Drying process overview

Frequently asked questions

Which 3D printing filaments should be dried?

ABS, PMMA, PA (Nylon), PC, PET, PETG, POM, TPU, advanced filaments like CF filled PA, PEEK, PEKK, ULTEM or flexible filaments should be dried before printing. We also recommend to feed preconditioned PLA or PP filaments, because it can improve the reliability of the printing process.

What does determine the ability of a 3D printing filament to absorb moisture?

It depends on the polarity of the main polymeric component, i.e. its chemical nature.

Why do the undried filaments print so bad?

The main negative effect of excessive moisture during processing of polymers is hydrolysis, i.e. the chemical breakdown of polymer macromolecules due to reaction with water at high temperatures.

What impact does moisture have on 3D printing process?

In the context of 3D printing high moisture content in the filament can give rise to the following 3D printing defects:

- **foaming, bubble formation, opaque appearance.** At the polymer processing temperatures the water will evaporate, expand, and form bubbles in the polymer melt, which will result in bad surface properties and deteriorate the optical properties of the final parts;

- **more oozing and more strings.** Water reduces the viscosity of the polymer melts, so they become more liquid;

- **pronounced warping.** The prints from undried material usually show worse dimensional stability, and become more prone to warping;

- **bad interlayer adhesion, compromised mechanical properties.** Due to the hydrolysis, the long macromolecule chains are split into shorter ones. This leads to the compromised mechanical properties of the solid parts, which can lead to the delamination during printing or even failure of 3D printed parts in service;

- **colour changes.** Hydrolysis products often lead to the colour changes of the polymer.

What impact does drying have on the quality of 3D printed parts?

The main advantage of using dryers is that it will reduce the number of moisture-induced 3D printing defects. We have also observed that the parts printed with dried materials sometimes exhibit more accurate dimensions than the parts printed with undried material (see Figure below). So if the dimensional stability of your 3D printed parts is important, we strongly advise you to use a filament dryer. In general, the use of dryers increases the overall 3D printing success rate, and makes the 3D printing process more stable, thus, even enabling a continuous 3D printing.

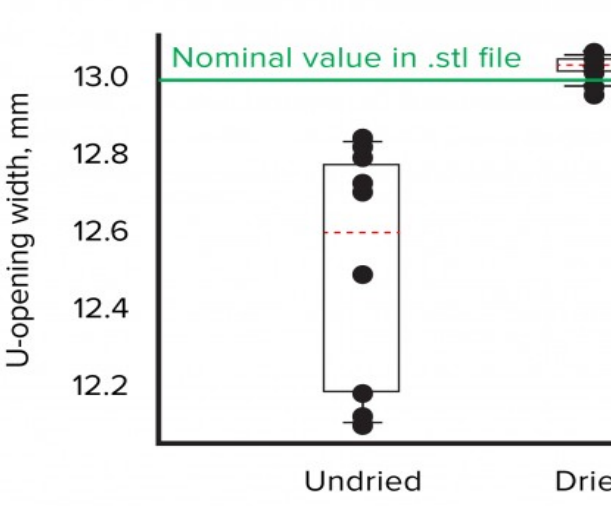


Figure: Drying effect on the dimensional stability of the printed parts: boxplot shows the U-shaped opening width of the spanners we printed using dried and undried PC filament (1.75 mm, natural colour). The width of the U-shaped opening in the parts printed with the dried material shows a much narrower value spread, and is much closer to the nominal value of 13 mm. The material was dried in FD5 dryer at 65 ℃ for 3.5 h with 20 % airflow, printed at 270 ℃ (extruder), 90 ℃ (printbed), nozzle diameter 0.4 mm using the same g-code for dried/undried filament. The undried filament was used after a prolonged exposure to the ambient conditions (room temperature, RH = 55-60 %).

How long does it take to dry a filament?

On average it will take around 5 h at 60 – 80 ℃ to dry a 1 kg filament spool, depending on the specific type of filament and the initial moisture content. Note that drying settings can vary largely even for nominally the same filaments coming from different manufacturers.

Why does filament drying take so long?

Moisture will not start to migrate out of the material until the temperature gradient across the filament is gone. As polymers are bad thermal conductors, it takes time for heat to penetrate to the centre of filament. Moreover, it takes even more time for the moisture to migrate to the surface. Exactly how much time it will take, depends on a number of factors including the specific type of polymer and the drying temperature.

How long does it take for a dried filament to regain moisture?

Moisture regain times vary greatly from filament to filament, and storing conditions. For some hygroscopic 3D printing filament under extreme cases (e.g. at high relative humidity conditions and very slow printing speeds) the moisture regain may be too rapid to avoid moisture-related printing defects, some other filaments can even be printed days after drying.

If the regain time is so short how can I be sure I will be able to print a bigger part?

We have incorporated a conditioning mode in our FD5 dryers, to ensure feeding of a properly dried filament for an unlimited time. Added to that, the filament is fed from the dryer into the printer through a closed shell tube to minimize the moisture uptake from the ambient atmosphere.

What makes your filament dryers to stand out from similar products?

At the moment the selection of filament drying solutions on the market is very limited: there is only one type of hot air dryer and desiccant box available. Our filament dryers are more than just a hot air dryer or desiccant box. The unique features of our filament dryers are:

- desiccant box system to dehumidify the incoming air,
- optimized heating and air flow systems to eliminate the hot spots in the drying chamber,
- low vibration and noise level,
- touch screen display to control and setup the drying settings,
- setup of custom or multistep drying settings,

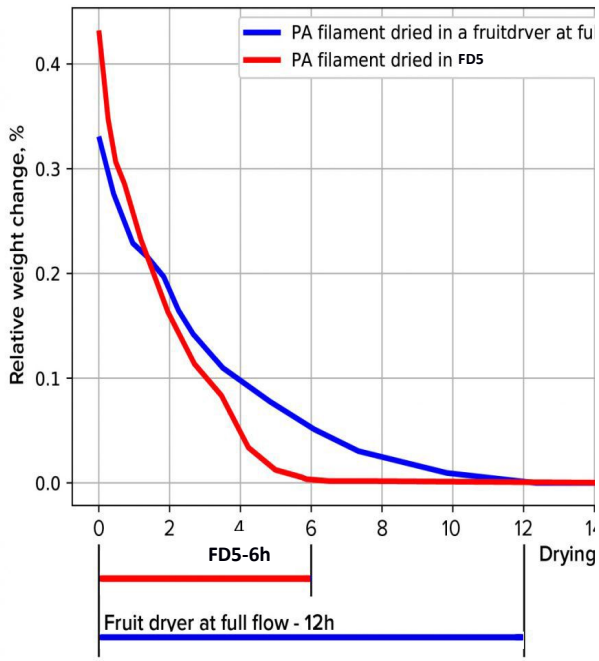
What are the advantages of FD dryers?

Being a compact device with a smaller footprint, FD dryers are easy to install. As no compressed air or chilling water is required, the dryers do not have any special installation requirements

I can dry my filament in my oven or fruit dryer. Why do I need your filament dryer?

Of course, you can dry your filaments in an oven or fruit dryer, you just have to bear in mind that it is not a good idea to dry filaments in the same equipment where you cook your meal.
Moreover, the desiccant system makes our filament dryers more efficient than fruit dryers, and on average it takes twice as less time

to dry the filament in our filament dryers than in a fruit dryer (see Figure below). Considering the generally long drying hours, it will result in significant time and money savings.



The relative weight changes of 0.5 kg Nylon filament dried in fruit dryer (at the maximum temperature of 72 C, at full air flow) and in our filament dryer (at T = 70 C, air flow = 20 %). This graph shows that drying in the filament dryer is clearly faster and more efficient than drying in a fruit dryer.

What are the main drying parameters?

The main drying parameters are temperature, air flow velocity, and drying time.

What drying parameters can be changed in FD1 dryers?

In FD5 dryers the user has an option to control drying temperature, and drying time.

What about the absolute water content in the incoming air? Does it have an impact on drying process?

The absolute water content in the incoming air is an important drying parameter, but there is no option to change it in the FD5 dryers. To reduce the moisture content in the incoming air, we use desiccant box, which are needed to be regenerated weekly. Our measurements show that ambient air with 55 % RH at 25 ℃ loses about a half of its water content when passing through a desiccant box.

How do I know what drying settings to use?

We are building a comprehensive database storing the drying (and printing) settings for different materials from leading 3D printing filament manufacturers.

Why is the maximum drying temperature in FD5 dryers limited to 150 ℃?

The main reason for the temperature limit is that is the drying temperature for such materials like PEEK, ULTEM, PEKK. User should check the spool material before using 80℃ or more as many manufacturers spin their filaments on PS or ABS spools. Unfortunately, these materials are prone to losing their shape at the temperatures needed to dry the spun material. The best solution is to dry the material on metal spools.

Where do the generic settings come from? Are they valid for all the filaments?

At present 3D printing filament producers' and suppliers' recommendations on how to dry their filaments are usually very scarce. Therefore, it is impossible for us to get information on the most efficient drying settings from the supplied material data sheets alone. Obviously finding the right settings by trial and error for all the filaments is out of a question. The generic settings are based on the typical temperatures used in the polymer industry, but considering all the additives producers put into 3D printing filaments the values should be rather seen as guide values, which can (and should) be adjusted if needed.

Should I try to dry out my filament as dry as possible?

Firstly, when you dry 3D printing filaments using air with the constant properties (constant temperature, relative air humidity, and airflow) the moisture content in the material will slowly approach the so-called equilibrium moisture content, and will not decrease any further (see Figure below). In other words, drying filament with drying air having a certain temperature, relative air humidity, and flowing velocity values will never result in a material with the moisture content below some equilibrium moisture content, no matter how long one dries the material.

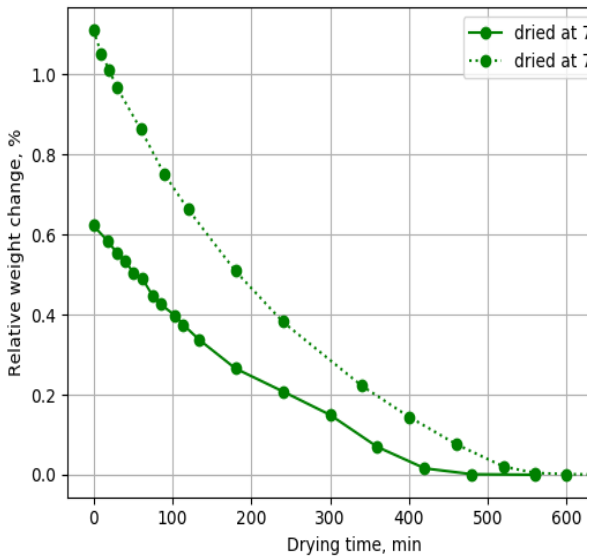


Figure: Drying curve for PA 3D printing filaments. The material was dried in FD5 dryer at 70 ℃ and 75 ℃, with 20 % airflow. The undried filament was used after a prolonged exposure to the ambient conditions (room temperature, RH = 55-60 %). Drying for 450 min @ 70 ℃ or for 550 min @ 75 ℃ is generally enough to dry the filament.

Secondly, some cheap filament manufacturers put a lot of additives into the filaments. These additives tend to migrate out during prolonged exposure at high temperatures; this phenomenon might be called overdrying. Printing with an overdried 3D filament will not result in a good print.

How does drying a filament influence the 3D printing settings?
Generally, when printing with a properly dried filament you have to increase the printing temperature.

Hot air dryers are often said to be incapable of removing enough water for proper processing of hygroscopic polymers. How adequate are FD5 dryers for drying 3D printing filaments?
Indeed the drying power of hot air dryers is often not adequate to dry hygroscopic polymers. That is why we incorporated a desiccant box to dehumidify the incoming air. This allows reducing the absolute humidity content in the incoming air by a factor of two before it gets into contact with the filament. This makes our dryer more efficient compared to drying in an oven or in a hot air fruit dryer.

How does one operate the filament dryers?
Purpose comprehensive embedded software has a number of features to set up, and edit your drying settings. Single click generic drying profiles are available for the most popular filament types. Of course, you can set up your own drying settings for a custom filament.

How safe are FD5 dryers?
Our filament dryers are the perfect solution when it comes to safety and user-friendliness: they are equipped with a built-in overcurrent, overheating protections, and door open/closed sensors.
Are filament dryers compatible with all 3D printing filaments?
FD5 dryers are compatible with all open-materials 3D printing filaments.

Are filament dryers compatible with all 3D printing printers?
In a standalone operation mode FD5 dryers are compatible with the most open-materials 3D printers which use standard filament sizes: 1.75 mm, 2.85 mm, 3.00 mm.

Comparison

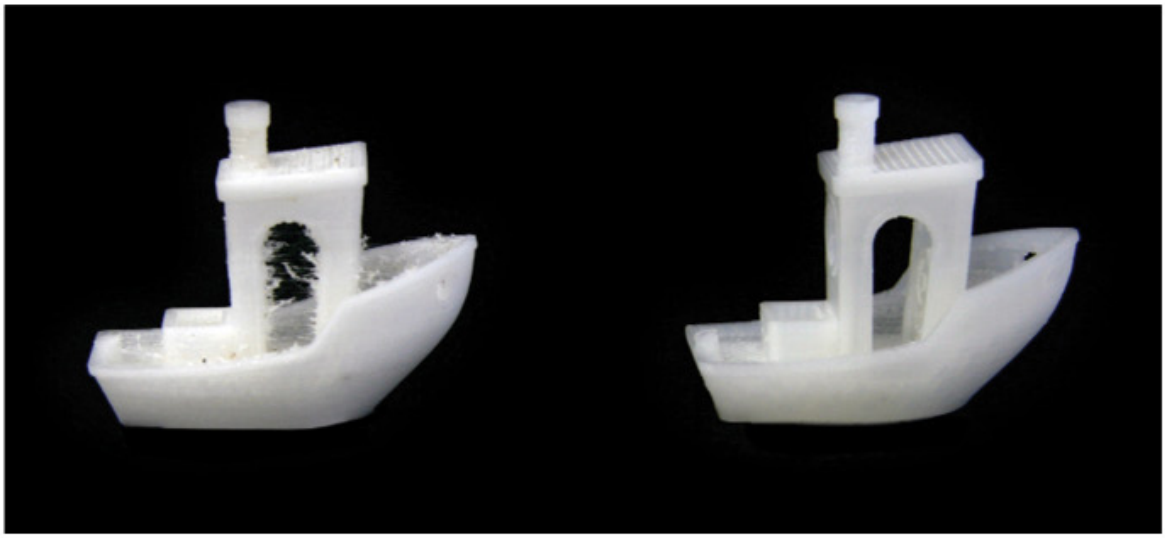
	FD1	FD5	Fruit Dryer	Oven	Dry Box
Temperature	80°C	150°C	60°C	200°C+	Room temperature
Capacity	1kg	5kg	N/A	N/A	1kg
Drying method	Dehumidified hot air	Dehumidified hot air	Hot air	Hot air	Passive
Dessicant	Regenerating	Regenerating	No	No	Expendable
Air filters	●	●	○	○	N/A
Drying efficiency	●	●	○	◔	N/A
Even heat distribution	●	●	○	○	N/A
During print conditioning	●	●	○	○	○
Computer controlled	●	●	○	○	○

Drying Requirements

Material	FD1	FD5	Fruit Dryer
PLA	●	●	●
ABS	●	●	◗
Nylon	●	●	◗
TPU	●	●	○
PC	◑	●	○
PEI	○	●	○
PEEK	○	●	○

Why do you need to dry?

To achieve better printing results
with moisture sensitive thermoplastic materials



3D Benchy printed with undried and dried filament — same settings, same g-code, same hardware

Drying, conditioning and feeding filament under optimal conditions unlocks the full potential of 3D printing materials

Many polymers absorb moisture from the ambient atmosphere. As the water molecule is polar, it can easily form hydrogen bonds with polar functional groups in polymers. First, moisture condenses at the filament surface (so-called surface moisture), but after some time moisture will also penetrate inside the material (so-called bulk moisture). Both moisture types have a tremendous negative effect on the processing of the most polymer materials when water reacts with polymer molecules and breaks them into smaller ones (hydrolysis).

Stable processing
While filament manufacturers spend considerable time to create moisture-insensitive filaments, there are still quite a few materials which have to be dried prior to printing. Using Mass Portal FD dryers ensures a more stable printing process, thus allowing you to print bigger parts more reliably with moisture-sensitive materials like Nylon or TPU.

Better mechanical properties
Hydrolysis causes a considerable decrease in mechanical properties of 3D printed parts, which can lead to the delamination or even structural failure of 3D printed parts in service.

Fewer cosmetic defects
Using Mass Portal filament dryers can eliminate a number of moisture-related 3D printing defects.