QUANTUM

OPHTHALMIC COATING

GUIDEBOOK

QUANTUM
CREATING SOLUTIONS

Thank you for choosing Quantum's Ophthalmic Coating Guidebook. We believe our customers deserve the best, including quality products and materials as well as top-notch service and support. You can count on us to be a true partner in your success, and we believe the use of this manual will help you ensure your coatings meet the highest quality standards.

In writing and distributing this guidebook, we aim to ensure ophthalmic coating labs produce the highest quality coatings for their customers. While broad in scope, this goal is attainable with adoption and implementation of standard best practices, processes and procedures for lab personnel to follow. The guidebook is backed by three decades of scientific experimentation and testing, return analysis, and modifications to previous standards. Know that we continue to conduct empirical research, testing, and validation, and will provide you with updates as we improve these practices. Training, experience and adherence to proper procedures always make the difference between producing a top-quality coating and a mediocre one.

As the industry leader in process development and education for ophthalmic coatings, we hope this guidebook is a valuable resource that contributes to your bottom line. The next time you seek to solve a problem or improve efficiency, keep Quantum in mind. We are in the business of providing our partners with innovative and integrated solutions aimed at ensuring success.

Norm Kester
Founder

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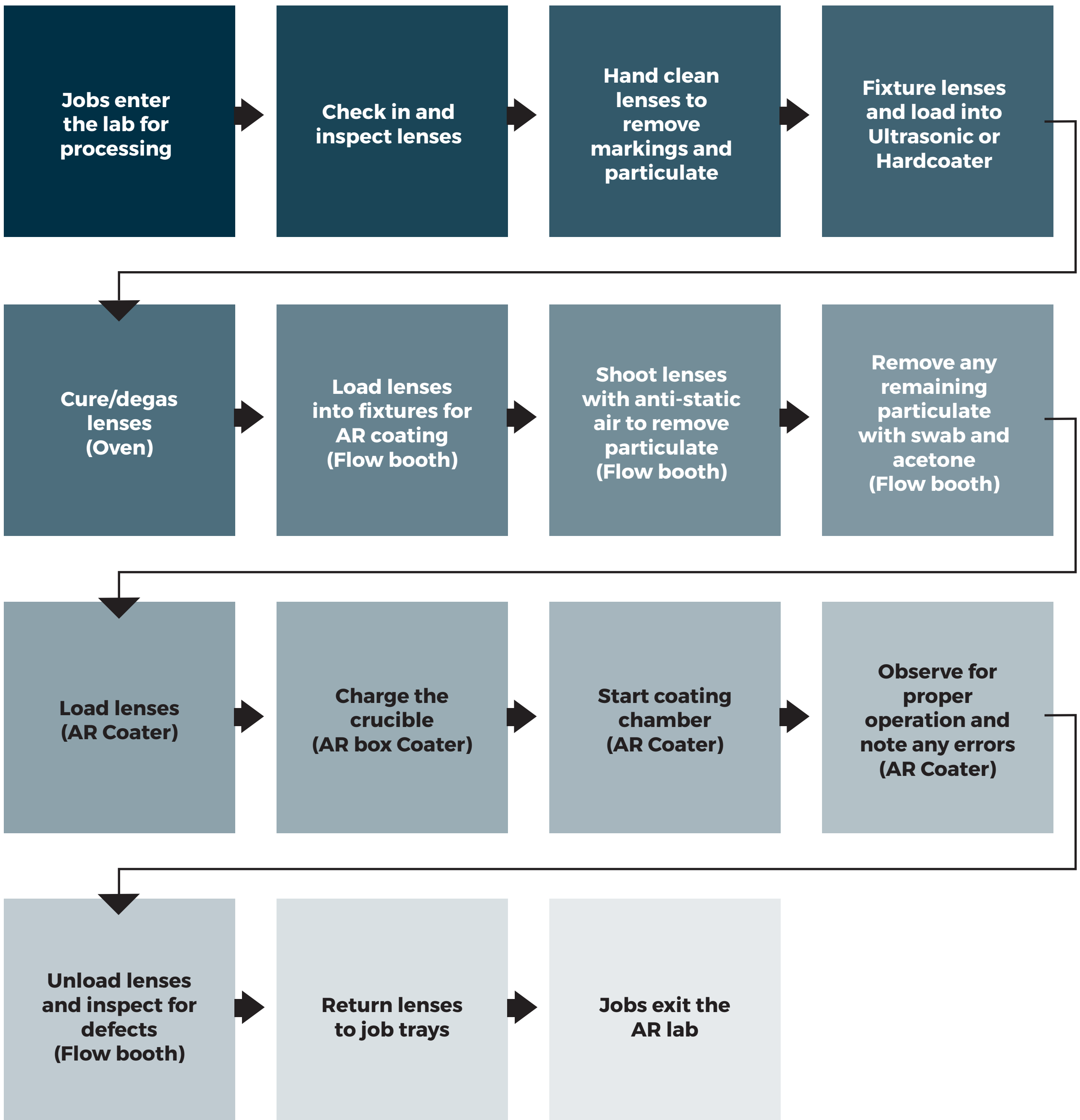
CHAPTER 1 // AR COATING PROCESS FLOW CHART

ILLUSTRATION OF THE PROCESS FLOW FOR AN AR LAB.

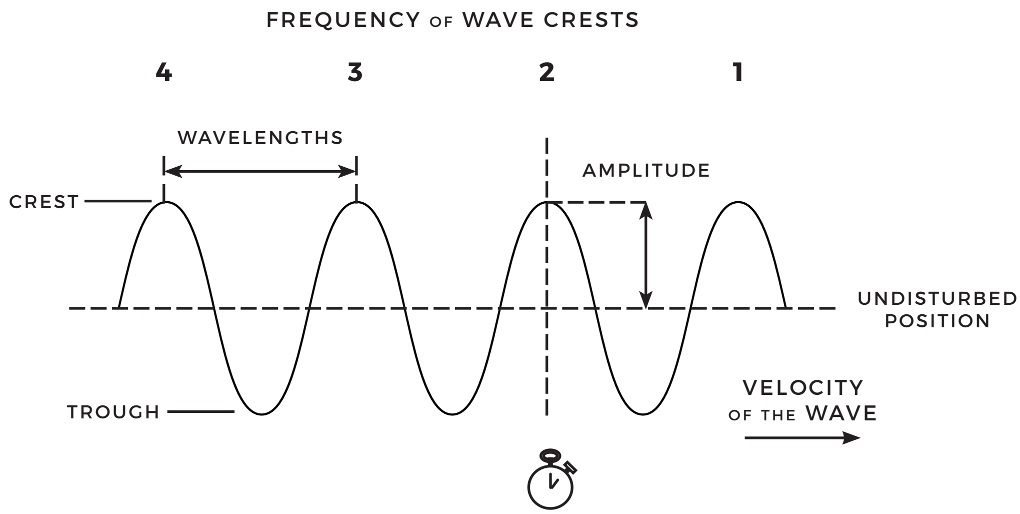


CHAPTER 2 // HOW AR WORKS

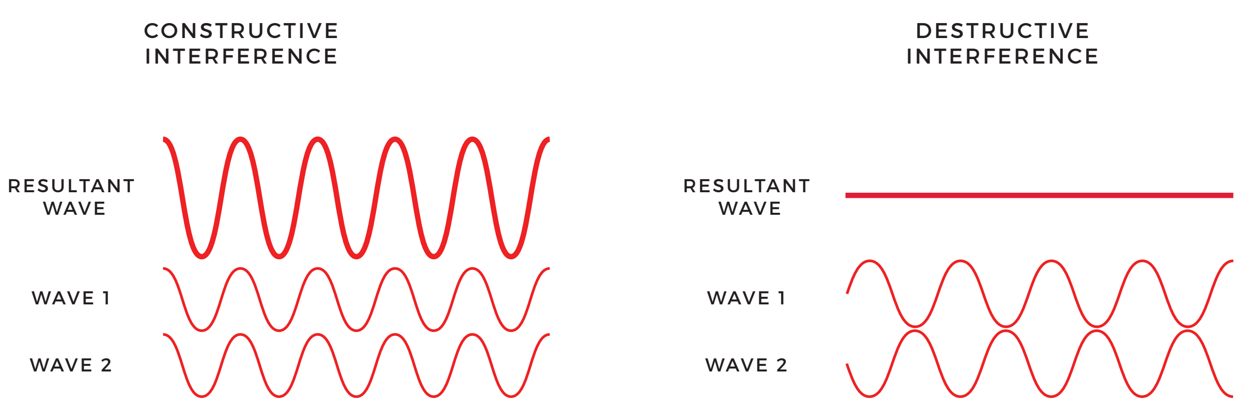
To effectively produce top quality coatings as well as understand the reasons for adherence to standard best practices, it is beneficial to recognize the complexities behind anti-reflective (AR) coatings and how they function. This is a brief summary of light and the basic principles by which thin film anti-reflective coatings work.

INTERFERENCE

Light moves in waves. The construction of the movement consists of crests and troughs. A wavelength is the distance from the top of one crest to the top of the next crest.



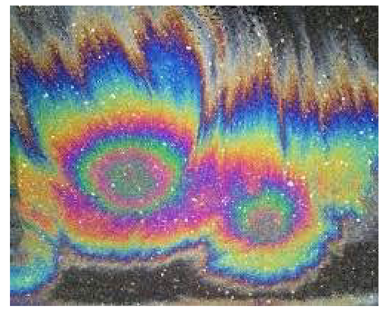
AR works on the principle of light wave interference. One type of wave interference is Constructive Interference, where the crests and troughs move together and enhance each other. Another type of interference is Destructive Interference, where the crests and troughs move opposite each other. When movement of light from the coating is ½ a wavelength out of sync with the movement of light from the lens, the crests of the coating move with the troughs of the lens. The two wavelengths cancel each other out and there is no reflection.

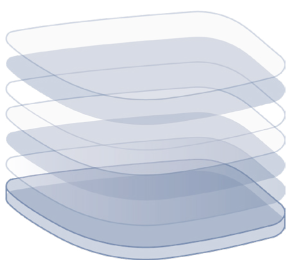


// ELEMENTS OF AN AR COATING //

HARDCOAT

A critical component of any anti-reflective treatment is the hardcoat. This is the first layer applied to a lens surface. The hard coat provides bonding of the AR layers to the lens surface. The overall quality of the AR treatment depends in large part on the quality of the hardcoat layer. Higher quality hardcoats are matched to specific lens materials for optimum adhesion, durability and stability. When the index of refraction of the hardcoat matches that of the lens material, reflections are minimized. If the index of refractions of the lens and the coating don't match, birefringence occurs. Birefringence is reflection off both the lens surface and the hardcoat, producing a rainbow effect on the front of the lens. If the coating and lens have the same index of refraction, light passes through as though the lens and the hardcoat were one material. This reduces reflections.





AR STACK

The AR coating is made up of a stack of alternating layers of high refractive index and low refractive index materials. The AR layers are responsible for creating the destructive interference patterns needed to knock out lens surface reflections.

OLEOPHOBIC

Premium ARs have an oleophobic treatment as the outside layer of their AR coating. The purpose of this layer is to repel grease and oil, making the lenses easier to clean. This topcoat is also very slick, allowing the cleaning cloth to slide over the lens with less chance of scratching. The oleophobic quality proves its worth with the touch of a finger. The higher the quality of this layer, the less oil is deposited on the lens when it is touched.

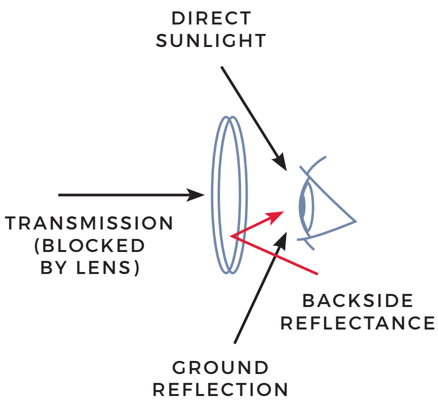
HYDROPHOBIC/OLEOPHOBIC

Premium Plus ARs have hydrophobic/oleophobic properties as their topcoat. This treatment causes water to bead up on the lenses so most of it can be shaken off and the lenses can be gently patted dry. The hydrophobic/oleophobic treatment seals and protects the AR layers. It also acts as an abrasion-resistant coating, protecting the lens from the assault of cleaning and constant use. This outer layer does not render the lenses scratch-proof, but it is very scratch-resistant.

ANTI-STATIC PROPERTIES

Anti-static properties allow the lenses to dissipate electric charges and prevent charge buildup. It helps keep dust and other airborne particles from clinging to the lenses. Without anti-static properties, static electricity builds up, causing the lenses to attract dust and particles. Wiping them becomes an exercise in futility - much like wiping a TV screen with a dry cloth. The cloth just chases the dust.

*** Without UVAR



UVAR

UV protection from the frontside of the lens can be provided by the lens itself, depending upon material chosen. Polycarbonate, High Index Plastics and Trivex lenses absorb the UV from the frontside. The backside of the lens is a different story, as there will be UV reflected from the backside of the lens into the wearer's eye. A UVAR coating added to the backside can transmit this UV light through the lens and away from the wearer's eye, increasing both safety and clarity of vision.

// BENEFITS OF ANTI-REFLECTIVE COATINGS //

INCREASED LIGHT TRANSMISSION

The light that is reflected off non-coated lenses is passed through AR coated lenses, making vision sharper and clearer.

REDUCED EYESTRAIN

AR reduces glare from computer screens and reflections from the sides and back of lenses, resulting in less competition with reflections and more comfortable viewing.

IMPROVED NIGHT VISION

Reflections and glare are reduced, making night vision sharper to improve night driving.

COSMETICS

AR allows the eyes to show bright and clear to others, without the distraction of room reflections.

LENSES THAT BENEFIT FROM AR

HI INDEX - Transmit less light than lenses of lower index because they are highly reflective. AR treatment can increase light transmission to 99%. AR should always be recommended with high index lenses.

ASPHERIC - Often made in high index materials and they have a flatter profile than nonaspheric lenses. Backside reflections are increased because of the flatter surface. This combination of features makes aspheric lenses excellent candidates for AR treatment.

DRESS EYEWEAR - Because anti-reflective coating increases light transmission, dress eyewear benefits from AR treatment. Vision in all light levels is enhanced, especially in low-level lighting, such as theaters, restaurants, churches.

SPECIALTY EYEWEAR - Such as for computer work, hobbies or sports, these benefit from AR treatment because of the sharp, clear vision it produces.

SUNWEAR - The tint on sunwear can make the lenses more reflective. A backside AR reduces reflections off the back of the lens while the front of the lenses maintains its ray-blocking properties.

CHAPTER 3 // AR LAB BEST PRACTICES

NOTE: This document is an overview. Detailed step-by-step best practices are equipment/process specific.

A successful AR coating lab needs to provide a high quality product to its customers. In order to do so, the lab must conform to well-established practices and procedures. It is the purpose of this document to provide an overview of the best practices for your lab.

TOPICS COVERED

- Personnel
- Lab Environment
- Job Preparation
- Initial Inspection & Hand Cleaning
- Ultrasonic Cleaning
- Backside Hardcoating
- Dip Hardcoating & Cure
- Degassing
- Fixturing
- AR Coating
- Flip/Final Inspection (Unloading)
- Bead Blasting
- Equipment Monitoring
- Quality Assurance
- Know Your Systems & Processes

PERSONNEL

Well-trained and well-instructed staff is essential. Each phase of lens handling and processing depends on personnel following best practices repeatably and consistently.

NOTE: Making these practices HABIT will help reduce chances of coating failure associated with lens handling and processing.

MATERIALS AND EQUIPMENT

The following items should always be worn in the AR lab, so should be available and readily accessible to the staff:

- Powder/lint free gloves
- Lab coats (laundered regularly)
- Disposable masks
- Eye protection
- Disposable shoe covers (or sticky mats at each entrance)

LAB ENVIRONMENT

Am I ready to receive work?

In order to help ensure repeatable, consistent results, the environment in the lab needs to be maintained and monitored.

ENVIRONMENTAL SPECIFICATIONS

- Relative Humidity = 45% ±5%,
- Temperature = 70˚ ±2˚F
- Air Quality = Class 100,000

PERIODIC MONITORING

Log the temperature and humidity periodically. Take action if environment is not to spec/function.

WEEKLY CLEANING

Every week, the entire room should be wiped down with damp lint-free wipes.

EVERY SHIFT

Every shift, the following housekeeping tasks should be done and documented:

- Wipe down inside of oven with clean/damp lint free wipes and 99% pure isopropyl alcohol (IPA)
- Wipe down horizontal surfaces with clean/damp lint free wipes and IPA (99%)
- Sweep and mop floor
- Log DI water quality

JOB PREPARATION

SEPARATE JOBS

Separate jobs into two groups and place in separate areas:

1. Sensitive lenses, including:
   - Hi index
   - Transitions
   - Glass
   - Thin center thickness
   - Knife-edge
   - Wafer
   - Polaroized
2. All other lenses

> NOTE: Generally, lenses over 1.60 index and/or with special properties will need to skip the first ultrasonic tank.

SPECIAL INSTRUCTIONS

1. Take note of any special instructions written on the job data sheet/envelopes and separate if necessary. Examples are:
   - Backside-only coating
   - Match coating
   - Strip
   - Recoat
2. Remove lenses from their tray/envelope and make a trace pattern on the sheet/envelope.
3. Place lenses on top of the sheet/envelope.

> NOTE: Glass lenses are processed differently than others; this topic is not covered in the scope of this guidebook. Please contact us directly for information regarding processing glass lenses.

INITIAL INSPECTION AND HAND CLEANING

Initial inspection is critical, as it is the only time defects can be identified as not originating in the AR lab.

MATERIALS AND EQUIPMENT

- Black background
- Inspection lamp
- Lint-free cloth
- IPA (99%)
- Progressive mark remover
- Lens cleaning solution (1gal DI water + ½ tsp Dawn dishwashing detergent)
- DI Water (1 gallon)
- Ultrasonic cleaning fixtures

HAND CLEANING

1. Hand clean each lens with good attention to detail. The ultrasonic cleaning system will not remove all defects, so all of the following must be removed by hand:
   - Smudges
   - Streaks
   - Dust
   - Specks
   - Coatings
   - Films

> REMEMBER: AR coatings highlight any and all defects on the lens prior to coating.

2. If there are ink marks or factory progressive marks on the lens, remove them with a non-acetone ink remover.
3. Use cleaning solution and a lint-free cloth to remove all contaminants from the lens.
4. Rinse the lens using DI water, then dry it. If contaminants remain, repeat steps 3 and 4 until clean.
5. After cleaning, inspect each lens for scratches and defects using the inspection lamp against the black background.
6. Mark any defects on the trace pattern on the sheet/envelope.
7. Once the lens is clean, place it in the ultrasonic lens fixture/basket.
   - On the envelope or job ticket, note which position and which basket the job is in.
   - Keep the two groups (Sensitive, Other) separate.
8. Run all Polycarbonate jobs on standard recipe; run CR-39 and Hi Index on material-specific recipes. Always run problematic lenses (Transitions, Trivex, some Hi Index) through material-specific recipes.
9. Once the ultrasonic basket is full, it is ready to be put in the ultrasonic cleaning unit.

> NOTE: In some cases, it will be required to completely strip sensitive jobs prior to dip coating.

ULTRASONIC CLEANING

MATERIALS AND EQUIPMENT

- Ultrasonic cleaning system
- Ultrasonic cleaning fixtures
- Ultrasonic cleaning detergents
- DI water (18-12 mega ohm)
- pH test strips

> NOTE: Generally, time in each tank is 4 minutes.

ULTRASONIC CONSIDERATIONS

1. Ultrasonic cleaning systems require systematic scheduled cleaning and maintenance in order to produce repeatable results.
2. Prepare your ultrasonic cleaning system per the manual.
3. The amount of detergent used in soap tanks is determined by tank size and detergent used.
4. Detergents have a shelf life. Do not use old detergents.
5. Be sure to pour the correct amount of detergent into each tank using a clean container.
6. After each 8 hour shift, drain soap tanks, then refill with fresh detergents.
7. When placing the basket in the ultrasonic unit, make sure to skip the first bath as required for the sensitive and special instruction lenses (strip and recoats).
8. Be certain that all the lenses remain securely in their fixtures as the lenses move through the cleaning system.
9. When the lenses complete the ultrasonic cycle, immediately transfer them to the degas oven.
10. Test pH of soap tanks weekly. Do not allow DI water quality to drop below 12 mega ohms.

BACKSIDE HARDCOATING

Hardcoating is the foundation on which the rest of the AR coating is built. Bad hardcoating equals bad AR coating, so adhering to good hardcoating practices and procedures is essential for high quality AR coatings.

MATERIALS AND EQUIPMENT

- Black background
- Inspection lamp
- Backside hardcoating system
- Backside hardcoat solutions (use Quantum-tested materials)
- Spectrophotometer
- UV dosimeter
- Tachometer

BACKSIDE HARDCOATING CONSIDERATIONS

1. Lenses must be clean before applying hardcoating, inspect carefully.
2. Hardcoating systems require systematic scheduled cleaning and maintenance in order to produce repeatable results.
3. Hardcoat solution has a pot/shelf life. Change it out per provided specifications.
4. Backside hardcoating systems have two variables which can affect the performance of the hardcoating:
   - Thickness
   - Curing
5. Hardcoating thickness needs to be between 3-5 microns (ref. manufacturer's spec).
   - Use a spectrophotometer to measure thickness.

6. Thickness is controlled by:
   - Hardcoating viscosity.
   - Spindle speed of the backside hardcoating system.
   - If the hardcoating is too thin, it will crack.
   - If the hardcoating is too thick, it will not cure properly.
7. Curing is controlled by the UV lamp and cure time in the backside hardcoater.
   - Over-cured hardcoating looks yellow.
   - Under-cured hardcoating looks clear and feels dry.
   - Under-cured hardcoating will have less scratch resistance and poor adhesion.
   - Use a UV dosimeter to check the UV lamp.
   - Use a tachometer to check spindle speed.

DIP HARDCOATING AND CURE

As stated earlier, hardcoating is the foundation on which the rest of the AR coating is laid. A high quality thermally-cured dip hardcoat provides the best scratch resistance and most durable foundation for AR coatings.

MATERIALS AND EQUIPMENT

- Black background
- Inspection lamp
- Dip hardcoating system
- Dip hardcoating fixtures
- Dip primer (use Quantum-tested material)
- Dip hardcoat (use Quantum-tested material)
- Solvents
- Percentage of solids management kit
- DI water (18-12 mega ohm)
- pH strips
- Spectrophotometer
- Cure oven

DIP HARDCOATING CONSIDERATIONS

1. Inspect carefully; lenses must be clean before applying hardcoating.
2. Hardcoating systems require systematic scheduled cleaning and maintenance in order to produce repeatable results.
3. Primer and hardcoat solutions have a pot/shelf life.
    - Change filters, primer and hardcoating out according to provided specifications
4. Dip hardcoating systems have two variables which affect the performance of hardcoating:
    - Thickness
    - Curing
5. Hardcoating thickness needs to be between 3-5 microns (ref. manufacturer's spec).
6. Thickness is controlled by:
    - Solutions percent of solids (viscosity) – primer, hardcoat
    - Extraction or drain speed of the dip hardcoating system

NOTE: If the hardcoating is too thin, it will crack. If the hardcoating is too thick, it will not cure properly.

7. Check and control percent of solids of primer and hardcoating daily. For Quantum products, these should be:
    - Primer: 4-5%
    - Hardcoat: 21-24%
8. Use a spectrophotometer to measure thickness.
9. Dip hardcoat systems partially cure hardcoating thermally using temperature and time.
10. Final cure of dip hardcoatings is done in an oven (ref. manufacturer's spec).
    - Cure temperature is 110˚C.
    - Cure time is 3 hours.
    - Over-cured hardcoating looks yellow.
    - Under-cured hardcoating looks clear and feels dry.
    - Under-cured hardcoating will have less scratch resistance and poor adhesion.
11. Test pH of soap tank weekly.
12. Do not allow DI water quality to drop below 12 mega ohms.

DEGASSING

Degassing is done after the lenses have been through an ultrasonic cleaning system or dip hard coater in order to remove all traces of water, as any water in/on the lenses will cause adhesion failure of the AR coating.

MATERIALS AND EQUIPMENT

- Oven
- Oven trays/racks

DEGASSING CONSIDERATIONS

1. Degas temperature is 55˚C.
2. Degas time:
    - Optimal degas time is 2 hours.
    - Minimum degas time is 1 hour.
    - If batching, cure times may vary.
3. Holding (overnight) temperature is 40˚C.
4. If lenses have been in the degas/holding oven for more than 24 hours, run them through the ultrasonic wash/degas cycle again.

FIXTURING

MATERIALS AND EQUIPMENT

- Flow booth
- Black background
- Inspection lamp
- Lint-free swabs
- Anti-static gun
- AR lens rings
- Ring spreader

Box Coaters only

- Sectors
- Sector stand

FIXTURING CONSIDERATIONS

1. When fixturing lenses, always work in the flow booth to lessen the possibility of airborne contaminants getting on lenses.
2. Before fixturing each lens, use the anti-static gun to remove any statically charged particles from both sides of the lens.
3. Inspect the lens for contamination and defects using the inspection lamp and black background.
4. Carefully remove any particles or defects which would cause the lens to be rejected, using lint free swabs.
5. Use a sector stand to support a sector.
6. Note the sector hole on the job tray/envelope.
7. Use a ring spreader to load each lens carefully into the AR lens ring, checking to ensure it is held firmly/evenly.
8. When the lens is firmly/evenly fixtured, place the ring into the previously noted hole in the sector, concave side down, to coat the backside first.
9. Do not leave any sector holes empty. Use a scrap lens or a lens ring covered with aluminum foil to fill the hole.
10. When a sector is full, load it into the dome, making sure to note which position the sector is in.
11. Continue loading additional sectors full of lenses or use blank sectors in the dome until it is full.
12. Store full sectors under flow hood or in degas oven.
13. If full sectors will not be processed for more than 1 hour, store in degas oven.

AR COATING

MATERIALS AND EQUIPMENT

- AR coating system (box coater)
- Evaporation materials
- Quartz crystals

Note: A run = door close to door open.

- Crucible liners
- Sample lenses

AR COATING CONSIDERATIONS

1. NEVER apply AR coating to lenses that have not been hardcoated.
2. AR coating systems require systematic scheduled cleaning and maintenance in order to produce repeatable results.
3. Run leak rate and pumping speed tests monthly.
4. Remove shields, clean chamber and bake out weekly.
5. Clean/rebuild e-gun emitter and i-gun according to hours used.
6. Clean 1/3 of the shields and crucible liners every 4 runs.
7. Include a witness sample lens in each run to test/ensure system performance. This will be used for Quality Assurance (Section 5).
8. Load recipe.
9. Charge crucible.
    - Adhesion material: Stir in pocket every run; replace every 8 runs
    - Low index material: Remove top crust, then "top off" every run
    - Hi index pill: Replace pill every run
    - Hydrophobic cup: Replace every run
10. Quartz crystal: Replace and verify frequency every run.
11. Shutter: Replace with clean every run.
12. E-gun: Clean with Scotch Brite and vacuum cleaner between each run.

FLIP/FINAL INSPECTION (UNLOADING)

MATERIALS AND EQUIPMENT

- Flow booth
- Black background
- Inspection lamp
- Lint-free cloth/swabs
- Anti-static gun
- Sector stand
- Sample lenses

FLIP/FINAL INSPECTION (UNLOADING) CONSIDERATIONS

1. When the AR coating system is finished coating and the door opens, carefully unload each sector from the dome.

2. Place sectors into the sector stand in the flow booth, being sure to note sector position in dome as it relates to position in stand.
3. When flipping the lenses in the sector, remove each AR ring from sector hole and blow off the lens.
4. Using the inspection lamp and black background, inspect each lens for debris and defects.
5. Carefully remove any particles that would cause a problem with the AR coating.
6. Place lens back into sector hole with the side needing to be coated (convex) facing down. Repeat steps in AR Coating Considerations section.
7. To unload fully coated lenses, remove each AR ring from sector hole and remove the lens from the AR ring.
8. Perform final inspection on each lens using an inspection lamp and black background.
9. Inspection consists of holding the lens up to the lamp in two positions:
   - Looking through the lens into the light to reveal any particles, scratches and defects
   - Looking at the reflection of the light bouncing off of the surface of the lens (flaring) to reveal coating voids and crazing
10. Compare AR color to sample lenses.
11. If lens passes final inspection, place it into the proper job tray or envelope and forward to finishing department.
12. If lens does not pass final inspection, forward to supervisor for review.

BEAD BLASTING

MATERIALS AND EQUIPMENT

- Bead blaster
- Disposable mask
- Blast media
- Blow-off nozzle
- Acetone
- Lint-free wipes

BEAD BLASTING CONSIDERATIONS

1. Maximum compressed air pressure = 60 psi.
2. Blast both sides of shields to prevent warping.
3. Always blow off and then wipe down with acetone all parts that have been blasted before putting them in the chamber.
4. In order to perform as designed, blasters require regular cleaning and maintenance.
5. Repair leaks, clean filters and replace media regularly.

6. Only AR chamber parts should go into the bead blaster. Never blast oily or greasy parts in the bead blaster. The media will become contaminated, which will later contaminate your chamber parts, possibly causing failure in your AR coatings

EQUIPMENT MONITORING

1. Create/use logs/charts to clearly and accurately record:
    - Maintenance tasks: daily, weekly and monthly.
    - System alarms as they occur. Include alarm number/description, date and time.
2. Use charts and alarm log to generate a daily report.
3. Review logs/charts and reports in order to identify problems before they can adversely affect production.

QUALITY ASSURANCE

MATERIALS AND EQUIPMENT

- Thermal shock (salt water boil) test kit
- Test chemicals
- DI water (18-12 mega ohm)
- Spectrophotometer

QUALITY ASSURANCE CONSIDERATIONS

1. Perform QA daily.
2. When performing QA tests, use -2.00 CR-39 hardcoated lenses for baseline.
3. Label test lenses clearly.
4. Do not perform thermal shock tests on lenses that do not have a hydrophobic coating.
5. Use a Sharpie marker as a quick check of hydrophobic performance.
    - If a lens has good hydrophobic on it, the ink will bead up
6. When inspecting lenses for color:
    - Be aware that several parameters have an effect on color, such as:
        - Light source
        - Angle between lens and eye
        - Lens geometry
        - Index of primer/hardcoating/lens material

- AR/mirror coating

7. Quantum provides QA support for customers.
   - Call to sign up for Quantum's QA program (888.214.7932).
   - Go to Qtmi.net for more information.

KNOW YOUR SYSTEMS AND PROCESSES

1. Read your user manuals and data sheets carefully. Make use of the instructions and explanations in them.
2. The knowledge of safe, continuous, high quality, trouble-free production depends primarily on the degree of your understanding of and the willingness of you and your staff to comply with best practices.
3. Please do not hesitate to contact Quantum with **any** questions.

CHAPTER 4 // WORK INSTRUCTIONS

This chapter contains the following modules:

MODULES

MODULE 1 // ULTRASONIC LENS CLEANING AND HARDCOAT

Proper preparation, cleaning and hardcoat are essential to successful AR coating.

EQUIPMENT AND MATERIALS

- Latex disposable gloves (powder/lint-free)
- Lens rings
- Ring spreader

INSTRUCTIONS

NOTE: Always wear latex gloves when handling lenses.

RACKING

1. Using the lens spreader, place lenses in the spring rings.
   - Rings should be inspected for fitness prior to using
   - Uncut lenses 71mm or smaller - use 81mm ring, 3-prong
   - Uncut lenses larger than 71mm - use 90mm ring
2. Place racked lenses into the baskets.
   - Work from back to front
   - Pair: place side to side
   - Half pair: locate in front of basket
3. Forward loaded basket to ultrasonic washer or dip hard coater.

CAUTION:
- Be careful when placing the lens in the rings. Racking requires practice and patience.
- Be sure lenses are well centered to avoid holder scratches which could result in breakage.

PROCESSING WORKLOADS

1. Place basket with lenses in front of START SENSOR.
2. Select appropriate process. Start.
3. Once basket is placed into vessel 1, visually check to make sure no lenses have fallen.
4. Remove workloads that are placed on the unload position by the robot. An alarm will sound if work has not been removed from unload position before the robot is ready to place the new workload there.
5. Visually check to make sure all lenses are still in the basket prior to removing from the washer.
6. Verify that lenses have been cleaned/coated thoroughly.
7. Visually inspect lenses per acceptance standards as required.

UPON COMPLETION OF THE WASH/COAT PROCESS

1. Inspect lenses for cleanliness.
2. Forward baskets to degas or cure oven.
    - Degas ultrasonic-cleaned lenses for 1 hour at 55˚C.
    - Cure dip hardcoated lenses for 3 hours at 110˚C.
3. Forward to flow booth for pre-AR inspection.

TROUBLESHOOTING

When process is not performed properly:

1. Lenses may show pits upon final inspection. Verify:
    - Cleanliness of surfaces
    - Proper inspection and cleaning
    - Age of ultrasonic chemicals (change if needed)
    - Age of hardcoat (change if needed)
2. Lenses may have smudges or fingerprints. Verify:
    - Fresh latex gloves are being used
    - Adequate inspection lighting
    - Proper pre-inspection (retraining required)
3. Lenses may have ring scratches. Verify:
    - Proper ring load and loading
4. Coating may exhibit signs of adhesion loss. Verify:
    - Proper soap concentrations (pH levels)
    - Lenses are spending full time curing/degassing
5. Coating may have voids (tiny spots of missing AR coating). Verify:
    - Proper inspection and cleaning/hardcoating
    - Chamber cleanliness (AR coater)
6. Jobs may be returned to incorrect tray. Verify:
    - Proper job tracking (retraining required)
    - Proper loading and unloading
    - Lenses not lost in ultrasonic/coating systems

MODULE 2 // CHARGING THE CRUCIBLE

Charging the crucible is an important step in the process of AR coating. This is where the consumable evaporant materials which comprise the coating are loaded into the AR system's crucible. It is important to use high quality materials supplied by your coating vendor so that material consistency can be counted on. This will lead to consistent machine deposition performance and high quality coatings.

EQUIPMENT AND MATERIALS

- Clean crucible
- Tweezers
- Vacuum cleaning system
- Evaporant materials (consumables)
- Clean, dry, lint-free cloth or swab
- Scotch-Brite™ pads

CHARGING INSTRUCTIONS

1. Under normal operation, the crucible will be loaded and unloaded from the charging screen.
2. Always use a freshly cleaned crucible for each run.
3. Clean crucibles ensure a minimum of contamination, better coating adhesion and lower pump times.

CLEANING THE CRUCIBLE

1. Unload used tablets contained in the crucible with tweezers.
2. Remove all oxidized (discolored) portions of the granulate compounds using tweezers.
3. Vacuum all loose dust and/or coating overspray from the crucible.
4. Clean liners using Scotch-Brite™ pads and acetone.

NOTE: In some systems, debris left on bottom of crucible causes insufficient contact with crucible carrier and can cause crucible overheating.

REFILL ALL CRUCIBLE HOLES

1. Fill appropriate pocket with new adhesion material (Quantum EV-00004 or EV-00012) granules until the granules are flush with the top of the crucible; do not mound the granules.
2. Fill appropriate pocket with new high index material (Quantum EV-00022, EV-00023 or EV-00026) tablet using tweezers; ensure tablet is centered and level.
3. Fill appropriate pockets with new low index material (Quantum EV-00003) granules until the granules are flush with the top of the crucible.
4. Fill appropriate pocket with new overcoat material (Quantum EV-00016) granules.
5. Fill appropriate pocket or boat with new copper super hydrophobic cup (Quantum EV-00038, EV-00042, or EV-00051) and lid (if needed).
    - Make sure lids, liners and pockets are clean and free of any carbon deposits or debris.
    - Use acetone and Scotch-Brite™ to clean when necessary.
6. Being careful to not tilt the crucible, wipe any debris from the bottom using a dry cloth or swab.
7. When loading into the chamber, align the crucible so that the steel pin on the front of the crucible carrier stand fits securely into the slot provided on the crucible.

WARM-UP CYCLE

1. Open chamber door and load a sample plano lens into clean sector/collet.
2. Check rotation of carousel for loose lens.
3. Load charged crucible and shutter.
4. Actuate shutter for proper travel and speed.
5. Change the crystal.
    - This is vital for EVERY run, as the crystal controls the deposition process.
6. Double check to ensure that all the above are correct, then push Start.
7. Observe all monitors during the run.
    - Note run-times, pressures and temperatures during warm-up.
8. Periodically observe electron beam aim.
    - Beam should be centered in substance.
    - **Caution: use the welder's glass for eye protection.**
9. After the cycle is complete, the machine will automatically vent and open the door.
10. After door is opened, remove the sector from the machine and place in the flow booth.
11. Clean electron beam gun with Scotch-Brite™.
12. Vacuum inside of chamber.

CAUTION: Wear proper eye protection when observing machine operation.

CHEMICALS USED TO MAKE THE AR

EV-00004 / EV-00012

Adhesion (granular) – the primary material between the hardcoat and the AR stack; it is the first line of defense in any good AR process. Proper adhesion of the AR to the lens increases AR quality, durability and the ability to warranty the job. Without this layer, the lab will see immediate returns and failures.

EV-00003

Low Index (granular) – the "quartz material" that interacts with light to create the anti-reflective properties. It also aids in the overall abraision resistence (hardness), which is increased by the aid of the ion source during deposition. Improper deposition of this material will result in inconsistent durability (too hard or too soft) in the coating.

EV-00022 / EV-00023 / EV-00026

High Index (pill) – the combination of this material with the low index is instrumental in creating the "green" color we are so used to seeing on the AR lens. Improper deposition of this material can create the wrong color, poor repeatability and overall quality issues for cleanability of the lens, poor protection from dust and oils, and patient dissatisfaction.

EV-00038 / EV-00042 / EV-00051

Super Hydrophobic (cup) – the layer responsible for overall cleanability of the lens. Improper deposition of this material will result in poor protection from dust and oils, and patient dissatisfaction.

EV-00016

Super Hydrophobic Overcoat (granular) – the final layer, which temporarily covers the super hydrophobic layer to allow edging without lens slippage. Improper deposition of this material may result in breakage due to slippage in the edging process.

MODULE 3 // MACHINE OPERATION

Maintaining a regular practice of following accepted procedures can greatly impact the success of your AR lab. This module discusses accepted practices for coating lenses using your AR coating system, starting at removal from the degas oven.

Equipment and Materials

- Clean air flow booth
- Anti-static gun
- Inspection lamp
- Powder-free latex disposable gloves
- Swabs
- Isopropyl alcohol (IPA)
- Clean cloth, lint-free
- Vacuum
- Tweezers
- Scotch-Brite™
- Small metal scoop for substances
- Ceramic substance containers / small bottles
- Crucibles
- Coating materials
- Sensor crystals
- Crystal snatcher
- Welder's glass
- Reducer ring - 90mm / 81mm
- Sectors
- Dome
- Pen/writing instrument
- Daily run sheet

INSTRUCTIONS

CAUTION: Watch for Backside Only (BSO) jobs!

These instructions are general in nature for dome configuration and may not provide all necessary steps for all types of AR coating equipment.

1. Always wear latex gloves when handling lenses.
2. Remove the baskets of lenses from the degas oven or holding oven.
3. Transport lenses to the air flow booth.
4. Unload baskets in sequence, beginning with top left corner of basket and finishing at bottom right corner.

5. Prioritize as required:
   - Mark hot jobs.
   - Mark and process by date entered the lab.
   - Note: Backside Only (BSO) jobs - leave in basket until coating second side.
6. Blow off each lens with anti-static gun.
7. Place each lens in front of inspection lamp and visually inspect both sides for dust, fingerprints, etc.
8. Remove all dust, fingerprints, etc. by swabbing each lens as necessary with IPA.
9. Load lenses on sector ensuring concave side (backside) is facing down to be coated first.
   - Start on the top tier at the start location, rotate around the sector in a counter-clockwise direction.
   - Work down through each tier, continuing in a counter-clockwise direction until complete.
10. Pairs of lenses must be together on same sector tier to achieve uniform color.
11. Make sure the ring fits the sector hole to avoid falling out.
12. Multifocal edged and uncut lenses must be aligned and uniform according to segment location. The segment is to be positioned at the bottom of the sector hole.
13. Edged single vision and progressive lenses must be positioned in the sector hole as they would be in the frame.
14. Keep loaded sectors on the top shelf inside the flow booth until the coating machine is ready.
15. Open the door on the AR machine.
16. Open the source shutter on the machine.
17. Remove the spent crucible. Caution: May be hot!
18. Swab the crucible chill plate and bottom of crucible with acetone while the crucible is out of the machine.
19. Insert alternate crucible pre-loaded with materials.
20. Change sensor crystal EACH run.
21. Close source shutter on machine.
22. Select correct process on machine.
23. Select concave program.
24. Place loaded sectors onto rotation cage without bumping or scratching the lenses.
25. If there are four (4) or more unused holes (no lenses) on the sector being loaded, place a blank-off in open holes.
26. Check rotation for loose lenses.
27. Close chamber door.
28. Push Start.
29. Forward route sheet and work tickets to hydro set-up table.
30. Observe all monitors during the run.
31. Using welder's glass for eye protection, periodically observe electron beam position; beam should be centered in pocket.
32. Refer to the work instruction for changing beam aim.

33. After the cycle is complete, the machine will automatically vent and open the door.
34. After the door opens, remove the sector from the machine and place in the flow booth.
35. Flip the lenses in the sector from concave side down to convex side down.
36. Add “BSO” lenses for backside coating.
37. Repeat the coating process, including cleaning and crucible charging, but selecting convex program.
38. Upon completion of the coating process, forward lenses in sector to flow booth for final inspection.
39. Place sector on correct route sheet.

QUALITY NOTES

Each employee is expected to:

- Be responsible for the quality of the work they perform.
- Know and understand the quality requirements of every operation they perform.
- Ensure that each step is performed correctly the first time, every time.

SAFETY NOTES

CAUTION: Make sure to use proper eye protection when observing machine operation.

Each employee is expected to

- Know and understand the safety requirements of every operation he/she performs.
- Be responsible for following safety requirements as defined in this manual, equipment manuals, and the lab’s safety manual.

HOUSEKEEPING

Employees are responsible for the housekeeping in their work area.

They are expected to:

- Keep their area clean, orderly and free of all unnecessary items.
- Assist in maintaining all common areas.

Recipe: The AR recipe is the formula that marries all of the preparation, careful adherence to best practices and quality assurance. Each recipe has a unique set of characteristics.

MODULE 4 // FINAL INSPECTION

Following accepted procedures for final inspection can greatly impact the success of your AR lab. This module discusses final inspection of AR coated lenses prior to release of the job to the finishing department.

EQUIPMENT AND MATERIALS

- Disposable latex gloves
- Inspection light box
- Lint-free tissues
- Lensometer
- Tissues or plastic baggie
- Pen/writing utensil
- Initial stamp
- Stamp: "Rejected, review required"
- AR lens replacement form
- Route inspection sheet book

INSTRUCTIONS

1. Always wear latex gloves when handling lenses.
2. Lenses are to be removed in correct sequence with envelope batch.
3. Carefully remove lenses from rings.
4. Verify:
    - Lens - match to tracing
    - Lens power - compare to Rx specifications
    - AR color
    - Lens surface - scratches, defects, etc.

ACCEPTABLE LENSES

1. On the convex (front) side of the right lens, place an identifier, per your lab's standard operating procedures:
    - On the upper right corner of edged lenses
    - On the outer edge of uncuts
2. Wrap lens in tissue or plastic baggie as required.
3. Place lens(es) in envelope.
    - Right lens - concave to front
    - Left lens - convex to front
4. If half pair - Note on work envelope.
5. Initial stamp the envelope and place in plastic bin.
6. Forward to AR (Data Entry) finishing station.

NON-ACCEPTABLE LENSES

1. Date and stamp “REJECT” on the routing sheet and add the reason for rejection.
   - The original routing sheet should remain with the batch.
2. Attach the stamped AR Lens Replacement Form -”Rejected”.
   - Staple both sheets TO ENVELOPE.
3. Place in Evaluation Bin Station for review by Supervisor.

QUALITY NOTES

Each employee is expected to:

- Be responsible for the quality of the work they perform.
- Know and understand the quality requirements of every operation they perform.
- Ensure that each step is performed correctly the first time, every time.

HOUSEKEEPING

Employees are responsible for the housekeeping in their work area. They are expected to:

- Keep their area clean, orderly and free of all unnecessary items.
- Assist in maintaining all common areas.

CHAPTER 5 // QUALITY ASSURANCE

This chapter contains the following modules:

MODULES

MODULE 1 // QUALITY ASSURANCE INTRODUCTION

Making sure that the coating produced meets intended specifications is very important to your lab's success. It is this evaluation process that will ensure your customers are receiving the high quality product they deserve, while both building and protecting your name in the marketplace as a maker of high quality products. This starts at the install phase and continues after our Process Engineers have departed your facility.

Following best practices and procedures is the surest way to a quality product, but it is equally important to perform daily testing to catch any issues that may occur with process quality.

Our objective is to get in front of any potential issues that could result in coating quality falling out of acceptable specifications. Your assistance with the program is extremely important. We ask that you complete the QA tests and report results to Quantum DAILY.

Daily monitoring of coating quality will lead to fewer returns and maintain the integrity of your lab and its brand in the market place.

STANDARD OPERATING PROCEDURES (SOPs)

Several standard operating procedures (SOPs) will be utilized to carry out the quality assurance program. These SOPs provide step-by-step procedures to follow for completing tests and recording results. In some instances, there is a video reference available. SOPs needed for daily testing include:

- Overcoat Removal
- Calibrating a Spectrophotometer
- Proper Use of a Spectrophotometer
- Measuring a Coating Using a Spectrophotometer
- Salt Water Boil Test (SWB)
- Tape Pull Test
- RHS-45 Solutions Management

Some vendor procedures may be needed, depending upon the equipment used in your lab.

PROCESS INSTALL EVALUATION

During the install process, Quantum's Process Engineer (PE) will conduct a series of coating evaluations for the installed coatings. These onsite test results will help determine if the coating meets the intended specifications.

Once the PE is satisfied the newly installed coating meets the intended specifications, he or she will run lenses to be sent to Quantum's Quality Assurance Lab to confirm that the coatings, in fact, meet specifications. Quantum will utilize a series of tests which may include: Bayer Abrasion, Water Contact Angle (WCA), Spectral Analysis (including hardcoat thickness, peak wave value, UV, % reflectance, % transmission, color), QUV, Real Life Simulation (RLS), Eraser Abrasion, Salt Water Boil (SWB), CHOCA, and Haze.

Based on the results of the tests run at the QA lab, the PE will determine the next steps, which may include:

- If there are failed tests, the PE will take the necessary steps to correct the process to yield passing results. This can include correcting the process, running lenses, testing lenses and sending lenses back to the QA lab.
- If all tests pass, the PE will complete training and an exit interview with the lab.
- In some cases, the engineer will run an additional set of lenses for third party evaluation and/or to keep a sample of the coating for baseline data. These lenses may also be needed to qualify the coating for specific Brand enablement if the coating is intended for that use. In an enablement situation, once Quantum validates the coating meets specifications, the Brand will test the lenses prior to certifying the lab for production of their brand.

DAILY TESTING

Each day, you will perform and record results for the below quality assurance tests. The objective is to get in front of any potential issues that could result in coating quality falling out of acceptable specifications. Your adherence with the program is extremely important.

The following tests will be performed on a daily basis by your lab, using CR-39 Plano or -2.00 lenses. Report results to Quantum. Coatings will be evaluated according to specifications provided to you by the PE during install. There may be different specifications for each
coating, meaning that a particular score may be rated as a pass for one coating and a fail for another.

PREPARATION

1. Run one (1) pair of UNC -2.00 lens through your dip hardcoating process and cure. Add these lenses to an AR run.
2. Remove the overcoat (grip) layer.
3. Measure the coating with the spectrophotometer and record results.
4. Test the hydrophobicity using the Tape Pull Test and record your results.
5. Finally, run the lenses through the Salt Water Boil Test (SWB) and record your results.
    - It is important to do the SWB after completing the other tests, as it is a destructive test and will damage the lens and/or coating.

GOODNESS OF FIT

The Goodness of Fit (GOF) evaluation will take place using a spectrophotometer (preferably Filmetrics) to determine if the coating meets both the spectral color and percentage reflectance standards for the designated coating.

The preprogrammed "curve" will be loaded and the system will evaluate the measured lens curve and give a pass or fail depending upon the amount of deviation of the measurement from the standard sample. In other words, how well does the produced coating fit the spectral curve of the defined standard coating?

PASSING STANDARD

A pass or fail will be determined by the coating specifications provided to you by the PE during install. As an example: Coating A specification = peak wavelength of 535nm with reflectance <1.5%. The spectrophotometer will give a pass if Coating A has a peak wavelength between 525nm and 545nm with reflectance 1.5% or less.

SOP REFERENCE

See Quantum's SOPs: *Proper Use of a Spectrophotometer, Calibrating a Spectrophotometer* and *Measuring a Coating Using a Spectrophotometer* for details about how to perform and record scores for this test.

TAPE PULL TEST

The "Tape Pull Test" is used to evaluate the hydrophobicity of the super hydrophobic layer. The accepted standard test for this characteristic is water contact angle (WCA), but there is a great amount of data to support a good correlation between the results of the tape pull test to a corresponding water contact angle score.

The purpose of this test is to provide an indication that the syper hydrophobic is acceptable, rather than a specific WCA score. The measurement will have you record the amount of force (f) in grams (g) it takes to peel tape off a lens.

PASSING STANDARD

A pass or fail will be determined by the coating specifications provided to you by the PE during install. We will normally look for a tape pull test result of 7 grams or less.

SOP REFERENCE

See Quantum's SOP: *Tape Pull Test* for details about how to perform and record scores for this test.

HARDCOAT THICKNESS

Measure two (2) times per day, following cure, using the spectrophotometer before AR coating. Record the results on your tracking sheet. This test will utilize the spectrophotometer to measure the thickness of hardcoat material applied to the lens. Thicknesses outside of specifications, high or low, can cause potential issues such as:

- Crazing
- Cracking
- Delamination
- Poor abrasion resistance

PASSING STANDARD

A pass or fail will be determined by measuring the thickness and comparing to vendor's coating specifications provided to you by the PE during install. Quantum's hardcoat material calls for a thickness between 3-5 microns.

SOP REFERENCE

See Quantum's SOP: *Measuring a Coating Using a Spectrophotometer* for details about how to perform and record scores for this test.

SALT WATER BOIL (SWB)

This is an environmental test to assess the robustness of an AR coating, its ability to adhere to a hardcoat, and the hardcoat's ability to adhere to a lens. A coated lens is inspected and then a crosshatch is cut into the lens. The lens is placed in boiling deionized salt water for two minutes, then placed into room temperature deionized water for one minute. The lens is then dried and evaluated for adhesion according to industry standards. Since this test is a destructive test, lenses identified specifically as test lenses must be added to a run in order to perform this test.

PASSING STANDARD

The test is considered a pass if the lens scores a minimum of 3 after 3 boils.

SOP REFERENCE

See Quantum's SOP: *Salt Water Boil with Crosshatch Adhesion* for details about how to perform and record scores for this test.

PERCENT OF SOLIDS

For dip hardcoat only, this test measures the density of the primer and hardcoat solutions, which have a direct effect on the material thickness that will be applied to the lens. As stated in previous sections, improper hardcoat density can adversely affect the performance of the hardcoat. Check your percent of solids two (2) times per day. Record the results on your tracking sheet.

PASSING STANDARD

A pass or fail will be determined by the vendor's coating specifications provided to you during install. Quantum's hardcoat material calls for density range of 21-24%; Quantum's primer calls for density range of 4-5%.

SOP REFERENCE

See Quantum's SOP: *RHS-45 (HC-00045-C/P) Solutions Management - Measuring Percent of Solids* for details about how to perform and record scores for this test.

REPORTING

It is important for that the product you are sending out performs well. Additionally, as your partner in success, we want to make sure that you are sending out a high quality product and that you do not have additional expenses associated with warranty returns. In order to have these assurances, Quantum has specific reporting requirements.

DAILY RESULT SUBMISSION

Record your daily test scores on the provided log(s), then submit your recorded scores to Quantum daily by email.

Our team will evaluate and track your daily performance characteristics. If issues arise, we can assist you with diagnosis and help bring your coating back into specification.

A single test fail may not be indicative of a problem, but a series of fails would signal that intervention is needed. This is why it is extremely important that we receive your results DAILY.

A PE will train you how to complete the tests and submit these scores daily.

QUANTUM QUALITY ASSURANCE

The Quantum Quality Assurance program will evaluate your coated lenses on a monthly basis. You will be asked to run lenses and return them to Quantum one time per month on a pre-set schedule so that we can continue to monitor your testing performance and ensure that your product is of the highest quality.

You will receive the results via email a short time after testing is completed. If issues are found, a PE will contact you to resolve.

Your testing schedule and procedures will be communicated to you after the process of installation. Contact Quantum if you need further assistance.

ENABLEMENT TESTING

In the event that the coatings installed are for a Brand enablement, the Brand will communicate with you regarding their testing requirements. In some cases, you will run and send lenses to their QA lab weekly.

MODULE 2 // OVERCOAT REMOVAL

STANDARD OPERATING PROCEDURE

AR Coated Lenses with Overcoat

REVISED 1-6-15

PREREQUISITES

The following items, and/or the following procedures need to be completed before executing this procedure.

- Set up overcoat cleaning station

REQUIRED TOOLS

- Gloves
- Clean microfiber cloth or cotton diaper
- Dishwashing detergent (Dawn)
- Container for cleaning solution
- Container for rinse water
- Warm water (Not hot)
- Cleaning solution (4 grams of detergent to 500 ml of warm water)

PRECAUTIONS

To prevent harm to AR coated lenses, special attention should be paid to the following.

- AR coating can be damaged by rough handling
- AR coatings can be damaged by high temperatures. Use warm water (70-90 F) not hot water.
- AR coatings can be damaged by aggressive cleaning solutions. Do not use high pH soaps or solvents such as acetone
- AR coatings can be damaged by dirty or abrasive cleaning cloths
- Do not use alcohol.

CLEANING PROCEDURE

1. Submerge overcoated lens and cleaning cloth into container with cleaning solution.
2. Rub wet cloth over wet overcoat to clean off and remove overcoat from lens.
3. Rinse lens in rinse container
4. Dry lens
5. Inspect lens. AR color should be evident edge to edge.
6. If overcoat not fully removed repeat.

MODULE 3 // CALIBRATING A SPECTROMETER | VERSION 7 FILMETRICS

F-10-AR, F-20-AR, F-10-ARc

REVISED 2-2-15

PREREQUISITES Spectrophotometer should be powered on and attached to a computer with the Version 7 Filmetrics software before executing this procedure.

REQUIRED TIME 5-10 Mins (Dependent on status of the Spectrophotometer)

REQUIRED TOOLS BK7 glass piece

SAFETY PRECAUTIONS Special attention should be paid to the following, to prevent harm to humans or the machine.

- Fiber optics cable can be broken
- Probe tip can be broken

PARTS INFORMATION

PART NAME	PART NUMBER	NOTE	QUANTITY

NOTE: Different versions will have different buttons/functionality

ADDITIONAL INFORMATION

PART NAME	PART NUMBER	NOTE	QUANTITY

REPAIR PROCEDURE

1. Connect power to the Filmetrics unit and connect the USB Connector to your computer
2. Connect the measurement head to the 2 fiber optic ports on the front of the Filmetrics unit
3. Turn on power to the Filmetrics unit. (Unit must be on for at least 5 minutes before a reading can be taken)
4. Open Filmetrics software on your computer
5. Select the AR Mode tab on the right-hand side of the screen
6. In the dropdown box, select the recipe for the coating that you are evaluating
7. Select Edit Recipe
8. Select Acquisition Settings
9. Verify that “Recommended Sampling Time” is selected
10. Click “OK” at the bottom of the dialogue box
11. Click the “Baseline” button
12. Follow the on screen prompts
13. Move the contact probe at an angle keeping one side of the contact probe in contact with the BK7
14. Press OK
15. Place contact probe on the BK7 and press measure on the main screen
16. You should have a reading of the BK7 approximately 4% flat line.
17. If you have a reading other than this, you should repeat the baseline process.

MODULE 4 // PROPER USE OF A SPECTROMETER

1 PURPOSE

1.1 Providing a method for properly:

1.1.1 Measuring an AR curve

1.1.2 Manipulating a measured Spectrum

1.1.3 Readjusting the depth of the Probe Shaft

2 SCOPE

2.1 Anybody using a Spectrophotometer

3 DEFINITIONS

3.1 SPECTROPHOTOMETER:

3.1.1 A tool used to measure the reflectance spectrum of an object

3.2 SPECTRUM

3.2.1 A broad range of varied but related objects, whose individual features tend to overlap to form a continuous series or sequence

3.3 PROBE

3.3.1 Device attached to a Spectrophotometer that makes contact with the object to be measured.

3.4 PROBE SHAFT

3.4.1 Part of the probe that transmits light, and receives the reflected light from the object's surface.

3.5 BK7

3.5.1 A specific, regulated type of glass used as standard for measuring curves

3.6 REFLECTANCE %

3.6.1 A percentage base measurement unit that shows what percent of light is being reflected

3.7 WAVELENGTH

3.7.1 A measurement, in nanometers, that relates to the visible light spectrum.

4 RESPONSIBILITY

4.1 Process will update this document if changes occur.

5 PROCEDURE

5.1 Measuring an AR

5.1.1 Turn on the Spectrophotometer

5.1.2 Allow the Spectrophotometer to warm up for five (5) minutes.

5.1.3 Baseline the Spectrophotometer

5.1.3.1 Click the "Baseline" button located underneath the "Start Measure" button.

5.1.3.2 Place the Probe the attached BK7

5.1.3.3 Ensure that the Probe is flush with the BK7

5.1.3.4 Click the "Acquire Reference" button

5.1.3.5 After it has acquired the reference, remove the Probe from the BK7

5.1.3.6 Point the Probe away from any light source

5.1.3.7 Click the "Acquire Background" button

5.1.4 Verify the baseline

5.1.4.1 Place the Probe on the BK7

5.1.4.2 Ensure that the Probe is flush with the BK7

5.1.4.3 Click the "Start Measure" button

5.1.4.4 The graph should be a relatively flat line around 4%

5.1.5 Adjust the Reflectance% scale to fit what you are going to measure

5.1.5.1 .R and Low Index Monolayers should be set to 0% Minimum and 5%Maximum

5.1.5.2 High Index Monolayers should be set to 20% Minimum and 30% Maximum

5.1.5.3 The Reflectance% scale for Mirrors varies by design.

5.1.6 Verify that you can view the Wavelength of the curve with your cursor

5.1.6.1 Right click on the graph

5.1.6.2 Mouse over “Marker Style”

5.1.6.3 Click “Show Wavelength” if it is not checked

5.1.7 Place Probe against the center of the face of the lens to be measured

5.1.7.1 The Probe should be flush with the surface of the lens

5.1.8 Click the “Start Measure” button

5.1.8.1 The button will the change to “Stop Measure”

5.1.9 After the curve has appeared on the graph click the “Stop Measure” button

5.1.9.1 The button will change back to “Start Measure”

5.1.9.2 A legend will appear in the upper left hand corner of the graph. This is used to navigate through the curves that have been measured.

5.2 Manipulating Spectrum Files

5.2.1 Deleting a Spectrum

5.2.1.1 In the legend in the upper left hand corner, click the Spectrum that you want to delete.

5.2.1.2 Right click on the Spectrum that you want to delete.

5.2.1.3 Click “Delete Spectrum”

5.2.2 Saving a Spectrum

5.2.2.1 In the legend in the upper left hand corner, click the Spectrum that you want to save.

5.2.2.2 Right click on the Spectrum that you want to save.

5.2.2.3 Click “Save Spectrum”

5.2.2.4 Give the Spectrum a relevant file name

5.2.2.5 If necessary, change the file type to the appropriate one for your needs

5.2.2.6 Click the “Save” button

5.3 Readjusting the Probe Shaft

5.3.1 Unscrew the three screws on the back side of the Probe

5.3.2 Remove the front half of the Probe

5.3.3 Loosen the screw on the placement ring on the Probe Shaft to allow the ring to move

5.3.4 Replace the front half of the Probe

5.3.5 Pull back on the cable attached to the Probe until the tip of the Probe Shaft slightly protrudes from the front of the Probe

5.3.6 Remove the front half of the Probe

5.3.7 Tighten the screw on the placement ring

5.3.8 Replace the front half of the Probe

5.3.9 Partially tighten the three screws on the back side of the Probe

5.3.10 Ensure that the Probe Shaft can move freely through the Probe

5.3.10.1 If it does not, wiggle the halves of the probe until it does move freely.

5.3.11 Finish tightening the screws.

MODULE 5 // MEASURING A COATING USING A SPECTROMETER

PURPOSE

This test ensures the coating displays the correct characteristics.

SCOPE

This document covers spectral testing done on a lens from any customer.

DEFINITIONS

- Spectral – Way to measure and analyze the optical characteristics of a coating

RESPONSIBILITIES

- Lens Tester – Person responsible for performing all aspects of lens testing after the lenses have been delivered by Receiving.

MATERIALS AND EQUIPMENT

- F10 AR Unit
- Probe
- BK7 Reflectance Standard

PROCEDURES

Calibration

1. Turn on power to the Filmetrics unit. (Unit must be on for at least 5 minutes before a reading can be taken) (Figure 1)
2. Open Filmetrics software and select AR mode (Figure 3)
3. Click the “Baseline” button (Figure 3.2)
4. Follow the on screen prompts
5. Move the contact probe at an angle keeping one side of the contact probe in contact with the BK7 (Figure 2.1)
6. Press OK in the Filmetrics program
7. Place contact probe on the BK7 and press measure on the main screen (Figure 7)
8. At 500 nm, the line should be between 4.1% and 4.3%
9. If you have a reading other than this, repeat the baseline process.

Measuring a Coating

1. On the right side of the screen, select the recipe dropdown button and then select the recipe that you will be measuring (Figure 5.1)
2. Adjust the reflectance maximum to accommodate what you are coating you are measuring (Figure 4)
    a. Double click on the graph field.
    b. Adjust the upper left field to the appropriate maximum
3. Ensure that both the “Measurement Status” and “Measurement Results” are expanded
4. Place the lens to be measured on the black felt cloth (Figure 2)
5. Press the probe down firmly in the center of the lens
6. Click the “Start Measure” button on the right hand side of the screen (Figure 2.1)
7. Verify that the “Measurement Status” box says “GOOD” and is Green (Figure 8)
8. If the “Measurement Status” box says “BAD”, the coating is out of spec. (Figure 6)

Measuring Hardcoat Thickness

1. Select, “Hardcoat Mode” (Figure 4.4)
2. Place probe on lens
3. Select, “Start Measure”
4. Hardcoat thickness measurement will appear in the, “Measurement Status” box (Figure 4.3)

Saving Spectral File

Figure 1 - Filmetrics Equipment

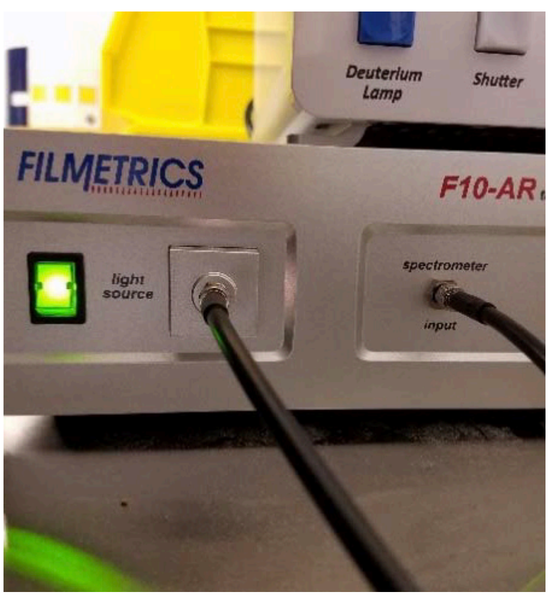
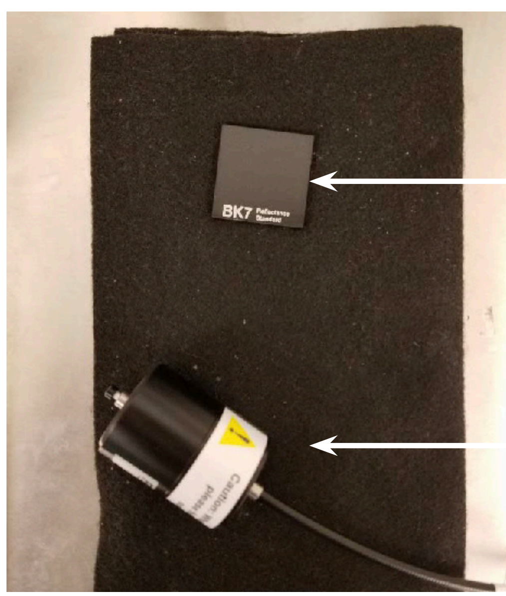


Figure 2 - Filmetrics Equipment



BK7 GLASS.
USED TO BASELINE THE SPECTRO UNIT

FILMETRICS PROBE.
USED TO MEASURE CURVE

Figure 3 – Filmetrics Program

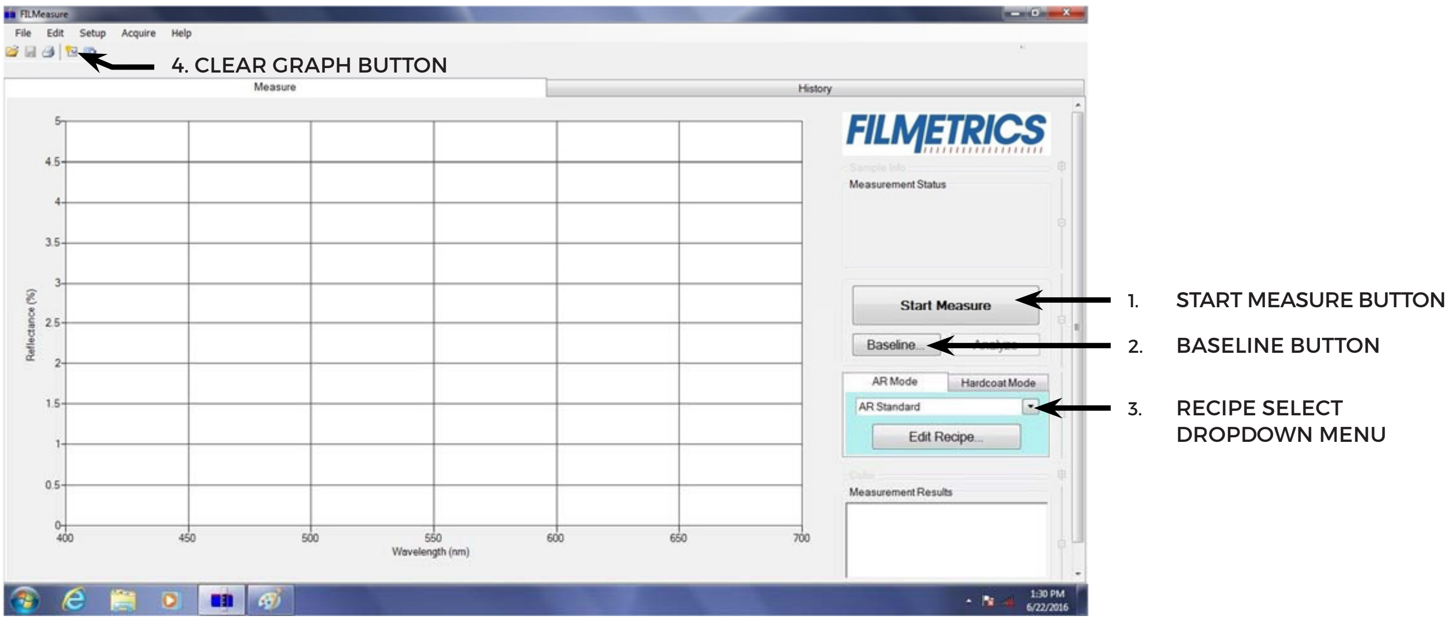


Figure 4 – Graph Limit Adjustment

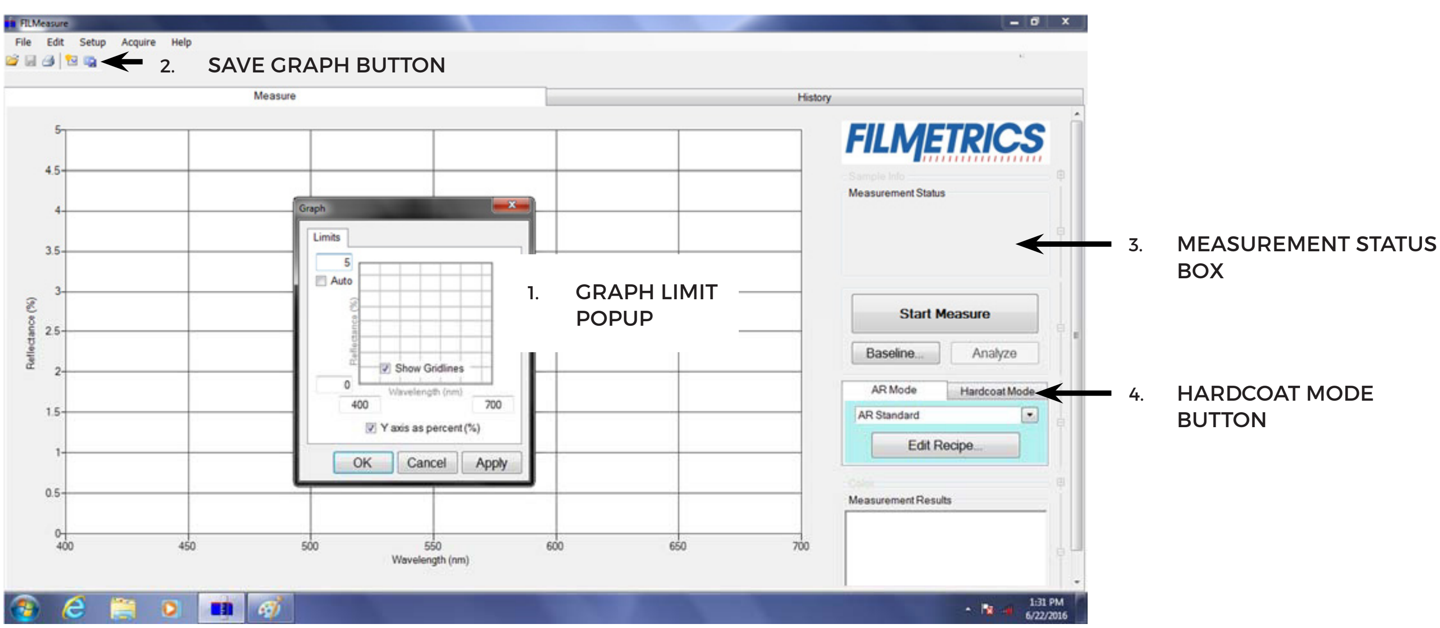
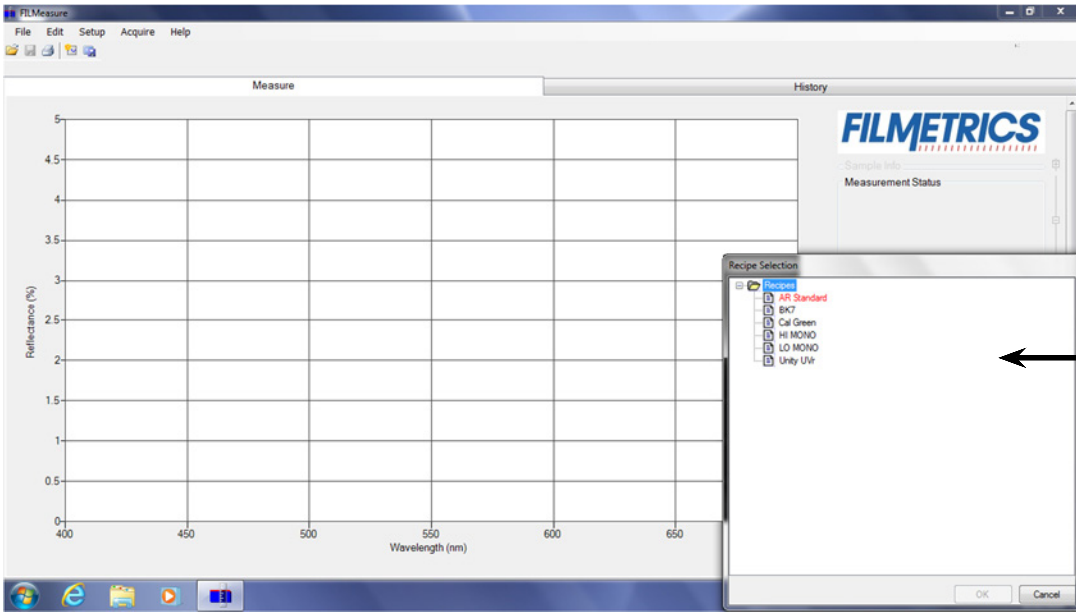
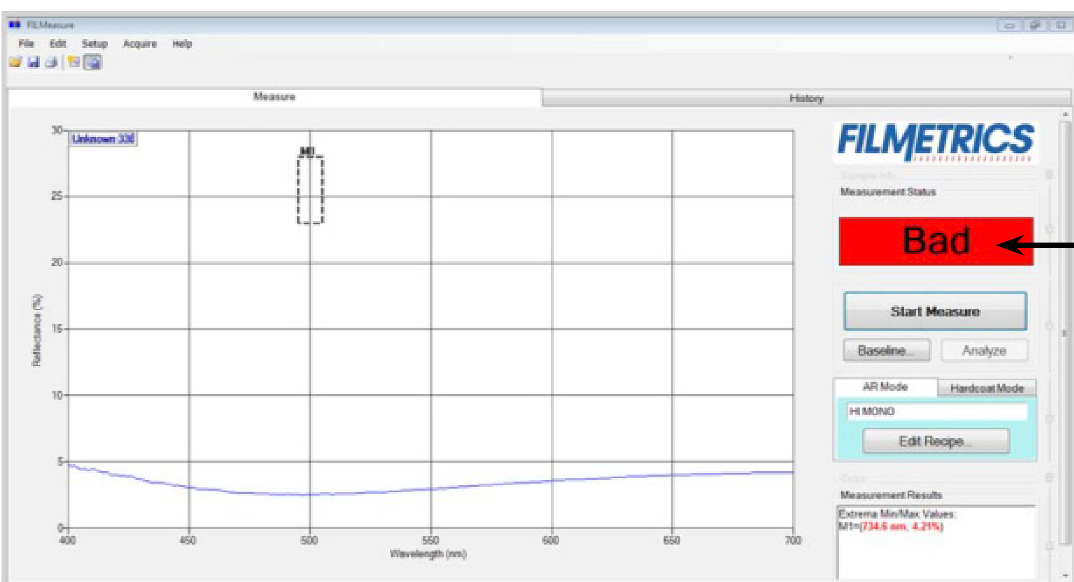


Figure 5 - Recipe Select



1. THIS POPUP ALLOWS YOU TO SELECT THE RECIPE YOU WISH TO MEASURE

Figure 6 – BAD Reading



1. IF A COATING IS OUT OF SPEC, IT WILL GIVE YOU THIS, "BAD" READOUT

Figure 7 – BK7 Line

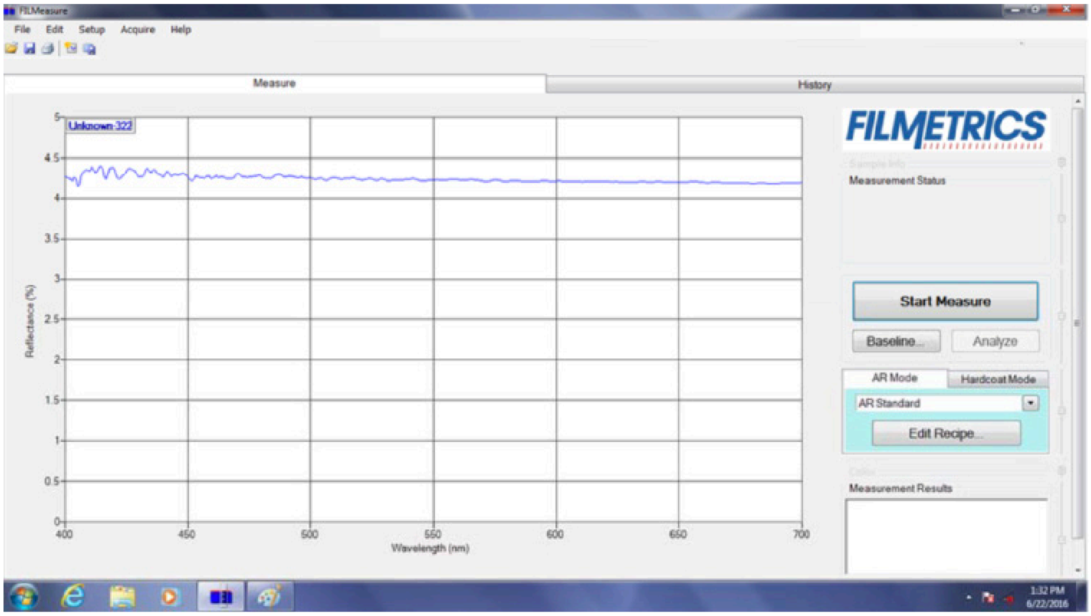
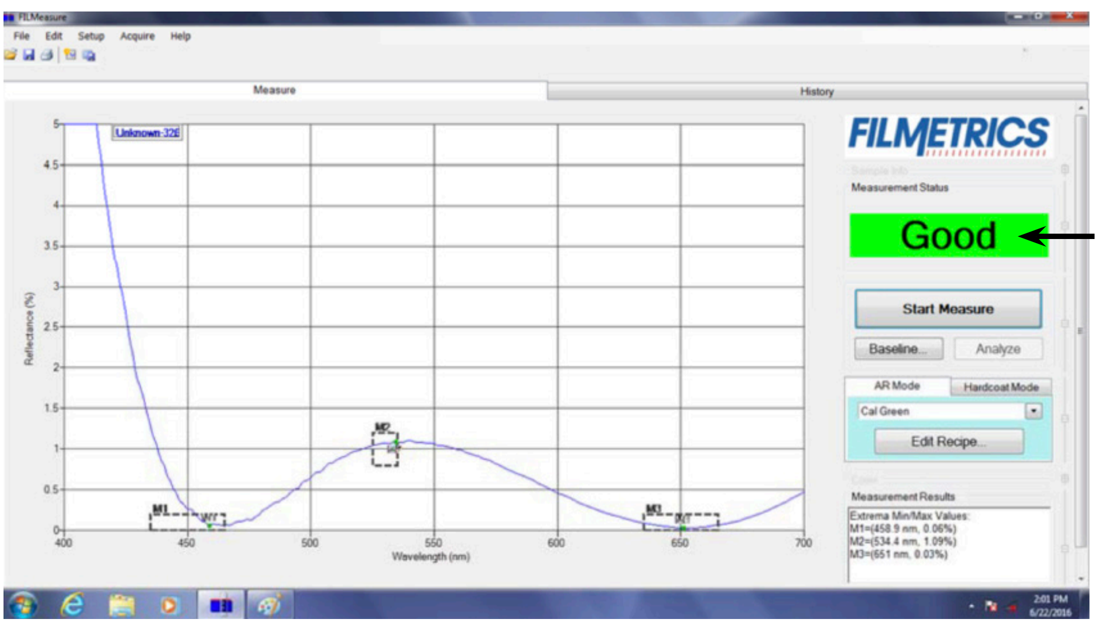


Figure 8 – GOOD Reading



1. IF A COATING IS IN SPEC, IT WILL GIVE YOU THIS, "GOOD" READOUT

MODULE 6 // SALT WATER BOIL TEST

PURPOSE

This is an environmental test to assess the robustness of an AR coating, its ability to adhere to a hardcoat, and the hardcoat's ability to adhere to a lens.

SCOPE

This document covers any testing done on a lens from any customer.

DEFINITIONS

- n/a

RESPONSIBILITIES

- Lens Tester – Person responsible for performing all aspects of lens testing after the lenses have been delivered by Receiving.

MATERIALS AND EQUIPMENT

- Burner*
- Burner plate*
- Lens holder*
- Gloves*
- Material #1*
- Material #2*
- Crosshatch tool*
- Scotch Brand Tape #600, 1" wide*
- Timer*
- Lint-free wipes*
- Deionized water
- 1 Glass beaker*, able to hold 2000 ml of D.I. Water
- 1 Plastic beaker*, able to hold 2000 ml of D.I. Water
- Inscribing Tool*
- USB microscope*
- Mild dish detergent*
- Soft synthetic sponge*
- Dry compressed air
- Data Sheet – FRM.0027

*Item included with Salt Water Boil Kit (SW.00001.4)

PROCEDURES

1. Receive lenses of each type and coating for Salt Water Boil with Crosshatch Adhesion testing. (A minimum of three lenses is recommended).
2. Clean the lenses
3. Fill the plastic shock beaker (Image 1), and glass boil beaker (Image 2) with deionized water (D.I. Water).
4. Bring D.I. water to test location.
   4.1. Keep containers filled:
      4.1.1. Fill glass beaker (used to boil lenses) to 1750 ml. The beaker must always be filled to this mark. Add D.I. Water as needed during testing process between boil cycles.
      4.1.2. Fill plastic beaker (used to shock lenses) to 2000 ml.
      4.1.3. Additional D.I. Water should be kept on hand to refill beakers as necessary.
         4.1.3.1. When additional water is added to glass beaker, the salt water solution must be allowed to return to a boil before continuing testing procedures.
5. Add salt water bag Material #1 (Image 3) to glass beaker that is filled with 1750 ml D.I. Water.
6. Add salt water bag Material #2 (Image 4) to glass beaker that is filled with 1750 ml D.I. Water.
7. Place burner plate (Image 5), on burner (Image 6). Place glass boil beaker with D.I. Water and salt solution on burner plate. Bring water to boil. Stir salt water solution occasionally to make sure water and salts are well mixed.
   7.1. Note: Covering glass beaker will help maintain consistent water temperature. D.I. Water must remain at a steady boil.
8. Begin new log sheet to track test results.
9. Put on gloves.
10. Mark identification numbers near the edge of the lens with engraving tool.
    10.1. Identification should include:
       10.1.1. Date of test
       10.1.2. Lens ID (A, B, C, etc.)
       10.1.3. Coating identifier, short abbreviation to allow for easy identification in log book
11. Enter info into the log book:
    11.1 Date
    11.2. Lens manufacturer
    11.3. Lens type
    11.4. Lens material

11.5. AR coatings

11.6. Hard coat

11.7. Tested by

12. Use your crosshatch tool (razor blade) to create crosshatching 5.10 mm from edge of lens.

    12.1. Crosshatching must be six equally spaced vertical lines and six equally spaced horizontal lines.

13. Clean off lenses with lint-free wipes.
14. Take off the exposed piece of tape (from the clear tape roll) and throw it away, so that you can start test with clean tape (dust can collect on tape in between test days).

    14.1. This step is only required at start of test.

15. Take a 3 inch piece of Scotch Brand #600 tape (Image 7), and smooth it across the crosshatching.

    15.1. Note: The tape should extend past the crosshatching by at least .".

16. Wait 30 seconds and rapidly rip off tape.
17. Make general visual inspection of entire lens surface. Look for defects such as stains, smears, streaks or cloudiness, etc. in the lens and coatings. Record findings prior to beginning salt water boil testing.

    17.1. Your labs high intensity lamp and a black background can help make the easier and produce more detailed results.

18. Make visual inspection of coating at the crosshatch intersections. Refer to the Crosshatch Chart in Appendix B and enter your findings on the log sheet.
19. Place lenses in the holders (Image 8), with the concave side facing the metal rods.
20. Repeat steps 9 – 17 for all lenses.
21. Set timer for 2.minutes (Image 9).
22. Place lenses in boiling salt water solution.
23. Start timer.
24. When timer goes off, quickly remove lens holder and place in plastic shock beaker.

    24.1. Tongs may be helpful to move from one container to the next to avoid burns from water.

25. Set time for one minute.
26. When timer goes off, remove lenses from plastic shock beaker.
27. Use lint-free wipe to gently dry lenses.
28. Use USB microscope (Image 10) (after installed on computer according to manufacturer's instructions), high intensity lamp and black background to examine lenses. Compare to charts in Appendix B. Look for:

    28.1. Delamination

    28.2. Crazing

    28.3. Cracking

    28.4. Orange Peel Affect (resemblance in texture)

29. Enter findings in log book on a scale of 5.0.
    29.1. See Classification ratings in Appendix A.
    29.2. Effects on the outermost edge of the lens (<1cm) do not impact the test results.
30. Repeat steps 20 – 28 six times, to all lenses.
    30.1. Record all findings.
    30.2. Notes: Make sure to keep glass beaker boiling (on burner) at 1750 ml.
    30.3. Make sure the plastic shock beaker stays at room temperature. Refill container as necessary to help regulate temperature of shock beaker, as the water can begin to heat up from the temperature of the boiled lenses.
    30.4. Report test finds as appropriate.

APPENDIX A: DEFINITIONS

Crosshatch Definition: A group of squares formed on the surface of a coating by cutting a series of parallel lines in one direction; then cutting a second series of parallel lines at 90 degrees from original lines.

Crosshatch Classification (X Effects on the log sheet)

Delamination Definition: When a coating lifts off the lens surface.

Classification DC: Relates to a dual coated product where both a hard coat and a thin film coating has been applied and together are delaminating. (i.e. HC & Thin Film).

DC – Delamination: Complete coating detachment Classification (DC Effects on the log sheet)

Classification DI: Relates to either a single layer hard coat or the thin film coating where one is delaminating and where one or both have been applied to the lens depending on the product type. (i.e., HC, Thin Film, HC & Thin Film).

Score	Description
5	The edges of the cuts are completely smooth; none of the squares of the cross hatched area are detached.
4	Small flakes of the coating are detached at the intersections of the squares. Less than 5% of the total area affected.
3	Small flakes of the coating are detached along the edges and at intersections of cuts. The area affected is 5 to 15% of the total area.
2	The coating has flaked along the edges and on parts of the squares. The area affected is 15 to 35% of the total area.
1	The coating has flaked along the edges of the cuts in large ribbons and whole squares are detached. The area affected is 35 to 65% of the total area.
0	Flaking and detachment worse than score 1.

Delamination Definition: When a coating lifts off the lens surface.

Classification DC: Relates to a dual coated product where both a hard coat and a thin film coating has been applied and together are delaminating. (i.e. HC & Thin Film).

DC – Delamination: Complete coating detachment Classification (DC Effects on the log sheet)

Score	Description
5	No delamination of individual layers over entire lens surface.
4	Partial delamination of individual layers, up to 25% of the surface.
3	Partial delamination of individual layers, up to 75% of the surface.
2	Total delamination of individual layers over the entire lens surface.

Classification DI: Relates to either a single layer hard coat or the thin film coating where one is delaminating and where one or both have been applied to the lens depending on the product type. (i.e., HC, Thin Film, HC & Thin Film).

DI – Delamination: Complete Interlayer Detachment Classification (DI Effects on the log sheet)

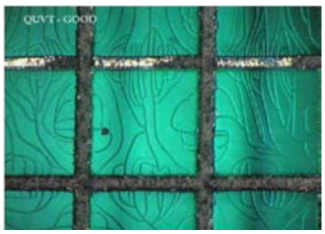
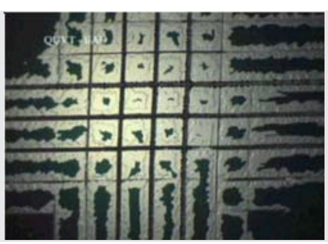
Score	Description
5	No coating delamination of all layers from the lens surface.
4	Delamination of all layers up to 25% of the surface.
3	Delamination of all layers up to 75% of the surface.
2	Complete coating delamination over the entire lens surface.

Crazing Definition: Fine cracks will appear and be joined at right angles to one another. When the coating does this, it is said to be crazed. Crazing is often caused by a mismatch in the thermal expansions of surfaces. The coating is pulling away from itself in this case.

Crazing Classification (C Effects on the log sheet)

Score	Description
5	No visible crazing.
4	Hairline crazing, only just visible points or cracks.
3	Hairline crazing up to 25% of the lens surface.
2	Hairline crazing up to 75% of the lens surface.
1	Hairline crazing over the entire lens surface.
0	Severe fern-like or matte-like crazing over any region of lens.

APPENDIX B: CROSSHATCH RATINGS

5		Classification Appearance Description All edges of cuts are clean and crisp and there is no peel
4		off or crazing in cross hatched area or out of it. All edges of cuts are clean and crisp and there is no peel off in the cross hatched area. Crazing has same reflection
3		as coating. All edges of cuts are clean and crisp and there is no peel off in the cross hatched area. Crazing has white reflection.
2		Crazing ≤ 20 microns wide. The coating has peeled off along the edges of the cuts and on parts of the squares. Crazing very evident with
1		white reflection. Crazing ≤ 40 microns wide average. The coating has peeled off in large areas. Crazing very evident with white reflection cross hatched area and/or
0		out of it. Crazing greater than 40 microns wide average. Peeling and detachment is very evident/visible after tape pull in cross hatched area and/or out of it.

APPENDIX C: IMAGES

IMAGE 1: PLASTIC SHOCK BEAKER

IMAGE 2: GLASS BOIL BEAKER

IMAGE 3: SALT BAG, MATERIAL # 1 & 2

IMAGE 4: INSPECTOR

IMAGE 5: CLEANING PAD

IMAGE 6: BURNER

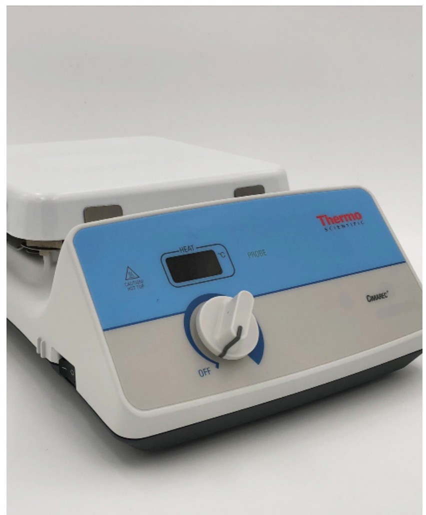


IMAGE 7: SCOTCH BRAND TAPE #600

IMAGE 8: LENS HOLDER

IMAGE 9: TIMER

IMAGE 10: USB MICROSCOPE

IMAGE 11: SCRIBER PEN

MODULE 7 // TAPE PULL TEST

PURPOSE : This document outlines the process for performing a Tape Pull test.

This document covers Tape Pull test done on a lens from any customer.

DEFINITIONS

- n/a

RESPONSIBILITIES

- Lens Tester – Person responsible for performing all aspects of lens testing after the lenses have been delivered by Receiving.

MATERIALS AND EQUIPMENT

- Scotch Magic Tape #810, 3/4" wide
- Force gauge
- Centimeter ruler
- Microfilament cloths
- Gloves

PROCEDURES

1. Remove and dispose of the first 10 cm of tape. This is to make sure the adhesive part of the tape has not been exposed to air.
2. Take off a 10 cm length of tape. Be careful not to touch the adhesive part to anything.
3. On the convex side of the lens, starting 2.5 cm down from the center of the lens, apply 5 cm of one end of the tape towards the top half of the lens. If done properly, approximately 2.5 cm of tape should be in each half of the lens and there will be 5 cm of unattached tape. The area of tape contact will be 9.5 cm2(A [cm2])
4. Flip the unattached tape up 90.. Attach the end of the tape to the gauge arm.
5. Smoothly pull the tape straight upwards from the lens, while watching the gauge.
6. Record the force that was required.
7. After the tape pull, wipe the lens with alcohol and a cloth to remove any adhesive residue.

5.8 – Hard Coat Solutions Management

The hard coat primer and hard coat solutions are designed for use in dip coating systems. The solvents used in the coating solutions (primer and hardcoat) evaporate quickly. During operation of the system, the solutions are exposed to air and the solvents evaporate, thus changing the viscosity of the solutions. The viscosity of the coating solutions is a critical component in creating the correct hardcoat thickness. The hardcoat thickness determines overall quality of the hardcoat. In summary, consistent viscosity of the coating solution is critical to the consistent quality of the hardcoat.

Viscosity of coating solutions is defined as "% of Solids". This is a ratio between the liquid components (solvent) and solid components (hardcoat) of the solution. If the % of solids in a solution needs to be decreased, which is generally the case, solvent is added to the solution. If the % of solids needs to be increased, it is done by adding a solution of a higher % of solids ratio or by evaporation of the solvent.

Before beginning production, the % of solids of the solutions in the coating system must be within specifications. Refer to the coating solutions Tech Sheets for these specifications. A measurement of the % of solids needs to be taken daily to determine what adjustments, if any, should be made to meet the specifications.

PERCENT (%) OF SOLIDS MEASUREMENT

EQUIPMENT AND MATERIALS

The following kit will be needed to perform this procedure:

Percent Solids Kit 90-500054-00

- Moisture Balance Analyzer 50-400460-00
    - Sample pans, disposable; Quantum part #HC-00005
    - Pipettes, disposable; Quantum part #HC-00007
    - Calculator

SET-UP

- Place the scale on a level surface for proper scale operation.
- Position the lamp close by for convenient use. The lamp should be a reflector type for focused heat energy on the pan of liquid. Heat should not be extreme enough that the liquid boils out of the pan; just enough to accelerate the drying process.

MEASUREMENT

- Place a clean pan onto the scale, write down the weight of the pan, then zero (tare) the scale. Make sure that the scale reads zero's in the display before the sample is placed in the pan.
- Using a pipette, remove liquid to be analyzed from the tank and place in the sample pan. Add liquid until 3.00g is indicated on the display.
- Set the sample pan with liquid under the lamp. Turn on the lamp and let sample dry completely. (Amount of time necessary will vary depending on the lamp and configuration used.)

- Place the sample back onto the scale and measure the dry weight. Subtract the empty pan weight from the dry weight measurement to get the weight of solids only.
- Using the calculator, divide the dry weight by the liquid weight then multiply by 100 for percentage. The result is the percentage of solids measurement. See the example below.

EXAMPLE

- Liquid weight = 5.00g
- Dry weight = 0.6g

1. 0.6g 5.00g = 0.12
2. 0.12 x 100 for percent = 12% solids

RECOMMENDED OPERATING GUIDELINES (SOLUTIONS)

*Longer cure time required when using cure temperatures at lower end of range.

DESCRIPTION	1.50 HARD COAT	1.50 PRIMER	1.60 HARD COAT	1.60 PRIMER
% of solids:	21-24	4-5	19-22	6-8
Viscosity @ 25˚C:	<14 cps	4-8 cps	<8.0 cP	≤10 cP
Relative Humidity:	40-60% @ 23˚C		35-60%	
Air Temperature:	20-25˚C (68-77˚F)		20-25˚C (68-77˚F)	
Air Flow:	Filtered, Laminar (Class 100)		Filtered, Laminar (Class 100)	
Coating Temperature:	16-18˚C	18-20˚C	16-18˚C	
Coating Filtration:	5-10 micron absolute		1-5 µm absolute	1-5 µm absolute
Extraction Speed:		10 in/min (4.2 mm/sec)	2.5-4.2 mm/s	0.8-1.5mm/s
• Cast Resin	6 in/min (2.5 mm/sec)		3 hrs @ 120˚C	
• Polycarbonate	12 in/mm (5mm/sec)			
Recommended Thickness:		0.5-1.0 µm		
• Cast Resin	2.0-3.0 µm		0.5-1.0 µm	
• Polycarbonate	3.5-4.5 µm			
Dry Time/ Temperature:	2-30 min/20-25˚C	15 min/20-23˚C or 5 min w/ infrared heat	10-12 min with Infr-red	5 min infrared heater or 10 min @ 80˚C
Cure Conditions:				
• Cast Resin	3 hrs @ 110˚C (230˚F)		3 hrs @ 120˚C	

TANK FILL PROCEDURE

- Add solvent or solution (hardcoat or primer) to the overflow side of the tank.
- Pour solvent or solution slowly and carefully so that no bubbles are formed.
- After adding solvent or solution, allow the solution in the tank to circulate for 15 minutes to completely mix in the added material.
- Measure % of solids after solution has been thoroughly mixed. The % of solids specification must be met before beginning production.

PERCENT OF SOLIDS ADJUSTMENT

Note: Do not add too much solvent to the solution. If the % of solids are too low, the necessary adjustment is time consuming and more difficult.

IF % OF SOLIDS IS TOO HIGH

DESCRIPTION	SPECIFICATION / ACTION
Recommeded % of solids:	21-24% (Hardcoat PIN HC-00045-C; Solvent PIN HC-00045-SC)
System Solution Volume:	System specific; refer to system documentation
Measured % of solids:	26% (out of spec)
Adjustment:	Add solvent, 4% by volume, to bring % of solids from 26% to 22%.
Calculation Example:	4% of 4732ml (tank volume)= 189.28ml
Procedure:	• Measure 189.28ml of HC-00045-SC (solvent) and add it to the hardcoat tank overflow. • Allow solution to circulate for 15 minutes. • Measure % of solids again. • If within specs, return to normal operation. • If not within specs, repeat procedure. (HC-00045-P).

IF % OF SOLIDS TOO LOW

DESCRIPTION	SPECIFICATION / ACTION
Recommeded % of solids:	4-5% (Primer P/N HC-00045-P; Solvent P/N HC.00045-SP)
Measured % of solids:	3% (out of spec)
Adjustment:	To increase solids:
Option A - Evaporate	• Allow the excess solvent to evaporate. • Ensure circulation pump for primer tank is ON. • The evaporation process can be accelerated by turning off the cooling water, if any, to the primer tank. (Make sure it is turned back on after evaporation process.)
Option B - Replace:	• Remove solution from primer tank (refer to system maintenance document). • Removed solution can be reserved for future use. • Refill tank with fresh primer (HC-00045-P).

MODULE 9 // LENS TESTING PROGRAM

COATING CONFIDENCE FOR YOU AND YOUR CUSTOMERS

Why is my company part of the lens testing program?

Quantum's Process ad Support Contracts include coating integrity testing and evaluation.

Why is this important to Quantum and me?

Early detection of trends can:

- Ensure your product performs well for your customers.
- Prevent additional expenses associated with warranty returns.
- Maintain the brands of both our companies.

What tests are run?

- Spectral - Color and characteristics of coating.
- Hardcoat Thickness- Thickness of hardcoat or backside spin hardcoat.
- Water Contact Angle - Hydrophobic coating quality.
- Salt Water Boil - Durability of coating.
- Bayer (upon request) - Durability of coating, specifically hard coat.

What's included in the program?

- Included are the labor and testing materials to perform all tests.
- Not included are the lenses and shipping.
- General guidelines:

DESCRIPTION	RESPONSIBLE FOR COST		NOTE
	KIT	FREIGHT	
Monthly Kit	Customer	Customer	Generally sent Ground
Resend kit due to Customer error	Customer	Customer	Wrong coating applied, envelopes not labeled, etc.
Resend Kit due to Quantum error	Quantum	Quantum	Improper test, etc.
Second kid due to test failure	Quantum	Customer	Generally sent overnight, to correct issue quickly

What happens with the results?

You will be notified by email with the test results attached.

What happens if lenses fail a test?

The type of failure will determine if additional action is needed

COATING CONFIDENCE FOR YOU AND YOUR CUSTOMERS

TEST	FAILING SCORE	NOTE	ACTION
Spectral	N/A	Helps us keep record of your coating over time.	Color issues will be worked on via customer request.
Hardcoat Thickness	N/A	Used as a tool to troubleshoot failures of other test, sauch as Salt Water Boil and Bayer.	N/A
Water Contact Angle	<100	Average score of the lot is <100:	Quantum Tech calls
Salt Water Boil	2 or lower in any of the first 3 boils	If any scoring criteria is a 0 after 1 boil: If all lenses fail: If 1 hardcoat/factory hardcoat & AR lenses fails:	Quantum Tech calls Quantum Tech calls Second kit sent for retest
Bayer (upon request)	<5	If 2 hardcoat/factory hardcoat & AR lenses fail: If average score of the lot is <5:	Quantum Tech calls Quantum Tech calls

How do I reach Quantum support?

- 888.214.7932
- technicalsupport@qtmi.net

Chapter 6 contains several reference documents which may be useful for your lab.

MODULES

MODULE 1 // CLEANING PROCEDURES FOR CLEAN ROOMS

The most important element of quality-control is to start with a clean lab and keep it clean. Lab personnel should adhere to all clean room protocol.

CLEANING PROCEDURES (CLASS 100,000 CLEAN ROOM)

A detailed cleaning schedule should be prepared for every clean room. Housekeeping maintenance of the clean room and restricted areas is essential to ensure quality. Cleaning of a clean room should be performed on a daily basis. Improper cleaning of the clean room can lead to contamination and a loss in end-user product quality.

EQUIPMENT AND MATERIALS

The following items should be purchased for and used only in the clean room:

- Mop bucket and wringer
- Mops
- Vacuum cleaner
- Wipes
- Cleaning and disinfecting solutions, such as Isopropyl Alcohol and Acetone

TASKS

Frequency will vary depending upon local requirements.

- Change all Hepa pre-filters.
- Vacuum (if allowed) the floors and work surfaces.
- Empty appropriate trash and waste.
- Clean the equipment, doors, door frames and lockers in the pre-staging areas using the approved cleaning solution.
- Mop cleanroom floors.
- Clean all work surfaces in the controlled environment.

MODULE 2 // ANTI-STATIC GUN

An ionizing air (anti-static) gun combines air ionization with a stream of compressed gas (air). It makes it possible to both clean and neutralize electrostatically charged items. By neutralizing the charges, particles will no longer be attracted to the surface.

The flow of air that comes from the unit is composed of both positive and negative air ions. Directing this flow at a lens that has a static charge will neutralize the charge and clear the item of dust particles. The gun can use dry compressed air up to 100 PSI.

To produce the ions within the air stream, a low current, high voltage transformer energizes a cartridge adjacent to the air outlet.

PURPOSE

Before a lens is placed into the chamber of an AR coating machine, it must be free of all particulate material. Dry compressed air is good at removing debris from the lens, but if there is an electric charge on the surface of the lens, it will attract dust particles between the time it is cleaned and when it enters the chamber. For this reason, an ionizing air gun is used. The ions remove the charge on the lens, helping to keep particles from being drawn to its surface.

OPERATION

Operation differs slightly depending on the style of unit that you have.

- Table-top version: Hold the lens in front of the sensor to activate the stream of ionized air.
- Hand-held version: Hold the gun 2-12 inches in front of the lens and pull the trigger.

The operation of the trigger, and the setting of the thumb wheel below it, will determine the amount and pressure of the ionized air coming out of the gun.

Regardless of the model, a side-to-side motion should be used to clear the surface.

MAINTENANCE

See manufacturer's manual/specification. For the hand-held Simco ionizing air gun, there are two maintenance items:

1. Every month the ion emitter should be cleaned to remove the build-up of debris on the emitter point. To clean the point:
    a. Disconnect the power to the unit.
    b. Carefully use a cotton swab moistened with alcohol to remove any foreign matter. Make sure that there is no cotton left on the point and that it is fully dried before turning the unit back on.
    c. Inspect the point to make sure that it is neither bent nor rounded.

2. The compressed air filter/nozzle assembly needs to be replaced once the filter material inside of it has turned red. The filter can be seen through the slot in the top of the gun.
    a. The filter/nozzle can be removed by inserting a small flat blade screwdriver between the clear filter housing and the gray locking ring and prying it off. It should take very little force to remove it.
    b. Press the new unit into the front of the gun.
    c. Replace clear filter housing.

SPECIFICATIONS: SIMCO HAND-HELD IONIZING AIR GUN

- Input Power: 120/230 VAC, 50/60 Hz, 0.05 Amps
- Input pressure: 100 PSI max
- Air Consumption: 7.4 scfm at max pressure

MODULE 3 // CURING AND DEGASSING OVENS

There are a variety of curing and degassing ovens used in ophthalmic labs worldwide. No matter the brand or model, all ovens in this industry have the same or similar functionality. They will have similar components, such as heating elements, fans, temperature and air controls, timers, alarms, etc.

PURPOSE

There are two reasons to have an oven in your ophthalmic lab:

- Degas lenses
- Cure dip hardcoat

NOTE: For the purpose of batch processing, the oven setpoint temperature needs to be 55ºC for no less than 1 hour.

DEGASSING LENSES

Lenses are baked in a degassing oven to remove all internal moisture and provide optimal conditions for a successful AR coating application. The lens substrate determines oven temperatures, varying from 50˚C to 75˚C, as well as processing time, varying from 1 to 4 hours.

CURING LENS COATINGS

There are two basic methods of curing ophthalmic coatings:

- Thermal (heat) ovens
- Ultraviolet (UV) light chambers

Thermal coatings are commonly used by lens manufacturers for the front side hard coat. Thermal curing tends to produce superior performance due to longer cure times allowing for more effective cross-linking.

Compared to UV curable coatings, thermally curable coatings usually have a higher concentration of "Colloidal Silica," which increases coating hardness. Thermal coatings potentially have more effective curing throughout the coating layer because of the heat distribution in the curing oven.

QUICK REFERENCE

KNOW YOUR SYSTEM

Read your user manual carefully. Make use of its instructions and explanations. The knowledge of safe, continuous, satisfactory, trouble-free operation depends primarily on the degree of your understanding of the system and of your willingness to keep all parts in proper operating condition.

PROPER LINE VOLTAGE

Voltage must correspond to the nameplate requirements of motors and controls. Refer to the section on power connections in your user manual.

PROPER VENTILATION

Do not be careless about restrictions in and around the fresh air and exhaust openings. If your unit has adjustable vents, make sure the vent is adjusted properly by opening or closing the vent. Do not permit them to become filled with dirt or debris so that the contaminants interfere with the proper volume of flow. The proper ventilation clearances should be fulfilled at all times. Refer to the set-up instructions in your user manual.

MAINTENANCE

NOTE: Never use the oven to heat or store food or any other item not intended for lens processing use.

KEEP EQUIPMENT CLEAN

Gradual dirt accumulation retards airflow. A dirty oven can result in unsatisfactory operation, such as:

- Unbalanced temperature in the work chamber
- Reduced heating capacity
- Reduced production
- Overheated components

CAUTION: DO NOT ATTEMPT ANY MAINTENACE OR REPAIR ON YOUR OVEN UNTIL YOU HAVE DISCONNECTED THE MAIN POWER.

Keep the walls, floor, and ceiling of the oven work chamber free from dirt and dust.

Keep all equipment accessible. Do not permit materials to be stored or piled on or against the oven.

PROTECT CONTROLS AGAINST EXCESSIVE HEAT

This is particularly true of controls, motors, and other equipment containing electrical components. Temperatures in excess of 51.5˚C (125˚F) should be avoided.

ESTABLISH MAINTENANCE & CHECK-UP SCHEDULES

Do this promptly and follow them faithfully. Careful operation and maintenance will result in continuous, safe, and economical operation.

- Lubrication: All door latches, hinges, door operating mechanisms, bearings, or wear surfaces should be lubricated to ensure easy operation.
- Repairs: Make repairs immediately. Delays may be costly in added expense for labor and materials and in prolonged shut down time.

PRACTICE SAFETY

Make it your primary policy to know what you are doing before you do it. Make CAUTION, PATIENCE, and GOOD JUDGEMENT the safety watchwords for the operation of your oven.

OPERATION

1. Start Oven
    a. Open oven door.
    b. Press POWER ON button or turn dial to I (you should hear the fan start circulating).
    c. Close oven door.
    d. Adjust vent to desired opening (vents will need to be adjusted accordingly for maximum performance at various operating temperatures).
    e. Check that the LED for the POWER is illuminated.

2. Enter Temperature Setpoint
    a. This will vary depending on the unit that you have installed; see manufacturer's manual.

3. Set HI-LIMIT Instrument
    d. This temperature should be set slightly higher than the setpoint of the oven or to a temperature that should not be exceeded in the process.

NOTE: For fastest oven heat-up time, close fresh air vent. After desired temperature is reached, adjust vent as needed.

4. Turn Heat Switch On
    e. If applicable, otherwise this is part of the Start Oven process.
    f. Note: Indicator LED should illuminate as the heater initially turns on to bring oven up to temperature and then cycles on/off while maintaining oven temperature through Temperature Control Unit.
5. Stop Oven
    a. Press POWER ON button or turn dial to O (you should hear the fan stop circulating).
    b. Open fresh air vent.
    c. Open door.

WARNING

Do not use flammable solvents or materials in any oven.

Do not process closed containers containing any substance or liquid in this oven as they may explode under heat.

MODULE 4 // DI WATER PURIFICATION

What is de-ionized water and why use it?

De-ionized (DI) water is water that has gone through a physical process to remove its mineral ions. Since the most common impurities in tap water are ions such as calcium, chlorides, and sodium, we want to clean our lenses with water that has these impurities removed, as all can leave residues that appear to the eye as water stains.

To remove these contaminants, water is moved through specially prepared resin tanks that exchange positively charged ions and negatively charged ions for hydrogen and hydroxyl ions. The end result is pure water with very low electrical conductivity (or high resistance) and few dissolved solids. With this property, we are able to measure or quantify what is "clean water."

For the application of cleaning ophthalmic lenses, Quantum recommends that the resistivity of your DI water is in the range of 18-12 mega ohms at 20˚C. A higher resistivity value is better.

The use of such clean, pure water will prevent a lens from becoming more contaminated than it already is from the surfacing and spin coating process. Also, since DI water is missing ions, it will be "hungry," seeking out and absorbing ions from other sources, like from the lens. This will help to enhance the "etching" process, which is important for proper adhesion of the AR stack to the lens.

PURPOSE

Cleaning a lens prior to AR (anti-reflective) processing is arguably more important than cleaning a lens prior to spin coating. The process of AR application to a lens is vastly different than the application of a primer or lacquer to a lens, so the requirements are significantly different. The conditions required for an AR to bond to a lacquer are different than the conditions needed for a primer or lacquer to bond to a lens.

A typical lens flowing through a surfacing lab will experience all kinds of contamination. Some examples are fingerprints, powders from slurry, ink marks, water stains, and even residual components of seemingly good cleaning products like dish washing detergent. All these contaminants need to be removed in order to bond an AR layer stack to the lacquer.

It is quite possible to remove many of these contaminants by "hand cleaning." However, there are some points to consider with this type of cleaning when trying to successfully process a lens through an AR coating lab. Hand cleaning does not lend itself to consistent reproducibility and is an acquired skill. Hand cleaning is slow. Most importantly, hand cleaning does not remove enough contaminants to ensure trouble-free and consistent adhesion of the AR treatment.

One also has to keep in mind why a lens gets a scratch. The most common reason is when an abrasive object comes in contact with it (touches it) and leaves a mark in the lacquer. This is most likely to happen during hand cleaning. To successfully process a lens through an AR process and retain high quality and high yield, a systematic approach must be used.

The best way to achieve such a goal is to clean lenses with de-ionized water, an appropriate cleaning agent, and use of a high quality automatic ultrasonic cleaning machine with appropriate fixturing that eliminates the necessity to touch the lens to render it clean.

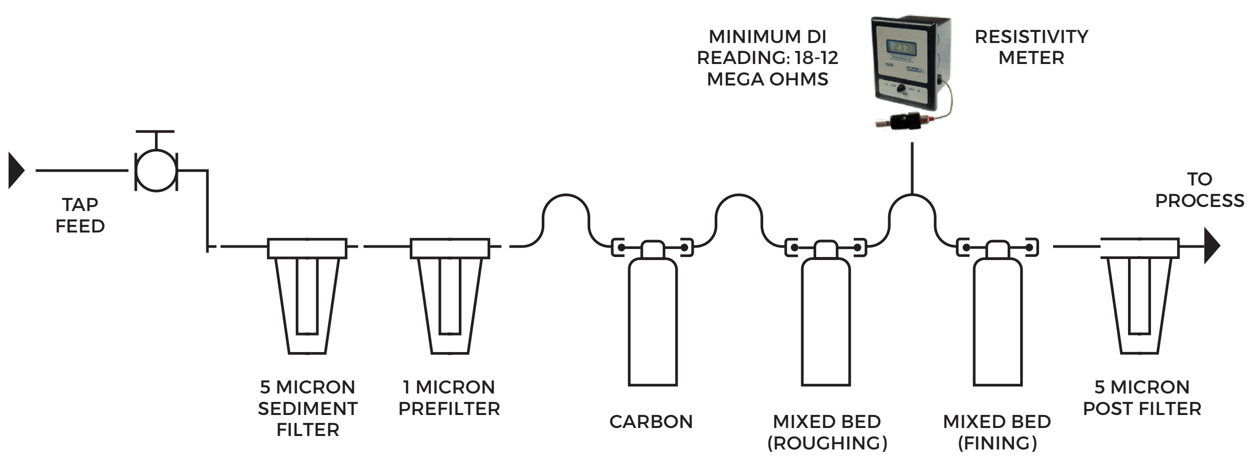
OPERATION

The de-ionized water purification system consists of ion exchange resin and/or other water treatment media contained in portable tanks of various sizes that are easily connected to your tap water supply. These tanks contain:

- Cation ion exchange resin
- Anion ion exchange resin
- Mixed bed resin and/or granular activated carbon

When the water quality drops below the setpoint, the DI water tanks are swapped for tanks with freshly regenerated ion exchange resins that have been processed at an ion exchange regeneration facility.

The DI water equipment comes in various sizes and can be custom configured to meet any flow rate or quality specification, no matter how demanding. See the figure for an example of the typical basic DI water purification system.



SERVICE DEIONIZATION

For small AR lab operations, Quantum recommends contracting with a local Service Deionization (SDI) vendor to supply and maintain the DI water purification system. This procurement option provides high purity DI water users with a cost effective alternative to the difficult issues associated with owning and operating regenerable deionizers or demineralizers.

Renting or leasing portable deionized water systems means no capital expenditure and eliminates the problems of:

- Chemical storage
- Chemical handling
- Operator training
- Waste treatment
- Environmental permitting

QUICK REFERENCE

Generally speaking, the DI water purification system requires little in the way of operating instructions. The vendor supplying the system will go over any system-specific operation not covered in this guide. It is important to understand how to properly read and record the resistivity using the vendor-supplied resistivity meter. This process will vary depending on the model used. Please refer to the documentation supplied with the meter for operational instructions.

NOTE: Quantum recommends a DI Water purity of 18-14 mega ohms. The water quality should never be allowed to drop below 12 mega ohms.

MAINTENANCE

Your SDI vendor will inform you of any on-site maintenance that falls under your responsibility.

You should contact your SDI vendor to schedule a system service when the reading on the resistivity meter reads between 14-13 mega ohms. This will allow the vendor enough time to service the system before the water purity drops below the minimum level of **12 mega ohms**.

The lab staff should check the water quality of the system daily, after the unit has been running for at least 30 minutes. The resistivity readings should be recorded and charted over time for reference as to when the system is likely going to need service.

For any questions, comments, or concerns, please contact Quantum Innovations at 888.214.7932.

MODULE 5 // DIP HARDCOATING

This module will answer frequently asked questions about dip hardcoating, such as:

- How does a dip hardcoating process work?
- What are the main parameters of the process?
- How is the best quality achieved?
- What kind of performance can be expected on different types of lenses (CR-39, Polycarbonate, Trivex, 1.6, etc.)?

MAIN PROCESS PARAMETERS

A successful dip coating process involves many different parameters:

- Lens material
- Lens type
- Surface preparation
- Regeneration rate of hardcoating
- Filter: flow rate, pore size
- Solution temperature (˚C)
- Viscosity: % of solids, solvent balance
- Ambient temperature (˚C) and relative humidity (RH %)
- Lift-out speed
- Mechanical stability
- Pre-cure
- Final cure
- Quality control

LENS MATERIAL

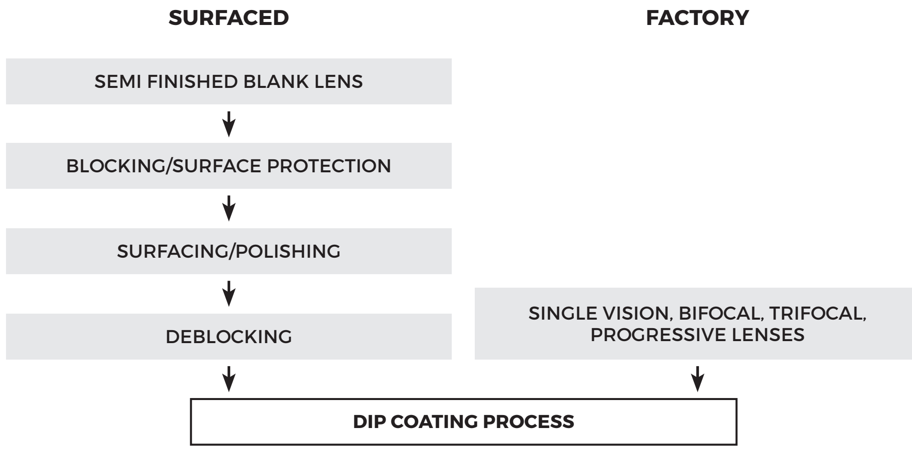
There are many different lens materials in use today, with new materials being introduced frequently. Each may require a specific surface preparation, as well as a specific coating (index matching). The main ones, by increasing refractive index, are listed below:

- CR-39 (1.49)
- Trivex (1.53)
- Mid-index materials (up to 1.56)
- Polycarbonate (1.58)
- MR-6 (1.6)
- MR-7 (1.66)
- MR-8

LENS TYPE

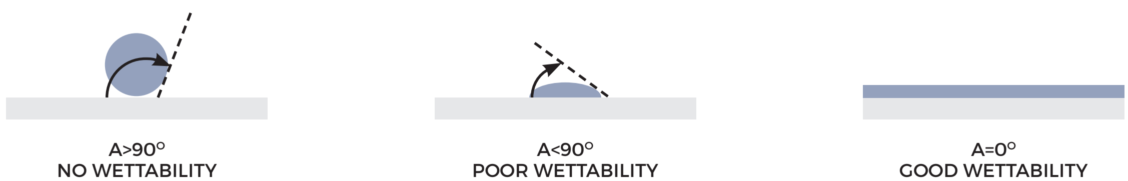
Surfaced lenses are different from single vision, bifocal, trifocal and progressive, in that they are subjected to several specific steps that increase the risks for surface defects in the hardcoating, while possibly adding debris, such as cerium oxide, to the surface of the lenses. These lenses may require a specific process before they join other lenses in the dip coating process.

SURFACED TO FACTORY LENS COMPARISON

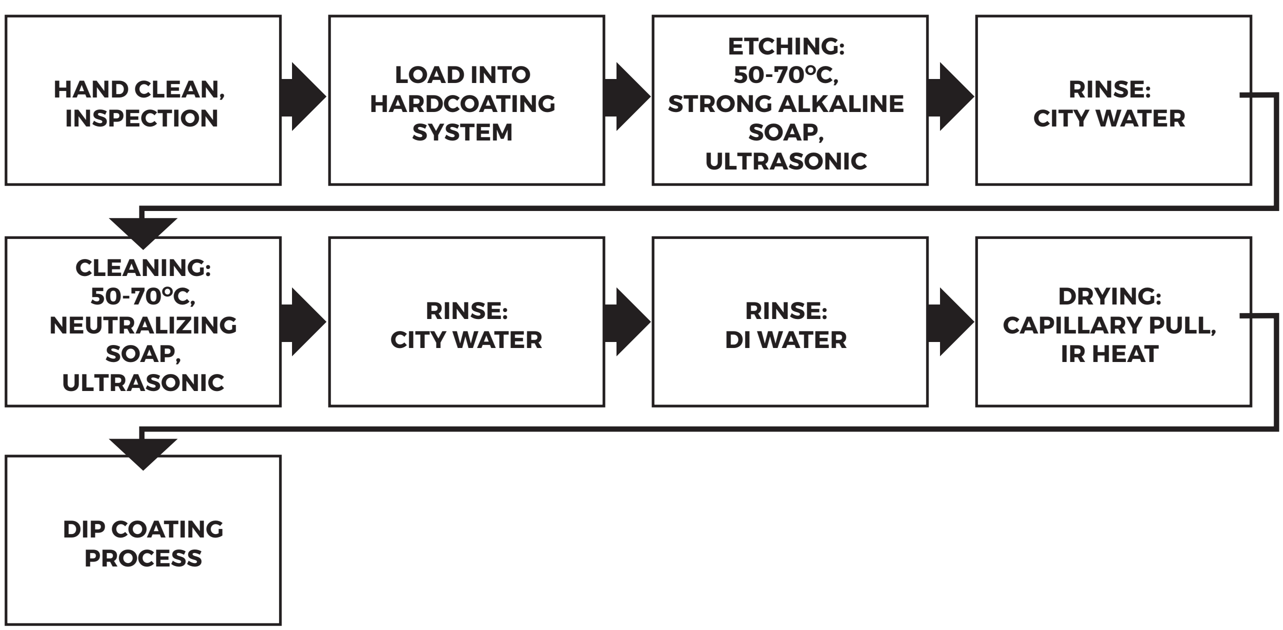


SURFACE PREPARATION

Surface treatments are used to prepare the lenses so that the required wettability needed to get an even layer of hardcoating is achieved. Wettability can be characterized by the contact angle between the surface of the lens and a drop of pure water. The lower the contact angle, the better the wettability.



SURFACE PREPARATION FLOW CHART



REGENERATION RATE OF HARDCOATING

- Hardcoat solution has a limited shelf life.
- Shelf life can be extended by cold storage (0˚F).
- Typical pot life in a dip hardcoating system is 10-16 weeks.
- In order to avoid problems, dip hardcoating systems are designed so that the contents of the primer and hardcoating tanks are replaced at least once every 25 days.

FILTER: FLOW RATE AND PORE SIZE

- Flow rate should allow at least 20 times the volume of the tank to be recycled per hour.
- Mechanically, a high recirculation flow rate works against a small pore size.
- Maximum pressure applied to the filters should be kept under 30 psi so that the gels generated by the coating cannot pass through the structure of the filters.

SOLUTION TEMPERATURE

When the temperature increases, the viscosity of the coating decreases, in turn decreasing the thickness of the hardcoat layer.

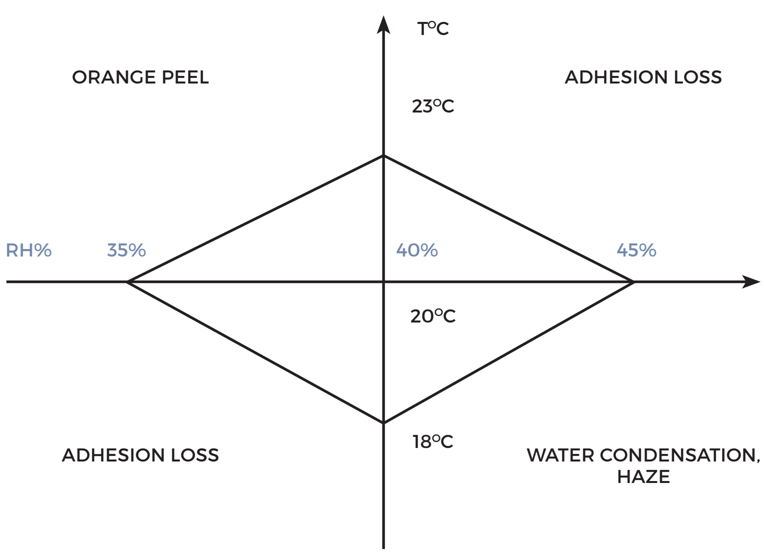
Temperature increase also causes a faster aging/deterioration of the hardcoating solution. It is important to keep this parameter as stable as possible. See manufacturer's specifications.

VISCOSITY: PERCENTAGE OF SOLIDS (DENSITY), SOLVENT BALANCE

- As soon as the percentage (%) of solids changes, the thickness of the hardcoating layer changes. This affects the performance of the hardcoat.
- It is vital that the % of solids is correct in order to get a high quality hardcoating on the lenses.
- The correct % of solids is maintained by adding the proper solvent to the primer and hardcoating.

AMBIENT TEMPERATURE (˚C) AND RELATIVE HUMIDITY (RH %)

SAFE PROCESS AREA: T°C 20°C +/-2; RH 40% +/-5



LIFT-OUT SPEED

The lift-out/withdrawal speed of the lens from the hardcoating solution, combined with the % solids ratio, determines the thickness of the hardcoat on the lens.

- A controlled lift-out speed helps to create an even hardcoat thickness.

MECHANICAL STABILITY

- No stability: Variations in lift-out speed cause waves in the hardcoat, resulting in optical power aberrations.
- Stability: Tightly controlled lift-out speed across the profile of the lens helps create an even hardcoat thickness on the lens.

PRE-CURE

During this phase, the solvents contained in the hardcoat are evaporated, so that the top layer of the hardcoat is dry.

- This prevents the hardcoat from being damaged while being handled.
- Most systems utilize infrared lamps to perform this function.
- The surface of the lenses must be gradually heated up and special care must be taken with tinted, high plus and high minus lenses in order to avoid overheating and cracking.

FINAL CURE

- Final curing in an oven develops the hardcoat to its final hardness.
- Attention must be paid to the temperature and the length of time the lenses are exposed to the curing heat. See manufacturer's specifications for correct settings.
- An undercured hardcoat will not deliver the expected scratch resistance and adhesion.
- An overcured hardcoat may cause a yellowing of the lens.

QUALITY CONTROL

Many quality control tests can be performed on hardcoated lenses:

- Adhesion:
  - Salt water boil with crosshatch
- Thickness:
  - Measurement using a spectrophotometer
- Scratch resistance:
  - Steel wool
  - Taber abrasion
  - Bayer
  - Tintability
  - AR compatibility
- Aging:
  - Xenon lamp
  - QUV

These tests are well known and widely used throughout the industry. Quantum offers these tests at no charge to our process contract customers.

TROUBLESHOOTING

PARAMETER	MAIN CAUSES OF FAILURE
Adhesion	Insufficient surface preparation
	Non-compatible hardcoat
	Wrong pre-cure
	Insufficient final cure
Scratch Resistance	Coating too thin
	Insufficient final cure
Tintability	Coating too old
	Insufficient thickness
	Overcured coating
AR compatibility	Overcured coating
	Coating too old
	Coating too hard (may require intermediate etching phase)
Aging	UV stability of the substrate
	Use of a primer

MODULE 6 // STRIPPING AR COATED LENSES

This module covers information and procedures involved in stripping coatings from lenses. In the event of a blown run, this process might be a viable soluition to be able to prep and recoat the lenses to reduce breakage costs.

MATERIALS AND EQUIPMENT

- BPI AR Dry or Optisource AR Stripper
- De-ionized (DI) water
- Plastic 1-quart container for mixing
- Plastic 1.5-quart container with lid for DI water
- Plastic container with lid for stripping
- Black pad
- Lint-free tissues
- Acid-resistant disposable rubber gloves
- Goggles
- Eye wash station
- Chemical spill body shower station
- Emergency spill equipment, pads/powder
- Lab coat
- Exhaust ventilation
- Timer

WARNINGS

- AR Stripper contains caustic acid.
- Read the supplier's SDS and instructions for use.
- Take necessary precautions to protect hands, arms, and eyes.
- Wear gloves, goggles and other PPE required by supplier's SDS.
- Do not allow contact with eyes, skin or clothing. If contact occurs, flush immediately with water.
- Do not breathe the fumes.
- Do not store in glass containers.
- Do not allow contact with metals.
- Wash hands well after use.
- Use only at room temperature.

INSTRUCTIONS

NOTE 1: Container should be placed over the black pad as this makes it easier to visually verify that the coating has been completely removed from the lenses.

NOTE 2: Supplier's formulas or instructions may change. If different from below steps, always use supplier's instructions.

IF USING BPI AR DRY:

1. Carefully open the bottle and pour contents into 1-quart plastic container.
2. Fill approximately 2/3 full with water.
3. Allow to stand for 20 minutes.
4. Transfer solution into container to be used for stripping.
5. Immerse lenses for stripping:
    a. AR removal - no longer than 30 seconds.
    b. Hardcoat removal - approximately 1 hour.
6. Remove lenses and rinse well with water.
7. Examine lenses for complete removal of AR or hardcoating. Repeat steps 5-6 if necessary.
8. In case of spill, use Emergency Spill pads or powder for clean up.

IF USING OPTISOURCE AR STRIPPER:

1. Pour stripping solution into stripping container.
2. Remove lid and place lens in solution:
    a. Be sure to remove air bubbles from under the lens.
    b. AR removal – 30 minutes.
    c. Hard coat removal - approximately 1 hour.
3. Remove lens, rinse 30 seconds in warm water and wipe with an alcohol saturated tissue.
4. Examine lens for complete removal of AR or hardcoating, repeat steps 2-3 if necessary.
5. In case of spill, use Emergency Spill pads or powder for clean-up.

NOTE: Change AR stripper when it becomes cloudy or has debris in it.

MODULE 7 // BASIC OPTHALMIC INDUSTRY GLOSSARY

This is a basic list of terms associated with the ophthalmic industry.

TERMS

20/20 The Snellen fraction that indicates normal visual acuity. (See Snellen acuity, Snellen chart, and Snellen fraction.)

"A" measurement The horizontal width of a lens shape's box measurement. (See Box measurements.)

Abbe value A relative measure of a lens material's dispersive power. The Abbe value of commonly-used eyeglass lens materials generally ranges from 20 to 60. Lenses with higher Abbe values have less chromatic aberration.

Aberration An optical defect causing blurred or distorted vision. In eyeglass lenses, aberrations are caused by a defect in the lens design or fabrication, or by optical limitations of the lens material. (See Chromatic aberration.)

Absorption The process in which light energy is converted into a different energy form (usually heat). Sunglass lenses use absorptive tints and filters to absorb excess light and reduce glare. (See polarizing filter.)

Acuity Sharpness of vision. Visual acuity is usually measured with a Snellen chart and recorded as a Snellen fraction (e.g. 20/20).

Add power In a multifocal lens, the added magnification power prescribed for that portion of the lens to correct the wearer's near vision.

ANSI Acronym for the American National Standards Institute, the organization that makes quality assurance recommendations to the eyewear industry.

Anti-reflective coating A vacuum-deposited coating applied to lenses to decrease surface reflections and increase light transmittance. Anti-reflective (AR) coatings make eyeglass lenses more attractive and provide better night vision, compared to uncoated lenses.

AR coating See Anti-reflective coating.

Aspheric Not spherical. Refers to the front surface of an eyeglass lens. The front surface of an aspheric lens gradually flattens or steepens from the center of the lens to its edge. Aspheric lenses have a slimmer, more attractive profile and provide sharper peripheral vision than conventional spherical lenses.

Astigmatism A refractive error resulting from unequal curvature in different radial meridians of the eye. Astigmatism is usually due to unequal curvature in the cornea. For example, the 12-to-6 o'clock meridian of the cornea may be steeper or flatter than the 3-to-9 o'clock meridian. An analogy often used to describe astigmatism is that the eye is shaped like a football instead of like a baseball. Astigmatism affects vision at all distances, and is corrected by eyeglass lenses that have cylinder power.

Autorefractor A computerized screening device used in an eye exam to detect and measure refractive errors (i.e. nearsightedness, farsightedness and astigmatism).

Axis Refers to the meridian of least power (on a 1-to-180 degree scale) in an eyeglass lens with cylinder power for the correction of astigmatism. The axis is the third number in an eyeglasses prescription, following the "x." For example, in the prescription -3.00 -1.00 x 180, the lens power includes 1.00 diopter of cylinder power, with its axis at the 180 (horizontal) lens meridian.

"B" measurement The vertical height of a lens shape's box measurement. (See Box measurements.)

Base curve Generally refers to the curvature of the front surface of a lens. A limited range of prescriptions can be created on a semi-finished lens of a given base curve. The base curve determines the profile (or "bulge") of the front of the finished lens.

Bevel The V-shape cut into the edge of an eyeglass lens so the lens fits securely in the groove of the frame's rim or eyewire.

Biconcave A lens shape where both the front and back surfaces have a concave (or minus power) shape. Used only on very strong lenses for the correction of high degrees of myopia.

Bifocal A lens with two distinct powers – one for distance vision and one for near vision. Bifocal lenses are generally used to correct presbyopia.

Binocular PD The distance between the pupils. Generally measured in millimeters. (Also see Monocular PD.)

Blank size The overall diameter of an eyeglass lens before it is cut to fit the size of the frame.

Box measurements A standardized way to measure the size of an eyeglass lens. The box measurements of a lens or frame are the horizontal ("A" measurement), vertical ("B" measurement) and diagonal ("ED" measurement) of an imaginary rectangle drawn around the lens shape.

Bridge The part of the eyeglass frame that rests on the wearer's nose.

Cataract Clouding of the lens inside the eye. Wearing sunglasses that block 100% of the sun's UV rays may decrease the risk of cataract formation.

Chromatic / -chromic Of or pertaining to color.

Chromatic aberration An optical imperfection wherein white light is broken up into a number of colors, with each color being refracted differently by the lens, similar to the effect of a prism.

Color vision deficiency The inability to distinguish certain colors, most commonly, shades of red and green. Often (incorrectly) called "color blindness."

Concave A shape where the center of the lens surface is depressed, compared to a flat surface. The opposite of a convex shape, where the center is elevated. In most eyeglass lenses, the front surface is convex and the back surface is concave. Also called a minus power (or "–") surface.

Converge / Convergence The inward movement of the eyes when we look at close objects. Accounts for why the distance PD measurement differs from the near PD measurement.

Convex A shape where the center of the lens surface is elevated, compared to a flat surface. The opposite of a concave shape, where the center is depressed. In most eyeglass lenses, the front surface is convex and the back surface is concave. Also called a plus power (or "+") surface.

Cornea The clear front surface of the eye that refracts (bends) light and allows it to enter the eye to create visual images.

CR-39® The trade name for the original and most popular plastic material used for eyeglass lenses. The abbreviation stands for "Columbia Resin #39," because it was the 39th formula of a thermosetting plastic developed by the Columbia Resins project of PPG Industries in 1940. The first commercial use of CR-39 monomer was to help create lighter, more durable fuel tanks for the B-17 bomber aircraft in World War II. After the War, the Armorlite Lens Company in California is credited with manufacturing the first CR-39 eyeglass lenses in 1947. CR-39 plastic has a refractive index of 1.498.

Crown glass The type of glass used for eyeglass lenses. Because glass is much heavier and less impact-resistant than plastic and polycarbonate, it is no longer a popular material for eyeglass lenses. Crown glass has an index of refraction of 1.523.

Cylinder power Power within an eyeglass lens to correct astigmatism. Characterized by unequal lens curvature in different meridians so the least powerful and most powerful meridians of the lens are at a right (90-degree) angle to each other.

DBL Abbreviation for "distance between lenses." The horizontal distance between the two lenses in an eyeglass frame, measured across the bridge of the frame. Typically, the DBL is measured in millimeters.

Demo lenses Thin, non-prescription plastic or acrylic lenses inserted in eyeglass frames for display purposes only.

Dispersive power The ability of a lens material to separate white light into its component colors. Lens materials with a low Abbe value have a higher dispersive power, resulting in chromatic aberrations.

Distance PD The measurement of the distance between a person's pupils when they are looking at a distant object.

Double-D A special type of occupational bifocal lens that has two near segments – one in the top half of the lens to see close objects above the wearer's normal line of sight, and one in the standard position in the bottom half of the lens. Double-D bifocals are very helpful for auto mechanics and other workers who have to frequently see near objects above their head.

Diopter (D) The standard unit used to measure the refractive power of a lens. Preceded by a "–" for minus power lenses that correct nearsightedness and nearsighted astigmatism. Preceded by a "+" for plus power lenses that correct farsightedness. Lens powers in eyeglass prescriptions are usually specified in quarter-diopter increments (e.g. -1.25 D, -1.50 D, -1.75 D, etc.).

Drop Ball Test The FDA-required test to measure the impact resistance of eyeglass lenses. A steel ball of a specified size and weight is dropped from a specified height onto the lens surface. To pass the test, the lens cannot chip, crack or break. Lens manufacturers are allowed to test a sampling of their lenses rather than every lens. Safety glasses have higher impact resistance requirements than regular eyeglass lenses.

Duty to Warn The responsibility of eyecare and optical professionals to fully inform consumers about the relative impact resistance of lens materials. Polycarbonate lenses provide the best impact resistance and should be recommended for children's eyewear and for sport and safety eyewear.

"ED" measurement The diagonal box measurement of a lens shape. The ED ("effective diameter") measurement determines the required blank size of the lens in order for it to fit in the frame. (See Box measurements.)

Electromagnetic energy The energy formed when a electrical field comes in contact with a magnetic field. Visible light is one form of electromagnetic energy. Others include radio waves, microwaves, ultraviolet (UV) radiation, and X-rays. Electromagnetic energy travels in radiating waves, and its strength is determined by its wavelength.

Executive A bifocal or trifocal lens where the near segment (and intermediate segment, in the case of a trifocal) extend across the entire width of the lens.

Eye size Refers to the width of the lens opening of an eyeglass frame, measured at the midway point between the top and bottom of the lens opening.

Facets / Faceting Diagonal cutting of the lens edge to create reflective surfaces for cosmetic reasons.

Farsightedness The ability to see with greater ease far away than up close. The medical/optometric term for the condition is hyperopia. Farsightedness is a common refractive error and can be corrected with single vision eyeglass lenses. It is often confused with presbyopia.

Finished lens A lens that has been surfaced to the specifications of a prescription. If the lens has also been shaped and edged to fit a frame, it is called a "cut" finished lens. If it has not yet been shaped and edged to fit in a frame, it's called an "uncut" finished lens.

Fitting height The proper placement of the seg height of a bifocal or trifocal lens so the near zone of the lens (and intermediate zone, in the case of a trifocal) can be comfortably accessed by the wearer without interfering with their distance vision.

Flat top (FT) The most common type of bifocal and trifocal lenses. Called this because the near segment (and intermediate segment, in the case of a trifocal) is flat (horizontal) at the top. Also called a "Straight Top" (ST) or "D seg."

Franklin See Executive.

FSV Abbreviation for "finished single vision" lens. These are single vision lenses that have been surfaced to the specifications of an eyeglasses prescription. (See Finished lens.)

Glass The most scratch-resistant lens material. But because glass lenses are significantly heavier and less impact-resistant than lenses made of other materials, glass has limited popularity as an eyeglass lens material. (See Crown glass.)

Gradient tint A lens tint that is darkest at the top of the lens and gradually gets lighter from top to bottom.

Grinding Refers to the process of using automated surfacing tools to cut the proper curves on the back surface of a semi-finished lens blank to create the desired finished prescription lens.

Hardcoat See scratch-resistant coating.

Hard resin The term generally used to describe conventional plastic lenses. (See CR-39®.)

High energy visible (HEV) light The violet and blue portions of the visible light spectrum: high energy light with wavelengths from 380 to 500 nm. Some researchers feel long-term exposure to HEV light may contribute to macular degeneration. For this reason, many eyecare professionals recommend wearing sunglasses that block HEV light as well as UV radiation.

High index Used to describe any lens material that has a higher index of refraction than crown glass (1.523) or CR-39 plastic (1.498). High index lenses are thinner than glass or plastic lenses of the same power. Generally, the higher the index, the thinner the lens. Popular high index plastic lens materials have indices of refraction ranging from 1.54 to 1.74.

Hydrophobic Literally, "water hating." Most anti-reflective (AR) coatings for eyeglass lenses include an outer hydrophobic layer that keeps the lenses clean longer and prevents water spots.

Hyperopia See Farsightedness.

Index of refraction Also called refractive index. A relative measure of a lens material's ability to refract (bend) light. The higher the index, the more efficiently the material is at bending light. Therefore, high index eyeglass lenses are thinner than lenses with a lower refractive index. The refractive index of popular lens materials ranges from 1.50 (hard resin plastic) to 1.74 (ultra high index plastic).

Inset The amount of inward displacement of the reading segment or near zone in multifocal eyeglass lenses so it is aligned with the eyes during reading, taking into account the normal convergence of the eyes when looking at close objects.

Intermediate zone Refers to the middle zone of sight, at approximately arm's length. Computer use is a good example of a visual activity in the intermediate zone of vision. If a person with presbyopia cannot see clearly in the intermediate zone with bifocal lenses, they could benefit from trifocals or progressive lenses.

Interpupillary distance (IPD) The distance between a person's pupils. More commonly called pupil distance (PD).

Iris The part of the inside of the eye that gives our eyes their color. The iris surrounds and controls the size of the pupil.

Lens blank A thick, semi-finished lens capable of having its back surface modified by an optical lab to create a finished prescription lens.

Lensometer / Lensmeter A manual or automated device that measures the power of eyeglass lenses.

Macular degeneration An age-related breakdown and loss of function of the tissues in the most sensitive part of the retina (the macula). Age-related macular degeneration (or AMD) causes a loss or distortion of central vision and can be very debilitating, making it difficult to read, recognize faces, or see road signs. AMD is the leading cause of blindness in Americans 65 years of age and older.

Meridian Any of a number or imaginary, radially-arranged lines superimposed on the eye (to localize astigmatism) or on an eyeglass lens (to localize cylinder power.) Meridians are numbered in degrees, as they are on a protractor scale, beginning with 001 on the right side of the lens and ending at 180 on the left side. The vertical meridian is the 90˚ meridian, and the horizontal meridian (to the left of center) is the 180˚ meridian.

Mirror coating A highly-reflective coating applied to the front surface of sunglass lenses to reduce the transmittance of light through the lens. Mirror coatings are applied using a vacuum deposition process, similar to the process for applying anti-reflective (AR) coatings.

Monocular Refers to one eye.

Monocular PD An individual pupil distance (PD) measurement for one eye. The measurement refers to the horizontal distance from the center of the pupil to the center of the bridge of the nose. Monocular PD measurements are required to properly fit progressive lenses.

Multifocal Refers to a lens with more than one power. Bifocals, trifocals and progressive lenses are all examples of multifocal lenses.

Myopia See Nearsightedness.

Nanometer (nm) The unit used to measure the wavelength of light and ultraviolet (UV) radiation. A nanometer (nm) is equal to 1 millionth of a millimeter (mm).

Nasal The side of a lens or frame that is closest to the wearer's nose, as opposed to the temporal side, which is farthest from the nose.

Nearsightedness The ability to see things close up but not far away. The medical/ optometric term for the condition is myopia. Nearsightedness is a common refractive error and can be corrected with single vision eyeglass lenses.

nm See Nanometer.

O.D. Latin abbreviation for "right eye." O.D. is also the abbreviation for the professional title, Doctor of Optometry.

O.S. Latin abbreviation for "left eye."

O.U. Latin abbreviation for "both eyes."

Occupational lens Any lens designed or prescribed for a specific visual task or work activity. Single vision "computer lenses" and special design multifocals (e.g. "Double-D" bifocals) are examples of occupational lenses.

Ophthalmic Pertaining to the eye. Eyeglass lenses are also called "ophthalmic lenses" because they are worn in front of the eyes.

Ophthalmologist A medical doctor (M.D.) specializing in eye care. Ophthalmologists can prescribe eyewear and treat eye health problems with medications and surgery.

Optical center (OC) The refractive center of the lens, where there is no prism power present. In a plus lens, the optical center is located at the thickest point on the lens. In a minus lens, the optical center is at the thinnest point of the lens. In general, eyeglass lenses should be positioned so the optical center of the lens is directly in front of the center of the wearer's pupil.

Optician An optical professional trained to fit and adjust eyewear. Training requirements for opticians vary from state to state. In some states, opticians are also allowed to fit contact lenses.

Optometrist A Doctor of Optometry (O.D.). Optometrists are not licensed to perform eye surgery, but they can prescribe eyewear and treat a variety of eye problems with medications.

PAL Abbreviation/acronym for "progressive addition lens." (See Progressive lenses.)

Pantoscopic tilt The vertical angle that exists in a properly-fit eyeglass frame so the top of the frame is slightly farther from the face than the bottom. A normal pantoscopic tilt is 10 to 15 degrees from vertical.

PD Abbreviation for "pupil distance." (See Binocular PD and Monocular PD.)

Photochromic Literally, "light coloring." Refers to lenses that automatically darken in response to sunlight, then return to a clear state indoors. The #1 manufacturer of photochromic technology for plastic and high index eyeglass lenses is Transitions Optical. For this reason, photochromic lenses are sometimes called "Transitions lenses."

Photosensitive See Photochromic.

Polarization The altering of light after it strikes a reflective surface so that light waves travel in a less random fashion. The result is an extremely bright refection of light that causes significant glare.

Polarized Refers to sunglasses that contain a special filter to reduce glare from reflected light. Polarized lenses are especially useful when performing activities in high-glare environments, such as boating, fishing, driving, skiing, or relaxing at the beach. Also, light reflecting from water, snow, sand and other surfaces is called polarized light.

Polarizing filter The thin filter within the lenses of polarized sunglasses that selectively absorbs light rays of a specific orientation. This filter reduces glare from reflected light significantly better than regular sunglasses.

Polycarbonate (PC) A lightweight and extremely impact-resistant high index eyeglass lens material. Polycarbonate lenses are up to 10 times more impact-resistant than glass or plastic lenses, making them the preferred choice for safety glasses, sports glasses, children's eyewear, and for anyone who has an active lifestyle. Polycarbonate lenses are also lighter and less expensive than lenses made of other high index lens materials, making them an excellent value for anyone wanting thin, light and affordable eyeglass lenses. Polycarbonate has a refractive index of 1.59.

Presbyopia The normal age-related loss of near focusing ability in the eye that becomes apparent to most people sometime after age 40. Vision problems due to presbyopia can be corrected with multifocal lenses or reading glasses.

Prism power An angular deviation of light as it passes through a lens. Sometimes, an eye doctor may specifically add prism power to an eyeglass prescription to treat an unusual vision problem. Prism power can also occur if the optical center of the lens is not properly aligned in front of the wearer's pupil. Unwanted prism power can cause eyestrain and headaches.

Progressive addition lens See Progressive lenses.

Progressive corridor The part of a progressive addition lens (PAL) that runs down the center of the lens and contains the power changes necessary for clear vision at intermediate distances (i.e. arm's length) and up close.

Progressive lenses Multifocal lenses that gradually change in power from the top of the lens (which contains the power for distance vision) to the bottom of the lens (which contains the add power for reading and other close-up tasks) with no visible lines in the lens separating the powers. Progressive lenses are also commonly called progressive addition lenses (PALs) and "invisible bifocals." Although the latter is a misnomer because a progressive lens has many lens powers, whereas a bifocal lens has only two powers – one for distance and one for near.

Pupil The circular opening in the eye that is surrounded by the iris. The size of the pupil determines how much light enters the back of the eye to be focused on the retina.

Pupil distance (PD) The distance between a person's pupils (binocular PD) or the distance from the center of pupil to the center of the bridge of the nose (monocular PD).

Pupillometer A manual or electronic device used to measure a person's binocular or monocular pupil distance (PD).

Readers Slang for reading glasses.

Reading glasses Glasses prescribed or made specifically for reading and other near vision tasks. Most reading glasses are single vision lenses.

Refractive error Any of the three common vision problems of nearsightedness, farsightedness and astigmatism.

Refractive index See Index of refraction.

Retina The inner lining of the back of the eye where light energy is transformed into electrical impulses that the brain then interprets to create visual images.

Rx Conventional symbol to indicate a doctor's prescription. Eyeglasses and contact lenses must be prescribed by a licensed eye doctor.

Scratch-resistant coating (SRC) A microscopic coating applied to eyeglass lenses to increase the hardness of the front and back surface. Lenses with a scratch-resistant coating are more durable and resist surface scratches significantly better than uncoated lenses. Glass lenses are the only lenses that don't benefit from a scratch resistant coating.

Seg / Segment The specific part of a bifocal or trifocal lens that contains the lens power for near vision (and intermediate vision, in the case of a trifocal).

Seg height The position of the top border of a bifocal or trifocal segment within an eyeglass frame. Commonly measured from the top of the segment to the lowest point on the finished lens.

Semi-finished lenses Lens blanks that have the front surface of the lens completed by the manufacturer, but the back surface is left unfinished so the optical lab can grind the curves on this surface to create the desired finished prescription lens. Because the final prescription has not yet been ground on the back surface, semi-finished blanks are much thicker than finished prescription lenses. Semi-finished lenses can be either single vision or multifocal lenses.

SFSV Abbreviation for "semi-finished single vision" lens. These are single vision lenses that the front surface of the lens has been completed by the manufacturer, but the back surface is left unfinished so the optical lab can grind the curves on this surface to create the desired finished prescription lens.

Single vision lenses Lenses that have the same power throughout the entire lens, as opposed to multifocal lenses that contain two or more powers. Single vision lenses are typically used to correct the common refractive errors of nearsightedness, farsightedness and astigmatism, or to create reading glasses for the correction of presbyopia.

Snellen acuity The most common measurement of clarity of eyesight (visual acuity). The measurement is accomplished by use of a wall chart with lines of letters in successively smaller sizes (the Snellen chart). The measurement is named after Hermann Snellen, a Dutch ophthalmologist who is credited with developing the technique in 1862.

Snellen chart The common wall chart of letters used to measure visual acuity. The letters on the chart get progressively smaller from top to bottom. The top of the chart usually has the large single letter "E," which corresponds to a Snellen fraction of 20/400. The small letters on the bottom of the chart correspond to visual acuity of 20/20 or better.

Snellen fraction The visual acuity measurement attained by using a Snellen chart, expressed in the form of a fraction, such as "20/20." In the Snellen fraction, the top number (typically "20") refers to the testing distance (usually 20 feet). The bottom number is the distance at which a person with normal vision can still see the letter on that line of the chart. For example, if the smallest letters you can see on the chart are on the 20/40 line, your vision is worse than normal, because someone with normal vision could be 40 feet away from the chart and still see letters of that size.
Conversely, if you can see letters on the bottom of the chart that are on the 20/15 line, your vision is better than normal, because a person with normal vision can only see those letters when they are closer to the chart – at a maximum distance of 15 feet.

Solid tint A tint that has the same density (darkness) throughout the entire lens.

Surfacing The act of grinding the back curve on a semi-finished lens blank to create a finished prescription lens.

Temporal The side of a lens or frame that is farthest from the wearer's nose, as opposed to the nasal side, which is closest to the nose.

Tint A colored dye applied to an eyeglass lens, either for fashion purposes (cosmetic tint) or for protection from sunlight (sunglass tint).

Titanium A very lightweight, strong and hypoallergenic metal that has become a popular material for eyeglass frames.

Trifocal A lens with three distinct lens powers – one for distance vision, one for intermediate vision (e.g. computer use), and one for reading and other close-up tasks.

Ultraviolet radiation / UV rays Invisible electromagnetic radiation that has higher energy than visible light. UV rays can cause sunburn and have been associated with cataracts and other eye health problems.

UV protection The degree to which a lens protects the wearer's eyes from the sun's harmful ultraviolet (UV) rays.

UVA Lower energy ultraviolet radiation that tans the skin. UVA rays have wavelengths in the range of 320 to 380 nm. (Some sources place the upper limit at 400 nm). Although they have less energy than UVB radiation, UVA rays can penetrate deeper into the eye and may contribute to the development of cataracts and macular degeneration. Good quality sunglasses should block 100% of UVA rays.

UVB Higher energy UV rays that cause sunburn and can cause premature aging of the skin, photokeratitis ("snow blindness") and other eye health problems. UVB rays have wavelengths in the range of 290 to 320 nm. Good quality sunglasses should block 100% of UVB rays.

Vertex distance The distance between the front surface of the cornea and the back surface of an eyeglass lens.

Visible light Electromagnetic energy that is visible to the human eye. Visible light has wavelengths ranging from approximately 380 to 700 nm.

Visual acuity Sharpness of vision. Usually measured with a Snellen chart and recorded as a Snellen fraction (e.g. 20/20).

Wavelength The distance between two identical points on adjacent electromagnetic waves. The shorter the wavelength, the higher the energy (frequency) of the wave – and the more potential it has to cause harm to our eyes and bodies. Visible light has wavelengths ranging from approximately 380 to 700 nm. The wavelengths of high energy visible (HEV) light range from about 380 to 500 nm. Ultraviolet (UV) radiation from the sun that reaches the Earth's surface has wavelengths ranging from 290 to 380 nm. Some sources place the break between UV radiation and visible light at 400 nm.

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LAB NAME:

DAILY QUALITY ASSURANCE LOG

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DAILY PERCET OF SOLIDS LOG

TESTER	DATE	TIME	TEMP	MACHINE ID	TANK	% SOLIDS	ADJUSTMENT	NOTES

LAB NAME:

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WEEKLY PUMP OIL LEVEL CHECK

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QUANTUM
CREATING SOLUTIONS

AR BOX COATER RUN & MAINTENANCE LOG

SYSTEM #:

RUN #	DATE/TIME	RECIPE	SIDE	TOTAL PROCESS TIME (MIN)	PRESSURE @ 18 MIN (PA)	REPLACE CRYSTAL	REPLACE EBG SHUTTER	REPLACE ION GUN SHUTTER, PROTECTIVE SHIELD	REPLACE ION GUN FILAMENT	CLEAN ION GUN ANODE, GAS DISTRIBUTOR, PLATES	REPLACE CRYSTAL SHUTTER, SHIELD & HOLDER	BEADBLAST S3F, S22P CRUCIBLE LINERS, CLEAN MIESNER	REPLACE CV LINER & LID	BEADBLAST SA1G LINER, DEGAS SA1G	REPLACE LENS SECTORS & CAROUSEL	REPLACE 2 LOWER R. SIDE SHIELDS	REPLACE 2 LOWER L. SIDE SHIELDS, UPPER CHEVRON	REPLACE 4 LOWER DOOR SHIELDS	REPLACE LOWER MAIN, MIESNER & HEATER SHIELDS	BEADBLAST CRUCIBLE COVER AND CLEAN CRUCIBLES	REPLACE CENTER SIDE SHIELDS	BEADBLAST S15G LINER, PRE-MELT S15G	REPLACE EBG FILAMENT, REBUILD EBG	REPLACE 2 LOWER PUMP CHEVRONS	INITIALS/COMMENTS
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POLYCOLD BALANCE PRESSURES

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