ETA®International
Photonics Technician - Specialist (PTS)
Competency Requirements

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

Specialist Level: These technicians work in areas that require the skills and knowledge of the Operator Level, but also required a higher level of knowledge of optics and photonics physics and technology and that require a greater variety of hands-on competencies in laser and optical components and systems. They typically work in applications such as the following:

1) research and development laboratory techs;
2) product development, test, and production techs who are team members for original equipment manufacturers (OEMs) of lasers, optics, and photonics components and systems
3) field service techs for OEMs or companies that manufacture and/or utilize lasers, optics, and photonics components and systems

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 Specialist 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.

<u>Specialist-Level Knowledge Competencies</u> – Certification as a "Photonics Specialist Technician" requires evidence of knowledge and competence in <u>all</u> of the knowledge areas for Operator-Level, <u>and</u> also in <u>all</u> of the following additional 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, and 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 θ.
   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 to include bar graphs, pie charts, and line graphs (linear, semi-log, log)
4) Read scale drawings
5) Understand and utilize basic geometry and trigonometry skills:
   a) Perform calculations using lines and angles (parallel and perpendicular lines)
   b) Know definition of and how to use basic trig functions: sine, cosine, tangent
   c) Perform calculations on perimeters and areas of rectangles, parallelograms, trapezoids, triangles, and circles (sine, cosine, tangent functions)
   d) Perform calculations on surface areas and volumes of boxes, cones, cylinders, and spheres

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
   e) Characteristics of photons—energy, momentum, frequency, and wavelength
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
k) Ray tracing to locate position, size, and orientation of images formed by systems of thin lenses and/or mirrors

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
   l) Bragg's law
   m) Birefringence

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
7) Q-switching, nonlinear optics (harmonic generation, mixing)
8) Methods to control or modify laser beams such as polarizers, attenuators, beam switches, faraday rotators, beamsplitters.
9) Properties of coating materials such as anti-reflection, highly-reflecting, dielectric vs. conductive, laser damage characteristics.

IV. Safety

1) Basic laser safety as defined in ANSI Z136.1-2007 American National Standard for Safe Use of Lasers
2) 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.
    g) Control measures for normal laser operation, and during service with defeated interlocks.
3) 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)

<u>Specialist-Level Hands-On Competencies</u> – Certification as a "Photonics Specialist Technician" requires evidence of training and/or experience and competence in <u>all</u> of the areas for Operator-Level, <u>and</u> also in <u>all</u> of the following additional 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"
12) Operate, clean, align, and perform necessary troubleshooting and maintenance to ensure proper operation on electronic, optical, and cooling subsystems of at least 4 types of laser devices as required (e.g., gas, ion, solid-state, dye, excimer, diode)
13) Calculate power density based on measurements done
14) Determine (measure) laser beam quality factor

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
10) Optimize photonic system parameters
11) Set up and align at least two types of interferometers (e.g., Fizeau, Twyman-Green, Mach-Zehnder, Michelson)
12) Build and test photodetector circuits
13) Interpret laser, light source, and detector specifications to determine optimal functioning levels of devices
14) Setup, install, and use at least two types of optical modulator devices [e.g., electro-optic (EO) and acousto-optic (AO)]
15) Understand operation and use of various photonics devices such as fiber Bragg gratings, optical modulators, etc.
16) Set up and calibrate optical detectors including focal plane arrays
17) Perform interferogram evaluation and wavefront fitting by measurement or calculation
18) Measure wavefront aberrations

III. Electronics skills

1) Analyze digital circuits using all of the following: probes, pulsers, logic analyzers, oscilloscopes, counters, and 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.
5) Identify and work within project constraints (physical, schedule, and budget)
6) Prepare schematic drawings, including scale drawings, as needed

End of Photonics Technician – Specialist 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

Find An ETA Test Site:
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

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, 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, 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

