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Status: Non-confidential

Subject: Tips and info for building with DuraForm® ProX™ FR1200 Engineered Thermoplastic on ProX™ SLS® systems

DuraForm ProX FR1200 is an engineered fire retardant production plastic for use in 3D Systems' ProX SLS systems. It is not recommended for general purpose use on a ProX SLS printer. DuraForm ProX FR1200 offers a combination of mechanical properties, fine feature details, smooth surfaces on a ProX SLS printer.

DuraForm ProX FR1200 is available in two modes, Standard Production (SP) Mode, and Advanced Mode. Material configuration files for SP and Advanced modes are offered by 3D Systems. The process settings in the SP configuration files have been optimized to provide a good starting point to operate while using this mode. Process settings for the Advanced configuration files offer more processing latitude for advanced users. SP Mode is the default configuration and the recommended mode by 3D Systems.

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 FR1200 on a ProX SLS system. For more details about this material, please refer to the DuraForm ProX FR1200 material guide and for more details about the ProX SLS system, please refer to the ProX SLS user guide.

1. **Hardware Modifications:** Customers who desire to process DuraForm ProX FR1200 Plastic material may require upgrading some printer components to successfully print FR1200 parts.

Counter Rotating Roller Upgrade: An upgrade to the Counter-Rotating Roller is required in order to successfully print with DuraForm ProXFR1200. Please contact your 3D Systems field service representative for more information upgrade. This upgrade is very critical for running DuraForm ProX FR1200 on a ProX SLS printer.

- 132782-00, /R ROLLER, TEXTURED, PROX SLS, FRU KIT

MQC Sifter Screen Upgrade: *Although NOT recommended*, customers who desire to recycle DuraForm ProX FR1200 Plastic material will require upgrading the sifter screen of the MQC. Please contact your 3D Systems field service representative for more information about this upgrade

- 75-0262, 15 inch Screen Element, 120 TBC Sifter Bonded, RVM-15E
- 77-0121, 12 inch Screen Element, 120 TBC Sifter Bonded, 147 micron Mesh

MQC Parameter Change: To successfully transfer and build reliable parts with DuraForm ProX FR1200 material, the recirculation of the blender and fresh bins **must** be turned off. This is automatically set when the RIFD tag for the material is scanned. However, make sure to reset the material information from the MQC after installing V3.6 on the MQC.

Hoper Feed Module (HFM) Heaters: DuraForm ProX FR1200 Plastic material will require feeding warmer powder from the HFM. Please contact your 3D Systems field service representative to verify you require this upgrade.

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2. **Software version:** DuraForm ProX FR1200 config files are supported with Sinter v6.1 and later versions. The MQC V3.6 firmware must be installed to load ProX FR1200.
3. **Build Preparation software:** SLS Build Packet Files are created in the build preparation 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 FR1200 material configuration files, are a good starting place for initial builds. Modification to parameter values may be required upon application or system condition.
4. **Material Configuration files:** LS 6.1 material config files are available for download from the 3D Systems website, InfoCenter.3DSystems.com>ProductionPrinters>SLS. The values in the material configs will be a good starting point for initial builds with FR1200.

NOTE: Two material configuration files are offered with DuraForm ProX FR1200: SP mode, and Advanced mode; SP mode contains default values for general fire retardant parts building. Advanced mode allows users to modify values to achieve desired properties; this mode may extend scanning layer times. These material configuration files offer recommended parameters. Customers running DuraForm ProX FR1200 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 FR1200 Material.

5. **SP vs. Advanced Mode:** SP mode controls the limits of the ProX SLS system to ensure customer get the performance they desire and removes variability that could occur during the standard print process. The Advanced mode offers more processing latitude for advanced users, and increases the allowed range for many of the parameter values.

NOTE: It is the customer's responsibility to validate results such as part quality and mechanical properties at the parameter values they use in Advanced Mode. Also, customers/users should note that 3DSystems Field Service might require the use of the SP mode during troubleshooting issues.

The following table highlights the default process parameter values for the SP print mode

Parameter	DuraForm ProX FR1200 SP
Part Bed Heater Set Point	171.5°C
Powder Layer Thickness	0.1 mm
Fill Laser Power	40 W
Outline Laser Power	13 W
Scan Spacing	0.20 mm
Fill Scan Count	1
Outline Scan Count	1
SinterScan™	1

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NOTE: Flammability properties are limited by part thickness. The minimum wall thickness of the part to pass a 12 second FAR25.853 test is 2.0 mm using SP mode.

6. **Shrink and Beam offsets:** The shrinkage of 100% fresh DuraForm ProX FR1200 is close to 3%. You should expect to evaluate and adjust the scale values used to compensate for shrink. 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 FR1200 SP
X scale	1.031
Y scale	1.031
Z scale	1.0240-1.181E-5z
X Fill offset	0.267 mm
Y Fill offset	0.267 mm
X outline offset	0.241 mm
Y outline offset	0.241 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.
 - It is recommended to orient parts to match flat surfaces with the XY plane to reduce surface area on parts to optimize the flammability properties of the material.
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, 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 SLS user guide and DuraForm ProX FR1200 material guide for more details.

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Routinely clean the roller with a clean wipe with alcohol. During the build process, the components of the material tend to form a film on the roller as the material smokes when the laser is scanning the bed. This film may create a smooth surface that covers the rough pattern of the roller.

10. **Material handling:** Follow proper PPE when handling DuraForm ProX FR1200. This includes safety glasses, protective gloves, and a dust mask. Please refer to the DuraForm ProX FR1200 Safety Data Sheet, ProX SLS user guide and the DuraForm ProX FR1200 Material Guide for more details.

NOTE: Fine dust dispersed in air in sufficient concentrations, and in the presence of an ignition source may become a potential dust explosion hazard. As reference, dust deflagration value (K_{st}) is 79 bar·m/sec for DuraForm ProX PA.

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 with DuraForm ProX FR1200, loose material from the print cake should not be sifted and reused in another print. Recycling of this specialty material is not recommended in order to maintain consistent material and fire retardant properties.

For the ProX SLS 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 SLS printer.

Should you (the customer) decide to recycle material, 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.

12. **Blending Fresh and Used Powder:** The MQC 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 SLS 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 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 default fresh powder ratio setting for DuraForm ProX FR120 material is 100%.

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NOTE: The material and fire retardant properties tested on the material were generated using 100% Fresh material. An 80% fresh powder ratio setting for DuraForm ProX FR1200 may result in orange peel, and/or deterioration of mechanical properties. Flammability properties may also become inferior to 100% 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.

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