Drying Solvay Specialty Polymers Resins

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Why The Need To Dry?

Solvay Specialty Polymers manufactures a broad range of high-performance thermoplastic resins that in most cases are hygroscopic in nature, meaning they absorb varying amounts of environmental moisture. If these polymers absorb moisture because of improper handling or storage, they must be dried prior to processing to prevent defects that would otherwise occur due to moisture. In the case of Ryton® PPS, the resin is not hygroscopic, but some mineral fillers may be; therefore, drying is particularly important for mineral-filled compounds as it encourages the elimination of volatile fractions remaining in the compound that might otherwise deposit on process tooling during injection.

This document discusses problems caused by inadequate drying, various drying technologies, proper drying techniques and suggestions for troubleshooting. Lack of adequate drying may encourage the following:

Unseen or Imperceptible Defects

- Increase in internal porosity, which may reduce impact and/or flexural strength
- Marked variations in processing parameters, dosing times, injection speed/pressure, and dosing characteristics
- Changes in molded-in stresses
- Problems balancing hot runner system nozzle flow
- Excessive mold plate-out or vent clogging when using Ryton® PPS

Visible Defects

- Parting line flash caused by severely reduced melt viscosity
- Appearance of splay, silver streaks, fogging, bubbles or flow lines
- Changes in dimensional tolerances
- Excessive drooling at the machine nozzle or hot runner nozzles
- Sprue sticking during ejection

Moisture Absorption Rates

The rate of absorption/desorption varies according to polymer chemistry (Figures 1 through 4), the dryness during packaging, level of and exposure to ambient humidity, ambient temperature, types of packaging (bag or box), and damage to packaging. Improper or inadequate drying may result in a multitude of possible defects. Data for Ryton® PPS is not included in the following figures due to its extremely slow and negligible moisture absorption.

Figure 1: Comparison of moisture absorption by immersion at 23 °C (77 °F)

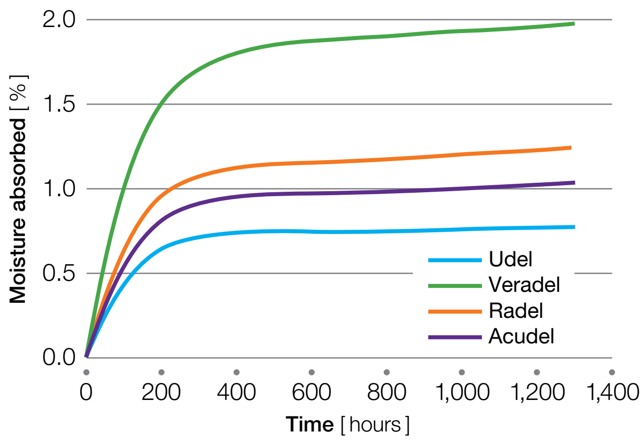


Figure 2: Ixef® PARA moisture absorption by immersion at 23 °C (77 °F)

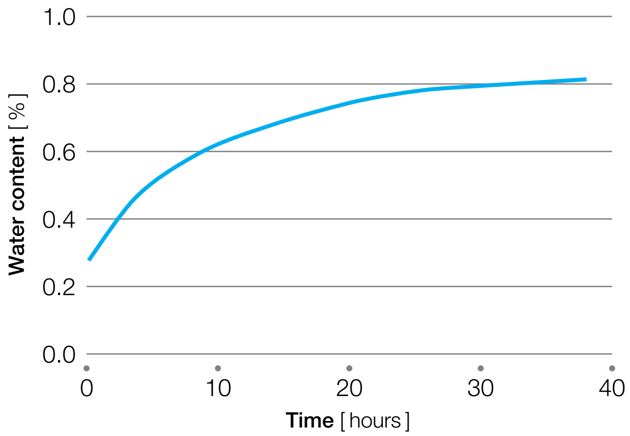


Figure 3: Udel® PSU moisture absorption by immersion at 23 °C (77 °F)

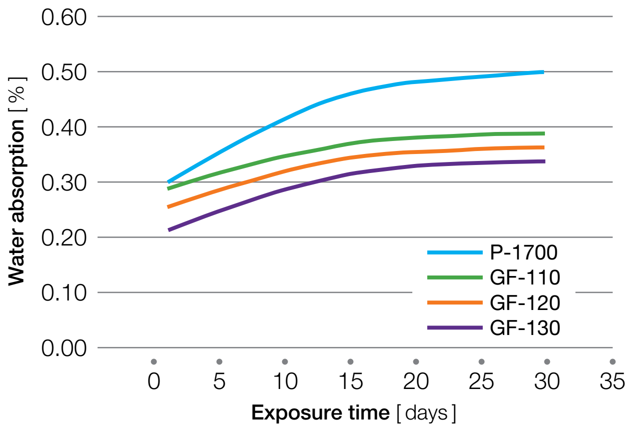
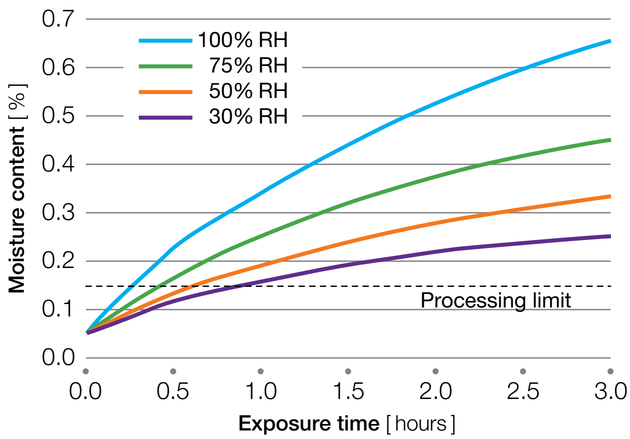


Figure 4: Amodel® PPA moisture absorption at varying relative humidity at 23 °C (77 °F)(1)



(1) *Initial pellet moisture content was 0.05%*

Resin Drying Technologies

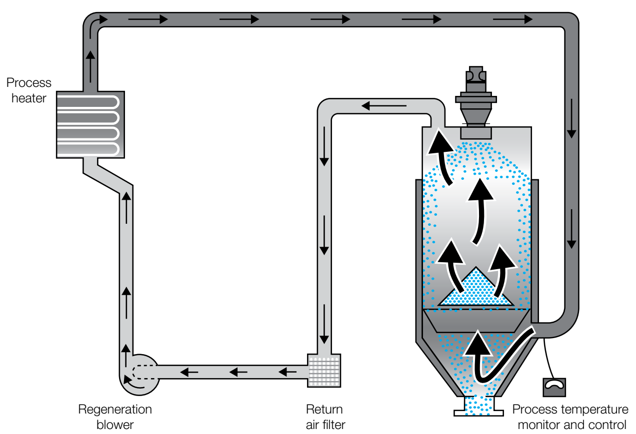
Five commonly used resin drying technologies are hot air, desiccant, compressed air, oven, and vacuum; however, not all of these technologies are well-adapted for use with Solvay's high-performance polymers.

Hot Air Drying

Hot air dryers are relatively simple and robust in their construction. Basic system elements include a hopper, air blower, heating element and controller for regulating the temperature. Ambient air obtained at the molding press is heated to a preset temperature, and then forced through the molding granulates held inside the hopper. The arrows in Figure 5 indicate the flow of hot air through the hopper.

Major dryer manufacturers offer a range of basic hot air dryers. Low investment cost and low-to-no-maintenance costs make these systems very attractive to processors. Because moisture cannot be accurately measured within the drying circuit and there is no physical means to **remove** moisture, the moisture content in the system is heavily influenced by ambient humidity levels at the molding machine. Given that, it is important to account for seasonal variations.

Figure 5: Typical hot air dryer



Occasionally, Solvay has endorsed hot air dryers for use with the Sulfone family of resins. In certain cases, use of hot air was acceptable, owing to the possibility to compensate for inadequate dryness through the use of additional back pressure during dosing. However, this exposes the resin to additional shear stress that may bring about polymer degradation.

With the exception of Ixef® PARA, Ryton® PPS and, in some special cases, sulfone-based polymers, hot air dryers are **not** recommended for Solvay's high-performance polymers.

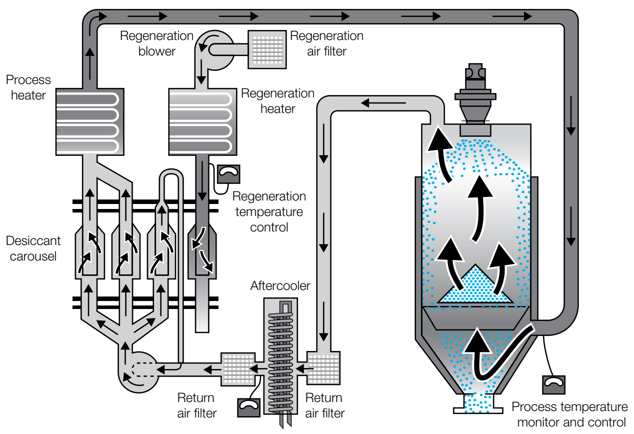
Desiccant Drying

Desiccant drying systems draw air from the drying hopper (Figure 6), chill it to room temperature, and then dry the air stream using a molecular sieve or cartridge. Most systems are equipped with two desiccant cartridges to increase the drying capacity. Cartridges can be installed in a carousel arrangement, where one cartridge is operating while the other is being regenerated.

Following the desiccating step, the air is reheated to the processing temperature which is specified by Solvay. Hot air is then forced back to the bottom of the hopper where dew point (ultimate moisture content) and temperature are monitored. Higher air temperatures accelerate moisture release and usually require shorter drying times.

Properly maintained and operated desiccant dryers are the most effective method for drying hygroscopic resins. Take care to maintain at least a –40 °C (–40 °F) dew point with these systems.

Figure 6: Typical desiccant dryer



Compressed Air Drying

Compressed air dryers use a rapid pressure drop to quickly remove any humidity contained in the drying air stream. These dryers are designed for production systems with very low resin throughput because their ability to remove large amounts of moisture is very limited.

Performance is inherently linked to the quality and volume of the compressed air supply. Air quality varies depending on seasonal levels of atmospheric humidity, and dew points rarely achieve –40 °C (–40 °F) for factory processed compressed air. Due to these factors, Solvay does **not** recommend this technology for its products.

Oven Drying

Oven drying is one of the oldest methods for drying hygroscopic resins and recognized as the simplest. Oven dryers expose granulate to a preset temperature in shallow trays stored horizontally in a rack. In most cases, no pre-treatment or pre-drying of air exists with these types of systems. The principle behind oven tray drying is that at elevated temperatures, moisture will be liberated from the granulate.

Unfortunately most oven dryers are not equipped with a draw-off system or other method for purging or evacuating evaporated or liberated moisture from the pellets within the airtight confines of the oven. Airflow is limited owing to the depth of the tray and circulating patterns of the airflow within. Oven drying is only recommended for very low throughput processing (laboratory or limited production run size situations). Oven dryers are often found in very controlled environment situations where resin storage has been optimum and there has been very limited exposure to atmospheric moisture (so little drying is effectively needed). Production situations would not be well adapted for this type of drying technology.

Vacuum Drying

Similar in configuration to simple oven dryers, vacuum ovens can provide improved drying performance. Vacuum ovens are equipped with negative pressure evacuation that removes moisture from the resin granulate while it is heated in the oven chamber. Key to its performance is the equipment's ability to pass enough air or other drying media through the resin granulate.

Vacuum dryers should be used with caution. They are not practical for deep oven storage trays due their limited ability to remove humidity completely. In questionable situations (e.g, deep trays, high incoming humidity levels, and resins stored for long periods of time), it is advisable to test the efficiency of the vacuum dryer for resins with varying hygroscopic characteristics.

Drying Conditions for Solvay Products

In many cases, Solvay's high-performance polymers are shipped pre-dried or partially pre-dried. They are packed in bags or boxes that contain several layers of moisture barrier film; however, as a precaution, Solvay advises molders to always dry these materials prior to processing. Hopper dryers should be operated with their covers tightly fitted in place. Minor exceptions to these conditions are noted in the Special Drying Considerations section of this bulletin.

Table 1 provides drying times and temperatures for several Solvay products. These conditions can be used in most processing situations. Because all process environments are not the same, additional precautionary measures may be required in certain situations.

Special Drying Considerations

Dryer Location

When the central resin handling area is located a significant distance from the machine's supply hopper or silo, ensure that all transfer lines are insulated to maintain a higher temperature in the transfer pipes and the handling air is properly desiccated. This will prevent re-introducing moisture to the resin during transfer. Additional drying capacity can also be installed at the press.

Table 1: Drying times, temperatures and moisture content for select Solvay high-performance polymers

Product	Moisture Content [ppm (%)]	Times [Hours]	Temperatures [°C (°F)]
Veradel® PESU / Radel® PPSU	≤ 500 (0.05)	3	177 (351)
		4	150 (302)
		5	135 (275)
KetaSpire® PEEK / AvaSpire® PAEK	≤ 1,000 (0.10)	4	149 (300)
Ixef® PARA	≤ 3,000 (0.30)	12	90 (194) (2)
		0.5 – 1	120 (248)
		1 – 3	100 (212)
		1 – 7	80 (176)
Udel® PSU	≤ 500 (0.05)	2	163 (325)(3)
		3	150 (302)
		4	135 (275)
		— (4)	— (4)
Amodel® PPA (1)	≤ 300 – 600 (0.03 – 0.06)	3	150 (302)
		2	135 (275) (3)
		4	120 (248)
Torlon® AI	< 2,000 (0.20)	4	121 (250)
		8	149 (300)
		4	177 (351)
Ryton® PPS	< 1,000 (0.10)	2 – 4	135-150 (275-302)
Ryton® PPS, XE Grades	< 1,000 (0.10)	4 – 6	80-85 (176-185) (3)
Ryton® PPS, XK Grades	< 2,000 (0.20)	4 – 6	80 (176)

(1) *AT and ET grades of Amodel® PPA and XE grades of Ryton® PPS should not be dried at temperatures in excess of 90 °C (194 °C) to prevent or avoid pellet sticking.*

(2) *Hot air*

(3) *Higher drying temperatures are not harmful, but they can cause clogging or agglomerating of pellets in the drying chamber*

(4) *Cannot over dry; yellows with longer drying times*

Using Regrind

All of Solvay's high-performance polymers maintain optimal physical properties when regrind is used; however, moisture absorption can be higher due to the change in aspect ratio (i.e., general surface aspect of the polymer particle) and the inevitable delay between the production of the reground resin and its consumption. To compensate, increase drying times by 15% when using regrind to ensure that any additional moisture is removed.

Bulk Packaging

Bulk containers such as octabins, gaylords or other oversized boxes should always be maintained in a closed condition, either with the original packaging liner (PE film) or a separate moisture-proof cover. Bulk containers are often left open in the handling area, thereby increasing the moisture content of the resin. Drying times for products kept in open containers will vary based on the factors previously discussed such as ambient air humidity, ambient temperature, and length of exposure.

Over Drying

Production logistics can pose the risk of over drying the resin. Drying times that exceed Solvay's recommendations for its products should not adversely affect the material's properties. Be aware that any thermoplastic resin kept at elevated temperatures for an extended time may experience a color shift due to oxidation, but this will not affect the physical properties of the molded part.

Please note that in the case of select Amodel® PPA or Ryton® XE grades that contain elastomeric modifiers, drying temperatures in excess of 90 °C (194 °F) will cause pellets to agglomerate and stick to each other due to the softening of the elastomeric component. Excessive sticking may cause problems when feeding resin granulates through the material handling system.

Moisture Ranges

Solvay recommends a moisture content range instead of a maximum value due to the wide range of injection molding conditions, presence or lack of a hot runner system, and choice of the hot runner nozzle configuration. Depending on the stability, nature and constraints of the injection process, manufacturers should determine the moisture level best suited for their molding equipment and processing conditions.

Moisture Analysis

Solvay employs moisture analysis equipment based on Karl Fisher reagent titration technology. We recommend that you use extreme caution when evaluating the performance of a drying system, either by trying to precisely determine the moisture content or by using a dryness indicator tool. Technologies offered by system suppliers introduce variabilities such as the ability to differentiate between moisture and off-gassing components, required maintenance level, precision of the technology used within the analyzer, and competency of the operator.

Troubleshooting Questions

- Is the drying issue limited to one lot, or does it occur frequently during production?
- Is the dryer being maintained to the manufacturer's specifications?
- Is the dryer properly adapted for Solvay products?
- Is Solvay's recommended drying procedure being followed?
- Are drying issues occurring seasonally?
- If incorporating a masterbatch into the raw material stream, have the masterbatch compounds also been dried properly?

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