Polyethylene for biogas plants

From Ulrich Seidelt[1]

1. Abstract

Only a verified quality of materials and components can ensure a long time life cycle and a failure-free operation of biogas plants.

To choose the right material for each application it is important to consider:

- Life cycle
- Mechanical resistance
- Chemical resistance
- Safe coupling technology,
- Resistance against UV-Radiation
- Resistance against corrosion
- Avoidance of encrustation
- Slow friction drag
- Closed ecological loop.

Pipes for biogas plants must guarantee the safe transportation of:

- Solid materials (biomass)
- Substratum
- Biogas
- Natural gas.

All these requirements are covered by pipes, fittings, endwise vertical tanks and concrete protective liners of polyethylene (PE).

The life cycle of polyethylene according to ISO 9080 is good for 100 years. Additional polyethylene is extreme impact resistance and good against abrasion. Polyethylene is insensitive against shock pressure and biogenic sulphuric acid corrosion. All existing chemical charges in a biogas plant will not influence polyethylene at all.

Pipes with polyethylene will be connected via butt fusion welding or electro fusion welding.

Polyethylene in black colour is long term stabilized against UV-radiation cause of an admixture of 2 % carbon. This will enable black coloured polyethylene for an aboveground installation. Blue (water) and orange-yellow (gas) coloured polyethylene is only approved for an outdoor storage up to two years. That is why these pipes are only good for buried installation.

Due to its waxen surface polyethylene gives no possibility for permanent encrustation and adhesion. The k-value of 0,007 leads to an high degree of utilisation of the whole clear cross section.

All the materials used must be approved!

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Test certifications according to the following needs must be delivered:

- Internal pressure test
- Behaviour after heat treatment
- Melt index
- Homogeneity
- Dimension stability
- Delivery condition
- Surface condition.

	Property	**Standard**	**Unit**	**PE 100 MFR-range T 005**
	Density at 23°C	DIN 53479 ISO 1183 ISO/R 1183	g/cm³	0,96
Mechanical properties	Yield stress	DIN 53495	N/mm²	25
	Tensile strength	DIN 53495	N/mm²	38
	Elongation at break	DIN 53495	%	> 600
	Elastic modulus (tensile)	ISO 527	N/mm²	ca. 1200
Thermical properties	Thermical conductivity (at 20°C)	DIN 52612	W/mK	0,38
	Thermical expansion coefficient	DIN 53752	1/°C	$1{,}8 \times 10^{-14}$
	Fire behaviour	DIN 4102-1 ÖN B 3800 T1	–	B2

Chart 1: Properties of polyethylene

Polyethylene is an only organic material and can be recycled or be feed in a waste incineration plant. No dioxin is outcome of this only water and carbon.

2. Biogas pipes with polyethylene

These dimensions mostly used in biogas plants:

d [mm]	s [mm]	SDR (d/s)	kg/m	Inner diameter [mm]
32	3,0	11	0,28	26,00
40	3,7	11	0,43	32,60
50	4,6	11	0,66	40,80
63	5,8	11	1,05	51,40
90	5,4	17	1,46	79,20
110	6,6	17	2,17	96,80
160	9,5	17	4,52	141,00
180	10,7	17	5,71	158,60
225	13,4	17	8,93	198,20
280	16,6	17	13,70	246,80
315	18,7	17	17,40	277,60
355	21,1	17	22,10	312,80
400	23,7	17	28,00	352,60

Chart 2: Standard dimensions for biogas pipes

Pipes will be delivered in straight lengths up to 20 m or in coils up to 125 mm outer diameter. Other dimensions on request.

The use of pipes thinner than SDR 17 is not recommended. Founded in safety reasons and the availability of fittings.

Pipes with polyethylene are good for the transportation of biomass, substratum, biogas and natural gas either buried or aboveground operation. For handling potable water a separate certification is needed.

The planner shall be responsible for the safety factor for the pressure calculation.

Depending on the safety factor the following pressures can be used (chart 3):

	SF = 1,25		**SF = 2,0**	
	SDR 17	**SDR 11**	**SDR 17**	**SDR 11**
Temperature 20°C	10,0 bar	16,0 bar	6,2 bar	10,0 bar
Temperature 50°C	5,9 bar	9,5 bar	3,7 bar	5,9 bar

Chart 3: Pressure in connection of temperature for pipes with polyethylene

3. Polyethylene VRC for sand free embedding

For the transport of biogas or natural gas as a buried pipe alternative polyethylene materials with an high resistance against crack propagation can be used. These pipes feature a high resistance against point loads and are approved for sand free embedding or trench less installation (VRC = **v**ery **r**esistant to **c**rack).

4. Double containment piping with polyethylene

Based on requests it may be necessary to use double containment pipes. The advantage is the monitoring. This monitoring can be done visual or automatically.

Following matching mostly used (chart 4):

Outer diameter PE			Inner diameter PE		
d [mm]	**s [mm]**	**SDR**	**d [mm]**	**s [mm]**	**SDR**
160	4,9	33	**90**	5,1	17,6
200	6,2	33	**110**	6,3	17,6
280	8,6	33	**160**	9,1	17,6
315	9,7	33	**200**	11,4	17,6
355	10,9	33	**250**	14,2	17,6

Chart 4: Standard dimensions of double containment piping

5. Fittings, long and short spigot – for butt fusion welding

Pipes and fittings only with the same dimension can be connected via butt fusion welding. Mostly fittings with long spigot are used. To design narrow radiuses and slow installation heighs fittings with short spigot are used. The suitability of the butt fusion machine for using the fittings with short spigot should be tested (length of restraint). Please note using the butt welding process an inner and outer welding seam is generated. That is why the butt welding is only recommended for gas or water transport.

6. Electro fusion fittings – for electro fusion welding

Using this welding method a separate fitting is needed, which must feature covered heating wires. These protected wires are necessary against corrosion in biogas plants!

Electro fusion fittings will not process an inner welding seam and will be used for connecting pipes and fittings with long spigot with the same outer diameter and different wall thickness. This kind of connection is recommended for biomass and substratum transport. Adapters from polyethylene must be solely with stainless steel. Adapters with brass or steel are under corrosion.

7.

8. Pipes and fittings with polyethylene with discharger capacity (PE-el)

Polyethylene with discharger capacity will be used in explosion proof zones and can be grounded. This special polyethylene is not so resistant against impact as standard polyethylene. The planner shall be responsible for the safety factor for the pressure calculation.

	SF = 1,6		SF = 2,0	
	SDR 17	**SDR 11**	**SDR 17**	**SDR 11**
Temperature 20°C (50 years)	4,1 bar	6,9 bar	3,3 bar	5,5 bar
Temperature 50°C (20 years)	2,3 bar	3,9 bar	1,9 bar	3,1 bar

Chart 5: Pressure in connection of temperature for pipes with polyethylene with discharger capacity

9. Concrete protective liner to lining the fermenter

During the fermentation evolves volatile sulphur compound in the upper area of the fermenter and after oxidizing sulphur.
By support of micro organisms then evolves biogenic sulphuric acid. This will destroy concrete. Oxygen is needed for this process. Conventional systems to protect the concrete will be separate added on the surface. An absolute dry condition for doing this is a must. If not, the coating will flaking from the concrete. A long term solution for this problem is the concrete protective liner with polyethylene.
Due of the factory-made anker stud added on the back side the protective liner is already perfect mechanical connected with the concrete during placing this. The grooves and the corners will be finally covered by a manual operated extruder.
Material for concrete protective liners with polyethylene with discharger capacity is possible. The minimum thickness of the liner is 3 mm heavy used areas can be provide with up to 12 mm wall thickness.

10. Tanks and shafts with wrapped polyethylene

Beside tanks and shafts with extruded standard polyethylene bigger dimensions can be made with wrapped polyethylene. Materials are also polyethylene or polyethylene with discharger capacity. In some cases a lighter inner surface is possible. The mentioned tanks must be calculated against outer loads. After that a complete inside installation with polyethylene is possible.

11. Wall penetrations

Wall penetrations will be done with paddle flanges or FRANK manhole connector sockets. Belated installed pipes will be tighten by annulus collector seals.

12. Geomembrans with polyethylene

Geomembranes with polyethylene used to tighten the construction against the ground and can be installed in combination with geotextile. It is possible to weld the geomembranes on request.

13. Geotextile

Geotextile is used for load balancing, armour, drainage and can be combined with geomembranes.

14. Butt welding machine

The butt welding machines are needed to connect pipes and fitting with the same dimension normally up to 315 mm outer pipe diameter. The machines are provided as manual operated or numeric controlled with logging.

15. Electro fusion box

Electro fusion boxes are needed to connect pipes with a separate fitting or pipes and a fitting. There is no limitation in diameter. Each fitting has its own code on the surface, to scan with a separate bar code reader belong to the box. A involuntarily manipulation is impossible. One option is to transfer the welding data on an USB-stick to read out on an PC.