SYSTEMS

3D Systems Inc.

SLA User's Hardware Reference Manual

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Explanatory Notes

The following is a list of symbols, abbreviations, and numerical value expressions found throughout the manual.

Symbols Used in this Manual

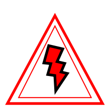
This symbol designates the accompanying texts or figures as a NOTE, <u>CAUTION</u>, or <u>WARNING</u>.

When accompanied by the word "NOTE", the text and symbol are meant to call attention to a practice whose implementation can save time or prevent subsequent inconvenience to the user.

When the symbol is grouped with texts labeled "<u>CAUTION</u>", the intention is to point out a condition or practice otherwise not covered by another type of symbol that presents a hazard to equipment that may be in the immediate area.

If the word "<u>WARNING</u>" is listed with the symbol, the texts highlight a practice or condition otherwise not covered by another type of symbol that presents a hazard to both equipment and personnel that may be in the immediate area.

RADIATION
This symbol is used to warn of the presence of *RADIATION* **from a UV Laser source.**



HAZARDOUS VOLTAGE
This symbol is used to warn of the presence of potentially *HAZARDOUS VOLTAGE*.

Abbreviations

in.	inch
ft.	foot
mm	millimeter
mW	milliWatt
nm	nanometer

Numerical Values

Numerical values are presented in millimeters first, followed by inches in parenthesis.

Introduction

This manual is a comprehensive reference for the Stereolithography Apparatus (SLA) user. It provides background information on the stereolithography process and operation of SLA 3500/5000/7000 equipment (see Figures 1, 2, and 3) to produce stereolithography parts.

Stereolithography Definition

Stereolithography is a three-dimensional printing process that produces a solid plastic model. Using proprietary software, CAD output data is sliced into very thin cross sections. The resulting slice sections are then transformed into files to be used at the Stereolithography Apparatus (SLA) buildstation. A laser generating a small, intense beam of Ultraviolet (UV) light is moved by a computer-controlled optical scanning system across the top of a vat containing liquid resin. The laser draws each layer of the part from the data provided by the build data file.

As the laser contacts the resin, the beam photopolymerizes the resin into a solid. When a layer is completed, an elevator lowers the part deeper into the vat, covering it with resin. Leveling and recoating systems establish the thickness and flatness of the liquid layer. When the resin surface is stable, the laser draws the next layer of the part.

As each layer is drawn, it adheres to the previous layer, creating a solid part. This process continues until the final layer has been drawn. The part is then removed from the SLA, cleaned and illuminated with high intensity UV energy to complete the polymerization process. The part may then be finished by various methods including sanding, sandblasting, painting or dyeing.

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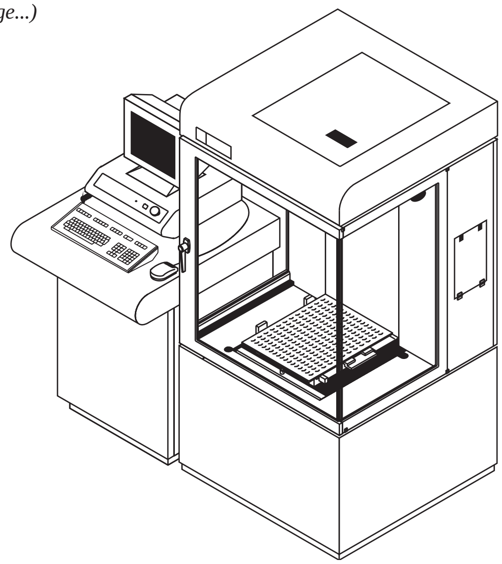

Figure 1. SLA 3500 Stereolithography Apparatus

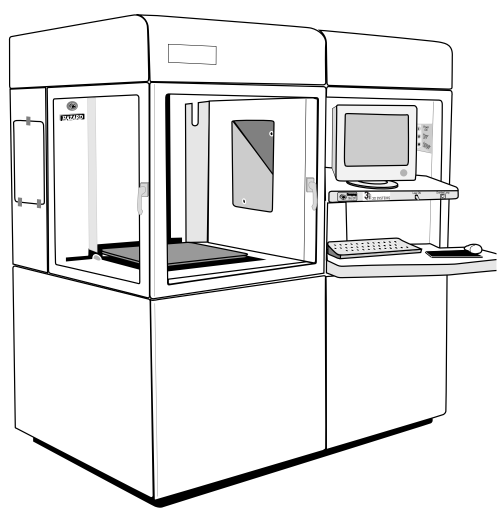

Figure 2. SLA 5000 Stereolithography Apparatus

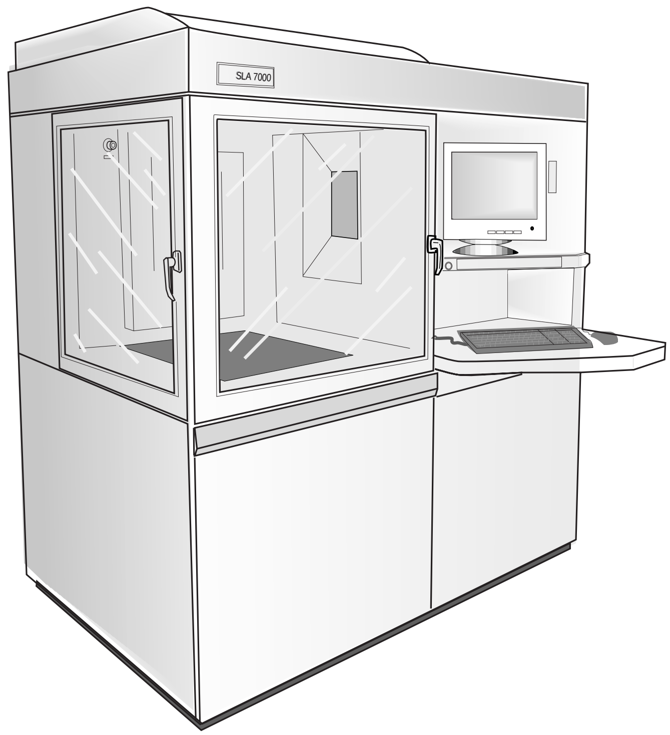

Figure 3. SLA 7000 Stereolithography Apparatus

The Stereolithography Process

There are three major steps in stereolithography, **CAD Preparation, SLA Build Process** and **Post Processing**.

CAD Preparation

CAD preparation includes the CAD Design and the CAD Interface. These two steps take the design image from a three-dimensional CAD image, directly to the 3D Systems' 3D Lightyear File Preparation Workstation Software, which then prepares the specially-formatted computer image files for use in stereolithography (Figure 4).

Figure 4. The Rapid Prototyping Process Wheel

CAD Design

Beginning with an object design, this design must be input into a three-dimensional solid or surface modeling CAD, CAM or CAE (Computer Aided Design, Manufacturing or Engineering) system. The subsequent computer model must represent an enclosed volume which is an object designed as a closed surface.

Solid Modelers

A solid modeler defines a mass having an interior that is completely enclosed and is filled with matter. Solid modelers always define objects that are complete and have continuity. These properties are required for stereolithography.

Surface Modelers

A surface modeler builds a number of mathematical patches or surfaces that, when joined together, form the desired object. Because there is no defined association between these surfaces, it is possible to have gaps, discontinuities or even completely missing surfaces within an object. To use a surface modeler in stereolithography, the object must be designed as a closed surface that unambiguously defines an enclosed volume. That is, the model data must specify the inside, outside and boundary of the object. This is sometimes referred to as "fully surfaced." If this is not done, the build file may lack the interior data needed to correctly create the part.

CAD Resolution

Some CAD systems internally approximate curved surfaces (cylinders, spheres) by polygons or facets. The larger the number of polygons, the more closely the surface is approximated. This results in a smoother curve on the finished part. When coarsely faceted data is used to direct the SLA, these approximations are reflected in the final part. To minimize this effect, the number of polygons used should be increased. As the number of polygons or facets increase, so does the file size.

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CAD Units

For SLA processing the CAD units must be either millimeters or inches.

1 millimeter = .03937 inches

1 inch = 25.4 millimeters

Wall Thickness/Feature Size

The minimum achievable wall thickness and feature size are generally resin and laser beam dependent. The minimum recommended wall thickness or feature size is generally 0.50 mm (0.020 in). Walls or features thinner than 0.50 mm (0.020 in) are achievable under special circumstances. The absolute minimum wall thickness or feature size is the cured line width for a particular resin/laser combination.

CAD Interface

The CAD model must be converted from the CAD internal format to a planar-faceted representation or surface-contour representation for use by the SLA software.

CAD vendors have written interfaces to convert their surfaces or solid models into readable formats for stereolithography. These formats are known as Stereolithography files (STL) or Stereolithography Contour files (SLC).

Classification of STL Files

The STL format is a faceted representation of the CAD model and is comprised of many triangles connected at the vertices. The triangles represent exterior and interior surfaces. The STL format specifies the X, Y and Z coordinates of the three vertices of each triangle and the unit normal for each triangle. The unit normal is used to determine surface orientation (inward and outward facing directions).

The STL file can be either ASCII or binary format. Binary is preferred for disk space and performance considerations. ASCII allows the user to visually examine, edit and print the data in the file.

Classification of SLC Files

SLC files are binary contour representations of the original CAD mathematical data. SLC files consist of successive cross-sections taken at ascending Z direction intervals. These cross-sections are represented by interior and exterior polylines, which are ordered lists of X and Y vertices that begin and end on the same vertex.

The order of the list describes the direction of connecting line segments. The direction of connecting line segments describes the polyline as an interior or exterior boundary.

SLA Build Process

The stereolithography build process contains seven major components: STL Verify, Orientation, Selecting Build and Recoat Styles, Support, Prepare, Build and Post Processing.

- The first step is verification of the STL file to assure the compatibility of the STL file created from CAD design
- The second step is orienting the part so that its supports and surfaces will be placed for the best results
- The third step, is to select the build and recoat styles
- The fourth step, is to create supports for the part
- The fifth step, prepare, includes slicing, converging and creating the build files
- The sixth step is the building of the part
- The seventh and final step is post processing

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Verification

3dverify™ allows a user to **verify only** or **verify and fix** STL files so that they build correctly. Typical flaws that are identified and fixed are:

- gaps between triangles
- overlapping triangles
- redundant triangles
- incorrect normal direction

See the *3D Lightyear File Preparation Software User Guide* for information regarding 3dverify on the workstation.

Orientation

Orientation can be done in CAD or with *3D Lightyear File Preparation Software*. See the *3D Lightyear File Preparation Software User Guide* for more information.

Object orientation for an SLA build should follow the following guidelines:

- Each object must reside entirely in the positive X, Y, Z octant of CAD space.
- The distance between the part and the CAD origin should be minimized.
- The part must be at least 10.0 mm (0.40 in) above the platform for sufficient draining. Supports that are too tall result in longer build times.
- Orient the part to minimize the height of the **build** for a faster build.
- Slanted or sloping surfaces should be minimized. The overlapping layers of these surfaces give the part a stair-step appearance with the thickness of each layer being the height of the step. Orienting a part to rest at a 45 degree angle can minimize the amount of supports needed during a build as the part is more self-supporting, so a trade off decision is necessary.
- Aesthetically important surfaces should be oriented in the X/Y plane. Vertical and upward-facing horizontal surfaces are smoother than downward-facing surfaces.

- The number of curved cross sections drawn in the horizontal plane should be maximized.
- Ensure that the part or parts fit in the build envelope. For the SLA 3500 the size is 350 x 350 x 400 mm (13.8 x 13.8 x 15.7 inches). For the SLA 5000 this size is 500 x 500 x 583 mm (20 X 20 X 23 inches). For the SLA 7000 this size is 500 x 500 x 600 mm (20 X 20 X 24 inches). If the part is too large, it may be sectioned, built in several runs and reassembled during post processing.

The relative importance of each of these factors depends on the user's objectives in building the part.

Selecting Build and Recoat Styles

Selecting build and recoat styles for an SLA 3500/5000/7000 is done at a workstation. See the *3D Lightyear File Preparation Software User Guide* for complete information.

Support

Supports are created using 3D Systems' *3D Lightyear File Preparation Software*. For automatic support generation, see the *3D Lightyear File Preparation Software User Guide* for information. Supports perform the following functions:

- Separate the object from the platform so the part is easily removed for post processing
- Anchor the part firmly to prevent it from floating
- Prevent part distortion during the build

Prepare

Preparation for building parts on an SLA 3500/5000/7000 is done at a workstation and involves slicing, converging, and creating the build file. Selecting the resin shrink factors and the number of copies for a given build file is done at the buildstation with the *Buildstation Control Software*. See the *3D Lightyear File Preparation Software User Guide* and the *Buildstation Control Software User's Guide* for complete information.

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Build

Building is the process where the solid part is produced by the laser beam as it draws over the surface of the liquid resin. This is done entirely on the SLA.

Prior to building, the platform is installed and the build options are selected. Build files created at the *3D Lightyear File Preparation Software* workstation and the *Buildstation Control Software* are used by the control computer to operate the SLA during the build.

The workstation data are in build (BFF) files; SLA hardware and software are initialized in the build. Buildstation data includes resin shrink factors, number of copies and user defined build options.

Before the build takes place, the system verifies the resin level in the vat. If the resin volume is too low, more resin must be added. This is done for the SLA 3500, SLA 5000 and SLA 7000, if the Resin Refill System is being used. If the resin volume is too high, resin must be removed by the user. When the resin is near the correct level, an automatic leveling system performs fine adjustment.

The laser power is read to set the scan speed of the laser beam movement during the build. At a given power, the speed primarily affects the depth, and to a lesser degree, the width of resin solidification.

The laser draws the first few support cross sections which adhere to the platform. After each layer is drawn, the elevator dips the solidified cross section below the surface, coating the cross section with resin. After drawing a number of support layers, the first part layer is solidified.

The elevator then places the part approximately one layer thickness below the resin surface and the recoater blade then makes a sweep before the next layer is drawn to apply a fresh coating of resin to the part.

Then the laser draws the second layer of the part. As the second layer is drawn, it becomes firmly attached to the first. This process is repeated until all layers have been drawn to form the three-dimensional object. The laser power and position is read between layers to ensure correct layer to layer adhesion and registration.

The SLA is designed for continuous operation and can operate while unattended. When the last layer has been drawn, the completed part is raised above the resin vat. The building time is logged into a history file and the laser is powered off.

Post Processing

After the part has been built it requires post processing. This includes cleaning and ultraviolet (UV) post curing. It may include final finishing.

Cleaning

First, the liquid resin is allowed to drain back into the vat from the part and platform. Often, tilting the platform improves the drainage. Then the platform, with the part still attached, is removed from the SLA process chamber and the remaining excess liquid is removed by various cleaning methods as described in the section, *Post Processing* later in this manual.

Ultraviolet (UV) Post Curing

UV post curing further solidifies the completed part. The cleaned part is cured by exposure to UV light in a 3D Systems Post Curing Apparatus (PCA). Usually the part is removed from the platform and the support structure is removed from the part before UV post curing. (For more information refer to the *PCA User Guide.)*

Finishing

Final finishing may include sanding, sandblasting, polishing, buffing, painting or dyeing.

Theory

Laser Concepts

The word laser is an acronym for Light Amplification by Stimulated Emission of Radiation. A laser produces a beam of coherent light (all component waves are uniform and in phase). The SLA 3500, SLA 5000 and SLA 7000 use a solid state UV laser to draw vectors on photo-curable resin, to form hard plastic parts. UV light is invisible to the human eye.

Solid State Laser

The solid state laser capitalizes on the unique properties of certain elemental crystals to generate an ultraviolet laser beam.

A power supply in the central module supplies current to the diode bar. This bar is an array of infrared diode lasers that aim their light into a fiber optic cable.

Light emerges from the fiber into the first part of the laser cavity. At the heart of the laser cavity is a Neodymium-doped Yttrium Vanadate crystal ($Nd{:}YVO_4$). The infrared laser beam pumps atoms in the crystal into an excited state. The $Nd{:}YVO_4$ laser then emits a different frequency of infrared light.

The $Nd{:}YVO_4$ laser has another crystal known as the Q Switch. This crystal acts as a light diffracting device. While this suppresses the lasing in the laser cavity, the $Nd{:}YVO_4$ crystals continue to increase in excitement.

When light is allowed to pass straight through, a short pulse of high-intensity infrared laser light is released. These pulses last 10 billionths of a second.

The pulsing bursts next pass through an Acousto-Optical Modulator (AOM). The AOM is a diffracting device configured to control the laser power and can also act as an on/off switch. The device directs the laser either into or away from the focal path. Only when the beam is directed into the focal path will the laser light reach the SLA build chamber.

Polymerization - Liquid to Solid

Stereolithography depends on polymerization, the conversion of liquid polymer into a solid. When this process uses an exposure to light as the needed energy source, it is called photopolymerization. Actinic exposure refers to the amount of light needed to cause the reaction. The degree to which polymerization occurs, and thus the level of solidification of the material, is dependent on the total absorbed light energy.

The polymerization of resins is not a new technology. It has been used in such applications as UV inks, coatings, varnishes and printed circuits for more than twenty year, The use of lasers as the actinic radiation source is a more recent innovation and the use for generating three dimensional objects is even newer.

Photopolymers

The photopolymers used in stereolithography are composed of two basic materials. The first is a photoinitiator that absorbs the laser energy and forms reactive radical or cationic species which initiate the polymerization process. The second is acrylic or epoxy functionalized monomers and oligomers, that polymerize upon exposure to either a free-radical or cationic species. In general, acrylic and epoxy monomers are polymerized by free-radicals and cations, respectively.

Stereolithography resin photoinitiators and monomers have excellent thermal stability at room temperature. The recommended temperature for part building is usually 28° C (82° F) Prolonged exposure to heat in excess of this can deplete the resin stabilizers and lead to a less controllable polymerization process.

CAUTION!
Please refer to the *Resin Handling and Safety Guide* (p/n 18439-M15-02 Rev. A) for information on how to care for resins.

Discussions of photopolymers and the photopolymerization process in user guides and resin manuals are brief. Detailed information can be found in *UV Curing, Volumes I and III*, S. Peter Pappas, Editor, Science and Technology Marketing Corp., Norwalk, Connecticut (1980).

More specific discussions of photopolymers for Stereolithography can be found in Chapter 2 of *Rapid Prototyping & Manufacturing, Fundamentals of Stereolithography* by Dr. Paul F. Jacobs, Society of Manufacturing Engineers, Dearborn, Michigan (1992).

Photopolymerization Process

The events in the photopolymerization process are explained in the following section, and are shown in Figure 5.

PHOTOINITIATORS

PI ————————> PI*

PRIMARY RADICALS OR CATIONS

ACRYLIC: PI* ——> RD   NOTE: RD = FREE*RADICAL
EPOXY: PI* ——> R+   R+ = CATIONS

POLYMER CHAIN

ACRYLIC: RD —M—> RMD —M—> RMMD ——— > > > ——— > ACRYLIC

Figure 5. Photopolymerization Process.

Photoinitiators

Photoinitiator (PI) molecules absorb actinic UV radiation from the laser and are converted to an excited state PI*. This short-lived, high energy species quickly relaxes to a lower energy excited state.

Primary Radicals or Cations

The excited PI* molecules catalyze formation of one or more (generally one) highly reactive species called primary radicals (**R●**) or cations (**R^+**), with the formation reaction and number dependent on the specific photoinitiator used.

Polymer Chain

The primary radical or cation then reacts with an acrylic or epoxy monomer (M) to form a new reactive species (**RM●**) or **RM^+**). This starts a chain propagation process (polymerization) in which the reaction is repeated over and over again to form a polymer chain involving many monomers.

Solidification

The polymer quickly increases in molecular weight until the viscosity increases to the point where the material is essentially a solid. The polymerization reaction slows down and eventually stops as the available monomer concentration decreases in the exposed regions. The polymerization reaction within the irradiated region continues for a prolonged period for epoxy resins. For acrylate resins, the reaction stops almost immediately after the actinic exposure is terminated. The overall dimensions of the solid polymer, formed when a UV laser is focused on the surface of a photopolymer, are controlled by the irradiance of the laser beam and the period of exposure. A longer exposure or increased laser power increases the depth and width of the solidified region.

Epoxy resins used for stereolithography are designed so the polymerization, and thus solidification, stays localized. This polymerization does not extend substantially beyond areas that are exposed with actinic laser photons. This characteristic property allows the generation of parts with extremely high definition and resolution.

Influencing Factors

A relatively small change in temperature can cause a large change in the viscosity, volume of resin and resin curing characteristics. Higher temperatures and reduced viscosity result in a thinner liquid that settles faster during dipping and drains faster during post processing. Higher temperatures also result in more voids or dimples, increased swelling and decreased green strength. The best results are obtained by working within the temperature range specified for a given resin.

Creating Solid From Liquid

Bullets

During the build process, a stationary UV laser beam focused on the surface of the photopolymer solidifies (cures) a small volume of liquid into the shape of a bullet (Figure 6).

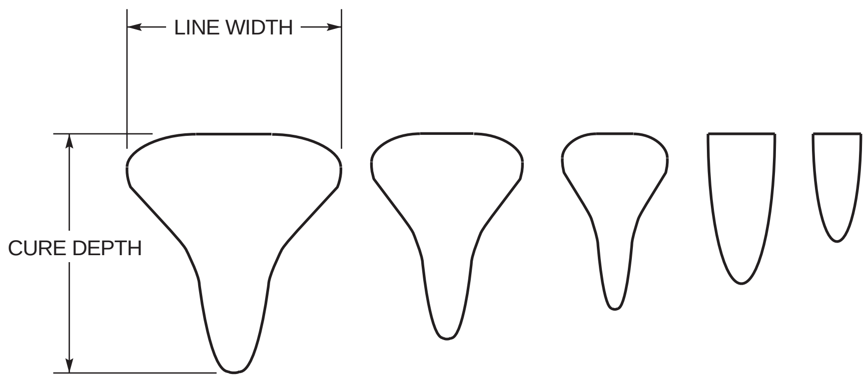

Figure 6. Plastic Bullet Shapes

The intensity profile of the laser beam varies from point to point with the maximum intensity near the center of the beam. As the laser beam strikes the surface, a quantity of light is absorbed (polymerizing the liquid) while a portion is transmitted to the liquid below it. The overall dimensions of the cured resin are determined by how much laser energy enters the liquid. This quantity of laser energy is the exposure.

Since the degree of polymerization is proportional to the amount of light absorbed, the surface area of the resin is more solid than the area below the surface, which hardens in proportion to the amount of light energy absorbed.

Cure Depth

The depth of the cured plastic increases as the exposure of light source increases. This exposure varies across the width of the laser beam since the beam cross sections are not uniform (Figure 7). The center of the beam cures to the greatest depth because it is the area of highest energy. The surrounding areas cure to lesser depths. The maximum solid depth achieved after laser exposure is known as the cure depth.

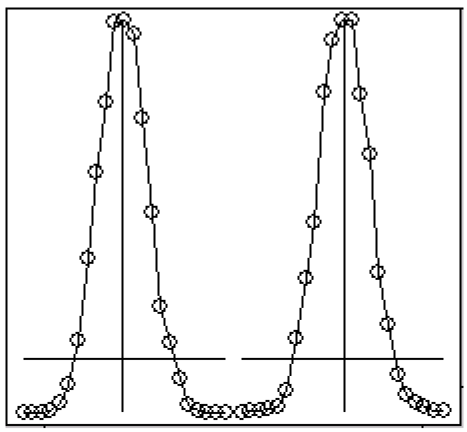

Figure 7. Laser Beam Cross Sections.

Stereolithography uses two values when defining cure depth: layer thickness and overcure. Layer thickness and overcure are specified by the user prior to slicing. (For additional information, refer to the *3D Lightyear File Preparation Software User's Guide*). Overcure is the amount of cure applied over or under the layer thickness. Border and hatch vector cure depth is the summation of the layer thickness and overcure amount. The cure depth of fill vectors is specified independently of layer thickness. Skin fills are used to fill in upfacing or downfacing horizontal surfaces. They are not used to bond layers together.

Bonding and Overlap

To adhere or bond the top layer with the previous one below it, the cure depth must be greater than the slice thickness by a layer overlap or overcure factor. This overlap value is the overcure amount (Figure 8).

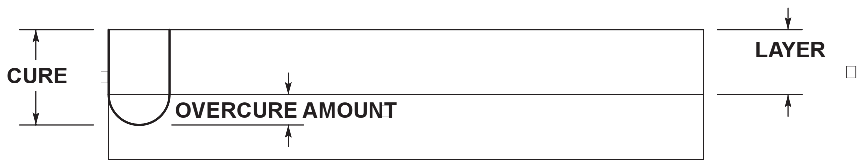

Figure 8. Layer Overlap Example

Layer-to-layer bonding occurs when the UV light of the laser, while curing the current layer, penetrates into to the previous layer. This forms a chemical bond between the lower layer and the newly formed top layer.

Strong layer-to-layer bonding, created by the required overlap, is needed to build strong parts. Excessive overlap may cause internal part stress and curl.

The Recoating Process

The recoating process combines elevator and recoater blade movements to apply liquid resin to the top of the part so the next layer can be built.

Zephyr™ Recoating Process

The Zephyr Recoating System is an improved type of recoater used on the SLA 3500, SLA 5000 and SLA 7000 systems. A reduced pressure reservoir within the blade holds a supply of resin. After each layer is drawn, the elevator dips the part approximately one layer thickness deeper into the resin vat. The Zephyr sweeps over the part, applying a one-layer-thick coat of resin on the previous layer. The SLA pauses briefly for the resin surface to stabilize and then begins drawing the next layer of the part. Figure 9 shows the recoating process with the Zephyr Recoater.

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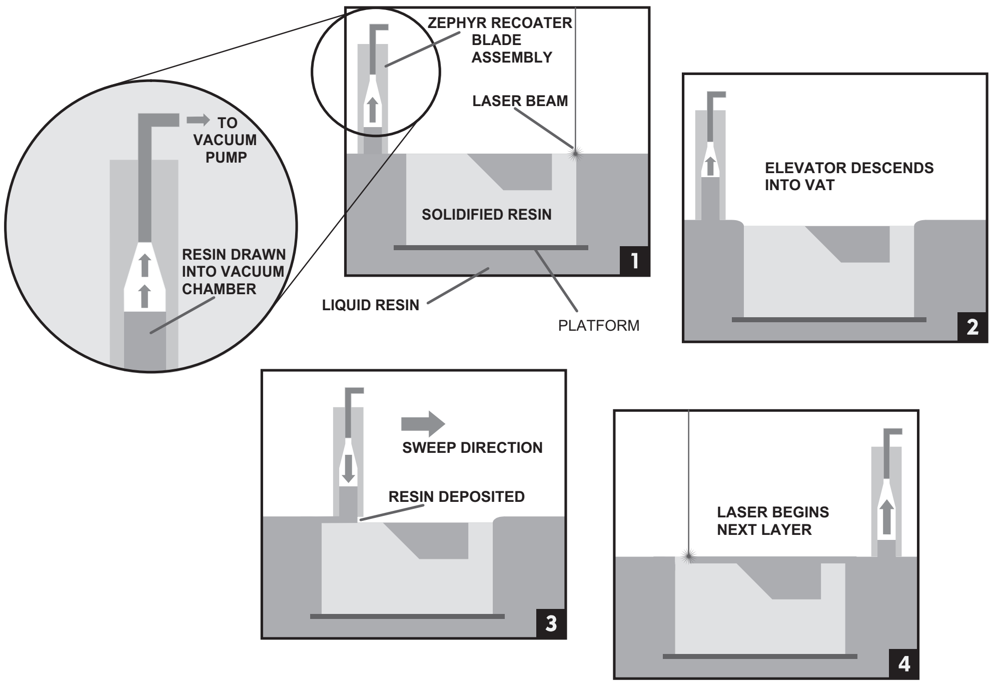

Figure 9. Zephyr Recoating Process.

SLA Hardware

Introduction

SLA Hardware focuses on the various components and systems which comprise an SLA. This chapter is presented in three main sections: System Components, Basic Operator Safety and Power Up Procedures. These sections provide a basic understanding of the SLA and its hardware. It is important to remember that not all component or system descriptions are applicable to all SLAs.

The following sections discuss the various components and systems used to control the SLA while building parts. For further understanding refer to the corresponding figures.

The three types of SLA machines discussed are:

- The SLA 3500 (Figure 10)
- The SLA 5000 (Figure 11)
- The SLA 7000 (Figure 12)

System Components

Power Supply

Power to the SLA is provided through a single power cord located at the rear of the system. The power supply is 200-240 VAC ± 10%, 50/60 Hz, single phase, 15 or 20 amps. Refer below for the specific configurations.

SLA 3500: 200-240 VAC, 50/60 Hz, 1 phase, 15 amps

SLA 5000/7000: 200-240 VAC, 50/60 Hz, 1 phase, 20 amps

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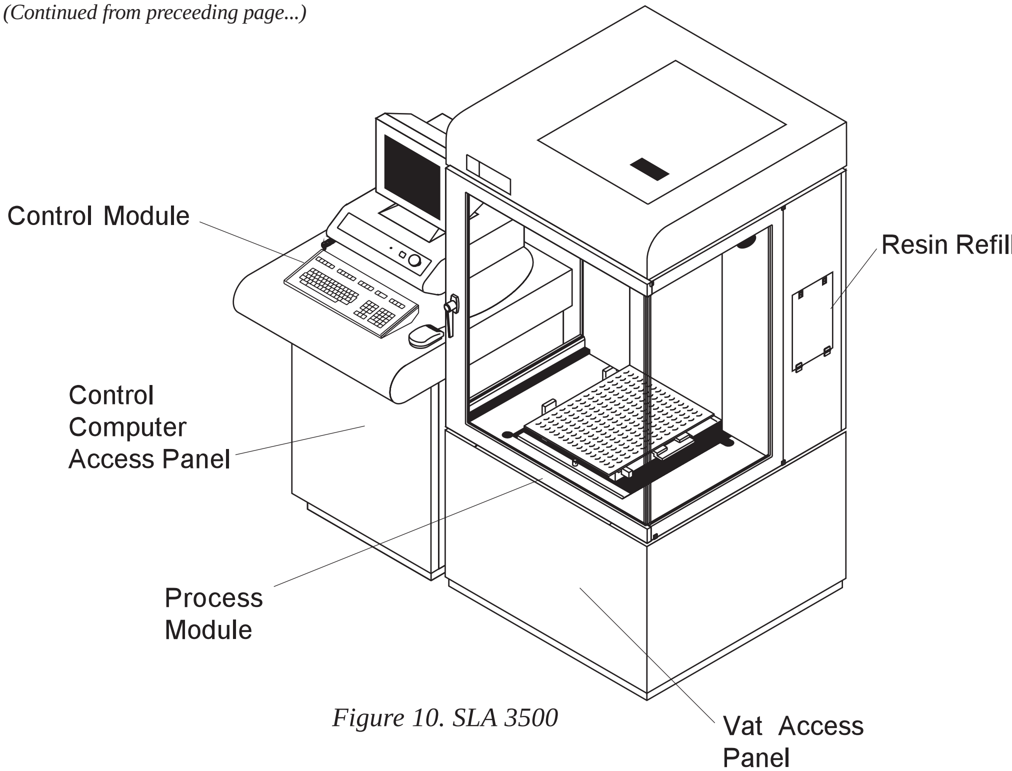

Figure 10. SLA 3500

SLA 3500

Control Module

The control module is located to the left of the build chamber. This module includes the monitor, keyboard, mouse and control panel used to control the SLA. This module also contains the control computer, electronic control systems, network connection and laser power supply.

Process Module

The SLA 3500 process module is located to the right of the control module and houses the build chamber, resin refill door, the SLA hardware, the optics and laser system which are controlled by the control computer located within the control module.

Build Chamber

The build chamber on the SLA 3500 is distinguished by the large ultraviolet (UV) protected windows which allow you to view the parts during a build. The build chamber is accessed through the chamber door as described below.

Chamber Doors

Chamber doors are used to gain access to the build chamber for removing or installing platforms and parts. The chamber doors come equipped with interlocks. If a chamber door has not been closed, the interlocks provide protection through a safety system which is described later in this chapter.

Resin Refill Door

The resin refill door is located on the right side of the build chamber. To open the door, pull both latches up, and, while holding the latches open, pull the door toward you and down. This door is used when replacing or removing the resin container. Discussion about the auto resin refill system can be found later in this chapter.

Access Panels

Removal of access panels is accomplished by disengaging the retaining hardware and lifting the panel up and away from the module. Removal of the control computer access panel is required when installing new software.

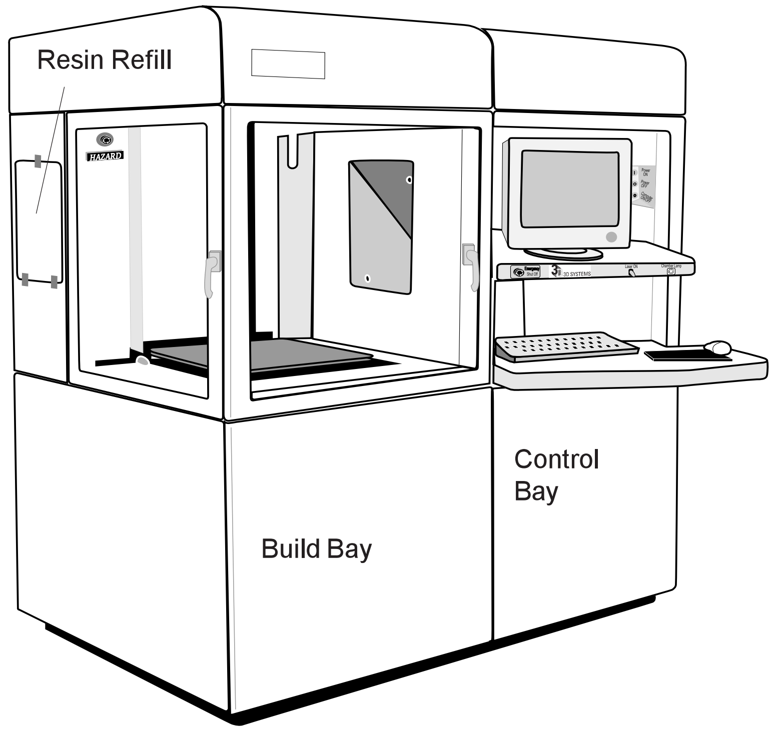

Figure 11. SLA 5000

SLA 5000

Process Module

The SLA 5000 is fully contained in one process module containing two bays: the Build Bay and the Control Bay.

Control Bay

The controls are located on the Control Bay section of the SLA and include the monitor, keyboard, mouse and control panel. Also included inside the Control Bay are the control computer, electronic control systems, network connection, scanning mirrors, laser and laser power supply.

Build Bay

The Build Bay on the SLA 5000 is easily recognized by the large ultraviolet (UV) protected windows which allow you to view the parts during a build. The build chamber is accessed through two chamber doors.

Chamber Doors

Chamber doors are used to gain access to the Build Bay for removing or installing platforms and parts. The chamber doors come equipped with interlocks. If a chamber door has not been closed, the interlocks provide protection through a safety system which is described later in this chapter.

Controller Access Door

The access door for the controller computer is located on the upper panel on the rear of the Control Bay. To open, pull the latch and lower the door.

Resin Refill Door

The resin refill door is located on the left side of the Build Bay. To open the door, pull the latch up and pull the door out and down. This door is used when replacing or removing the resin container. Discussion about the auto resin refill system can be found later in this chapter.

Access Panels

Removal of access panels is accomplished by disengaging the retaining hardware and lifting the panel up and away from the module.

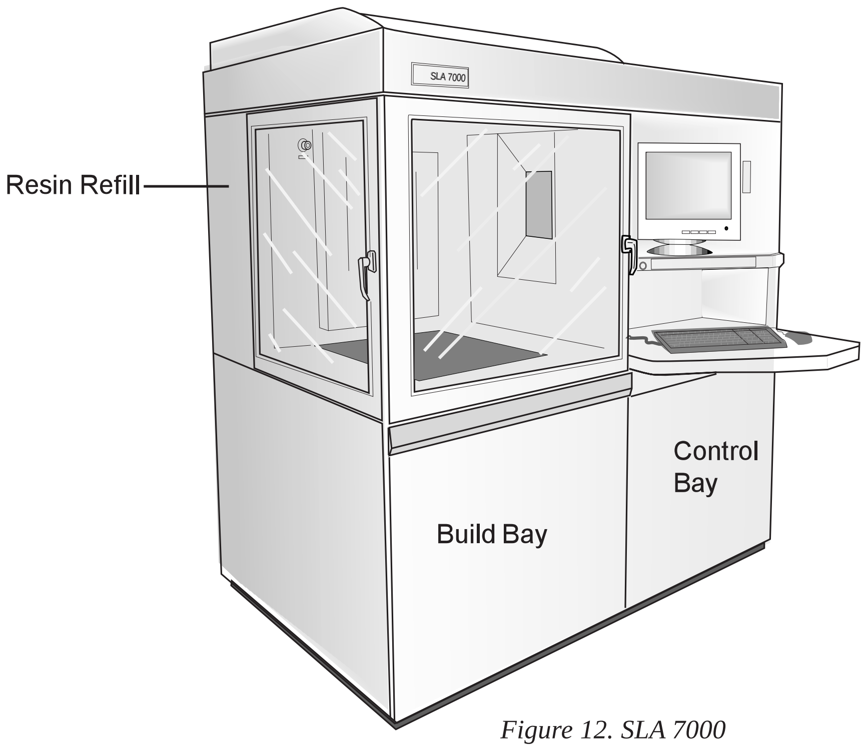

Figure 12. SLA 7000

SLA 7000

Process Module

The SLA 7000 is fully contained in one process module containing two bays: the Build Bay and the Control Bay.

Control Bay

The controls are located on the Control Bay section of the SLA and include the monitor, keyboard, mouse and control panel. Also included inside the Control Bay are the control computer, electronic control systems, network connection, scanning mirrors, laser and laser power supply.

Build Bay

The Build Bay on the SLA 7000 is easily recognized by the large ultraviolet (UV) protected windows which allow you to view the parts during a build. The build chamber is accessed through two chamber doors.

Chamber Doors

Chamber doors are used to gain access to the Build Bay for removing or installing platforms and parts. The chamber doors come equipped with interlocks. If a chamber door has not been closed, the interlocks provide protection through a safety system which is described later in this chapter.

Controller Access Door

The access door for the controller computer is located on the upper panel on the rear of the Control Bay.

Resin Refill Door

The resin refill door is located on the left side of the Build Bay. To open the door, first open the outer panel then pull the latch up and pull the door out and down. This door is used when replacing or removing the resin container. Discussion about the auto resin refill system can be found later in this chapter.

Access Panels

Removal of access panels is accomplished by disengaging the retaining hardware and lifting the panel up and away from the module.

Resin Leveling and Refill System

All SLA models contain a resin leveling system which monitors the level of resin within the vat. When the resin falls below the prescribed range, the buildstation software notifies the user to add resin. The SLA 3500, SLA 5000 and SLA 7000 contain an additional feature which adds resin using the Auto Resin Refill System.

Resin Leveling System

The resin level is monitored by a small diode laser and sensor. Located at the rear of the vat, the sensor reads the diode laser as it reflects off the current resin level and provides feedback regarding the resin level within the vat. To maintain the resin level in proper relationship to the laser and platform, an electronic assembly controls a system of vat lifters. These lifters move the vat of resin up or down as the resin level fluctuates within the vat. When the electronic assembly is unable to raise the vat height to meet the optimum resin level needed, the buildstation software will notify the user to add resin into the vat.

To add resin manually, refer to the section *Adding Resin Manually* for all SLA systems. To add resin automatically, refer to the section *Auto Resin Refill System* for all SLA systems.

Adding Resin Manually

The following procedure allows the user to manually add resin to the vat. SLA 3500, SLA 5000 and SLA 7000 users should refer to the section *Auto Resin Refill System*, unless you desire to add resin manually. If the message, **Add resin until prompted to stop**, is displayed on the monitor, you must add resin to the vat.

CAUTION!
Before adding resin it is very important to verify which type of resin is currently in use. Do not mix resin types!

While wearing protective clothing, disposable nitrile gloves and goggles:

1. **Open the front Process Chamber door for the SLA 3500 or the left Process Chamber door for the SLA 5000 and SLA 7000 to access the vat of resin.**

CAUTION!
Cover the two beam profilers with paper towels to prevent resin from dripping or splashing on the surface of the profilers. One beam profiler is located at the left front corner of the rim, and the other is located at the right rear corner of the rim. *Refer to the Beam Profilers section later in this manual for more information.*

2. **Using the same resin currently in the vat, slowly pour the resin in the corner of the vat.**

NOTE!
It is important to pour resin into the corner nearest the Z-stage (rear of vat) to assist the system in quickly recognizing whether overall resin temperature needs to be adjusted. By pouring the resin slowly, bubbles will be significantly reduced.

When the message, *Stop adding resin. Press any key to continue*, is displayed, an audible beep will sound. Stop pouring resin immediately.

3. **Remove the protective towels from the beam profilers.**
4. **Close the chamber door.**
5. **Press any key (or the spacebar) to continue.**

Auto Resin Refill System

The auto resin refill system is located behind the auto resin refill door as described earlier. This system is designed to add resin to the vat from a resin container placed within the auto resin refill slot. When the diode laser leveling system senses that the resin level is too low it will first use the vat lifters to raise the vat. If the resin level is still too low, the auto resin refill system will then display the message, **Resin Autofill in Progress**, and will add resin from the resin container.

If the refill resin container is empty, the control computer will wait until a new resin refill container is installed (see *Adding New Resin Containers*) or resin is added manually. Once resin has been added to the vat, the build will start.

Removing Empty Resin Containers

The following procedure is used when the resin container is empty and additional resin is needed. Before proceeding with this procedure it is important to verify the type of resin currently in the vat.

While wearing protective clothing, disposable nitrile gloves and goggles:

1. **Open the resin refill door (Figure 13) until the vent hole, on the upward end of the bottle, is visible.**
2. **Place the vent cap on the vent hole and screw tight to prevent resin from spilling.**
3. **Continue to open the resin refill door until the container has been completely inverted. Wait 5-10 minutes for excess resin to drain from the hose and seal.**
4. **Once the resin has been properly drained, release the inner latch and lift until the resin container is visible.**
5. **Using a disposable paper towel wipe all resin from the container seal assembly.**
6. **Finally, to remove the container, carefully lift it from the container slot, recap it, and dispose in accordance with local regulations.**

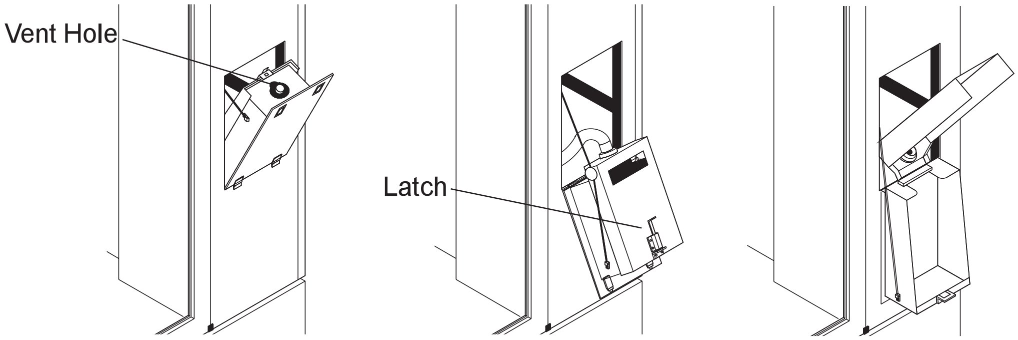

Figure 13. Auto Resin Refill System (SLA 3500, SLA 5000 & SLA 7000)

Adding New Resin Containers

This procedure assumes that the container slot is empty. If a container is present, refer to the previous section, *Removing Empty Resin Containers*, before continuing. While wearing protective clothing, disposable nitrile gloves and goggles;

1. **Open the resin refill door until completely inverted**
2. **Release the inner door latch and open the container holder door.**
3. **Place a resin container into the container slot and remove both the container lid and induction seal.**
4. **Close the container holder cover until the inner cover latch has been properly locked.**

CAUTION!
If the "O-ring" is not seated correctly inside the neck of the resin container, or the door is not properly latched, a resin spill is likely.

5. **Lift the resin refill door until the vent cap is facing upward and the refill door is nearly closed.**

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6. **Remove the vent cap and place it on the cap retainer for storage.**

7. **Using the puncture tool place a small vent hole in the center of the vent spout.**

8. **Once the vent hole has been made, return the puncture tool to the holding clips.**

9. **Close the resin container door firmly until it is securely latched.**

Recoating System

The recoating system consists of the platform and platform supports, recoater blade and elevator. The Buildstation software controls all movement of the recoating system as needed to build on the SLA.

Platform and Platform Supports

The platform supports hold the platform while it moves up and down during part building. The platform is made of perforated stainless steel and has special locking slots to secure it to the platform supports.

NOTE!
Verify that the platform has been thoroughly cleaned and dried before placing the platform into the platform support frame.

SLA 3500

The SLA 3500 platform support is a frame which has a spring loaded platform clamp with rotating knob on the right side and two locating points on the left. Install the platform onto the platform support assembly by making sure the left side of the platform engages the locating points on the platform support. Once the platform has been installed properly, turn the knob counterclockwise to secure it. See Figure 14 for proper platform orientation.

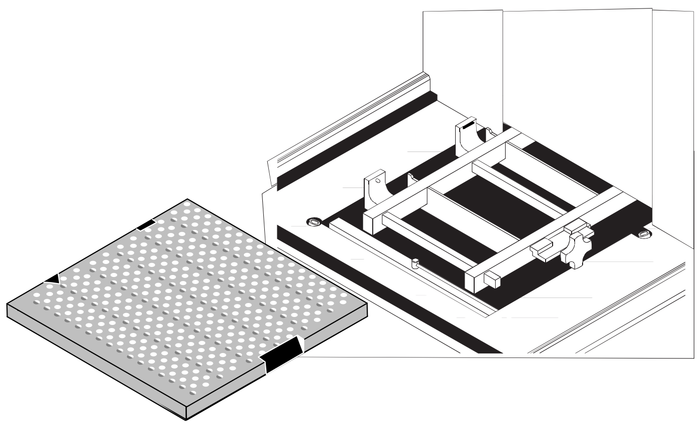

Figure 14. SLA 3500 Platform and Platform Support

SLA 5000 & SLA 7000

The platform support is a frame with a sliding clip and two locating points. To load the platform, open the left process chamber door and loosen the clip (counter clockwise) with a hex wrench. Then orient the platform so that the two locating point notches are located on the farthest side of the platform (see Figure 15 for proper orientation). Slide the platform into the locating points and tighten the clip (clockwise) with the hex wrench.

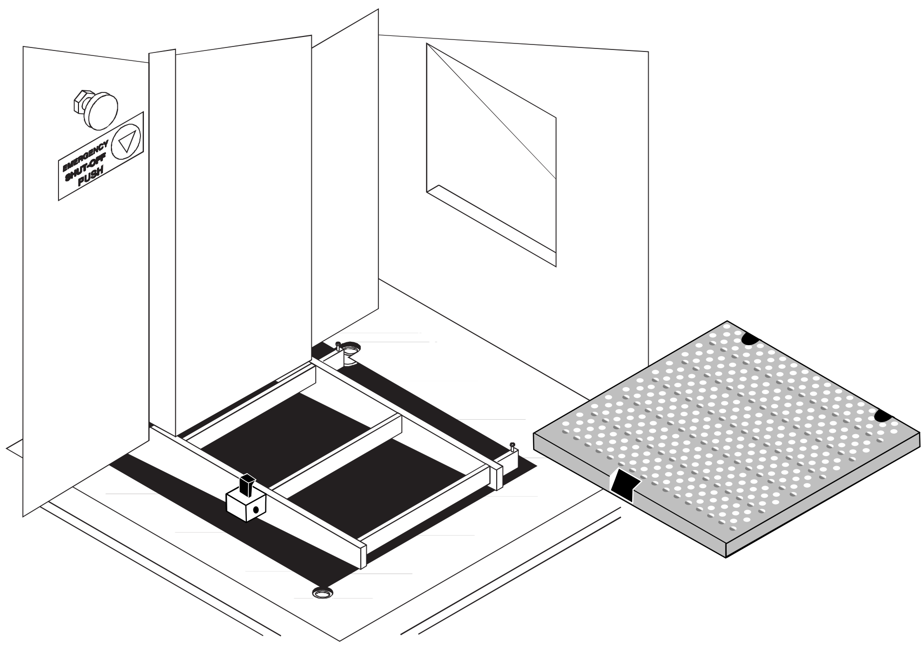

Figure 15. SLA 5000 & SLA 7000 Platform and Platform Support

Recoater Blades

The recoater blade is located on a rail system above the vat.

Zephyr™ Recoating System (SLA 3500, SLA 5000 & SLA 7000)

The Zephyr blade is part of an assembly called the Rim assembly. The blade is hollow to provide a reservoir for the resin. There is a window located on one face of the blade to view the level of resin inside the reservoir. The blade is attached at both ends to precision antifriction linear guides. The guides are in turn attached to the Rim. The Zephyr blade is driven by a stepper motor and ball screw (SLA 3500), or two drive belts (SLA 5000 & SLA 7000). A vacuum system attaches to the blade to maintain the level of resin within the blade. 3D Systems Customer Support Engineers will adjust the blade for proper part building during installation and setup of the SLA.

SmartSweep™

SmartSweep reduces the time it takes to build. Previously, the recoater blade would have to travel the entire length of the vat during a sweep regardless of the size of the part being built. Using SmartSweep, the recoater blade only sweeps across that portion of the vat where a part is being built, optimizing sweeping for minimum overhead.

NOTE!
As the geometry of a part changes in the Z-axis during a build, the SmartSweep system will adjust the sweep length of the recoater blade to account for the change in geometry. If the geometry is going from larger to smaller during the build, it takes approximately 3.175 mm (0.125 in) of layer building in the Z-axis before the recoating length is adjusted to its new length after any change in geometry. This is required to ensure that filling of the Zephyr blade is unobstructed by previous layers.

Laser and Optics

The laser provides energy to cure the liquid photopolymer resin within the vat. Each SLA model type uses a different laser.

Lasers

SLA 3500, SLA 5000 & SLA 7000

These SLAs use solid state lasers which are frequency-tripled, diode pumped Nd:YVO4 (Neodymium-doped Yttrium Vanadate). The constant power output is at least:

* 160 mW for the SLA 3500
* 216 mW for the SLA 5000
* 825 mW for the SLA 7000

at the vat for 5,000 or more hours of operation. These lasers emit UV energy at a 354.7 nanometer wavelength.

Laser Power Supply

SLA 3500, SLA 5000 & SLA 7000

In the SLA 3500, the laser power supply is located within the control module near the control computer and can be accessed through the front control module access panel. In the SLA 5000, the laser power supply is located in the Control Bay beneath the laser head and can be accessed by removing the lower right panel on the end of the Control Bay. In the SLA 7000, the laser power supply is located in the Control Bay within the electronics module and can be accessed by removing the lower back panel of the Control Bay.

CAUTION!
The SLA 7000 uses a water chiller to cool the laser head. The chiller must be filled with distilled water and must be turned on before turning the laser on. The chiller is located just next to the laser power supply. Any servicing must be performed 3D Systems Field Engineers.

Orion™ Imaging System

The Orion Imaging system controls laser drawing. It provides efficient use of computational resources and is performance tuned for the draw speeds used on each SLA. For an SLA 3500, the set maximum recommended draw speed is 2,540 mm (100 in) per second. For the SLA 5000, the maximum recommended speed is 5,080 mm (200 in per sec). For the SLA 7000, the maximum recommended speed draw speed is 13,335 mm (525 in per sec).

Beam Profilers

The SLA contains two beam profilers that are located near the front and rear of the vat. The profilers determine the actual X and Y axis location of the laser beam relative to the build zone. The profilers then feed this X and Y axis location information to the control computer where real time accuracy adjustments can be made to account for changes that may occur layer to layer.

Optics

SLA 3500, SLA 5000 & SLA 7000

The optics (except for the dynamic scanning mirror) are all found within the laser module. The SLA 5000 and SLA 7000 has one additional optic, a large fixed mirror in the upper portion of the Build Bay. After the beam exits the laser, it passes the safety shutter. The safety shutter is a metal blade that is held open to allow the beam to pass. If either the chamber door or the panel in front of the vat are opened, this shutter blocks the laser beam. The safety shutter is located just outside the laser head but before the dynamic mirrors.

Process Chamber Temperature Control

The temperature within the SLA process chamber must be kept within an optimum range. The recommended temperature for most resins is 28° C. Ensure the chamber temperature is set appropriately for the resin in use. This is accomplished by the use of a heater and fan that are controlled by the Buildstation Contrlrl Software.

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Heater/Fan Assembly

Temperature of the SLA is maintained by the use of a heater that warms the air as it is circulated around the vat of resin and into the process chamber. For the SLA 3500, SLA 5000 and SLA 7000 the heater and fan unit are built into the back of the Build Bay to maintain a closed loop circulation system.

Vent Fan/Filter

The process chamber is equipped with a vent fan to remove the potential buildup of volatile organic compounds. As the vent fan circulates the air within the build chamber it is sent through a charcoal filter. Regular maintenance of the charcoal filter is required. Ask 3D Customer Support for more information.

Temperature

The SLA contains a thermostat that provides the temperature reading for the resin within the vat. The current temperature of the resin can be displayed on the Buildstation Software. Further discussion of setting the temperature is found in the *Buildstation Control Software User's Guide*.

Control Module/Bay

This section covers the Control Module, including the control panel, that is used to control the SLA.

The Control Module/Bay that was described earlier in the chapter, contains several important components. The following figures illustrate the basic components used to control the SLA such as the monitor, mouse, keyboard, control panel, emergency stop button and the master power shut-off button.

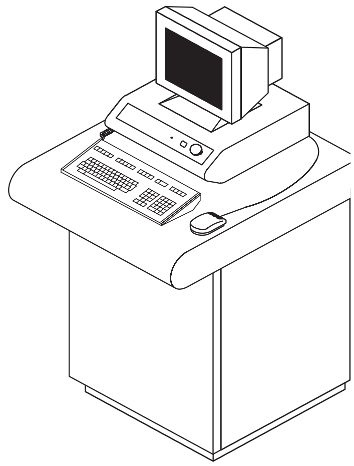

Figure 16. SLA 3500 Control Module

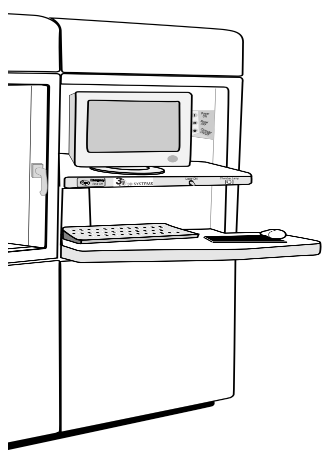

Figure 17. SLA 5000 & SLA 7000 Control Bay

Control Computer Reset (SLA 3500)

Located behind the monitor stand is the control computer *ON/OFF* button.

Control Computer Reset (SLA 5000 & SLA 7000)

Located to the right of the monitor is the control computer *ON/OFF* button.

Monitor

The color monitor located on the top of the control module displays the current buildstation software screens. Using the keyboard and mouse, all input and output of information are displayed through the monitor.

Keyboard And Mouse

Located below the monitor, is a 101-key standard keyboard and mouse used to enter commands and responses as prompted by the Buildstation Software.

Control Panel (SLA 3500, SLA 5000 & SLA 7000)

The control panel of the SLA 3500, SLA 5000 and SLA 7000 contains the following features: *Laser On* indicator, *Chamber Lamp* on/off button and the *Emergency Shut-Off* button.

Laser On Indicator

When the laser is **ON**, the indicator LED will be **Green**. Any time the laser is **OFF**, the indicator LED will not be lit. The LED is used to monitor the status of the laser.

Chamber Lamp Button

In order to turn the process chamber interior light **on** or **off**, press the *Chamber Lamp* button.

Emergency Shut-off Button

In case of an emergency, press the large red emergency button located below the monitor to turn off all power to the SLA. **This method of turning off power to the SLA is only recommended in the event of an emergency.** Further discussion of this feature is found in the section *Basic Operator Safety*.

Network

To locate the network connector on the SLA 3500, remove the rear panel on the Control Module.

To locate the network connector on the SLA 5000 and SLA 7000, remove the upper panel on the back of the Control Bay.

NOTE!
Guide the network cable under the frame of the process module to allow the panel which covers the network connector to close properly.

Basic Operator Safety

Master Power Shut-off Button

The master power shut-off button turns off all power sent to the SLA. The master power shut-off button is located as follows:

- The SLA 3500 master power shut-off button is located behind the control module (Figure 18)
- The SLA 5000 and SLA 7000 master power shut-off button is located to right of the monitor (Figure 19)

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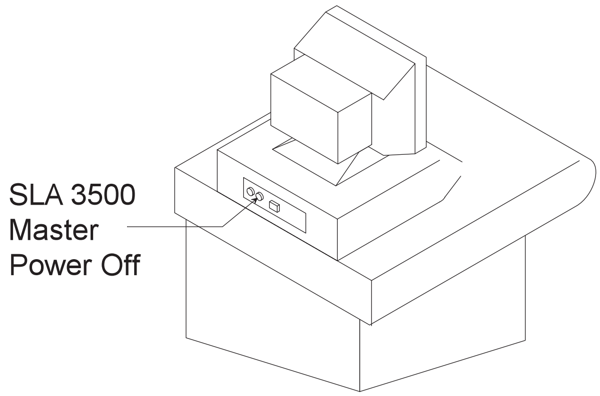

Figure 18. SLA 3500 Master Power Off Button

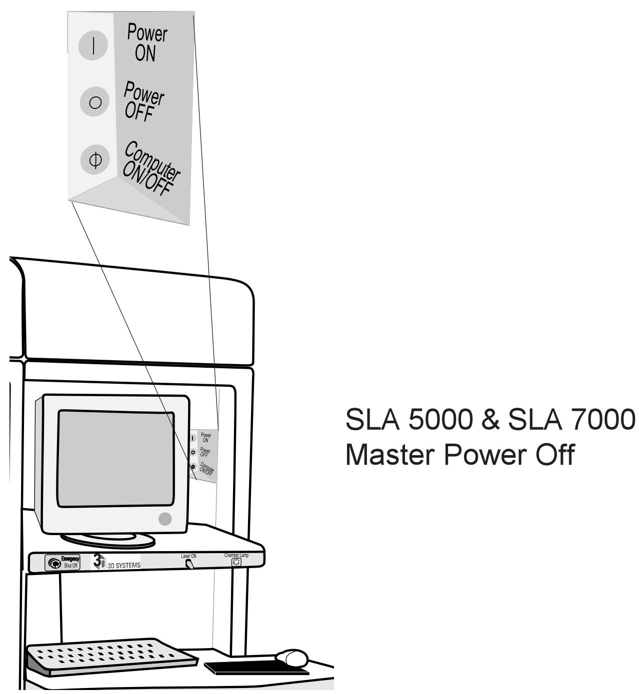

Figure 19. SLA 5000 & SLA 7000 Master Power Off Button

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Safety Interlocks

RADIATION
The SLA contains several safety interlock mechanisms, which, when enabled, allow safe system operation. Do not disable any safety interlocks.

Each SLA contains several safety interlock switches which close the safety shutter and prevents the laser beam from entering the Process Chamber when the Process Chamber doors are opened or Vat Access Panels removed. For further information see the section on *"Laser Safety" in Appendix C.*

Each SLA also has a laser interlock, which will not allow the laser to operate unless the interlock is properly activated. The laser interlock for the SLA 3500 is located beneath the right threaded screw hole that secures the laser access door. The laser interlock for the SLA 5000 and SLA 7000 is located inside the scanning mirror cover. In each case, if the laser access door is opened or scanning mirror cover removed, the laser will shut down and will not restart until the interlock has been properly engaged.

Emergency Shut-off Button

The SLA contains two emergency shut-off buttons. The first button is located on the control panel and the second button is located within the SLA process chamber. To activate either emergency shut-off button, push firmly until all power to the SLA is turned off. To reset the emergency shut-off button, turn the button counterclockwise. To restart the SLA, refer to the next section. **This method of turning off power to the SLA is only recommended in the event of an emergency**.

Power Up Procedures

Starting the Hardware

Typically, the hardware is already on and set up by 3D Systems installation personnel.

This should mean the heater has warmed the build resin to its recommended operating temperature, usually around 28°C (recommended for most CIBATOOL resins).

If this is the case, refer to the the *Buildstation Control Software User's Guide* for instructions on using the Buildstation Software.

If this is not the case or the SLA has been powered off, follow these steps.

Power Up

A quick check of the electrical connections is helpful before the machine is powered up. Consult with the system manager if there is any question regarding the power available to the unit.

Once availability of correct power is ensured, switch the machine ON.

The SLA 3500 power switch is located behind the control module (see Figure 20).

The SLA 5000 and SLA 7000 power switch is located to the right of the monitor (see Figure 21).

NOTE!
If the stereolithography apparatus is being powered up from a cold start, it can take as long as 36 hours for the resin to reach operating temperature.

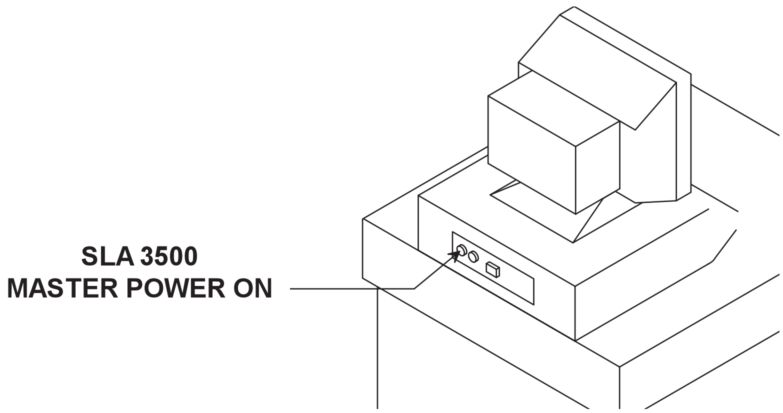

Figure 20. SLA 3500 Master Power On Switch

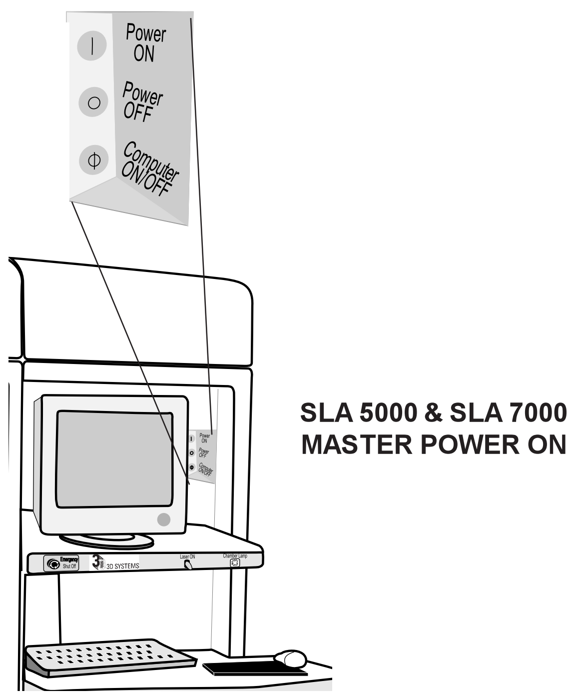

Figure 21. SLA 5000 & SLA 7000 Master Power On Switch

Post Processing

Overview

Post processing involves cleaning, final curing and finishing the stereolithography parts. An SLA produces partially cured (green) parts. Excess liquid resin must be cleaned off the parts before the parts are fully cured. Once the part is fully cured it can be finished in a variety of ways, e.g. sanding, buffing, painting, dyeing, etc., as the job requires.

WARNING!
Always wear proper protective clothing (goggles, gloves and lab coat) when working with resin.

The major post processing steps for parts include:

1. **Draining excess liquid resin from the part.**
2. **Thoroughly cleaning uncured resin from the part.**
3. **Removing the part from platform.**
4. **Removing supports from the part.**
5. **Placing the part in a Post Curing Apparatus (PCA) to solidify uncured portions of the part by allowing the part to undergo exposure to UV light.**
6. **Finishing the part by: sanding, polishing, sandblasting, bonding, assembling, repairing, painting, drilling, tapping, milling, turning and/or metallic plating (to conduct electricity).**

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NOTE!
Generally, it is best to post-process parts as soon as possible after they are built. Parts can be ruined by excessive exposure to air, moisture, cleaning solvent or light. Some resins need time to allow green strength to build up and should be left for at least 30 minutes before post processing. Contact 3D Systems Customer Support for more Information.

Draining

When the build is finished, lift the platform and parts above the vat. Wearing protective safety gear, tip the platform and suspend it on the elevator arms, resting against the Z axis shield, so that liquid resin can drain back into the vat.

Depending on the part, 5 to 15 minutes of draining is sufficient. Long exposure to air, especially when humidity is high, may cause water absorption to damage or ruin the part. Use care when tilting and handling green parts.

CAUTION!
Refer to the resin data sheet for humidity effects on your resin.

To drain solid ACES or WEAVE parts:

1. **Cover both beam profilers with paper towels.**
2. **Raise the platform clear of the vat.**
3. **Tilt the platform to remove the resin from the exterior and to drain the liquid from trapped volumes.**

   Be careful to avoid dripping resin on the rim cover and beam profilers.
4. **Drain as required.**

For QuickCast parts:

1. **Cover both beam profilers with paper towels.**
2. **Raise the platform clear of the vat.**
3. **If vents and drains were not built into the part, drill 1.00 mm (0.040 in) for vents and drains in the part to allow resin to drain from the inside of the part.**

NOTE!
Several drain holes may be needed.

4. **Tilt the platform to get resin off the exterior and to drain the liquid from trapped volumes.**

   Be careful to avoid dripping resin on the rim cover and beam profilers.

5. **Drain as required.**

Excess Resin Removal

For Solid Parts

After draining, excess resin can be removed from a solid part by placing the part in a solvent bath, by wiping the resin off or by using a centrifuge.

CAUTION!
Refer to the Tips and Information Technical Bulletin "Recommended Part Cleaning Procedures" for the recommended cleaning solvents. Using an improper solvent can cause swelling or other distortion.

NOTE!
The following are tips on removing excess resin from solid parts. They are tips, not rules, because what works on some parts may not work on others.

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Tip #1: Use an absorbent, non-fibrous swab or brush to remove excess liquid trapped in corners and around small details of the part. Put solvent on the swab or brush to dissolve resin.

Tip #2: The easiest (and perhaps best) method is to use a mechanical solvent bath agitator.

WARNING!
Do not use a flammable solvent in the mechanical agitation unit unless the unit is designed and approved for use with flammable liquids.

1. **Place the platform with parts in the solvent.**

   If the part has reverse trapped volumes, tip the platform upside down while submerged in the solvent so all air bubbles escape,

2. **Secure the platform before turning on the agitator.**

   Parts with trapped volumes or reverse trapped volumes may be placed in the agitator at an angle that allows the solvent to flow into the trap to wash the resin away.

3. **Turn on the mechanical agitation and wash parts for about 30 minutes.**

NOTE!
Parts may distort if overexposed to liquids.

4. **Remove parts from the agitator and rinse, following the "Water Rinse and Dry Procedure" in the next section.**

WARNING!
Treat used solvent and rinse water as hazardous waste.

Tip #3: Clean solid parts in a manual solvent bath.

1. **Pre-clean platform and parts with solvent using a paper towel or wicking sponge.**
2. **Place the entire platform with the parts or parts alone, in a solvent bath.**
3. **Agitate the parts in the solvent for ten to twenty seconds and then let them soak for two minutes.**
4. **Repeat process for 20 to 30 minutes. Remove the parts from the bath and drain them.**
5. **Follow the "Water Rinse and Dry Procedure" in the next section.**

The amount of time a part can be left in solvent depends upon several factors including the type of resin, how the part was built (e.g., using ACES or STAR-WEAVE) and how many times the solution has been used. Generally, the less time parts spend in solvents the better.

Tip #4: Use a spray bottle filled with solvent to remove resin from small, detailed areas of a part.

1. **Fill a spray bottle with solvent.**
2. **Squirt the solvent onto surfaces that need cleaning while the part and platform sit over a drain pad or a solvent agitator tank.**
3. **Follow the water rinse and dry procedure below.**

Water Rinse and Dry Procedure

1. **Using a pressure water spray and a rinse tank, thoroughly rinse with water for less than one minute, turning the parts to clean all sides.**

   The shorter the rinse the better, as uncured parts absorb water.

2. **Dry the parts with compressed air.**

   Ensure the parts are completely dry and free of resin. If the compressed air does not blow the water off the part easily, there is resin remaining on the part.

3. **Inspect the part for remaining excess resin. (The part will look wet where resin remains.)**

4. **If necessary, return the part to the agitator for 20 to 30 minutes, rinse and dry the parts again.**

For QuickCast Parts

Never place QuickCast parts in any solvent bath and do not rinse them with water. Instead, do the following:

1. **If there are any pockets of resin remaining in the part, and vents and drains were not built into the part, drill 1.00 mm (0.040 in) or smaller drain holes to allow resin to drain from the inside of the part.**

2. **Place in a centrifuge and spin for 5 minutes.**

3. **Examine the part. If required, place more drain holes where resin collects.**

4. **Centrifuge for 30 minutes.**

5. **Repeat drilling and centrifuging until part is completely drained (approximately 4-5 reorientations).**

6. **Dry air may be blown into a vent hole to help force resin out, but the air pressure must not exceed 2 or 3 psi. High-pressure air will destroy the part.**

7. **Wipe down the sides with paper towels or paper towels and solvent.**

8. **Cure in a PCA for at least 5 hours.**

QuickCast parts should be drained and cured as soon as possible after the build. QuickCast parts are especially prone to water absorption and loss of dimensional stability until the curing process has been completed.

Removing Supports

Prior to curing, support structures should be removed from the part and the places where the supports touched the part should be smoothed off before the part is cured. It is much harder to remove supports after curing. Remove supports carefully with the proper tool to avoid damaging the part.

To remove part supports:

1. **While wearing the proper safety equipment, remove supports by carefully breaking them off or by using an appropriate tool. See the next section on tools.**

Post Processing Tools

The proper tools for post processing are essentially whatever tools work. At 3D Systems, post processors use a variety of tools, many of them improvised. X-acto blades, scrapers, putty knives, spatulas, dental picks, etc. get filed, bent, twisted, cut off or in some way modified to do the particular job. The least inexpensive things can make the best tools.

After patience, creativity is probably the primary requirement for a good post processor. In prototyping, the unique configuration and requirements of the different parts challenge the post processor to find creative solutions.

Post Curing

Final UV Curing of green parts is done in a Post Curing Apparatus (PCA). Parts should be cured as soon as possible to maintain structural soundness. A green part exposed to humidity above 50% for more than a few hours before final curing may absorb water, become tacky and never cure properly. It may also swell, reducing part accuracy.

Post Curing Guidelines

For Solid Parts

Curing slowly at low power generally produces less post-cure distortion than curing rapidly at high power. A part exposed in the PCA for a longer time than recommended will not overcure, though the color may darken.

Figure 22 shows typical experimental data for CIBATOOL resins cured in a PCA. The log plot shows the minimum post cure time versus part mass. The surface cure function is described by a horizontal line. This means surface curing time is independent of part mass. The horizontal line (called the H_{MIN} line) at 45 minutes indicates that a minimum of 45 minutes is required to eliminate surface tackiness regardless of part size.

After surface tackiness is eliminated, the remainder of the cure time is a function of the part mass as described by a diagonal line. For a part having a mass less than the transition mass at the intersection of the two lines, the post cure interval is determined solely by the surface cure time (in this case, 45 minutes).

You must allow one hour of cure time for each centimeter of cure penetration.

For QuickCast Parts

Cure parts in a non-stress position with all bulbs in the PCA on. A part exposed in the PCA for a longer time than recommended will not overcure. QuickCast parts should be cured from 5 to 10 hours.

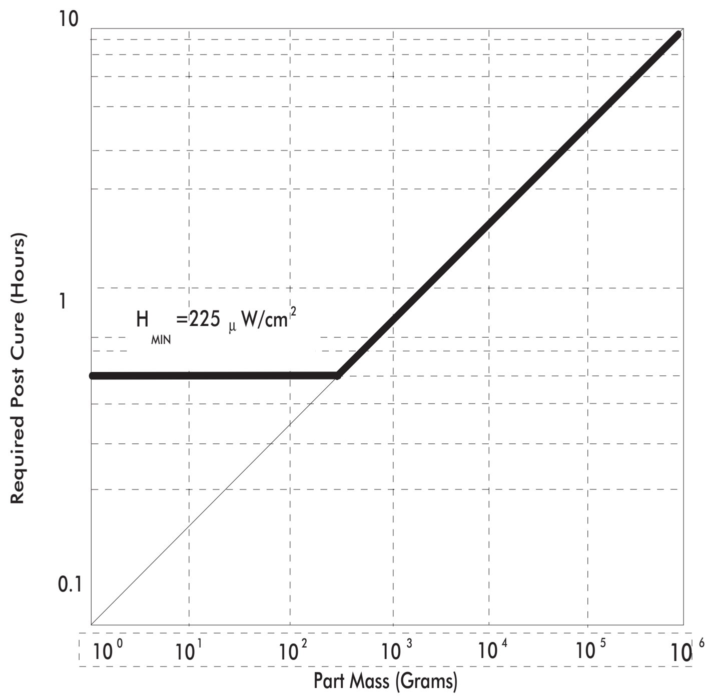

Figure 22. PCA Cure-Time Map

Painting and Dyeing Parts

Proper finishing before painting is essential for a good result. Paint covers whatever is underneath it. If the finish is rough, the final paint job will look rough; if smooth, it will look smooth. Lacquer, enamel, latex and epoxy-based paint will work in either aerosol or air brush applications.

Clear Finish

To give parts a clear finish, use clear coat aerosol spray on the cured part or buff or polish the cured part.

Dyeing is usually done only for show parts. Parts that require dimensional accuracy or surface hardness should not be dyed. Dyeing is done with water-based dyes, which penetrate only the outermost surface of the part skin. Dyeing ought to be the final operation done by a post processor, because any finishing after dyeing such as sanding or polishing will remove the surface that was dyed. A buffed part will not accept dye because the buffing compound and water are incompatible and because the part loses porosity when buffed.

To dye cured parts:

1. **Mix the dye according to the manufacturer's instructions or in a liter of water at 71°C (160°F).**
2. **Let the dye cool to between 27 and 49°C (80 to 120°F).**
3. **Dip the part in the solution for 20 minutes.**
4. **Rinse with fresh water and dry part.**

Part Finishing Techniques

Depending on the accuracy and finish required, cured resin may be removed in the final phase of assembly.

A variety of standard tools and techniques may be used. Standard materials include:

- Sandpaper, usually 150 to 600 grit
- Wood or soft rubber sanding blocks
- Needle files (fine, medium and coarse)
- Bead blasting equipment
- Hand drill (Dremel type) with assorted bits
- Hobby knife

The tools and techniques selected depend upon the desired result. Some factors to be considered are: layer thickness, the quality of the contours and features to be preserved, the smoothness of the finished surfaces, etc. Generally, the finer the CAD resolution and layer resolution, the easier it is to work with the part.

Machining Parts

Resin properties determine how cured parts behave when clamped, machined or finished. Some resins may produce brittle parts that chip when machined with a milling cutter. Climb cutting, where the leading edge of the cutter rotates toward the inside or solid portion of the work piece may reduce chipping.

Surface Finish

Part smoothness is determined by layer thickness and the finishing process. With the right work, the surface can become almost as smooth and clear as glass.

Attaching Parts and Assemblies

Standard epoxy glues can be used to join parts together. The resin itself, with UV curing, is an excellent bonding agent for thin walls up to 3.175 mm (0.125 in). For thicker walls, up to 6.35 mm (0.25 in), resin can be used if it can be cured on both sides.

Part defects, such as cracks and holes, can be ground out, filled with resin and cured. Acrylate resin works best for this patching as it is thicker, needs less exposure and is easier to keep in the correct place while it is being cured. A UV light source will cure the resin quickly.

Gluing and Bonding

A thin layer of resin can be used to join finished parts to each other and to repair broken parts. The mating surfaces must be roughened to ensure a good bond. The mated parts are then cured in the PCA. Epoxies and glues specified for use with plastic can also be used.

A variety of standard tools and techniques may be used. Tools and materials include:

- Drill motor with grinding wheel (to roughen mating surfaces).
- Resin.
- Adhesive (Zap Gap, Pacer brand, epoxy or equivalent).
- Accelerator (Z-Foam Primer, Z-FP brand or equivalent).
- Tape or clamps (for holding parts in place until cured).

Appendix A.

Part Building Limitations

The following list indicates problems that may be encountered when building parts.

- Part complexity and detail can never exceed that of the CAD model.
- Details requiring a fine resolution may be lost or magnified.
- While stereolithography can reproduce the part as input from the CAD system, tolerances will vary based on laser, optics, dynamic mirrors and type of resin.
- Supports are required for all parts. This is especially true of parts which generate islands when sliced. For example, a part representing a room with a hanging chandelier would require supports to anchor the first layer of the chandelier.
- The properties of the resin, the curing process and the post processing used determine the final properties of the plastic part.
- The formed part (object and supports) is limited to the vat size. You can build sections of a large part in several runs and reassemble it easily during post processing.
- Parts must be attached to the platform (they cannot be built in free space).
- Vertical and up-facing horizontal skins are smoother than down-facing skins. The impact of this limitation can be reduced by orienting the part so aesthetically important surfaces are vertical, or facing upward.
- Minimum horizontal feature size is limited to one line width, i.e. about 0.254 mm (0.010 in) depending on resin type.
- Vertical resolution is limited to one layer thickness.

Appendix B.

Troubleshooting

The following problems can typically be solved using the solutions listed here. If the problem is still unresolved, call 3D Plus+ Customer Service at 1-800-793-3669 (U. S. or Canada). From outside the U. S. and Canada, call your local 3D Systems Representative.

Hardware

Symptom	Cause	Solution
Entire system does not power up.	Emergency stop switch (chamber or control panel) depressed.	Reset switch and power up the system.
	Main power plug not engaged.	Plug cord into the wall outlet.
	No power from the wall.	Reset circuit breaker for the wall outlet.
Controller does not operate.	Breaker on DC power supply tripped.	Reset breaker.
	Loose cables or poor connection at the plug.	Check the plugs and cables to ensure that they are tightly connected and that the electrical outlet is working. Verify that the unit power switches are ON. Check the contrast and brightness on the monitor.

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Symptom	Cause	Solution
The laser does not operate.	The laser is not turned on.	Turn the power supply key to the ON position. Verify that the switch on the laser power supply is ON. Turn the laser on.
	Laser interlock not satisfied.	Read error shown on laser power supply. Call 3D Field Service.
	3D equipment interlock safety relay not satisfied (SLA 3500/5000/7000).	Satisfy all safety interlocks or the laser will not operate. If interlocks cannot be satisfied, call 3D Field Service.
Elevator, leveler or sweeper doesn't move.	Loose cables.	Secure all connections.
	Door or vat panel interlock not engaged.	Check door/vat panel interlocks are closing.
	A blown fuse.	Call 3D Field Service.
	Bad PC21 board or motor-driver.	Try to move using the Buildstation's Toolbar. Reboot. Call 3D Field Service.
Excess vibration/noise during sweeping.	Wiper rails are dirty.	Clean according to Field Service direction.
	Loose ball screw drive assembly (SLA 3500) or drive belts (SLA 5000 & SLA 7000).	Call 3D Field Service.

Symptom	Cause	Solution
Heater does not operate.	Breaker on DC power supply tripped. No power to coil.	Reset breaker. Check plugs and wiring.
Vacuum pump does not operate.	Breaker on DC power supply tripped. No power to pump (220VAC for SLA 3500, SLA 5000 & SLA 7000).	Reset breaker. Check plugs and wiring.
Resin valve does not operate.	Breaker on DC power supply tripped. No power to valve.	Reset breaker. Check plugs and wiring.
Sweeper stalls at limit switch or jerks during SmartSweep.	Slippage in drive couplings or belts.	Call 3D Field Service.

Appendix C.

Safety

General

Always follow the safety procedures. Do not, in any way, risk injury by working dangerously. Safety is a part of work, and not an obstacle to it.

Laser Safety

The SLA is designated as a Class I Laser Device by the Center for Devices and Radiological Health (CDRH). Class I devices are not considered harmful and require no special safety precautions. In normal operation, the laser beam is completely confined and the viewing windows in the Process Module block UV radiation.

RADIATION
Operating the equipment or performing procedures other than those specified within this guide may result in exposure to hazardous, invisible laser radiation.

RADIATION
Never stare directly into a laser beam, nor into any beam reflection, whether diffused or from a mirrorlike surface.

RADIATION
During normal operation, and with all panels installed, the SLA 3500/5000/7000 are classified as Class I laser devices. If the interlock is defeated, the SLA 3500/5000 becomes a Class IIIb device and the SLA 7000 becomes a Class IV device.

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If system interlocks are defeated for any reason (including performance of service procedures), laser power at wavelengths of 351 nm, 354.7 nm, 364 nm, 532 nm, 670 nm, and 1064 nm could be emitted and the unit would be considered a Class IV laser device. Class IV devices are the most dangerous. Eye damage can occur by looking directly into the beam or by viewing any type of beam reflection.

RADIATION
Interlocks are to be defeated only by trained personnel when needed during service procedures.

Control Switches

The locations of control switches are described in the Chapter, *SLA Hardware*. Master and Emergency power shutoff switches are located as described below.

Master Power Shutoff

The SLA 3500, SLA 5000 and SLA 7000 have no master circuit breaker—simply unplug the machine to shut off all power after either a planned shutdown or emergency shutdown.

Emergency Shutoff

All SLAs have two emergency shutoff switches: one on the front panel of the Control Module/Bay; the other inside the Process Chamber. (See Figures 23, 24 and 25.) They are bright red with a yellow background. Pressing either switch cuts off all electrical power to the system, including the laser.

CAUTION!
This method of power shutoff is not recommended and should only be used in an emergency.

To restart the system after an emergency shutoff:

- Rotate the Emergency OFF button clockwise to reset it, then press the ON button. For the location of the Power On button, see the Power Up section in the Chapter, *SLA Hardware*.

Control Panel Laser LED (SLA 3500, SLA 5000 & SLA 7000)

An LED light displays the current status of the laser (on/off). For more information see the Control Panel section in the Chapter, *SLA Hardware*.

ID/Certification Labels

On all SLAs, a label certifies laser safety conformance to the Code of Federal Regulations (CFR), power and ID information are also given. On the SLA 3500, the label is on the top rear corner of the Process Module. On the SLA 5000 and SLA 7000, the label is on the lower rear panel of the Control Bay.

Safety Warning Labels

Laser safety warning labels for the SLA 3500/5000/7000 are affixed inside the process module and vat panel doors. These labels conform to the requirements for Non-Interlocked, Class IIIb and Class IV lasers. Refer to Figures 23, 24 and 25 for their locations.

Safety Interlock Switches

Safety interlock switches protect the user from possible UV laser radiation exposure when certain doors or panels are opened. The locations of these switches are shown in Figures 23, 24 and 25.

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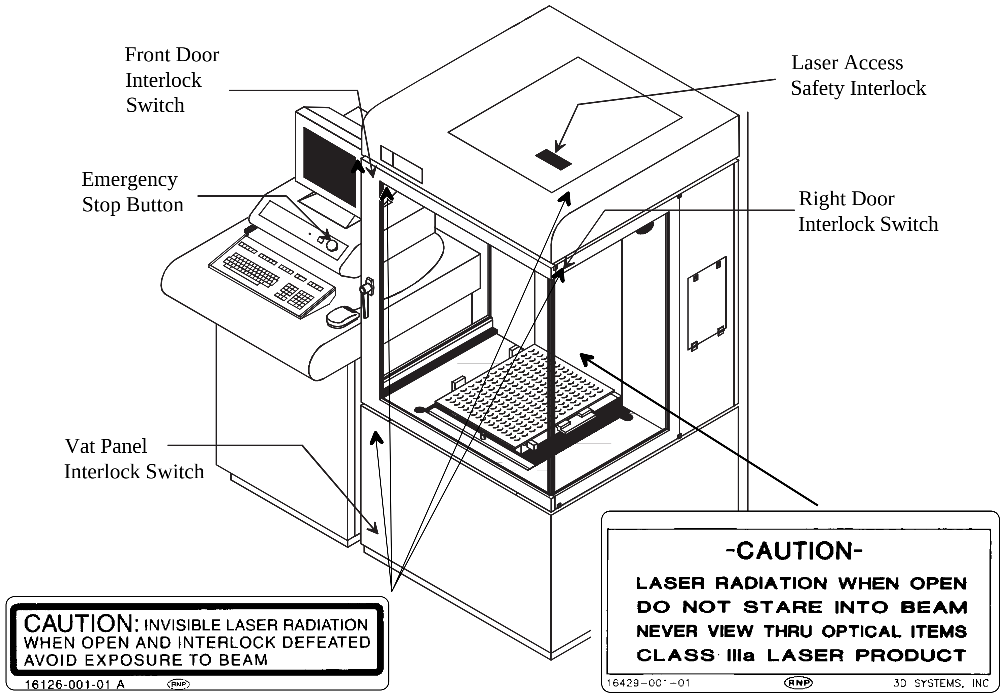

Figure 23. Safety Features for SLA 3500

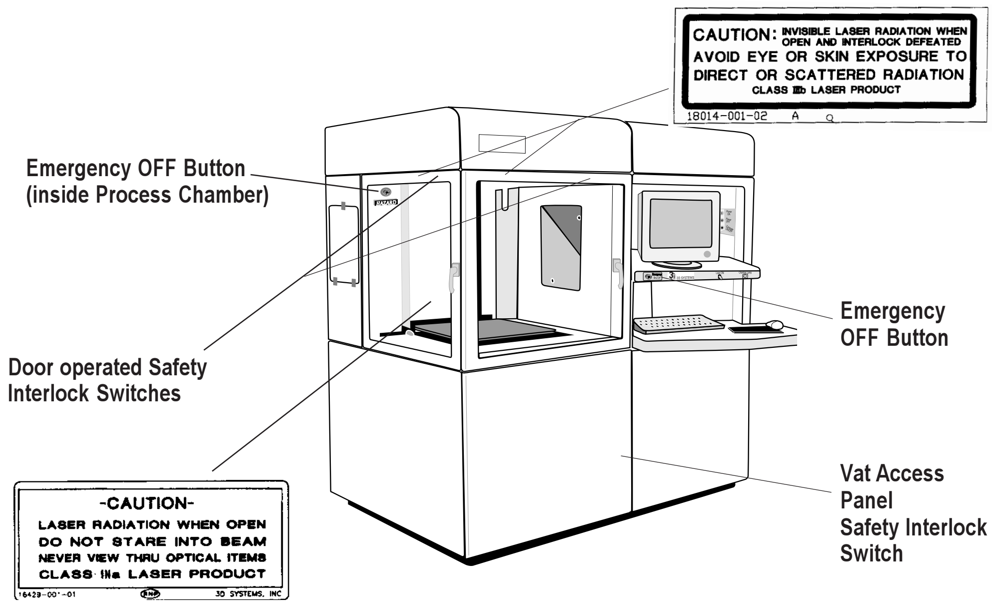

Figure 24. Safety Features for SLA 5000

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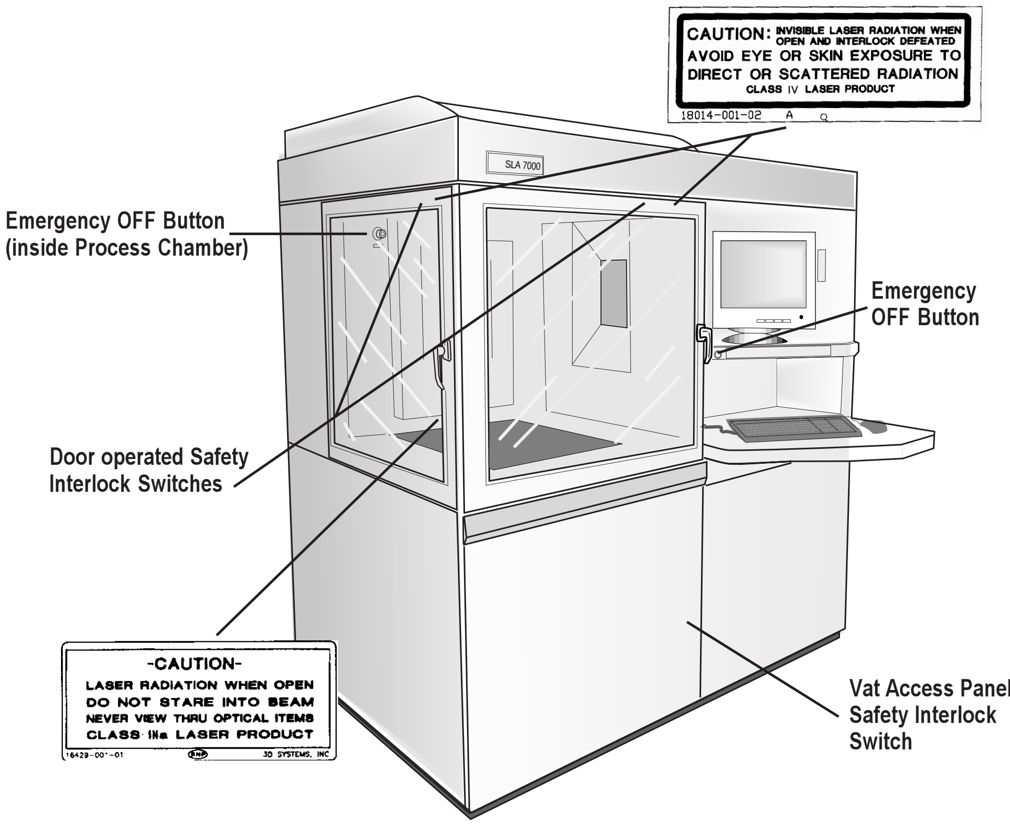

Figure 25. Safety Features for SLA 7000

Chemical Safety Warnings

WARNING!
Always wear chemical-resistant gloves, goggles, and protective clothing when handling resin. Avoid skin contact. Avoid breathing resin fumes.

- Always wear approved goggles, nitrile gloves and protective clothing when working near resins or with partially cured parts. Epoxy resin is less viscous and splashes more easily than acrylate resin.
- Wearing contact lenses when working with resins is not recommended.
- Always wear chemical-resistant gloves whenever handling resins or partially cured parts. Recommended gloves are 100% (Blue) Nitrile. Do NOT wear latex gloves.
- Always work in a well ventilated area when using resins. Avoid breathing vapors.
- Always wash skin thoroughly with abrasive soap and COLD water after working with resins. DO NOT USE HOT WATER OR SOLVENTS to wash hands, as it will result in absorption through the skin.
- Use extreme care when handling solvents used to remove excess resin from uncured parts. These solvents (e.g., denatured alcohol, isopropyl alcohol) are very flammable.
- Keep all resins away from heat, sparks and flame. Resin containers may rupture when exposed to extreme heat. **Use National Fire Protection Association Class B extinguishers such as carbon dioxide, dry chemical or foam.**

Resin Characteristics

The photopolymers used in stereolithography may be hazardous if handled improperly. Repeated skin contact with resins may cause sensitization. Consult the manufacturer's Material Safety Data Sheet (MSDS) for information on specific resins. For further information on this and related topics, consult the 3D Systems' Resin Handling and Safety Guide.

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Resin Storage

Resin should be stored in opaque, non-reactive containers, according to the guidelines given in the MSDS included with the resin. Protect resin from sunlight and ambient room light. Resin may be stored in SLA 3500/5000/7000 vats with the lid securely fastened.

Pouring resin back into the original containers is acceptable, but be sure to leave several inches of air above the resin in the sealed container. This will leave room for expansion and also inhibits spontaneous polymerization for some resins. Always label resin by type and usage history.

Never mix different resins.

Resin Disposal

Do not dump used resin down any drains. Follow disposal rules established by company, local, state and federal authorities.

Resin Spill Containment

Your company has the responsibility to define what constitutes a major spill. Personnel who are involved in cleaning up major spills of resin should wear NIOSH/ MSHA approved respirators designed for use with organic chemical vapors. In addition, each person should wear protective goggles, rubber boots, and 100% nitrile gloves to minimize exposure to resin, which can cause eye, skin and respiratory irritation, as well as possible skin allergies and respiratory reactions.

WARNING!
Resin is combustible. Care should be taken during resin containment and cleanup operations.

A supply of dikes and control booms should be stocked so they are available to contain the affected area in the event of a major resin spill. The spilled resin should then be absorbed on inert absorbent material and placed into drums for transfer to an approved waste disposal site.

After cleaning up the spill, individuals should wash thoroughly with soap and cold water. All clothing should be washed before reuse. Refer to the MSDS before using any chemicals. Repeated or prolonged skin contact may cause sensitization. Vapor may be harmful.

First Aid

Below are listed some general first aid procedures for resin exposure. If professional medical attention is necessary, take the Material Safety Data Sheet (MSDS) for the exact resin involved to the attending physician.

Skin Contact

Should resin come in contact with skin, wash thoroughly with soap and **cold** water and immediately remove contaminated clothing and shoes. If skin is irritated, get medical attention. Dry-clean contaminated clothing. Discard contaminated shoes and leather products.

Eye Contact

Safety goggles should be worn to prevent accidental splashes into the eyes. Flush immediately with large amounts of water for 15 minutes, avoid sunlight, fluorescent light, and other ultraviolet light and obtain immediate medical attention. Eye wash facilities and a first aid kit should be readily available and close to the resin.

Contact Lenses

If resin splashes into the eye when contact lenses are worn, flush the eye with water immediately. Verify that flushing has removed the contact lens from the eye. Protect eyes from light and obtain immediate medical attention. Discard contact lenses that come into contact with liquid resin.

Fume Inhalation

Remove the person to fresh air. Give artificial respiration or cardiopulmonary resuscitation (CPR) if required. If breathing is difficult, give oxygen. Obtain immediate medical attention.

Glossary

Acousto-Optic Modulator (AOM)

An electronic device which diffracts laser light to interrupt the laser beam as an on/off switch. AOMs are used on the SLA 3500, SLA 5000 and SLA 7000.

Actual blade gap

The physically set blade gap performed by field service when setting up an SLA.

Beam analysis

A laser utility option that moves the laser beam across the beam profilers which are mounted in the process chamber. The laser beam power, diameter and X/Y ratio are measured.

Beam profile

A pattern of circles or numbers representing the spatial distribution of laser beam power. This power distribution is used to automatically calculate drawing speeds, to determine whether the laser should be adjusted or replaced and to indicate whether the optics should be adjusted, replaced or cleaned.

Beam profiler

A UV-sensitive detector over which the laser beam is moved to generate beam profiles. Two beam profilers are mounted in the process chamber, one on left front corner of the rim and the other on the right rear corner of the rim.

Birdnesting

Misalignment of layer borders that occurs when a QuickCast™ inner layer border drifts from its original position before hatching is drawn, attaching it to the outer layer border.

Blade gap

Distance between the resin surface and bottom of the recoating blade.

Blade gap percent

A factor which, when multiplied by the layer thickness gives the clearance between the blade and the part during sweep.

Build computer

See control computer.

Build file(s)

The data file(s) produced by the *3D Lightyear File Preparation Software* and used by the controller to build parts. SLA 3500, SLA 5000 and SLA 7000 build file names have a .bff extension.

Build part

Combined object and supports.

Build program

Controller software which controls the building of stereolithography parts on an SLA.

Build style

A template file that defines slicing and part-building parameters.

Bullet

The characteristic shape of the solid plastic created by a stationary laser beam on the surface of photo-curable resin.

CAD

Computer-Aided Design. The process of designing products by interaction with a computer rather than by the traditional method of hand-drawing on paper.

CAD resolution

The internal approximation of surfaces within a CAD model.

CAD units

Units of measurement used to construct the CAD model, such as millimeters or inches.

CAE

Computer-Aided Engineering. The process of solving engineering problems by interaction with a computer. Computer-Aided Design is a subset of CAE.

Calibration

A field service procedure which generates a data file needed to draw accurately on the resin surface.

CAM

Computer-Aided Manufacturing. Managing and directing manufacturing operations with the assistance of computers.

CDRH

Center for Devices and Radiological Health.

Cfm

Cubic feet per minute. A measure of air flow.

CFR

Code of Federal Regulations.

Chamber temperature

The controlled temperature in the process chamber.

Circular web support

A hollow tube structure that can support large, heavy parts.

Component

A file (STL or SLC) which is loaded into *3D Lightyear File Preparation Software*.

Control module

One of the two modules that comprise the SLA 3500.

Control computer

The computer mounted in the SLA cabinet that controls the building of stereolithographic parts. Also known as controller.

Controller

See control computer.

Cross-web support

Two straight web supports that intersect at right angles.

Cross hatch

A vector that is drawn between layer borders and comprises the interior of the part.

Cure

The process of turning liquid resin into a solid by exposure to UV light.

Cure depth

The thickness or depth of a line of cured resin. The cure depth of any line is determined by the laser beam power and distribution, laser draw speed and resin characteristics used to draw the line. Also known as line height.

Curl

A characteristic type of part deformation.

Default

The normal state, particularly in the context of computers. A value automatically used or an action automatically carried out unless another is specified.

DiskAccess™

Network access software from INTERGRAPH. See also Network File System.

Draining

Allowing resin to drip from the finished part into the vat when the elevator is at its top position.

Drawing speed

The speed at which the laser traces over the surface of the resin to form solid plastic lines and surfaces. The laser drawing speed varies depending on the depth of solidification requested, laser beam power and distribution and resin characteristics.

DSP

Digital Signal Processor. An integrated circuit that converts analog inputs into digital form, executes operations on those signals under program control, and provides one or more digital outputs. A fast, single-purpose computer.

Dynamic mirrors

Motor driven scanning mirrors with encoder feedback that direct the laser beam to any point on the surface of the resin.

Elevator

The hardware components that raise and lower the platform and part in the vertical (Z) axis. Also called Z-stage.

Exposure

The total light energy absorbed by a point on the resin surface. Exposure increases with higher laser power and decreases with higher drawing speed.

FAD

Full Area Detector. A power measuring device that accepts the full beam for power determination.

Ftp

See file transfer protocol.

File server

A computer that responds to a request from another computer for data or action and provides access to files for the other computers on a network. Also known as server.

File transfer protocol

A Transmission Control Protocol (TCP) service that transfers files between systems on a network without regard to the operating systems of the machines involved in the transfer.

Fill vectors (skin fill)

Overlapping parallel vectors that comprise the horizontal surfaces (skins) of stereolithographic parts.

Green part

A stereolithographic part prior to UV postcuring, but after laser curing in the vat.

Hatch

See cross hatch

Hatch spacing

A parameter that specifies the perpendicular distance between cross hatches.

Initialization

Calibration of the home positions of the leveling mechanism and elevator.

Internet Protocol (IP)

Computer communication protocols developed by the U.S. Department of Defense for the scientific community. The common ones include TCP/IP, Telnet and ftp.

Laser

Light Amplification by Stimulated Emission of Radiation. The device that generates the light energy required to polymerize photocurable resin.

Layer

Thin horizontal section of laser solidified resin.

Layer border

A vector that defines the perimeter of a layer. Cross hatch and fill vectors are drawn between layer borders.

Layer hatch

See cross hatch.

Layer thickness

The depth of a solidified layer of resin, as requested by the user.

Leveling

The process whereby the surface of the resin is adjusted to the correct distance from the dynamic mirrors.

Line

A line of cured plastic generated by overlapping bullets. See also vector.

Line height

The vertical height of a laser-cured resin line. See also cure depth.

Linewidth

The horizontal width of a laser-cured resin line.

Local Area Network (LAN)

Two or more computers, usually within one building, connected by networking hardware and software which enables file sharing and access to peripheral equipment.

Low Profile Sweeping (LPS) (preferred blade gap)

A software feature that allows the user to use resins or styles requiring different blade gaps without having to physically recalibrate the blade gap.

Monomer

A low molecular weight chemical species, which is a building block of polymers.

MSDS

Material Safety Data Sheet. Federal government mandated information about the chemical makeup of any chemical substance, such as resin. Usually includes identification of toxic substances and safe handling guidelines.

Network File System (NFS)

A facility that allows sharing of files in a heterogeneous environment of machines, operating systems, and networks.

NIOSH

National Institute for Occupational Safety and Health.

NT™

Microsoft Windows NT, the operating system on the SLA 3500, SLA 5000 and SLA 7000 Controllers and required for the *3D Lightyear File Preparation Software* workstation.

Object

CAD model (may be a group of detail pieces).

Optics plate

The plate that supports the laser and optical components in precise alignment.

Photoinitiator

A chemical in photopolymers that reacts with photons and catalyze the polymerization process.

Photopolymer

A chemical substance composed of photoinitiators and monomers that polymerizes when exposed to light energy.

Photopolymerization

The process whereby light energy converts monomers into a polymer.

Platform

The perforated base on which parts are built by the SLA.

Platform locators

Pins that secure and position the edges of the platform.

Platform supports

L-shaped brackets that support the platform and attach it to the elevator.

Polymer

A material built up from a series of smaller units (monomers). The molecular size of the polymer helps to determine the mechanical properties of the plastic material.

Polymerization

The process of linking small molecules (monomers) into larger molecules (polymers) comprised of many monomer units.

Post Curing Apparatus (PCA)

A device which generates ultraviolet energy used to cure green stereolithographic parts.

Post process

The process of cleaning, curing and finishing stereolithographic parts.

Process chamber

The chamber in which the resin vat, elevator and beam profilers are located.

Process module

The largest of the two modules which make up the SLA 3500 machine. The SLA 5000 and SLA 7000 is made up of just one module which combines all functions. The process module is where the actual part building takes place.

Random Access Memory (RAM)

The memory within a computer that stores data and programs while they are being executed.

Range

A set of one or more slice layers, defined by upper and lower dimensions in CAD units. A new range must be created to change a part building parameter value.

Recoating

The process of adding a layer of liquid resin with a user-specified thickness on top of the previously cured layer.

Recoat style

A style file that defines parameters associated with recoating during the stereolithographic process.

Recoater assembly

The assembly of an SLA that either applies resin to, or removes excess resin from, the part as the recoater blade moves across the vat.

Recoater blade

The part of the recoater assembly that contacts the resin.

Resin

Another name for the photopolymer chemical used in stereolithography.

Right Hand Rule (RHR)

Makes use of the right hand coordinate system used in stereolithography. Defines X, Y and Z coordinates such that when the thumb points upward, the second or index finger points ahead and the middle finger is perpendicular to the index finger. How the hand is rotated will not change the relationship of the axes to each other.

Safety shutter

A mechanical device that blocks the laser beam when an interlock switch is activated or when closed via the computer user interface.

Sensitization

An allergic response to a chemical stimulus, such as resin, generally resulting from repeated skin contact.

Server

A computer that responds to a request from another computer for data or action and provides access to files for the other computers on a network. Also known as file server.

Settling

The gradual flattening of the resin surface that occurs during the Z-level wait time of the recoating process.

Skin (skin fill)

See fill vectors.

SLA

See Stereolithography Apparatus.

Stereolithography Apparatus

The equipment used to produce stereolithographic parts.

Slice file (SLI)

The slice output file which contains vector data used to build the part.

Slice resolution

A slice parameter that specifies the number of slice units assigned to each CAD unit of measure.

Slice units

A 3D Systems unit of measure used to represent the CAD file after it has been sliced. The CAD unit, multiplied by the slice resolution, equals a slice unit.

SmartSweep™

A feature used to reduce the build times by sweeping only over that portion of the vat where a part is being built instead of sweeping the full area of the vat. See sweep.

Stereolithography

A three-dimensional imaging process that forms plastic objects by solidifying successive layers of photocurable resin.

Stereolithography file (STL)

The tessellated (triangulated) CAD input to slice.

Straight web

A thin rectangle or fin structure type of support defined by six surfaces.

Supports

Structures designed on the CAD system or by *3D Lightyear File Preparation Software* to support a part above the elevator platform, provide a rigid foundation on which the object may be built and attach and support layer sections.

Sweep

A pass of the recoater blade from the front of the vat to the rear or from rear to front. The act of removing excess resin from the upper surface of the part or adding a layer of fresh resin during the recoat process. See recoating and also see SmartSweep™.

Sweep velocity

The rate at which the SLA 3500, SLA 5000 and SLA 7000 recoater blade moves during a sweep. This parameter is set in the recoat style.

Tessellate

To represent CAD surfaces in polygonal format.

Trapped volume

During building, a volume of resin within the part that cannot flow out to the surrounding liquid.

Triangle normal

A line perpendicular to a triangle starting at its center and pointing away from the mass of the part. Triangle normals are used to differentiate between inside and outside surfaces of a solid.

Triangle web

A triangular-shaped support structure. See web support.

Ultraviolet (UV)

Electromagnetic radiation having a wavelength shorter than visible light, (i.e. below 390 nanometers).

Vat

The metal container inside the SLA process chamber that holds the resin in which the object is formed.

Vector

A directed line segment represented by starting and ending coordinates as defined in a stereolithography slice or build file.

Vector block

A set of like vectors (i.e., layer borders, cross hatches, or skin fill).

Web support

A style of support recommended for use in stereolithography because of its ease of creation and removal. Webs are very thin and can be rectangular, triangular or have almost any shape.

Workstation

The high powered personal computer with graphics capabilities, running the *3D Lightyear File Preparation Software 1.0* which creates the build files.

Z-level wait

A part-building parameter that defines the time between dipping and sweeping one layer and the beginning of the vector drawing for the next layer. The Z-level wait allows the resin surface to settle.

Zephyr™

A recoater blade system that uses an internal vacuum cavity to deposit resin on the part thereby reducing Z-level wait and trapped volume sweeping.

Z-Stage

See elevator.

60/120 hatch vector

Cross hatch vectors drawn 60 and 120 degrees from the X axis.

3dverify™

A function in *3D Lightyear File Preparation Software* that is used to verify and fix STL files.

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