GP Lens Manufacturing Guide

BAUSCH + LOMB

INTRODUCTION

This document provides guidance for using Boston® materials in the manufacture of finished gas permeable lenses. The information contained in this document is predicated upon use of equipment, metrology, process parameters, etc. that are typical within the specialty lens industry. The following are recommended manufacturing practices when using these materials. They are not intended to be formal process specifications, but to serve as guidelines which can be refined based upon users' specific equipment and lens design requirements.

Manufacturing Process Guidelines for Boston® Materials

LATHE SETUP AND CALIBRATION

The lathe is the heart of the lens manufacturing system **(1)**. Therefore, it is important that the lathe is operating at the highest level of performance. If the lathe setup and calibration are incorrect, then all other operations in the manufacturing system will be negatively affected.

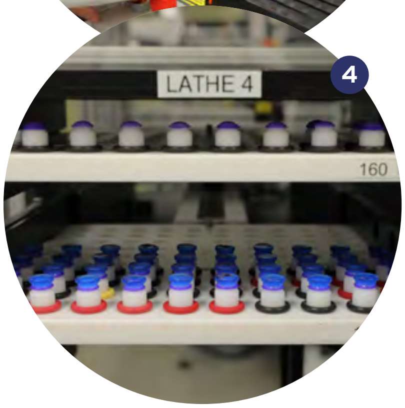
The lathe should be calibrated on a regular basis to ensure optimal performance. Some of the critical areas of lathe setup and calibration are diamond tool height, spindle RPM, slide movement, and axis alignment. These items should always be set and maintained with precision. Always refer to the lathe manufacturer's recommended maintenance and setup procedures for the lathe you are using.

Note: Blanks are available to help facilitate lathe setup and calibration. Contact your Boston® Regional Sales Representative for more information.

Selection of diamond tools is an important consideration **(2)**. Utilizing natural diamonds with a tool radius of 0.25 mm to 0.50 mm is recommended.

Diamond tools should be inspected daily, as the diamond will need re-lapping after a certain number of cuts **(3)**. The number of cuts before re-lapping is necessary can depend on the specific materials being used. Generally, diamond tools can deliver at least 500 cuts, and potentially more than 1,000 cuts **(4)**.

High temperature can reduce diamond tool life and can induce stress into the material. Cooling the tip of the diamond tool with a continual concentrated jet of compressed air, combined with a strong vacuum to remove the swarf that accumulates during cutting, helps optimize the lens surface conditions and extend diamond tool life.



Diamond tools can be inspected under a microscope. The presence of small ruptures indicates the need for re-lapping. You can also evaluate surface texture of the lathed button and/or polishing time as indicators of diamond tool life.

Base Curve Lathing

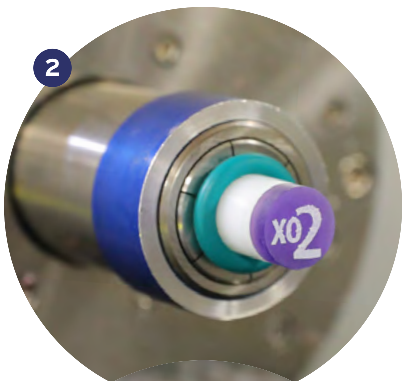
1

DIRECT COLLET METHOD

A 12.7 mm (0.500") diameter collet is recommended for all Boston® products **(1)**. The pressure of the collet on the periphery of the button material is a critical factor that should be controlled. Excessive collet pressure can cause base curve warpage and/or stability problems. The collet closure mechanism should be adjusted for minimum pressure on the button, while still sufficiently holding the button during the lathing process.

The depth of the collet is also an important consideration. If the depth is too shallow, there may not be sufficient clamping force to adequately hold the button during the lathing process. A collet with a depth greater than 1.02 mm (0.040") is recommended. If this depth is not feasible given a specific lens design, then utilizing the open collet (base curve blocking) method is recommended.

2



3

BLOCKED BUTTON COLLET METHOD

An alternate method of lathing the base curve is to block the button onto a flat-topped arbor **(2)**. This approach ensures there is no excessive collet pressure exerted on the button material.

When utilizing this approach, it's important to use a solid, sturdy blocking arbor **(3)**. Delrin, brass, and stainless steel are good options. Avoid hollow arbors, as they do not typically provide sufficient support to the button during the lathing process.

There are several commercially available blocking waxes that can be used to block the button to the arbor. Be sure to follow the appropriate manufacturer's recommendations with respect to temperature. Ideally, button materials should not be exposed to temperatures above 75°C (167°F).

Note: We recommend using a water-soluble blocking wax for all Boston® materials.

Utilizing a lathe spindle speed in the range of 7,000 – 9,000 RPM should produce an optimal surface quality resulting in minimal polishing times. Lathe spindle speed can be easily checked by placing reflective tape on the spindle and measuring it with an electronic tachometer.

The recommended cutting depth and feed rate for both the rough lathe cuts and finish lathe cuts are summarized in the following table. The feed rate on the finish cut should be slow and steady to avoid surface irregularities.

LATHE RECOMMENDED PARAMETERS

Spindle speed	7,000 – 9,000 RPM
Rough cut depth	0.50 mm – 0.75 mm
Rough cut feed rate	80 mm/min – 100 mm/min
Finish cut depth	0.05 mm – 0.10 mm
Finish cut feed rate	0.15 mm/min – 25 mm/min

Polishing the Base Curve Surface

Polishing the base curve surface can be accomplished using either a 6-spindle **(1-4)** or bladder polishing system. There are several options available for polishing cloths, pads, and polishing medium.

One of the advantages of using a bladder polishing system is that one tool is used to polish most radii, whereas the 6-spindle method is best served by matching the tools to the appropriate radii.

The polishing equipment should be capable of both rotary and oscillatory movement. Recommended equipment parameters are included in the table below. The oscillation cycle should be equidistant from the lens center, and the polishing spindle should be slightly offset (either forward or backward) from the part center.

The polishing time can vary depending on the surface quality of the lathe, but a general recommendation is to not exceed 1 minute with minimal weight added (< 100 g). Polishing tools should be kept wet with polish and never allowed to run dry. Frequent application of polish during the polishing cycle, and a clean filtered water rinse during the last few seconds of the cycle, will help produce high-quality surfaces.

Care should be taken to use only cloth made for the optical industry. The recommendation is to use either a silk or microfiber cloth. The cloths will gradually wear over time so they should be replaced at regular intervals.

The recommendation is to use an alumina-based polishing compound. There are several widely available for use in polishing lenses. Avoid polishes that contain alcohol, solvents, or silicone oils as they can damage the lens surface.

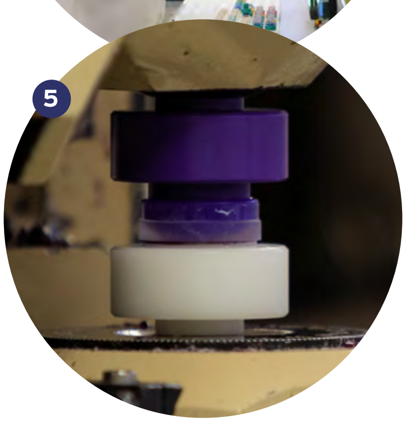
RECOMMENDED POLISHER SETTINGS

	6-SPINDLE METHOD	BLADDER METHOD
Spindle speed	800 - 1,000 RPM	50% RPM setting
Oscillation speed	2 - 4 strokes/10 seconds	60% oscillation setting
Oscillation distance	5.0 - 6.5 mm	3.5 - 5.0 mm
Offset	0.5 - 1.5 mm	0.5 - 1.5 mm
Weight	< 100 g	< 100 g
Polishing time	20 - 30 seconds, NTE 1 minute	20 - 30 seconds, NTE 1 minute

Base Curve Inspection

Inspecting the base curve after polishing **(1)** helps to identify potential issues and allows the base curve to be either recut or repolished, thereby saving material and production cost.

It's recommended that the quality of the lens surface be inspected using a microscope (minimum 20x) to identify any surface anomalies, and the radius and optical quality of the lenses be measured and assessed using a radiuscope **(2)**.



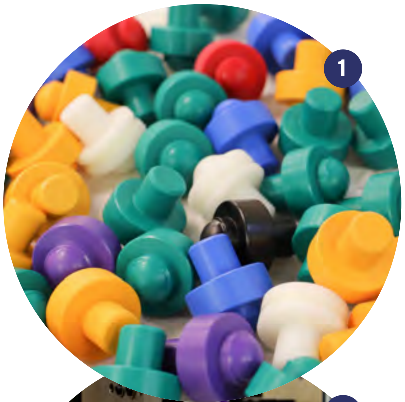
Blocking the Base Curve Blank

While there are several commercially available blocking compounds that can be used with GP lens materials, we highly recommend use of a water-soluble wax, as it eliminates the need for any harsh solvents and simplifies the lens cleaning process.

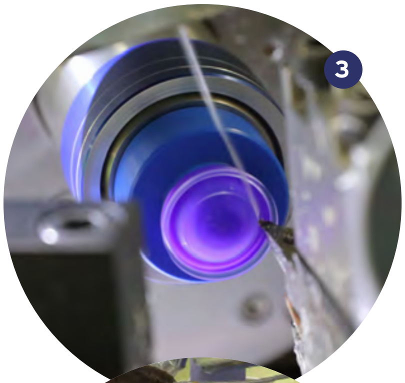
Temperature of the blocking wax should be kept as low as possible to avoid distortion of the lens **(3)**. To protect the material, it should be no more than 167°F or 75°C. Be sure to consult the wax distributor to determine the best working temperature of the wax being used. Always monitor the wax temperature during production. Overheating the wax can destroy its working properties **(4)**.

We recommend these valuable tips for working with water-soluble wax:

- Keep unused wax in a storage area with desiccant or in a "dry box." This is especially important when humidity levels are high.
- Heat and melt only enough wax to last for the day's production. Some water-soluble wax tends to break down and lose important hardening and holding properties if left heated for extended periods of time.
- Controlling the thickness of the wax layer is important **(5)**. A moderate, consistent wax layer will provide sufficient support to the lens during processing. A wax thickness that is extremely thin or extremely thick can result in aberrations and/or distortions in the finished lens.



- It is important to make sure that the crowns (tops) of all blocking arbors are smooth and free of dents and other damage **(1)**. The dents and damage can transfer into the lens and appear as aberrations and/or distortions in the finished lens.
- When using Delrin-tipped blocking arbors **(2)**, be sure the surface of the Delrin has been lightly sanded with fine sandpaper or emery cloth. This will aid in making the wax stick to the arbor and lenses will deblock cleaner.
- When using brass blocking arbors, be sure to warm them slightly to ensure adhesion of the wax.
- When cutting lens designs with extremely flat or extremely steep base curves, it might be helpful to cut arbors with a crown radius more closely aligned to the base curve.



Front Surface Lathing

Front surface cutting is a critical process step, as this is where the lens power, thickness, and other important optical characteristics are realized.

Be sure to input the correct refractive index value of the material being processed **(3)**.

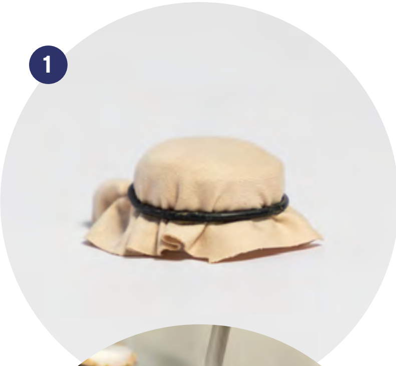
Similar to base curve lathing, calibration and appropriate setup of the lathe is critical. Critical elements of calibration include diamond height and lateral, radius, and center thickness **(4)**.

Recommended lathe parameters are specified in the table below.

LATHE RECOMMENDED PARAMETERS

Spindle speed	7,000 - 9,000 RPM
Rough cut depth	0.50 mm - 0.75 mm
Rough cut feed rate	80 mm/min - 100 mm/min
Finish cut depth	0.05 mm - 0.10 mm
Finish cut feed rate	0.15 mm/min - 25 mm/min

1



2

3

4

Polishing the Front Surface

Processing techniques and considerations for polishing the front surface of the lens are similar to those used in polishing the base curve. The same 6-spindle or bladder polishing equipment can be used and there are several options available for polishing cloths, pads, and polishing medium **(1-4)**.

The polishing equipment should be capable of both rotary and oscillatory movement. Recommended equipment parameters are included in the table below. The oscillation cycle should be equidistant from the lens center, and the polishing spindle should be slightly offset (either forward or backward) from the part center.

The polishing time can vary depending on the surface quality off the lathe, but a general recommendation is to not exceed 1 minute with minimal weight added (< 100 g). Polishing tools should be kept wet with polish and never allowed to run dry. Frequent application of polish during the polishing cycle, and a clean filtered water rinse during the last few seconds of the cycle, will help produce high-quality surfaces.

Care should be taken to use only cloth made for the optical industry. The recommendation is to use either a silk or microfiber cloth. The cloths will gradually wear over time so they should be replaced at regular intervals.

The recommendation is to use an alumina-based polishing compound. There are several widely available for use in polishing lenses. Avoid polishes that contain alcohol, solvents, or silicone oils as they can damage the lens surface.

RECOMMENDED POLISHER SETTINGS

	6-Spindle Method	Bladder Method
Spindle speed	800 – 1,000 RPM	50% RPM setting
Oscillation speed	2 – 4 strokes/10 seconds	60% oscillation setting
Oscillation distance	5.0 – 6.5 mm	3.5 – 5.0 mm
Offset	0.5 – 1.5 mm	0.5 – 1.5 mm
Weight	< 100 g	< 100 g
Polishing time	20 – 30 seconds, NTE 1 minute	20 – 30 seconds, NTE 1 minute

Lens Deblocking

If using a water-soluble blocking compound, an ultrasonic cleaning unit containing a mixture of water and a mild detergent is an efficient method for removing the lens from the blocking arbor. For best results, the temperature of the liquid in the ultrasonic system should be maintained on the cooler side – not to exceed 40°F or 4°C.

If not using a water-soluble blocking wax, the ultrasonic system will likely need to contain a mild solvent to ensure efficient removal of the blocking pitch from the lens. This is not the recommended method, as use of solvents requires certain safety precautions and prolonged exposure can damage the lens surface **(1)**.

1

Lens Cleaning

After deblocking, lenses should be cleaned thoroughly to remove any residual pitch or blocking wax **(2-4)**.

If lenses were blocked with a water-soluble wax, cleaning is best conducted using filtered, distilled, or deionized water. If lenses were blocked using a non-water-soluble compound, use a mild solvent to thoroughly clean the lenses.

Dispense a small amount of liquid onto a clean tissue. Using a gentle blotting action, remove any residual pitch or wax residue from the lens surface. Avoid aggressively rubbing the lenses as this may scratch the lens surface. Solvent exposure should be kept to a minimum – no more than ten to fifteen seconds.

The lens should undergo a final cleaning with Boston® Laboratory Lens Cleaner, and then be thoroughly flushed with clean water. Dry the lens with a clean, dry tissue to ensure no deposits remain on the surface.

Note: Be sure to adhere to all manufacturer's guidelines for the safe handling of solvents and be sure to comply with all regulatory requirements for their safe and proper disposal.

2

3

4

Edge Polishing

The edge of the finished lens should be polished and shaped to produce a well-tapered round edge **(5)**. Although manual edging is possible, auto-edging machines are recommended, to provide more uniform and consistent edge profiles. Care must be taken to use modest spindle speeds and adequate amounts of polish to avoid burning the lens surface. Machine setup is important to achieve the correct edge profile. The setup will vary depending on the type of machine being used. On all machines, it is important to be sure the lens edge is deep enough into the sponge to get the required results.

5

Lens Inspection

It is recommended that all finished lenses be inspected per the requirements below. Reference ISO 18369-2:2017 and/or ANSI Z80.20 for recommended methods and tolerances.

It's important that all inspection equipment be calibrated on a regular basis to ensure accurate and consistent measurements.

- Inspection of the front and back surfaces and edge profile should be performed using a 20x microscope to ensure there are no areas of mottling, scratching, or other degradation of the lens surfaces.
- Inspection of the edge should be performed for shape and chipped or broken areas.
- Measurement of lens center thickness should be performed using an analog or digital thickness gauge.
- Measurement of lens power, optical quality, and prism should be performed using a focimeter (e.g., lensometer, vertexometer, NIMO, etc.).
- Measurement of lens diameter should be performed using a V-slot diameter gauge.
- Inspection of lens optic and lenticular zones should be performed using a 10x loupe with a scale or some other magnifying instrument with a measuring system.
- Measurement of base curve radius and optical quality should be performed using a radiuscope or interferometer.

Final Lens Cleaning

It is recommended that all lenses be cleaned using Boston® Laboratory Lens Cleaner, followed by a clean water rinse to ensure that all residue from manufacturing and handling is removed.

Plasma Treatment

Lenses manufactured from Boston® materials can be plasma treated **(1)**. Plasma treatment of finished lenses produces hyper-clean surfaces by removing a thin layer of organic contamination that is present on almost all surfaces. Plasma treatment is performed with oxygen gas and leaves no residue on the lens surface. Plasma treatment helps to improve surface wettability characteristics, which can result in increased comfort and fewer deposits. Please be sure to adhere to the specific equipment manufacturer's instruction manuals.

RECOMMENDED EQUIPMENT

- AST Products PJ-II Bench Top Plasma Surface Treatment System **(2)**:
  Bench Top Plasma Treatment System - PJ (astp.com)
- Diener Tetra-8 Plasma Chamber:
  Diener North America (thierry-corp.com)

Lens Packaging

Finished lenses may be packaged and shipped either wet or dry **(3)**.

If lenses are to be shipped dry in standard lens cases, it's important that the lens cases be thoroughly cleaned to prevent lens contamination. It is recommended to use Boston® Laboratory Lens Cleaner to clean the lens cases prior to packaging.

If lenses are to be shipped wet, in solution, it's important to note that Boston Simplus and Boston Advance Conditioning Solution **(4)** are the only solutions that should be used to wet-ship the finished lenses. Once packaged in bottles with Boston Simplus or Boston Advanced Conditioning Solution, the finished lenses have a 30-day expiration date.

Note: Be sure to adhere to any country-specific regulatory requirements with respect to wet shipping of GP contact lenses.