Customer Information Bulletin

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Status: Non-confidential

Subject: Tips and info for building with DuraForm® EX Engineered Thermoplastic on Sinterstation® HiQ™ SLS® systems

DuraForm EX is a high modulus thermoplastic material, designed specifically for use on 3D Systems' SLS systems. Mechanical properties, especially impact resistance, are significantly superior to general prototyping materials. DuraForm EX is processed in a high energy mode to create useful parts, with performance beyond what is expected of typical prototypes. DuraForm EX is processed with higher laser power and heater settings than traditional thermoplastics, with resulting consequences and benefits. The same heat that leaves the part cake somewhat tougher also makes the part inside tougher.

1. **Sinterstation HiQ**: It is recommended that DuraForm EX is processed in a HiQ-equipped system, due to the high temperature required. No modifications to the hardware are required. If a system without the Intelligent Thermal Control is employed to process DuraForm EX, a unique Part Bed Temperature "ramp" must be derived. You can find instructions for creating a temperature ramp in the DuraForm PA/GF Handling Guide in the Build Setup software.

2. **Software version**: Version 3.4 or higher is required for HiQ systems. The SinterScan™ option is highly recommended for all systems, and is required to maximize mechanical properties for HS systems.

3. **Build Setup software:** SLS Build Packet Files are created in the Build Setup software. In table and graphical form, the values for parameters of system operation, such as piston displacement and roller/sweeper velocity, are given. A Build Packet File (BPF) contains special instructions that are system and material specific. These initial parameter values, referred to as DEFAULTS, are acceptable for operation. Modification to parameter values may be indicated based on application or system condition. The parameters programmed (through Build Setup) into the Build Packet File are similar to 3D's most popular thermoplastic, DuraForm PA. The following table is a list of the major differences:

Parameter		DuraForm EX	DuraForm PA
Part Bed temperature	Sinterstation HiQ	187	173
Feed Bed temperature		135	145
Laser power (base)		13W	12W
Laser power (HS)		40W	42W
Scan spacing (base)		0.15mm (0.006")	0.15mm (0.006")
Scan spacing (HS)		0.25mm (0.010")	0.3mm (0.012")

4. **Configuration files**: Config files are available for download from the 3D Systems website, at www.3dsystems.com. Look in the customer support section, software downloads, and enter the license key you used for your software 3.3 (or higher) download to access the area to find the DuraForm EX configuration files. These are a good starting point for your initial builds with the material.

Note: ***Two material configuration files for the HiQ+HS*** system are supplied with DuraForm EX, one that has default values for ***general purpose part building*** and one that has default values for ***increased mechanical properties***. A software patch for the slicer, correcting a problem when scanning over 64 parts on a layer, is also supplied. There is just one configuration file required for non-HS systems.

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5. **Routine maintenance**: Part building with DuraForm EX creates more dust than with DuraForm PA. Thus more powder buildup in the system can be expected. Exercise care when removing this residue from sensitive surfaces. Powder buildup should be vacuumed, and oily residue should be wiped with a scratch resistant cloth.

6. **Part bed temperature:** Distortion that is a function of cooling rate (Post Build Curl) can be minimized by increasing the Part Bed Temperature Setpoint in the Warmup Stage. Setting a greater Part Bed Temperature Setpoint for the Warmup will "superheat" this underlying powder and reduce the distortion that may occur when cooling is too rapid. Be aware that the Black Body of the Intelligent Thermal Control (aka HiQ) is offset above the Part Bed Setpoint. This step will work in unison with the Piston Heater and the base, or sacrificial part.

7. **Feed Bed Temperature:** Note in the table above that the Feed Bed Temperature Setpoint is LESS for DuraForm EX than for DuraForm PA. This is required for efficient delivery of the feed powder by the roller. The DuraForm EX material can become clumpy if too hot. Note in "Additional Settings" the reference to Post Add Powder Delay.

8. **Warmup time:** DuraForm EX uses a longer warmup time than other materials. DuraForm EX does not build well when the system or the powder is cold. Always err on the side of long warmup time.

9. *LEAN***:** Lean is a type of post build distortion. Lean occurs at the boundary of the acceptable build area, where the shrinkage of a part has different rates for different regions. Maintaining the most uniform temperature distribution, by modifying the Inner/Outer Zone Ratio, the Cylinder Heater, and the Piston Heater will minimize lean.

10. **Part orientation in the SLS build volume:** There are three primary considerations relative to part orientation.
    - Large "blocky" sections or structures are susceptible to distortion (post-build curl). Rotating the .stl file a few degrees about X and/or Y is can help to mitigate this distortion. Rotation to 30 degrees is shown to give good properties and less distortion.
    - A larger gap between parts is appropriate for DuraForm EX, compared to the gap for DuraForm PA. The default Auto Part Placement parameters in the provided configuration files create slightly larger gaps between parts, to minimize growth.
    - For challenging parts, such as large structures, orient the .stl file such that the part starts in a hot region, typically the back and right area of the part bed.

11. **Breakout and recycling:** Expect DuraForm EX to have a firmer part cake than DuraForm PA. Use the same size sifting screen as used with DuraForm PA. Blending ratios are the same as DuraForm PA, at 1/3, 1/3, 1/3.

12. **Roller speed and layer thickness**: Roller traverse speed and layer thickness are the same as the default values of other DuraForm thermoplastic materials. Layer thickness less than 0.1mm (0.004") or greater than 0.127mm (0.005") have not been tested.

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13. **Mechanical Properties versus Throughput:** DuraForm EX can be processed to give durable nylon parts with extended mechanical property values. Using the SinterScan feature AND a Scan Count = 2 will delivery more laser energy to each layer. The effect of this higher dose of laser energy is more melting of the powder and results in a more dense part. The consequence of this method is a slower build rate. To recover throughput at the expense of some mechanical property loss:

- Increase Scan Spacing. A 20 to 40% increase in spacing will reduce the number of scan lines used to Fill an area, and reduce the time it takes. The geometry of the slice will dictate how large the scan spacing can be. As a rule of thumb thin wall parts cannot be spaced wider than default, without a reduction of mechanical property performance. Large area slices can use much wider spacing.

- Layer thickness can be increased, from the default of 0.1mm (0.004") to 0.12mm (0.005"). Such a change requires an associated laser power increase. Testing of this method to reduce layer count is limited.

- When using scan count = 2 along with Smart Feed, the system may overfeed. If you have enough material in the feeds to allow this, simply let the system overfeed. If you don't have enough powder or piston stroke to spare, turn off Smart Feed and profile feed distances manually, according to the parts you have in the build. This issue will be corrected in a future software release.

14. **Additional Settings Information:**
The configuration files for DuraForm EX have some special settings already incorporated. These are mentioned because they are different than what you may be familiar with in the DuraForm PA configuration files.

- Post Add Powder Delay gives time for a new layer to reach appropriate temperature *before scanning*. Short layer times may require a delay of this kind.

- Fill Scan Count > 1 executes the fill vectors more than once, per layer. Depending on orientation, mechanical properties may be enhanced with additional fill scans. For High Speed systems, the configuration which maximizes mechanical properties already has the scan count set to 2.

- SinterScan = 1 sets the scan vectors to alternate, every other layer. This option can result in smoother side walls and enhance properties. It is recommended.

- Scale factors are slightly greater than those for DuraForm PA. Beam offset is similar.

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