Customer Information Bulletin

CIB

CIB#: CIB00111
Date: March 2019
Status: Non-confidential

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

DuraForm ProX EX NAT is an engineered production plastic for use in 3D Systems' ProX SLS systems. It is especially considered a high performance material for use on a ProX SLS 6100 printer. DuraForm ProX EX NAT offers a combination of mechanicals, fine feature details, smooth surfaces, flat parts and recyclability on a ProX SLS printer.

DuraForm ProX EX NAT is available in 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 the machines installed location, environmental conditions and thermal sensors. As a result, the process parameters, more specifically the temperature set points and scale & offset values, may need slight adjustments from the defaults for optimal results. Additionally, an offline IR sensor calibration is recommended before every build with EX NAT to ensure successful builds.

Selected below is the most important information in order to build successfully with DuraForm ProX EX NAT on a ProX SLS system. For more details about this material, please refer to the DuraForm ProX EX NAT material guide and for more details about the ProX SLS system, please refer to the ProX SLS User Guide.

1. **Hardware Requirements:** We recommend using a ProX 6100 printer for EX NAT material which has modified heaters and provides more uniform thermal distribution on the part bed. These upgrades are standard parts on the ProX 6100 and not needed for that system. Customers who desire to print DuraForm ProX EX NAT Plastic material on the ProX 500 will require upgrading some components in the printer. The accuracy and mechanical properties are not guaranteed to be optimized for EX NAT material on ProX 500. The upgrades needed for the ProX 500 are:

Counter Rotating Roller: An upgrade to the Counter-Rotating Roller is required to successfully print with DuraForm ProX EX NAT. Please contact your 3D Systems field service representative to verify you require this upgrade. This upgrade is very critical for running DuraForm ProX EX NAT on a ProX SLS printer.

- **132777-00**, /R ROLLER, TEXTURED, PROX SLS

Hopper Feed Module (HFM) Heaters: DuraForm ProX EX NAT Plastic material will require feeding warmer powder from the HFM. Please contact your 3D Systems field service representative to verify you require this upgrade. If short feeding occurs during a build, please lower feed temperatures to 140˚C and consult the EX NAT material guide.

For more information, contact 3D Systems' Customer Hotline at (800) 793-3669, or contract your local account representative.

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- **76-0310**, ASSY, HFM HEATER W-CONN

Feed Roller Seal: DuraForm ProX EX NAT Plastic material will require feeding warmer powder from the HFM and may be more aggressive on some components. Please contact your 3D Systems field service representative to verify you require this upgrade.

- **132784-00**, SWEEPER BEARING UPGRADE KIT

2. **Software Requirement**: DuraForm ProX EX NAT configuration files are supported with Sinter V6.3 and later versions.

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 EX NAT 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. Please ensure you are using 3D Sprint version 2.11 or higher or Build Setup version 6.3 or higher. See section 4 for details.

4. **Material Configuration Files**: DuraForm ProX EX NAT material configuration files require Sinter version 6.3 and are offered and compatible with the following build preparation software: 3D Sprint version 2.11 or higher or with Build Setup version 6.3 or higher. For ProX 6100 users with 3D Sprint and ProX 500 users with Build Setup you will need to update to this version of 3D Sprint (ProX 6100) or Sinter (ProX 500) to be able to run EX NAT. The EX NAT configuration files can be downloaded from ProX SLS 500 or ProX SLS 6100 and added to the C: > dtm > config > material folder located on the hard drive of the printer. This will enable use of the material on either system that has the required software version. We recommend running ProX EX NAT material on ProX 6100 printer for best results.

NOTE: The following are the material configuration files offered for DuraForm ProX EX NAT: SP Mode and Advanced Mode. SP mode contains the default values for general purpose part building. The material configuration file offers the recommended parameters. The values in the material configuration files will be a good starting point for initial builds; however, some customers running DuraForm ProX EX NAT may need to optimize certain parameters for their systems.

NOTE: A setting of 5 L/min for N2 laser window flow is recommended for DuraForm ProX EX NAT material. For customers running ProX 500 systems, please verify and adjust flow to the recommended setting. Please see the EX NAT material guide for more information. This setting is standardized at 5 L/min and non-adjustable for customers running ProX SLS 6100 systems.

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

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

Parameter	DuraForm ProX EX NAT
Part Bed Heater Set	182.5°C
Powder Layer	0.1 mm
Fill Laser Power	79 W
Outline Laser Power	30 W
Scan Spacing	0.15 mm
Layer Thickness	0.1 mm
Fill Scan Count	1
Outline Scan Count	1
SinterScan™	1

NOTE: The online EX NAT technical specification values report performance of builds with the parameters above and 80% fresh powder blend ratio. It is the customer's responsibility to validate part quality and mechanical properties for any custom parameters and blend ratios used with Advanced Mode. Please see the EX NAT Material Guide for more details. Please note, 3D Systems Field Service might require the use of the SP mode during troubleshooting issues.

6. **Shrink and Beam offsets**: The shrinkage of 100% fresh DuraForm ProX EX NAT is slightly higher than that of blended DuraForm ProX EX NAT. 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 for 80% fresh powder blend and default parameters mentioned in section 5. These are the same values as in the material configuration files.

Parameter	DuraForm ProX EX NAT 80% Fresh
X scale	1.04
Y scale	1.04
Z scale	1.0357 -5.749E-5z
X Fill offset	0.36mm

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Y Fill offset	0.29mm
X outline offset	0.34mm
Y outline offset	0.26mm

7. **Part Placement and Orientation in the SLS build volume**:
   - Large "blocky" sections or structures are susceptible to distortion (post-build curl). Rotating the .stl file about X and/or Y can help to mitigate this distortion when used to minimize cross-sections on a per layer basis. Use the *View* application, and Clipping function in the Z Axis to identify large cross-sections. Please refer to sections "Setting Up a Print" and "Part Placement and Orientation Guidelines" in the material guide for more details.
   - Start these demanding parts later in the build (at greater Z) after other parts have been built.
   - Parts with wide flat bottoms are recommended to be oriented by 10 degree angle in X and Y to eliminate distortion (i.e. bowing) at the bottom. This will also help reduce layer time.
   - Use the *Estimate* application to identify regions with high layer times and make adjustments in part placement and orientation to minimize layer times. Please read the section "Cross-sections" in the material guide for more details.

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 slight modifications to one or both of the following may help minimize lean: Part Heater Set Point, Part Heater Output Limit. Using Real Monitor, please ensure the target set point temperature is being reached every layer for the part bed temperature. If problems with lean do occur, increase the part heater set point in increments of 0.5-1˚C. Additionally, eliminating the piston temperature ramp during warm-up and using maximum piston temperature throughout the build may also help reduce and minimize lean.

9. **Routine Maintenance**: Avoid leveling powder while purging the system. Exercise care when removing powder residue from sensitive surfaces. Powder build up 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 EX NAT material guide for more details.

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

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NOTE: Fine dust dispersed in air in sufficient concentrations, and in the presence of an ignition source may become a potential dust explosion hazard. The dust deflagration value (K_{st}) is 75 bar·m/sec.

11. **Part Breakout, Powder Recycling & Sifting**: Do not remove the part cake from the process chamber until the part bed temperature is approximately 80°C. Allow parts to continue cooling to 50°C before trying to break them out of the part 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 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.

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 EX NAT 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 incorporates new particles of appropriate size. Blending also helps combat the changes 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 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. For any particular fresh powder ratio setting, the minimum volume of fresh and used powder required to initiate a blend is displayed on the MQC home screen. Please refer to the respective ProX SLS User Guide and MQC User Guide for more information.

The default fresh powder ratio setting for DuraForm ProX EX NAT material is 80%.

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.

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NOTE: An 80% fresh powder ratio setting for DuraForm ProX EX NAT does not result in orange peel. Parts that are prone to distortion tend to print better (with less distortion) at 80% fresh powder ratio setting.

NOTE: Approximately 0.66 Kgs (1.3 liters) of powder is required for every 10 mm of z-height (please remember to include warm-up, build, and cool-down heights in total build height 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 time *Estimate* application in the build preparation software also provides the approximate volume of powder required to complete a build.

13. **Mechanical Properties:** Mentioned below are some of the most notable factors that will affect mechanical properties of EX NAT parts. Please also see the EX NAT Material Guide section on "Recycling Material". Any changes to build parameters, part parameters and powder blend ratios may lead to changes in mechanical properties and part quality. Please note the information in this section while setting up any custom build styles in Advanced Mode, especially if mechanical properties in the Z orientation are important to your application.

- The part build orientation affects the mechanical properties of printed parts due to the anisotropy caused by layer bonding. Components built along the Z-axis will show a considerable drop compared to components built along the XY plane. Please refer to the technical specs datasheet for more information.
- The part bed temperature is one of the most significant parameters in the sintering process. The part bed temperature setting is optimal for EX NAT in the SP and Advanced Mode default configuration parameters. However, due to the possible machine to machine variations mentioned above, or application part specific requirements, the part bed temperature may need to be slightly adjusted to ensure optimal melt flow, crystallization rate and densification of parts takes place to achieve uniform mechanical properties. Particularly, failure strain or elongation at break along the Z-axis is most sensitive to thermal variations in the print process. We recommend a gradual increase (0.5-1 °C) at a time in part bed temperature if needed. Please note that increasing the part bed temperature will gradually lead to much harder part cake and depending on the temperature, may even cause growth on printed part surfaces.
- The blend ratio of fresh and used powder significantly affect mechanical properties in the Z-axis while X-Y plane directional properties show only slight changes. As the recycled powder in the blend ratio increases, the melt viscosity increases and the melt flow rate decreases. This is because fresh powder has higher melt flow than recycled powder. The technical specs reported online are results for 80% fresh powder ratio (20% recycled). Using 100% fresh powder will improve elongation at break in Z up to 3 times and improve tensile strength, while 60% fresh powder ratio will lead to drop in strength and elongation by half.
- The heating and cooling cycles during a print are affected by 1) the number and size of parts in a build (a.k.a. part build density) and 2) the number and cross-section of parts per layer (a.k.a. part layer density). Builds with higher build density are usually taller builds with more parts and keep the entire build in higher temperatures for a longer duration. Higher part layer density occurs when there are a larger number of sections (more parts) and/or larger areas that needs to be scanned in a single layer. The

longer duration of build and retention of high temperatures may affect the thermal history of the printed parts as well as the degradation and recyclability of the support powder material surrounding the printed parts. Higher part layer density increases the layer time as well as the likelihood of part distortion. Please read the section "Cross-sections" in the material guide to avoid potential problems related to part build density and part layer density.

- Part location has an effect on mechanical properties of printed parts. Parts placed in the center of the build have been shown to have better mechanical properties compared to parts built close to the edges of the build area.
- Using Double-Scan filling (fill scan count 2) increases the melt flow during the print by allowing higher energy input without degrading the powder. Although this might increase the mechanical properties in XY plane, using scan count of 2 also increases the Layer Time (the time that is taken to scan each layer) and depending on the laser power being used, the chance of growth. As mentioned earlier, EX NAT material is very sensitive to layer time and using scan count 2 could lead to more inconsistency in Z direction.