Technical Tip

Laboratory Processing Guide for Polycarbonate Lenses

Introduction
Polycarbonate lenses, as other high index materials, CR-39, and glass have certain unique properties that influence the laboratory processing of each material.

The properties that make polycarbonate lenses the lightest and most impact resistant lenses also indicate certain procedural changes in the lab. Any problems associated with surfacing or finishing polycarbonate can be resolved when the differences between types of materials are realized and labs accommodate the differences.

The purpose of this technical manual is to describe successful laboratory techniques that are currently being utilized. It describes alternate methods for each phase of the fabrication process and, in cases where appropriate, indicates the preferred method for the highest degree of success.

It also suggests proven methods of backside coating.

NOTE: The information contained in this guide reflects current product and processing technology. The "State of the Art" in polycarbonate manufacturing and lens fabricating is constantly improving. Keep in touch with your Lens Manufacturer and Equipment suppliers for updated technical information.

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Polycarbonate Surfacing Procedure

Polycarbonate Material Definition
Polycarbonate is a lightweight, extremely impact resistant material with a high 1.586 refractive index with a specific gravity of 1.20 grams/cc.

Blank Selection
The higher index of refraction of polycarbonate requires modifications to the calculations. High refractive index materials will often mean a different front base curve. (Refer to Vision-Ease Lens base curve selection charts.)

Base Curve Selection
There are multiple base curve selection charts that vary due to different fitting distances. Typical base curve selection assumes a fitting distance of 13mm.

Layout/Marketing
Follow standard procedures of axis, prism, and centration. All lens marking inks should be water soluble to avoid permanent penetration into the lens. Maintain marking materials to avoid damaging the lens with dried-out tools. Layout areas may be used to proofread the printed computation ticket for correct data including prescription, lens material, lens data, and measurements.

Front Surface Protection
After layout ink has dried, apply a surface protection tape to the lens front surface. Be careful to ensure no bubbles or foreign matter are trapped between the tape and lens. There are many tapes available that are designed for polycarbonate and provide excellent results.

Blocking
Blocking systems designed for plastic lenses may be used with polycarbonate. Use a large diameter block of nearest curvature to the lens for best full support to avoid lens flexing during surfacing operations. Maintain blocking medium at a temperature less than 126° F and ensure the medium is free of contaminating matter. Allow blocked lenses to acclimate to room temperature for one half-hour prior to generating. These steps are particularly important when processing lenses to less than 1.5mm minimum thickness.

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Generating

There are currently two primary types of proven curve generation: traditional cutting wheel (two-axis) and multiple-axis "CNC" type equipment.

Traditional equipment provides acceptable results requiring some minimal skills. The use of coolant in traditional style generation will provide best heat and finish control. Due to inherent elliptical error, compensations must be made for high cylinders. Minimize unwanted de-blocking by avoiding excessive removal amounts and speeds.

A polycrystalline fly-cutter (recommended) will provide less heat, faster cutting, and a smoother finish than a diamond cup. The depth of cut is limited only to the size of cutting wheel-typically about 2.0mm. The final cut of 0.3mm should be on automatic sweep (if available) and slow (approximately 15 seconds).

Diamond cups should be at least 20/40 grits, a smaller grit size will create excessive heat. Two-step fining will be required when generating with diamond cup methods.

Multiple-axis equipment provide superior quality, increased accuracy, expanded range capacity, and elimination of elliptical error, dramatically increasing laboratories' yield.

In general, the following will optimize generating results:

- allow for 0.35 to 0.40mm stock removal during fining operations, 0.20 with one step fining
- frequently maintain removal of cutting swarf from cutting chamber
- cutting tools must be kept sharp and calibrated, minimizing heat damage to lens
- calibration of curves, thickness, prism, and axis should be checked daily
- chamfering/pin beveling the generated surface after generating will remove the rolled edge allowing better flow of fine and polish fluids, increasing fining quality

NOTE: To improve operator safety, a brake may be installed to stop rotation of the cutter when the cycle is completed Removal of polycarbonate swarf can be accomplished with a wet/dry vacuum system, or manually with a metal tong (avoiding contact with cutter).

Tooling

Laps/tools are an important aspect in quality surfacing. High index materials (polycarbonate) typically require more tooling increments than lower indexed materials on standard systems for the same level of power tolerance. A system of 0.10 Diopters will provide the required accuracy of accepted standards for all materials. Aluminum tool materials provide the best heat diffusion and stability, although some of the latest formulations of plastic tooling provide acceptable results. Most curves can be cut on a 3 1/2-inch tool that offers the most lens support and consistent surface.

Other important tooling aspects include:

- curve accuracy should be within 0.03D: both base and cross
- allow for correct pad compensation-duplicate data within computing system
- re-measure tool curves often-possibly after every five lenses surfaced
- tools should be cleaned after each use
- re-cut tools if they become damaged: dented, nicked, or gouged
- re-cut tools when curves measure more than 0.03D from labeled curve

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Fining

Basic fining requires enough stock removal to assure a consistent accurate surface that will easily polish to an acceptable finish. The usual procedure will incorporate a first fine pad of 280 grit abrasive then stacked with a second fine pad of 1000/1200 grit. Extreme removal rates such as correcting large amounts of elliptical error can be achieved by first roughing in with a 180-grit pad. One step fining requires accurate three-axis generation.

Other important polycarbonate fining aspects include:

- first fine pads should be mechanically pressed, assuring no wrinkles or folds
- padded tools should always be rinsed and pre-wet prior to fining operation
- lenses should be rinsed between each operation
- second fine pad is to be applied on top of the first fine pad after rinsing
- a two minute cycle time of each fining step produces best results
- fining at high speed yields best results
- pin pressure (measured at the pins-not airline gauge) is best between 12 and 16 PSI
- machines should be regularly calibrated for axis, orbit, stroke, and centering

Fining water can be re-circulated or supplied fresh. Re-circulated water should be filtered and cooled. Ideal water temperature is between 45°F and 65°F; temperatures outside this range will not provide desired accuracy. Heating of tools for faster removal of pads is NOT recommended due to heat transfer to polish.

POLISHING

Procedures of fining are similar to polishing operations. The polishing pad can be applied after fining pad removal, rinsing of tools and lenses, and drying of tool. High nap densely flocked pads offer the best finish. Application of the polishing pad should ensure no wrinkles or folds. Maintain polish at the manufacturer's recommended Baume' and pH, and continuously filtered and chilled to 45° to 65°F. Other criteria for ideal polishing include:

- padded tools should always be pre-wet with polish prior operation
- lenses should be rinsed before and after polishing
- a four minute minimum cycle time is best
- high speed yields best results
- pin pressure (measured at the pins-not airline gauge) is best between 14 and 18 PSI
- machines should be regularly calibrated for axis, orbit, stroke, and centering
- do not allow liquids to dry on a polished lens surface

NOTE: Express care after polishing due to the raw surface- uncoated polycarbonate scratches extremely easily. Hard coating must be applied to the lens back surface after surfacing. Polycarbonate front surfaces are already coated at the factory.

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De-Blocking and Cleaning

After polishing, de-blocking can easily be accomplished using the shock/tube method, be careful to avoid touching the backside. Clean the lens in warm soapy water with a warm clean water rinse. A mild non-detergent dish soap is excellent for cleaning lenses. Immediately dry lenses with clean compressed air or other air source. Isopropyl alcohol may be used, but avoid any contact with acetone, MEK, or other solvents.

Back-Side Coating

After surfacing, a hard coating must be applied to the lens back surface before further handling. Although coating will cover some minor surface defects, lens surfaces should be visually inspected for surfacing imperfections. Experience will help determine which defects will be covered with the backside coating acceptably. Practice caution as some swirls covered by coating may reappear after tinting. There are many acceptable coating types, but they must be evaluated for required characteristics such as tintability or hardness. Many are typically tintable, reasonably hard, and radiation (UV light) cured, but most are designed specifically for particular curing units with specific wavelength of cure lamp.

Surface Inspection

After hard coating, inspection should be provided to assure prescription requirements and cosmetic quality. Take care in excessive abrasion or wiping of the lens, as laboratory back- side coating usually requires additional time to fully harden. Lensometer and marking inks should be water based to avoid permanent penetration into the coatings.

Finish Blocking

After inspection, prepare lens for edging in the typical manner as other materials. Avoid allowing lenses to be blocked for over one hour as some blocking pad adhesives bond with coatings over extended lengths of time. Pads should be evaluated for adhesion, loss of adhesives upon lens, and ease of removal.

Edging

Most typical edging equipment will provide excellent results with polycarbonate if the cutter sharpness is maintained. Although actual cutting must be accomplished without liquid coolant, many edgers provide a wet final cycle that slightly polishes the final edge. Router style edging, creating the least amount of heat, is recommended for polycarbonate lenses. Wheel type edgers must be fit with an aggressive roughing wheel designed for polycarbonate, and differential to finishing diamond adjusted to about 0.75 millimeter. Wet cycles must not remove extra material. It is important to monitor sizing accurately. Keep cutting chambers clean at all times.

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Pin Beveling

Provide a light bevel on each side of the edged lens to approximately one half millimeter at a 45 degree angle. In addition to removing the edge sharpness, this procedure also relieves heat-induced stress from the edging process. Beveling waste can be easily removed if the lens is beveled dry. Use a light scraping movement with a plastic straight edge or light pressure on a buffing wheel.

Grooving

Standard equipment with a sharp aggressive cutter operated dry will provide optimum results. A second rotation will clean cutting material from the groove. It is recommended to polish edges before grooving.

Drilling

Use a sharp drill bit, preferably a carbide dental burr, with the speed reduced to approximately 160-180 RPM. Light pressure will create less heat and a cleaner cut.

Faceting/Special Beveling

Follow standard procedures, assuring a dry beveling surface. Reduce pressure to assure minimal induced heat, which may produce surface cracks.

Polishing Edges

Follow standard procedures. Dry polishes are recommended with premium rouge and minimal pressure lower speeds. Excessive heat build-up can reduce lens size and create edge cracks over time. Do not use chemical polishes on polycarbonate as they are typically solvent based and will eventually destroy lens integrity.

Engraving

Practice caution to minimize heat damage in cutting operation. Wax type color fillers are recommended since some paints or inks may be solvent based and will react with the polycarbonate material.

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Pre/Post Lens Treatments
It is best to utilize clean warm water with a few drops of mild dish soap to prepare the lens. Isopropyl alcohol, when needed, may also be used. Prior to tinting, assure all markings have been entirely removed.

Dye Quality
Most dyes marketed today provide an excellent end product. Manufactures of dye, lenses, and varieties of lens material and coatings all contribute to alteration of the final lens color and transmission, so some experimentation is recommended for best results. Pay attention to maintaining a fresh dye mixture, as extended use will deplete vital pigments for obtaining the desired hue balance.

Tinting Unit
Dye heating units directly affect tint quality. Ideal units will be able to closely control temperature within a few degrees. Circulating the dye mixture adds to ease of operation.

Water
Tap water is typically best for initial mixing; electrolytes in tap water actually enhance the tinting process. Non-coated monomers such as CR39 work well with DI, distilled, or reverse osmosis treated water, but scratch coatings introduce different requirements. Tap water yields the best results after allowing settling a few hours, which allows suspended sediments to settle. Beyond the needed electrolytes, most purified water will actually create an acidic solution. Slightly alkaline water produces faster and darker tints. Purified water is excellent for replenishing the evaporated water.

Mixing Procedures
When mixing fresh dyes, it is important to rinse the dye container completely and begin with a clean tank. Any settled dye will affect the final lens hue. Dyes should be mixed with warm water and possibly balanced to pH 8.1 to 8.9. Since most labs do not have pH testing equipment, one half teaspoon of baking soda per gallon of dye at the time of mixing will typically provide the recommended balance (DI water only). Dye mixtures should be brought up to working temperatures for one hour prior to actual use, thus assuring activation of all pigments.

Temperature
Required hue and transmission is directly dependent upon working temperatures. Typical black dyes will exhibit red hues at 201°F and blue hues at 208°F. Ideal temperatures for most dyes will be at 205°F. Primary colors such as blue, red, and yellow do not require temperatures quite as hot. Do not heat neutralizers beyond 195°F, as they can damage coatings. Rather than rely on unit settings, measure each container, as variances of up to 20° are observed.

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Tinting Length of Time

Some polycarbonate lenses can be dyed to a sunglass shade in about fifteen minutes and others will not absorb tint. Clear semi-finished product, dependent on lab backside coating, usually can reach a sunglass shade in about five minutes. Cosmetic tints can be reached within seconds to minutes. In any case, recommended maximum tinting times of 30 minutes should not be extended. Remember that gradient tints can also create possibly damaging heat and extreme humidity on the portion of lens above the dye, whether or not the lens is in the dye. Always note tinting capability recommendations of specific products and coatings.

Technique

Standard practice as with other products will produce excellent results. Due to the nature of polycarbonate, there are suspended gasses within the dye will adhere to the lens, creating "white spots". Agitation of the lenses every three to five minutes while in the dye will dislodge bubbles. If a clear spot does appear, re-dying the lens for five minutes will usually help.

Neutralizing

The most efficient bleaching agent we have tested is a 10% to 30% mild dish soap and water solution at a temperature of 190°F. Most commercial neutralizers have been found to attack the polycarbonate substrate, eventually damaging the coating. One can expect to remove as much as 70 to 90% of the unwanted dye. This method also works with other ophthalmic materials.

Tinting Prior to Anti-Reflective Coatings

The cleaning process in anti- reflective coatings often removes the outer most portion of dye causing a slight bleaching of tint and sometimes hue alteration. For example, in a pair of lenses dyed to a dark tint that required one lens to be hue modified (such as a little extra blue dye), it is common for those lenses to be returned unmatched. Tinting slightly darker than needed, and a final light dip of both lenses in the final desired color followed by a quick exposure to hot water or neutralizer will typically assure the desired final results.

Manufacturer/Material Varieties

Lens materials and various coatings provide different tinting results. It is best to allow different dye mixtures for the various materials to achieve the best color sample match. Due to variations in manufacturing, even the prescription power can cause differences in the final hues and intensities.

Coating Varieties

Not all coatings are tintable. Some coatings are specially formulated for increased scratch resistance, which will typically eliminate dye absorbency, although some dye may enter the coating. Do not attempt tinting lenses if suggested as non-tintable by the manufacturer.

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UV Treatments
The nature of polycarbonate requires no further ultraviolet filtering. Do not attempt to apply UV dyes as structural damage may occur to the lens.

Glazing
While glazing polycarbonate lenses, always minimize stress, which may lead to eventual cracking. Stress can appear from improper sizing, excessive mounting pressure, or excessive heat. Reduce lens size if too large. Do not immerse lenses in salt pans.

Impact Testing
Vision-Ease lenses can be processed to a 1.0mm minimum thickness providing correct processing technique is followed Polycarbonate lenses should easily pass all impact tests with as little as 1.0 lens thickness.

Vision-Ease Polycarbonate lenses are warranted to meet the drop-ball impact resistance requirements of ANSI Z80.1 and the FDA impact resistance regulations 21 CFR 801.410 when laboratory finished according to surfacing chart specifications and procedures. Note: " impact resistant lenses are neither shatterproof nor unbreakable."

For further assistance contact:

Technical Service
Phone: 1-800-367-2544 ext. 200
Fax: 1-320-203-7710
Email: techservices@vision-ease.com

Customer Service
Phone: 1-800-328-3449
Fax: 1-800-289-5456