Processing of VESTAMID® L, D, E und *Terra*

VESTAMID® compounds are processed mainly in the form of granules. For processing we recommend that you follow the information in this flyer.

Evonik offers extensive technical service that is dedicated to finding technically sophisticated system solutions together with our customers. This includes support with simulation calculations for developing tools and molds.

Drying

VESTAMID® polyamide compounds are supplied as granules in 25 kg moisture-proof bags; octabins of 1,000 kg can also be provided on request. In our experience, the shelf life is virtually unlimited under normal storage conditions if the packaging is not damaged. The storage temperature should not exceed 45°C, particularly for plasticized molding compounds.

Prior to the opening of the bag, the contents should be allowed to reach the ambient temperature, in order to avoid moisture condensing on the cold granules. VESTAMID® granules will slowly absorb moisture from the air and hence any bags that are opened but not completely used should be closed again as tight as possible. Feed hoppers of the processing machines should not be filled excessively with more granules than the processing limit within two hours and should be closed with a lid.

Drying of the granules is necessary only if the packaging has been damaged or the pack has been open for more than two hours. In such cases the compounds should be dried until the water content again falls below 0.1 percent. Excessively high moisture content in the compound leads to processing problems and/or poor molding properties.

Recommended drying conditions for VESTAMID® compounds

Type	Drying temperature [°C]	Drying periode [h]		
		dehumidified air drying oven	circulated air drying oven	fresh air drying oven
PA 12	80 – 100	2 – 4	2 – 16	2 – 10
PA 12 plasticized	80	2– 4	2 – 12	2 – 8
PA 1010 PA 1010 plasticized	80 – 100 80	2 –4 4	2 – 16 2 – 12	2 – 10 2 – 8
PA 612 PA 612 plasticized	80 – 100 80	2 –4 4	2 – 16 2 – 12	2 – 10 2 – 8
PA 610 PA 610 plasticized PA 1012 PA 1012 plasticized	80 – 110 80 80 – 100 80	2 –4 4 2 – 4 4	2 – 16 2 – 12 2 – 16 2 – 12	2 – 10 2 – 8 2 – 10 2 – 8
PEBA	80	2 – 4	2 – 10	2 – 6

Incompatibility with other thermoplastics

VESTAMID® is not compatible with the other polyamides, and is least to mention about other plastics too. It shall be noted that even VESTAMID® resins based on PA 12 and PA 612 are not compatible with each other. However PA 12 and PA 12 elastomers will posses limited compatibility with each other. Molded parts of VESTAMID® which contain traces of foreign polymers will normally embody inferior properties compared with uncontaminated polyamide. The weld lines of the melt behind mandrel carriers in the extrusion or behind cores in injection molding will especially initiate a substantially reduced strength in case of contamination with foreign polymers. Thus, it is extremely important to clean the machine thoroughly before start up of the production.

Coloring of VESTAMID®

VESTAMID® compounds are supplied in a range of standard colors. Special colors are available for orders of viable commercial quantities.

VESTAMID® compounds are pigmentable during processing. The preferred method is by using a color concentrate based on PA 12 for PA 12 or PEBA compounds and PA 612 for PA 612 compounds. The same is valid for PA 610, PA 1010, and PA 1012 compounds. Dry coloring by tumbling with finely powdered colorants is another possibility but is nonetheless inconvenient. Pneumatic conveyance is then ruled out. The use of color pastes or color concentration having a "neutral" (e.g. PE) base can lead to incompatibility with PA 12 and hence creating poor parts properties (inferior weld line strength or cold impact resistance). Therefore, preliminary testing of compatibility is absolutely important.

Processing of VESTAMID® compounds

Generally, the working areas of all thermoplastics processing should be well ventilated especially during the production. It is recommended that an exhaust system should be located over the machine nozzles. This is particularly true for resins containing plasticizers or flame retardant additives.

Under the circumstances of unfavorable conditions, for example given in the processing of excessively elevated temperatures, or during cleaning of the screws by burning off remaining polymer residues, it is possible that small amounts of noxious fumes would be produced. Therefore, the cleaning of screws by burning off should always be done under an exhaust hood. Further details are notable from the relevant safety data sheet.

Injection molding

Plasticizing unit

Screw and cylinder:

- Three zone screw with a length between 18 and 22 D
- Depth flight ratio shall be ≥ 2
- Minimum flight depth: 2 mm in the metering zone, and 4 mm in the feeding zone
- Screw and barrel diameter should be in the magnitude that a metering stroke between 1 D and 3 D is realizable

For more information see Figure Three-zone-screw on page 3.

Peripheral Screw Speed:

- In the range of 3 – 12 m/min optimal
- · Larger speeds (e.g. > 18 m/min) can be applied, but might lead to problems in processing.

Nozzle:

- In general free-flow nozzles, for low viscous resins (e.g., VESTAMID L1670, VESTAMID L1723) externally operated shut-off nozzles (e.g. needle valve nozzle) are recommended
- Bore of nozzle should be app. 0.5 to 1.0 mm smaller than the gate

Back flow valve:

- Clearance between back flow valve and cylinder shall be ≤ 0.02 mm

Cleaning:

- Light contamination (e.g. cleaning due to changing of resin)
  1) Prepare the mixture of high viscous PP and purging resin PLEXIFIX with a mixing ratio of 2:1.
  2) Increase the temperature settings of heating zones by 30 to 40 K but not above 300 °C.
  3) Plasticise the mixture with a long metering stroke and high dynamic pressure and discharge with high speed into the atmospheric environment.
  4) Flush the plasticating unit with the new resin until no purging mixture is contained in the melt.

- Persistent contamination
  - Persistent contamination can be mostly removed only by mechanical cleaning of screw, cylinder, back-flow valve etc.
  - Sometimes a cleaning of the cylinder can be avoided by using special purging material such as RAPID PURGE, SUPERNOVA or ASACLEAN.

Clamping Unit

Clamping force:

- Guide number for maximal pressure in cavity with VESTAMID® resins: 200 to 600 bar.

Mold

Gate:

- All established types of sprues, runners and gates are possible.
- Diameter or thickness of pin, submarine and film gates shall be ≥ 0.6 mm

Hot runner:

- Externally heated hot runners with open sprue nozzle is recommended, nozzle diameter shall be ≥ 0.6 mm

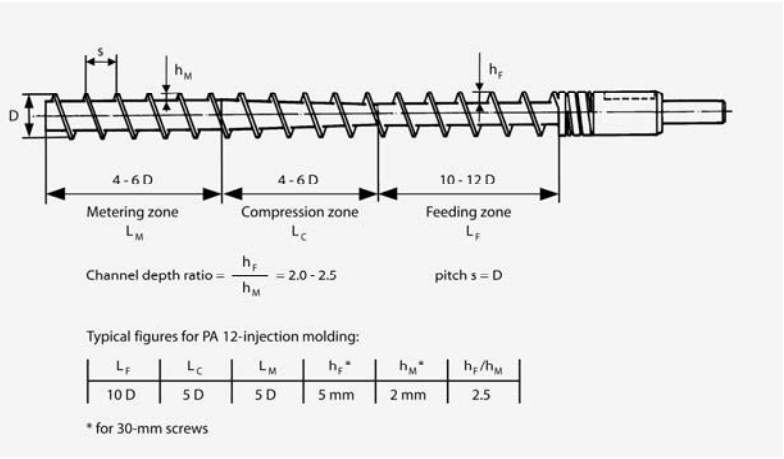
Venting

- Venting slots in mold parting surface: 0.01 to 0.03 mm deep, 4 to 5 mm wide

Steel:

- Suitable steels: 1.2767 (X45NiCrMo4), 1.2379 (X155CrVMo121), 1.2312 (40CrMnMo58) and 1.2343 (X38CrMo V 51).

Design of a three-zone screw



Typical figures for PA 12-injection molding:

L_F	L_C	L_M	h_F*	h_M*	h_F/h_M
10 D	5 D	5 D	5 mm	2 mm	2.5

* for 30-mm screws

Pressure sensor:

- Use of a pressure sensor for the cavity pressure is recommended to facilitate the carefully setting of change-over point.

Demolding:

- Usually a demolding agent is not necessary.
- Decrease of mold temperature very often eases demolding.
- Suitable coatings of mold surface are Ni-P-PTFE, and TiAlOx.

Processing condition

Temperatures:

- Refer to the following table for general settings on melt temperatures
- Mold temperatures for PA12 and PA612 grades 30 – 100 °C, for PEBA grades 15 to 40 °C, for PA610, PA 1010, and PA 1012: 60 – 100°C.
- In general temperature of nozzle and heating zone close to nozzle to be set on melt temperature; in case of free-flow nozzles setting of nozzle temperature 10 K below desired melt temperature might be advantageous for non reinforced resins.
- Decreasing temperature profile in the heating zones towards hopper in steps of 10 K is recommended
- Cooling of feeding zone should be 40 – 80°C.

Interruption of Production

- For short production breaks (e.g., up to 1 hour): discharge of the plasticting unit, moving of screw to ultimate front position and decreasing temperature setting at heating zones down to 150°C.
- For long production breaks: flushing of the plasticating unit with high viscous PP or PMMA, discharge of the plasticating unit, moving of screw in ultimate front position, switch off of cylinder heating. Remove resin left in the hopper and store in moisture proof packaging

Trouble Shooting

- Please contact the indicated persons.

General melt temp. settings for PA 12 grades

VESTAMID®	Processing temp. [°C]
L1600	190 – 230
L1670	180 – 220
L1700	190 – 230
L1723	190 – 230
L1833	240 – 280
L1901	200 – 240
L1930	240 – 280
L1940	200 – 240
L1950 sw	200 – 240
L2128	200 – 240
L-CF15 sw	230 – 270
L-GB30	230 – 270
L-GF15	230 – 270
L-GF30	240 – 280
L-R1-MHI sw	240 – 280
L-R2-GF25 sw	230 – 270
L-R3-MHI sw	230 – 270
L-R4-MHI sw	230 – 270
L-R7-MHI sw	230 – 270
L-R9-MHI sw	230 – 270
LX9012	200 – 240
X3500 sw	240 – 280
X7000	210 – 250
X7166	200 – 240
X7373	200 – 240+
X7380 sw	240 – 280

(sw = black)

General melt temp. settings for PA 612 grades

VESTAMID®	Processing temp. [°C]
D16	230 – 270
D18	230 – 270
D22	250 – 290
DX9300	230 – 270
DX 9323	240 – 280 (GF35)
DX9321	240 – 280
DX9322	240 – 280
X7094	230 – 270
X7099	230 – 270

General melt temp. settings for PEBA grades

VESTAMID®	Processing temp. [°C]
E40-S1	180 – 220
E40-S3	180 – 220
E47-S1	180 – 220
E47-S3	180 – 220
E55-S1	200 – 240
E55-S3	200 – 240
E58-S4	200 – 240
E62-S1	200 – 240
E62-S3	200 – 240
EX9200	200 – 240

General melt temp. settings for PA 1010, PA 610, and PA 1012 grades

VESTAMID® *Terra*	Processing temp. [°C]
DS 16	220 – 250
DS 18	220 – 250
DS 22	230 – 260
DS 18-GF30	230 – 260
HS 16	240 – 270
HS 18	240 – 270
HS 22	240 – 270
HS 18-GF30	240 – 270
DD 16	210 – 240

Extrusion

General information

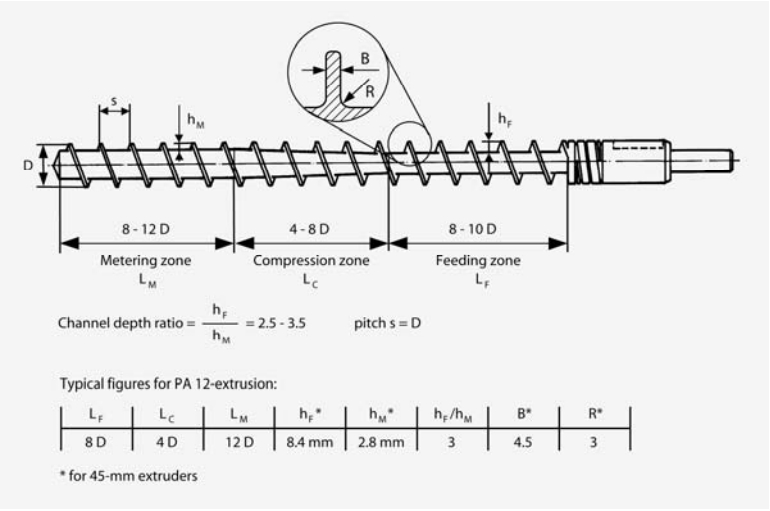
Screw and Extruder Design:

- Conventional three zone screw with a length ≥ 24 D
- Flight depth ratio ranging from 2.5 to 3.5 : 1
- Suitable ratios between feeding / compression / metering zone: 2:1:3, 2:2:2, 1:1:1
- Radial clearance between screw and barrel: 0.1 – 0.2 mm
- Mixing and shear elements may be useful to increase the melt homogeneity (e.g. processing films from resins coloured with pigment concentrates.

For more information see Figure Three-zone-screw

Note: Other screw designs (e.g. barrier screws) may lead to proper processing conditions as well.

Design of a three-zone-screw



Typical figures for PA 12-extrusion:

L_F	L_C	L_M	h_F*	h_M*	h_F/h_M	B*	R*
8 D	4 D	12 D	8.4 mm	2.8 mm	3	4.5	3

* for 45-mm extruders

Breaker plate

- Not necessary for the processing of virgin material, recommended only as support for screen packs, e.g., when processing regrind

Gear pump

- Recommended when processing regrind or if tolerances have to be kept in an absolute narrow range (e.g. for barrier layers in multilayer tubing)
- In general not required with properly designed screw

Temperature setting

- Cooling of the feeding section is mostly required.
- General temperature setting strongly depends on resin to be processed and type of extrudate (tube, film, coating), thus a general recommendation can not be given. Temperatures in first heating zone should be set app. 20 K above melting point of resin. Increasing temperature profile from first heating zone to tip of extruder. It might be of advantageous to reduce the temperature setting in the adapter and die slightly to increase stiffness of melt leaving the die (e.g., when manufacturing tubing).
- Optimizing temperature setting by monitoring the temperatures of the heating zones, the melt temperature and the consistency of the melt leaving the die:
  - high pressure build-up and a dull surface of the melt leaving the die: increase temperature profile
  - melt with a low stability: decrease temperature profile

In case of large discrepancies between temperature setting and measured temperature the screw design might not be suitable for the processing of VESTAMID®.

Temperature setting of heating zones should always be >10 K above melting point of resins.

Cleaning

1) Raise temperature of all heater bands for about 20 °C and purge by using polypropylene (PP with MFI 230/5 = 12 g/10 min) (MFI 230/5 ≈ 12 g/10 min)
2) Dissemble the die
3) Continue to purge extruder with PP and reduce temperature to about 170 °C
4) At this temperature replace PP by a purging mixture comprising heat stabilised PVC/ cleaning fluid/glass fibres (ratio 98:1:1). If the PVC grade is not sufficiently heat stabilized, degradation may easily occur.
5) Release the screw out from extruder barrel and remove plastic residues away
6) Remove plastic residues from the die for polishing

Trouble shooting

- Pulsation of melt caused by the extruder
  - Insufficient cooling of feeding section
  - Insufficient lubrication of pellets
  - Shape of pellets inhomogeneous (e.g., when processing regrind)
  - Pressure build-up at die too low
  - Improper design of feeding section (grooved/smooth)
  - Improper screw design
  - Problems with motor/gear box

Note: Pulsation of melt can be caused by the downstream equipment as well, e.g. see trouble shooting when processing tubing.

- Inconsistencies in temperature measurement
  - Dirt in bore of thermocouple
  - Tip of thermocouple not in contact with metal surface
  - Problems with thermocouple and/or recording device

Tubing

Typical tubing outer diameters are in the range of 6 and 16 mm. For information concerning larger diameters please contact us.

Die:

- For monowall tubing conventional extrusion dies (mandrel carried by a breaker plate or by spiders) are sufficient.
- Land length between 20 and 50mm
- Draw down ratio (DDR = mean diameter of die gap divided by mean diameter of tubing): 2:1 to 1.7:1
- Wall thickness ratio (WTR = die gap width divided by tubing wall thickness: (almost) equal to DDR.
- Extrusion line should be equipped with a air hood located close to the die to take off vapors evaporating from melt leaving the die.

Calibration unit

- Calibration by disk or perforated tube sizing
- Inlet of sizing should be rounded, r = 5 to 6mm
- Inlet of sizing must be covered by a well balanced water film to pre-quench the melt entering the sizing. This will avoid the sticking of melt on metal surface of sizing. Sandblasting of front plate and inlet of sizing helps to evenly distribute water film around the tubing.
- Tolerances in water flow must be kept to a minimum, e.g., variation in pressure level of water supply can be eliminated by using a water reservoir generating constant static pressure.
- Inner diameter of sizing 3 to 6 % larger than nominal tubing outer diameter.
- Vacuum level in the range of 0.1 to 0.3 bar. Vacuum should be used only for fine adjustment of outer diameter. For example: If a higher vacuum level is needed to achieve the nominal tubing outer diameter, another sizing with a slightly higher diameter should be used.

Puller

- Smooth belt type puller is preferable over block type (caterpillar) puller.

Flame treatment

- Applied to improve adhesion of printing and mechanical properties.
- Positioning of burners must be circumference to the tubing, not only on one side of the tubing.
- Additional quenching bath behind flame treatment is recommended.

Trouble shooting

Many problems from the processing of PA12 tubing are caused by an improper water flow at the sizing inlet. Thus, the adjustment of a proper water flow is of major importance.

Surface quality

- Dull surface
  - Melt temperature too low
  - Improper water flow at sizing inlet
  - Contamination of resin with incompatible thermoplastics
- Grooves and stripes on outer surface
  - Hole in guiding discs of vacuum tank too small
  - Improper water flow at sizing inlet
  - Die damaged
  - Sizing damaged
  - Contamination of resin with incompatible thermoplastics
- Bubbles on tubing surface
  - Too high moisture content of resin
  - Vacuum too high
  - S Water splashing on melt due to too large water flow at sizing inlet
  - Water drops on tubing surface before flame treatment
  - Large air bubbles on tubing surface in vacuum tank
- Wave structure on outer or inner surface of tubing
  - Vibration of components of extrusion line (e.g. cutter, puller)
  - Hole in guiding discs to small
  - Line speed too small when using a disk type sizing
- Uneven tubing surface
  - Draw down ratio (wall thickness ratio) too small or too high
  - Water in vacuum tank sloshing

Tubing geometry

- Ovale tubing
  - Vacuum too small
  - Distance between belts of puller too small
  - Tube too hot when winded to coil
- Uneven wall thickness
  - Improper centring of die
  - Uneven water flow at sizing inlet
- Twisting of tubing
  - Uneven water flow at sizing inlet
  - Improper alignment of tubing and pulled belt
- Curvature of tubing
  - Inhomogeneous wall thickness distribution
  - Uneven water flow at sizing inlet
  - Flame treatment from one side only
  - Offset between longitudinal axis of die and sizing
  - Too hot when winded to coil

Mechanical performance of tubing

- Ultimate elongation too low
  - Vacuum level to high
  - Sharp edges in sizing
  - Radius of sizing inlet too small
  - Improper water flow at sizing inlet
  - Melt temperature too low
  - Flaming from one side only (or no flaming used at all)
  - Offset between longitudinal axis of die and sizing
  - Contamination of resin with, e.g., other thermoplastics, dirt, dust etc.
  - Degradation of resin
- Insufficient cold impact resistance
  - Contamination of resin with, e.g., other thermoplastics, dirt, dust etc.
  - Melt temperature too low
- Splitting of tubing
  - Melt temperature too low
  - Contamination in weld lines

Wire coating

Maximum line speed up to 2000 m/min

Die

- Sleeve coating die
- Draw down ratio (DDR = cross section of die divided by cross section of coating): 15 to 20:1
- Vacuum level app.: 0.2 bar

Calibration unit

- Apply cold water cooling

Fiber optic jacketing (loose buffer tubes)

Die

- Sleeve coating die
- Draw down ratio (DDR = cross section of die divided by cross section of tube): 9:1
- at extrusion speeds > 200 m/min: 12:1 to 15:1
- Draw ratio balance (DBR = ratio of die to mandrel diameter divided by ratio of outer to inner diameter of tubing): 1:1
- at extrusion speeds > 200 m/min: 1.2 to 1.3

Calibration unit

- Apply cold water cooling

Cast film and sheet extrusion

Roll

- Temperature setting in the range of 45 – 110°C

Fabricating and finishing of molded parts and semi-finished products

Bonding

Adherent surfaces should be kept clean. Avoid use of remolding aids when manufacturing parts to be bonded. Maximum speed of fabricating up to 2000 m/min.

Adhesives

Commercially available adhesives based on

- Epoxies: One- or two-pack adhesives (gap filling) suitable for larger adherent surfaces. Hot setting adhesives reduce clamping time and may increase adhesion strength.
- Polyurethane: One- or two-pack and (reactive) hot melt adhesives (gap filling, flexible adhesives mostly with longer pot life and clamping time) suitable for larger adherent surfaces.
- Cyanoacrylates: One-pack adhesives (short setting time) suitable for small glue-lines and adherent surfaces.

Pre-treatment

Improvement of bonding strength by a pre-treatment of the surface to be bonded, e.g., by use of primers, roughening, electrical discharge, chemical treatment or flame treatment. Apply safety instructions especially when using primers and chemical treatment.

Machining

Sawing, turning, milling, drilling, and planning of VESTAMID® parts are possible. We recommend to cool by fluids or compressed air to reduce heating up of the VESTAMID® parts and hence to avoid problems with sticking.

Printing and painting

Laser marking

- Laser-markable VESTAMID® compounds are available.

Inks and paints

- For sublimation colors most types of inks are possible.
- Screen printing colors must be modified for application on VESTAMID® parts.

Pre- and post-treatment

- Surface treatment, e.g., by electrical discharge, flame treatment or bristling very often lead to an improvement of the adhesion of the ink.
- After printing the adhesion of the ink can be improved, e.g., by heating or flame treatment.

Thermoforming of PA12 tubing

Data listed are meant only for monowall tubing, with multilayer tubing thermoforming conditions might be different.

- Polyethylene Glycol: forming temperature: 150 to 155°C, forming time: < 5 min
- Hot air: forming temperature: 150 to 170°C, forming time: 15 to 30 min
- Steam: forming temperature: 130 to 145°C (3 to 5 bar pressure), forming time: < 1 min
- Other thermoforming procedures (e.g., infrared radiation, high frequency) are possible.

Welding

All established types of welding technologies can be applied to VESTAMID®; typical technologies used are:

- Hot plate welding: Apply PTFE coated hot plate welding tools to avoid/reduce sticking of the resin at temperatures up to 270 °C.
- Ultrasonic welding: joint design like a triangular projection (called an energy director) or like a shear joint. Welding of resins with a low E-modulus is hardly possible by applying the far field technology.
- Friction welding by rotation or vibration
- High frequency welding

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