Recommendations for injection molding

Envalior
Imagine the Future

Stanyl® TW371 & TW371-K

(PA46+PTFE)

Heat Stabilized, Wear and Friction Modified

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GRADE CODING

Stanyl® PA46 non-reinforced and non-flame-retardant injection molding grades.

INTRODUCTION

The objective of this document is to provide recommendations that guide the molder in setting the injection molding process as to produce parts that have good surface quality, mechanical properties, and wear and friction properties. This document does not imply that good quality parts can be obtained only at the recommended conditions: with the large variety in injection molding machines, molds and part designs, slightly deviating conditions may also lead to a satisfactory result. In case of doubt, contact your Envalior representative.

Like other polyamides, Stanyl® is susceptible to degradation during processing (reduction of molecular weight). Degradation is affected by three primary factors:

- The melt temperature of the material.
- The time during which the material is in molten state (the melt residence time)
- The moisture content of the material when it is molten.

These three factors enhance each other. If one of them is high, the other two must be kept low in order to minimize polymer degradation.
Stanyl® is hygroscopic; if left in contact with ambient atmosphere, it could absorb 0.5 w% of moisture within a day.

GCP (Gas Counter Pressure)

This GPC technology is proven to contribute to achieve a better surface quality. Potential risks as gasses (blister/streak) showing at the surface of the molded part are prevented.

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MATERIAL HANDLING

Storage
In order to prevent moisture pick-up and contamination, the supplied packaging should be kept closed and undamaged. For the same reason, partially emptied bags should be re-sealed as soon as possible after use before re-storage.
It is advised to store at room temperature.

Packaging
Stanyl® grades are supplied in airtight, moisture-proof packaging.

Moisture content as delivered
Stanyl® grades are packaged at a moisture level less than 0.1 w%.

Conditioning before molding
To prevent moisture condensing on the granules, bring cold intact bags up to ambient temperature in the molding shop while keeping the packaging closed.
Pre-drying is required in case the material has been exposed to moisture before molding (packaging has been damaged or open for longer period of time).

Moisture content before molding
Moisture can have a negative impact on processing. If the moisture content is too high, there will be a risk of degradation by hydrolysis (particularly at elongated residence times) resulting in loss of mechanical properties.

If the moisture content is too low, the melt viscosity will increase and excessive shear heating may occur during filling of the mold. It will thereby enhance the risk of surface defects. We suggest a Design-Of-Experiments to determine what settings work best for your configuration at hand.

Measurement of moisture content is therefore essential and must be available at the molding shop. Moisture content can be checked by water evaporation methods or manometric methods (ISO 15512). A successful example: molding the material with a moisture level between 0.03w% and 0.08w%, with an optimum between 0.05w% and 0.06w% (see below for drying recommendations).

Drying
Preferred driers are de-humidified air driers operating between 80°C (176°F) and 110°C (230°F) with dew points maintained between -30 and -40°C / -22 and -40°F. To decide on the best drying procedure, the initial moisture content must be known (measured). The higher the initial moisture content, the longer the required drying times, as indicated in the graph below. The graph intends to provide a good starting point for estimating the residence time in the dryer. We suggest that you measure the moisture content as function of time to establish a correlation curve for your equipment and dryer settings. For example (see arrows in the graph): if the initial moisture content is 0.4 w% and the drier operates at 100°C, then it will take about 12 hours of residence time in the dryer to lower the moisture content to 0.05 w%. Vacuum driers with N2 purge can also be used. Although over-drying can occur at excessive drying times, Stanyl® can be left in the drier at the recommended drying temperatures for 2-3 days without degradation.
Hot air ovens or hopper driers (operating at high dew point) are not suitable for pre-drying Stanyl® grades; the use of such driers may result in non-optimum performance.

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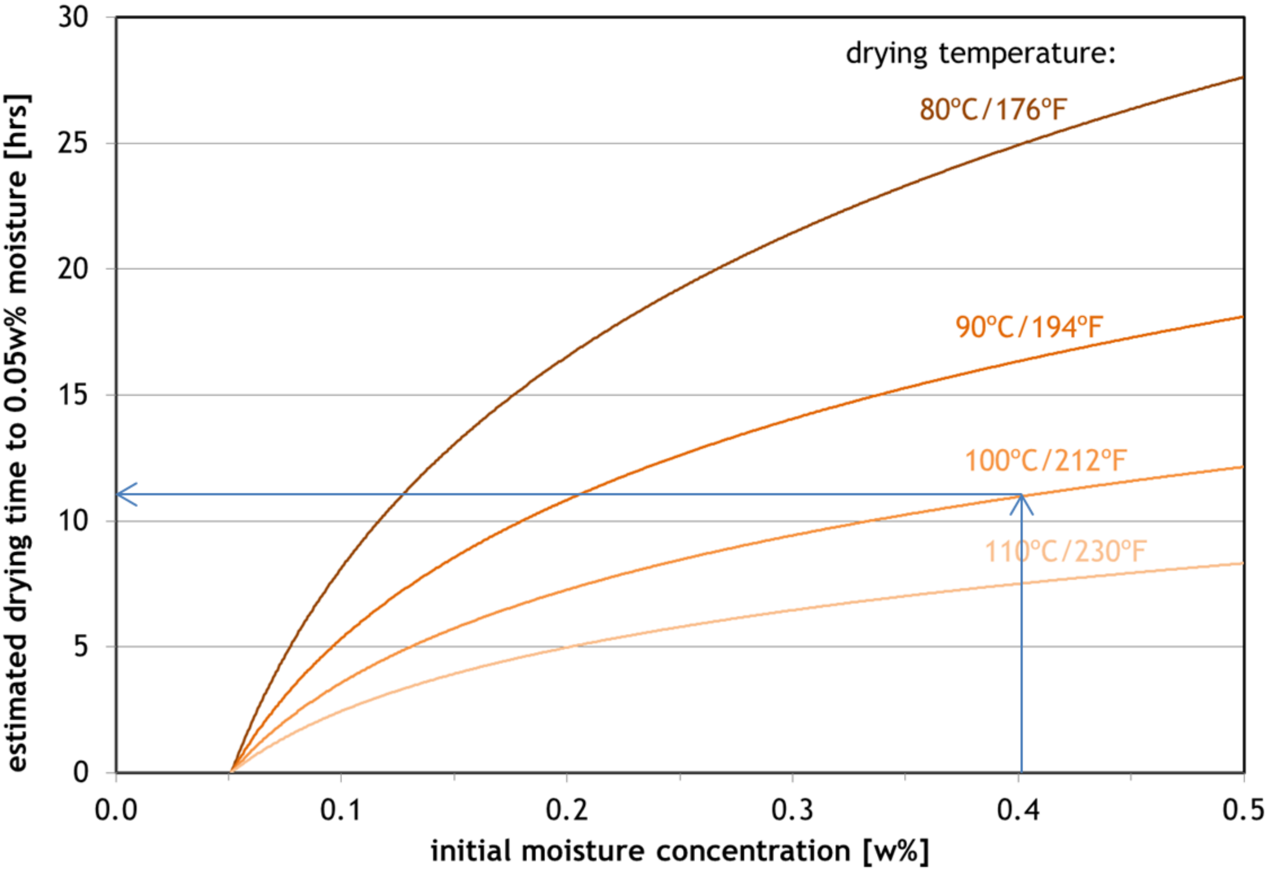

Regrind

Since degradation occurs during molding, it is recommended not to use regrind. In specific cases, a design of experiments can be performed to verify to what extent the use of regrind can be accepted from part performance point-of-view.

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MACHINERY

Stanyl® grades can be processed on general injection molding machines.

<u>Screw geometry</u>

Most screws used for unfilled PA46 work also for Stanyl® TW371 and Stanyl® TW371-K. Typically 3-zone screw designs with compression ratios of approximately 2.5 work fine. In a common 3-zone screw, the feeding zone takes up 50-60% of the screw length, the compression zone takes up 20-25% of the screw length, and a metering zone of 20-25% of the screw length. For small screws (up to 40 mm diameter), the recommended channel depth is the feed zone is between 0.15×D (larger D) and 0.2×D (smaller D). Larger channel depths may lead to dosing problems. To promote a good melt quality and to avoid excessive melt residence times, the screw diameter D should be chosen such that the plasticating stroke is between 1×D and 3×D. Shorter residence time is preferred from degradation point of view.

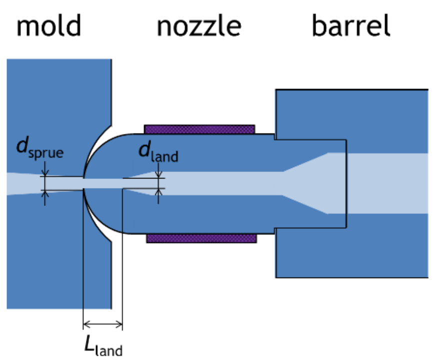
<u>Steel type</u>

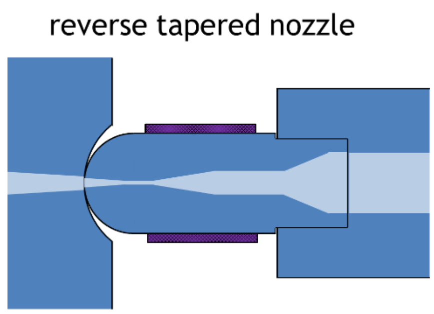
Tool steels that are suitable for processing temperatures up to 350°C are to be used for cylinders, screws and nozzles.

<u>Nozzle temperature control</u>

Due to the combination of the high melting temperature and the fast crystallization of Stanyl® (at its high crystallization temperature) it needs to be processed at high temperature. In order to prevent premature freeze-off (cold slug) as well as unnecessary degradation and drooling, it is necessary to have a good temperature control of the nozzle. The use of an open nozzle, or even better a reverse tapered nozzle, with a nozzle heater band that is controlled by thermocouple positioned close to the tip is recommended. The nozzle temperature should be set as high as possible to prevent a cold slug, yet low enough to prevent excessive drooling.

To decrease the effect of shear heating, use a nozzle with a short land length L_{land} (preferably 5 mm or less; see drawing below) and a large diameter. Note, however, that the nozzle diameter d_{land} should remain smaller (by at least 0.5 mm) than the diameter of the sprue entrance d_{sprue}.





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Mold venting design

A good venting design is crucial for good molding behavior (easy filling). Blocked vents can lead to incomplete parts and/or burning at the end of the flow path (diesel effect). Vents should not be bridged (combined) into a common exhaust but should be directly leading out to the edge of the tool. Vents should have a depth of 0.02 mm and a land length of 1.5mm.

It is recommended to use venting on all inserts as well as on the runner system. Decreasing the injection speed during filling will facilitate mold venting.

Runner and gate layout

Stanyl® TW371 and Stanyl® TW371-K are sensitive to degradation due to shear heating which may lead to surface defects. Short runners of large diameter will mitigate this risk. Also thin (pinhole) gates may create a lot of shear heating and are therefore to be avoided. We recommend the use of end gating (at one end of the part) over central gating (in the middle of the part) to diminish the risk of surface defects.

Cold runners are preferred over hot runners, as cold runners cause less thermal loading to the material compared to hot runners. Cold runner systems should preferably be equipped with cold slug wells.

Hot runner layout

Because of additional thermal load, we do not recommend the use of hot runners.

GCP (Gas Counter Pressure)

This GPC technology is proven to contribute to achieve a better surface quality. Potential risks as gasses (blister/streak) showing at the surface of the molded part are prevented.

TEMPERATURE SETTINGS

Mold temperature

Stanyl® can be used with a wide range of tool temperatures (80-120°C, 176-248°F). However, to achieve optimal mechanical properties, appearance and dimensionally stable parts, it is recommended to apply a tooling temperature at the higher side of this range (120°C, 248°F). This implies a mold cooling regulator capable of running at high temperatures (oil or pressurized water). Due to the fast crystallization speed of Stanyl®, the mold temperature has less influence on the cycle time.

Barrel temperature

Optimal settings are governed by barrel size and residence time. Due to the high melting point of Stanyl®, the barrel temperature should be set high enough to provide a homogeneous melt which is indicated by a consistent screw recovery (consistent dosing time, cushion). A flat or rising temperature profile is recommended.

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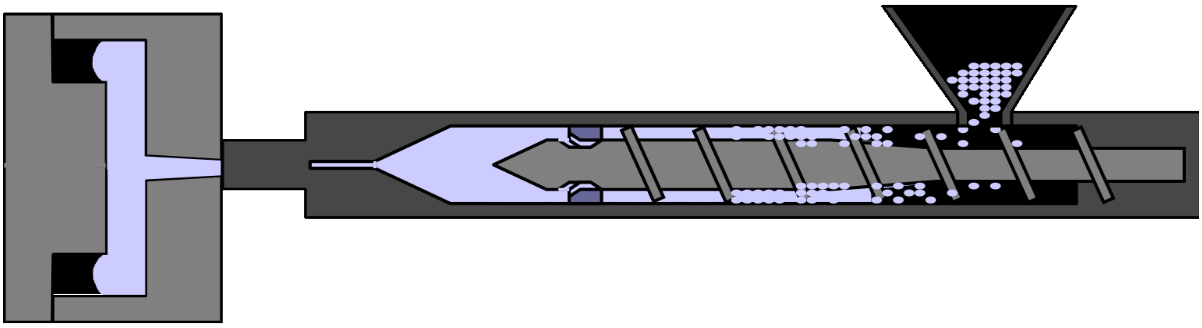

Mold	Melt	Nozzle	Front	Center	Rear	
80 - 120°C *176 - 248°F*	300-315°C *572-599°F*	295-315°C *563-599°F*	300-315°C *572-599°F*	295-315°C *563-599°F*	290-315°C *554-599°F*	

Melt temperature

To generate a good and homogeneous melt, the melt temperature (as measured with a probe in the melt rather than machine setting) should always be above 300°C (581°F). Too low melt temperatures may lead to unmelts and embrittlement of parts. Optimal parts will be achieved at melt temperatures between 305-315°C (581-599°F). The risk of surface defects increases with higher melt temperature and longer residence time.
It is advised to frequently measure the melt temperature by pouring the melt in a Teflon cup and inserting a pre-heated temperature probe into the melt.

GENERAL PROCESSING SETTINGS

Screw rotation speed

To realize a good and homogeneous melt, it is advised to set a screw rotation speed resulting in a plasticating time that is just within the cooling time. Excessive screw rotational speeds may cause overheating leading to degradation.
The rotational speed of the screw should not exceed 6500/D RPM (where D is the screw diameter in mm). For a 30 mm diameter screw, the maximum RPM would be around 200 rpm. Lower RPM is better since that reduces the shear heating in the melt.

Back pressure

Back pressure should be between 10-50 bars (145-725 psi) effective. Keep it low in order to prevent nozzle drooling, excessive shear heating and long plasticating times while maintaining a stable cushion.

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Decompression

In order to prevent nozzle drool after plasticating and retracting the nozzle from the mold, a short decompression stroke can be used. However, to prevent oxidation of the melt, which may result in surface defects on the parts, it is recommended to keep the decompression as short as possible.

Injection speed

The aim of injection speed control should be to maintain a flow front velocity that is as uniform as possible throughout the mold filling stage. Stagnation or hesitation of the flow front can result in surface marks or defects due to the fast crystallization of Stanyl®. Note that the more cavities are to be filled, the more difficult it is to keep the flow front velocities uniform over all those cavities. End gating of the part is preferred to ensure steady flow front speeds at all times. Central gating would double the amount of flow fronts during filling of the cavities, thus increasing the risk of flow front hesitation at any of the flow fronts.

For Stanyl® TW371 and Stanyl® TW371-K, low to moderate injection speeds are required in order to obtain a better surface finish. The recommended injection speed profile goes from slow (for sprue and runner filling) to moderate (for part filling). Excessively low speeds may hamper mold filling due to the high crystallization speed of Stanyl®, whereas too high filling speeds may induce shear heating leading to surface defects such as streaks. Note that the risk of shear heating is higher for longer, thinner runners with smaller diameters. A process DOE is suggested for optimizing the injection speed.

Injection pressure

The actual injection pressure is the result of the flowability of the material (as affected by crystallization rate, flow length, wall thickness, and filling speed). The set injection pressure should be high enough to maintain the set injection speed (use set injection pressure higher than the peak pressure if possible). Adequate mold venting is required to obtain optimum filling pressure and prevent burn marks.
Check pressure profiles on machine display and avoid excessive pressure peaks due to cold slugs or overfilling.

Holding pressure

The most adequate holding pressure is the level whereby no sink marks or flash are visible. A holding pressure that is too high can lead to stresses in the part.

Holding time

The effective holding time is determined by part thickness and gate size. Holding time should be maintained until a constant product weight is achieved. Due to its fast solidification, holding time for Stanyl® is short compared to other engineering plastics.

Cooling time

The actual cooling time will depend on part geometry and dimensional quality requirements as well as on the tool design (gate size). Due to the fast crystallization of Stanyl®, a short cooling time is possible.

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RESIDENCE TIME

Melt residence times at elevated melt temperatures are the main reason for thermal degradation of material. Additionally, hydrolysis due to high moisture content will enhance degradation. For this reason, the melt residence time (MRT) for Stanyl® in general should be as short as possible and not exceed 3 minutes. Optimal melt residence time for Stanyl® TW371 & Stanyl® TW371-K with respect to surface quality is less than 2 minutes. To promote a good melt quality and to avoid excessive melt residence times, the screw diameter D should be chosen such that the plasticating stroke is between 1×D and 3×D.

The MRT can be estimated as

$$MRT = \frac{\pi D^3 \rho}{m} * \frac{t}{60}$$

Whereas:

MRT	= melt residence time	[minutes]
D	= screw diameter	[cm]
ρ	= melt density	[g/cm³]
M	= shot weight	[g]
T	= cycle time	[s]

OVERALL ASSESSMENT OF GOOD MOLDING PRACTICE

An effective assessment for good molding practice (that shows limited degradation of the polymer) is to measure the drop in relative viscosity number (VN) from granules to molded part. Good molding practice is characterized by an VN drop up to 5% of the mid spec VN of the material. A drop of 5% - 10% is acceptable. Anywhere between 10% and 15% drop is an indication that the molding process could be improved from the combination of moisture content, melt temperature and residence time perspective. Beyond 15% VN drop one should expect to see the onset of loss of functional robustness of the molded parts.

SAFETY

For the safety properties of the material, we refer to our MSDS which can be obtained at our sales offices. During practical operation we advise to wear personal safety protections for hands, eyes, and body.

If the hot runner, nozzle, or even the screw is blocked, be aware that a sudden outburst of molten material may take place, either through the nozzle or backward through the hopper.

STARTUP, SHUT DOWN, AND CLEANING

Production has to be started and stopped with a clean machine. Cleaning can be done with PA6-GF or PA66-GF, applicable cleaning agents or HDPE. Hot runners can also be cleaned with PA6-GF or PA66-GF.

PRODUCTION BREAKS

During production breaks longer than a few minutes, we advise to empty the barrel. The temperature of the barrel and the hot runner (if applicable) should be reduced to a level far enough below the melting point of the compound in order to stop decomposition of the compound.

After a production break, the first 10 shots after the machine has reached steady operation should be discarded.

TROUBLESHOOTING

Contact Envalior in case more information is required on material or processing.