Customer Information Bulletin

CIB

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Subject: Tips and info for building with DuraForm® ProX™ PA Engineered Thermoplastic on ProX™ 500 SLS® systems

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DuraForm ProX PA is an engineered production plastic for use in 3D Systems' ProX 500 SLS systems. It is also the recommended general purpose material for use on a ProX 500 SLS printer. DuraForm ProX PA offers the best combination of mechanicals, fine feature details, smooth surfaces, warpage and recyclability on a ProX 500 printer.

DuraForm ProX PA is available in two print modes namely the Standard Production (SP) Mode and the High Production (HP) Mode. The default mode or the recommended mode by 3D Systems is the SP Mode. HP Mode is available for customers who have a desire to increase their productivity. HP Mode offers about 20% reduction in total print time in comparison to the SP Mode. Conversely, in comparison to SP Mode, HP Mode results in about a 20% drop in mechanical properties. Parts printed using HP Mode also exhibit slightly rougher sidewalls. HP Mode uses different process settings than the SP Mode. Material configuration files for both the modes are offered by 3D Systems. The process settings in these configuration files have been optimized for each of these and provide a good starting point to operate while using one of these modes.

The material process parameter set points may vary slightly from machine to machine, due to differences in material conditions and thermal sensors. As a result, the process parameters, more specifically the temperature set points, may need to be adjusted slightly from the defaults. An offline IR sensor calibration is required before using a material for the first time.

Below are the important pieces of information to know in order to build successfully with DuraForm ProX PA on a ProX 500 SLS system. For more details about this material, please refer to the DuraForm ProX PA material guide and for more details about the ProX 500 SLS system, please refer to the ProX 500 user guide.

1. **Software version**: Software version 6.0 or higher is required. Sinter V6.0 and Build Setup V6.0 are the recommended software versions.

2. **Build Setup software**: SLS Build Packet Files are created in the Build Setup software. A Build Packet File (BPF) contains special instructions that are system and material specific. The initial default parameter values, provided in the DuraForm ProX PA material configuration files, are a good starting place for your initial builds. Modification to parameter values may be recommended based on application or system condition.

3. **Material Configuration files**: LS 6.0 material config files are available for download from the 3D Systems website, www.3dsystems.com (i.e. Resources>Customer Support>Software Support>SLS software). The values in the material configs will be a good starting point for your initial builds with this material.

    Note: Two material configuration files are offered with DuraForm ProX PA: SP mode and HP mode. SP mode contains the default values for general purpose part building. HP mode contains values for faster build times and higher production output.

    Note: The material configuration file offers the recommended parameters. Customers running DuraForm ProX PA may need to optimize certain parameters for their systems.

    Note: A setting of 5 lpm for N2 laser window flow is recommended for DuraForm ProX PA material.

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4. **SP mode versus HP mode**: The following table highlights the major differences in default process parameter values for the SP and HP print modes.

Parameter		DuraForm ProX PA SP mode (default)	DuraForm ProX PA HP mode
Part Bed Heater Set Point		168.5°C	168.5°C
Powder Layer Thickness		0.1 mm	0.125 mm
Fill Laser Power	ProX 500	62 W	94 W
Outline Laser Power		20 W	28 W
Scan Spacing		0.20 mm	0.25 mm
Fill Scan Count		1	1
Outline Scan Count		1	1
SinterScan™		1	1

The following table highlights the expected differences in print and part mechanical properties for each mode. While HP mode builds a given part faster, there is a reduction in mechanical properties and part density.

Property		DuraForm ProX PA SP mode (default)	DuraForm ProX PA HP mode
Overall Build Time		-	20% Faster
Tensile Strength		47 MPa	38 MPa
Elongation at Break	ProX 500	22%	15%
Tensile Modulus		1772 MPa	1460 MPa
Sintered Part Density		0.95 g/cc	0.91 g/cc

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5. **Throughput vs Mechanical Properties/Surface Finish**: DuraForm ProX PA can be processed faster using the HP mode when higher production and throughput of parts is desired. HP mode cuts down the overall build time. However, in comparison to SP mode, parts printed in HP mode have lower mechanical properties and slightly rougher sidewalls.

6. **Shrink and Beam offsets**: The shrinkage of 100% fresh DuraForm ProX PA is slightly higher than that of blended DuraForm ProX PA. You should expect to evaluate and adjust the scale values used to compensate for shrink as the fresh powder ratio in the blend changes. Note that shrinkage may vary slightly based on part geometry. The following table offers the starting values to use for scale and beam offsets. These are the same values as in the material configuration file.

Parameter	DuraForm ProX PA SP mode	DuraForm ProX PA HP mode
X scale	1.031	1.031
Y scale	1.031	1.031
Z scale	1.0240-1.181E-5z	1.0240-1.181E-5z
X Fill offset	0.267 mm	0.279 mm

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Y Fill offset	0.267 mm	0.279 mm
X outline offset	0.241 mm	0.254 mm
Y outline offset	0.241 mm	0.254 mm

7. **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 can help to mitigate this distortion. Rotation to 30 degrees is shown to give good properties and less distortion.

   - Start these demanding parts later in the build (at greater Z) after other parts have already been built underneath.

   - Parts with wide flat bottoms are recommended to be oriented by 10 degrees in X and Y to eliminate distortion (i.e. bowing) at the bottom.

8. **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 various Heater Ratios, the Cylinder Heater Set Point, and the Piston Heater Set Point will minimize lean.

9. **Routine maintenance**: Avoid leveling powder while purging the system. Exercise care when removing powder residue from sensitive surfaces. Powder buildup should be vacuumed and oily residue should be wiped with a scratch-resistant cloth. Clean laser window with mild liquid detergent under running warm water, then clean with ethanol and a dust-free lens wiping tissue. Refer to the ProX 500 user guide and DuraForm ProX PA material guide for more details.

10. **Material handling**: Follow proper PPE when handling DuraForm ProX PA. This includes safety glasses, protective gloves, and a dust mask. Please refer to the ProX 500 user guide and the DuraForm ProX PA material guide for more details.

11. **Part Breakout, Powder Recycling & Sifting**: Do not remove the print cake from the process chamber until the part bed temperature is approximately 85°C. Allow parts to continue cooling to 50°C before trying to break them out of the print cake.

    After a print, loose material can be sifted and reused in another print. Consistent recycling procedures are important in order to maintain consistent material properties. If recycling procedures are not followed, problems such as variable shrinkages and surface imperfections like "orange peel" may appear.

    For the ProX 500 system, the part breakout, powder sifting and powder recycling operations are performed at a station called the Material Quality Control (MQC) System. The MQC is an integral part of the ProX 500 printer.

    Remove loose powder surrounding the parts with a brush. Use a combination of part breakout tools and a bead blaster to fully remove the powder adhering to the parts. Sift the loose powder into the used bin of the MQC System. Discard any hard, chunky powder and the powder directly surrounding the parts.

    The DuraForm ProX PA Plastic material is a very fine blend of small particles. As you run prints, the material is exposed to heat and energy, and as a result the particles in the used powder tend to stick together forming larger particles. You can combat this trend with sifting and blending. Sifting removes undesirable particles from the used powder and blending adds new particles of appropriate size. Blending also helps combat the changes

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in material melt viscosity of the used powder by creating a final blend with uniform material melt viscosity that shows less variance from blend to blend.

12. **Blending Fresh and Used Powder**: The MQC automatically blends the fresh and used powder. The ratio of the fresh to the used powder in a blend can be set for each material and blend. 3D Systems offers a recommended fresh powder ratio to use for each material.

Note: For a ProX 500 system, there is no overflow powder to use for a blend unlike the previous generation SLS systems. The overflow powder is recirculated back into the feed hopper during the print process and is ultimately consumed for the print process.

The MQC automatically initiates a blend cycle when it has enough material to blend a total of about 40 liters. For example, at a 50% fresh powder ratio, it requires about 20 liters in the fresh bin and about 20 liters in the used bin in order to initiate a new blend cycle. At any particular fresh powder ratio setting, the minimum volumes of fresh and used powder required to initiate a blend are displayed on the MQC home screen.

The range for fresh powder ratio setting on the MQC System for DuraForm ProX PA material is from 20% to 100%. The default fresh powder ratio setting for DuraForm ProX PA material is 40%.

Note: While the default fresh powder ration setting for DuraForm ProX PA is 40%, a setting of as low as 30% can be used with this material. A 30% fresh powder ratio setting for DuraForm ProX PA does not result in orange peel or deterioration of mechanical properties, however, parts that are prone to distortion tend to print better (with less distortion) at a 40% fresh powder ratio setting than at a 30% fresh powder ratio setting.

Note: Approximately 0.55 Kgs (1.3 liters) of powder is required for every 10 mm of z-height (please include warmup, build, and cooldown heights for calculation). This number holds true when the volume percentage of parts in a build is about 8%. For builds with higher part volume percentage a larger quantity of powder will be required. The Information tab in Build Setup also provides the approximate volume of powder required to complete a build.

13. **Additional Settings Information:**

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