SLS® Systems User's Guide

Contents

What's New?

This section describes the new Sinterstation® HiQ™ SLS® System supported by version 3.4 (v3.4) of the SLS system software's **Build Setup** and **Sinter** applications. Operating instructions, safety guidelines, and maintenance procedures for the new HiQ SLS system are covered later in this guide along with instructions and procedures for older SLS system models.

New and changed SLS system software functions in v3.4 are also described in this section. Unless noted otherwise, you can use these new software functions with all SLS system materials on any SLS system running v3.4.

- [New Sinterstation HiQ SLS System](#)
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New Sinterstation HiQ SLS System

This new system provides unparalleled temperature accuracy through automatic temperature sensor calibration. HiQ-specific features supporting this enhanced thermal control include:

- Improved IR temperature sensors

- A blackbody temperature reference device mounted on the roller for precise and highly repeatable IR temperature sensor calibration

- Software management of the calibration process

- Automatic, real-time (in-build) calibration for DuraForm PA, DuraForm GF, and LaserForm A6 Steel materials.

- Offline calibration (in Manual Operations) for all other materials

- Over-temperature protection

The Sinterstation HiQ's superior thermal management enables you to run the same build packet on multiple HiQ machines using the same heater setpoints on all machines. It also increases the recyclability of unused material by drastically reducing the incidence of powder overheating, especially at the end of the build.

Temperature management in the Sinterstation HiQ enhances safety as well as thermal accuracy. For example, if the HiQ senses a feed heater or part bed heater over-temperature condition; i.e., above 350° C for the left or right feed heater and above 425° C for the part bed heater, the system automatically shuts down the build and disables the laser and all heaters.

Vanguard and Vanguard HS systems can be upgraded to Sinterstation HiQ systems.

Improved Build Time Estimation and Smart Feed

In v3.4, 3D Systems further improves build time estimates. With added heuristic intelligence and more hardware information, v3.4 software can predict build times more accurately than ever.

For the first time, Wait for Temps times are taken into account in estimates. The system also now performs Smart Feed calculations whenever you run a build time estimate. Since the system now automatically performs a build time estimate at the start of every build, Smart Feed powder requirements are automatically calculated then as well.

The Smart Feed feature can also now be used with the CastForm PS material.

For more information about time estimates, see <u>Time Estimate Button</u> or your Build Setup online Help, v3.4.

More Ways to Cut STL Files

The v3.4 STL file cutting function in Build Setup significantly increases the functionality of its v3.3 predecessor. Before, you could only cut STL files with a plane; now you can also use an irregular line to define your cut, or even punch a hole in the STL file. Precise multi-hole patterns can be added to parts by repeatedly punching a hole in the STL file. A wizard interface for the Cut STL File tool makes getting the results you want fast and easy.

Faster Nesting

3D Systems added automatic part nesting to Build Setup in the v3.3 release; with v3.4, the feature has been improved, and now performs up to 10 times faster.

New CAD-style User Interface Options in Build Setup

In Build Setup, you can now rotate and zoom the Workspace with your pointing device:

■ Hold down the right mouse/trackball button and drag the pointer to *rotate* the Workspace.

■ If your pointing device has a wheel control, use it to zoom in on or out from the Workspace.

RealMonitor Tracks Calibration Events

For Sinterstation HiQ systems, the RealMonitor and RealMonitor Viewer utilities now indicate the start and end of real-time calibration as an event in the log. For more information, see your *Software Utilities Guide.*

New Configuration File Error-Checking Codes

With the release of new software and hardware features, 3D Systems has put new error-checking codes in many of the configuration files used by the SLS systems; including build packet files. The installation program for v3.4 attempts to locate and convert all of your existing configuration files to make the transition as seamless as possible. However, it will not find files in nonstandard locations, or files with nonstandard names. In general, if you attempt to use a file with an old (pre-v3.4) or missing error-checking code, the system allows you to use it—but may restrict some parameter values to those licensed for use on your system.

The v3.4 error-checking code update affects the following file types:

■ Machine configuration files

■ Machine overlay files

- Material configuration files
- User saved material defaults (.opd, .obd, .osc, .opo and .obo files)
- Customized configuration files (.cmd files)
- User saved part, build, and scale name files
- Build packet files (.bpf and .bpz files)

If you are unable to use an older file after upgrading to v3.4, see Contacting 3D Systems Customer Support.

Overview

This guide describes how to use 3D Systems' Sinterstation 2000/2500/2500^{plus}, Vanguard, and Sinterstation HiQ SLS systems.

This section introduces the *User's Guide*, the selective laser sintering (SLS™) process, the SLS systems, their facility requirements, and the software that manages them. It includes the following topics:

- How to Use this Guide
- Other Documents
- Overview of the SLS Process
- Major Components of the SLS System
- Internal Components
- Back Views of the SLS Systems

- Computers and Controls
- Buttons and Indicators
- 3D Systems Software Provided with the SLS System
- Third-party Software Provided with the SLS System
- Installation and Facilities Requirements

How to Use this Guide

This guide provides the procedures and guidelines necessary to operate an SLS system. For general instructions on using the on-line documentation, see How to Use the On-line Documentation in the documentation index. See also "Other Documents" on page 9.

This guide uses the following conventions:

Items of Special Interest If an item is of special interest, the guide uses the *note* format to call attention to it. A note is preceded by the symbol ✒.

Cautions and Warnings The guide uses two ways to warn of dangerous or hazardous situations:

Caution	**A *caution* indicates something may happen that will cause loss of data or some other undesirable effect**.
Warning	**A *warning* indicates you could be in physical danger or that you are about to do something that will damage the machinery.**

Menus When you need to choose an option from a menu, the word "select" is used, followed by the menu name, an arrow, and the option. For example, to tell you to choose the Exit option from the File menu, the text would read "select File→ Exit."

Keys The names of keys on the keyboard, such as Enter, Shift, or Ctrl, appear in their own distinctive font.

Other Documents

There are other documents you can go to for information on the system and the SLS process:

■ Build Setup Help: Launch the Build Setup Help while you are using the Build Setup application, by selecting Help→ Help on Build Setup. The Build Setup Help system provides information on all aspects of setting up a build.

■ Other on-line documents: To get to an index of on-line documents, click the Home button at the top of any page of this document.

Click here to return to the main index

Overview of the SLS Process

1. Design the model on a CAD system, create the STL file, and transfer it to the SLS system computer.

2. Set up the build packet. See the Help for Build Setup and the material-specific *Material Guide*.

3. Clean the machine if required, and load powder. See "Preparing the Machine for a Build" on page 53.

4. Build parts in the SLS system process chamber, where:

- A roller delivers powdered material in very thin layers across a flat platform.

- A laser beam traces across each layer, fusing the powders in specific areas to create a cross-section of the current part.
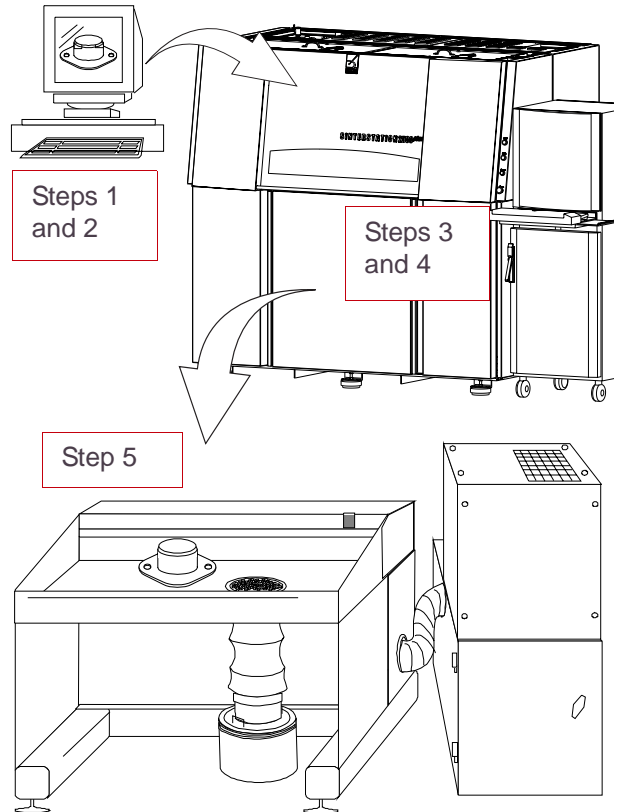
See "Running a Build" on page 66, as well as the *Material Guide* for the material you are using.

5. Break the part out of the powder cake. See "Breaking Out Parts: Overview" on page 78 as well as the appropriate *Material Guide*.

Steps 1 and 2

Steps 3 and 4

Step 5

Major Components of the SLS System

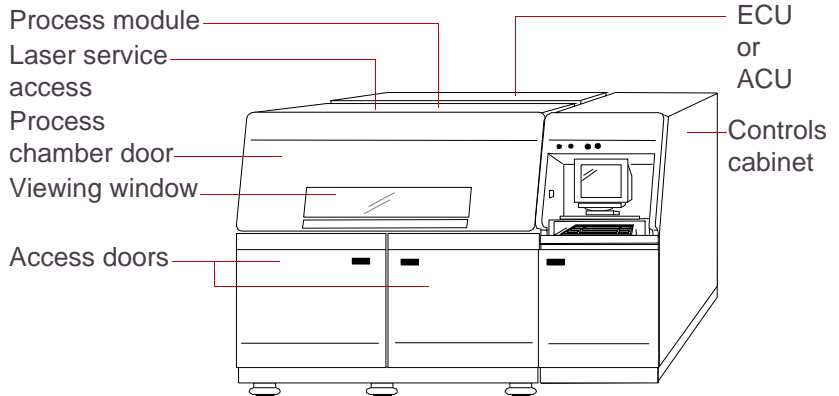Each system contains the following components:

- Process module (for 2000/2500 systems) or process station (for all other models).

- Controls cabinet (for 2000/2500 systems) or computer cabinet (for all other models).
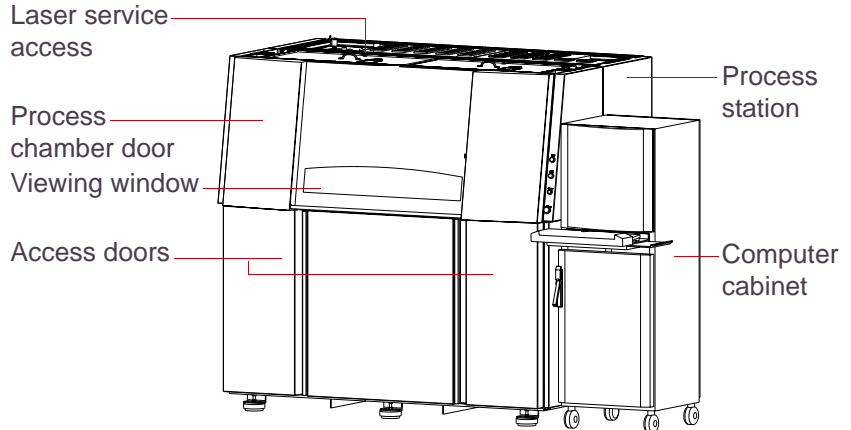
✏ 2000 and 2500 SLS systems house their atmosphere, inerting, and airflow systems in either an Environmental Control Unit (ECU) or Atmospheric Control Unit (ACU). See .

2500^{plus}, Vanguard, and HiQ SLS Systems

Laser service access
Process chamber door
Viewing window
Access doors
Process station
Computer cabinet

2000 or 2500 SLS System

Process module
Laser service access
Process chamber door
Viewing window
Access doors
ECU or ACU
Controls cabinet

Internal Components

Generic internal view of the SLS system

Beam delivery system

Heater assembly

Part bed

Overflow cartridge

Powder feed

Roller

Part cylinder
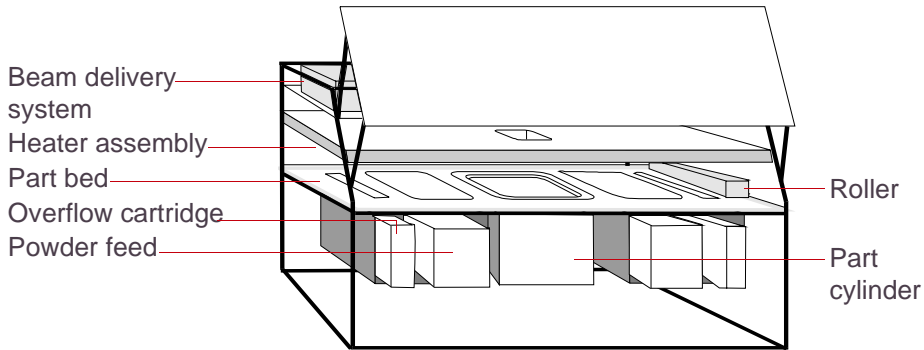
Back Views of the SLS Systems
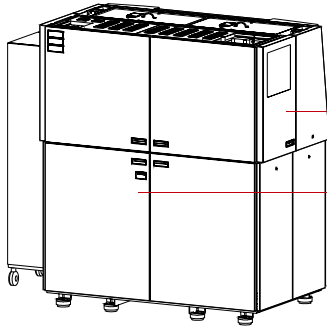
Gauge panel and gauge panel access door

Service panel for access to Main Power Disconnect switch

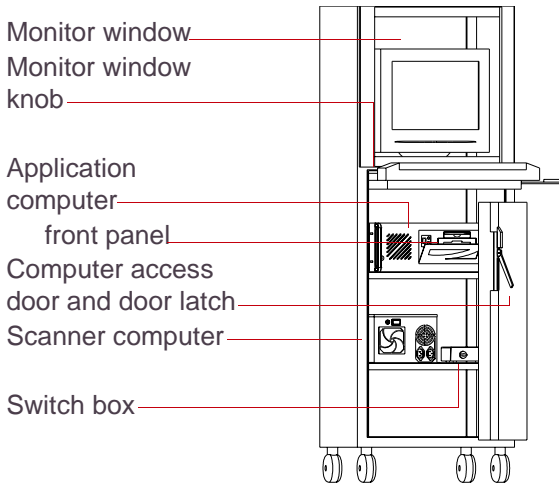**2500^{plus}, Vanguard, and HiQ SLS**
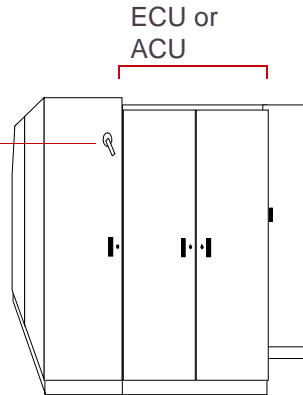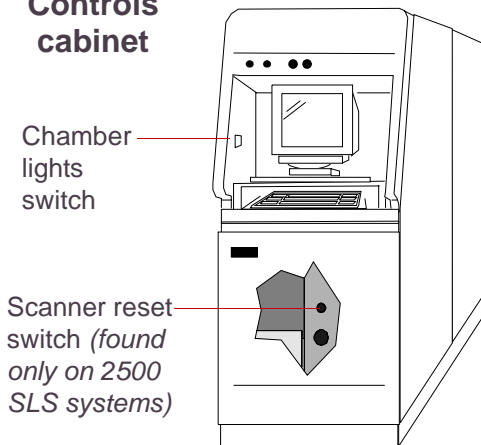
ECU or ACU

Main power disconnect handle

2000 or 2500 SLS systems

Computer cabinet

Monitor window
Monitor window knob

Application computer front panel
Computer access door and door latch
Scanner computer

Switch box

Controls cabinet

Chamber lights switch

Scanner reset switch *(found only on 2500 SLS systems)*

Computers and Controls

You control the SLS system with the application computer and a set of buttons and indicators. The application computer runs the SLS system software, which runs builds, build setup, and manual operations.

Computer Cabinet (Most SLS Systems)

Most SLS systems come with a *computer cabinet* that contains the system computer and the scanner computer. For instructions on opening the computer cabinet and turning the computers on and off, see .

Controls Cabinet in 2000 and 2500 SLS Systems

2000 and 2500 systems come with a *controls cabinet* that contains the system computer and the programmable logic controller (PLC). In 2500 SLS systems, it also contains a scanner computer.

Buttons and Indicators

Upper-right corner, Most SLS systems

Controls cabinet, 2000/2500 SLS systems

System Active
System Enabled

System Off button (red)
System On button

Start button
Stop button (red)
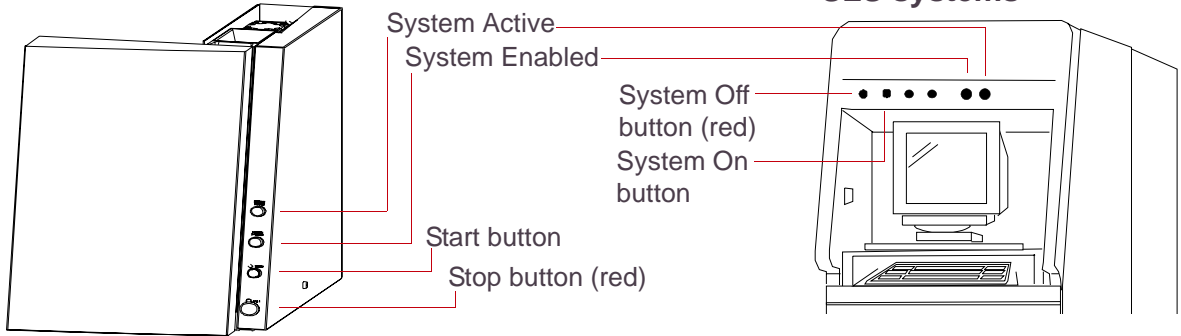
Button/Indicator		Purpose
2500^{plus}/ Vanguard/HiQ SLS systems	2000 and 2500 SLS systems	
Stop button (red)	System Off (0) button (red)	Stops roller and piston motion and turns off the heater and laser power.
Start button (green)	System On (1) button (green)	Turns on various contactors depending on the state of the machine. You must push this button before you can start the build.
System Enabled status indicator (green)		Indicates that the powder feed and part pistons can move. If the door is latched, the system also allows roller motion.
System Active status indicator (green)		Indicates you can use the heaters, laser, powder feed and part piston motion, and the roller motion.

3D Systems Software Provided with the SLS System

SLS System Software

The SLS system software controls the SLS system. With it, you can:

- Set up *build packets*, which store instructions for a build, and preview them. See the Build Setup Help for more information.

- Run builds. See "Running a Build" on page 66 for more information.

- Manually control the SLS system. See Chapter 1, "Manual Operations" in your *Reference Guide* for more information on manually controlling the system.

To start the software, see "Starting and Using the SLS System Software" on page 45.

3D Systems Utilities

In addition to the software that controls the SLS system, 3D Systems provides utility applications with additional functions, such as reducing log files or checking the status of the system from a remote computer. For more information, see your *Software Utilities Guide.*

Major software components

Main application (Sinter.exe)
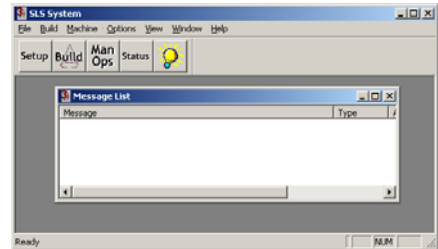
Build Setup application
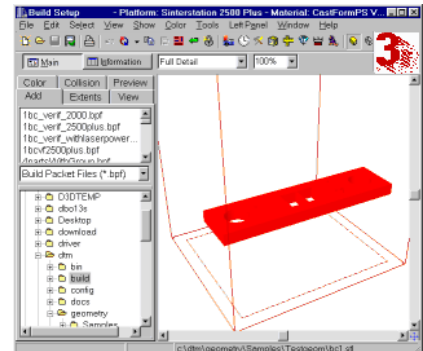
Third-party Software Provided with the SLS System

An STL file editor software package called *Materialise Magics RP* is included with your SLS system shipment. See the *Magics RP* software documentation for instructions. To start the *Magics RP* software, double-click the *Magics RP* icon on your Windows desktop.

Basic functions of the software are free. The software's advanced functions are free for 60 days, and then must be purchased. The 60-day evaluation period is activated by the 3D Systems representative who installs your system. If you do not purchase the activation password, advanced functions are disabled.

Basic Functions	Advanced Functions
■ View STL files ■ Rotate STL files ■ Translate STL files (offset parts from their base location) ■ Scale STL files (increase or decrease the size of a part proportionately)	■ Hollowing parts ■ Changing wall thicknesses ■ Repairing STL files[a] ■ Mold creation ■ Collision detection ■ Cutting parts[a] ■ Punching holes in parts[a] ■ Triangle reduction

a.You can also repair, cut, and punch holes in STL files within Build Setup v3.4. See your Build Setup Help for details.

✎ If your company purchased the password at the same time that it purchased the SLS system, the software will be fully activated by the field service representative who installs your system. If you did not order a permanent activation password for Magics RP software when you purchased your SLS system, you can order one by contacting Materialise. See your Magics RP software documentation for information.

Installation and Facilities Requirements

3D Systems personnel install the SLS system. Prior to installation, your company receives specific facilities requirements and a pre-installation facility checklist from 3D Systems. For complete information, refer to the *Summary of Facilities and Safety Information* (for 2000, 2500, and 2500*plus* systems) or the *Site Preparation Guide* (for Vanguard and Sinterstation HiQ systems).

✏️ The pre-installation facility checklist must be completed and returned to 3D Systems Customer Support before you can schedule installation.

The SLS system computer can be on a TCP/IP network. However, unless your system is a 2000 system, if you connect its computer to a network, do not use the following IP addresses:

- 192.88.202.1
- 192.88.202.2

These addresses are used by the beam delivery system. If this presents a problem, see Contacting 3D Systems Customer Support.

Safety

Before using the SLS system, your company should have a safety program in place. The safety program should:

- Label and point out hazardous equipment, materials, and procedures.

- Explain what to do in an emergency situation.

- Provide information about the hazards of equipment and materials in the form of Material Safety Data Sheets (MSDS's). The MSDS's are provided with all materials supplied by 3D Systems.

This section points out some safety considerations that specifically concern the SLS system. It includes the following topics:

- Safety Design Features in the SLS system

- Safety Hazards and General Guidelines

- Safety Labels

- Environmental Issues

- Laser Safety

- Powder Safety

- Nitrogen/Oxygen Safety

- Pinch Points

- Hot Surfaces and Powders

- Lifting Safety

- Electrical Safety

Safety Design Features in the SLS system

One of the design goals of the SLS system was to provide a safe operating environment.

Warning   **If any of the following safety features fail, your actions may be all that will prevent potentially hazardous operating conditions.**

- Safety interlocks at the SLS system process chamber doors and limited access to electrical cabinets are intended to prevent accidental exposure of the user to the laser beam, thermal hazards, or electrical shock.

- The design of the beam delivery system and the laser window is intended to prevent the laser from being aimed outside the area of the process chamber.

- Limited access to service areas prevents accidental exposure to electrical shock hazards.

- The viewing window to the process chamber prevents user exposure to laser emission while observing operations.

- Limited access to powder areas during builds prevents accidental exposure to thermal hazards.

- The design of the Breakout Station (BOS) and Rough Breakout Station (RBO), in accordance with standard industrial ventilation practices, is intended to remove airborne powder during breakout procedures.

- The use of a room oxygen monitor is intended to automatically implement a shutdown when it detects too little oxygen in a room.

- If the SLS system detects certain unsafe conditions during operation, it is designed to shut down immediately.

Safety Hazards and General Guidelines

The SLS system was designed with safety in mind. However, as with all equipment, improper use, malfunctions, and excessive exposure could cause injury.

When operating the SLS system, always keep the following points in mind:

- Do not operate the SLS system before receiving proper training.

- Follow the procedures in this guide.

- Conform to all the safety rules in this section and the remainder of this guide.

- Use common sense in dealing with the heated, inert environment of the process chamber.

- Do not access any area of the machine near the powder engine and overflow cartridges during high-temperature-material builds.

- Do not use any material without first reviewing its Material Safety Data Sheet (MSDS).

- For SLS systems with computer cabinets, do not pull the computer cabinet away from the process station; this makes the cables connecting the two modules a trip hazard and runs the risk of breaking a connection.

- Do not attempt to access, service, or adjust the laser system in any way.

- Do not attempt to perform any service or maintenance procedures unless you have been specifically trained to do so:

    - *Operators* are trained to operate the system and perform all the necessary tasks to build a part.

    - *Certified service personnel* are 3D Systems, customer, or contract personnel who have completed the 3D Systems service training package and are certified
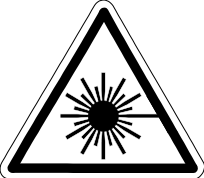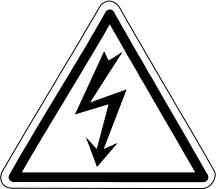
to perform corrective service tasks. Certification may occur at various levels, and the servicer should only be authorized to perform tasks he/she is certified to complete.

■   Do not enter any area displaying posted warning signs during open beam operations. *Open beam operations* refer to the laser, and they occur *only* during service procedures.

■   If you hear an audible alarm, look at the message displayed on the computer screen and refer to Chapter 7, "Messages" in your *Reference Guide*.

Safety Labels

Safety labels are posted on the SLS system machine. The following table contains an illustration and description of each of these labels.

Safety Label	What it Means
	Hot Surfaces Hazard There are surfaces and powders in the vicinity that may be hot and could cause severe burns.
	Laser Radiation Hazard Invisible laser radiation is accessible in the vicinity of this sign or behind the access panel. Direct and scattered radiation can cause severe burns and blindness. Access panels are for service only and should be opened only by certified service personnel. See "Laser Safety" on page 25.
	Electric Shock Hazard High voltage electricity is accessible in the vicinity of this sign or behind the access panel. High voltage can cause severe burns or death. Access panels are for service only and should be opened only by certified service personnel or trained maintenance personnel.

Environmental Issues

The SLS system emits no toxic substances when using materials approved by 3D Systems. This subsection describes environmental issues to be aware of. For more information, see your *Summary of Facilities and Safety Information* (for 2000/2500/2500^{plus} SLS systems) or *Site Preparation Guide* (for other SLS systems)

Emissions

Analytical testing on 3D Systems powders indicates no detectable emissions outside acceptable limits from the SLS system. (See the MSDS's.) The SLS system uses nitrogen, which must be vented to the outside.

Waste Heat

The SLS system produces waste heat, which must be considered when attempting to maintain the temperature specifications in the installation room.

Powder Disposal

When you dispose of powder, refer to the MSDS for that material and follow any applicable local regulations.

Noise Levels

The following table quantifies the noise levels for various components of the SLS system.

Component	Noise Level
SLS System (not including the BOS/RBO station)	60 dB*A*
RBO station composite (sifter and air handler) RBO sifter only BOS composite (station and air handler) Air handler only (BOS and RBO) Air handler self-cleaning cycle	84 dB*A* @ operator standpoint 82 dB*A* @ operator standpoint 79 dB*A* @ operator standpoint 79 dB*A* @ operator standpoint 83 dB*A* @ operator standpoint

Laser Safety

The SLS system contains a 25-, 30-, 50-, or 100-watt CO_2 continuous-wave laser that operates at a 10.6 micrometer wavelength. The laser itself is a Class IV laser. A very brief exposure to a direct—or specularly or diffusely reflected—laser beam can cause significant injury or blindness. It also can be a fire hazard.

During normal operations of the SLS system, the laser beam path is wholly contained within the machine. This makes the entire machine a Class I Laser System. That means the SLS system does not produce damaging emissions under normal operations.

Class I and Class IV are designations established by the U. S. Department of Health and Human Services, Public Health Service, Food and Drug Administration, Center for Devices and Radiological Health (CDRH), and by IEC 825 (the International Electrotechnical Commission's *Radiation Safety of Laser Products, Equipment Classification Requirements, and User's Guide*). You can also read about these designations in *ANSI Z136.1-1993* (the American National Standards Institute standard for the safe use of lasers). This laser classification also complies with DIN VDE 0837/02.86+A1/07.90.

Reporting Laser Radiation Exposure

If anyone at your site is exposed to laser radiation from the SLS system, report the following information to 3D Systems, Inc.:

- Nature of the accident and circumstances surrounding it
- Where the accident occurred
- Model number of the machine
- Number of people involved
- Any other pertinent information

Please send this information to 3D Systems within a day of the accident. The information can be sent by regular mail to 3D Systems marked "Attention: Laser Safety Officer" or by e-mail to LaserSafetyOfficer@3DSystems.com.

Laser Safety Label Locations in 2500^{plus}, Vanguard, and HiQ SLS systems

One external label on each of two laser access panels

Two labels behind the process chamber door

Top Front View
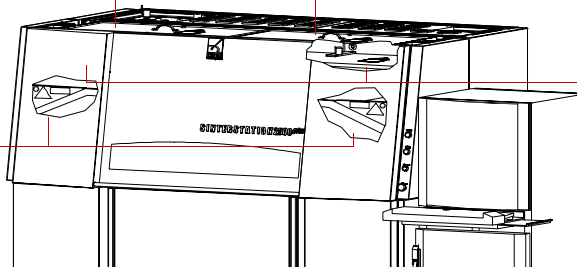
One label underneath each laser access panel

Inside Back View

Two labels inside the process chamber, on inner back wall

One label on each side of the process station, on process chamber side panels (far side not shown)

Two labels on process chamber back panels

Laser Safety Label Locations in 2000 and 2500 SLS systems

DANGER
INVISIBLE LASER RADIATION
WHEN OPEN.

DANGER:	INVISIBLE LASER RADIATION WHEN OPEN. AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION.
DANGER:	RAYONNEMENT LASER INVISIBLE PENDANT OUVERTURE. EVITER UNE EXPOSITION DES YEUX OU DE LA PEAU AU RAYONNEMENT DIRECT OU DISPERSÉ.
GEFAHR:	UNSICHTBARE LASERSTRAHLUNG IM GEÖFFNETEN ZUSTAND. AUGEN UND HAUT NICHT DIREKTER ODER DIFFUSER STRAHLUNG AUSSETZEN.
PERICOLO:	RADIAZIONI LASER INVISIBILI QUANDO APERTO. EVITARE L'ESPOSIZIONE DEGLI OCCHI O DELLA PELLE ALLE RADIAZIONI DIRETTE O DISPERSE.
PELIGRO:	EXISTE IRRADIACIÓN LASÉRICA INVISIBLE CUANDO ESTÁ ABIERTA. NO DEBEN EXPONERSE LOS OJOS NI LA PIEL A LA RADIACIÓN DIRECTA O DIFUSA.

General Laser Safety Rules

Warning

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

Failure to follow laser safety rules can result in exposure to hazardous radiation. Radiation can cause burns on the skin and cornea, which can temporarily or permanently damage your vision.

You should always comply with the following rules when working with laser equipment.

■ Operators must attend a training class for SLS system procedures.

■ Operate the SLS system *only* with the process chamber door latched and all covers in place. The SLS system laser is enclosed in a protective housing to prevent exposure to radiation. *The protective housing has tool-access locks to prevent access to the laser during normal SLS system operation.* However, if someone tampers with or defeats the interlocks and opens the protective housing, the potential for exposure exists.

■ Do not look directly into a laser beam or even at diffuse reflections of a beam.

■ Do not operate the SLS system with a broken or missing window.

■ Operate the SLS system in accordance with all local regulations. If your state or national government does not provide guidelines for operation of Class I laser systems, refer to *ANSI Z136.1-1993* (American National Standards Institute standard for the safe use of lasers).

- Only certified service personnel specifically trained in laser safety should perform laser service procedures.

- Do not enter any area displaying posted warning signs during *open beam operations*. Open beam operations occur only during service procedures and with a warning sign posted.

Laser Service Guidelines

On occasion, certified service personnel must perform alignment or focus adjustments on the SLS laser or beam delivery system. When this occurs, certified service personnel at your site should follow the special laser safety precautions described in the following list:

■ *Certified service personnel should secure the room containing the SLS system; it is called the Nominal Hazard Zone* (NHZ). The room must have locks on the door(s) that limit entry but do not restrict exit. If the SLS system is in an area that cannot be secured by door locks, *your company* must provide laser safety curtains or alternative safety precautions.

■ Certified service personnel should post *Exposed Non-Visible Laser in Operation* signs at each entrance to the room containing the SLS system.

■ Certified service personnel should notify and instruct everyone in the area to wear safety glasses (ANSI Z136.1-1993 section 4.6.2 and ANSI Z87.1; DIN 58215/01.86 and DIN 58219/02.86). The CO_2 laser wavelength cannot travel through glass. It will create a visible indication on polycarbonate. *Your company* must provide industrial safety glasses of either glass or polycarbonate for adequate eye protection.

■ If your company requires any precautions beyond these, such as a flashing red light to be in operation during the process, *your company* must provide the equipment. Certified service personnel should comply with all of your safety requirements.

Powder Safety

All powders certified by 3D Systems are safe during normal operation. However, you should be aware of the following issues:

■ Any powder, powder-like substance, or airborne cloud of powder has a remote chance of rapid combustion.

■ Breathing some powders may cause certain people to experience respiratory irritation.

■ Powder safety hazards are minimized by good industrial housekeeping and ventilation practices.

■ Spilled powder can cause the floor to become very slippery.

■ Powder should be sifted in a well-ventilated room.

Refer to the MSDS's and to 3D Systems material guides for information on specific powders.

Warning **Using materials that have not been certified for use in the SLS system may cause health or safety hazards and may cause damage to the SLS system and void the warranty.**

Powder Ignition Information

Powdered materials can be flammable and can be ignited by static electricity in a non-inert environment. Refer to each powder's MSDS for specific information.

Finding Powder Safety Information

Use the following table to as a general guide to help you find powder safety information. Check the MSDS of the material used for the specific precautions to be observed.

Powder Safety Information	Refer to:		
Standard industrial ventilation practices	**US**: American Conference of Governmental Hygienists, Committee on Industrial Ventilation **Europe**: *Maximale Arbeitsplatz Konzentration*, January 1990		
Housecleaning and prevention of accumulation of explosive dust concentrations	**US**: NFPA 654: Standard for the Prevention of Dust Explosions in the Plastics Industry; National Fire Protection Association, Volume 5 of the National Fire Codes **Europe**: *Maximale Arbeitsplatz Konzentration*, January 1990		
Powder exposure	**US**: *Code of Federal Regulations, 29 CFR*, section 1900.1000, available from Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 **Europe**: DIN EN 26184 Teil 1 /06.91		
Specific powdered materials	Material Safety Data Sheets (MSDS) from 3D Systems, Inc.:		
		US/**Canada**:	**Europe**
	Mfgr. Contact:	3D Systems, Inc. 26081 Avenue Hall Valencia, CA, 91355, U.S.A.	3D Systems GmbH Guerickeweg 9 D-64291 Darmstadt, Germany
	Information	Phone: 970-257-4700 or Toll-free: 800-793-3669	Phone: +49 (0) 6151 357-357 Fax: +49 (0) 6151 357-111
	Emergency	800-424-9300 - Chemtrec	703-527-3887 - Chemtrec (U.S.)

Powder Handling Precautions

During normal operation of the SLS system using 3D Systems' materials, you are not required to wear a dust mask or special personal protection equipment unless specifically designated. Check the MSDS of the material used for the specific precautions you should observe. Use the following table of precautions as a general guide:

Category	Precaution
Fire/Heat	■ Never smoke or ignite any materials around powder. ■ Maintain proper clearance from powders when using portable heating devices. ■ Store flammable liquids away from powder. ■ After removing a part from the process chamber, allow it to cool to room temperature in a well-ventilated area. ■ Use an anti-static mat in front of the SLS system machine.
Inhalation	■ Avoid breathing powdered materials; when exposure to dust or fumes is likely, wear a NIOSH approved respirator appropriate to the airborne concentration. ■ Always provide adequate ventilation.
Shop Safety	■ Train operators in SLS system procedures. ■ Wear safety glasses. ■ Use extreme care with all heated powders. ■ Make sure that the room is well ventilated.

Category	Precaution
Avoiding Spills	■ Keep containers closed when not in use. ■ Have a fully-grounded internal non-ignition vacuum cleaner ready to use. ■ Have any equipment specified in the MSDS ready to use.
MSDS	■ Give operators access to the MSDS's that apply to materials they will be handling and ensure that they read them. If necessary, translate them. ■ File MSDS's in an easily accessible location for immediate reference. ■ Strictly follow all the conditions in each MSDS.

Nitrogen/Oxygen Safety

The SLS system uses nitrogen to create an inert atmosphere in the process chamber. The nitrogen inhibits any potential rapid combustion of particulate matter during the selective laser sintering process.

The oxygen content of air is approximately 21 percent. Displacement of the normal atmosphere with an inert gas, such as nitrogen, can reduce the oxygen content in a room. In the remote chance that nitrogen leaks into the room during the sintering process, the situation can be hazardous.

Your site must have an oxygen monitor installed in the room containing the SLS system. This monitor will alert you if the oxygen level drops below a designated point. It can be wired to trigger an immediate shutdown of the SLS process.

Warning **Exposure to an atmosphere containing 12 percent or less oxygen causes unconsciousness without any warning symptoms. This happens so quickly that you cannot help or protect yourself.**

The table on the next page explains the potential effects and symptoms that can occur at different concentrations of oxygen in the atmosphere.

When you work in an environment that may become oxygen-deficient, make sure you comply with the following items:

- You have received oxygen/nitrogen safety training.
- The room is well-ventilated.
- Self-contained breathing apparatus is available and easily accessible.
- The room oxygen monitor is functioning.
- The room oxygen monitor alarm is audible.

■ Listen for the monitor alarm while working at the SLS system.

Oxygen Content (% by volume)	Effects and Symptoms at Atmospheric Pressure
15 - 19 percent	Decreased ability to work strenuously. May impair your coordination or may induce early symptoms in persons with coronary, pulmonary, or circulatory problems.
12 - 14 percent	Increases respiration during exertion. Pulse rate goes up. May experience impaired coordination, perception, and judgment.
10 - 12 percent	Respiration continues to increase in rate and depth. Lips become blue. *May* lose consciousness at this point.
8-10 percent	Mental failure. Fainting and unconsciousness. Face becomes ashen, lips become blue. Nausea and vomiting may occur.
6 - 8 percent	100% fatal after 8 minutes of exposure. 50% fatal within 6 minutes. Recovery with treatment within 4 to 5 minutes.
4 - 6 percent	Coma within 40 seconds; convulsions, respiration ceases, death occurs.
From Safety Bulletin SB-2 - 1983—©1983 by the Compressed Gas Association, Inc. 1235 Jefferson Davis Highway, Arlington, VA 22202	

Pinch Points

You should be aware of the following pinch points in the SLS system:

Process Chamber Door The process chamber door is hinged with a linkage that can crush your hand if you place it in the hinge path. To avoid potential injury, follow these safety precautions:

■ Always open and close the door completely, using *both hands* on the handles. Do not allow the door to rest partially open.

■ Keep your hands away from the hinge area; always check that no one else is in the area.

Powder Lids For some powder containers, there is a pinch point on the powder barrel retaining ring when you close it from an open position. The two edges can close to create a severe pinch point if your fingers are between them.

Keep hands away from hinges

Use both hands on door handles to open door to ensure your hands are away from pinch points
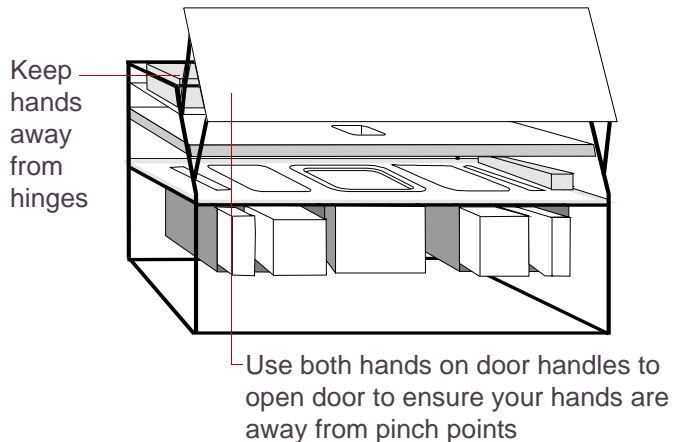
Hot Surfaces and Powders

The SLS process chamber contains heaters. During and after a build, the process chamber contains hot materials. Avoid burns by taking the following precautions:

■ Allow the process chamber to cool after opening the process chamber door.

■ Know which surfaces in the process chamber are likely to be hot after a build. These are indicated by warning labels (described in "Safety Labels" on page 23). Avoid those surfaces when moving the heater assembly and removing parts from the process chamber. In particular, avoid the floor of the process chamber.

■ Use appropriate gloves when removing the part cake from the process chamber, or let the part cake cool for several hours before you touch it.

Heater assembly

Process chamber floor will be extremely hot after a build

Allow system to cool with door open after a build
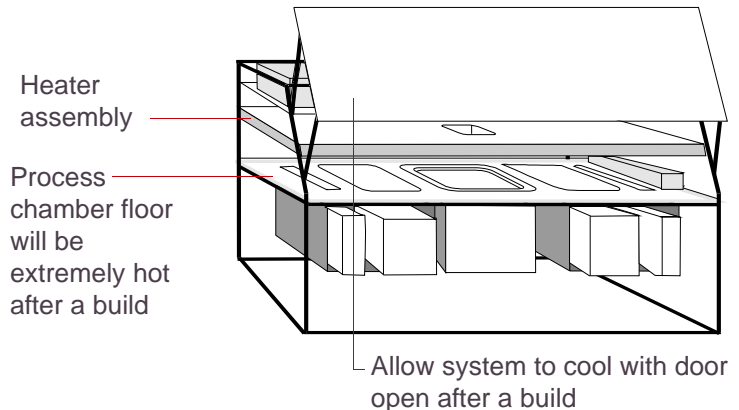
Lifting Safety

The following table gives weights of items that may need to be lifted while using the SLS system. Use standard lifting practices (one person per 22.7 kg (50 lb)) when loading these items in or out of the SLS system. If you are not accustomed to lifting this much weight, or if you have back problems, do any or all of the following to protect yourself: use additional people to lift the items, scoop out powder to reduce weight, or use an optional material handling lift cart.

Item	Weight for 2000 SLS Systems	Weight for 2500 SLS Systems	Weight for other SLS Systems
Feed cartridge, empty	10 kg (22 lb)	10 kg (22 lb)	N/A
Feed cartridge, full	30 kg (66 lb) to 136 kg (300 lb)	33 kg (72 lb) to 175 kg (385 lb)	N/A
Small overflow cartridge, empty	4 kg (8 lb)	N/A	N/A
Small overflow cartridge, full	6 kg (14 lb) to 55 kg (120 lb)	N/A	N/A
Standard overflow cartridge, empty	5 kg (10 lb)	5 kg (10 lb)	5 kg (10 lb)
Standard overflow cartridge, full	12 kg (26 lb) to 99 kg (218 lb)	13 kg (28 lb) to 109 kg (240 lb)	25 kg (55 lb) to 134 kg (296 lb)
Feed transfer container, full	N/A	N/A	20 kg (44 lb) to 129 kg (284 lb)
Part transfer container, full	22 kg (48 lb) to 152 kg (335 lb)	42 kg (92 lb) to 243 kg (536 lb)	42 kg (92 lb) to 243 kg (536 lb)

Electrical Safety

The SLS system was designed to minimize operator exposure to electrical hazards during normal operations. All exposed electrical circuits in the SLS system are inside limited-access cabinets. This is to separate the operator from service and maintenance areas.

When operating the SLS system, keep the following points in mind:

- Only certified service personnel should operate the SLS system with the access panels and service doors open.

- Heed the warning signs regarding high voltage.

- Use common sense and take the usual safety precautions when operating any electrical equipment.

- After any change to the electrical wiring, make sure the system is properly grounded.

SLS System Basics

This section describes basic tasks for using the SLS system. It contains the following topics:

- [Turning on the Equipment](#)
- [Logging In to Windows](#)
- [Starting and Using the SLS System Software](#)
- [Message List Window](#)
- [Selecting a Display Language](#)

- [Shutting Down the Computer Normally](#)
- [Using the Stop/System Off Button to Stop Motion, Heating, and Laser Power](#)
- [Shutting Down the Entire SLS System](#)

Turning on the Equipment

3D Systems designed the SLS system to remain with the power on at all times. You seldom need to power-up the machine or computer. If you ever find the power off, this subsection describes how to turn on the system.

Turning on the SLS System Machine

1. Make sure the facility power to the system is turned on.

2. On the back of the SLS machine, turn the Main Power Disconnect to the On position.

<div align="center">

2000/2500 SLS systems   **2500^{plus}, Vanguard, and HiQ SLS systems**

</div>

Back of machine

Main power disconnect handle

Back of machine

Service panel for access to Main Power Disconnect switch
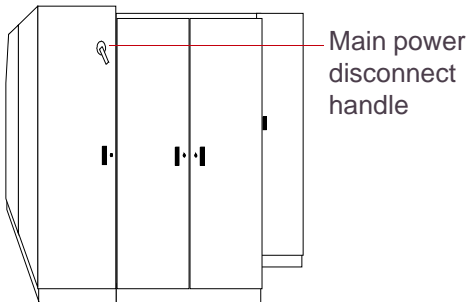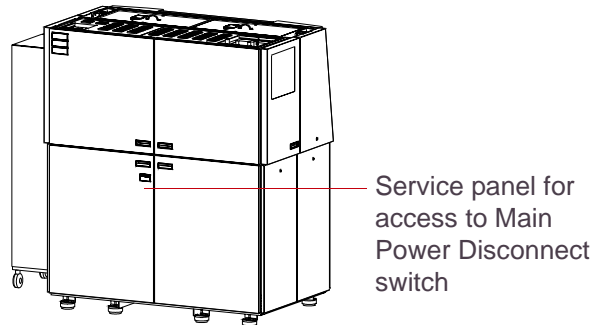
Turning on the SLS System Computer(s)

To turn on the SLS system computers:

1. Open the computer access door located below the monitor alcove.

2. Press the application computer On/Off switch.

✏️ On some systems, you will need to open a panel on the computer to access the On/Off switch.

3. Close the computer access door.

4. *For all non-2000 SLS systems,* turn on the scanner computer (below the application computer) by pressing its On/Off switch.

5. Turn on the monitor by pressing the power button.

✏️ For 2500^{plus}, Vanguard, or HiQ SLS systems, you will need to open the monitor window to access the monitor. Pull the monitor window knob inside the keyboard cavity to open the monitor window.

Computer cabinet (2500^{plus}/ Vanguard/HiQ SLS system)

Monitor window knob

Application computer front panel

Scanner computer
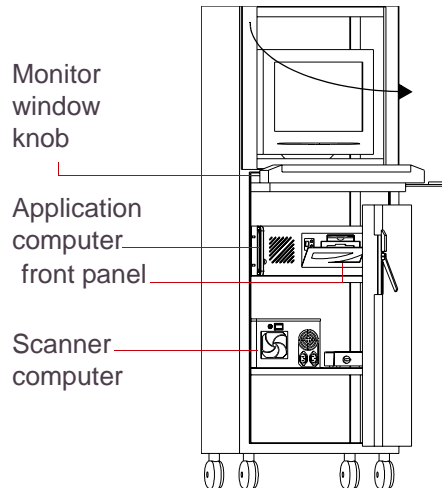
Computer access door latch

Slide button cover up, then press metal button

Turn handle
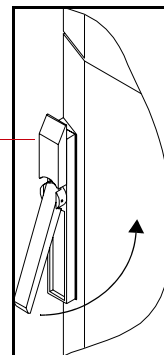
Logging In to Windows

When you turn on the SLS system computer, the system starts the Windows operating system. You will need to log in before you can run the SLS system software. When prompted by the operating system, press the Ctrl-Alt-Del keys at the same time to display the login panel. Then enter your username and password in the fields provided. Your system administrator may provide you with a username and password; if not, the default username is Administrator, with no password required. For more information, see your Windows documentation.

Starting and Using the SLS System Software

Main window, in Main mode
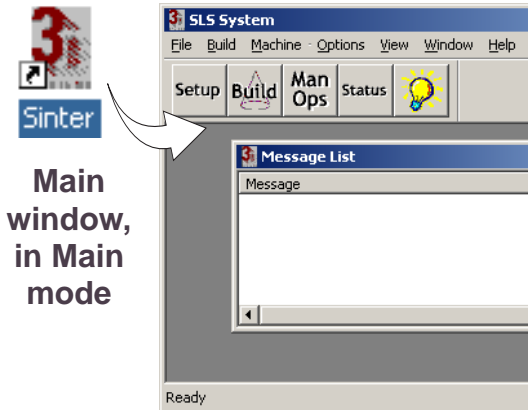
To start the software, double-click the Sinter icon on your Windows desktop, or select Programs→SLS system→Sinter from the Start menu.

Modes

The SLS system software has three modes. In each mode, a different toolbar appears on the main window.

When you start the SLS system software, the software is in *Main mode* and displays the Main toolbar. You use Main mode to get to the other modes and to launch other applications.

Main mode
Launches other applications, modes

Build mode
Starts a build

Manual Operations mode
Runs machine hardware
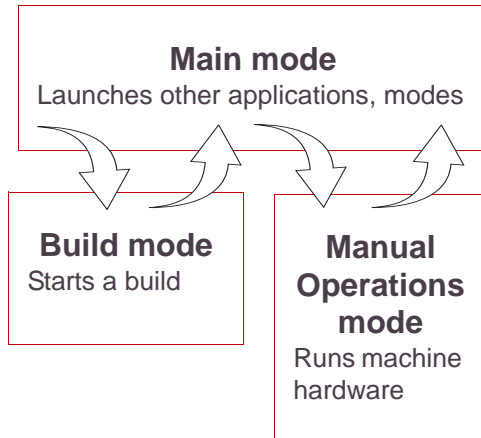
Main toolbar

Set up a build (launches the Build Setup application)
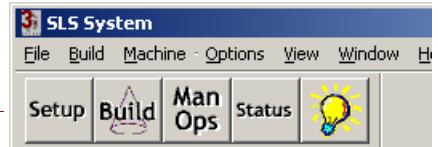
Enter Build mode (see)

Enter Manual Operations mode

Display a Status window

Chamber lights on/off (not available on some systems)
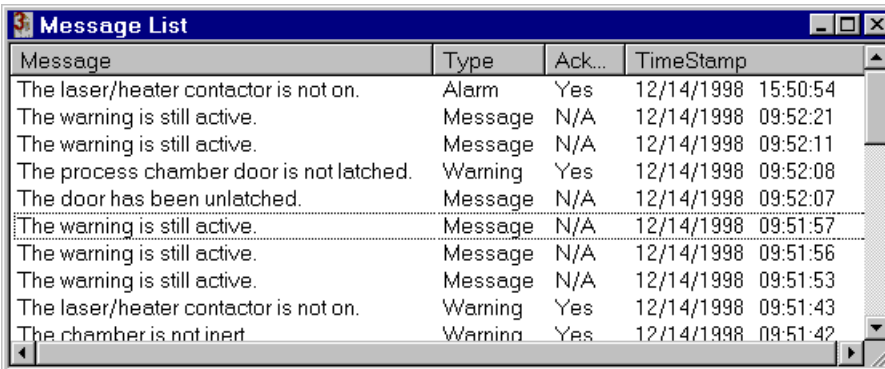
Message List Window

The Message List window appears within the main SLS System window. It displays messages about the operation of the system. As new events occur, descriptive messages are added to the list. You can minimize this window, but you cannot close it.

The Message List window is available in all three software modes.

There are four types of messages: Messages, Advisories, Alarms, and Warnings. The last three types also display pop-up boxes. Each pop-up box contains a Help button that you can click for more information about the specific Advisory, Alarm, or Warning.

✔ For more information on the types of messages that you can receive, see Chapter 7, "Messages" in your *Reference Guide.*

Message	Type	Ack...	TimeStamp
The laser/heater contactor is not on.	Alarm	Yes	12/14/1998 15:50:54
The warning is still active.	Message	N/A	12/14/1998 09:52:21
The warning is still active.	Message	N/A	12/14/1998 09:52:11
The process chamber door is not latched.	Warning	Yes	12/14/1998 09:52:08
The door has been unlatched.	Message	N/A	12/14/1998 09:52:07
The warning is still active.	Message	N/A	12/14/1998 09:51:57
The warning is still active.	Message	N/A	12/14/1998 09:51:56
The warning is still active.	Message	N/A	12/14/1998 09:51:53
The laser/heater contactor is not on.	Warning	Yes	12/14/1998 09:51:43
The chamber is not inert	Warning	Yes	12/14/1998 09:51:42

Selecting a Display Language

The SLS system software can use languages other than English. To choose one, select **Options**→ **Language**. The Change Language dialog box appears. Select a language from the drop-down list and click the OK button. You can also select a language in the Build Setup application through its Preferences dialog box.

Shutting Down the Computer Normally

3D Systems designed the SLS system to remain with the power on at all times. You seldom need to power-down the computer, unless:

- You are shutting down the entire SLS System.

- The computer requires service.

- The system loses facility power and does not regain it immediately.

- The system will be idle over an extended period of time.

> **Caution**   **Before you turn off the computer, the Windows operating system must manipulate files and processes to prevent file corruption. The steps in the following procedure describe how to perform an orderly shutdown that prevents file corruption.**

1. Exit the SLS system software.

2. From the Windows Start menu, select Shut Down.

   The system displays a dialog box asking you to verify that you want to shut down the computer. Select Shut Down and click the Yes button.

   Wait for the computer to display the following message before proceeding:

   ```
   It is now safe to turn off your computer.
   ```

3. Turn off the application computer and monitor by pressing their power switches. In all but 2000 systems, also turn off the scanner computer.

   See steps 1 through 5 of .

Using the Stop/System Off Button to Stop Motion, Heating, and Laser Power

If you need to immediately stop motion, heating, or laser power, press the Stop/System Off button.

You must shut down the heater, the laser, piston motion, and roller motion when any mechanical binding occurs with the roller, the feed pistons, the belt seal, or the part piston.

Depending on the function that you are performing, you may receive alarm messages indicating that you have lost the roller, the stepper motor, or laser/heater contactors. When you are ready to start the system again, follow normal start-up procedures, except that you may need to home the feed and part pistons. See . For information on homing the pistons, see "Piston Control" in Chapter 1 of your *Reference Guide*.

Shutting Down the Entire SLS System

Power down the entire SLS system when:

- 3D Systems instructs you to do so
- The machine will be idle over an extended period of time
- It is required as part of a company-wide shutdown

To shut down the entire system:

1. Exit the SLS system software and Windows and turn off the computer.

    For instructions, see .

2. Turn the Main Power Disconnect switch on the back of the SLS system to the Off position.

Turning off the SLS system

2000/2500 SLS systems   **2500**^{plus}**, Vanguard, and HiQ SLS systems**

Back of machine

Main power disconnect handle

Back of machine

Service panel for access to Main Power Disconnect switch
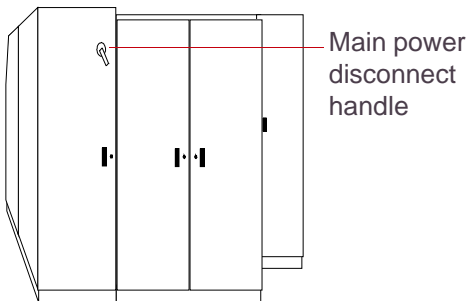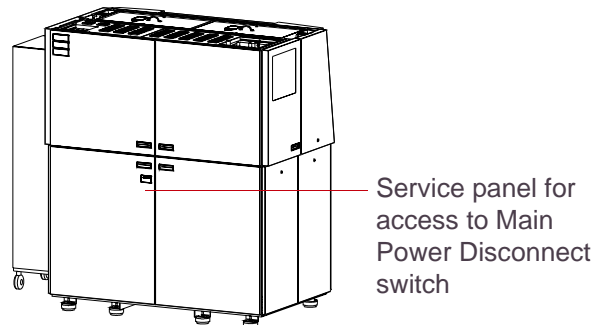
Building Parts

This section covers the tasks involved in building parts. It contains the following topics:

- [Pre-build System Checklist](#)
- [Preparing the Machine for a Build](#)
- [Verifying Powder Quantity](#)
- [Unloading Cartridges in 2000 and 2500 SLS Systems](#)
- [Loading Cartridges in 2000 and 2500 SLS Systems](#)
- [Filling Feeds](#)
- [Pressing Powder](#)
- [Emptying Overflow Cartridges](#)
- [Installing and Removing the Feed Heat Deflector on the 2000 SLS System](#)
- [Running a Build](#)
- [Restarting a Terminated Build](#)
- [Viewing a Build While In Progress](#)
- [Changing Critical Parameters During a Build](#)
- [Calibrating IR Sensors](#)
- [Pausing a Build](#)
- [Modifying a Build in Progress](#)
- [When a Build Ends](#)
- [Breaking Out Parts: Overview](#)
- [Preparing to Remove a Part Cake](#)
- [Removing a Part Cake from the Process Chamber](#)
- [Using the BOS](#)
- [Using the RBO](#)
- [Breaking Out Parts at the BOS or RBO](#)
- [After Breakout](#)

Pre-build System Checklist

Check the following items before starting a build:

- At least 50 MB of hard-disk space on the SLS system computer.

- Enough nitrogen available.

  The SLS system uses as much as 2800 liters of nitrogen during the initial purge for a build. ill, Vanguard, and HiQ SLS systems use up to 7 lpm during the build; 2000 and 2500 SLS systems use up to 1.4 m^3/hour (23 lpm) of nitrogen during the build. If you know how long the build will take, calculate the nitrogen needed; if you are not sure, estimate and make sure you have plenty of extra nitrogen and/or the ability to easily switch nitrogen tanks.

✏ Some materials require less nitrogen, and some require no nitrogen. Consult the appropriate *Material Guide* for more information.

- Enough powder in the feeds. See .

- Verify that the gas flow rates are set properly. See *"Monitoring/Adjusting Gauges" in Chapter 2* of your *Reference Guide.*

Preparing the Machine for a Build

Model-specific Tasks

2000 and 2500 SLS systems Load cartridges and install the downdraft screen or plate (depending on the material) and set the custom downdraft flow rate, if necessary. See "Using Downdraft in 2000/2500 Systems" in Chapter 4 of your *Reference Guide*.

2500 Systems Only Attach the rear reflector. Center the rear reflector over the IR sensor and push it gently to snap it onto the ball studs.

Feed Heat Deflector in 2000 SLS systems You may want to use it for some materials, such as Somos 201 powder. See "Installing and Removing the Feed Heat Deflector on the 2000 SLS System" on page 64.

HiQ, Vanguard, 2500^{plus}, or 2500 SLS systems Insert the swing gates, if you have not already done so.

HiQ systems Clean the blackbody before every build when you clean the process chamber (step 1, below). Lower the blackbody and wipe its surface with a clean dry, lint-free cloth or lens tissue, moistened with ethanol if needed. Do not spray the blackbody with ethanol. After you clean the chamber and level powder as described below, run an offline calibration if one has not been performed recently; see Calibrating IR Sensors.

All SLS Systems

1. Clean the process chamber. See "Cleaning the Process Chamber" in Chapter 2 of your *Reference Guide*.

2. Move the heater assembly into build position. When moving the heater assembly, grasp the heater assembly handles with both hands. *In 2000 or 2500 SLS systems,* lower the heater assembly, and then install the diffuser, if needed. *In other*

systems, pull the heater assembly out. *In HiQ Systems,* after you pull the heater assembly out, raise the blackbody.

3. Put the SLS system software in Manual Operations mode by clicking the Man Ops button on the main toolbar.

4. Close the process chamber door and latch it using the SLS system software (see "Latch" in Chapter 1 of your *Reference Guide)*.

5. Level powder with the Level Powder dialog box (see "Level Powder" in Chapter 1 of your *Reference Guide*).

Verifying Powder Quantity

Before you start a build, make sure there is enough powder to complete it.

Determining Available Powder

1. With the SLS system software in Main mode, select Build→ Parts or click the Build button on the toolbar.

   The Build Parts window appears.

2. Check the Powder Remaining value on the Build Parts window.

   This value indicates how much powder remains in the powder feed with the *least* powder remaining.
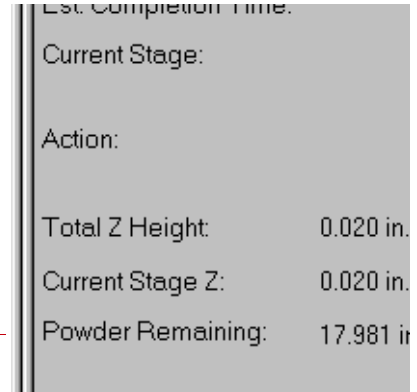
Determining Powder Needed

Open the build packet in the Build

Build Parts window

Powder Remaining

Est. Completion Time:	
Current Stage:	
Action:	
Total Z Height:	0.020 in.
Current Stage Z:	0.020 in.
Powder Remaining:	17.981 ir

Build Setup window, Information view, Powder Needed

Property Name	Value
Warm-up Height	0.150 in.
Build Height	7.849 in.
Cool-down Height	0.000 in.
Powder Needed	9.308 in.

Setup application. Display the Information view by clicking the Information button on the toolbar. Check the Powder Needed amount in the Build Setup window.
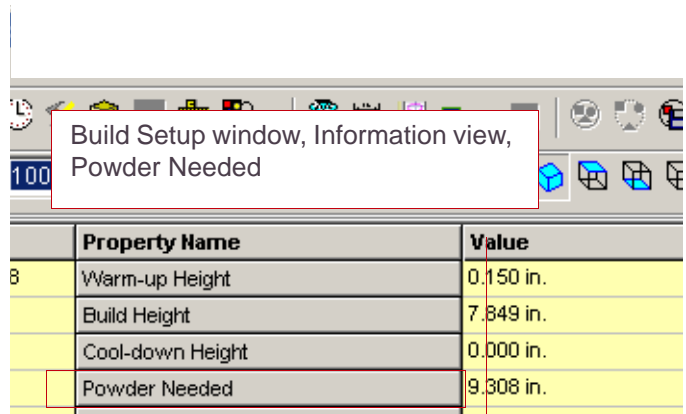
✏ If Powder Needed is in red, the Build Packet has Smart Feed enabled but Powder Needed has not been calculated yet. Run Time and Powder Estimation or a Build Preview to calculate Powder Needed.

Unloading Cartridges in 2000 and 2500 SLS Systems

This topic applies only to 2000 and 2500 SLS systems, which have removable powder feed cartridges; other SLS systems have permanently installed feeds. This procedure contains two topics:

■ Unloading Cartridges from the SLS System

■ Physically Removing Cartridges

✏ In 2000 and 2500 SLS systems, always keep the default material set to the material that is in the machine. The SLS system uses the material setting to enable the IR sensor block heater. If you change materials, the IR sensor block heater may need to either warm up or cool down, depending on the material chosen. Once the heater reaches the material setpoint, it takes an additional 20 minutes to stabilize.

Warning

If you change from a low to a high temperature material on a 2500 SLS system, the system displays the following warning:

You are going from a low temperature material to a higher temperature material. You must clean out the part piston seal. Failure to do so will cause damage to the SLS System.

Clean the piston seals to avoid damaging them.

Unloading Cartridges from the SLS System

1. Put the SLS system software in Man Ops mode.

2. Click Unlatch on the toolbar.

3. Press the System On button.

4. Click Unload Powder on the toolbar; the Unload Powder Cartridges dialog box appears.

5. Click on one or both check boxes to select cartridges.

6. Click this button to unload the selected cartridges.

7. Close the dialog box. A Material Confirmation dialog box appears. Change the material to the one *you will be loading.*

Unload Powder Cartridges

Select cartridge(s) to unload:

☐ Left
☑ Right

Move piston(s) to refill position

Piston(s) moved to refill position: None

Open cartridge door(s) and remove cartridge(s)
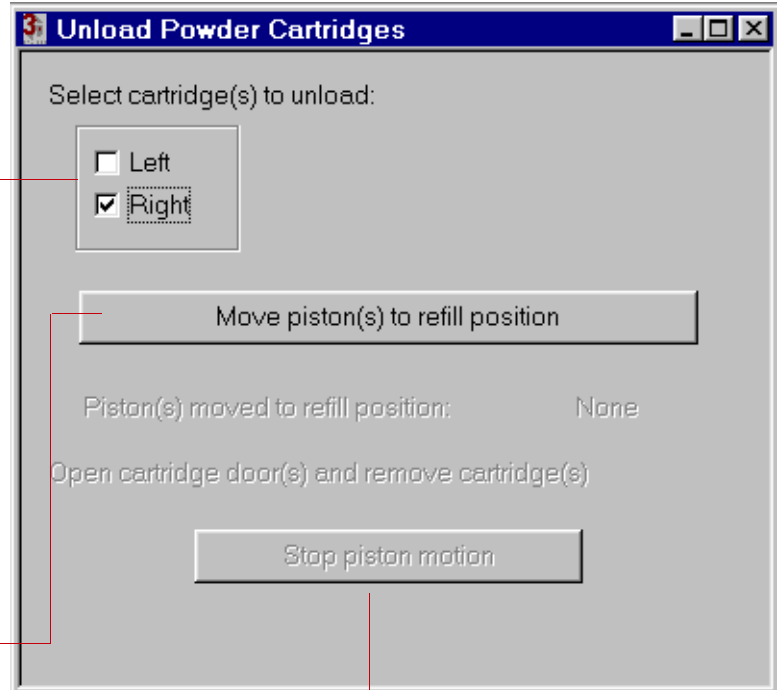
Stop piston motion

When the piston is moving, the Stop piston motion button becomes active

Physically Removing Cartridges

3D Systems recommends you use a material handling lift cart, as shown below.

Caution **Use safe lifting practices when loading and unloading cartridges. Full cartridges can weigh more than one person can safely lift; for weight information, see "Lifting Safety" on page 39. If you are running one of the heavier materials, you may need to empty the overflow cartridges frequently so they do not become too heavy.**

Warning **Use caution when removing a cartridge after a high temperature build to avoid burns.**

1. *If you are using a 2000 system*, open the powder access doors.
   If you are using a 2500 system, you may need to press the safety latch button to release the door, then open the powder access doors.

   The safety latch is adjacent to the middle leg of the powder engine frame. The process chamber door must be open to access the release button.

2. Grasp the handle on the top front of the cartridge or the front flange.

3. Slowly slide the cartridge straight out toward you until you can firmly grasp the handles on the sides of the cartridge.

4. Firmly grasping the cartridge handles, slowly slide it toward you.

Material handling lift cart

Cartridge chain

Conveyor assembly
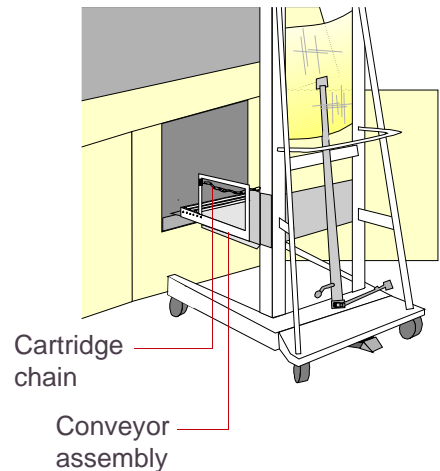
Loading Cartridges in 2000 and 2500 SLS Systems

This topic describes how to load powder feed and overflow cartridges in a 2000 or 2500 SLS system (you do not need to load cartridges in other SLS systems). This procedure contains two topics:

■ Getting Started

■ Loading Powder Cartridges

✏ If you have not already done so, clean the gaskets and reference plates before you load the cartridges. See "Cleaning Cartridge Gaskets/Reference Plates" in Chapter 2 of your *Reference Guide.*

Getting Started

✏ Some 2500 SLS systems have a safety latch button that releases the doors. The safety latch is adjacent to the middle leg of the powder engine frame. The process chamber door must be open to access the safety latch button.

Open the powder access doors. Put the SLS system software in Man Ops mode. Press the System On button to activate the machine.

> **Caution**
>
> **Use safe lifting practices when loading and unloading cartridges. Full cartridges can weigh more than one person can safely lift; for weight information, see "Lifting Safety" on page 39. If you are running one of the heavier materials, you may need to empty the overflow cartridges frequently so they do not become too heavy.**

Loading Powder Cartridges

1. Click the Load Powder button; a dialog box appears.

2. *If the dialog box controls are dimmed,* press the System On button.

3. Click the Left and/or Right check boxes.

4. Using safe lifting practices, lift a feed cartridge by its two side handles; slide it into position.

5. Hold the cartridge level and slide it toward the back of the machine until it can go no further.

6. Insert the overflow cartridge.

7. *If you selected both Left and Right,* insert the remaining set of feed and overflow cartridges.

8. Click the Move piston(s) to start position button. The dialog box indicates the piston progress.

Load Powder Cartridges

Select cartridge(s) for powder loading:

☐ Left
☑ Right

Insert cartridge(s)

Cartridges inserted: Right

Move piston(s) to start position

Piston(s) moved to start position:
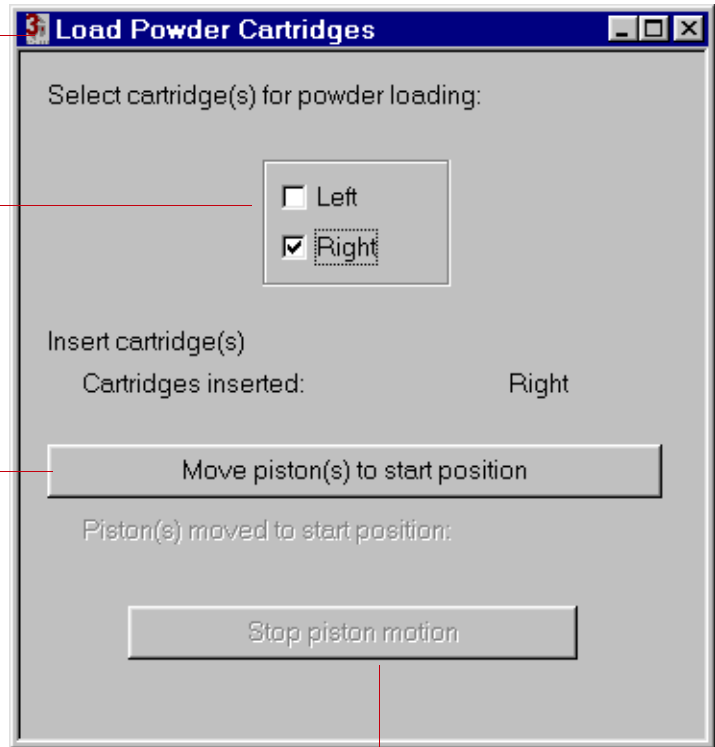
Stop piston motion

When the piston is moving, the Stop piston motion button becomes active

Filling Feeds

This topic describes how to fill feeds with powder. To fill the feeds, you will need to perform manual operations described in Chapter 1, "Manual Operations" of your *Reference Guide.*

✏ See "Powder Safety" on page 31 for appropriate guidelines and precautions.

✏ If you have new piston seals, make sure the piston is pushed down as far as it will go in the bottom of the cartridge.

✏ For systems with a blackbody on the roller, install the blackbody cover provided before adding powder. Powder residue on the blackbody face can reduce its accuracy as a temperature reference.

Feed Differences and Filling Methods

In most models, the feeds are permanently installed. 2000 and 2500 systems have feed cartridges which can be removed. This difference determines which methods can be used for which systems:

Scoop method This method involves scooping powder directly into the feeds. You can use this method with any SLS system.

Transfer container method This method involves placing a container of powder on a tray over the feed, removing the tray, and lowering the feed piston so that the powder slides down into the feed. Use this method for systems with permanently-installed feeds; such systems come with appropriate feed transfer containers.

Cartridge method This method involves scooping powder into the feed when it has been removed from the system. It can only be used with 2000 and 2500 systems.

✏ Due to the weight of the feed cartridges, you may need to fill them only *partially* full when they are outside the SLS system. After loading the feed cartridges into the SLS system, you can finish filling them by scooping powder in by hand.

✏ When initially filling a cartridge, do not fill it all the way to the top; the powder should be approximately 0.5 inches (12.7 mm) from the top.

Pressing Powder

After you fill the feeds, use a flat plastic or heavy cardboard plate the size and shape of the feed opening to tamp the powder in the feeds. In 2000 and 2500 SLS systems, cut a notch in the plate so it will clear the feed thermocouple. Compressing powder in the feeds provides the maximum amount of powder for the build.

✎ When filling cartridges outside of the SLS system, pay extra attention to pressing down the powder.

Caution   **Do not drop cartridges on the ground to settle powder. This can cause metal fatigue, and the cartridges may bend.**

Emptying Overflow Cartridges

After removing an overflow cartridge, do not discard the powder; most powders can be sifted and reused.

Warning **Full cartridges can weigh more than one person can safely lift; for weight information, see "Lifting Safety" on page 39. If you are running a heavy material, empty the overflow cartridges before they become too full for you to safely lift.**

✏️ Before reusing powder, you must sift it. Refer to the appropriate *Material Guide* for additional information.

Removing Overflow Cartridges

In 2000 and 2500 SLS systems, unload powder cartridges before removing the overflow cartridges. See "Unloading Cartridges in 2000 and 2500 SLS Systems" on page 56.

In other SLS systems, you need only open the latches on the overflows.

Overflow cartridges

Reusing Powder

When you empty an overflow cartridge containing reusable powder, you can do one of the following:

■ Pour the powder directly into a storage container.

■ Pour the powder into the sifter.

When you empty an overflow cartridge containing a powder that cannot be reused, discard it according to instructions in the MSDS and in compliance with state and local regulations.
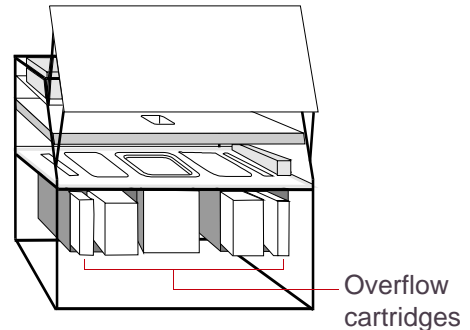
Installing and Removing the Feed Heat Deflector on the 2000 SLS System

The *feed heat deflector* is a separate sheet-metal shroud that attaches to the bottom of the heater assembly. Consult the *Material Guide* for the material you are using to determine if you should use the deflector.

To install or remove the deflector, refer to the figure below and the instructions that follow.
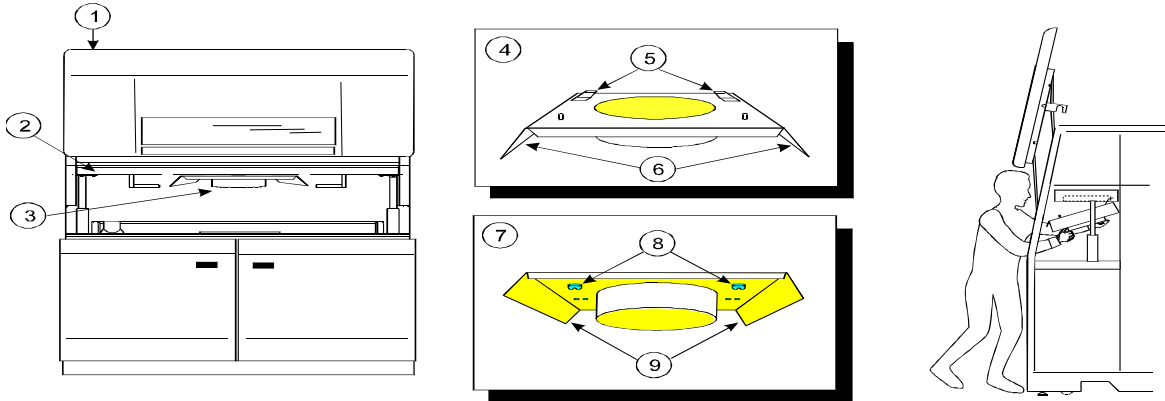
(1) Process chamber door, front view with door open	(6) Wings (viewed from above)
(2) Heater Assembly in up position	(7) Feed heat deflector (viewed from below)
(3) Installed feed heat deflector	(8) Studs (these attach to the front of the heater assembly)
(4) Feed heat deflector (viewed from above)	(9) Wings (viewed from below)
(5) Metal tabs (these attach to the back of the heater assembly)	

Installing the Feed Heat Deflector

1. Grasp the heater assembly by both handles and move it to the fully up position.
2. Grasp the feed heat deflector with one hand on the front of the center ring and one hand at the back.

Warning **Be careful. Sharp edges on the heat deflector can cut you.**

3. Orient the two metal tabs toward the back of the process chamber.
4. Slide the deflector up and back under the heater assembly.
5. Fit the metal tabs snugly into the back of the feed-through slots
6. Lift up the front end of the deflector so that the shafts of the two studs fit into the corresponding holes in the retainer.
7. Carefully turn the wings of the studs *counterclockwise* one-fourth of a turn to secure them.

   When the studs are secured, the flat faces of the wings are facing the side walls of the process chamber.
8. Lower the heater assembly to the fully down position, put in the diffuser, and close the process chamber door.

Removing the Feed Heat Deflector

1. Hold the center ring with one hand; with the other hand, turn each of the wings on the studs *clockwise* one-quarter turn, releasing the deflector's front end.
2. Holding the center ring, pull down and forward to release the tabs.

Running a Build

Before you run a build, prepare the SLS system as described in "Preparing the Machine for a Build" on page 53.

Build Mode

Before you start a build, put the system in Build mode by clicking the Build button on the toolbar. The Build Parts window and the Build Viewer window appear.

When you open the Build Parts window, the actual values for

Time Estimate button

The Build Parts window displays information during a build

The Build Viewer window is described in "Viewing a Build While In Progress" on page 70

the oxygen level and temperatures are displayed immediately. The setpoints display the default or previous values until you press the Start/System On button, at which time the system will supply actual setpoint information.

✏ If any of the temperature labels are dim, they will not be controlled during the build. Although setpoints will not be updated, you will see actual values.
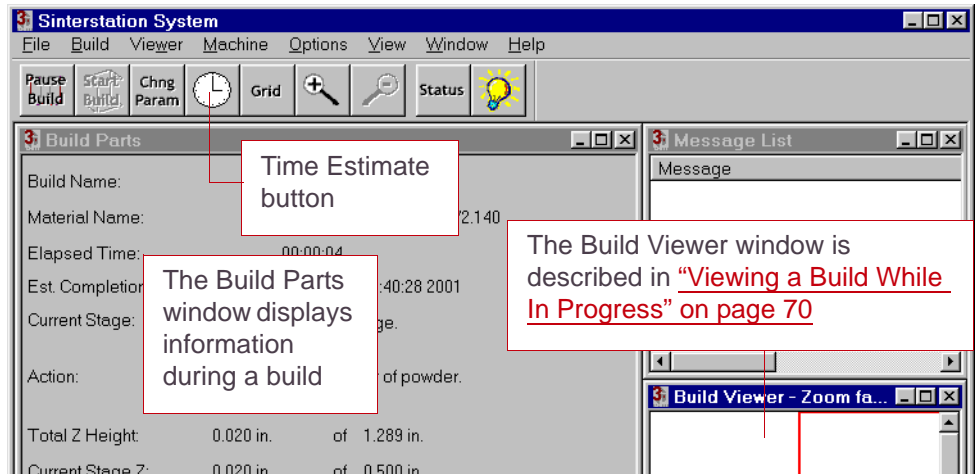
Automatically Emptying Feeds

You can click this check box to automatically empty feeds when a build is done if, for example, you want to change materials after a build. Although the screen text refers to cartridges, the option applies whether your system has cartridges or permanently-installed feeds.

✏ When the build completes, wait while the feeds empty automatically.

Current Stage Z:	0.000 in.	of 0.000 in.
Powder Remaining:	18.000 in.	

☐ Automatically empty feed cartridges at end of build

	Setpoint	Actual
Laser:		
Oxygen:	0.0 %	< 0.1 %
Left Feed Temperature:	0.0 C	0.0 C
Part Bed Temperature:	0.0 C	0.0 C

The SLS system empties the feeds by repeatedly adding powder layers without lowering the part piston. This pushes each new layer of power into the overflow cartridges until the feeds are empty.

When the feeds are empty, remove the overflow cartridges, clean the machine, and load new or different material.

Starting a Build

Click the Start Build button. If the last build was not completed, the system asks you if you want to restart it; see . Otherwise the system displays an Open dialog box to let you choose a build. If you are not using the default material, the system will ask you to confirm the material choice before beginning to build parts. If you have a HiQ system, it will remind you to make sure that the blackbody is in the up position before proceeding.

After the SLS system reaches inert, you must push the (physical) Start button. A message window pops up to remind you to push Start. This window will not close unless power is reaching the SLS system contactors.

Build Log File Archiving at Start of Build

When you start a new build, the Sinter application automatically:

■ Renames States.blog, the most recent build log file, for archiving. The archived build log file name matches the time stamp of its first entry.

■ Opens a new States.blog file to log the new build information.

If you choose to automatically delete log files when prompted on exit from the Sinter application, only the States.blog file is deleted. Use Windows Explorer if you want to delete, or, move, copy, rename, etc., any archived build log files.

Time Estimate Button

After you start a build, the Time Estimate button becomes active on the toolbar. Click the Time Estimate button to display

Time Estimate button

a detailed estimate for the build, if an estimate was run earlier from Build Setup. If no estimate exists, the button is disabled, but an estimate will automatically be run when the build starts. The system calculates Smart Feed powder requirements at this time as well, if your system has the Smart Feed feature.

3D Systems expects the estimate to be accurate to ±10% of actual build times for most models of SLS systems. However, the time estimate algorithm for 2000 SLS systems cannot account for variable scanner load times, so you should expect less accuracy with that system.

✎ The estimate includes time spent waiting for the machine to achieve desired temperatures (Wait for Temps) during warm-up and cool-down; however, an unusually long or short Wait for Temps period can skew the estimate.
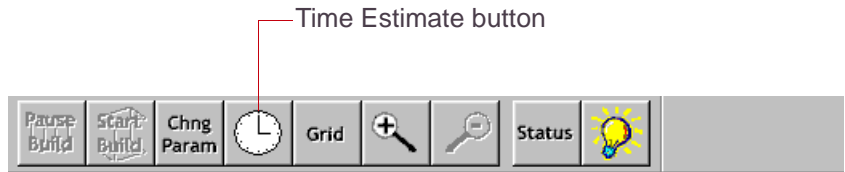
Restarting a Terminated Build

If you terminate a build before completion, you may be able to restart it. This depends on the material in use and the temperature at which you were running the build.

✏ When you restart a build, it resumes building at the layer it was on when the build was terminated. Therefore, if the part piston was moved after you terminated the build, some parts in the build might be ruined.

Keep the following in mind:

■ After restarting the build, you may need to increase the laser power for the first few layers to make sure the layers bond properly.

■ Make sure the powder is feeding properly.

Viewing a Build While In Progress

During a build, the Build Viewer window displays the slice that the system is currently scanning. Click on a part to display its name at the bottom of the main window.

✏ If you close the Build Viewer window when a build is *not* running, you exit build mode. You cannot close this window while a build is running, but you can minimize it.

Options on the Toolbar

While the system is in Build mode, the Build toolbar appears at the top of the main window. Some of the buttons on the toolbar control options for the Build viewer.
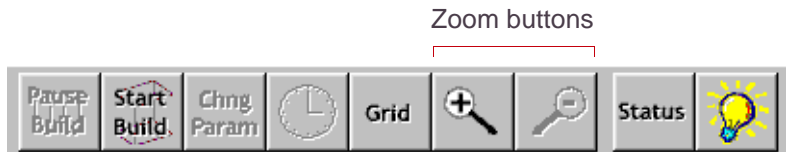
Zoom buttons

Click the Grid button to turn the display of grid marks on or off. Click the zoom buttons to expand or contract the scale of the Build Viewer window.

Options on the Viewer Menu

While the system is in Build mode, you can set the following options for the Build Viewer. These options appear on the Viewer menu in the main window:

Set grid size   This option displays a dialog box that lets you control the size of the grid drawn on the Build Viewer window.

Grid marks   This option is the same as the Grid button on the toolbar.

Clear after every slice   When this option is checked, the system erases the display before drawing a new slice. Otherwise, the system draws new slices on top of old ones.

Dark background   You can toggle this option on or off by selecting it. When checked, the system displays a dark background in the Build Viewer window.

Changing Critical Parameters During a Build

During a build, you can change three critical temperature parameters from the Build Parts window.

📨 If you have Variable Layer Thickness enabled on a 2500^{plus}, Vanguard, or HiQ SLS system, these heater setpoints change automatically when layer thickness changes.

Guidelines

■ Changes are saved to the build packet, even if you terminate the build.

■ Changes apply only to the current stage.

■ If you change a setpoint during the Build Preparation stage (during inerting), the system assumes the value is for the Warmup stage.

■ A new value clears all higher Z values for that stage. If you had ramped values, you may need to pause and re-profile the build, or continue to monitor the build.

Build Name:	1bc_verif_2500plus.bpf
Material Name:	DuraForm Polyamide V
Elapsed Time:	00:00:04
Est. Completion Time:	Fri Feb 02 19:40:28 2001
Current Stage:	Warmup stage.

...ding layer of powder

Build Parts Window
1. Click the text box for the parameter you want to change.
2. Press Enter.
3. Type the desired new value and press Enter again.

of 1.289 in.

of 0.500 in.

Setpoint

Laser: 0.0

Oxygen: 5.5 %

Left Feed Temperature: 106.0 C

Part Bed Temperature: 110.0 C

Right Feed Temperature: 104.8 C

Calibrating IR Sensors

For DuraForm PA, DuraForm GF, and LaserForm A6 Steel materials, Sinterstation HiQ systems can recalibrate their IR sensors dynamically during a build. This calibration is a quick process which occurs multiple times during a build to compensate for sensor drift and changing environmental conditions within the machine.

✒ You must perform an initial **offline calibration** to enable automatic, real time re-calibration during the build. If re-calibration requires too great an adjustment, a message pops up advising you to perform offline calibration again when the build completes.

Running an Offline Calibration

To run an offline calibration:

1. Put the system in Manual Operations mode. See Chapter 1, "Manual Operations" of your *Reference Guide.*

2. Raise the blackbody to the up position.

✒ If you perform a calibration with the blackbody in the down position, your calibration file receives abnormally large values. To recover from this, you must delete the file ircal.ini (found in your c:\dtm\config\machine folder), then either run a new offline calibration (which will create a new ircal.ini file) or rename ircal.backup to ircal.ini, then run offline calibration.

3. Latch the chamber door with the Latch button.

4. Click the IR Cal button.

   The Offline IR Sensor Calibration dialog box appears. The dialog displays the current roller speed value from the material configuration file for the current material. Change this value only if it is not the value you normally use for this material.

5. Check the roller speed setting, then click the Start button on the dialog box.

✏ During the calibration, an Abort button appears; click it if you need to stop the calibration process for any reason.

Verification Option

If you click the Verification Only check box, the system does not perform a calibration. Instead, it verifies the IR sensors by setting the blackbody to various temperatures and then checking its temperature with all three sensors. The results are plotted and displayed in an IR Verify Result dialog box. The dialog box includes a Save to File option for saving the data to a tab-delimited external file.

Pausing a Build

When the Pause Build button is active, click on it to stop the build and display options.

Caution **If you are running a material that requires heating, resume the build as soon as possible.**

Pause Build

The build has been suspended.

| Resume Build | Enter Next Stage | Terminate Build | Change Profiles/ Prime Cycle |
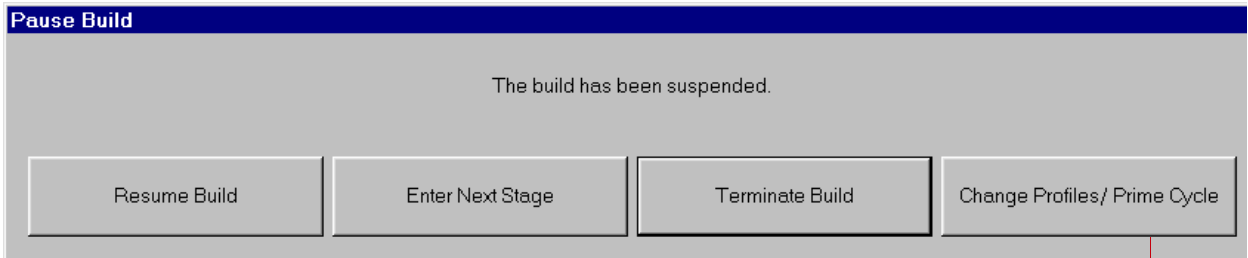
Click on the Change Profiles/Prime Cycle button to display additional options

Resume Build Click this button to continue the build.

Enter Next Stage Use the Enter Next Stage button to move from Warmup to Build, etc.

Terminate Build Click this button to stop the build.

If you terminate a build when the system is in the Build stage, and you do not want to restart the build from the termination point, remove any parts from the part bed and review the build packet in Build Setup and make any changes that can improve the build.

Change Profiles/Prime Cycle Click this button to modify a profile, add/delete parts, or run a prime cycle. See .

Modifying a Build in Progress

Make changes during a build with the Build Modify dialog box. To display it, click the Change Parameter button; if the build is paused, click the Change Profiles/Prime Cycle button in the Pause Build dialog box.
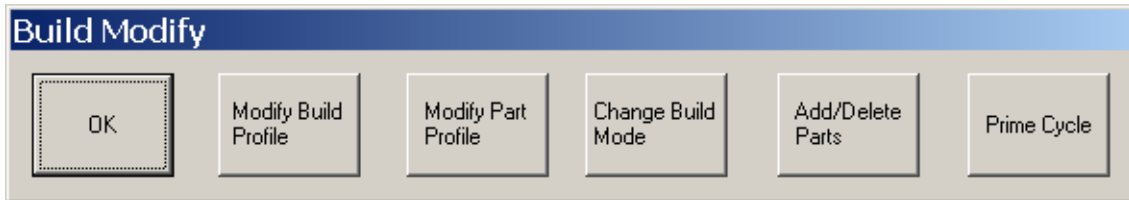
This subsection contains three topics:

■ Modifying Part and Build Profiles

■ Adding and Deleting Parts and Other Changes

■ Running a Prime Cycle

Modifying Part and Build Profiles

Click the Modify Build Profile or Modify Part Profile button to display a profile editor dialog box from the Build Setup application. Use the Change Build Mode button to access the Change Build Mode dialog box. Modify parameters as described in the Build Setup Help.

In most respects these dialog boxes work just as they do in the Build Setup software, with the following differences:

■ Settings for Z levels below the current are yellow and cannot be changed.

■ The current Z level is displayed as a green vertical line in the parameter chart.

- In the Build Profile Editor, a new button appears, the ⊞ button. Use this button to make a profile change at the current Z level. Click the button and a new row appears in the current build stage. Click in the Value column and enter a value, then click Apply. When the system applies the value, it updates the row to the current Z level.

- If you make changes near the current Z, the system may not be able to apply them. If you do *not* get the message `The parameter change has been applied` after clicking Apply, try again at a higher Z. (There is no message when the attempt fails.)

Adding and Deleting Parts and Other Changes

Click the Add/Delete Parts button to launch the Build Setup application, where you can modify most aspects of your build packet during the build. The application works just as described in the Build Setup Help, except that it also displays a plane marking the current Z level. Changes you make below the plane, such as adding or moving parts, will not affect the current build, although they will be saved and will affect future runs of this build packet. Parts are initially displayed in Box view.

Running a Prime Cycle

Click the Prime Cycle button to spread powder across the part bed without moving the part piston, which can compensate for a short feed.

When a Build Ends

At the end of a build, the Sinter application displays a summary of the actual build times.

Time Estimate	Total	Warm-up Stage	Build Stages	Cool-down Stage
Pause Time	0:00:00	0:00:00	0:00:00	0:00:00
Wait for Temperature Time	0:00:15	0:00:15	0:00:00	0:00:00
Add Powder Layer Time	0:38:02	0:04:53	0:33:09	0:00:00
Scan Time	0:01:05	NA	0:01:05	NA
Summary	0:39:22	0:05:08	0:34:14	0:00:00

Above is the summary of the actual time used by this build. For more detailed inform

Save the build time summary to a tab-delimited text file

See Chapter 5, "Build Report" in your *Software Utilities Guide* for more information on the Build Report utility

| Close | Save to File | Print ... | Launch Build Report |

Breaking Out Parts: Overview

When a build is complete, you need to remove the sintered parts from the process chamber and clean them. The parts and the surrounding powder are called a *part cake*. Removing parts from the part cake is called *breakout*. Once you remove a part cake from the SLS system, you move it to a *breakout station* (BOS) or *rough breakout* (RBO) station—a stand-alone work area for cleaning off unmelted powder.

✏ You can find material-specific information about breaking out and cleaning parts in each *Material Guide*.

BOS or RBO

You can have one of two work areas used for breaking out parts: the breakout station (BOS) or the rough breakout (RBO) station, included with 2000 SLS systems purchased before March 1996.

Breakout Details

For more information, see:

■ Preparing to Remove a Part Cake

■ Removing a Part Cake from the Process Chamber

■ Using the BOS or Using the RBO

■ Breaking Out Parts at the BOS or RBO

■ After Breakout
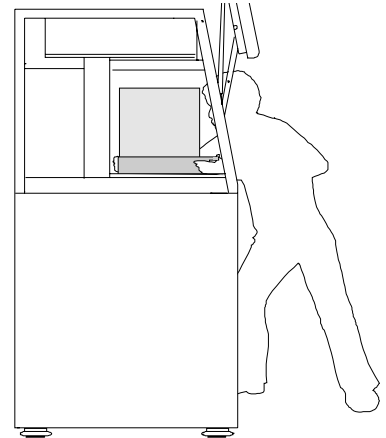
Preparing to Remove a Part Cake

Before You Begin

- Know the size, shape, and placement of the parts in the cylinder.

- Make sure there is adequate ventilation in the SLS system area.

- Make sure the parts are cool enough to prevent permanent deformation.

  If the core temperature of the part cake is greater than 60 $^{\circ}$C (140 °F), do not continue.

✏ If you do not have a thermometer, insert a metal probe or breakout tool into the part cake for 15 seconds; if it is too hot to hold, do not continue. Also refer to the appropriate *Material Guide*.

- Make sure the roller is at a limit.

- Put the SLS system software into Man Ops mode.
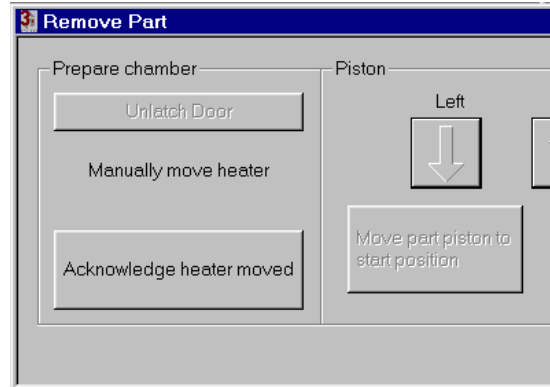
Preparation

Warning	**When you open the process chamber door, do not touch any parts or machine surfaces that are still hot, such as the heater assembly. When moving the heater tray and removing the part, wear gloves and touch only the handles of the heater assembly.**

1. Click the Remove Part button on the toolbar to display the Remove Part dialog box.

✔ See also "Remove Part" in Chapter 1 of your *Reference Guide* for instructions on using the dialog box.

2. Click the Unlatch Door button in the Remove Part dialog box.

3. Open the process chamber door.

4. *For all systems other than 2000/2500 systems,* remove the swing gates.

5. *For 2000/2500 SLS systems,* remove the diffuser (if installed).

6. Move the heater assembly out of the way.

Removing swing gates

7. *In 2000 or 2500 SLS systems,* raise the heater assembly. *In all other systems*, push the heater assembly back.

8. *For 2000 SLS systems,* remove the feed heat deflector, if installed.

   See "Installing and Removing the Feed Heat Deflector on the 2000 SLS System" on page 64.

9. Click Acknowledge heater moved.
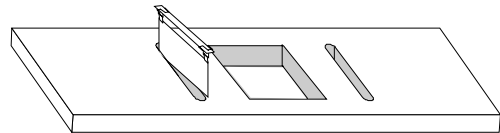
When you are done, go to the next topic, "Removing a Part Cake from the Process Chamber" on page 81.

Removing a Part Cake from the Process Chamber

There are two methods for removing a part cake. Before using either method, complete the steps in the preceding topic, .

The two methods are:

- Removing a Part Cake Using the Part Transfer Tray

- Removing a Part Cake Without Using the Part Transfer Tray

Caution **If you are removing a part cake that is 15.5 in (393 mm) tall or more, *do not* use the part transfer tray method.**

Warning **Builds of high temperature materials can create burn hazards from hot powder and hot machine surfaces once you unlatch the process chamber doors.**

Removing a Part Cake Using the Part Transfer Tray

When you use the part transfer tray to remove a part cake, you place a bottomless container over the part piston and raise the part cake up into the container with the piston. You then slide a tray under the container and use it to slide the part cake out of the process chamber.

Part transfer container

1. Place the part transfer container on top of the part cylinder

2. Hold the part transfer container down and click the Move part piston to start position button in the Remove Part dialog box.

3. Continue to hold the part transfer container down as the system pushes powder up into the part transfer container.

4. Insert the part transfer tray under the part cake: Point the edge of the tray *without the lip* toward the part transfer container, hold the back of the container with one hand, and slide the tray under the container.

Part transfer container and tray

5. Slide the tray forward, lift it out, and move to the breakout area.
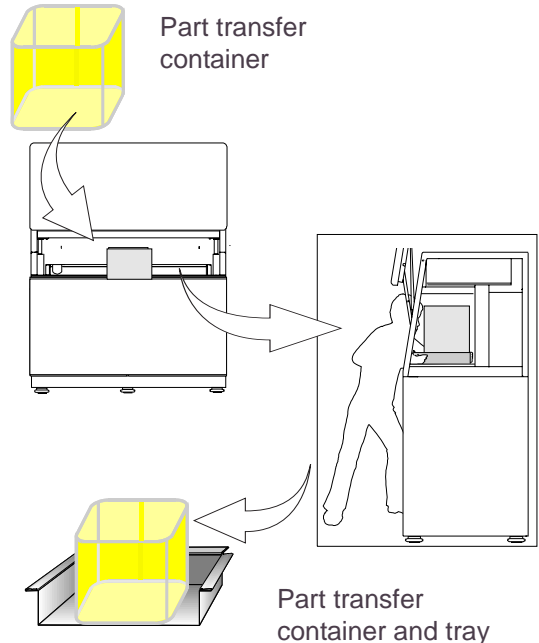
Removing a Part Cake Without Using the Part Transfer Tray

This method involves raising the part piston and allowing powder to fall away from the part as the part cake rises.

✏️ If you use this method with a part cake that is 394 mm (15.5 in) or taller, first cover the feed openings with cardboard to prevent any part cake powder from falling into the feeds. If you have a HiQ system, protect its blackbody with the provided cover.

✏️ If you are removing a part cake taller than 432 mm (17 in) from a 2500^{plus}, Vanguard, or HiQ system, use the red laser window plug. Remove the laser window baffle and insert the plug before breakout. Push the plug up into the laser window opening and let the rope handle hang down. Use the rope handle to remove the plug after breakout, and remember to reinstall the laser window.

Caution | **If your build used high cylinder heat, the part cake will be extremely hot. 3D Systems does not recommend removing such a part cake without the part transfer tray, unless it is too tall (more than 394 mm (15.5 in)). In that case, allow for a prolonged cool down (up to 24 hours) before removing the part cake.**

Use the Remove Part dialog box to raise the part piston incrementally. As you raise the piston, remove surrounding powder from the outline of the parts with a spatula and brush. When you can easily grasp a part, carefully lift it. In the case of a tall single part, you may need to tilt it to clear the top of the process chamber. Gently brush off the parts and place them on the part transfer tray.

✏️ If a part is not completely cool, wait until it has cooled to brush off any powder clinging to it.

Using the BOS

The breakout station (BOS) provides a work area for removing powder from parts. It includes a work table with an area for you to clean parts, and an air handler unit. The air handler removes airborne dust particles from the work area during part cleaning.

✏️ If you are sifting powder, refer to the appropriate *Material Guide* and the documentation that came with your sifter. Also see "Using the Sifter Connection" in Chapter 4 of your *Reference Guide.*

You can use various hand tools, such as scrapers, knives, and brushes, at the BOS as you perform part breakout.

✏️ 3D Systems recommends placing an anti-static mat in front of the BOS, as suggested in the *Summary of Facilities and Safety Information.*

The illustration on the next page shows the BOS.

✏️ SLS systems purchased after January 1999 include detached air handlers that use a suction hose which hangs over the BOS table, instead of an attached air handler as shown. Also, a standard-volume sifter will be included, which will fit under the BOS table much as shown in the diagram in "Using the RBO" on page 86.

Breakout station (BOS)

Attached
air
handler
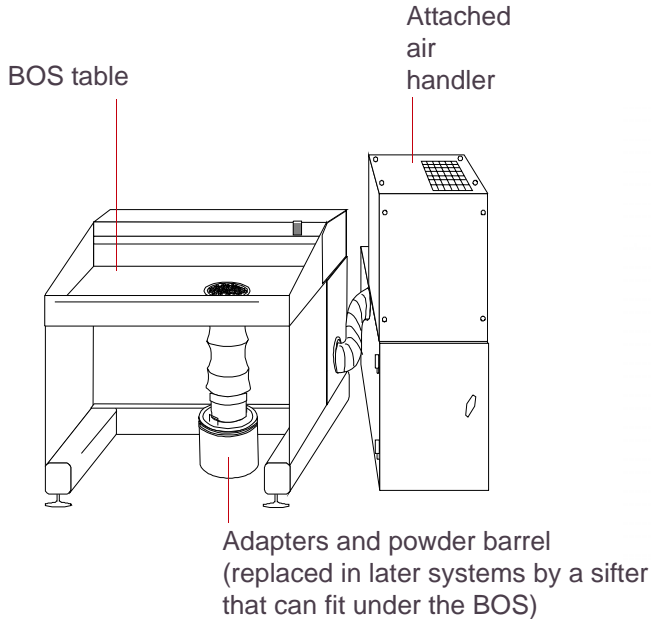
Detached air handler (shipped
with systems purchased after
January 1999)

BOS table

Adapters and powder barrel
(replaced in later systems by a sifter
that can fit under the BOS)
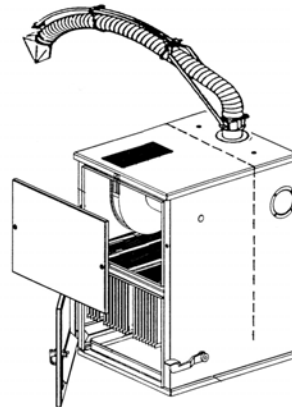
Using the RBO

The rough breakout station (RBO) provides a work area for removing powder from parts. It includes a work table with an area for you to clean parts, and an attached air handler unit. The air handler attaches to the back of the table with a flexible duct hose; its function is to remove airborne dust particles from the work area during part cleaning.

✏️ If you are sifting powder, refer to the appropriate *Material Guide* and the documentation that came with your sifter. Also see "Using the Sifter Connection" in Chapter 4 of your *Reference Guide.*

You can use various hand tools, such as scrapers, knives, and brushes, at the RBO as you perform part breakout.

✏️ 3D Systems recommends placing an anti-static mat in front of the RBO, as suggested in the *Summary of Facilities and Safety Information.*

(1) Removable plenum

(2) Side trays

(3) Removable center screen

(4) Storage shelf

(5) Sifter Assembly

(6) Shutoff valve handle

(7) Storage area

(8) Powder feed cartridge

(9) Cartridge adapter

(10) Compressed air supply switch

(11) Hopper

(12) Duct hose

(13) Air handler

(14) Dust drawer door
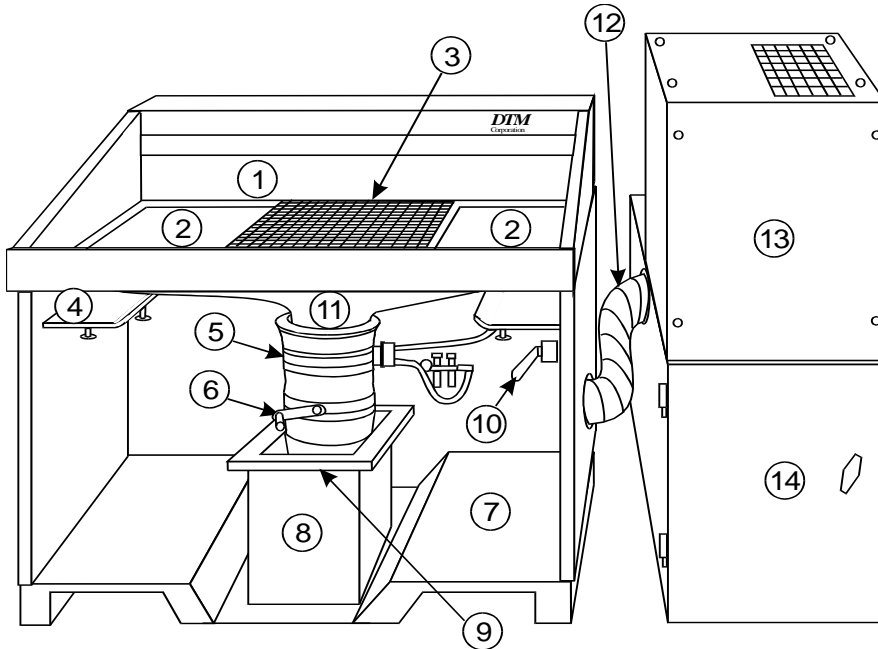
Rough breakout station (RBO)

Breaking Out Parts at the BOS or RBO

After you remove the part cake, clean (break out) the part to remove excess powder.

✔ You can find additional breakout information in the appropriate *Material Guide.*

Warning   **Make sure that the part cake is adequately cooled before you touch it. Hot powder is a burn hazard.**

📖 If the current part is a different material than the last one broken out at this station, clean the breakout area first to prevent contamination of reusable materials. See "BOS/RBO Maintenance" in Chapter 2 of your *Reference Guide.*

📖 For an RBO, make sure the sifter assembly attached to the hopper is for the correct material.

1. Connect powder container

2. Place part on table

3. Turn on air handler

4. Remove loose powder with tools
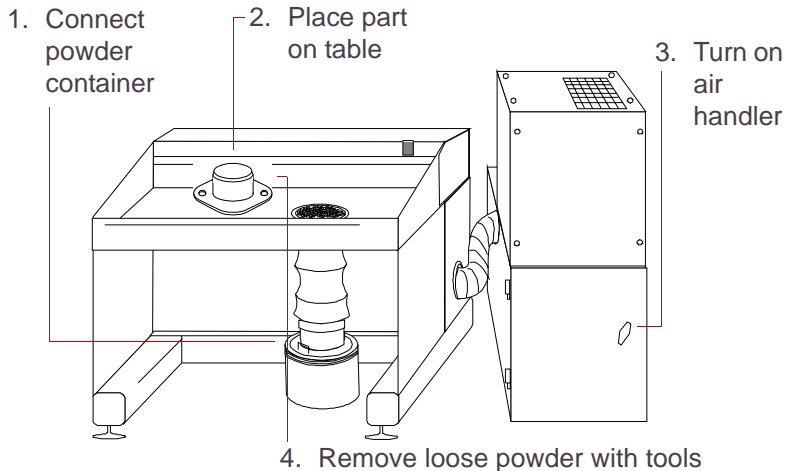
1. Connect a powder container to the tube extension (for the BOS) or the sifter assembly (for the RBO). Use a clean container or one that previously held the same material.

2. Place the part on the Breakout Station or on the center tray of the RBO table.

Warning   **The breakout station is designed to support no more than 34.0 kg (75 lb). Some materials may produce parts heavier than this.**

3. Turn on the air handler with the switch on the back right side.

    If using an RBO, turn on the vibrator and open the compressed air valve fully. The valve is under the front right corner of the RBO.

4. Using tools and brushes, remove the loose powder and debris from the part, taking care not to damage fragile areas of a part. While cleaning the part:

    ■   Check the container periodically to prevent overflows. When the container becomes almost full, turn off the vibrator (*if using an RBO)* and replace the full container with an empty one.

    ■   Brush any loose powder into and through the grate.

    ■   Brush chunks and debris onto either side of the table. Dispose of chunks and debris in accordance with state and local ordinances.

✍ *If you are using an RBO* and powder sticks in the funnel of the hopper, lift the grated center tray and the presifter and brush the powder into the sifter.

After Breakout

This topic covers tasks you may want to perform after you break out parts. These include sifting powder, cleaning the part transfer container, and post-processing.

Sifting Powder

After breakout, powder to be reused is sifted in a sifter. For information on how to use the sifter, refer to the documentation that came with it. For information on connecting the sifter, see <u>"Using the Sifter Connection" in Chapter 4</u> of your *Reference Guide.* For guidelines on sifting, refer to the appropriate *Material Guide*.

Cleaning the Part Transfer Container

Follow these guidelines when cleaning the part transfer container:

■ Clean the container thoroughly prior to switching materials to avoid powder contamination.

■ Clean the container with a non-ignition vacuum cleaner or a dry rag to remove accumulations of powder.

Post-Processing Options

You can use several post-processing procedures to further refine the surface finish of a part. The procedure you choose depends on the material used, the part design, and the projected use of the part. For more information about post-processing options, refer to the appropriate *Material Guide*.

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