– Satisloh GmbH –

Introduction to Alloy-free lens production

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INTRODUCTION

For more than 50 years ophthalmic prescription lenses (R_x) have been fabricated using a production technique that has involved attaching a raw lens blank to a holding piece (a metal block) using melted alloy. The alloy compound contains a number of toxic heavy metals now found on the United Nations Environment Program short term hit list. This fact combined with unstable alloy costs have caused optical machinery suppliers to enter into a race to see who can be the first to introduce a practical and cost effective alloy replacement technology. Although one manufacturer introduced a wax based alternative to alloy back in the 80's, the wax tended to contaminate other process within a lab such as the AR coating process (anti-reflective coating) and the wax did not offer enough support for today's more sophisticated Rx grinding techniques. By today, with the exception of very small labs, wax blocking has nearly disappeared from the market.

Satisloh, a Swiss based optical equipment manufacturer, became the first to introduce a non alloy and no wax blocking technology in 2010 and this technical paper describes the process and equipment utilized along with its newest version (ART introduced in 2014) which is quickly being excepted into the global ophthalmic lab market.

1. Overview about today's lens production process

1.1 Traditional lens production

To produce an ophthalmic lens different machining operations are needed to transform a raw lens blank into an Rx lens. This process is typically referred to as "surfacing or grinding" and involves process like milling or grinding, turning and polishing. To hold the raw lens (blank) inside the machine a work piece holder (block) is needed and a low melting metal (Alloy) connects the block and the blank (picture 1). The alloy does not stick well on the surface of the blank and can influence the surface quality and therefore a protection tape must be applied on the surface of the blank before it can be connected with the block using hot alloy (picture2).

After polishing the lens is typically separated from the block for lens inspection, front- and backside coating and finishing (edging/glazing). For the last finishing process where the lens gets the edge shape which is needed for the spectacle frame, this lens must be blocked again to get connected with the special and much smaller work piece holder for the Edger (picture 3).


Picture 1


Picture 2


Picture 3

1.2 Alloy blocking

The most popular Alloy in the ophthalmic industry worldwide is the Alloy 47/117 which has a melting point of 47° Celsius or 117° Fahrenheit.

This Alloy is easy to melt and because of the low viscosity in the liquid phase easy to apply. The low melting temperature does not damage the lens blank, but to make sure the block sticks to the blank and to avoid thermal tensioning it should not be too hot and there is a need to wait 30-45 minutes to allow the blank to cool down before the next process step can start. After solidification the alloy is no longer flexible and gives the blank the needed support during the production process.

1.2.1 Alloy compounds

The word 'Alloy' describes a mixture of different materials like shown in Table 1 for the Alloy 47/117 and two other Alloys exemplary.

Alloy	Tin [Sn]	Lead [Pb]	Bismuth [Bi]	Cadmium [Cd]	Indium [In]
47/117	8,3	22,6	44,7	5,3	19,1
58/136	12	18	49		21
79/174	17		57		26

Table 1

Lead (Pb), Cadmium (Ca) and Indium (In) are all toxic elements and endanger the environment and the staff in the production lab. There are alloys available which do not have lead or cadmium, but there is still a big portion of indium needed. Furthermore the melting point of these specialized alloys is much higher and the price of those alloys is cost prohibitive.

UNEP
United Nations Environment Programme

The hidden costs of alloy - As mentioned earlier, some of the heavy metals used in alloy are toxic and listed in the UNEP hit list. Alloy should be handled in special ways in any lab and the costs of doing so depend on how compliant a lab desires to be and/or how local government interprets EPA regulations. Handing and clean-up costs associated with using alloy should include water cleaning and filtering systems, glove and clothing cleaning/handling, alloy disposal costs, and special reporting costs. In at least one area of the World, the local government is now requiring labs to conduct blood testing each month for any employees who handle alloy. The cost of handling alloy is quickly increasing although the ultimate costs depend on volume used along with a labs interpretation of compliance. In the US, some labs are now being designated as being alloy Super Users by the EPA (Environmental Protection Agency). These labs now estimate special handling costs of alloy as being as ranging from $0.10-$0.40 per lens.

2. Introduction into alloy free lens production

2.1 Alloy-free block materials

There are some alternatives to the easy to process but dangerous Alloy process. Products like wax, hot-melt adhesive (thermo-plastic), putty, plaster or UV-light curable adhesive are known.

To evaluate the materials in a more comprehensive way shows some advantages and disadvantages for all of them. Wax, like alloy requires a protection tape, is not as stiff as the other materials and is shown to have a negative impact to the AR coating of a lens. Today's digital surfacing technologies require a very firm foundation and the sophisticated designs used are compromised by wax blocking. Hot-melt adhesive materials also require protection tape and because of the temperature there is a waiting time between blocking and the next process step. In addition, to date no company has been able to develop a practical de-blocking technology for either technology. The one advantage of both technologies is the cost due to being able to re-melt the materials, although this also requires new steps in the production process. Both technologies utilize expensive metal block which require cleaning, but they can be reused many times.

Non-Toxic UV-light curable adhesives such as the one used by Satisloh are cured or hardened using a low heat LED UV light. Because most lenses block UV light, the UV light source must be emitted from behind the lens (through the block) and therefore this process requires a clear organic block material that allows UV light to pass. Fortunately there are a number of such materials available in a very rigid form that can be used many times before being discarded. The advantages of UV curable blocking adhesives are that little to no curing time is needed, there is nearly no cooling shrinkage (distortion) and once cured, the material is very rigid making it the perfect foundation for today's Digital surfacing turning technologies. In addition, the material allows a lab to block without needing protection tape and does not contaminate any other process within the lab. The adhesive is even stable enough to be used within the AR vacuum coating process should a lab wish to keep a lens on the same block throughout the lab. The one disadvantage of UV cured adhesives is that they cannot be re-melted and re-used making that one component more expensive than the alternatives, although eliminating the need for tape makes up for most of the cost difference. In addition, because tape is not needed, for the first time there is an effective and affordable technology available to automatically de-block and clean lenses. As a summary, the advantages of UV cured adhesive blocking are:

- No hazardous substances like heavy metals to pollute waste water and process waste
- High-precision blocking
- Precise blocking without block rings
- No cooling time due to UV-curing
- Front side protection by adhesive, no taping needed
- Machinable block provides stability and full lens support
- Highly efficient re-use of block-pieces

To offer a replacement technology which fulfills the demand of the customers in the different world wide markets, Satisloh has now introduced two ways to use is ART blocking technology. The OBM (On Block Manufacturing) and the OPS (Open Platform Surfacing) process. OBM, also sometimes referred to as One-Block process allows a lens to be held on the same block throughout the entire lab including AR coating and even edging. OBM requires specialized Satisloh equipment throughout the lab. OPS, Open Platform Surfacing process is designed for labs who already have traditional coating and edging in their labs, or for labs that utilize non Satisloh surfacing equipment and in this process the block is only used in the surfacing process of a lab. The ART blocking equipment used in both process is exactly the same…the only difference is blocking chuck used to hold the 2 different block pieces.

2.1.1 OPS process

With the OPS-block piece (Open Platform Surfacing), Satisloh offers a solution which can seamlessly integrated into existing production lines as the block piece fits all common generating and polishing equipment. The OPS block, although offering near full support is typical slightly smaller than the front side blank diameter (picture 5).

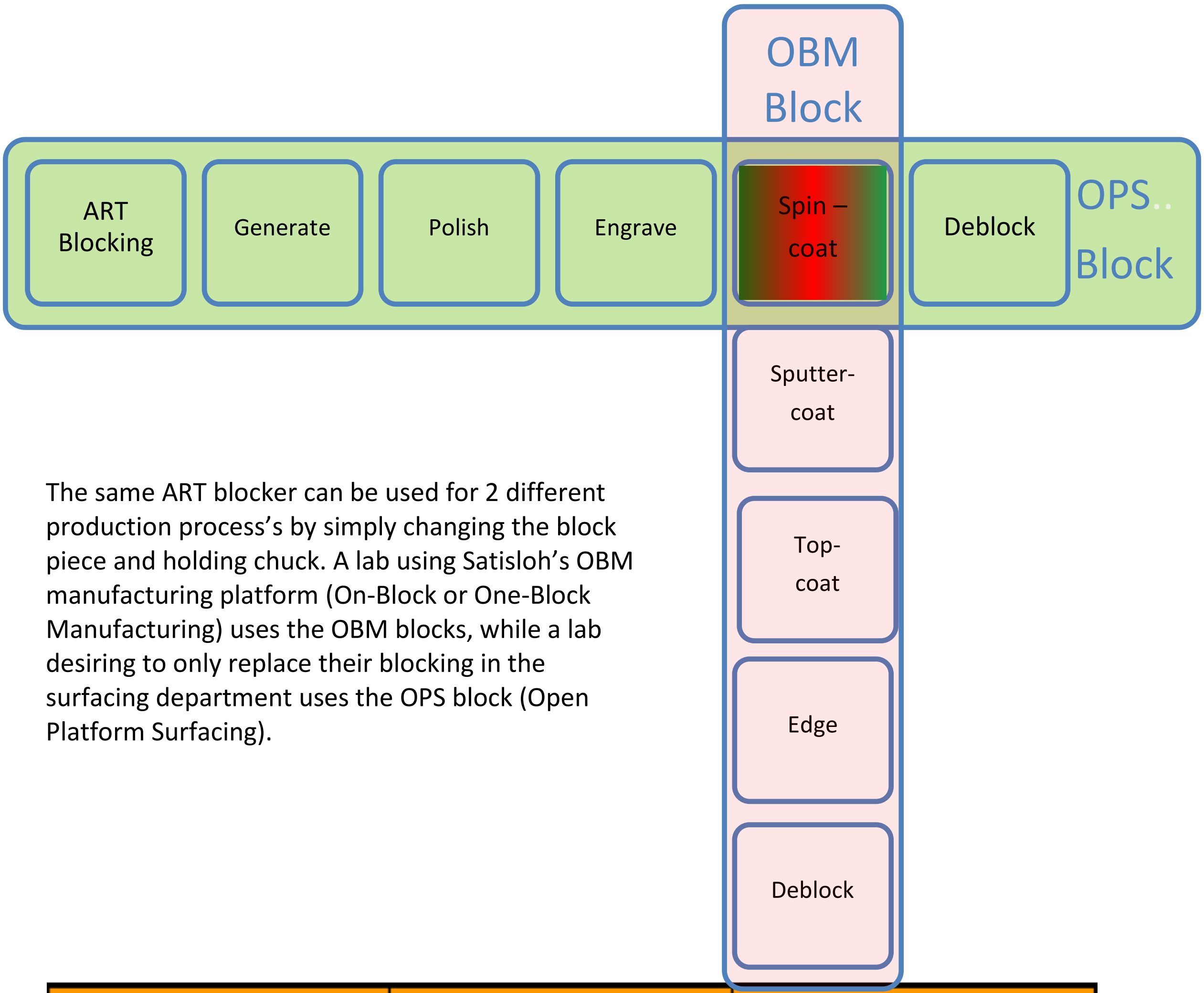
2.1.2 OBM process

As a specific version for the Alloy replacement a so called OBM-block piece (On-Block Manufacturing) is available. The OBM-block is designed as part of the so called OBM line. The feature of such an OBM-line is that only front side coated lenses are blocked. After complete surfacing the lens remains on the block and will be coated (Spin- and AR-coating) on the backside. This requires full support from block to lens to cover and protect the complete front side to avoid pollution during backside coating (Picture 4).

Picture 4: Full support OBM block

Picture 5: OPS Overlap (block smaller than lens)

Beside the different block pieces both processes are almost similar. Differences will be addressed in the specific chapters. However, the focus of this document is the OPS process.



The same ART blocker can be used for 2 different production process's by simply changing the block piece and holding chuck. A lab using Satisloh's OBM manufacturing platform (On-Block or One-Block Manufacturing) uses the OBM blocks, while a lab desiring to only replace their blocking in the surfacing department uses the OPS block (Open Platform Surfacing).

Alloy	OBM	OPS
• Toxic, banned by 2020 • Surfacing only • Uncontrollable price • Metal block • Cool down period • Requires Tape	• **Alloy Free; UV curable adhesive** • Same OBM block in surfacing, coating and finishing. • Block used up to 5x • Only for SL equip	• **Alloy Free; UV curable adhesive** • Same OPS block in surfacing & spin coating • Uses less adhesive • Block Used up to 100x • Works on any equip

3. Consumables for the ART process

3.1 Block pieces

To optimize optical power and to reduce the amount of adhesive there are 5 different block curvatures introduced. Those are 60, 80, 110, 180 and 500mm to cover a working range of plano (0dpt) lenses up to 35mm (15dpt).

Those 5 different blocks have the same diameter which is 65mm for the OPS block piece and 75mm for the OBM block piece. The bigger OBM block diameter is caused by the need to cover and protect the whole frontside of the lens to avoid getting the coating of the backside displaced on the frontside.

The block material is SAN (Styrol-Acryl-Nitril) which is machinable and can be cut down together with the lens to a smaller geometry to give the lens the best support without overlap of lens to block.

Picture 6: OBM block style

Picture 7: OPS block style

3.1.1 Re-use procedure

Both ART block piece versions can be used more than once to save cost and to reduce the amount of waste in the production lab.

OPS block pieces can be used up to 100 cycles. After 100 uses, the mechanical wear and/or reduced ability to pass UV light could lead to reduced lens quality.

OBM block pieces are limited to 5 cycles because of the build-up of process residue which can interfere with the vacuum coating process as well as mechanical wear which will end up in reduced lens quality.

Identification of right block type (curvature)

Five different front-curvatures of the block pieces are available for optimized fit of different blank base curvatures. This blank to block combination defines the space between both curvatures and therefore the volume of the adhesive to fill out this ‘space for maximum lens support. For ‘full support’ application no overlap of final lens diameter to block is allowed. Optimizing the match between the block curve and diameter to the lens blank front curve not only maximized design quality but also minimizes the amount of glue required significantly reducing glue cost.

For the identification of the correct block style a so called ‘cut-off-table’ exists. Table 1 shows which blank base-curvatures will be combined with the different block curvatures. The table can be made accessible in a labs LMS (lab management software) and can be modified by the customer, if needed.

BP base	Text Block	Radius of block	Min r of blank	Max r of blank	Block Diam
1	BP1	500.00	275.001	99999999	75
3	BP3	180.00	130.001	275	75
5	BP5	110.00	85.001	130	75
7	BP7	80.00	67.001	85	75
9	BP9	60.00	30	67	75

Table 1: cut-off table

Determination of the right block diameter

Depending on the specific customer production situation, see Diagram 1, the original block diameter (65mm for OPS or 75mm for OBM) will be reduced by the generator. For best lens support by means of the block the overlap of final lens diameter in relation to the block diameter must be smaller than 4mm therefore, additional block diameters like shown in Table 2 are defined.

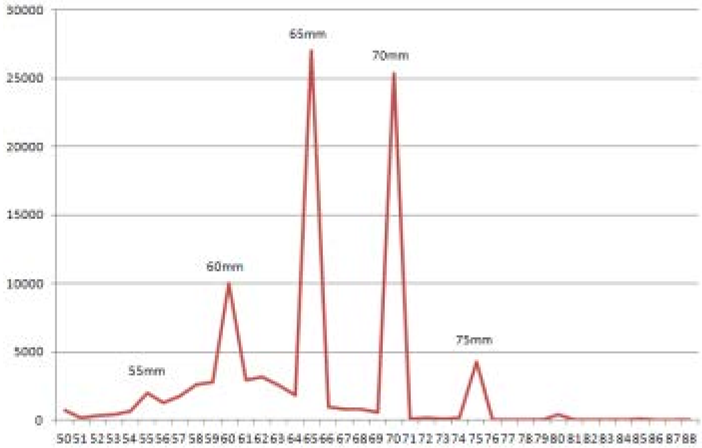


Diagram 1: variation of final lens diameter

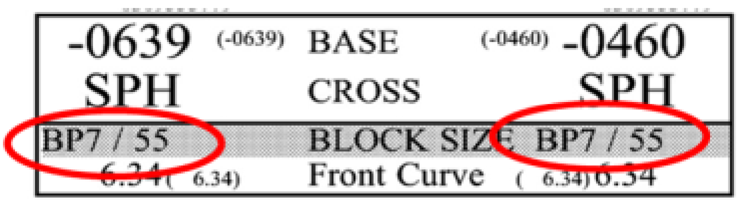
Diameter selection for Block

Min Crib	Max Crib	Diam
00	55	55
55	60	60
60	65	65
65	70	70
70	85	75

Table 2: Block diameter

The lab LMS is calculating the right block-diameter according Table 1 and Table 2

This information about the best diameter (group) and base curvature (block style) will be printed on the job-ticket to give the operator the needed data to put the correct block piece in the job tray.



-0639	(-0639)	BASE	(-0460)	-0460
SPH		CROSS		SPH
BP7 / 55		BLOCK SIZE		BP7 / 55
6.34	(6.34)	Front Curve	(6.34)	6.34

Table 3: Block style and diameter on job-ticket

Scenarios for matching block-blank diameter combination

- Block diameter is bigger than final lens diameter
  Block will be cribbed down during generating process together with the lens. Normal situation for new OBM block pieces. Gives best support. Optimal combination.
- Block diameter is the same as the final lens diameter
  Full support possible. Normal situation for re-use on OPS and OBM blocks.
- Block diameter is smaller than the final lens diameter
  Normal situation on OPS on any lens diameter above 65mm as well as on OBM on lens diameter above 75mm. Cleaning of lens needed. Total amount for overlap of final crib to block diameter depends on customer quality expectations.
  Same situation as in the Alloy-blocking process. Bending issues expected.

Selection scenario (example)
Referring to table 2 the following situation, for a 60mm lens diameter, can occur:
- LMS calculated 60mm as the needed block diameter
  - 60mm blocks are available → Operator takes 60mm
  - 60mm blocks are not available → Operator has to choose the next bigger one which is 65mm. If this is not available he has to choose (only OBM) the 70mm or then 75 mm diameter.

* The most customers accept or do not look for optical power issues on the last 2 mm of the lens.

Live scenarios for OPS block pieces:

- A new 65mm block is used the first time for a
  - 65 to 80mm lens diameter
    - This block stays in group ‘65’ and can be used again for any other lens diameter as long as the maximum amount of usage cycles is not reached
  - 60 to 64mm lens diameter
    - This block moves to group ‘60’ and can be used again for any lens diameter equal or smaller than 60 mm as long as the maximum amount of usage cycles is not reached
  - 55 to 59mm lens diameter
    - This block moves to group ‘55’ and can be used again for any lens diameter equal or smaller than 55mm as long as the maximum amount of usage cycles is not reached
  - 50 to 54mm lens diameter
    - This block moves to group ‘50’ and can be used again for any lens diameter equal or smaller than 50mm as long as the maximum amount of usage cycles is not reached
    -
  - Smaller than 50mm lens diameter
    - This block is smaller than the minimum diameter now and is going to ‘recycling’

Block to Blank combinations

OPS

<table>
<tr><th rowspan="2">Block group</th><th colspan="13">Final lens diameter</th></tr>
<tr><th>66</th><th>65</th><th>64</th><th>63</th><th>62</th><th>61</th><th>60</th><th>59</th><th>58</th><th>57</th><th>56</th><th>55</th><th>54</th></tr>
<tr><td>65</td><td colspan="2">stays in</td><td colspan="10">goes to next smaller group</td><td>no</td></tr>
<tr><td>60</td><td colspan="2">should be</td><td colspan="3">stays in group</td><td colspan="2">stays in group</td><td colspan="5">goes to next smaller group</td><td>no</td></tr>
<tr><td>55</td><td colspan="7">should be avoided</td><td colspan="3">stays in group</td><td colspan="2">stays in</td><td>no</td></tr>
</table>

Usage of blocks if 3 different block diameters are defined (65, 60 & 55mm)

<table>
<tr><th rowspan="2">Block group</th><th colspan="13">Final lens diameter</th></tr>
<tr><th>66</th><th>65</th><th>64</th><th>63</th><th>62</th><th>61</th><th>60</th><th>59</th><th>58</th><th>57</th><th>56</th><th>55</th><th>54</th></tr>
<tr><td>65</td><td colspan="2">stays in</td><td colspan="10">goes to next smaller group</td><td>no</td></tr>
<tr><td>55</td><td colspan="7">should be avoided</td><td colspan="3">stays in group</td><td colspan="2">stays in</td><td>no</td></tr>
</table>

Usage of blocks if two different block diameters are defined (65 & 55mm)

OBM

<table>
<tr><th rowspan="2">Block group</th><th colspan="13">Final lens diameter</th></tr>
<tr><th>71</th><th>70</th><th>69</th><th>68</th><th>67</th><th>66</th><th>65</th><th>64</th><th>63</th><th>62</th><th>61</th><th>60</th><th>59</th></tr>
<tr><td>75</td><td colspan="13">goes to next smaller group</td></tr>
<tr><td>70</td><td colspan="2"></td><td colspan="11">goes to next smaller group</td></tr>
<tr><td>65</td><td colspan="2">should be avoided</td><td colspan="2">stays in group</td><td colspan="3">stays in group</td><td colspan="6">goes to next smaller group</td></tr>
<tr><td>60</td><td colspan="7">should be avoided</td><td colspan="2">stays in group</td><td colspan="3">stays in group</td><td></td></tr>
<tr><td>55</td><td colspan="12">should be avoided</td><td></td></tr>
</table>

Usage of blocks if 5 different block diameter are defined (75, 70, 65, 60 & 55mm)

<table>
<tr><th rowspan="2">Block group</th><th colspan="13">Final lens diameter</th></tr>
<tr><th>71</th><th>70</th><th>69</th><th>68</th><th>67</th><th>66</th><th>65</th><th>64</th><th>63</th><th>62</th><th>61</th><th>60</th><th>59</th></tr>
<tr><td>75</td><td colspan="7">goes to 65mm group</td><td colspan="6">no further re-use possible</td></tr>
<tr><td>65</td><td colspan="2">should be avoided</td><td colspan="2">stays in group</td><td colspan="3">stays in group</td><td colspan="6">no further re-use possible</td></tr>
</table>

Usage of blocks if two different block diameters are defined (75 & 65mm)

Oval block shapes

In principle a block, if cribbed oval or noncircular to the centre, can be re-used to.

- Block can be used according to the b-axis for a round shape with a smaller or same diameter as this short axis. A-axis information needs to be provided to the Blocker as well as to the generator to avoid a ‘crash’ situation.
- Block can be used based on b-axis for an oval shape where the new a-axis is smaller or same as the new b-axis. A-axis information needs to be provided to the blocker as well as to the generator to avoid a ‘crash’ situation.
- If the customer is blocking the same axis all the time, - blocks can be defined as a new blank group and used again for those oval shaped lenses with the same or smaller dimensions on a and b- axis.

Because of the adhesive application procedure where the adhesive is applied in the centre of the block, it is not possible to give an oval cribbed lens - full support by an already oval shaped block even if both dimensions for a and b-axis are the same.

All noncircular shaped blocks are not used for further re-use cycles.

Parameter for ‘end of live’:

- Diameter less than 50mm
- Amount of ‘allowed’ re-use cycles reached (5 for OBM; 100 for OPS)
- Mechanically destroyed e. g. by water jet: chipping, scratches…
- Datamatrixcode no longer readable
- Soiling of block (e. g. polishing slurry) which cannot be removed by washing

3.1.2 Manual reading station

To identify block pieces e. g. after manual Deblocking or cleaning an identifying process is required to make the data for the actual diameter and the amount of use-cycles for the specific block visible to the operator.

The information of the data matrix code will be scanned and the block-information will be requested by the re-use database.

Feedback from the database such base curvature, amount of use-cycles, actual dimensions (a- and b-axis) and to which diameter group the block belongs will be displayed on a screen.

Every Satisloh OBM and OPS block piece has a unique Data Matrix Bar code printed on it that can be read by the ART blocker and de-blocker. Usage database tracks number of uses, curvature and diameter information so that automatic or manual systems can be used to sort or dispose of blocks.

3.1.3 Block piece cleaning

During multiple use-cycles process fluids like polishing slurry or water will dry and accumulate on the block piece and make it difficult to read the data matrix information on the block. In addition the adhesion force to the block is affected.

Therefore a cleaning process is required twice during the lifetime of an OPS block at 34 uses and 67 uses. The re-use database is tracking the number of uses and gives information to the automated Deblocker or to the manual scanning station about the need for cleaning.

See chapter 'Block cleaning' for more information about cleaning procedure and equipment.

3.2 Adhesive

To connect the blank with the block piece holder - an ultraviolet (UV) -curable adhesive is used. The cured adhesive is machinable like the blank and the block piece itself and does not contain any hazardous substances. Toxic waste handling at the end of the lens production is no longer required.

The adhesive is a mixture of different components with an oligomer acrylate as the main component.

Picture 8: Bucket with adhesive

3.2.1 Adhesive curing process

The curing time depends on the thickness of the adhesive layer. The thickness itself depends on the match between the block- and the blank curvature as well as the decentration and prism which might be needed for the specific job. Therefore the curing time differs between 5 and more than 30 seconds.

The operator is protected from exposure to ultraviolet radiation by the Plexiglas cover of the Blocker. No special P.P.E. is required.

4. Software and calculation

4.1 Job-calculation system

Like in the Alloy process, all jobs will be calculated in a system like Rx-pert, Rx-universe or the systems of competitors like Lensware, DVI, Visionstar, and OptiFacts. Because of the different block piece geometries the calculation system has to define the right block and has to take this block-piece data for calculating the relevant labels like _LBLHI or SVAL.

Block hight (BLKCEHI)

Blocktype	Name	BLKRD block (mm)	BLKCEHI OBM block (mm)	BLKCEHI OPS block (mm)
1	BP1	500	10	6
3	BP3	180	6	6
5	BP5	110	6	6
7	BP7	80	3,5	6
9	BP9	60	4,5	6

Table 4: Block height

4.2 Re-use database

To track the lifetime and the actual dimensions of - block pieces a so called re-use database is required. This database is connected to the ART-Blocker and the automated ART-Deblocker and can be connected to the (Satisloh) Generator as well. The re-use database can be used in conjunction with various competitor equipment.

The Blocker sends a request to the reuse database after scanning the data matrix code and identifying the individual serial number of this block.

As - feedback the blocker gets the information about the dimensions of the block (a- and b- axis) and the base curvature. If all data fits the job information the blocker takes the block and continues the process. In case of a mismatch the blocker rejects the block and is offloading the blank and block back into the job tray.
If the maximum number of use-cycles for cleaning or ‘end-of-life’ is reached the automated Deblocker is sorting the block into a specific bin inside the machine. In case of a manual reading station this information will be shown on a screen to give the operator the information about how to sort the block back for further re-use, for cleaning or for ‘end of life-time’.

4.3 Optimized optical power calculation

The ARTAutoBlocker measures base curvatures of any blank. As an option this data can be send back to the LMS system. The actual curvature, which is more precise than the data of the blank supplier, is therefore known in the system. This data can be used to calculate the back curvature to get an improved optical lens power. Option available only for spherical front side lens surfaces.

5. Individual machines and production steps

5.1 Blocking

Satisloh now makes two different non-alloy ART blockers. A manual version for low volume labs, and an automated version for high volume labs.

5.1.1 Automated blocking

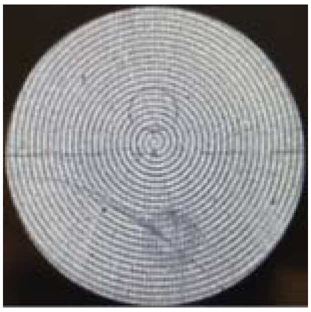
Picture 9: ART-Blocker-A

The blocking process is called ‘spatial blocking’. This means there is no block ring between the block and the blank which gives the geometrical height orientation including prism or decentration during the solidification of the UV adhesive same as for Alloy blocking. The blank is secured by a ‘pick-up-head’ during the curing cycle.

The automated Blocker is able to block all organic lens materials and blank styles like SV, PR, Bifo and Trifo. In addition the Blocker can block up to 5,5 degrees of prism.

Mineral lens materials:

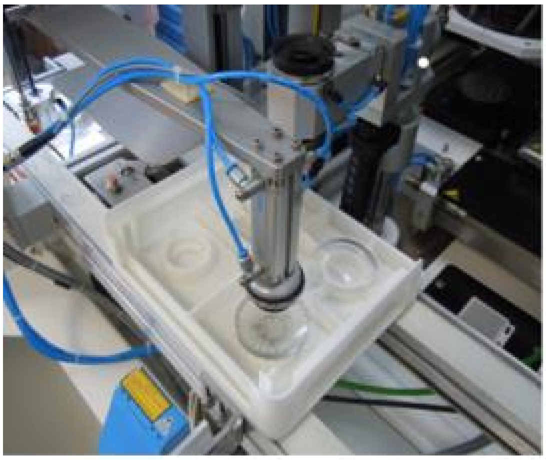
If pattern recognition is needed the quality of the back curvature is important and should not influence the imaging process. Almost all mineral blanks have a strong pattern caused by the mould in a shape of a spiral or parallel lines (see picture 10). Spherical mineral blanks can be blocked.



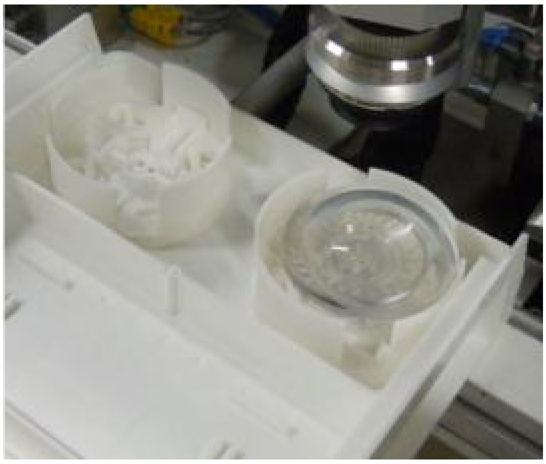
Picture 10: Mineral blank

5.1.1.1 Blank and block-piece supply

An automated production process requires blank and block in the tray. Different options are available to fit the conditions at the customer like ‘block in tray’, shown in picture 11 and ‘blank on block’, shown in picture 12. In the first version (block in tray), the block is located in the rear part of the tray by a special insert fits either OBM or OPS block and a transfer loader inside the blocker moves the block over from this position to the opposite side of the tray where the blocker can pick it up. The second option uses a different tray insert, the block piece is located below the blank in the same location currently used in an alloy process. The benefit of this ‘blank-on-block’ loading option is that the rear part of the job tray stays free and customers can still use this area for putting frames or work tools in the tray.   Blocks can be loaded in the tray up room as operators load blanks into the trays. SL also makes available a pick to light system to assure that tray up personnel load the right blocks into the tarys. It should be noted that SL will introduce an automated block loading system in early 2016.



Picture 11: Full support OBM block



Picture 12: OPS Overlap (block smaller than lens)

5.1.1.2 Job identification

Similar to the Alloy process the blocker scans the job ticket and requests the job data from the LMS system. If valid feedback is received from the LMS, the blocker takes the job data and the automated blocking process will start.

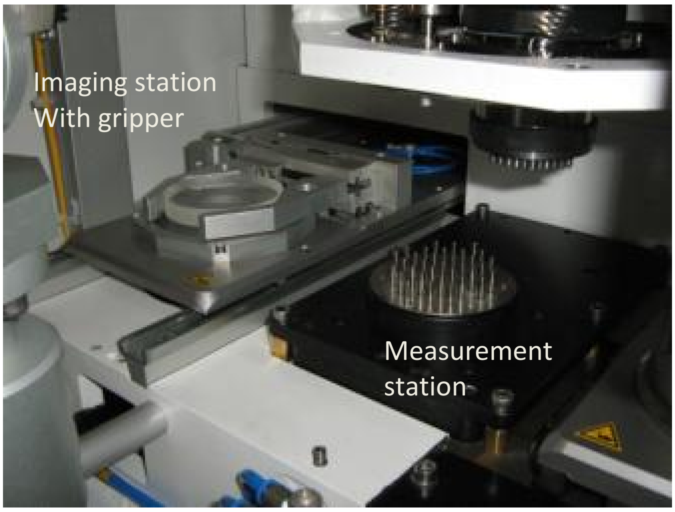
If the job data is not valid, the job will be automatically rejected by the blocker to minimize lost production time.

5.1.1.3 Blank loading and recognition

The lens blank if transferred from the job tray to the imaging station through the use of an automated loading system.

In the imaging station the blank will be mechanically centered by two gripper arms (left side on picture 14).

If the job requires the machine to take into account axis orientation of the blank – all non SV blanks – the video recognition software takes a snapshot of the pattern visible on the front surface of the blank (see picture 13). This is achieved by using an IR light source in combination with a high resolution camera. The imaging station is covered by a metal shield to protect the operator and to be independent from individual light conditions in the production area.



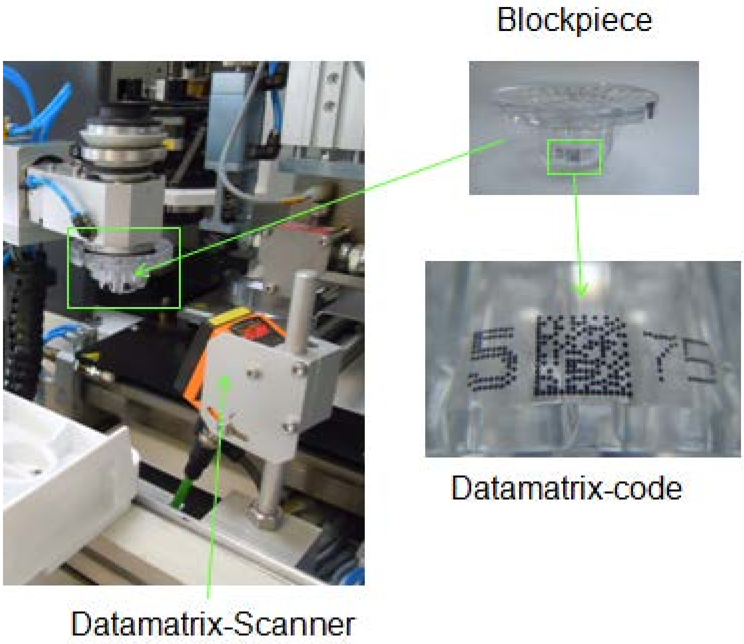
Picture 13: Full support OBM block

Picture 14: OPS Overlap (block smaller than lens)

After successful imaging the next step is measuring the base curvature - By using a tactile process with 33 pins (right side on picture 14) the front side will be touched to get the information about the height profile (geometry of the front side).

5.1.1.4 Block-piece loading and recognition

The block is loaded into the machine while it is recognizing the blank. After the loader takes the block out of the tray the machine is scanning the block data-matrix-code (see picture 15). The information about the block-style and the block diameter is required. It has to fit to the job data (block geometry). The machine compares the information and continues the process if the actual block matches the requirements and rejects both the block and blank if this condition is not met.

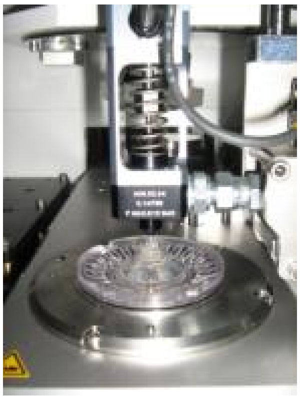


Picture 15: Full support OBM block

5.1.1.5 Adhesive application

The blocker uses the measuring station (right side on picture 14) to determine the correct amount of adhesive to dispense. This is essentially a calculation of the volume of space between the lens blank and the assigned block piece. Factors such as block dimensions and blank dimensions along with prism requirements are used in this calculation. The goal is to minimize the volume of adhesive necessary while maintaining a high level of quality.

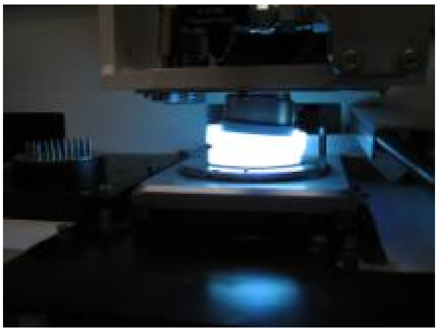
The adhesive is applied directly onto the block using a delivery system which pumps adhesive from a storage container (see picture 16) up to the dispensing valve (see picture 17).



Picture 16: Storage container   Picture 17: Dispensing valve

5.1.1.6 Adhesive curing

To cure the adhesive a LED based UV-light source is used. The light source is in the lower part of the machine under the blocking station. The UV light passes through the block to the adhesive and blank material (see picture 18)



Picture 18: UV curing station

The curing time depends on the thickness of the adhesive and is about 7 seconds per mm. In this particular case note that the lens was lowered onto the block and glue at an angle to block a certain degree of prism. This patented process called spatial prism blocking eliminates the need for prism rings.

5.1.1.7 Job reject

The blocker is looking for valid job data, compares the given data from the job file to the measured data of pattern and base curvature of the blank. In addition the block piece will be identified. In case of any type of mismatch the machine will not block the lens to avoid breakage. This comparison will be done for each lens separately which means that in case of a job with two lenses where only one is rejected the second will be blocked.

5.1.1.8 Off load

In case of a reject the blank and the block piece are transferred back to the tray and the Blocker provides a so called 'bad-job' signal to avoid moving an unblocked lens to the next machine causing an error there.

This signal can be used in different ways.

- The blocker writes the information 'bad-job' back to the LMS and the LMS takes care that the job will not be accepted by any other machine in the production process until the job is not completely done by the Blocker.

- The tray can be stopped at the last stopper and must be taken off by hand. This stops the automated lens production process.

- The signal can be detected by a plug at the blocker to use it for a so called 'off-load-unit' to automatically take the job out of the production process. Such an off-load unit can be a tray-stacker which picks the 'bad-job' or a separate conveyor -.

After feedback from the off-load-unit about taking over the bad-job from the blocker, the blocking process continues.

5.1.2 Manual blocking (machine being released in fall of 2015)

The manual Blocker is able to block all organic lens materials and blank styles like SV, PR, Bifo and Trifo. Beside this the Blocker can block prism of 1, 2, 3, 4 or 5 degree but unlike the automated blocker, this machine does require the use of prism rings. A manual blocker is perfect for a small volume lab (less than 150 j/d) or as a complement to the ART autoblockers for out of range jobs.

Mineral lens materials:

If pattern recognition is needed the quality of the back curvature is important and should not influence the imaging process (almost all mineral blanks have a strong pattern caused by the mould in a shape of a spiral or parallel lines). The operator is able to differ the unwanted pattern on the backside and the needed pattern on the frontside and do the axis adjustment in the right way.

Picture 19: ART-Blocker-M

5.1.2.1 Job identification

By manually scanning the job-ticket the Blocker requests the job data from the LMS system and displays the relevant job data on the screen.

Relevant job data for the operator are: block-style, block-diameter, block ring, prism axis.

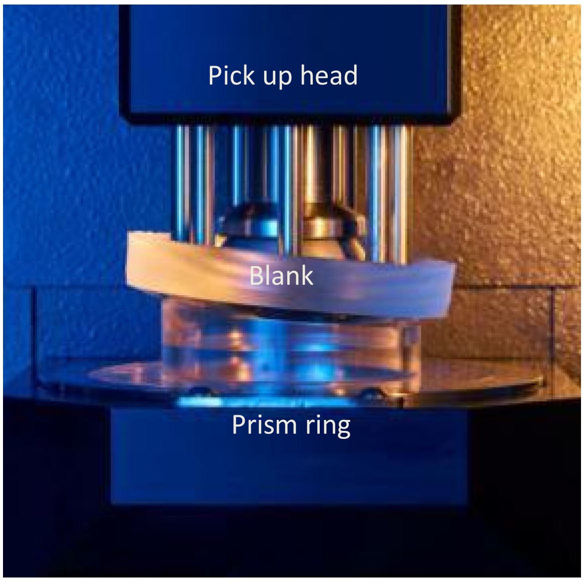
The operator can setup the manual blocker as a stand-alone unit if no LMS system is available. In addition to the information below, the machine needs input data of blank-style and blank-diameter.

5.1.2.2 Block rings

The manual Blocker does not measure the front curvature of the Blank. Block rings will be used to give the blank the needed height orientation including prism and decentration (see picture 20).

There are 6 different block rings available with 0°, 1°, 2° 3° 4° and 5° of prism.

The insertion of the block ring is the first step in manual blocking.



Picture 20: Full support OBM block

5.1.2.3 Blank loading and recognition

The blank will be taken manually out of the tray and placed on the block ring. If the job requires the need to control the axis of the blank – all non SV blanks – the machine displays a live image of the lens blank. The image is displayed on the screen. The blank can be moved to the correct position and orientation manually to align with the specific markings displayed by the image recognition software.

5.1.2.4 Block loading and recognition

The block will be taken manually out off the tray and placed into the block reception.

The operator has to control the block-style and the block diameter.

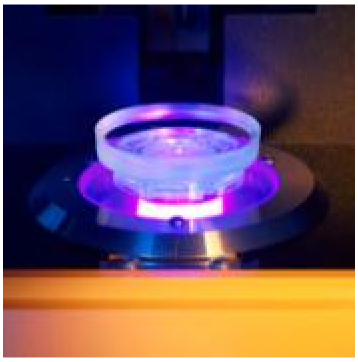
5.1.2.5 Adhesive application

The blocker is calculating the correct amount of adhesive in regards to the space between blank and block (same as the automated process).

The adhesive comes from a metal bucket using a so called drum pump outside the machine (same as automated process).

5.1.2.6 Adhesive curing

To cure the adhesive a LED based UV-light source is used -. The light source is in the lower part of the machine under the blocking station. The UV light passes through the block to the adhesive and blank material (see picture 21).



Picture 21: Full support OBM block

The curing time depends on the thickness of the adhesive and is about 7 seconds per mm.

5.2 Generating

OPS block pieces can be used with generators without any adaptation. It has the same geometry as the Alloy-block piece. The only exception is an additional axial beam in the collet chuck of the generator for the Alloy process. This axial beam is sometimes used to avoid a 180° axis loading error due to an operator putting the lens in the tray using the wrong orientation in the . Such an axis beam is not needed for the ART process but can cause errors in a mixed production mode if Alloy and ART blocked lenses will be generated in the same Generator.

The geometry of the OBM block piece is different to the Alloy block piece. Because of this difference a special clamping chuck is needed for the generator.

If an Alloy blocked lens must be generated in a generator with the clamping chuck for OBM, special Alloy block pieces are needed.

5.3 Polishing

ART does not generally require any different parts in the Polisher or a special polishing process.

For the Polisher Duo-Flex in combination with OBM lens production lines an optimized washing station (02-061-408) is mandatory to avoid contamination of the COB-coating module. This washing option is recommended for all ART installations if automation is the focus.

5.4 Engraving

ART does not require any different parts in the engraving process.

5.5 Deblocking

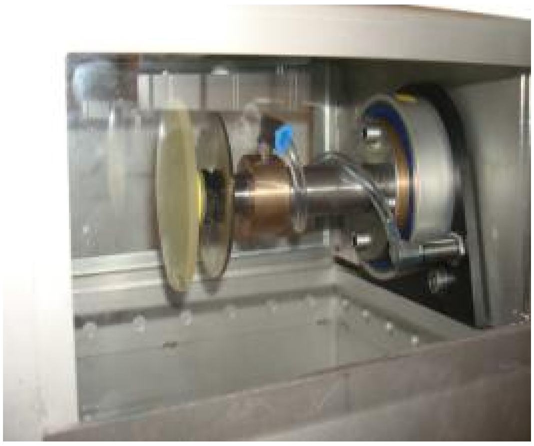
Deblocker is available in either manual or automated version to fulfill different customer requirements worldwide.

In contrast to the Alloy process it is possible block a blank with a smaller diameter than the block (or better than the block ring). Because of the specific conditions in the deblocking process the final lens diameter has to be bigger or the same as the block diameter.

5.5.1 Automated Deblocking

Picture 22: ART-Deblocker-A

The automated Deblocker separates block piece, lens and adhesive by using a high pressure water beam with about 150 bar water pressure (picture 23, 24).



Picture 23: Deblocking chamber

Picture 24: Deblocked lens

A 40 liter water-tank is inside the Deblocker. A high-pressure pump is located in a movable housing outside the Deblocker.

After successful deblocking, the lens will be put back in the job tray, the block piece will be sorted according to block-style and block-diameter into 12 different bins inside the Deblocker (see picture 25). The adhesive stays in a mesh in the machine as well for disposal at a later time.

Picture 25: ART-Deblocker-A

The lens will be blown off on both sides by using an air-knife system (see picture 26). Small amounts of water can remain on the lens after the drying process is done. The lens is not clean enough for an optical and cosmetic inspection or coating. It is recommended to do an visual inspection including cleaning straight after deblocking to avoid water spots on the lens surface, to separate lenses which could not be deblocked and to peel of adhesive residues which sometimes stays on the lens.

Picture 26: Air knife system

To speed up the deblocking process the automated Deblocker is working with warm water with a temperature of 50 degrees Celsius.

Water will be heated up inside the water tank and must be replaced regularly to avoid contamination of the lens because of glue particles in the water. Replace the water manually or after a specific amount of deblocking cycles has been reached.

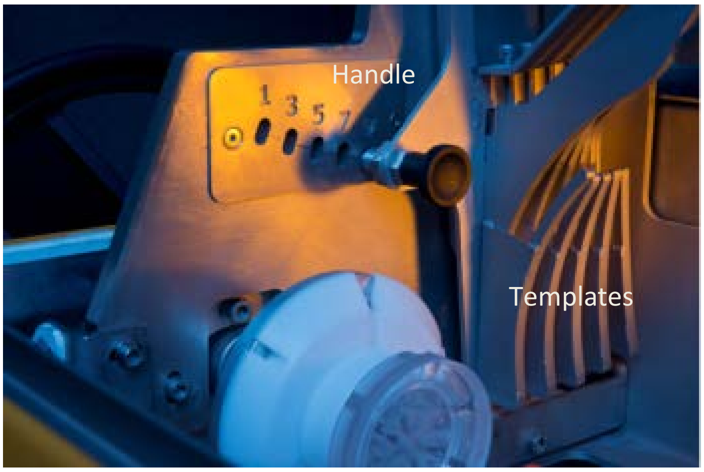
5.5.2 Manual Deblocking

Picture 27: ART-Deblocker-M

The manual Deblocker separates lens and block by using a high pressure water beam with about 150 bar water pressure. A 60 liter water tank is mounted on a movable slide-in cart inside the Deblocker along with the high pressure pump.

Depending on the blank material or front side coating the adhesive stays either on the blank or on the lens and must be peeled off by hand.

Regarding the five different block-styles the operator has to select the right template inside the Deblocker by a handle (see picture 28).



Picture 28: Handle and templates

The water must be replaced regularly to avoid contamination of the lens due to glue particles in the water. Replacing water is done manually.

6. Peripherals

6.1 Manual scanning station

Picture 29: Manual reading station

On multiple process steps like, matching block pieces and blanks for the job, sorting back after manual Deblocking or cleaning the block piece, identification of a block piece is needed.

This manual scanning station consists of a block piece adapter with an integrated scanner, a computer and a screen.

After scanning the data-matrix code on the block the information about the block-style, the block-diameter, the diameter group the block belongs to and the use-cycles are shown on the screen. In addition the correct bin for sorting back will be shown as well.

This station is also able to scan the bar-code on the job ticket. In this situation the information about the needed block data like block-style, block-diameter and the diameter group the block belongs to are shown on the screen. In addition the bin of where to pick the block piece will be shown as well.

6.2 Block sorting system

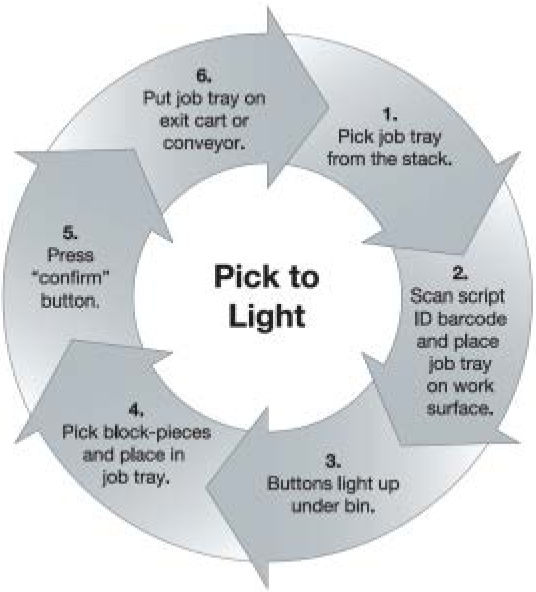
The functionality of the 'manual reading station' is implemented in a block piece sorting and a block piece identification system, developed by NCC, to make the Tray-up at the job assembling area or the identification for further re-use after deblocking or cleaning more convenient. Those systems are able to manage 12 different block styles, like described at chapter 3.1.1

6.2.1 Pick to light for job assembling

Picture 30: Pick to light station

Picture 31: Bin identification

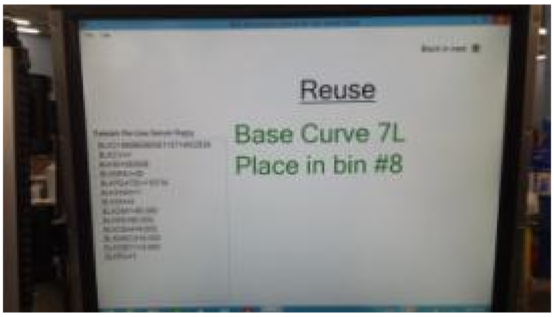
In the assembling, or tray-up, area a PTL (pick to light) system stores the block pieces for job-assembly. After scanning the barcode on a job ticket the job information will be shown on a screen and in addition buttons light up under the bin where the right block is in (see picture 31). After pushing the confirmation button the system is ready for the next assembly. PTL process flow is shown in picture 32.



Picture 32: Manual reading station

6.2.2 Sort to ID for block re-use

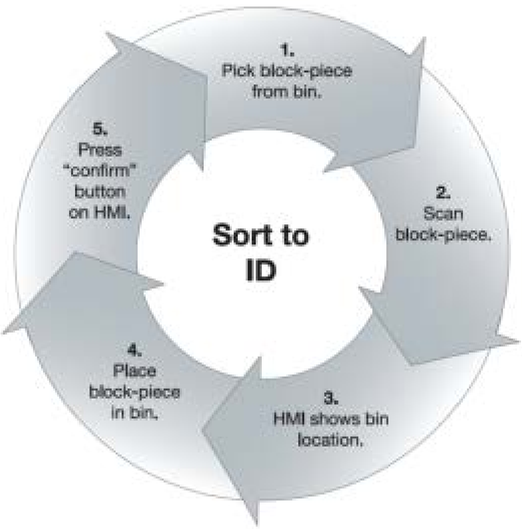
Picture 33: Sort to ID station



Picture 34: Bin identification

After deblocking or cleaning the blocks can be identified by a S2L (sort to ID) system. This system offers the opportunity to let the block dry before they can be used again.

After scanning the QR-code on the block the information about which bin this block belongs to is shown on a screen (see picture 34). S2ID process flow is shown in picture 35.



Picture 35: Manual reading station

6.3 Block cleaning

Picture 36: Ultra sonic block cleaning station

To clean block pieces an ultrasonic cleaning bath like Satisloh's SW-12 (Article 01-050-477) with a portion of 3% of cleaning agent OP164 (Article 92-000-121 or 92-000-179) and a 10 minute cleaning cycle is sufficient.

The number of block pieces to clean is approx. 11 pieces for one blocker in an 8 hour shift.

In case of adhesive residue on the block, which is more often seen with manual deblocking, this residue must be peeled off by hand before the block can be used again.

If a data matrix code is not readable the block piece must be checked. The area of the data matrix code can be cleaned manually by using light alcohol with a cloth used for manual lens cleaning or simply wiping the block piece off with a finger.

6.3.1 Amount of blocks to be cleaned

How often a block must be cleaned within the life time depends on the situation at the customer like washing process during/after Polishing and water replacement for manual or automated Deblocker. The number of cleaning cycle within the life time of the block can be calculated with the formula below. So far the expected cleaning cycle is 34

$$\left(\frac{\text{maximum } use\ cycles}{cleaning\ cycle}\right) - 1 = Cleaning\ cycle\ within\ block\ life\ time$$

$$\left(\frac{100}{34}\right) - 1 = 3 - 1 = 2$$

How many block pieces must be cleaned each day can be calculated with the formula below.

$$\left(\frac{lenses\ per\ day}{maximum\ use\ cycle * cleaning\ cycle\ within\ block\ life\ time}\right) = Blocks\ to\ clean$$

Example 1:

1 ART Blocker; 70 lenses/hour; 8 hour a day → 1 * 70 * 8 = 560 lenses a day

$$\left(\frac{560}{100 * 2}\right) = 11\ blocks\ to\ clean$$

Example 2:

6 ART Blocker; 70 lenses/hour; 12 hours a day → 6 * 70 * 12 = 5040 lenses a day

$$\left(\frac{5040}{100 * 2}\right) = 100\ blocks\ to\ clean$$

6.4 Lens cleaning

Like in the traditional Alloy process lenses must be cleaned before quality inspection or coating.

6.4.1 Manual lens cleaning

Residue of adhesive and/or adhesive and process water mix which can contaminate the lens surface, can easily be wiped off with a cloth and a light alcohol like isopropyl (IPA) used for lens inspection.

6.4.2 Automated lens cleaning

Picture 37: SCL auto cleaning system

Traditional US- or brush systems can be used to clean the lenses after deblocking. Depending on the specific machine and the additives the customer is working with, a process adaptation might be necessary. Additional cleaning might be necessary if glue residue remains on the lens.

The well known company SCL, located in France, offers a fully automated lens cleaning machine UHP150 which is optimized for the ART process and shown in picture 37. This machine cleans residue from polishing liquids and adhesive remnants. In some seldom cases the glue layer or bigger parts of it can remain on the lens after deblocking. Therefore it is recommended to install a manual inspection between deblocking and automated lens cleaning.

6.4.2.1 Automated cleaning process with UHP150

The UHP150 cleans the already deblocked lenses in 6 steps

Step 1: Polishing removal
Step 2: Tap water Rinsing
Step 3: Adhesive removal
Step 4: Tap water Rinsing
Step 5: DI water rinsing
Step 6: Drying with compressed air

6.5 Off-load-unit

A tray stacker or an additional conveyor belt can be used as an 'offload' unit to pick up jobs which were rejected by the Blocker. For this function the ART-Blocker-A offers a specific plug where the 'reject signal' can be taken in a handshake scenario.

7. Lens production procedure –mixed mode-

The traditional alloy process and the ART process can be used parallel. This makes it possible to use only one LMS or job calculation system. However it is not possible to mix OBM and OPS and Alloy production at the same time. It is either OPS or OBM together with Alloy

7.1 Job calculation

No need to define blocking process during job-calculation!

E. g. RxUniverse is calculating all needed parameters for both blocking processes. If the Job is done at an Alloy-blocker the next machine gets the already pre-calculated information. If the job is done at an ART-Blocker the LMS takes back the blocking information and overrides the relevant labels.

7.2 Job ticket

Both information for ART and Alloy is printed to the ticket. The operator is able to see which OPS/OBM block is the right one and which Alloy block and block ring fits the job.

7.3 Re-use database

The re-use database uses data from our VFT generator to always get the correct information for the block diameter into the database. If the job was done on ART-Blocker the label 'BLKTPY' changes its information as soon as the Blocker writes back the specific labels. The VFT looks to the label 'BLKTYP' and knows if there is a need to send data back (ART) or not (Alloy).

8. Available machine documentation

In Table 5 all available machine documentation is listed.

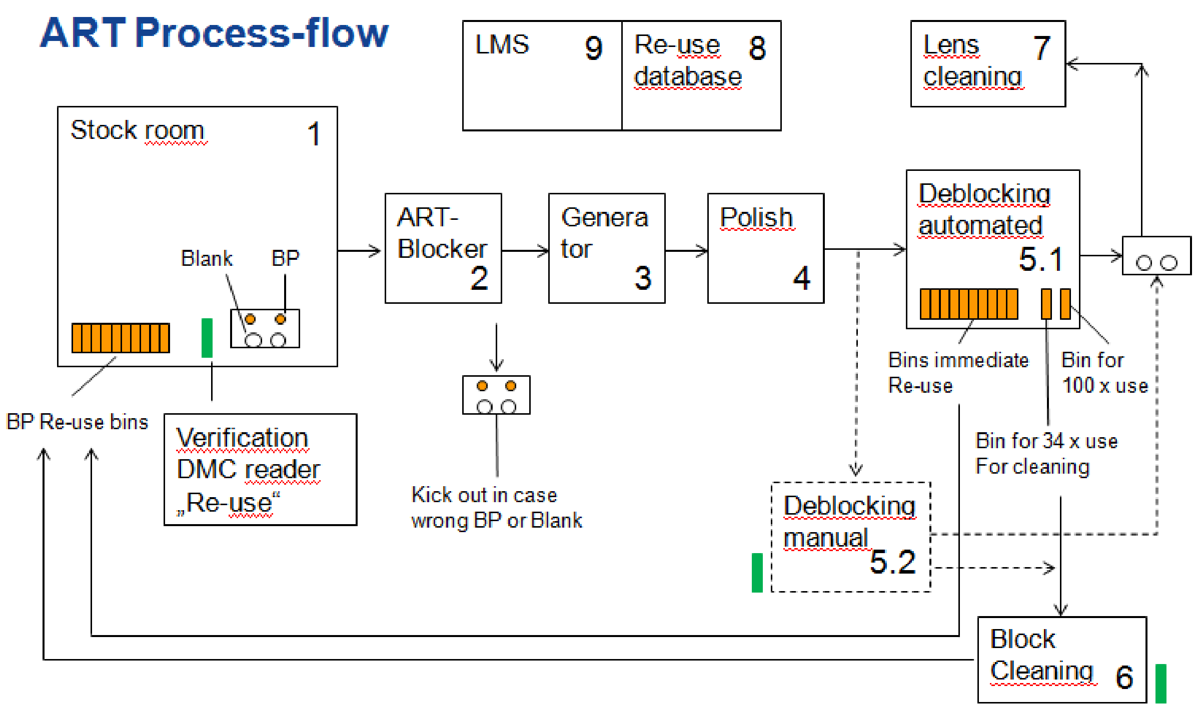
	ART (OPS)				ART (OBM)			
	Automated		Manual		Automated		Manual	
	Blocker	Deblocker	Blocker	Deblocker	Blocker	Deblocker	Blocker	Deblocker
Operation	G	G	G / E	G	(G / E)	G		(G / E / F / S / I)
Spareparts	G / E / F	G / E / F	G / E / F	G / E / F	G / E / F	G / E / F		G / E / F
Transport	G / E	G	G / E	G	G / E	G		(G / E / F / S / I)
Software	(G)	(G)		X	E	G		X
Maintenance	G / E	G / E		G	E	G		(G / E / F / S / I)
Service				G				(G)

Table 5: Machine documentation

G – German E – English F – French S – Spanish I – Italian X – not needed
( ) – preliminary version

9. ART process flow overview

The ART process flow is very similar to the Alloy process, which is a precondition for a replacement purpose.



10. Front side coated blank

The ART process fits coated and uncoated Blanks in general. The benefit of using a coated lens is faster deblocking (manual and automated) as well as less effort on lens cleaning.

11. ART cost comparison to Alloy

Because of the specific conditions at any customer (such as production volumes, labor rates, depreciation schedules, and alloy clean up costs), it is not possible to do a generic cost per lens calculation.

An Excel based calculation sheet is available where various parameters such as depreciation longevity, labor rates and production volumes can be manipulated to come up with a cost estimate.

For more precise comparison please get in contact to Product management (frank.heepen@satisloh.com)