

---

# The National Precision Optics Skill Standards for Technicians

---

January 2009

**OP-TEC**

National Center for Optics and Photonics Education



---

*Endorsed by:*



© CORD 2009

This document was produced by OP-TEC: The National Center for Optics and Photonics Education, an NSF Advanced Technological Education (ATE) Center of Excellence (NSF award 0603275). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

For more information about OP-TEC, contact either of the following persons:

Dan Hull, PI  
Executive Director, OP-TEC  
324 B Kelly  
Waco, TX 76710  
(245) 741-8338  
(254) 399-6581 fax  
hull@op-tec.org  
www.op-tec.org

Dr. John Souders  
Director for Curriculum Materials  
324 B Kelly  
Waco, TX 76710  
(254) 772-8756 ext 393  
(254) 772-8972 fax  
souders@op-tec.org  
www.op-tec.org

Published and distributed by:

CORD Communications  
P.O. Box 21689  
Waco, Texas 76702-1689  
254-772-8756  
800-972-2766  
<http://www.cord.org/>

ISBN 1-57837-562-2  
978-1-57837-562-2

## **INTRODUCTION**

### **About Precision Optics Technicians**

Precision optics technicians (POT) produce, test, and handle optical (infrared, visible, and ultraviolet) components that are used in lasers and sophisticated electro-optical systems for defense, homeland security, aerospace, biomedical equipment, digital displays, alternate energy production, and nanotechnology. POTs also integrate precision optical components into these electro-optical systems and maintain them.

Throughout the 20th century, precision opticians were mostly prepared under a “European-style, apprenticeship” training process, requiring the trainee (apprentice) to serve and learn for 6–8 years under the guidance and mentoring of a master optician. In the early 1960s and 1970s a few community and technical colleges initiated training programs for optical technicians.

Today, there is a perceived shortage of POTs that could require our country to outsource this work to foreign nations—a situation that would compromise our nation’s security and sacrifice a vital sector of future economic development.

Several factors have contributed to this shortage:

- The apprenticeship training for POTs is not subscribed to or adopted in our country to any significant extent.
- Many experienced POTs have retired, and more are expected to retire in the near future.
- The community colleges that have offered education and training in precision optics have discontinued their programs due to faculty retirements and poor support. One of these colleges, Monroe Community College, has committed to updating and reinstating its POT program.

Furthermore, the skills and knowledge necessary for success in today’s precision optics jobs require more education in science and technology (particularly in materials science, optical phenomena, and the operation of optical instruments and interpretation of their measurements). Also, the manufacture of most precision optics (particularly spherics and aspherics) uses high-precision, computer numerical controlled (CNC) machines. POTs are often required to set up, operate, calibrate, and maintain this equipment. Clearly, the job requirements for POTs have been raised, and significant changes are required in the education and training of these technicians.

## **OP-TEC: The National Center for Optics and Photonics Education**

In 2006, the National Science Foundation, through its Advanced Technological Education (ATE) Program, established OP-TEC: The National Center of Excellence in Optics and Photonics Education through a grant to the Center for Occupational Research and Development. OP-TEC and its eight Partner Colleges are committed to building the capacity of our nation's community colleges to provide the quality and quantity of technicians needed in this critical and emerging field. OP-TEC projects the job market, maintains skill standards, designs curricula, tests innovative recruiting and teaching strategies, and supports ongoing and new AAS programs and retraining efforts at community and technical colleges by providing studies, technical assistance, and faculty development opportunities. OP-TEC also continually examines the field of optics and photonics to identify and support new education and training for emerging and changing technologies related to photonics. Precision optics is an example of a changing technology.

Under a supplemental grant from NSF, OP-TEC and the Photonics Industry Clusters are conducting studies and preparing to support the development of additional POT programs at community colleges.

### **The Need for Skill Standards**

Skill standards are employer-driven statements of expectation as to what workers should know and be able to do on the job. Skill standards are employers' "specifications." They are the primary means by which employers communicate to educators their (the employers') requirements regarding the content of the courses and programs that will produce their future employees. Skill standards such as those contained in this document are necessary to ensure that technicians are well prepared for the challenges that await them in today's high-tech, globally engaged workplace.

### **About the *National Precision Optics Skill Standards for Technicians***

These standards, by design, are very broad and comprehensive. We do not expect every technician working in the precision optics area to have this full range of skills. Instead, these standards should provide a base that employers and educators can customize to meet local industry needs.

The standards represent the consensus of a broad cross-section of U.S. employers regarding the technical and workplace skills required of precision optics technicians. They are designed to give educators and employer advisory committees a solid foundation for generating courses and programs that will enable U.S. two-year colleges (and their feeder high schools) to produce globally competitive workers. OP-TEC will use these standards to design model curricula and develop appropriate instructional materials.

For the purposes of developing these skill standards, we defined POTs as:

*Specialists in the technical field of optical component fabrication where required surface tolerances are of the order of 1/16th wavelength (38 nanometers) and positional tolerances are 10 wavelengths (6350 nanometers). They work in optical shops for optics manufacturers, and in quality control (incoming inspection) departments for organizations that incorporate precision optics into various systems.*

## **The Development Process**

The standards were developed by OP-TEC using a four-phase process similar to that used by OP-TEC to develop the *National Photonics Skill Standards for Technicians*, now in its third edition.

1. *Draft*—OP-TEC staff and a subject matter expert developed a first draft.
2. *Industry review*—The first draft was edited by a panel of precision optics industry representatives and college faculty.
3. *Web review*—The second draft was reviewed through an online survey by 22 industry professionals.
4. *Final review*—The final draft was reviewed by a group of academic and industry representatives from the precision optics field.

## **How the Standards Will Be Used**

The *National Precision Optics Skill Standards for Technicians*—the employers' specifications for new technicians in precision optics—will be used as the basis for a new curriculum design. OP-TEC is designing the new curriculum model for preparing POTs. The Rochester Photonics Cluster is preparing a design and an equipment list for college labs to train POTs. OP-TEC, through the University of North Texas, is conducting an employer needs assessment to determine the number of POT jobs that will need to be filled over the next five years.

OP-TEC will host meetings for regional teams of colleges and employers that have an interest in initiating education and training for POTs. Hopefully, several teams will be identified and committed to begin planning POT education and training programs. OP-TEC will then move forward to secure funding to support them through their start-up process. We will also search for support to equip the laboratories.

## **ACKNOWLEDGEMENTS**

*Content expert*—Dr. Larry DeShazer, Center for Applied Competitive Technologies, Irvine Valley Community College

*Skill standards development*—Dr. John Souders, OP-TEC Director of Curriculum

*Rochester Regional Photonics Cluster*—Tom Battley, Executive Director

*Final content approval*—Jim Sydor (Sydor Optics), Mike Mandina, and Jim Van Kouwenberg (Optimax Systems, Inc.)

## **ENDORSEMENTS**

American Precision Optics Manufacturers Association

Florida Regional Photonics Cluster

Rochester Regional Photonics Cluster

The OP-TEC staff invites you to review the standards and welcomes your recommendations for their improvement.

Daniel M. Hull  
Executive Director, OP-TEC

# PRECISION OPTICS SKILL STANDARDS FOR TECHNICIANS

## CRITICAL WORK FUNCTIONS and TASKS

- 1. Identify, inspect, and qualify bulk materials for manufacturing high-tolerance optical components.**
  - a. Review incoming material certification sheets to match print specifications.
  - b. Inspect and evaluate materials for defects such as inclusions, bubbles, striae, scratches, bulk stress, scattering, fractures, and impurities.
  - c. Ensure physical safety in handling the material by following prescribed procedures.
  - d. Follow material handling procedures to ensure physical safety, avoid contamination, and maintain material identification.
  - e. Maintain prescribed documentation of bulk materials using a job jacket or its equivalent.
  
- 2. Plan and upgrade high-tolerance optical fabrication processes.**
  - a. Use design specifications and technical drawings to meet specified tolerances.
  - b. Use basic processing techniques for producing plano, cylindrical, spherical, and aspheric optics.
  - c. Assist in the selection of fabrication processes and their sequencing.
  - d. Recommend process changes to increase quality and efficiency.
  - e. Identify standard operating and safety procedures of the optics shop and equipment required in the process.
  
- 3. Shape and finish bulk materials to generate high-tolerance optical components.**
  - a. Determine and perform procedures for tooling, blocking, generating, shaping, beveling, grinding, polishing, and centering.
  - b. Practice accepted procedures for handling optical materials.
  - c. Apply appropriate procedures for processing a variety of optical materials such as glass, crystals, optic ceramics, and plastics.
  - d. Measure and record dimensionality to ensure adherence to specifications and tolerances.
  - e. Retrieve, clean, store, secure, and document the finished optical components to ensure their integrity and proper identification.
  
- 4. Operate, maintain, and calibrate high-tolerance optics manufacturing and testing equipment.**
  - a. Use proper procedures to operate CNC machines.
  - b. Apply accepted standards to maintain work area cleanliness.
  - c. Inspect and maintain equipment to ensure optimal use and productivity.
  - d. Use the work instruction template to verify set points in the control screens.
  - e. Detect malfunctioning equipment and adjust or repair as necessary and/or notify appropriate work personnel.

**5. Conduct optical metrology measurements and inspections for final distribution.**

- a. Coordinate with quality assurance to ensure compliance to design specifications and documentation requirements.
- b. Develop an inspection plan that uses the appropriate metrology for all measured specifications.
- c. Test finished components by appropriate means including test plate or interferometric techniques to ensure compliance with design specifications.
- d. Use autocollimators to measure dimensional and angular deviations in finished components.
- e. Use collimator or interferometer to measure focal length and on-axis aberrations.
- f. Inspect surface quality of finished product to comply with appropriate scratch-and-dig standards as specified on the component drawing or specification sheet.
- g. Measure surface roughness using white light interferometry or other optical means.
- h. Measure the processed surfaces of components using appropriate equipment (e.g., profilometer, optical comparator, or coordinate measuring device).
- i. Determine and select using written instructions and specifications appropriate packaging for protecting, storing, and shipping optics.
- j. Document final inspection results according to instructions or specifications to close out job jacket or its equivalent.
- k. Determine the functions of a quality assurance department and its role in the manufacturing process.
- l. Use statistical process control guidelines for sampling finished components.

**6. Assemble optical components and systems.**

- a. Interpret assembly drawings.
- b. Apply proper cleanroom and air-flow workbench procedures.
- c. Use proper alignment techniques for assembly processes.
- d. Select and/or use appropriate optical adhesives or epoxies (UV, etc.).
- e. Mount optical components in mechanical assemblies.
- f. Align and pot elements in cells.
- g. Measure conformance and performance via mechanical and/or optical means.

**7. Apply coatings to optical components.**

- a. Interpret drawings for coating specifications.
- b. Clean and inspect optics for coating using accepted procedures.
- c. Load and operate coating equipment to apply thin film coatings.
- d. Operate spectrometer to test coating performance on witness samples and verify results with drawing specifications.

## TECHNICAL SKILLS

1. Determine optical, chemical, thermal, and mechanical properties of selected materials from handbooks, supplier specification sheets, and Internet sources and assess their relevance to specified manufacturing processes.
2. Apply chemical safety procedures.
3. Evaluate physical properties of materials for hardness, cleavage, fracturing, and chemical stability and assess their relevance to specified manufacturing processes.
4. Use a loupe to identify bulk material defects such as inclusions, bubbles, striae, scratches, and fractures.
5. Use polarization measurement techniques to identify internal stress.
6. Use hardness testing procedures and equipment such as Mohs scratch and Knoop hardness instrument.
7. Measure the refractive index of optical materials using procedures such as Abbe refractometer.
8. Follow accepted handling procedures to ensure personal safety, prevent material damage, avoid contamination, and maintain material identification.
9. Read and interpret technical drawings and specifications.
10. Operate common machine shop equipment for metals such as lathes, band saws, drill presses, and milling machines.
11. Select appropriate abrasives including grit size and composition to achieve design tolerances and specifications for specific materials.
12. Optimize fabrication tools and parameters to increase efficiency and quality.
13. Prepare fixtures for mounting starting material as part of the fabrication process.
14. Determine the interaction between various materials used in high-tolerance optics fabrication such as hot pitch and acetone.
15. Operate appropriate equipment (e.g., cutoff and wire saws, abrasive grinding machines, and coring machines) to shape optical materials to specifications.
16. Operate appropriate grinding and polishing machines to generate cylindrical and toric optics.
17. Inspect finished products following accepted procedures to ensure compliance with established specifications.
18. Maintain and prepare conduits and pumps for cooling and slurry delivery to work surfaces.
19. Align physical and optical centers per specifications.

20. Use appropriate hand tools (e.g., calipers, micrometers, depth gauges, and spherometers) during fabrication and inspection of optical components.
21. Clean optics using proper techniques to appropriate specification levels.
22. Store optics in appropriate containers with environmental controls.
23. Measure deviations from specifications in dimensionality and surface quality.
24. Program CNC controllers according to specifications.
25. Assess CNC performance against established specifications.
26. Apply appropriate maintenance instructions from manufacturers' equipment manuals.
27. Use established instructions for entering and operating in cleanrooms.
28. Measure and evaluate optical surfaces using an interferometer.
29. Measure optical properties using appropriate equipment (e.g., autocollimator).
30. Measure surface quality using appropriate equipment (e.g., scratch-and-dig inspection box, microscope, loupe, and magnifiers).
31. Measure surface roughness with appropriate equipment (e.g., white light interferometry or laser surface profiler).
32. Measure shapes using appropriate equipment (e.g., profilometer or coordinate measuring device).
33. Evaluate shipping conditions for finished optical components to determine appropriate packaging.
34. Use basic mathematics concepts to include fractions, decimals, ratio, proportion, powers, algebra, units and conversion, angle measurements, geometry, scientific notation, and trigonometry.
35. Use and convert metric and English units and optical units.
36. Identify the functions and shapes of various optics components.
37. Use quality assurance criteria to determine deficiencies in materials and optics using established design specifications.
38. Assess coatings using thin film principles.
39. Design new tooling and evaluate performance of existing tooling.
40. Prepare appropriate bevels.

## **EMPLOYABILITY SKILLS**

1. Read instructions (in English) and follow established procedures.
2. Present in English technical information clearly and concisely in written and oral form.
3. Manage and communicate time schedules and schedule changes.
4. Use materials and resources efficiently.
5. Use hand calculators and computers proficiently.
6. Maintain effective tracking data on parts and support materials distribution systems.
7. Establish and maintain effective working relationships with others involved in the processing and fabrication of materials and parts.
8. Identify and assimilate information from prior shifts to determine process status on parts.
9. Perform problem solving within established troubleshooting strategies.
10. Work responsibly with minimum supervision.
11. Work cooperatively with others.
12. Follow established safety rules and regulations.
13. Exercise good judgment in quickly and accurately reporting accidents and equipment malfunctions to supervisors.
14. Navigate the Internet to gather information.
15. Meet established schedules for work days, assignments, and tasks.
16. Evaluate graphical and tabular data.
17. Maintain daily laboratory notebooks.
18. Create and implement system-schedule maintenance plans.