog circuit diagrams and layouts

### IV. Basic technical skills

- 1) Read and interpret mechanical/optical drawings or schematics for dimensions, tolerancing, and data reference
- 2) Collect data and use computer spreadsheet software (e.g., Excel) for data collection, reduction, presentation.
- 3) Read and understand CAD drawings
- 4) Utilize documentation procedures: logbooks, schedule tracking, expenses

**End of Photonics Technician – Operator Competencies Listings:  
(with 4 major Knowledge categories and 4 major Hands-On categories)**

**[Find An ETA Approved School Site:](http://www.eta-i.org/eta_schools.html)**  
[http://www.eta-i.org/eta\\_schools.html](http://www.eta-i.org/eta_schools.html)

**[Find An ETA Test Site:](http://www.eta-i.org/testing.html)**  
<http://www.eta-i.org/testing.html>

## Suggested Study Material and Resources:

(also see websites for even more detail information)

**LIGHT- Introduction to Optics and Photonics (hardcover);** Judith Donnelly, Nicholas Massa; ISBN 978-09815318-09; New England Board of Higher Education; Jan. 2010; pgs.377.

Also available in paperback, black & white paperback, and PDF download at

<http://stores.lulu.com/photon2>

**Optics for Engineers;** Charles DiMarzio; ISBN 978-14398072-5-5; CRC Press; Aug. 2011; pgs.558. <http://www.crcpress.com/product/isbn/9781439807255>

**Optical Communications Essentials;** Gerd Keiser; ISBN 978-00717379-99; McGraw-Hill Companies; July 2003; pgs.396.

**Understanding Lasers: An Entry-Level, 3E;** Jeff Hecht; ISBN 978-04700889-06; Wiley-IEEE Press; June 2008; pgs.496.

**Optics, 4E;** Eugene Hecht; ISBN 978-0805856-63; Addison Wesley; Aug. 2001; pgs.680.

**Basic Electro-Optics for Electrical Engineers;** Glenn D. Boreman; ISBN 978-08194280-66; SPIE Publications; March 1998; pgs.97. [http://spie.org/x648.html?product\\_id=294180](http://spie.org/x648.html?product_id=294180)

**NOTE:** The following are to be used as a resource, not intended to replace the approved course training in photonics or precision optics, required in order to sit for the certification qualifying exams.

**OP-TEC** websites: <http://www.op-tec.org/>; <http://www.op-tec.org/index-1.php>;  
<http://www.op-tec.org/OPCN.php>; <http://www.op-tec.org/index-3.php>

**SPIE** open access self-study resources:

**[Fundamentals of Photonics](http://spie.org/x17229.xml)**, 10 tutorial modules written by experts, part of a project funded by the Center for Occupational Research and Development (CORD) and the Scientific and Technological Education in Optics and Photonics (STEP), and supported by SPIE and other organizations. <http://spie.org/x17229.xml>

**[Optipedia](http://spie.org/x32276.xml)**, a collection of encyclopedic articles on key topics in optics and photonics. Text, equations, and graphs were originally published in SPIE Press books.

<http://spie.org/x32276.xml>

Other **SPIE** publications in their “**Field Guides**” series, <http://spie.org/x647.xml>, (mainly aimed at engineers, but could also be useful to technicians):

[Field Guide to Infrared Systems, Detectors, and FPAs, Second Edition](#)

[Field Guide to Optical Fiber Technology](#)

[Field Guide to Geometrical Optics](#)

[Field Guide to Lasers](#)

[Field Guide to Polarization](#)

[Field Guide to Infrared Systems](#)

[Field Guide to Laser Pulse Generation](#)

[Field Guide to Optical Thin Films](#)

[Field Guide to Interferometric Optical Testing](#)