Blocking in Contact Lens Manufacturing

How the way a lens is mounted decides its prism, its thickness profile, and your yield.

1. Introduction

Custom-made lenses keep failing final inspection for power profile, edge profile, and thickness. Each lens is its own lot of one, so every reject is a remake. The lathe gets blamed first, then the button material. Both check out. The cause sits two stations upstream, at the blocker, where the semi-finished lens was waxed onto its second block. On a typical rigid lens, 25 µm of decentration on that block puts roughly 0.14 prism diopters and a 38 µm side-to-side difference in edge thickness into the finished part, and a wax film 20 µm too thick uses the whole center thickness tolerance. No amount of precision in the front-curve cut can take any of it back out.

Blocking is the least visible step in lathe-cut lens production. It has no international standard of its own, the blocker is not calibrated often, and its errors show up at the final inspection station, far from where they are made. It is also the step that sets the geometric relationship between the two optical surfaces of every lathe-cut lens. This article works through that relationship: what each blocking error does to the finished lens, how large the effect is, and which choices of wax, fixture, and centering method keep it under control.

2. Two kinds of blocking: raw-material and transfer

A lathe-cut lens is mounted twice, once for each optical surface, and the two mounting events carry very different risk.

Raw-material blocking mounts the raw button to a block (arbor) before the base curve is lathed. Its job is to register the button to the spindle so the first surface can be cut. Errors here are mostly recoverable, because the base curve is cut fresh relative to the spindle wherever the button happens to sit. For non-rotationally symmetric designs (torics, prism-ballasted lenses, quadrant-specific sclerals), the first mount matters for a second reason: it is where the 0° reference mark is set, and the front lathing uses that mark as the reference for the orientation of the front surface.

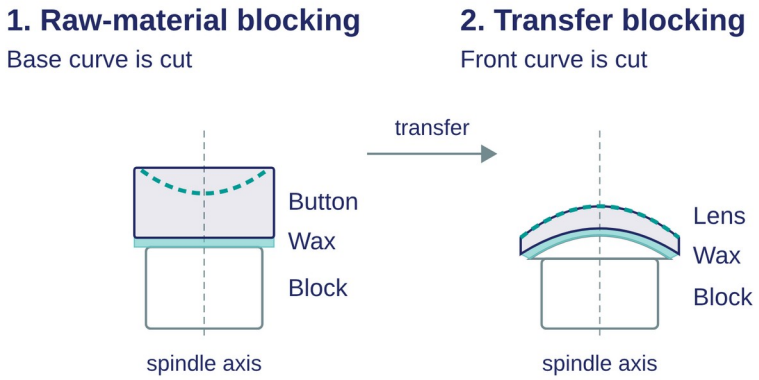
Transfer blocking (reblocking) happens after the base curve is cut. The semi-finished lens is moved onto a second block, seated on its freshly cut base curve through a wax film, and the front curve is then cut relative to wherever that base curve landed. This is the only step that sets the relationship between the two surfaces. Any decentration, tilt, or height error introduced here goes straight into the finished lens.

The typical sequence on a base-curve-first line:

1. Button inspection (diameter, thickness, material lot)
2. Raw-material blocking, or collet mount of the button

3. Base curve, peripheral curves, and the back portion of the edge lathed; the last pass of this cut generates the lens diameter
    a. Back surface polish, if the process is not polish-free
4. Transfer blocking onto the base curve
5. Front curve, lenticulation, and the front segment of the edge lathed
    a. Front surface polish, if the process is not polish-free
6. Deblocking
7. Cleaning and wax removal
8. Edging and polishing where not done on the lathe
9. Inspection; for soft lenses, hydration, extraction, and wet inspection

Each lens is mounted twice; only the second mount aligns the two surfaces



Schematic, not to scale. Dashed line = the surface being cut. An offset made in step 2 stays in the finished lens.

3. To block or to collet the raw button

Mounting the raw button directly in a collet seems to be faster when done manually. Blocking it, however, enables automation, gives better registration, and removes clamping stress on the material.

Table 1. Collet mounting vs. raw-material blocking for the first surface

Factor	Collet / direct chucking	Raw-material blocking
Cycle time	Shortest: load, clamp, cut	Adds wax application, set time, and later a deblock
Heat input to button	None	Wax heat soaks into the button
Registration	Depends on button OD and roundness tolerance, plus collet runout and wear	Set by the block and blocking fixture, independent of button OD
Mounting stress	Radial clamping force can distort the button; the cut surface relaxes after release	Low mechanical stress; thermal and wax-shrinkage stress instead

Factor	Collet / direct chucking	Raw-material blocking
Usable material	Collet grips the button edge; limits cutting near the clamping zone	Block on one face frees the full diameter for cutting
Residue on back surface	None	Wax residue
Consumables and inventory	Collets per button diameter	Blocks, wax, cleaning loop
Identity and orientation	Carried by tray or traveler	Block can carry an ID and an orientation mark

Two points are easy to miss. First, collet mounting is only as good as the button. If the button supplier's diameter tolerance or the collet's runout is a significant fraction of your centration budget, the collet imports that variation into the base curve. Second, choosing the collet for the first cut does not remove blocking from the process. The front surface still has to be cut, which means transfer blocking still happens, and it is still the larger risk.

4. Fixture materials: aluminum vs. plastics

No block material wins outright: metal holds geometry and moves heat, plastic protects the lens and is cheap to cut to radius, and each changes how the wax behaves.

Table 2. Block materials compared (property values are typical handbook ranges, not supplier data)

Material	Thermal conductivity (W/m·K)	Thermal expansion (µm/m·K)	Wear and dimensional stability	Re-cut to radius	Risk to lens surface	Cost and reuse	Typical use
Aluminum	~150–235	~23	Good; holds radius and runout over many cycles	Possible but slower; usually a fixed library	Hard edge can mark a finished base curve	Higher unit cost, long life	Stock radii, repeat SKUs, automated blockers
Brass / steel	~110 / ~15–50	~19 / ~11–17	Best stability	Rarely	Highest marking risk	Highest cost	Precision spindle arbors, reference blocks
PMMA	~0.2	~70	Moderate; scratches, can craze in solvent	Easy and fast	Low	Low; semi-disposable	Made-to-radius blocks for custom work
Acetal (POM-C)	~0.23–0.31	~95–110	Good wear; some creep	Easy	Low	Low	General-purpose reusable plastic blocks

Material	Thermal conductivity (W/m·K)	Thermal expansion (µm/m·K)	Wear and dimensional stability	Re-cut to radius	Risk to lens surface	Cost and reuse	Typical use
Delrin® (POM-H)	~0.35–0.40	~85–120	Very good; stiffer and stronger than copolymer; thick rod can have center-line porosity	Easy	Low	Low to moderate	Delrin-tipped metal arbors; reusable plastic blocks
PEEK	~0.25	~45–55	Very good; resists most solvents	Moderate	Low	High for a plastic	Solvent-release wax lines, long-life plastic blocks
Polycarbonate	~0.2	~65–70	Moderate; attacked by many solvents	Easy	Low	Low	Disposable blocks with water-soluble wax

The biggest difference between the two families is thermal. Aluminum conducts heat roughly 500 to 1,200 times better than the plastics, so wax on an aluminum block sets fast. That shortens cycle time and limits how long heat soaks into the lens. It also means the wax skins quickly, and the operator has a short window to seat and center the lens before it stops flowing. A plastic block insulates: the seating window is forgiving, but set time is longer and more heat is held at the lens.

Expansion cuts the other way. Plastic blocks expand two to five times more than aluminum, so a block cut to radius at room temperature is a slightly different radius at wax temperature. Block, wax, and lens then contract at different rates on cooling, and the mismatch ends up as residual stress in the lens or as a gap in the wax film.

A metal block library holds its radius and runout for a long time, but it has to be stocked for every base curve, and that becomes a planning problem as SKU counts grow. Plastic blocks can be cut to the exact radius of each job, which suits high-mix scleral and ortho-K work. They also wear, creep, and absorb solvent, so they need a life limit.

Before committing to a block material, check it against the wax remover. Several common solvents attack PMMA and polycarbonate; PEEK and the metals tolerate most of them.

5. The arithmetic of a bad transfer block

On a typical rigid lens, every 10 µm of transfer-block decentration adds about 0.06 prism diopters, so holding prism to a quarter of a 0.25 Δ prism limit means centering the base curve to about 10 µm.

Example lens (illustrative inputs): rigid gas permeable, total diameter 9.5 mm, back optic zone radius r_2 = 7.80 mm, center thickness 0.20 mm, refractive index n = 1.45, back vertex power −3.00 D. Solving the thick-lens equation gives a back surface power F_2 = −57.7 D and a front surface power F_1 = +54.3 D

(front radius 8.29 mm). The surfaces are each about 55 D; the lens is only 3 D. That ratio is why blocking matters: small geometric errors act on the large surface powers, not on the small labeled power.

5.1 Lateral decentration

If the base curve sits a distance d off the spindle axis on the transfer block, the front curve is cut on the spindle axis and the back surface is decentered relative to it. Prentice's rule applied to the decentered surface gives the induced prism:

$$P(\Delta) = d(cm) \times |F_2| = 100 \times (n - 1) \times d / r_2$$

The optical center then moves by P/F, where F is the lens power, and edge thickness becomes uneven around the lens because the back sphere is shifted under a centered front sphere.

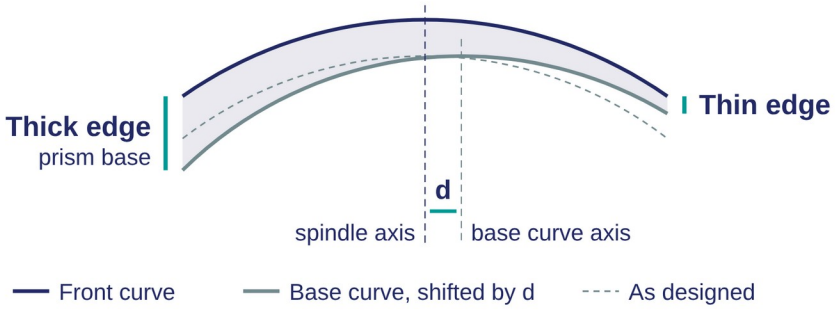
5.2 Tilt

A spherical base curve tilted by angle α about its apex is the same as moving its center of curvature by r_2 sin α. On a rotationally symmetric lens, tilt and decentration are one error in two forms. The induced prism and the equivalent decentration are:

$$P(\Delta) \approx 100 \times (n - 1) \times \tan \alpha \qquad d(equivalent) = r_2 \times \sin \alpha$$

The edge thickness difference then follows from the equivalent decentration, as in 5.1. For torics, prism-ballast, and quadrant-specific designs, tilt and rotation also move the axis and zone positions, so they must be tracked separately.

A base curve off the spindle axis becomes a wedge: prism and uneven edges



Schematic; shift and thickness exaggerated. Tilt on the block draws the same picture: on a sphere, a tilt equals a shift of r2 × sin(tilt).

5.3 Axial (height) error

If the front cut is referenced to the block and not to the lens, a wax film thicker or thinner by δ changes center thickness by δ, one to one. The thick-lens back vertex power responds as:

$$F'v = F_1 / (1 - (t / n) \times F_1) + F_2 \qquad dF'v / dt \approx F_1^2 / n$$

For this lens that is about 0.002 D per micrometer of thickness error.

5.4 Wax wedge

A wax film thicker on one side than the other tilts the lens even when the operator centered it correctly. A thickness difference Δw across a seat diameter of 8 mm gives α = arctan(Δw / 8 mm), which then feeds the tilt formula above.

5.5 Results

Table 3. Impact of transfer-blocking errors on the example lens

Error source	Input error	Induced prism (Δ)	Edge thickness difference, opposite sides (µm)	Other effect
Decentration	10 µm	0.058	15	Optical center moves 0.19 mm
Decentration	25 µm	0.144	38	Optical center moves 0.48 mm
Decentration	50 µm	0.288	77	Optical center moves 0.96 mm
Tilt	0.05°	0.039	10	Equals 7 µm decentration
Tilt	0.10°	0.079	21	Equals 14 µm decentration
Tilt	0.25°	0.196	52	Equals 34 µm decentration
Wax wedge over 8 mm	2 µm	0.011		Tilt 0.014°
Wax wedge over 8 mm	5 µm	0.028		Tilt 0.036°
Wax wedge over 8 mm	10 µm	0.056		Tilt 0.072°
Axial (wax height)	10 µm			CT error 10 µm; power +0.02 D
Axial (wax height)	20 µm			CT error 20 µm; power +0.04 D
Axial (wax height)	30 µm			CT error 30 µm; power +0.06 D

The table takes the lens rim on the front-surface axis, which keeps the arithmetic simple. On a line where the back cut generates the diameter, the rim follows the base curve instead: edge thickness differences then come out about 10% smaller and prism measured at the geometric center about 6% lower. Neither changes the conclusions.

5.6 What the tolerance allows

ISO 18369-2:2017 sets the tolerances these errors are judged against. For rigid corneal lenses, center thickness is ±0.02 mm (Table 1, measured per ISO 18369-3:2017, clause 4.5) and label back vertex power is ±0.12 D for powers up to ±5.00 D (Table 2, measured per ISO 18369-3:2017, clause 4.3). The 2017 rigid-lens optical table lists back vertex power, cylinder power and cylinder axis, but no prism row. The previous edition, ISO 18369-2:2012, limited unintended prism to 0.25 Δ (0.25 cm/m, measured at the geometric center of the optic zone) for back vertex powers up to 6 D, This article uses that historical 0.25 Δ value as an assumed internal limit.

If blocking may use no more than 25% of that prism limit, leaving the rest for the lathe, the material, and measurement, the budget is 0.06 Δ. On this lens, with each error acting alone, that means **base curve centration within about 11 µm, or tilt within about 0.08°**, or a wax wedge of about 11 µm across an 8 mm seat. In practice the errors add, so each has to sit well inside its own figure. A 30 µm wax height error alone would exceed the ±0.02 mm center thickness tolerance by 10 µm and use half of the power tolerance. A manual blocker is routinely assumed to hold these numbers, and in most cells nobody measures whether it does.

5.7 Beyond prism: center thickness and eccentricity

Decentration barely changes center thickness, but it moves where the lens is thinnest and it shifts everything the front cut makes relative to the lens edge. The center thickness risk sits with wax height and block fit, not with centering.

Center thickness. A sideways shift of a sphere changes thickness at the geometric center only by about $d^2 / 2r_2$, which is second order. On the example lens, even 50 µm of decentration changes thickness at the geometric center by less than 0.2 µm. What does move is the thinnest point of this minus lens, which moves off the geometric center: about 0.42 mm at 25 µm of decentration, slightly less than the 0.48 mm shift of the optical center. The minimum thickness drops by 0.1 µm at 10 µm decentration, 0.6 µm at 25 µm, and 2.6 µm at 50 µm. That is small against a ±20 µm tolerance, but it matters if the CT gauge is assumed to read the thinnest point. Tilt about the lens apex behaves the same way. Tilt that pivots on the block edge also lifts the apex, which turns into axial error and from there into center thickness error one to one (section 5.3).

Eccentricity between the surfaces. The last pass of the back-surface cut generates the lens diameter, so the edge and every back zone are concentric with the base curve. The front cut makes the front surface and the front side of the edge on the transfer block's spindle axis, and it is not meant to change the diameter. An eccentricity d between the two axes therefore shows up in four places (Table 4).

Table 4. Where an eccentricity d shows up on the example lens

Effect of eccentricity d	10 µm	25 µm	50 µm
Prism (from Table 3)	0.058 Δ	0.144 Δ	0.288 Δ
Optical center offset from geometric center	0.19 mm	0.48 mm	0.96 mm
Edge thickness difference, opposite sides	15 µm	38 µm	77 µm
Front optic zone and lenticular junction, distance to the lens edge: difference between opposite sides (2d)	20 µm	50 µm	100 µm

The back zones stay concentric with the lens edge, because the same cut made both, so the fitting surface itself is not distorted. What moves is everything the front cut makes. The front optic zone, any lenticular junction, and the front side of the edge sit off center by d, so the carrier is 2d wider on one side than the other. On designs where front-surface optics have to register to back-surface zones, 50 µm of eccentricity is 50 µm of misregistration between the two.

The wax gap when the block does not match the base curve. If the block radius differs from the base curve, the wax gap is not uniform even with perfect centering. A block steeper than the base curve touches near the center and the gap opens toward the edge: a 7.70 mm block under a 7.80 mm base curve leaves about 17 µm more wax at a 4 mm seat radius than at the center, measured along the lens

axis, and a 7.75 mm block about 8 µm. A block flatter than the base curve does the reverse: the lens rests on the rim and the thickest wax sits at the center, where it changes center thickness directly. Either way the uneven film adds shrinkage stress and makes the seat sensitive to tilt. The practical rule: match the block radius to the base curve closely, and measure lens height after blocking instead of trusting the block.

5.8 How lens design changes the impact

The same blocking error produces the same prism and the same absolute edge asymmetry on every lens with the same base curve, but thick plus lenses and thin minus lenses fail in different ways.

Prism from decentration is $100(n-1)d / r_2$: it depends on the base curve radius, not on the labeled power. Edge thickness asymmetry depends on the back surface slope at the edge, so it is also nearly the same across powers. What changes is how much margin each design has to absorb it.

Table 5. One blocking error, three designs (base curve 7.80 mm, diameter 9.5 mm, n = 1.45; single-curve back surface without lenticulation, so absolute edge values are illustrative and the differences are what matter)

Design	Center thickness	Nominal edge thickness	Edge difference at 25 µm decentration	Difference as % of nominal edge	Edge difference at 50 µm	Difference as % of nominal edge	Optical center shift at 25 µm	Power change per 10 µm CT error
−6.00 D, thin minus	0.12 mm	330 µm	38 µm	12%	77 µm	23%	0.24 mm	0.018 D
−3.00 D, low minus	0.20 mm	317 µm	38 µm	12%	77 µm	24%	0.48 mm	0.021 D
+5.00 D, thick plus	0.30 mm	147 µm	38 µm	26%	77 µm	52%	0.29 mm	0.027 D

Thick plus lenses. The edge is already the thin part of the lens, so the same side-to-side difference costs more. The 38 µm difference at 25 µm decentration means the thin side loses about 19 µm, or 13% of the nominal 147 µm edge; at 50 µm decentration it loses about 38 µm, or 26%. The thin side can fall below the minimum edge thickness, chip during deblocking, or polish through to a knife edge. On lenticulated plus designs, decentration also moves the lenticular junction off center, which shows up as an uneven carrier. Power is also about 30% more sensitive to center thickness error than on the −3.00 D lens, and about 50% more than on the −6.00 D lens, because the front surface power is higher, so wax height control matters more.

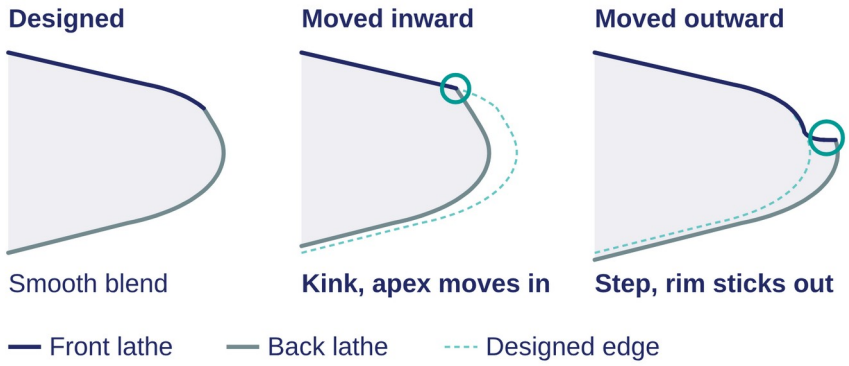
Thin minus lenses. The edge has margin, and the risk moves to the center. A 20 µm wax height error is 17% of a 0.12 mm center thickness, against 7% on a 0.30 mm plus lens. Thin lenses are also more flexible, so mounting distortion and wax shrinkage stress (section 7) are more likely to leave a surface that relaxes off the block into a different shape. Low-power minus lenses have the largest optical center shift for a given decentration, because the shift is prism divided by power.

5.9 Eccentricity and the shape of the edge

A rounded edge is made in two operations, and most of it comes from the first. Lathing the back surface on the first block cuts the peripheral curves and carries on around the rim, forming most of the edge round and setting the lens diameter. Lathing the front surface on the transfer block then adds a short blend radius that joins the front curve to that round, concentric to the front surface. A transfer-block eccentricity d puts the back-cut round off center by d relative to the front blend, so the junction between them no longer lands where it was designed. The front cut is not meant to change the diameter, but with the two axes misaligned both the shape of the edge and the diameter are affected.

- **Radial position of the apex.** On the side where the base curve moved outward, the back-cut round sits further out than the front blend expects. The front blend cuts into the round and leaves a step, and where it reaches the rim it also takes material off the diameter the back cut generated. On the opposite side the round sits further in, so the front blend runs out before it reaches it, and the front curve meets the round at a kink instead of a smooth blend. The mismatch between the two sides is 2d: 50 µm at 25 µm eccentricity, 100 µm at 50 µm.
- **Axial height of the apex.** The back surface at the rim moves up on one side and down on the other by about d times the back surface slope at the edge. With a peripheral curve of 9.5 to 11.0 mm, that is roughly ±12 to ±14 µm per side at 25 µm eccentricity and ±24 to ±29 µm at 50 µm. That is the change in the manufactured rim height; what it does to edge lift and clearance on the eye depends on the fit.
- **Polishing does not fix it.** The exact shape of the kink and the step depends on the tool paths used for the back round and the front blend. Edge polishing softens both but cannot restore the designed round, because the material that should form it is either missing or in the wrong place.

Rounded edge: one offset gives a kink on one side and a step on the other



Schematic, offset exaggerated. Lens body to the left; circles mark the defects (same lens, opposite sides).

The same offset leaves a kink on one side and a step on the other, so a single edge section can look fine while the opposite side does not.

A lens can therefore pass diameter, power, and even prism inspection and still carry an asymmetric edge profile, which shows up later as a comfort complaint or inconsistent edge lift. Inspecting the edge profile at more than one clock position is the only way to see it.

6. Wax: quantity, material, water-soluble vs. solvent-release

The wax film is a precision component of the process: its thickness sets center thickness, its uniformity sets prism, and its chemistry decides how the lens comes off and how clean it is when it does.

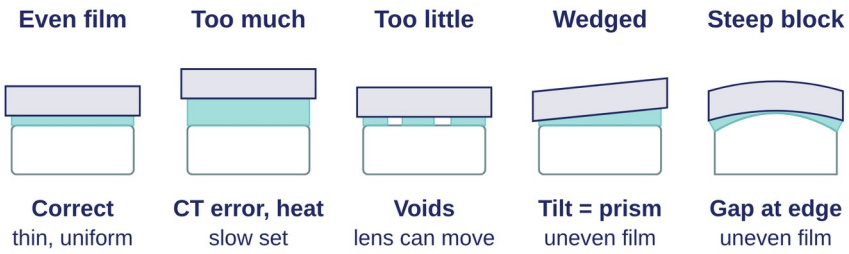
6.1 Quantity

Too much wax gives a thicker film with more room for wedge, more heat delivered to the lens, longer set time, more shrinkage on cooling, and squeeze-out that has to be cleaned off. The calculation in section 5 shows the cost directly: film thickness variation becomes center thickness error one to one, and film non-uniformity becomes prism.

Too little wax leaves voids and an incomplete seat. The lens is supported at a few points instead of over the whole surface, so it can shift, chatter under cutting load, or release mid-cut.

Control the dose, not the operator's judgment of it: dispensed volume or pre-formed wax discs, controlled wax and block temperature, a defined seating force and dwell, and a fixed cooling time before the block goes to the lathe. Measuring lens height on the block after setting, and compensating the front cut for it, removes the axial error even when the film varies.

The wax film is part of the lens geometry



Schematic; film thickness exaggerated. A block flatter than the base curve does the reverse of the last panel and puts the thickest wax at the center.

Only the first condition leaves the lens where the process assumes it is. The others turn into center thickness error, movement, or prism.

6.2 Material

The properties that matter are:

- Melting or softening point, which sets how much heat reaches the lens
- Viscosity at application temperature, which sets how evenly the film spreads
- Hardness and stiffness when set, which set how well it resists cutting forces on long passes
- Shrinkage on cooling, which pulls the lens toward the block unevenly
- Adhesion to both the block material and the lens material
- Purity and ash content, which drive residue
- Color or contrast, which helps operators and cameras see voids and squeeze-out

Low-melt waxes protect heat-sensitive materials but bond less firmly and can creep during long cuts. Higher-melt waxes bond better and put more heat into the lens. Wax that is remelted repeatedly changes

properties and collects debris; set a reuse limit or do not reuse it. Check wax compatibility against the lens material supplier's processing guidance. As an example, Contamac's technical sheet for its Definitive lathe-cut silicone hydrogel calls for a low-temperature blocking wax with an operational temperature of 60 °C, in a controlled environment of 21 ± 2 °C and 45–60% relative humidity. A Boston (Bausch + Lomb) technical bulletin for rigid materials makes the same points from the RGP side: keep the wax layer thin and controlled, do not overheat brass blocking arbors, and confirm the working temperature with the wax supplier.

6.3 Water-soluble vs. non-water-soluble

Table 6. Water-soluble vs. non-water-soluble blocking wax

Factor	Water-soluble wax	Non-water-soluble (solvent or thermal release)
Removal	Warm water or aqueous detergent	Solvent bath or heat
EHS burden	Low	Solvent handling, ventilation, waste
Bond strength and stability	Can be weaker; sensitive to humidity and water-based coolant	Stronger, stable, insensitive to coolant and humidity
Effect on blocks	Compatible with most plastics	Solvent can attack PMMA and polycarbonate blocks
Residue risk	Lower if the rinse is validated	Higher; solvent-borne residue and extractables
Rigid lenses	Good fit for many lines	Common where bond strength matters
Xerogel soft buttons	**High risk:** water starts hydrating the lens before it is finished, changing dimensions and surface	Usually the safer choice

For soft lenses the choice is close to forced. A soft lens is lathed dry because its dimensions are only stable dry. Any water in the blocking or deblocking step starts the hydration that the process is designed to do later, under control.

Whatever the wax, cleaning must be validated, because residue is both a cosmetic reject and a biocompatibility and extractables question. Changing wax type or supplier is a change-control event under ISO 13485 and 21 CFR 820, not a purchasing decision.

7. Centration, orientation, and thermal effects

The centering method sets the floor on blocking accuracy, and for non-symmetric designs the orientation method matters as much as the centering.

Centering methods, in rising order of repeatability:

1. **Manual visual centering**: operator judgment, often by reflected image or edge alignment. Fast to set up; accuracy depends on the person and the shift.
2. **Mechanical self-centering fixtures**: a seat or cone registers the lens to the block. Repeatable if the fixture is maintained; only as good as the lens edge it references.

3. **Automated transfer blockers**: dosing, centering, seating, and cooling in one controlled cycle, with the centration result recorded per lens.

Orientation is a separate problem from centering. Toric back surfaces, front torics, prism-ballasted designs, truncations, and quadrant-specific scleral designs are not rotationally symmetric, so the base curve's axis has to be carried across the transfer block for the front surface to be cut in the right rotational relationship. That takes a reference mark or flat on the lens, an index on the block, and a check that the two agree before the front cut.

Then there is heat. Hot wax goes onto a material that is about to be cut to micrometer tolerances. In rigid materials this can leave residual stress that shows up as distortion or crazing after deblocking, or later in cleaning solvent. In soft lens materials the stress may only appear after hydration, when the lens swells and the stress relaxes into a shape change. High-Dk rigid materials and xerogels are generally the most sensitive.

Mounting distortion is the mechanical version of the same problem. Uneven wax shrinkage or clamping force can strain the lens while it is cut. The surface is cut true in its strained state, then relaxes off the block into a different shape, and the symptom is a surface that measured well on the lathe and poorly at inspection.

8. Deblocking and cleaning

The deblock method is chosen when the wax is chosen, and each method carries its own risk to the lens.

- **Thermal release**: reheat until the wax softens. Simple, but a second heat cycle on a finished lens, with the same stress risks as blocking.
- **Freezing (cold shock)**: freeze the block so the wax turns brittle and the lens can be removed mechanically. Edge chipping and cracking risk rise on thin or high-minus lenses, and it works better on metal blocks than plastic.
- **Solvent release**: dissolve the wax with the lens still on the block. Gentle mechanically, but adds solvent exposure to the lens material and the block.
- **Water release**: for water-soluble wax only. Low EHS burden, but not appropriate for xerogels (section 6.3).
- **Mechanical release**: prying or twisting the lens off. The most common source of edge damage and should be the exception.

After deblocking, wax residue must come off the finished surfaces, the edge, and any fenestrations or drilled features. Residue left behind is both a cosmetic defect and a source of extractables, so the cleaning step needs validation with a defined, risk-based residue acceptance criterion.

9. Throughput, automation, and the capital decision

Blocking often paces the lathe cell, and automating it pays back through repeatability and data more than through labor savings.

Automation fixes centration repeatability, wax dose and temperature, and cooling, and it gives a per-lens record of centration and height that turns blocking into a measured process. It does not fix a worn or wrong block library, contaminated or degraded wax, material stress from the wrong wax temperature, or a cleaning process that was never validated.

Product mix decides the case. High-volume stock rigid lenses on a narrow set of base curves suit a metal block library and an automated transfer blocker. High-mix scleral and ortho-K work, with many radii and orientation-critical designs, usually suits made-to-radius plastic blocks, and there the argument for automation rests on orientation control and a recorded centration result for every lens more than on speed.

Whatever the level of automation, blocking is often the least documented skilled job in the cell. Write standard work for the station, qualify operators against it, and track it on the skills matrix. ISO 13485 clause 7.5.6 requires process validation where the output cannot be, or is not, verified by later monitoring or measurement. Blocking effects that final inspection does not measure directly, such as residual stress and edge asymmetry away from the inspected section, can fall on that side of the line. Changes to wax, block material, or centering method go through change control, with their impact documented. Heron's metrology articles cover the measurement instruments themselves; the point here is where in the flow to use them.

From a Lean point of view, block inventory, block cleaning loops, wax remelting, waiting for set time, and changeover between radii are all waste. SMED thinking applies: prepare the next block and wax dose while the current lens sets, and keep the block library at the point of use, sorted by radius.

10. Conclusion

Transfer blocking is the step that decides how the two surfaces of a lathe-cut lens relate, and a 10 µm error there spends a meaningful share of the prism tolerance before the lens reaches inspection. Wax dose, wax chemistry, block material, and centering method are precision variables and should be specified, measured, and controlled like any other. Moving the check from final inspection to the moment after transfer blocking turns scrap into a minute of rework.

Heron Operational Excellence works with contact lens and ophthalmic manufacturers on this kind of hidden yield loss: mapping where defects are created versus where they are found, building the controls at the source, and validating the change.

11. References and Sources

- ISO 18369-2:2017 (Edition 3, confirmed 2023), *Ophthalmic optics — Contact lenses — Part 2: Tolerances*. ISO catalogue
- ISO 18369-3:2017 (Edition 2, corrected version 2017-10, confirmed 2023), *Ophthalmic optics — Contact lenses — Part 3: Measurement methods*. ISO catalogue
- ISO 13485:2016, *Medical devices — Quality management systems*.
- 21 CFR Part 820, Quality Management System Regulation (FDA). eCFR

- Prentice's rule and thick-lens power: standard ophthalmic optics texts, e.g. Jalie, *The Principles of Ophthalmic Lenses*. 6th edition, Association of British Dispensing Opticians (ISBN 978-0-900099-03-8).
- Material and block property values: typical published values, for example aluminum 6061 at 167 W/m·K and 23.6 µm/m·K (Aluminum Association typical data); confirm against supplier datasheets for the grades in use. Delrin® homopolymer values from published typical properties (ASTM D696 expansion 4.7 × 10^{-5} in/in/°F; thermal conductivity 2.5 BTU·in/hr·ft^2·°F).
- ISO 18369-2:2012 (withdrawn), *Ophthalmic optics — Contact lenses — Part 2: Tolerances*, Table 2, prismatic error for rigid lenses.
- Contamac, *Definitive Technical Sheet*, version 1.1, blocking and environment recommendations. contamac.com
- Boston (Bausch + Lomb), *Tech Talk* bulletin on lathing practice for rigid materials. PDF

The calculations in section 5 use an illustrative lens and were checked numerically. The same formulas apply to any design: substitute your own base curve, diameter, center thickness, and refractive index.