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PE - Drainage Pipes

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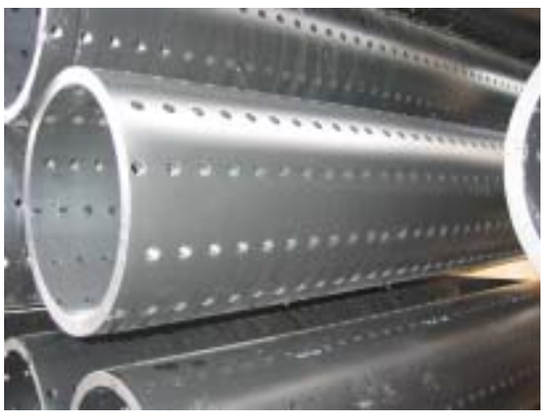
Pipe Systems

Due to our extensive production capabilities, AGRU is able to supply the widest range of polyethylene products required in environmental engineering.
In addition to the HDPE liners, AGRU has specialised in manufacturing flexible liner products (AGRUFLEX), the AGRULOCK-profile for vertical cut-off walls, HDPE pipes, fittings and walves for degassing, leachate drainage and control, and also concrete protective liners.
Mainly pipes out of PE 80 MRS 8, PE-el or raw materials of the 3rd generation like PE 100 MRS 10 and PP are used.

PE 80 Pipes and Fittings

HDPE is distinguished by an excellent permeation resistance, a high resistance against UV-radiation as well as a very high resistance to chemicals. HDPE is physiologically nontoxic.
Therefore, it is suitable for gas transportation, all applications in the field of water supply, the conveyance of chemicals, and outdoor piping systems.
Drainagepipes are almost exclusively produced out of PE80. The Advante of PE80 versus PE100 for this Application is the higher flexibility compared to PE100 Materials.
The weldability among these two PE-Types is given without problems.



Modified Polyethylene PE 80-el (electro-conductive)

Due to its ability to conduct electricity, PE 80-el is often used where highly combustible media, e.g. fuel, is transported. It also suits for the conveyance of dust as this piping system can be earthed to prevent static.

Polyethylene Type PE 100

These materials can also be described as polyethylene types of the third generation (PE-3) respectively as MRS 10 materials.
This is a further development of the PE materials which shows an amended molmass allocation due to a modified polymerisation process. That is why PE 100 types have a higher density and therefore improved mechanical properties such as increased stiffness and hardness. Also the creep pressure has been raised.

Consequently PE 100 is suitable for the production of e.g. pressure pipes with larger diameters than convent-ional pipes out of HDPE (PE 80) the corresponding pressure rate being achieved with less wall thickness.
Now the standard material for producing pressure pipes and fittings is PE 100

Specific properties PE

	Property	Standard	Unit	PE80 (MD)	PE80 (HD)	PE100	PE80-el
	Specific density at 23°C	ISO 1183	g/cm^3	0,94	0,95	0,95	0,99
	Melt flow index MFR 190/5 MFR 190/2,16 MFR 230/5 MFI range	ISO 1133 ISO1872/1873	g/10min	 0,9 T012	 0,50 T006	 0,3 <0,1 T003	 T001
Mechanical Properties	Tensile stress at yield	ISO 527	MPa	20	22	25	26
	Elongation at yield	ISO 527	%	10	9	9	7
	Elongation at break	ISO 527	%	>600	>600	>600	
	Impact strength unnotched at +23°C Impact strength unnotched at -30°C	ISO 179	kJ/m^2	no break no break	no break no break	no break no break	
	Impact strength notched at +23°C Impact strength notched at 0°C Impact strength notched at -30°C	ISO 179	kJ/m^2	12 4,5	12 4,5	16 6	5,0 3,0
	Ball indentation hardness acc. Rockwell	ISO 2039-1	MPa	36	42	46	
	Flexural strength (3,5% flexural stress)	ISO 178	MPa	18	21	24	
	Modulus of elasticity	ISO 527	MPa	750	950	1100	1150
Thermal Properties	Vicat-Softening point VST/B/50	ISO 306	°C	63	72	77	83
	Heat deflection temperature HDT/B	ISO 75	°C	60	70	75	
	Linear coefficient of thermal expansion	DIN 53752	$K^{-1} \times 10^{-4}$	1,8	1,8	1,8	1,8
	Thermal conductivity at 20 °C	DIN 52612	W/(mxK)	0,4	0,4	0,4	0,43
	Flammability	UL94 DIN 4102	–	94-HB B2	94-HB B2	94-HB B2	 B2
Electrical Properties	Specific volume resistance	VDE 0303	OHM cm	$>10^{16}$	$>10^{16}$	$>10^{16}$	$\leq 10^{8}$
	Specific surface resistance	VDE 0303	OHM	$>10^{13}$	$>10^{13}$	$>10^{13}$	$\leq 10^{6}$
	relative dielectric constant at 1 MHz	DIN 53483	–	2,3	2,3	2,3	
	Dielectric strength	VDE 0303	kV/mm	70	70	70	
	Physiologically non-toxic	EEC 90/128	–	Yes	Yes	Yes	Nein
	FDA	–	–	Yes	Yes	Yes	Nein
	UV stabilized	–	–	carbon black	carbon black	carbon black	carbon black
	Colour	–	–	black	black	black	black

PE100 - PE80 - PPH - PPR

The most important components in our suplyprogram are:

- Pipes
  10mm bis 1.400mm (Ventilation, SDR41, SDR33, SDR26, SDR17, SDR11, SDR7,4)
- Elongated fittings
  20mm up to 315mm
- Short fittings
  20mm up to 630mm
- Electro fusion fittings
  20mm up to 315mm
- Socket welding fittings
  20mm up to 110mm
- Valves, mountings
  20mm up to 140mm
- Accessories (flanges)
  20mm up to 630mm
- Welding technology
  Welding machines + mounting tools

PE80-el

The most important components in our supply program are:

- Pipes
  20mm up to 1.200mm (Ventilation, SDR41, SDR33, SDR11)
- Short fittings
  20mm up to 500mm
- Accessories (flanges)
  32mm up to 160mm
- Welding technology
  Welding machines + mounting tools

Due to the additional additives especially the high carbon black content in the modified material types these materials do **not comply** with the relevant food contact regulations and therefore they are not suitable for the transport of drinking water and contact with foodstuff.

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Pipe Systems at Landfills

At Landifll constructions Pipe Systems are mostly in use for Drainage Pipes and Degasing

Degasing Systems

because of this systems (vertical or horizontal) acrueing gases have to be drained, collected and used. Depending on the gas quantity the gases can be deliverd to an existing gas supply system or can be transfered to a gas burner

Drainage Pipes

are a very important component for the overall function of a landfill. They make sure that the leachate is collected and drained away correctly. Afterwards the leachate is collected and transported to the collecting and treatment facilities.

The different type of pipes are available in various dimensions and types. The design of the pipes is executed acc. guideline ATV A 127.

The design of the drill-holes or the slos at drainagepipes is calculated project related acc. the yearly expected rain quantity.

Also Drainage Pipes with coextruded light colour inside signal layer are offered. This is necessary to achieve the appropriate lightness in the system for recording and / or photographing. A further advantage is that deposits and / or damages are visible much more better.

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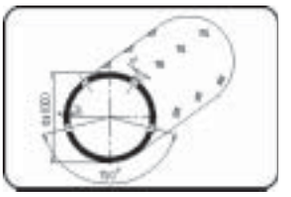
Suply Program: DRAINAGE PIPES

2/3 perforated

Code 730

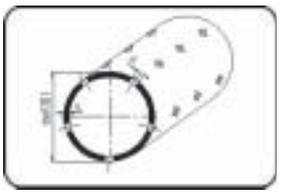
da 63 - da 110:
4 drill-holes
da 125 - da 400:
8 drill-holes
da 450 - da 1000:
8/16 drill-holes



perforated

Code 731

da 63 - da 110:
6 drill-holes
da 125 - da 400:
12 drill-holes
da 450 - da 1000:
12/24 drill-holes

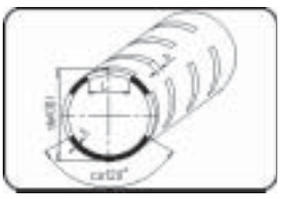


Drilldiameter d: 6, 8, 10, 12, 15 mm

2/3 slotted

Code 732

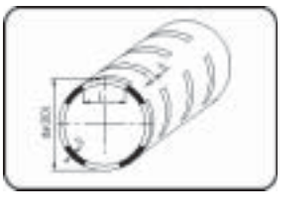
da 110 - da 355:
3 slots
da 400:
6 slots



slotted

Code 733

da 63 - da 90:
2 slots
da 110 - da 355:
4 slots
da 400:
8 slots



Slotwidths: 2, 3, 4 , 5, 6, 8, 10 mm
Slotlengths: see table on page 5

In general, the design of the drainpipes (diameter of drill-holes, slot widths,..) can be carried out according to individual requirements - usually the water entry surface increases with rising pipe diameters.
100 to 200 cm²/m water entry surface are in common use for sole drainages.
The center distance between the openings should amount to 20 mm as a minimum.
For static reasons, the remaining space between two gaps must be at least as wide as the wall thickness of the pipe.

The following information is demanded for drainage pipe
orders:
Code number
e.g.: 20.7310.200.11

- material code
- item code
- dimension(diameter,length)
- SDR-rate

for a perforated PE 80-pipe; da 200; PN 10

- Drill-hole diameter or width of the slot
- Center distance between the gaps
- Pipe length

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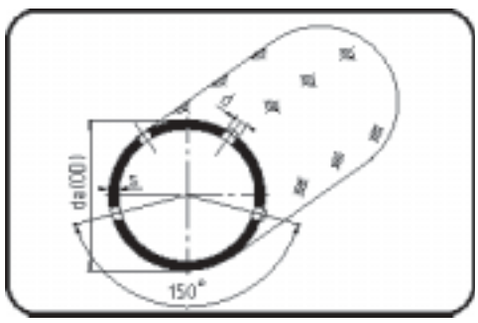
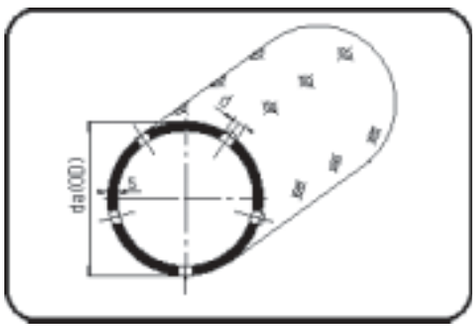
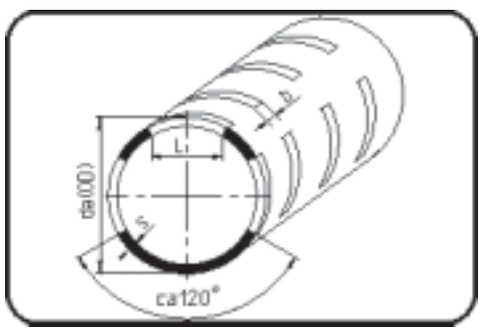
PE 80 -Drainage Pipes
OENORM B 5172
DIN 8074 / 8075



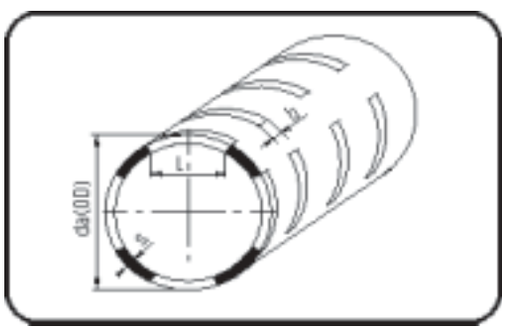
Code730



Code 731



Code 732



Code 733

da	PN 6 ISO S[2] -8,3 SDR[1] 17,6		PN 10 ISO S[2] -5 SDR[1] 11		PN 12,5 ISO S[2] -4 SDR[1] 9		PN 16 ISO S[2] -3,2 SDR[1] 7,4		PN 20 ISO S[2] -2,5 SDR[1] 6	
	s[3]	Schlitzlänge slot length	s[3]	Schlitzlänge slot length	s[3]	Schlitzlänge slot length	s[3]	Schlitzlänge slot length	s[3]	Schlitzlänge slot length
[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
63	3,6	47	5,8	43	7,0	41	8,7	38	10,5	
75	4,3	51	6,9	46	8,3	43	10,4	39	12,5	
90	5,1	54	8,2	48	10,0	44	12,5	38	15,0	
125	7,1	57	11,4	47	13,8	41	17,3	31	20,9	
140	8,0	57	12,8	46	15,6	38	19,4	24	23,4	
160	9,1	82	14,6	72	17,8	66	22,1	56	26,7	
180	10,2	84	16,4	72	20,0	64	24,9	52	30,0	
200	11,4	84	18,2	70	22,2	61	27,6	46	33,4	
225	12,8	84	20,5	67	25,0	55	31,1	34	37,5	
250	14,2	83	22,8	63	27,8	48	34,5		41,7	
280	15,9	93	25,5	72	31,1	56	38,7		46,7	
315	17,9	91	28,7	65	35,0		43,5		52,5	
355	20,1	88	32,3	55	39,4		49,0		59,2	
400	22,7	84	36,4		44,4		55,2		66,7	

1) Standard Dimension Ratio **SDR** » $\frac{da}{s}$ 2) Serie **S**= $\frac{SDR-1}{2}$ 3) wall thickness

The grey-marked dimensions are not suitable for slotting.

General chemical properties of PE

In comparison to metals where an attack of chemicals leads to an irreversible chemical change of the material, it's mostly physical processes at plastics which reduce the utility value. Such physical changes are e.g. swelling and solution processes at which the composition of the plastics can be changed in this way that the mechanical properties are affected. There have to be taken reducing factors into consideration at the design of facilities and parts of those in such cases.

PE is resistant against diluted solutions of salts, acids and alkalis if these are not strong oxidizing agents. Good resistance is also given against many solvents, such as alcohols, esters and ketones.
At contact with solvents, as aliphatic and aromatic compound, chlorinated hydroxycarbon, you have to reckon upon a strong swelling, especially at raised temperatures. But a destruction commences only rarely.
The resistance can be strongly reduced by stress cracking corrosion due to ampholytiocs (chromic acid, concentrated sulphuric acid).

Lyes

Alkalis
Diluted alkali solutions (e. g. caustic lye), even at higher temperature and with higher concentrations do not react with PE and can therefore be applied without problems, unlike to PVDF or other fluoroplastics.

Bleaching lye
As these lyes contain active chlorine, only a conditional resistance is given at room temperature. At higher temperatures and concentrations of the active chlorine, PE is rather only suitable for pressureless piping systems and tanks.

Hydrocarbons
PE can be used for the conveying up to temperatures of 40°C and for the storage of these media up to temperatures of 60°C.
Only at temperatures > 60°C is PE conditonally resistant as the swelling is > 3 %.

Acids

Sulphuric Acid
Concentrations up to approximately 70% change the properties PE only slightly. Concentrations higher than 80 % cause already at room temperature oxidation.

Hydrochloric acid, hydrofluoric acid
Against concentrated hydrochloric acid and hydrofluoric acid, PE is chemically resistant.

Nitric acid
Higher concentrated nitric acid has an oxidizing effect on the materials. The mechanical strength properties are reduced at higher concentrations.

Phosphoric acid
Against this medium, PE is also at higher concentrations and at raised temperatures resistant.

For more detailed information regarding the chemical resistance of our products, our application engineering department will be at your disposal at any time.

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Media list for chemical resistance factors f_{CR}=1 (acc. DVS 2205, part 1)

The values stated are for those media for which a f_{CR} factor of 1 has to be applied due to many years of experiences. The in the table contained temperatures are maximum temperatures upto which the resistance factor is valid.

Medium	1)	2) Share [%]	Testing strength [N/mm²]	Temperature [°C] PEHD
aceto-acetic ester	O	100	2,0...3,0	60
acetic		H		60
air O_2N_2	A	100		60
alum (Me(I)- Me(III)-sulfate)	A	≤ GL		60
aluminium chloride $AlCl_3$	A	≤ GL		60
aluminium sulfate $Al_2(SO_4)_3$	A	≤ GL		60
ammonia, liquid NH_3	A	TR		60
ammonia, gaseous NH_3	A	TR		60
ammonia solution NH_4OH	A	≤ GL		60
ammonium acetate CH_3COONH_4	A	≤ GL		60
ammonium bromide NH_4Br	A	≤ GL		60
ammonium carbonate $(NH_4)_2CO_3$	A	≤ GL		60
ammonium chloride NH_4Cl	A	≤ GL		60
ammonium fluoride NH_4F	A	< 10		60
ammonium hydrogen carbonate NH_4HCO	A	≤ GL		60
ammonium nitrate NH_4NO_3	A	≤ GL		60
ammonium phosphate $(NH_4)_3PO_4$	A	≤ GL		60
ammonium sulfate $(NH_4)_2SO_4$	A	≤ GL		60
ammonium sulfide $(NH_4)_2S$	A	≤ GL		60
antifreezing compound	M	100	5,0...3,0	60
apple juice	O	H		60
barium carbonate $BaCO_3$	A	≤ GL		60
barium chloride $BaCl_2$	A	≤ GL		60
barium hydroxide $Ba(OH)_2$	A	≤ GL		60
barium nitrate $Ba(NO_3)_2$	A	≤ GL		60
barium sulfate $BaSO_4$	A	≤ GL		60
barium sulfide BaS	A	≤ GL		60
barium salts	A/M	≤ GL		60
battery acid	A	H		60
beer	O	H		60
borax $Na_2B_4O_7$	A	≤ GL		60
buttermilk	O	H		60
cadmium chloride $CdCl_2$	A	≤ GL		60
cadmium cyanide $Cd(CN)_2$	A	≤ GL		60
calcium acetate $(CH_3COO)_2Ca$	M	≤ GL		60
calcium bromide $CaBr_2$	A	≤ GL		60
calcium carbonate $CaCO_3$	A	≤ GL		60
calcium chloride $CaCl_2$	A	≤ GL		60
calcium fluoride CaF_2	A	≤ GL		60
calcium hydroxide $Ca(OH)_2$	A	≤ GL		60
calcium nitrate $Ca(NO_3)_2$	A	≤ GL		60
calcium sulfate $CaSO_4$	A	≤ GL		60

Medium	1)	2) Share [%]	Testing strength [N/mm²]	Temperature [°C] PEHD
calcium sulfide $CaSO_3$	A	≤ GL		60
carbon dioxide, gaseous CO_2	A	each		60
caustic soda NaOH	A/M	50	4,0...2,0	60
cider	O	H		60
citric acid $(CO_2H).CH_2.CO_2H$	O	≤ 10		60
copper (II)-chloride $CuCl_2$	A	≤ GL		60
copper (I)-cyanide CuCN	A	≤ GL		60
copper electrolyte solution	A	20/5	4,0...2,0	60
copper (II)-nitrate, liquid $Cu(NO_3)_2$	A	≤ 30		60
copper (II)-sulfate $CuSO_4$	A	≤ GL		60
dextrose	O	≤ 20		60
ethylene glycol CH_2OH . CH_2OH	O	100	4,0...2,0	60
ferric (II)- and (III)-chloride	A	≤ GL		60
fruit juice	O	H		60
fructose	O	> 10		60
hexanol $C_6H_{13}OH$	O	100	3	60
hydrogel-emulsion (pH-value = 9,5)		100		
hydroxyl ammonia sulfate	O	≤ 12		60
kitchen salt solution NaCl	A	25		60
lead acetate	A	≤ GL		
lead sulfate $PbSO_4$	A	≤ GL		60
magnesium carbonate $MgCO_3$	A	≤ GL		60
magnesium chloride $MgCl_2$	A	≤ GL		60
magnesium hydrogencarbonate	A	≤ GL		60
magnesium salts	A/M	≤ GL		60
magnesium sulfate $MgSO_4$	A	≤ GL		60
manuring salts	A	≤ GL		60
mercury salts	A/M	≤ GL		60
methanol CH_3OH	O	100	4,0...2,0	60
milk	O	H		60
mineral water	A	H		60
mono ethyl amine $CH_3.CH_2.NH_2$	O	100	2,5...1,5	
natural gas (main content CH_4)	O	100	4,0...2,0	60
natural gas condensate	O	100	2	60
nickel salts	A	≤ GL		60
octanol $C_6H_{17}OH$	O	100	5	40
	O	100	4,0...2,0	60
oxygen O_2	A	100	4,0...2,0	60
phosphate	A	≤ GL		60
phosphoric acid H_3PO_4	A	75	4,0...2,0	60
potassium hydroxide KOH	A	≤ 50		60
potassium borate $K_2B_4O_7$	A	≤ GL		60

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Media list for chemical resistance factors f_{CR}=1 (acc. DVS 2205, part 1)

The values stated are for those media for which a f_{CR} factor of 1 has to be applied due to many years of experiences. The in the table contained temperatures are maximum temperatures upto which the resistance factor is valid.

Medium	1)	2) Share [%]	Testing strength [N/mm²]	Temperature [°C] PEHD
potassium bromate, liquid $KBrO_3$	A	≤ 10		60
potassium carbonat K_2CO_3	A	≤ GL		60
potassium chlorate $KClO_3$	A	≤ GL		60
potassium chloride KCl	A	≤ GL		60
potassium cyanide KCN	A	≤ GL		60
potassium fluoride KF	A	≤ GL		60
potassium hexacyanoferrate- (II) + (III)	A	≤ GL		60
potassium hydrogencarbonate $KHCO_3$	A	≤ GL		60
potassium iodide KJ	A	≤ GL		60
potassium nitrate KNO_3	A	≤ GL		60
potassium phosphate KH_2PO_4	A	≤ GL		60
potassium sulfate K_2SO_4	A	≤ GL		60
salmiac NH_4OH	A	≤ GL		60
sulphuric acid H_2SO_4	A	40	3	60
		78	4,0...2,0	60
		85	3	60
sea water	A	H		60
silver nitrate $AgNO_3$	A	≤ GL		60
silver salts	M	≤ GL		60
soda Na_2CO_3	A	≤ 50		60
sodium acetate CH_3COONa	A	≤ GL		60
sodium bromide NaBr	A	≤ GL		60
sodium carbonate, liquid Na_2CO_3	A	≤ 50		60
sodium chlorate $NaClO_3$	A	≤ GL		60
sodium chloride NaCl	A	≤ GL		60
sodium hydrogencarbonate $NaHCO_3$	A	≤ GL		60

Medium	1)	2) Share [%]	Testing strength [N/mm²]	Temperature [°C] PEHD
sodium hydrogensulfate $NaHSO_4$	A	≤ GL		60
sodium hydrogensulfite $NaHSO_3$	A	> 10		60
sodium nitrate $NaNO_3$	A	≤ GL		60
sodium nitrite $NaNO_2$	A	≤ GL		60
sodium phosphate Na_3PO_4	A	≤ GL		60
sodium silicate Na_2SiO_3	A	≤ GL		60
sodium sulfate Na_2SO_4	A	≤ GL		60
sodium sulfide Na_2S	A	≤ GL		60
sodium sulfite, liquid Na_2SO_3	A	≤ GL		60
sodium tetraborate $Na_2B_4O_7$	A	≤ GL		60
sodium thiosulfate $Na_2S_2O_3$	A	≤ GL		60
sodium hydroxid NaOH	A/M	50	4,0...2,0	60
spirits	O	H		60
starch	O	each		60
sugar syrup				
tartaric acid $C_4H_6O_6$	O	≤ 10		60
tin (II)-chloride $SnCl_2$	A	≤ GL		60
tin (VI)-chloride $SnCl_4$	A	≤ GL		60
transformer oil	O	100	3	60
		100	2	60
triacethyl glycerine	O	100	4,0...2,0	60
urea $CO(NH_2)_2$	O	≤ GL		60
water H_2O	A	100		60
wine	M	H		60
yeast	O	each		60
zinc salts	A/M	≤ GL		60

Footnotes

1) A: anorganic substance
O: organic substanz
M: mixture out of anorganic and organic substances

2) GL: saturated (at 20°C) , diluted solution
TR: technical clean medium
H: commercially available composition or as present in nature

Media list for chemical resistance factors f_{CR}=1 (acc. DVS 2205, part 1)

Medium	[1]	[2] Share [%]	Testing strength [N/mm²]	PE 80°C	PE 60°C	PE 40°C	PE 20°C
acetic acid CH_3COOH	O	60	5,0...2,0			1,72	
			4,0...2,0	1,25	1,43	1,64 [6]	1,85 [6]
		98	5,0			3,85	5,00
			4,0	1,67	3,45	4,76	5,56
			3,0	1,67	5,00	5,56	6,67
			2,0	1,67	7,69	8,33	8,33
aceto-acetic ester	O	100	4,0	1,25			
aceto-acetic acid methyl ester	O	100	4,0...2,0	1,18			
alkaline solution [4]	M	100	4,0...2,0	2,00			
antifreezing compound	M	50	5,0	1,67			
benzine C_5H_{12} to $C_{12}H_{26}$	O	100	4,0	1,47	1,59	1,72 [6]	1,85 [6]
			3,0	1,28	1,33	1,39 [6]	1,45 [6]
			2,0	1,06	1,08	1,09 [6]	1,10 [6]
benzol C_6H_6	O	100	4,0	1,33	1,37	1,41 [6]	1,45 [6]
			3,0	1,16	1,09	1,02 [6]	1,00 [6]
chloroform $CHCl_3$	O	100	4,0		2,22		
			3,0		2,10		
			2,0		1,82		
chromic acid $H_2Cr_2O_4$	A	10	4,0...2,0	1,43	1,61	1,89	2,04 [6]
		20	5,0			2,86	4,76
			4,0	1,72	2,38	3,23	5,56
			3,0	2,00	2,78	4,00	6,67
			2,0	2,63	3,57	5,00	9,10
chromic-sulphuric acid	A	100	5,0...3,0		> 100		
decylhydride $C_{10}H_{22}$	O	100	4,0	1,39			
			2,0	1,05			
desinfectant	M	100	4,0...2,0	1,54			
dichloroethylene $CH_2 = CCl_2$	O	100	5,0...2,0		> 100		
dimethylsulfate $(CH_3)_2SO_4$	O	100	4,0...2,0	1,15			
etyhlene chloride $C_2H_4Cl_2$	O	100	4,0...2,0	1,11			
formaldehyde CH_2O	O	40	5,0...2,0			1,61	
fuel oil	O	100	4,0		1,43		
			3,0		1,25		
			2,0		1,06		
hexanol $C_6H_{13}OH$	O	100	4,0	1,11			
hydraulic oil	O	100					
hydrochloric acid HCl	A	20					
		30					
		33	4,0...2,0	1,33			
methylene chloride CH_2Cl_2	O	100	4,0	1,49	1,47	1,45 [6]	1,43 [6]
			3,0	1,25	1,28	1,32 [6]	1,35 [6]
			2,0	1,05	1,06	1,08 [6]	1,09 [6]
natural gas condensate (mixture of	O	100	5,0				> 7a [7]
aromatic and aliphatic compounds)			4,0	1,28			
			3,0	1,11			

Media list for chemical resistance factors f_{CR}=1 (acc. DVS 2205, part 1)

Medium	1)	2) Share [%]	Testing strength [N/mm²]	PE 80°C	PE 60°C	PE 40°C	PE 20°C
nitric acid HNO_3	A	15					
		50					
		53	5,0...2,0	3,30		2,00	2,00
		65	4,0...2,0	3,30			
nitric acid + hydrofluric acid	A	15 + 4					
oil, unfractionated (mixture of	O	100	4,5		1,35		> 25a [7]
aromatic and aliphatic compounds)			4,0		1,25		
			2,8		1,00		> 25a [7]
peanut oil	O	100	5,0...3,0	1,37			
phosphoric acid H_3PO_4	A	75					
polysufides MeS_{1+X}	A	100	4,0...2,0	1,33			
sewage of a cellulose factory [4]	M	100	4,0...2,0	1,05			
sewage of a synthetic fibre fabric [3]	M	100	4,0...2,0	1,33			
sewage of a whey utilization [3]	M	100	4,0...2,0	1,37			
sodium hydroxide NaOH	A	30					
sulphuric acid H_2SO_4	A	85	2,0	3,30			
		90	3,0	2,00			
			2,0	9,09			
		95	3,0	10,0			
			2,0	> 100			
		98	5,0			2,86	
			4,0		2,44	3,33	5,56
			3,0	20,0	3,85	4,17	7,14
			2,0	> 100	7,69	5,56	10,0
tetrachloromethane CCl_4	O	100	4,0	1,43	1,54	1,67 [6]	1,79 [6]
			3,0	1,25	1,43	1,67 [6]	1,85 [6]
			2,0	1,05	1,25	1,49 [6]	1,75 [6]
toluene $C_6H_5CH_3$	O	100	4,0	1,54			
			3,0	1,33			
			2,0	1,05			
transformer oil	O	100	4,0	1,33	1,18	1,04 [6]	
			3,0	1,19			
trichlorofluoromethane CCl_3F	O	100	4,0...2,0	1,82	1,43	1,12 [6]	
1, 3, 5 trimethylbenzol $C_6H_3(CH_3)_3$	O	100	4,0	1,54			
			3,0	1,33			
			2,0	1,11			
water with surface active-agent	M	2	4,0...2,0	1,67			

Footnotes

1) A: anorganic substances
   O: organic substances
   M: mixture out of anorganic and organic substances
   GL: saturated (at20°C), diluted solution
2) TR: technical clean medium
   H: commercial available composition or as present in the nature
3) not transferable to other sewage
4) 88,25 parts water, 10 parts sodiumperchlorat, 1 part sodiumhydroxid, 0,25 parts Anilin, 0,25 parts monochlorobenzol, 0,25 parts toluoldiamine
5) extrapolated values acc.Doc. ISO/TC 138/SC 3 N 382 (version 20.08.83)
6) time to fail in years

Liners

General - Materials

AGRU HDPE Liners are manufactured since 20 years in a high-precision calendering extrusion process in compliance with the highest quality standards.

In addition to the renowned AGRU HDPE Liners other polyolefin Liner types are produced to have a liner types for manifold application areas

LLDPE - Linear Low Density Polyethylen
VLDPE - very low density Polyethylen
PP-FLEX- flexible Polypropylen
FPO - Flexible Polyolefin
TPO - Thermoplastic Polyolefin

Depending on the application area the adequate material can be choosen.
For special applications like sealing of flat roofs thermoplastic alloys FPO/TPO are used, which are adjusted to the requirements for this application.
Those liners can additonally be reinforced with a glass fibre fabric, scrim reinforcement or both.
AGRU offers additonal to polyolefin geomembranes a complete supply range for flat roofs, wich is distributed under the brand name AUSTROPLAN. Separate Product catalagous are available and the AUSTROPLAN supply range is included to the product group building engineering.

Process Engineering

Each raw material, which is selected in accordance to the rigorous AGRU Delivery standards, is subject of the quality assurance from the delivery to the finished product.
The quality assurance starts with a sample of raw material taken directly from the silo truck, the release for stocking in the silos, the complete recording of the batch/lot which are manufactered and the product tests and the final control of the Liner roll before shipping.

Manufacturing

For processing the raw material is plastified and homogenized by means of temperature and pressure buildup in the single-screw extruder. The forming of the melt is performed by a heated flat die, which is equipped with costly distribution and centering systems. The pressed out extruded material is flattened by a secondary three-roll calendar. Afterwards, the take-off unit, the edge trimming unit, the marking facility and the coiling device are placed.

The thickness of the liner is permanently in line controlled during the production process over the entired production width.

The flat die calendering technology enables to manufacture liners with a homogenous structure. Those structured liners at slopes of different layers construction as **AGRU MICRO-SPIKE MST/MSB** ensure a safe design with excellent interface friction properties

Reports and Research studies in close cooperation with well known geotechnical institutes to determine the stability of different combinations are available. Shearing Diagrams are available of various combiantions to predetermine the optimum liner structure combination.
Our technical department can assist to choose the best surface combination for precise applications.

Also **coextruded** liners are available,e.g. for minimizing heating up by sun radiation and for visual leakage control (white) or for optical reasons (green).

HDPE Liners
Material characteristics of HDPE

Due to a permanent enhancement of PE moulding materials in the last years the efficiency of HDPE liners was improved substantially.
This circumstance was acommodated with test standards like the FNCT test according to EN14 576 or NCTL test according ASTM D 5397, the test methods which describe the resistance against environmental affected stress cracking.

Nowadays therefore critisism on the stress cracking of HDPE liners is not vindicable because only highest quality raw material types, which are designated for gomembrane manufacturing developed together with well known raw material suppliers, are in use.
Also evaluations on installed systems showed absolutely perfect behaviour and performance of HDPE geomembranes after 20 years of use.

The properties which are neccessary for lining technology like good flexibility, high strength and elongation properties in combination of high chemical resistance and verified long life expectations are standard at AGRU.

Lasting Containment

Concerning the life expectasions of HDPE Liners many expert opinions, expertises and technical surveys have been published.
The tests for thermal oxidizing stability are performed by oven aging at an increased temperature. According to the known ratios (Arrhenius´ Law) it is possible to estimate sevice life for the PEHD-types used in landfill construction. Based on temperature evaluations typically measured above the base liner of exisiting municipal waste disposals in between 20° C and 30° C for which an extrapolated calculation for 25°C service life of 300-400 years can be expected even if the leachate is saturated with oxygen.
(out of OFI (Austrian Research Institute) expert opinion for the use of AGRU-PEHD liners landfill and hydraulic engineering
expert opinion N° 47.814 / 2003)

Advantages of HDPE Liners

Compared to other thermoplastic materials HDPE shows a high resistance against diffusion.
Therefore beside the use of geomembranes for ground water protection, aquacultural and civil engineering as piping systems for the secure transportatin of gases out of HDPE are in use.

By adding of 2-3% fine dispersed carbon to the natural PE-raw material liners are UV- and weathering resistant.
After 15 years outdoor exposure AGRU HDPE liners show no change of the mechanical properties compared with reference specimens.

Typically HDPE liners show following advantages:

- high chemical resistance
- high strength and elongation at break
- high puncture resistance
- flexible at low temperatures
- high compression strength
- Resistant to UV- and Weathering
- Resistant against roots and rodents
- good weldability
- physiolical harmless

HDPE is superior compared to PVC for :

- 25% lower density
- free of plasticizers
- halogen free
- free of heavy metals
- generally better chemical resistance
- varios applications in the food industry and storage of potable water
- no dangerous HCL gases at burning or welding
- HDPE keeps its mechanical properties (no volatile additives)

Field of Applications

HDPE Liners are commonly used for:

- Sealing of base and capping at municipal, industrial and hazardous waste disposals
- Sealing at groundwater endangering media
- Detention Basins for industrial and municipal waste water and mire
- Ground water protection at railways and roads
- Storage basins for oil, industrial and sewage sludge
- Spill containment for chemical and petrochemical industries
- Sealing of heap leach pads at mining applications
- Storage of agricultural slurries
- Lining of canals and rivers
- Erosion protection
- AGRULOCK sealing of vertical cut-off walls
- Water reservoirs
- Balancing lakes
- Sealing of aquacultural basins
- Flood or rain water detention basins

Simple Installation

The proper installation and welding of the AGRU HDPE Liners are of paramount importance since integrity and long term performance are dependent upon it.
Typically seaming the liners is carried out by hot wedge welding that provides a double welded seam with a test channel.
The installation of AGRU HDPE Liners is performed by qualified and authorized installers.

Quality Assured

Applying a strict Quality Managment program summerized by internal quality control, ISO 9001:2000 certification, frequent external quality inspections by state authorized testing institutes such as MPA, SKZ, ÖFI etc. and approval quality marks by BAM, DIBt, OENORM, KIWA, Asqual... ensures continuous high quality of AGRU products.
Tracing and control from the incoming raw materials to the finished liners allow work certificates to be issued linked to the used raw material batch (acc. to EN 10204/DIN 50049).

AGRU HDPE Supply Range

The various approvals for AGRU HDPE liners and differences on the requirements for national regulations a modification for our supply range has been introduced for quick and easy finding of the proper type of liners and reuqired approval for our customers.The new supply range for HDPE is split in three main groups for harmization of our stock data
Project specific tender documents needs to be agreed by special order with project data sheets issued by our technical department.

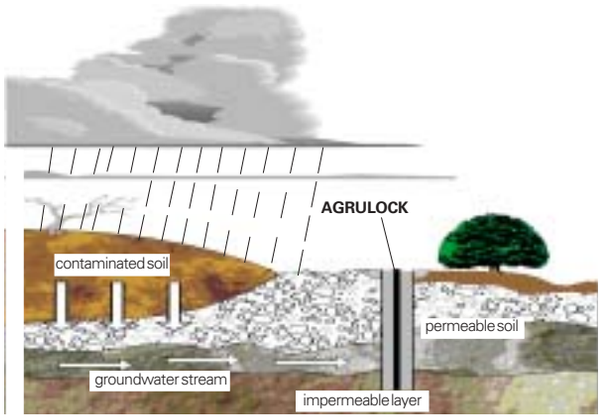
Liner with Aluminium Barrier

The AGRU CHC/CFC barrier-liner is manufactured in the same extrusion process as HDPE liners in 1,35m width. A special PE-coated 0,15mm thin aluminium liner is laminated in between two HDPE liner layers wich provides a diffusion barrier for CHC/CFC and FCHC.

AGRULOCK Vertical Sealing System

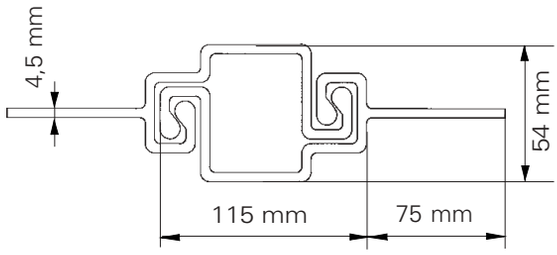
Sealing of cut off walls by bentonite only gives certain permeation reduction but no permeation stop. Using AGRU LOCK systems a laminar permeation stop is achieved and percolation only is possible at panel joints for which the AGRU LOCK design has elongated percolation path.
AGRU LOCK Systems are installed where contaminated groundwater streams needs to be stopped or treated by "gate & fence" systems but also for encapsulation of construction sites for lowering groundwater table.

Function



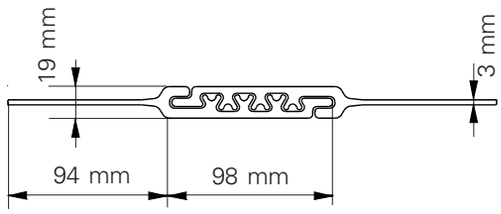
Special Features of Type A Code 590.5

- ❑ outstanding high horizontal elongation of the interlock
- ❑ robust design
- ❑ easy downfeed into each other
- ❑ possibility of filling the hollow with a special sealing compound
- ❑ identical male and female profile
- ❑ horizontal separation load:
  > 25 kN/m run of interlock



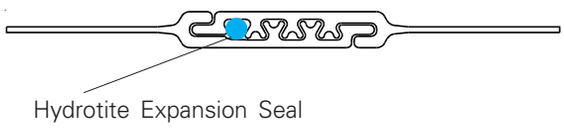
Special Features of Type B Code 591.5

- ❑ horizontal separation load:
  > 45 kN/m run of interlock
- ❑ flat design
- ❑ easy downfeed into each other
- ❑ identical male and female profile
- ❑ delivered as straight strips or on rolls



Special Features of Type B.Q Code 591.Q

- ❑ the insertion of a Hydrotite expansion seal makes the interlock watertight
- ❑ horizontal separation load:
  > 37 kN/m run of interlock
- ❑ flat design
- ❑ easy downfeed into each other
- ❑ identical male and female profile
- ❑ delivered as straight strips or on rolls



HOME


Code 500/507

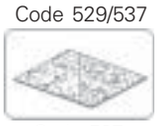

Code 529/537


Code 530


Code 528


Code 520


Code 522


Code 527


Code 517


Code 20.568

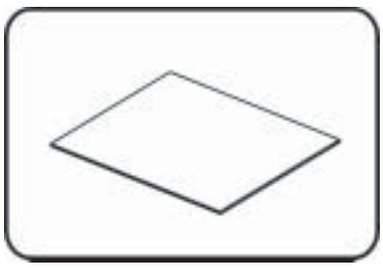

Code 609

HOME

Material Properties
Installation Guidelines
Calculation Guidelines
Connection Systems
Applications and References
Approvals and Standards

HOME

- **Liner G/G**
  surface smooth/smooth-5/7m
  calendered
- **Hot-wedge-welding**
- **HDPE black**



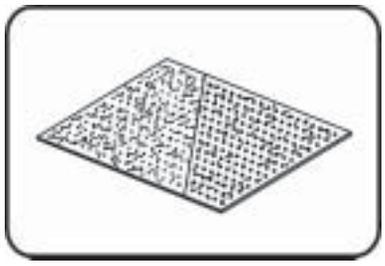
Code 500/507

Property	Standard		Unit	0,75mm	1,00mm	1,50mm	2,00mm	≥ 2,50 mm
	DIN OEN EN ISO	ASTM						
Nominal Thickness	DIN 53 370		%	≤ ± 10	≤ ± 10	≤ ± 10	≤ ± 10	≤ ± 10
Density (black)	ISO 1183	D 792	g/cm³	≥ 0,94	≥ 0,94	≥ 0,94	≥ 0,94	≥ 0,94
MFR Melt Flow Rate (190°C/5kg)	ISO 1133 Cond. T	D 1238 Cond. P	g/10 min	0,6 - 1,4	0,6 - 1,4	0,6 - 1,4	0,6 - 1,4	0,6 - 1,4
Heat Reversion (100°C/1h)	OENORM S 2073	D1204	%	≤ 2,0	≤ 2,0	≤ 1,5	≤ 1,0	≤ 1,0
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	130	130	130	130	130
Multiaxial Tension	OENORM S 2073		%	≥ 15	≥ 15	≥ 20	≥ 20	≥ 25
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 16	≥ 16	≥ 16	≥ 16	≥ 16
Elongation at Yield	ISO 527	D 6693	%	≥ 9	≥ 9	≥ 9	≥ 9	≥ 9
Elongation at Break	ISO 527	D 6693	%	≥ 400	≥ 500	≥ 700	≥ 700	≥ 700
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 300	≥ 450	≥ 800	≥ 1500	≥ 2000
		D 4833	N	240	320	480	640	800
Low Temperature Brittleness	DIN 16 726	D 746	°C	-20	-20	-20	-20	-20
Water Absorption	ISO 62	D 570	%	≤ 0,1	≤ 0,1	≤ 0,1	≤ 0,1	≤ 0,1
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*	fulfilled*
Rodent Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*	fulfilled*
Resistance to Leachates	OENORM S 2073	D 543	%	dimensional change ≤ 5 change of mechanical properties ≤ 20				
ESCR-Behaviour		D 1693	(h)	> 2000	> 2000	> 2000	> 2000	> 2000
Carbon Black Content	ISO 6964	D 1603	%	≥ 2	≥ 2	≥ 2	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11420	D 5596		A - 2	A - 2	A - 2	A - 2	A - 2

The data in this table are approximate values and based upon results of the internal inspection, data of raw material suppliers as well as tests in the course of approval procedures and external inspections. The results can differ slightly from the indicated mean values in longitudinal and transverse direction and due to different nominal thicknesses and raw materials. In any case requirements relating to a special project (tender documents) have to be agreed with AGRU.
Independent of the indicated test standards, internal tests and data on test certificates are generally carried out in accordance with the appropriate test procedures according to OENORM (Austrian Standard) resp. DIN (German Standard) or EN ISO.
AGRU assumes no liability in connection with the use of this data. The specifications on this sheet are subject to change without notice.

*) acc. OENORM S2073 liners made of polyolefins shall be considered resistant without proof being furnished.

- **Liner MST/MSB**
  microspike/microspike-5,15/7m
  calendered
- **Hot-wedge-welding**
- **HDPE black**



Code 529/537

Property	Standard		Unit	1,00 mm	1,50 mm	2,00 mm	≥ 2,50 mm
	DIN OEN EN ISO	ASTM					
Nominal Thickness	DIN 53 370		%	≤ ± 10	≤ ± 10	≤ ± 10	≤ ± 10
Density (black)	ISO 1183	D 792	g/cm³	≥ 0,94	≥ 0,94	≥ 0,94	≥ 0,94
MFR Melt Flow Rate (190°C/5kg)	ISO 1133 Cond. T	D 1238 Cond. P	g/10 min	0,6 - 1,4	0,6 - 1,4	0,6 - 1,4	0,6 - 1,4
Heat Reversion (100°C/1h)	OENORM S 2073	D 1204	%	≤ 2,0	≤ 2,0	≤ 2,0	≤ 1,0
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	130	130	130	130
Multiaxial Tension	OENORM S 2073		%	≥ 15	≥ 15	≥ 15	≥ 15
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 16	≥ 16	≥ 16	≥ 16
Elongation at Yield	ISO 527	D 6693	%	≥ 9	≥ 9	≥ 9	≥ 9
Elongation at Break	ISO 527	D 6693	%	≥ 150	≥ 400	≥ 400	≥ 400
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 450	≥ 800	≥ 1500	≥ 2000
		D 4833	N	267	400	534	667
Low Temperature Brittleness	DIN 16 726	D 746	°C	-20	-20	-20	-20
Water Absorption	ISO 62	D 570	%	≤ 0,1	≤ 0,1	≤ 0,1	≤ 0,1
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Rodent Resitance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Resitance to Leachate	OENORM S 2073	D 543	%	dimensional change ≤ 5 change of mechanical properties ≤ 20			
ESCR-Behaviour		D 1693	(h)	> 2000	> 2000	> 2000	> 2000
Carbon Black Content	ISO 6964		%	≥ 2	≥ 2	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11 420			A - 2	A - 2	A - 2	A - 2

The data in this table are approximate values and based upon results of the internal inspection, data of raw material suppliers as well as tests in the course of approval procedures and external inspections. The results can differ slightly from the indicated mean values in longitudinal and transverse direction and due to different nominal thicknesses and raw materials. In any case requirements relating to a special project (tender documents) have to be agreed with AGRU.
Independent of the indicated test standards, internal tests and data on test certificates are generally carried out in accordance with the appropriate test procedures according to OENORM (Austrian Standard) resp. DIN (German Standard) or EN ISO.
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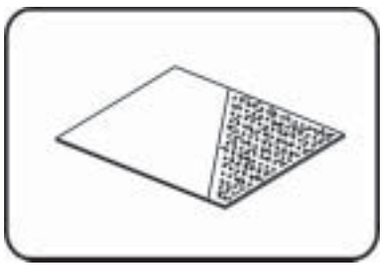
*) acc. OENORM S2073 liners made of polyolefins shall be considered resistant without proof being furnished.

- **Liner G/MSB**
  smooth/microspike-5,15m
  calendered
- **Hot-wedge-welding**
- **HDPE black**



Code 530

Property	Standard		Unit	1,00 mm	1,50 mm	2,00 mm	≥ 2,50 mm
	DIN OEN EN ISO	ASTM					
Nominal Thickness	DIN 53 370		%	≤ ± 10	≤ ± 10	≤ ± 10	≤ ± 10
Density (black)	ISO 1183	D 792	g/cm³	≥ 0,94	≥ 0,94	≥ 0,94	≥ 0,94
MFR Melt Flow Rate (190°C/5kg)	ISO 1133 Cond. T	D 1238 Cond. P	g/10 min	0,6 - 1,4	0,6 - 1,4	0,6 - 1,4	0,6 - 1,4
Heat Reversion (100°C/1h)	OENORM S 2073	D 1204	%	≤ 2,0	≤ 2,0	≤ 2,0	≤ 1,0
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	130	130	130	130
Multiaxial Tension	OENORM S 2073		%	≥ 15	≥ 15	≥ 15	≥ 15
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 16	≥ 16	≥ 16	≥ 16
Elongation at Yield	ISO 527	D 6693	%	≥ 9	≥ 9	≥ 9	≥ 9
Elongation at Break	ISO 527	D 6693	%	≥ 150	≥ 400	≥ 400	≥ 400
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 450	≥ 800	≥ 1500	≥ 2000
		D 4833	N	267	400	534	667
Low Temperature Brittleness	DIN 16 726	D 746	°C	-20	-20	-20	-20
Water Absorption	ISO 62	D 570	%	≤ 0,1	≤ 0,1	≤ 0,1	≤ 0,1
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Rodent Resitance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Resitance to Leachate	OENORM S 2073	D 543	%	dimensional change ≤ 5 change of mechanical properties ≤ 20			
ESCR-Behaviour		D 1693	(h)	> 2000	> 2000	> 2000	> 2000
Carbon Black Content	ISO 6964		%	≥ 2	≥ 2	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11 420			A - 2	A - 2	A - 2	A - 2

The data in this table are approximate values and based upon results of the internal inspection, data of raw material suppliers as well as tests in the course of approval procedures and external inspections. The results can differ slightly from the indicated mean values in longitudinal and transverse direction and due to different nominal thicknesses and raw materials. In any case requirements relating to a special project (tender documents) have to be agreed with AGRU.
Independent of the indicated test standards, internal tests and data on test certificates are generally carried out in accordance with the appropriate test procedures according to OENORM (Austrian Standard) resp. DIN (German Standard) or EN ISO.
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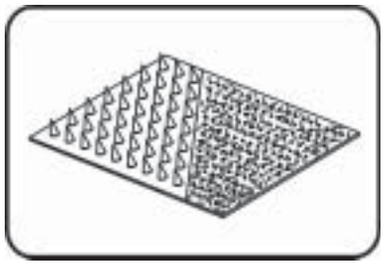
*) acc. OENORM S2073 liners made of polyolefins shall be considered resistant without proof being furnished.

- **Liner S/MSB**
  spike/microspike-5,15m
  calendered
- **Hot-wedge-welding**
- **HDPE black**



Code 528

Property	Standard		Unit	1,50 mm	2,00 mm	2,50 mm	≥ 3,00 mm
	DIN OEN EN ISO	ASTM					
Nominal Thickness	DIN 53 370		%	≤ ± 10	≤ ± 10	≤ ± 10	≤ ± 10
Density (black)	ISO 1183	D792	g/cm³	≥ 0,94	≥ 0,94	≥ 0,94	≥ 0,94
MFR Melt Flow Rate (190°C/5kg)	ISO 1133 Cond. T	D 1238 Cond. P	g/10 min	0,6 - 1,4	0,6 - 1,4	0,6 - 1,4	0,6 - 1,4
Heat Reversion (100°C/1h)	OENORM S 2073	D1204	%	≤ 2,0	≤ 2,0	≤ 1,5	≤ 1,5
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	130	130	130	130
Multiaxial Tension	OENORM S 2073		%	≥ 15	≥ 15	≥ 15	≥ 15
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 16	≥ 16	≥ 16	≥ 16
Elongation at Yield	ISO 527	D 6693	%	≥ 9	≥ 9	≥ 9	≥ 9
Elongation at Break	ISO 527	D 6693	%	≥ 400	≥ 400	≥ 400	≥ 400
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 800	≥ 1500	≥ 2000	≥ 2000
		D 4833	N	400	534	667	800
Low Temperature Brittleness	DIN 16 726	D 746	°C	-20	-20	-20	-20
Water Absorption	ISO 62	D 570	%	≤ 0,1	≤ 0,1	≤ 0,1	≤ 0,1
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Rodent Resitance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Resitance to Leachate	OENORM S 2073	D 543	%	dimensional change ≤ 5 change of mechanical properties ≤ 20			
ESCR-Behaviour		D 1693	(h)	> 2000	> 2000	> 2000	> 2000
Carbon Black Content	ISO 6964		%	≥ 2	≥ 2	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11420			A - 2	A - 2	A - 2	A - 2

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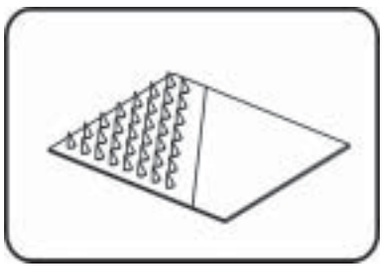
*) acc. OENORM S2073 liners made of polyolefins shall be considered resistant without proof being furnished.

- **Liner G/S**
  surface spike/smooth-5,15m
  calendered
- **Hot-wedge-welding**
- **HDPE black**



Code 520

Property	Standard		Unit	1,50 mm	2,00 mm	2,50 mm	≥ 3,00 mm
	DIN OEN EN ISO	ASTM					
Nominal Thickness	DIN 53 370		%	≤ ± 10	≤ ± 10	≤ ± 10	≤ ± 10
Density (black)	ISO 1183	D792	g/cm³	≥ 0,94	≥ 0,94	≥ 0,94	≥ 0,94
MFR Melt Flow Rate (190°C/5kg)	ISO 1133 Cond. T	D 1238 Cond. P	g/10 min	0,6 - 1,4	0,6 - 1,4	0,6 - 1,4	0,6 - 1,4
Heat Reversion (100°C/1h)	OENORM S 2073	D1204	%	≤ 2,0	≤ 2,0	≤ 1,5	≤ 1,5
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	130	130	130	130
Multiaxial Tension	OENORM S 2073		%	≥ 15	≥ 15	≥ 15	≥ 15
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 16	≥ 16	≥ 16	≥ 16
Elongation at Yield	ISO 527	D 6693	%	≥ 9	≥ 9	≥ 9	≥ 9
Elongation at Break	ISO 527	D 6693	%	≥ 400	≥ 400	≥ 400	≥ 400
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 800	≥ 1500	≥ 2000	≥ 2000
		D 4833	N	400	534	667	800
Low Temperature Brittleness	DIN 16 726	D 746	°C	-20	-20	-20	-20
Water Absorption	ISO 62	D 570	%	≤ 0,1	≤ 0,1	≤ 0,1	≤ 0,1
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Rodent Resitance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Resitance to Leachate	OENORM S 2073	D 543	%	dimensional change ≤ 5 change of mechanical properties ≤ 20			
ESCR-Behaviour		D 1693	(h)	> 2000	> 2000	> 2000	> 2000
Carbon Black Content	ISO 6964		%	≥ 2	≥ 2	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11420			A - 2	A - 2	A - 2	A - 2

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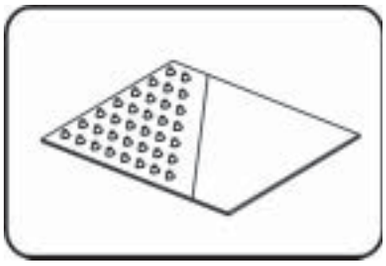
*) acc. OENORM S2073 liners made of polyolefins shall be considered resistant without proof being furnished.

HOME

- **Liner D/G**
  smooth/drainage stud-5,15m
  calendered
- **Hot-wedge-welding**
- **HDPE black**



Code 522

Property	Standard		Unit	1,50 mm	2,00 mm	2,50 mm	≥ 3,00 mm
	DIN OEN EN ISO	ASTM					
Nominal Thickness	DIN 53 370		%	≤ ± 10	≤ ± 10	≤ ± 10	≤ ± 10
Density (black)	ISO 1183	D792	g/cm³	≥ 0,94	≥ 0,94	≥ 0,94	≥ 0,94
MFR Melt Flow Rate (190°C/5kg)	ISO 1133/18 Cond. T	D 1238 Cond. P	g/10 min	0,6 - 1,4	0,6 - 1,4	0,6 - 1,4	0,6 - 1,4
Heat Reversion (100°C/1h)	OENORM S 2073	D1204	%	≤ 2,0	≤ 2,0	≤ 1,5	≤ 1,5
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	130	130	130	130
Multiaxial Tension	OENORM S 2073		%	≥ 15	≥ 15	≥ 15	≥ 15
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 16	≥ 16	≥ 16	≥ 16
Elongation at Yield	ISO 527	D 6693	%	≥ 9	≥ 9	≥ 9	≥ 9
Elongation at Break	ISO 527	D 6693	%	≥ 400	≥ 400	≥ 400	≥ 400
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 800	≥ 1500	≥ 2000	≥ 2000
		D 4833	N	400	534	667	800
Low Temperature Brittleness	DIN 16 726	D 746	°C	-20	-20	-20	-20
Water Absorption	ISO 62	D 570	%	≤ 0,1	≤ 0,1	≤ 0,1	≤ 0,1
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Rodent Resitance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Resitance to Leachate	OENORM S 2073	D 543	%	dimensional change ≤ 5 change of mechanical properties ≤ 20			
ESCR-Behaviour		D 1693	(h)	> 2000	> 2000	> 2000	> 2000
Carbon Black Content	ISO 6964		%	≥ 2	≥ 2	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11420			A - 2	A - 2	A - 2	A - 2

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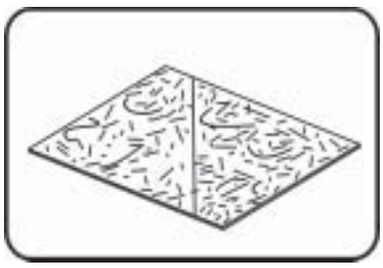
*) acc. OENORM S2073 liners made of polyolefins shall be considered resistant without proof being furnished.

Liner T/T
surface textured/textured-7m
calendered

Hot-wedge-welding

HDPE black



Code 527

Property	Standard		Unit	1,50mm	2,00mm	2,50 mm	≥ 3,00 mm
	DIN OEN EN ISO	ASTM					
Nominal Thickness	DIN 53 370		%	≤ ± 10	≤ ± 10	≤ ± 10	≤ ± 10
Density (black)	ISO 1183	D 792	g/cm³	≥ 0,94	≥ 0,94	≥ 0,94	≥ 0,94
MFR Melt Flow Rate (190°C/5kg)	ISO 1133/18 Cond. T	D 1238 Cond. P	g/10 min	0,6 - 1,4	0,6 - 1,4	0,6 - 1,4	0,6 - 1,4
Heat Reversion (100°C/1h)	OENORM S 2073	D1204	%	≤ 1,5	≤ 1,5	≤ 1,0	≤ 1,0
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	130	130	130	130
Multiaxial Tension	OENORM S 2073		%	≥ 20	≥ 20	≥ 20	≥ 20
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 16	≥ 16	≥ 16	≥ 16
Elongation at Yield	ISO 527	D 6693	%	≥ 9	≥ 9	≥ 9	≥ 9
Elongation at Break	ISO 527	D 6693	%	≥ 700	≥ 700	≥ 700	≥ 700
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 800	≥ 1500	≥ 2000	≥ 2000
		D 4833	N	480	640	800	960
Low Temperature Brittleness	DIN 16 726	D 746	°C	-20	-20	-20	-20
Water Absorption	ISO 62	D 570	%	≤ 0,1	≤ 0,1	≤ 0,1	≤ 0,1
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Rodent Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Resistance to Leachates	OENORM S 2073	D 543	%	dimensional change ≤ 5 change of mechanical properties ≤ 20			
ESCR-Behaviour		D 1693	(h)	> 2000	> 2000	> 2000	> 2000
Carbon Black Content	ISO 6964	D 1603	%	≥ 2	≥ 2	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11420	D 5596		A - 2	A - 2	A - 2	A - 2

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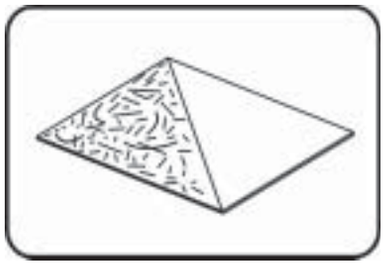
*) acc. OENORM S2073 liners made of polyolefins shall be considered resistant without proof being furnished.

HOME

- **Liner T/G**
  surface smooth/textured-7m
  calendered
- **Hot-wedge-welding**
- **HDPE black**



Code 517

Property	Standard		Unit	1,50mm	2,00mm	2,50 mm	≥ 3,00 mm
	DIN OEN EN ISO	ASTM					
Nominal Thickness	DIN 53 370		%	≤ ± 10	≤ ± 10	≤ ± 10	≤ ± 10
Density (black)	ISO 1183	D 792	g/cm³	≥ 0,94	≥ 0,94	≥ 0,94	≥ 0,94
MFR Melt Flow Rate (190°C/5kg)	ISO 1133/18 Cond. T	D 1238 Cond. P	g/10 min	0,6 - 1,4	0,6 - 1,4	0,6 - 1,4	0,6 - 1,4
Heat Reversion (100°C/1h)	OENORM S 2073	D1204	%	≤ 1,5	≤ 1,5	≤ 1,0	≤ 1,0
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	130	130	130	130
Multiaxial Tension	OENORM S 2073		%	≥ 20	≥ 20	≥ 20	≥ 20
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 16	≥ 16	≥ 16	≥ 16
Elongation at Yield	ISO 527	D 6693	%	≥ 9	≥ 9	≥ 9	≥ 9
Elongation at Break	ISO 527	D 6693	%	≥ 700	≥ 700	≥ 700	≥ 700
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 800	≥ 1500	≥ 2000	≥ 2000
		D 4833	N	400	534	667	800
Low Temperature Brittleness	DIN 16 726	D 746	°C	-20	-20	-20	-20
Water Absorption	ISO 62	D 570	%	≤ 0,1	≤ 0,1	≤ 0,1	≤ 0,1
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Rodent Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Resistance to Leachates	OENORM S 2073	D 543	%	dimensional change ≤ 5 change of mechnaical properties ≤ 20			
ESCR-Behaviour		D 1693	(h)	> 2000	> 2000	> 2000	> 2000
Carbon Black Content	ISO 6964	D 1603	%	≥ 2	≥ 2	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11420	D 5596		A - 2	A - 2	A - 2	A - 2

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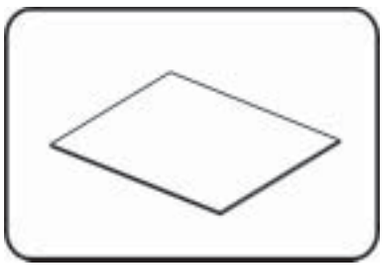
*) acc. OENORM S2073 liners made of polyolefins shall be considered resistant without proof being furnished.

HOME

- **Liner with Aluminium-Barrier**
  1,35m
  calendered
- **Hot-wedge-welding**
- **HDPE black**



Code 20.568

Property	Test Method	Unit	2,50 mm	3,00 mm
Thickness	DIN 53 370	%	± 10	± 10
Density (black)	ISO 1183	g/cm³	≥ 0,94	≥ 0,94
Melt Flow Index (190°C/5kg)	ISO 1133 Cond. T	g/10 min	0,6 - 1,4	0,6 - 1,4
Heat Reversion (110°C/1,5h)	ISO 14 632	%	≤ 3	≤ 3
Elongation at Yield	ISO 527	%	≥ 9	≥ 9
Tensile Stress at Yield	ISO 527	N/mm²	≥ 16	≥ 16
Elongation at Break	ISO 527	%	≥ 700[1)]	≥ 700[1)]
Root Resistance	OENORM S 2073		fulfilled*	fulfilled*
Microorganism Restistance	OENORM S 2073		fulfilled*	fulfilled*
Rodent Residence	OENORM S 2073		fulfilled*	fulfilled*
Resistance to Leachate	OENORM S 2073	%	dimensional change ≤ 5 change of mechanical properties ≤ 20	dimensional change ≤ 5 change of mechanical properties ≤ 20
Carbon Black Content	ISO 6964	%	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11420		A - 2	A - 2

width of the aluminium barrier 1,298m

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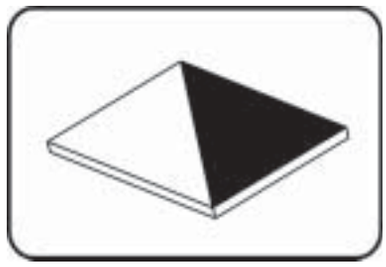
HOME

- **Liner with Signal-Layer**
  surface smooth/smooth-5m
  coextruded/calendered
- **Hot-wedge-welding**
- **HDPE black/white**



Code 609

Property	Standard		Unit	1,50mm	2,00mm	≥ 2,50 mm
	DIN OEN EN ISO	ASTM				
Nominal Thickness	DIN 53 370		%	≤ ± 10	≤ ± 10	≤ ± 10
Density (black)	ISO 1183	D 792	g/cm³	≥ 0,94	≥ 0,94	≥ 0,94
MFR Melt Flow Rate (190°C/5kg)	ISO 1133 Cond. T	D 1238 Cond. P	g/10 min	0,6 - 1,4	0,6 - 1,4	0,6 - 1,4
Heat Reversion (100°C/1h)	OENORM S 2073	D1204	%	≤ 1,5	≤ 1,0	≤ 1,0
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	130	130	130
Multiaxial Tension	OENORM S 2073		%	≥ 20	≥ 20	≥ 25
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 16	≥ 16	≥ 16
Elongation at Yield	ISO 527	D 6693	%	≥ 9	≥ 9	≥ 9
Elongation at Break	ISO 527	D 6693	%	≥ 700	≥ 700	≥ 700
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 800	≥ 1500	≥ 2000
		D 4833	N	480	640	800
Low Temperature Brittleness	DIN 16 726	D 746	°C	-20	-20	-20
Water Absorption	ISO 62	D 570	%	≤ 0,1	≤ 0,1	≤ 0,1
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Rodent Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Resistance to Leachates	OENORM S 2073	D 543	%	dimensional change ≤ 5 change of mechanical properties ≤ 20		
ESCR-Behaviour		D 1693	(h)	> 2000	> 2000	> 2000
Carbon Black Content	ISO 6964	D 1603	%	≥ 2	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11420	D 5596		A - 2	A - 2	A - 2

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*) acc. OENORM S2073 liners made of polyolefins shall be considered resistant without proof being furnished.

HOME


Code 500/507


Code 529/537

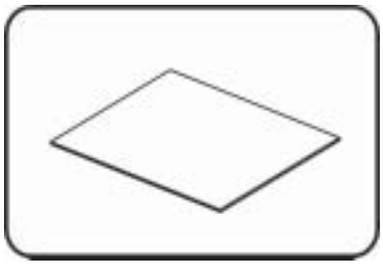

Code 530/540

HOME

Material Properties
Installation Guidelines
Calculation Guidelines
Connection Systems
Applications and References
Approvals and Standards

HOME

- **Liner G/G**
  surface smooth/smooth-5/7m
  calendered
- **Hot-wedge-welding**
- **HDPE black**



Code 500/507

Property	Standard		Unit	2,00mm	2,50 mm	3,00 mm
	DIN OEN EN ISO	ASTM				
Nominal Thickness	DIN 53 370		%	≤ +10/- 0	≤ +10/- 0	≤ +10/- 0
Density (black)	ISO 1183	D 792	g/cm³	≥ 0,94	≥ 0,94	≥ 0,94
MFR Melt Flow Rate (190°C/5kg)	ISO 1133 Cond. T	D 1238 Cond. P	g/10 min	1,6 - 3,0	1,6 - 3,0	1,6 - 3,0
Heat Reversion (100°C/1h)	OENORM S 2073	D1204	%	≤ 1,0	≤ 1,0	≤ 1,0
Tear Resistance	ISO 34-1	D 1004	N/mm	120	120	120
Multiaxial Tension	OENORM S 2073		%	≥ 20	≥ 25	≥ 25
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 15	≥ 15	≥ 15
Elongation at Yield	ISO 527	D 6693	%	≥ 12	≥ 12	≥ 12
Elongation at Break	ISO 527	D 6693	%	≥ 800	≥ 800	≥ 800
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 1500	≥ 2000	≥ 2000
		D 4833	N	640	800	960
Low Temperature Brittleness	DIN 16 726	D 746	°C	-20	-20	-20
Water Absorption	ISO 62	D 570	%	≤ 0,1	≤ 0,1	≤ 0,1
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Rodent Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Resistance to Leachates	OENORM S 2073	D 543	%	dimensional change ≤ 5 change of mechanical properties ≤ 20		
ESCR-Behaviour		D 5397	(h)	> 300	> 300	> 300
Carbon Black Content	ISO 6964	D 1603	%	≥ 2	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11420	D 5596		A - 2	A - 2	A - 2

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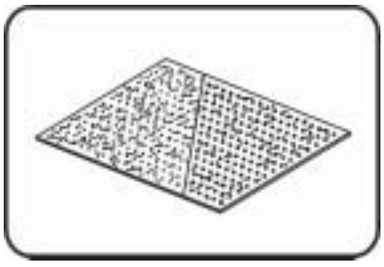
*) acc. OENORM S2073 liners made of polyolefins shall be considered resistant without proof being furnished.

- **Liner MST/MSB**
  microspike/microspike-5,15/7m
  calendered
- **Hot-wedge-welding**
- **HDPE black**



Code 529/537

Property	Standard		Unit	2,00 mm	2,50 mm	3,00 mm
	DIN OEN EN ISO	ASTM				
Nominal Thickness	DIN 53 370		%	≤ +10/- 0	≤ +10/- 0	≤ +10/- 0
Density (black)	ISO 1183	D 792	g/cm³	≥ 0,94	≥ 0,94	≥ 0,94
MFR Melt Flow Rate (190°C/5kg)	ISO 1133 Cond. T	D 1238 Cond. P	g/10 min	1,6 - 3,0	1,6 - 3,0	1,6 - 3,0
Heat Reversion (100°C/1h)	OENORM S 2073	D 1204	%	≤ 2,0	≤ 1,0	≤ 1,0
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	130	130	130
Multiaxial Tension	OENORM S 2073		%	≥ 15	≥ 15	≥ 15
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 15	≥ 15	≥ 15
Elongation at Yield	ISO 527	D 6693	%	≥ 12	≥ 12	≥ 12
Elongation at Break	ISO 527	D 6693	%	≥ 400	≥ 400	≥ 400
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 1500	≥ 2000	≥ 2000
		D 4833	N	530	667	800
Low Temperature Brittleness	DIN 16 726	D 746	°C	-20	-20	-20
Water Absorption	ISO 62	D 570	%	≤ 0,1	≤ 0,1	≤ 0,1
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Rodent Resitance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Resitance to Leachates	OENORM S 2073	D 543	%	dimensional change ≤ 5 change of mechanical properties ≤ 20		
ESCR-Behaviour		D 5397	(h)	> 300	> 300	> 300
Carbon Black Content	ISO 6964		%	≥ 2	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11 420			A - 2	A - 2	A - 2

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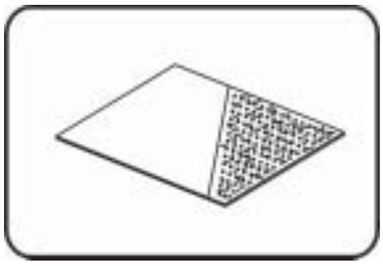
*) acc. OENORM S2073 liners made of polyolefins shall be considered resistant without proof being furnished.

HOME

- **Liner G/MSB**
  smooth/microspike-5,15m
  calendered
- **Hot-wedge-welding**
- **HDPE black**



Code 530

Property	Standard		Unit	2,00 mm	2,50 mm	3,00 mm
	DIN OEN EN ISO	ASTM				
Nominal Thickness	DIN 53 370		%	≤ +10/-0	≤ +10/-0	≤ +10/-0
Density (black)	ISO 1183	D 792	g/cm³	≥ 0,94	≥ 0,94	≥ 0,94
MFR Melt Flow Rate (190°C/5kg)	ISO 1133 Cond. T	D 1238 Cond. P	g/10 min	1,6 - 3,0	1,6 - 3,0	1,6 - 3,0
Heat Reversion (100°C/1h)	OENORM S 2073	D 1204	%	≤ 2,0	≤ 1,0	≤ 1,0
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	120	120	120
Multiaxial Tension	OENORM S 2073		%	≥ 15	≥ 15	≥ 15
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 15	≥ 15	≥ 15
Elongation at Yield	ISO 527	D 6693	%	≥ 12	≥ 12	≥ 12
Elongation at Break	ISO 527	D 6693	%	≥ 400	≥ 400	≥ 400
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 1500	≥ 2000	≥ 2000
		D 4833	N	530	660	800
Low Temperature Brittleness	DIN 16 726	D 746	°C	-20	-20	-20
Water Absorption	ISO 62	D 570	%	≤ 0,1	≤ 0,1	≤ 0,1
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Rodent Resitance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Resitance to LeachateS	OENORM S 2073	D 543	%	dimensional change ≤ 5 change of mechanical properties ≤ 20		
ESCR-Behaviour		D 5397	(h)	> 300	> 300	> 300
Carbon Black Content	ISO 6964		%	≥ 2	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11 420			A - 2	A - 2	A - 2

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Code 500.1/507.1

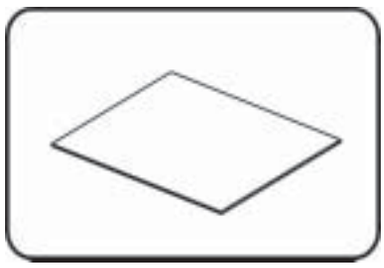

Code 529.1/537.1


Code 530.1

HOME

HOME

- **Liner G/G**
  surface smooth/smooth-5/7m
  calendered
- **Hot-wedge-welding**
- **HDPE black**



Code 500.1/507.1

Property	Standard		Unit	2,50 mm
	DIN OEN EN ISO	ASTM		
Nominal Thickness	DIN 53 370		%	≤ + 10/- 0
Density (black)	ISO 1183	D 792	g/cm³	≥ 0,94
MFR Melt Flow Rate (190°C/5kg)	ISO 1133 Cond. T	D 1238 Cond. P	g/10 min	1,6 - 3,0
Heat Reversion (100°C/1h)	OENORM S 2073	D1204	%	≤ 1,0
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	120
Multiaxial Tension	OENORM S 2073		%	≥ 20
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 15
Elongation at Yield	ISO 527	D 6693	%	≥ 12
Elongation at Break	ISO 527	D 6693	%	≥ 800
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 2000
		D 4833	N	800
Low Temperature Brittleness	DIN 16 726	D 746	°C	-20
Water Absorption	ISO 62	D 570	%	≤ 0,1
Root Resistance	OENORM S 2073			fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*
Rodent Resistance	OENORM S 2073			fulfilled*
Resistance to Leachates	OENORM S 2073	D 543	%	dimensional change ≤ 5 change of mechanical properties ≤ 20
ESCR-Behaviour		D 5397	(h)	> 300
Carbon Black Content	ISO 6964	D 1603	%	≥ 2
Carbon Black Dispersion	ISO 11420	D 5596		A - 2

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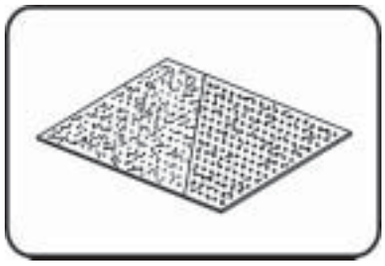
*) acc. OENORM S2073 liners made of polyolefins shall be considered resistant without proof being furnished.

- **Liner MST/MSB**
  microspike/microspike-5,15/7m
  calendered
- **Hot-wedge-welding**
- **HDPE black**



Code 529.1/537.1

Property	Standard		Unit	2,50 mm
	DIN OEN EN ISO	ASTM		
Nominal Thickness	DIN 53 370		%	≤ + 10/- 0
Density (black)	ISO 1183	D 792	g/cm³	≥ 0,94
MFR Melt Flow Rate (190°C/5kg)	ISO 1133 Cond. T	D 1238 Cond. P	g/10 min	1,6 - 3,0
Heat Reversion (100°C/1h)	OENORM S 2073	D 1204	%	≤ 1,0
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	130
Multiaxial Tension	OENORM S 2073		%	≥ 15
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 15
Elongation at Yield	ISO 527	D 6693	%	≥ 12
Elongation at Break	ISO 527	D 6693	%	≥ 400
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 2000
		D 4833	N	667
Low Temperature Brittleness	DIN 16 726	D 746	°C	-20
Water Absorption	ISO 62	D 570	%	≤ 0,1
Root Resistance	OENORM S 2073			fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*
Rodent Resitance	OENORM S 2073			fulfilled*
Resitance to Leachates	OENORM S 2073	D 543	%	dimensional change ≤ 5 change of mechanical properties ≤ 20
ESCR-Behaviour		D 5397	(h)	> 300
Carbon Black Content	ISO 6964		%	≥ 2
Carbon Black Dispersi	ISO 11 420			A - 2

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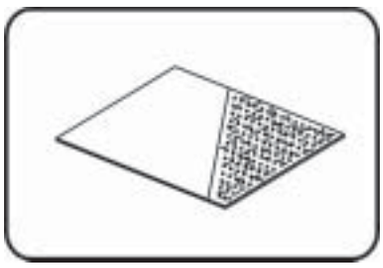
*) acc. OENORM S2073 liners made of polyolefins shall be considered resistant without proof being furnished.

- **Liner G/MSB**
  smooth/microspike-5,15m
  calendered
- **Hot-wedge-welding**
- **HDPE black**



Code 530.1

Property	Standard		Unit	2,50 mm
	DIN OEN EN ISO	ASTM		
Nominal Thickness	DIN 53 370		%	≤ ± 10
Density (black)	ISO 1183	D 792	g/cm³	≥ 0,94
MFR Melt Flow Rate (190°C/5kg)	ISO 1133 Cond. T	D 1238 Cond. P	g/10 min	1,6 - 3,0
Heat Reversion (100°C/1h)	OENORM S 2073	D 1204	%	≤ 1,0
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	120
Multiaxial Tension	OENORM S 2073		%	≥ 15
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 15
Elongation at Yield	ISO 527	D 6693	%	≥ 12
Elongation at Break	ISO 527	D 6693	%	≥ 400
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 2000
		D 4833	N	660
Low Temperature Brittleness	DIN 16 726	D 746	°C	-20
Water Absorption	ISO 62	D 570	%	≤ 0,1
Root Resistance	OENORM S 2073			fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*
Rodent Resitance	OENORM S 2073			fulfilled*
Resitance to Leachates	OENORM S 2073	D 543	%	dimensional change ≤ 5 change of mechanical properties ≤ 20
ESCR-Behaviour		D 5397	(h)	> 300
Carbon Black Content	ISO 6964		%	≥ 2
Carbon Black Dispersion	ISO 11 420			A - 2

The data in this table are approximate values and based upon results of the internal inspection, data of raw material suppliers as well as tests in the course of approval procedures and external inspections. The results can differ slightly from the indicated mean values in longitudinal and transverse direction and due to different nominal thicknesses and raw materials. In any case requirements relating to a special project (tender documents) have to be agreed with AGRU.
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HOME

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AGRUFLEX VLDPE Liners

The PE poduct range is completed with the AGRUFLEX VLDPE Liners.
Those combine advantages of HDPE Liners with a highest flexibility.
The "ultra-light" Polyethylens are defined by increased branching factor of the PE molecular structure which results in a lower density.
The AGRUFLEX VLDPE liners are a high quality sealing element, developed according to the latest state of art material and production technology.
Its excellent physical properties and good chemical resistance provide a wide application range for lining products out of VLDPE.

Lasting Containment

Concerning the long time behaviour VLDPE as a polyolefin product similar performance as HDPE can be expected.
Polyolefin liners are used for sealing of tunnel constructions.Tunnel liners are mechanically and chemically strained by settlements and displacements of rock and aggressive mountain waters.
Typically those constructions are designed for a minimum of 100 years lifetime.
VLDPE contains no volatile plasticizers so perfect properties of high flexibility, tensile and elongation at break remain the whole lifetime.

Advantages of AGRUFLEX

VLDPE has compared to HDPE no defined yield point, whereby the material can be elongated at the multiaxial tension at more than 250% and so a good adjustement to the existing contour at complex aquacultural constructions is given.
The chemical resistance compared to HDPE is e.g. for hydrocarbons significantely lower, but VLDPE shows very good chemical resistance compared to similar liner materials.

More advantages of VLDPE liners are:

- low density
- good weldability
- hight flexibility
- high tear strength and elongation at break
- highest multiaxial tension
- high compression strength
- Resistant to UV- and weathering
- Resistant to roots and rodents
- food grade
- physiolical harmless

VLDPE is superior to PVC for the following reasons:

- 1/3 lower density
- free of plasticizers
- halogen free
- free of heavy metals
- generally better chemical resistance
- varios applications in the food industry and storage of potable water
- no dangerous HCL gases at burning or welding
- VLDPE keeps its mechanical properties (no volatile additives)

HOME

Applications

AGRUFLEX Liners are perfect for engineered waterprofing for a wide range in civil- and hydraulic engineering applications:

- tunnel constructions
- pond construction
- erosion control
- canal sealing
- basin lining
- tank sealing
- waste disposal lining
- drinking water tank sealing
- contamination protection of tanks

Simple Installation

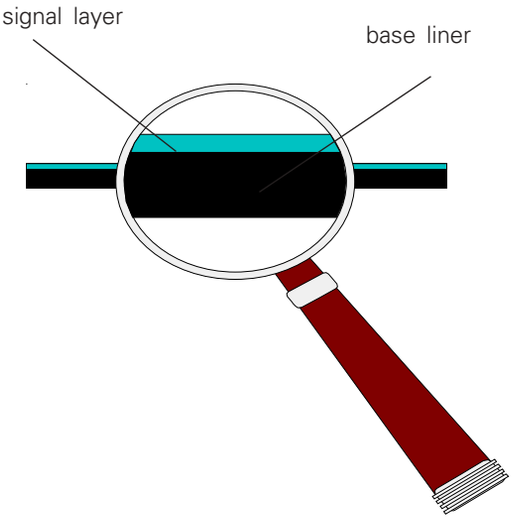
The proper installation and welding of the AGRU VLDPE Liners are of paramount importance since integrity and long term performance are dependent upon it.Typically seaming the liners is carried out by hot wedge welding that provides a double welded seam with a test channel.
The installation of AGRU FLEX Liners is performed by qualified and authorized installers.

Quality Assured

Applying a strict Quality Managment program summerized by internal quality control, ISO 9001:2000 certification, frequrent external quality inspections by state authorized testing institutes such as MPA, SKZ, ÖFI etc. and approval quality marks by BAM, DIBt, OENORM, KIWA, Asqual... ensures continuous high quality of AGRU products.
Tracing and control from the incoming raw materials to the finished liners allow work certificates to be issued linked to the used raw material batch (acc. to EN 10204/DIN 50049).

AGRU Pondliner

The AGRU VLDPE Pondliner is manufactured with a black base liner and a coextruded thin colour layer. This homogenous liner with a signal layer, which is UV stabilized, can be used for ponds without cover or recultivation layer.
The turquoise signal layer results in optical depth effect, which looks very natural. The ground layer (VLDPE black) fullfills the mechanical properties.
The signal layer beside the optical appearance it is an indicator for damages .
(special colours on request)



HOME


Code 500


Code 529


Code 530


Code 609


Code 609.1

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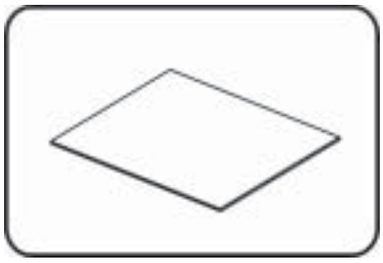
- **Liner G/G**
  surface smooth/smooth-5m
  calendered
- **Hot-wedge-welding**
- **Agruflex VLDPE black**



Code 500

Property	Standard		Unit	1,00mm	1,50mm	≥ 2,00mm
	DIN OEN EN ISO	ASTM				
Nominal Thickness	DIN 53 370		%	≤ ± 10	≤ ± 10	≤ ± 10
Density (black)	ISO 1183	D 792	g/cm³	≥ 0,90	≥ 0,90	≥ 0,90
MFR Melt Flow Rate (190°C/2,16kg)	ISO 1133 Cond. D	D 1238 Cond. E	g/10 min	0,8 - 1,2	0,8 - 1,2	0,8 - 1,2
Heat Reversion (80°C/6h)	DIN 16 726	D1204	%	≤ 3	≤ 2	≤ 2
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	70	70	70
Multiaxial Tension	OENORM S 2073		%	≥ 50	≥ 100	≥ 100
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 5	≥ 5	≥ 5
Elongation at Break	ISO 527	D 6693	%	≥ 600	≥ 700	≥ 700
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 350	≥ 600	≥ 800
		D 4833	N	200	300	400
Low Temperature Brittleness	DIN 16 726	D 746	°C	- 40	- 40	- 40
Water Absorption	ISO 62	D 570	%	≤ 1,0	≤ 1,0	≤ 1,0
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Rodent Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
ESCR-Behaviour		D 1693	(h)	> 2000	> 2000	> 2000
Carbon Black Content	ISO 6964	D 1603	%	≥ 2	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11420	D 5596		A - 2	A - 2	A - 2

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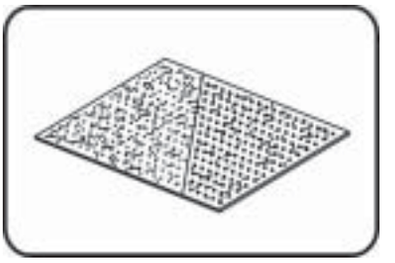
HOME

- **Liner MST/MSB**
  microspike/microspike-5,15m
  calendered
- **Hot-wedge-welding**
- **Agruflex VLDPE black**



Code 529

Property	Standard		Unit	1,00mm	1,50mm	≥ 2,00mm
	DIN OEN EN ISO	ASTM				
Nominal Thickness	DIN 53 370		%	≤ ± 10	≤ ± 10	≤ ± 10
Density (black)	ISO 1183	D 792	g/cm^3	≥ 0,90	≥ 0,90	≥ 0,90
MFR Melt Flow Rate (190°C/2,16kg)	ISO 1133 Cond. D	D 1238 Cond. E	g/10 min	0,8 - 1,2	0,8 - 1,2	0,8 - 1,2
Heat Reversion (80°C/6h)	DIN 16 726	D1204	%	≤ 3	≤ 3	≤ 3
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	70	70	70
Multiaxial Tension	OENORM S 2073		%	≥ 50	≥ 100	≥ 100
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 5	≥ 5	≥ 5
Elongation at yield	ISO 527	D 6693	%	≥ 15	≥ 20	≥ 20
Elongation at Break	ISO 527	D 6693	%	≥ 400	≥ 600	≥ 600
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 350	≥ 600	≥ 1000
		D 4833	N	200	300	500
Low Temperature Brittleness	DIN 16 726	D 746	°C	- 40	- 40	- 40
Water Absorption	ISO 62	D 570	%	≤ 1,0	≤ 1,0	≤ 1,0
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Rodent Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
ESCR-Behaviour		D 1693	(h)	> 2000	> 2000	> 2000
Carbon Black Content	ISO 6964	D 1603	%	≥ 2	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11420	D 5596		A - 2	A - 2	A - 2

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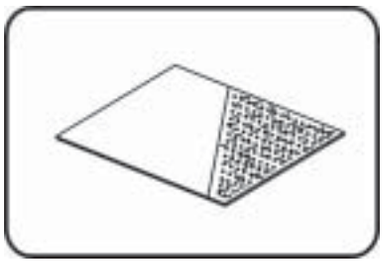
HOME

Liner G/MSB
smooth/microspike-5,15m
calendered

Hot-wedge-welding

Agruflex VLDPE black



Code 530

Property	Standard		Unit	1,00mm	1,50mm	≥ 2,00mm
	DIN OEN EN ISO	ASTM				
Nominal Thickness	DIN 53 370		%	≤ ± 10	≤ ± 10	≤ ± 10
Density (black)	ISO 1183	D 792	g/cm^3	≥ 0,90	≥ 0,90	≥ 0,90
MFR Melt Flow Rate (190°C/2,16kg)	ISO 1133 Cond. D	D 1238 Cond. E	g/10 min	0,8 - 1,2	0,8 - 1,2	0,8 - 1,2
Heat Reversion (80°C/6h)	DIN 16 726	D1204	%	≤ 3	≤ 3	≤ 3
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	70	70	70
Multiaxial Tension	OENORM S 2073		%	≥ 50	≥ 100	≥ 100
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 5	≥ 5	≥ 5
Elongation at yield	ISO 527	D 6693	%	≥ 15	≥ 20	≥ 20
Elongation at Break	ISO 527	D 6693	%	≥ 400	≥ 600	≥ 600
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 350	≥ 600	≥ 1000
		D 4833	N	200	300	500
Low Temperature Brittleness	DIN 16 726	D 746	°C	- 40	- 40	- 40
Water Absorption	ISO 62	D 570	%	≤ 1,0	≤ 1,0	≤ 1,0
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Rodent Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
ESCR-Behaviour		D 1693	(h)	> 2000	> 2000	> 2000
Carbon Black Content	ISO 6964	D 1603	%	≥ 2	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11420	D 5596		A - 2	A - 2	A - 2

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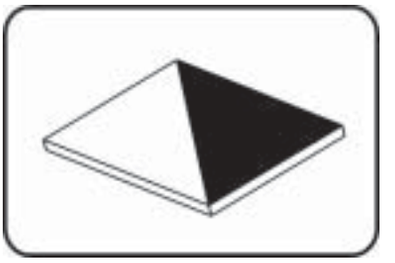
*) acc. OENORM S2073 liners made of polyolefins shall be considered resistant without proof being furnished.

HOME

- **Liner with Signal-Layer**
  surface smooth/smooth-5m
  coextruded/calendered
- **Hot-wedge-welding**
- **AGRUFLEX VLDPE black/white**



Code 609

Property	Standard		Unit	2,00mm	≥ 2,50mm
	DIN OEN EN ISO	ASTM			
Nominal Thickness	DIN 53 370		%	≤ ± 10	≤ ± 10
Density (black)	ISO 1183	D 792	g/cm³	≥ 0,90	≥ 0,90
MFR Melt Flow Rate (190°C/2,16kg)	ISO 1133 Cond. D	D 1238 Cond. E	g/10 min	0,8 - 1,2	0,8 - 1,2
Heat Reversion (80°C/6h)	DIN 16 726	D1204	%	≤ 2	≤ 2
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	70	70
Multiaxial Tension	OENORM S 2073		%	≥ 100	≥ 100
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 5	≥ 5
Elongation at Break	ISO 527	D 6693	%	≥ 700	≥ 800
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 800	≥ 1000
		D 4833	N	300	400
Low Temperature Brittleness	DIN 16 726	D 746	°C	-40	-40
Water Absorption	ISO 62	D 570	%	≤ 1,0	≤ 1,0
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*
Rodent Resistance	OENORM S 2073			fulfilled*	fulfilled*
ESCR-Behaviour		D 1693	(h)	> 2000	> 2000
Carbon Black Content	ISO 6964	D 1603	%	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11420	D 5596		A - 2	A - 2

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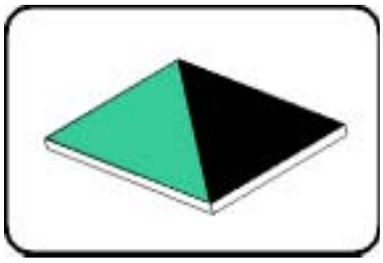
HOME

Pondliner
surface smooth/smooth-2m
coextruded/calendered

Hot-wedge-welding

VLDPE black/turquoise RAL5018



Code 609.1

Property	Standard		Unit	1,50mm
	DIN OEN EN ISO	ASTM		
Nominal Thickness	DIN 53 370		%	≤ ± 10
Density (black)	ISO 1183	D 792	g/cm³	≥ 0,90
MFR Melt Flow Rate (190°C/2,16kg)	ISO 1133 Cond. D	D 1238 Cond. E	g/10 min	0,8 - 1,2
Heat Reversion (80°C/6h)	DIN 16 726	D1204	%	≤ 2
Tear Resistance	DIN EN ISO 34-1	D 1004	N/mm	70
Multiaxial Tension	OENORM S 2073		%	≥ 100
Tensile Stress at Yield	ISO 527	D 6693	N/mm²	≥ 5
Elongation at Break	ISO 527	D 6693	%	≥ 700
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 600
		D 4833	N	300
Low Temperature Brittleness	DIN 16 726	D 746	°C	- 40
Water Absorption	ISO 62	D 570	%	≤ 1,0
Root Resistance	OENORM S 2073			fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*
Rodent Resistance	OENORM S 2073			fulfilled*
ESCR-Behaviour		D 1693	(h)	> 2000
Carbon Black Content	ISO 6964	D 1603	%	≥ 2
Carbon Black Dispersion	ISO 11420	D 5596		A - 2

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HOME

HOME

AGRUFLEX FPP (PP-flex)

The latest polyolefine material, which was introduced by Montell in the early 1990's.
This on rather stiff Polypropylen based material, wich has been specially developed for sealing engineering, is manufactured in a reactor in which EPR (Ethylen Propylene Rubber) is arranged into semi-cristalline PP-Matrix.
This alloy combines, because of the very low cristalllinity without addition of volatile plasticizers, the resistance and strength of PP with highest flexibility and is thereby completely homogenous. In addition, FPP shows high permeation resitance and a good chemical resistance. Liners out of FPP have a lower thermal expansion coefficient than materials which are based on PE, having a higher puncture resistance and are non-sensitive against stress cracking.
The AGRU FPP liners are a high qualitative sealing element, developed after the newest state of art, and open a wide application range.
Beside smooth liners also structured and scrim reinforced liners are available.

Lasting Containment

FPP was tested several times und shows excellent behaviour in stress cracking and artificial UV-weathering like Emmaqua or Xenon irridation which indicate the durability of the product.
Also at miscellaneous applications with direct weathering of the liners had no change of the properties after 10 years occur.

Advantages of FPP

FPP is as a result of the low cristillinity a high flexible material, which shows no distinctive yield point and because of this pre-make of large areas and delivery in folded status is possible. The ductility and the nearly rubberelastic behaviour of the liner offers new constructive ways and closest application radii at transitions.

FPP advantages are:

- low density compared to otherplastics good weldability
- high flexibility
- very tough
- high resistance against chemicals
- excellent ESCR-behaviour
- UV-resistant
- no volatile additives
- preservation of the mechanical properties
- food grade
-

FPP is superior to PVC for the following reasons:

- 1/3 lower density
- free of plasticizers
- halogen free
- free of heavy metals
- generally better chemical resistance
- varios applications in the food industry and storage of potable water
- no dangerous HCL gases at burning or welding
- FPP keeps its mechanical properties (no volatile additives)

HOME

Applications

FPP Liners are especially used for water engineering solutions such as:

- civil engineering
- pond construction
- erosion protection
- tank sealings
- waste disposal cappings
- sealing of indoor/outdoor water basins
- floating covers (scrim reinforced)

AGRUFLEX FPP pond liner with glass fibre fabric reinforcement

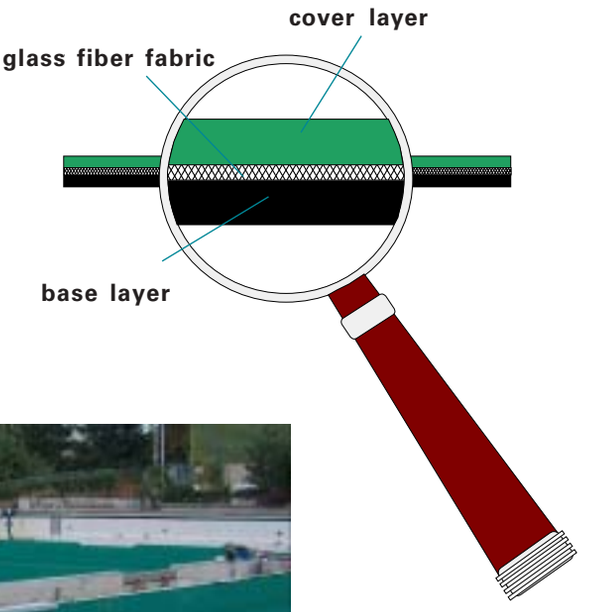
The AGRU FPP supply range has been extended with coextruded liners(5m width) but also with a centric laminated glass fibre fabric(2m width) achieving dimensional stability for swimming pond applications.
The typical behaviour of thermal epansion (waviness) for polyolefin liners is significantly minimized by glass fibre reinforcement and results in perfectly flat appearance of lined surfaces.
The signal layer (green similar to RAL 6001) is generelly manufactured with optimized UV-stabilization.
The physical properties and weldability are identical to the Austroplan G-types.

Installation

FPP liners can not be welded together with products or liners based on Polyethylene, but good welding results with PP products can be achieved.
FPP shows a large welding window and it's possible to weld it by hand-welding for small areas because of its tender-elastic properties.
The proper installation and welding of the FPP Liner is of paramount importance since the integrity and long term performance are dependent upon it.
The welding is carried out either by hot gas welding, hot gas double seam or hot wedge welding according to DVS standards (German Welding Standard). With hot wedge welding, the surfaces to be joined are first melted and then bonded by means of rollers.

Quality Assured

Due to our extensive ISO 9000 certified quality assurance programs via internal and external control by state authorised testing institutes the continuous high quality of FPP liners is ensured.
Strict quality controls from the incoming raw material to the final control of the finished liner allows works certificates to be issued for each batch.



HOME


Code 500


Code 529

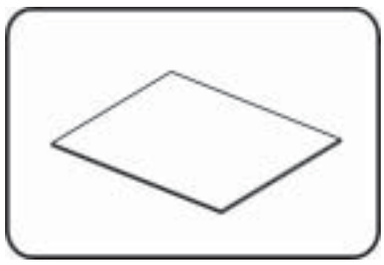

Code 530


Code 531

HOME

HOME

- **Liner G/G**
  surface smooth/smooth-5m
  calendered
- **Hot-wedge-welding**
- **Agruflex FPP black**



Code 500

Property	Standard		Unit	1,00mm	1,50mm	≥ 2,00mm
	DIN OEN EN ISO	ASTM				
Nominal Thickness	DIN 53 370		%	≤ ± 10	≤ ± 10	≤ ± 10
Density (black)	ISO 1183	D 792	g/cm^3	≤ 0,90	≤ 0,90	≤ 0,90
MFR Melt Flow Rate (230°C/2,16kg)	ISO 1133 Cond. M	D 1238 Cond. L	g/10 min	0,2 - 0,6	0,2 - 0,6	0,2 - 0,6
Heat Reversion (80°C/6h)	DIN 16 726	D1204	%	≤ 2	≤ 2	≤ 2
Tear Resistance	ISO 34-1	D 1004	N/mm	60	60	60
Multiaxial Tension	OENORM S 2073	D 5617	%	≥ 50	≥ 50	≥ 50
Tensile Stress at Break	ISO 527	D 6693	N/mm²	≥ 12	≥ 12	≥ 12
Elongation at Break	ISO 527	D 6693	%	≥ 300	≥ 300	≥ 300
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 350	≥ 600	≥ 800
		D 4833	N	130	195	260
Low Temperature Brittleness	DIN 16 726	D 746	°C	- 40	- 40	- 40
Water Absorption	ISO 62	D 570	%	≤ 1,0	≤ 1,0	≤ 1,0
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
Rodent Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*
ESCR-Behaviour		D 1693	(h)	> 2000	> 2000	> 2000
Carbon Black Content	ISO 6964	D 1603	%	≥ 2	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11420	D 5596		A - 2	A - 2	A - 2

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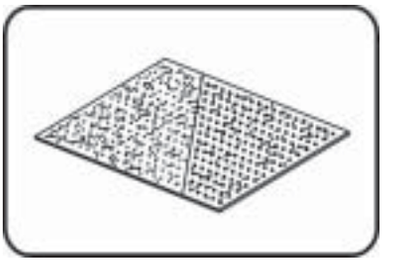
HOME

- **Liner MST/MSB**
  microspike/microspike-5,15 m
  calendered
- **Hot-wedge-welding**
- **Agruflex FPP flex**



Code 529

Property	Standard		Unit	1,00mm	1,50mm	2,00mm	≥ 2,50mm
	DIN OEN EN ISO	ASTM					
Nominal Thickness	DIN 53 370		%	≤ ± 10	≤ ± 10	≤ ± 10	≤ ± 10
Density (black)	ISO 1183	D 792	g/cm³	≤ 0,90	≤ 0,90	≤ 0,90	≤ 0,90
MFR Melt Flow Rate (230°C/2,16kg)	ISO 1133 Cond. M	D 1238 Cond. L	g/10 min	0,2 - 0,6	0,2 - 0,6	0,2 - 0,6	0,2 - 0,6
Heat Reversion (80°C/6h)	DIN 16 726	D1204	%	≤ 2	≤ 2	≤ 2	≤ 2
Tear Resistance	DIN EN ISO 34-1	D 1004	N	60	60	60	60
Multiaxial Tension	OENORM S 2073		%	≥ 50	≥ 50	≥ 50	≥ 50
Tensile Stress at Break	ISO 527	D 6693	N/mm²	≥ 12	≥ 12	≥ 12	≥ 12
Elongation at Break	ISO 527	D 6693	%	≥ 300	≥ 300	≥ 300	≥ 300
Puncture Resistance	DIN 16 726 (Drop Test)		mm	≥ 350	≥ 600	≥ 800	≥ 1000
		D 4833	N	130	195	260	325
Low Temperature Brittleness	DIN 16 726	D 746	°C	- 40	- 40	- 40	- 40
Water Absorption	ISO 62	D 570	%	≤ 1,0	≤ 1,0	≤ 1,0	≤ 1,0
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Rodent Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
ESCR-Behaviour		D 1693	(h)	> 2000	> 2000	> 2000	> 2000
Carbon Black Content	ISO 6964	D 1603	%	≥ 2	≥ 2	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11420	D 5596		A - 2	A - 2	A - 2	A - 2

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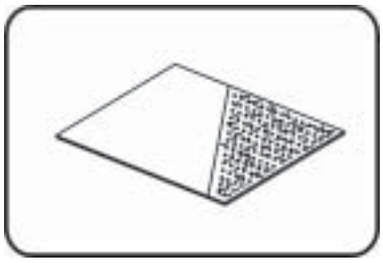
HOME

- **Liner G/MSB**
  smooth/microspike-5,15m
  calendered
- **Hot-wedge-welding**
- **Agruflex FPP black**



Code 530

Property	Standard		Unit	1,00mm	1,50mm	2,00mm	≥ 2,50mm
	DIN OEN EN ISO	ASTM					
Nominal Thickness	DIN 53 370		%	≤ ± 10	≤ ± 10	≤ ± 10	≤ ± 10
Density (black)	ISO 1183	D 792	g/cm³	≤ 0,90	≤ 0,90	≤ 0,90	≤ 0,90
MFR Melt Flow Rate	ISO 1133	D 1238	g/10 min	0,2 - 0,6	0,2 - 0,6	0,2 - 0,6	0,2 - 0,6
(230°C/2,16kg)	Cond. M	Cond. L					
Heat Reversion	DIN 16 726	D1204	%	≤ 2	≤ 2	≤ 2	≤ 2
(80°C/6h)							
Tear Resistance	DIN EN ISO 34-1	D 1004	N	60	60	60	60
Multiaxial Tension	OENORM S 2073		%	≥ 50	≥ 50	≥ 50	≥ 50
Tensile Stress at Break	ISO 527	D 6693	N/mm²	≥ 12	≥ 12	≥ 12	≥ 12
Elongation at Break	ISO 527	D 6693	%	≥ 300	≥ 300	≥ 300	≥ 300
Puncture Resistance	DIN 16 726		mm	≥ 350	≥ 600	≥ 800	≥ 1000
	(Drop Test)						
		D 4833	N	130	195	260	325
Low Temperature Brittleness	DIN 16 726	D 746	°C	- 40	- 40	- 40	- 40
Water Absorption	ISO 62	D 570	%	≤ 1,0	≤ 1,0	≤ 1,0	≤ 1,0
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
Rodent Resistance	OENORM S 2073			fulfilled*	fulfilled*	fulfilled*	fulfilled*
ESCR-Behaviour		D 1693	(h)	> 2000	> 2000	> 2000	> 2000
Carbon Black Content	ISO 6964	D 1603	%	≥ 2	≥ 2	≥ 2	≥ 2
Carbon Black Dispersion	ISO 11420	D 5596		A - 2	A - 2	A - 2	A - 2

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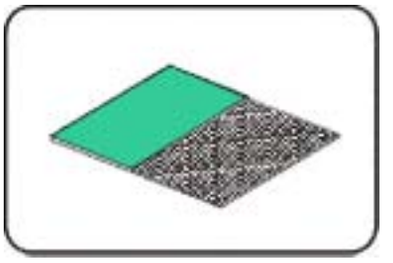
HOME

- **Liner G/G - G**
  smooth/reinforced-2m RAL6001
  calendered
- **Hot-wedge-welding**
- **AGRUFLEX FPP black/green**



Code 531

Property	Standard		Unit	1,50mm	2,00mm
	DIN OEN EN ISO	ASTM			
Nominal Thickness	DIN 53 370		%	≤ ± 10	≤ ± 10
Density (black UV-resistant)	ISO 1183	D 792	g/cm^3	≤ 0,90	≤ 0,90
MFR Melt Flow Index	ISO 1133	D 1238	g/10 min	0,2 - 0,6	0,2 - 0,6
(190°C/2,16kg)	Cond. M	Cond. L			
Heat Reversion	DIN 16 726	D1204	%	≤ 1	≤ 1
(80°C/6h)		(180°F/1hr.)			
Tensile Strength	SIA 280	D 751	N	≥ 9	≥ 9
Elongation at Break (Liner)	SIA 280	D 6693	%	≥ 300	≥ 300
Puncture Resistance	DIN 16 726		mm	≥ 500	≥ 750
		D 4833	N	≥ 225	≥ 300
Low Temperature Brittleness	DIN 16 726	D 746	°C	- 40	- 40
Water Absorption	ISO 62	D 741	%	≤ 1,0	≤ 1,0
Root Resistance	OENORM S 2073			fulfilled*	fulfilled*
Microorganism Resistance	OENORM S 2073			fulfilled*	fulfilled*
Rodent Resistance	OENORM S 2073			fulfilled*	fulfilled*

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HOME

AGRUFLEX VLDPE tunnel liner

Since 1970, a steady development of sealing in underground construction in rock has occured, started by the use of the NOET „Neue Oesterreichische Tunnelbauweise"; at first with geotextiles as drain layers later with lining mateials out of ECB or PVC.
AGRU did research on the most suitable liner material combining flexibility with good tensile properties, chemical resistance and long term performance for tunnel sealing alreadyin the middle of the 1980's .
VLDPE was chosen to fulfill the requirements for tunnel liners by far .

Sealing for Generations

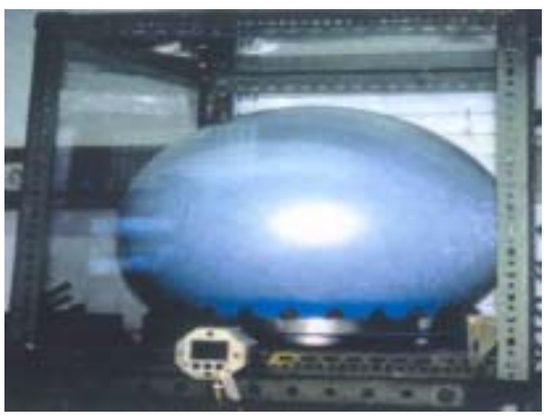
Tunnel Liners shall keep their properties under typical installation situations for tunnels for the whole lifetime.
As tunels are designed for a minimum of 100 years lifetime, materials having no change of the mechanical properties.
Because VLDPE contains no volatile plastizicers the liners keep their properties.
This ensures a tight tunnel constuction for generations.

Advantages of AGRUFLEX

VLDPE has compared to HDPE no definitive yield point, whereby the material can be elongated at the multiaxial tension at more than 250% and so a good adjustement to the existing contour at tunnelconstructions and safety for settlements is given.
Against high agressive mountain water VLDPE shows no changing of the properties.

More advantages of VLDPE liners are:

- low density
- high flexibility
- high tear strength and elongation at break
- highest multiaxial tension
- high compression strength
- Resistant against roots and rodents
- good weldability
- excellent mechanical properties
- physiological harmless



VLDPE is superior to PVC for the following reasons:

- 1/3 lower density
- free of plasticizers
- halogen free
- free of heavy metals
- generally better chemical resistance
- varios applications in the food industry and storage of potable water
- no dangerous HCL gases at burning or welding
- VLDPE keeps its mechanical properties (no volatile additives)

HOME

Supply Program

AGRUFLEX tunnelliners are deliverd with a white signal layer and black base liner homogeneousely manufactured by coextrusion process .
Depending on various specifications of different countries the signal layer is part of the nominal thickness or additional to it.
In addition to the standard AGRUFLEX tunnel liner which fulfills DIN EN 13 501-1 Class E (DIN 4102 B2) also a flame retardant type according to EN ISO 13 501-1 Class C (DIN 4102 B1) is available.
The supply program for tunnel lining contains fasteners, jointing profiles, drainange pipes and other accessories.

Simple Installation

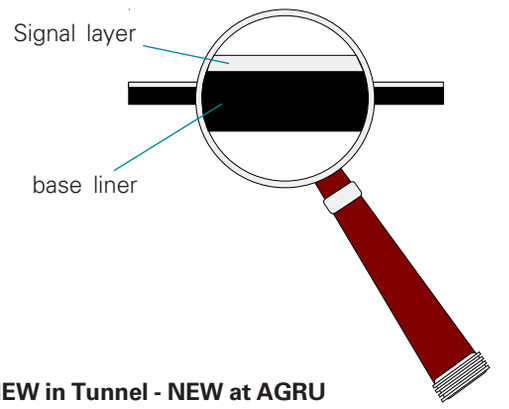
The installation and welding of the AGRUFLEX Tunnelliner is of paramount importance as the tightness and permanent function of the sealing constructions are dependent on it.
The joining of the Tunnelliner with the discs is done by means of hot gas welding. Preset breaking points on the discs ensure that the discs, not the liner break, in case of an overload, which does not affect the tightness.
The joining of the AGRUFLEX Tunnel Liner is performed by means of hot wedge double seam welding according to DVS 2225. The hot wedge welding process, the surfaces of the area to be bonded are melted with an electrically heated wedge. This area is then pressed together continuously with two geared roll pairs. The double welded seam provides an air pressure test channel to verify the integrity of the seam.

The Tests

AGRUFLEX VLDPE Tunnel liner corresponds with the highest requirements like the german ZTV-Ing (street work tunnels), DS 853 (railroad tunnels), SIA 280 and also the issue 365 for Austria.
Accordant test certificates and also external control from the SKZ (Sueddeutsches Kunststoffzentrum) and the OFI (Oesterreichisches Forschungsinstitut) garantee a consistent high qualitiy standard of the AGRUFLEX VLDPE Tunnelliner.

Design of the AGRUFLEX Tunnelliner

The signal layer made out of VLDPE white is used as indicator for damages of the Tunnelliner or to improve the illuminating.
(Special types on request).
The base liner is made out of VLDPE black and fullfills the required mechanical and thermal requirements.



NEW in Tunnel - NEW at AGRU AGRUFLEX EasyFix-Systems

The Installation of Tunnel liners are normally executed with high manual welding efforts for the fusion of the tunnel liner to the fixation disc shot to the concrete shell.
The AGRU Easy-Fix Hook&Loop fixation method results in a fixation of the liner to the disc without welding as the AGRUFLEX tunnel liner is backed with geotextile and the fixation discs are laminated with Hook&Loop belt to create bonding between geotextile and disc.
This results in a easy and fast installation of the tunnel liner.

HOME

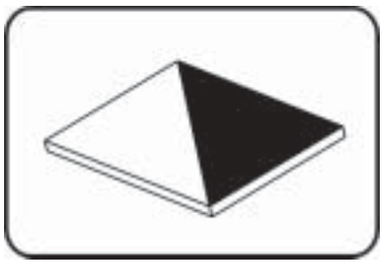

Code 60.609


Code 61.609

HOME

HOME

- **Tunnel Liner**
  width: 2m
  coextruded/calendered
- **Hot-wedge-welding**
- **AGRUFLEX VLDPE 2 colours**



Code 60.609

Property	Standard	Unit	AGRU Tunnel Liner
Surface Visual inspection	DIN 16726 section 5.1	–	no tears, bubbles, pores or damages complete connection between ground material and signal layer
Straightness	DIN 16726 section 5.2	mm	≤ 50
Flatness			≤ 10
Nominal thickness (incl. signal layer)[1)] Average Value Mimimum value Maximum value Thickness of signal layer	DIN 16726 section 5.3.1	mm mm	4,0 ; 3,0; 2,0; ≥ nominal thickness average value - 5% average value + 5% 0,2
Density	DIN EN ISO 1183	g/cm³	≥ 0,9
Melt Flow Rate MFR (190°/2,16kg)	DIN EN ISO 1133/4	g/10 min	0,7-1,3
Break Strength	DIN 16726 section 5.6.1 table 1: A-VII DIN EN ISO 527	N/mm²	≥ 15
Elongation at Break		%	≥ 500
E-Modulus between 1 and 2 % elongation length and crosswise	DIN 16726 section 5.6.2 table 1: A-II	N/mm²	≤ 100
Multiaxial tension	following DIN 53861 ∅ 1,0 m	%	≥ 50
Slit Pressure Resistance	DIN 16726 section 5.11 (72 h/6 bar)	–	tight
Puncture Resitance (Drop Test)	DIN 16726 section 5.12 750 mm, 500 g	–	tight
Heat Reversion/Dimensional Stability (80°C/6h)*	DIN 16726 section 5.13.1	%	± 2,0
Visual appearence after heat reversion	section 5.13.2	–	no bubbles
Low Temperature Brittleness (-20 °C)	DIN 16726 section 5.14	–	fulfilled - no tears
Behaviour after heat aging (70 d, 80 °C)	DIN 16726	%	change of tensile strength and of elongation at break as received ≤ 20
Behaviour after storage in warm water (8 months, 50 °C)	SIA-V 280 test Nr. 13	%	change of tensile strength and of elongation at break as received ≤ 20; change of weight ≤ 4
Behaviour after storage in watersoluable agents a) saturated lime water dilution b) 5-6 % sulfuric acid	DIN 16726 section 5.18	%	change of tensile strenght and of elongation at break as received ≤ 20
Flammability Classification	DIN 4102/EN 13501-1	–	B2 / Class E

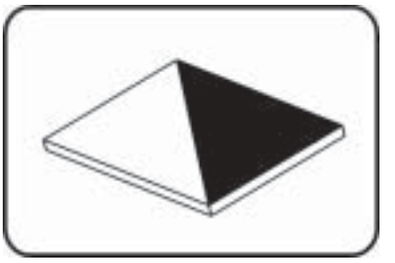
*)tunnel liners with refractory deformation temperature <100°C

1) for Germany signal layer excluded

The data in this table are approximate values and based upon results of the internal inspection, data of raw material suppliers as well as tests in the course of approval procedures and external inspections. The results can differ slightly from the indicated mean values in longitudinal and transverse direction and due to different nominal thicknesses and raw materials. In any case requirements relating to a special project (tender documents) have to be agreed with AGRU.
Independent of the indicated test standards, internal tests and data on test certificates are generally carried out in accordance with the appropriate test procedures according to OENORM (Austrian Standard) resp. DIN (German Standard).
AGRU assumes no liability in connection with the use of this data. The specifications on this sheet are subject to change without notice.
*) acc. OENORM S2073 liners made of polyolefins shall be considered resistant without proof being furnished.

HOME

- **Tunnel Liner Flame RetardentB1**
  width: 2m
  coextruded/calendered
- **Hot-wedge-welding**
- **Agruflex VLDPE 2 colours**



Code 61.609

Property	Standard	Unit	AGRU Tunnel Liner
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Straightness	DIN 16726 section 5.2	mm	≤ 50
Flatness			≤ 10
Nominal thickness (incl. signal layer)[1)] Average Value Mimimum value Maximum value Thickness of signal layer	DIN 16726 section 5.3.1	mm mm	4,0 ; 3,0; 2,0; ≥ nominal thickness average value - 5% average value + 5% 0,2
Density	DIN EN ISO 1183	g/cm³	≥ 1,0
Melt Flow Rate MFR (190°/2,16kg)	DIN EN ISO 1133/4	g/10 min	0,7-1,3
Break Strength	DIN 16726 section 5.6.1 table 1: A-VII DIN EN ISO 527	N/mm²	≥ 15
Elongation at Break		%	≥ 500
E-Modulus between 1 and 2 % elongation length and crosswise	DIN 16726 section 5.6.2 table 1: A-II	N/mm²	≤ 100
Multiaxial tension	following DIN 53861 ∅ 1,0 m	%	≥ 50
Slit Pressure Resistance	DIN 16726 section 5.11 (72 h/6 bar)	–	tight
Puncture Resitance (Drop Test)	DIN 16726 section 5.12 750 mm, 500 g	–	tight
Heat Reversion/Dimensional Stability (80°C/6h)*	DIN 16726 section 5.13.1	%	± 2,0
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Behaviour after storage in warm water (8 months, 50 °C)	SIA-V 280 test Nr. 13	%	change of tensile strength and of elongation at break as received ≤ 20; change of weight ≤ 4
Behaviour after storage in watersoluable agents a) saturated lime water dilution b) 5-6 % sulfuric acid	DIN 16726 section 5.18	%	change of tensile strenght and of elongation at break as received ≤ 20
Flammability Classification	DIN 4102	–	B1

*)tunnel liners with refractory deformation temperature <100°C

[1)] for Germany signal layer excluded

The data in this table are approximate values and based upon results of the internal inspection, data of raw material suppliers as well as tests in the course of approval procedures and external inspections. The results can differ slightly from the indicated mean values in longitudinal and transverse direction and due to different nominal thicknesses and raw materials. In any case requirements relating to a special project (tender documents) have to be agreed with AGRU.
Independent of the indicated test standards, internal tests and data on test certificates are generally carried out in accordance with the appropriate test procedures according to OENORM (Austrian Standard) resp. DIN (German Standard).
AGRU assumes no liability in connection with the use of this data. The specifications on this sheet are subject to change without notice.
*) acc. OENORM S2073 liners made of polyolefins shall be considered resistant without proof being furnished.

General chemical properties of PE & FPP Liner Materials

In dependence of the application whether for containment or secondary containment of chemicals and ground water endangering media a verification for the suitability of the liner material needs to be done.
For PE-liner types the chemcial resistance is linked with the density so for chemicals for which HDPE is already considered limited resistant the use of lower density material is not recommended.
PE und FPP are resistant against diluted solutions of salts, acids and alkalis if these are not strong oxidizing agents. Good resistance is also given against many solvents, such as alcohols, esters and ketones.
At contact with solvents, as aliphatic and aromatic compound, chlorinated hydroxycarbon, you have to reckon upon a strong swelling, especially at raised temperatures. But a destruction commences only rarely.
The resistance can be strongly reduced by stress cracking corrosion due to ampholytiocs (chromic acid, concentrated sulphuric acid).

Base sealing of Petrolstation

Biological Treatment pond

Lyes

Alkalis
Diluted alkali solutions (e. g. caustic Soda), even at higher temperature and with higher concentrations do not react with PE and FPP and can therefore be applied without problems.
Chlorine
All polyolefin based resins are critical at applications with free chlorine as the active chlorine causes stress cracking already at very low concentrations. For treatment of water typically used chlorine content does not exceed 0,5ppm (0,5mg/l).
For this concentration PE and FPP liners can be considered resistant .
Bleaching Agents
As these lyes contain active chlorine, only a conditional resistance is given at room temperature.
At higher temperatures and concentrations of the active chlorine, PE and FPP are rather only suitable for low concentrations.
Hydrocarbons
FPP is not resistant against hydrocarbons (benzine as well as other fuels) already at ambient temperature (swelling > 3 %).
PE however can be used for the conveying up to temperatures of 40°C and for the storage of those media up to temperatures of 60°C.
Only at temperatures > 60°C PE is conditonally resistant as the swelling will be > 3 %.

Acids

Sulphuric Acid
Concentrations up to approximately 70% change the properties of PE and FPP only slightly. Concentrations higher than 80 % cause already at room temperature oxidation. At higher temperatures, this oxidation can even go to a carbonization of the surface of the PP based products.
Hydrochloric acid, hydrofluoric acid
Against concentrated hydrochloric acid and hydrofluoric acid, PE and FPP are chemically resistant.
But there appears a slight diffusion of HCl (concentrations > 20 %) and of HF (concentrations > 40 %) at FPP, which does not damage the material, but causes secondary damages on the base substrate.
Double containment Lining systems have proven such applications.
Nitric acid
Higher concentrated nitric acid has an oxidizing effect on the materials. The mechanical properties will be reduced at higher concentrations.
Phosphoric acid
Against this medium, PE and FPP is also at higher concentrations and at raised temperatures resistant.

For more detailed information regarding the chemical resistance of our products, our application engineering department will be at your disposal at any time.

Media List for PE Liners

List of media against the "AGRU PE-Liner X" is impermeable and chemically resistant for the stress class "high" including clas "middle" and "low" according TRwS sealing areas*.

Fluids	Media group
Otto fuels, supergrade petrol and regular grade petrol (acc. DIN EN 228: 2004-03) with max. 5 Vol.-% bio alcohol	1
Otto fuels, supergrade petrol and regular grade petrol (acc. DIN EN 228: 2004-03) with max. 20 Vol.-% bio alcohol	1a
Aviation Fuel	2
Fuel oil EL (acc. DIN 51 603-1), unused combustion motor oils, unused motor vehicle gear oisl and mixture of saturated and aromatic hydrocarbons with an aromatic content lower 20 weigth-% and a flash point > 55°C	3
Diesel fuel (acc. DIN EN 590: 2004-03) with max. 5 Vol.-% bio diesel fuel (acc. DIN EN 14214: 2003-11)	3a
Diesel fuel (acc. DIN EN 590: 2004-03) with max. 20 Vol.-% bio diesel fuel (acc. DIN EN 14214: 2003-11)	3b
All hydrocarbons as well as mixtures containing benzene with max. 5 Vol.-% Benzol, except otto fuels	4
Benzene and mixtures containing benzene	4a
Crude oils	4b
Used combustion motor oils and used motor vehicle gear oils with a flash point > 55°C	4c
All alcohols and glycols ether	5a, 5 and 5b
All aliphatic halogenated hydrocarbons $\geq C_2$; a minimum liner thickness of 3mm is required	6
Halogenated hydrocarbons = C_1	6a
Aromatic halogenated hydrocarbons	6b
All organic ester and ketones (including bio diesel fuel acc. DIN EN 14214: 2003-11)	7, 7a and 7b
Aliphatic aldehyds and ist aqueos solutions	8a and 8
Orgnaic acids (carboxylic acids except formic acid > 10 %) and its aqueos solutions (in all concentrations) as well as their salts (in aqueos solutions)	9 and 9a
Mineral acids up to 20 % as well as acid hydrolising inorganic salts in aqueos solutions (pH < 6), except hydrofluoric acid and oxidising acid as well as their salts	10
Inorganic alkali solution as well as alkali hydrolyzing inorganic salts in aqueous solution (pH >8) except ammonia solutions and oxidizing solutions of salts (e.g. hypochlorit)	11
Aqueos solutions of inorganic not oxidising salts with a pH value between 6 to 8	12
Amines as well as their salts (in aqueos solution)	13
Aqueos solutions of organic tensides	14
Cyclic and acyclic ethers	15 and 15a

- list of media No. 59 to 21 (dated July 199) by DIBt

*technical regulations of wter pollution materials - TRwS, performance of sealing areas; DVWK, regulations water resources policy 132/1997

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Transport and handling

At the transport and handling of pipes and fittings, the following guidelines have to be observed in order to avoid damages:

Pipes out of PP-H, special materials (PP-R-s-el, PP-H-s, PE-el) and prefabricated components (for example segmented bends) may only be loaded resp. transported with special care at pipe wall temperatures below 0°C.

Impact- and bending stresses at temperatures < 0°C have to be avoided.

Damages of the surface (scratches, marks, ...), as they occur at dragging of pipes, have to be avoided.

Storage

At the storage of pipes and fittings, the below stated regulations have to be observed in order to avoid a quality decrease:

The storage area has to be even and free from waste, such as stones, screws, nails, etc.

At piling of pipes, storage heights of 1 m may not be exceeded. In order to avoid a rolling away of the pipes, wooden wedges have to be situated at the outside pipes. At pipes > OD 630mm, maximum two rows may be stored on top of one another. Pipes > OD 1000mm have to be stored loosely.

Pipes have to be stored flat and without bending stress, if possible in a wooden frame.

Natural and grey coloured products have to be protected against UV radiation at a storage outdoors. Yellow PE pipes may be stored up to 9 months outdoors.

Pipes and fittings out of PP-R-s-el and PE-el have to be protected at storage against humidity and UV radiation (no outdoor exposure, use of dry ware-houses).

Attention!
As the special types PP-R-s-el and PE-el suffer the danger of absorption of humidity at a storage period

General Installation guidelines Piping Systems

Due to the lower stiffness and rigidity as well as the potential length expansions (caused by changes in temperature) of thermoplastics in comparison with metallic materials, the requirements for the fixing of piping elements should be met.

On laying of pipes above ground expansion and contractions of pipes in both radial and axial directions must not be hindered - that means, installation with radial clearance, position of compensation facilities, control of changes in length by reasonable arrangement of fixed points.

Attachments have to be calculated so as to avoid pin-point stresses, that means the bearing areas have to be as wide as possible and adapted to the outside diameter (if possible, the enclosing angle has to be chosen > 90°).

The surface qualities of the attachments should help to avoid mechanical damage to the pipe surface.

Valves (in certain cases also tees) should basically be installed on a piping system as fixed points. Valve constructions with the attachment devices being integrated within the valve body are most advantegous.

Fixing by means of pipe clips

Attachments made of steel or of thermoplastics are available for plastics pipes. Steel clips have at any rate to be lined with tapes made of PE or elastomers, as otherwise the surface of the plastics pipe may be damaged. AGRU plastics pipe clips as well as pipe holders are very good suitable for installation. These may be commonly applied and have especially been adjusted to the tolerances of the plastics pipes.

Therefore they serve e. g. as sliding bearing at horizontal installed piping systems in order to take up vertical stresses. A further application range of the AGRU pipe clip is the function as guiding bearing which should hinder a lateral buckling of the piping system as it can also absorb tranversal

Installation guidelines for electro-conductable materials

The general installation guidelines are valid fundamentally.
At the installation of earthing clips it has to be taken care that the pipe surface below the clip is abraded. It is therefore absolutely necessary to remove the eventually present oxide film in order to be able to guarantee the necessary surface resistance of $< 10^6$ Ohm.

At flange joints, electro-conductable flanges or steel flanges have to be applied.

The end-installed and connected to earth piping system has to be subjected to a final evaluation by competent pro-fessional employees regarding the bleeder resistors in any case.

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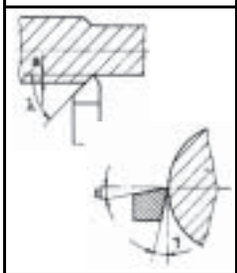
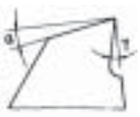
Machining of PE
(valid for cutting, turning, milling and drilling)

	**Cutting**			
	Clearance angle α	[°]	30 ÷ 40	Band saws are appropriate for the cutting
	Rake angle γ	[°]	0 ÷ 5	of pipes, blocks, thick sheets
	Pitch t	[mm]	3 ÷ 5	and for round bars
	Cutting speed	[m/min]	upto 3000	
	**Cutting**			
	Clearance angle α	[°]	10 ÷ 15	Circular saws can be used for the
	Rake angle γ	[°]	0 ÷ 15	cutting of pipes, blocks and sheets.
	Pitch t	[mm]	3 ÷ 5	HM saws have a considerably
	Cutting speed	[m/min]	upto 3000	longer working life
	**Turning**			
	Clearance angle α	[°]	5 ÷ 15	The peak radius (r) should be at least
	Rake angle γ	[°]	0 ÷ 15	0,5mm. High surface quality is obtained
	Tool angle λ	[°]	45 ÷ 60	by means of a cutting tool with a wide
	Cutting speed	[m/min]	200 ÷ 500	finishing blade.
	Feed	[mm/Umdreh.]	0,1 ÷ 0,5	Cut-off: Sharpen turning tool like a knife.
	Cutting depth a	[mm]	upto 8	
	**Milling**			
	Clearance angle α	[°]	5 ÷ 15	High surface quality is obtained by
	Rake angle γ	[°]	upto 10	means of a milling machine with fewer
	Cutting speed	[m/min]	upto 1000	blade - this increases cutting capacity.
	Feed	[mm/Umdreh.]	0,2 ÷ 0,5	
	**Drilling**			
	Clearance angle α	[°]	12 ÷ 16	Spiral angles 12 - 15°. For holes with
	Rake angle γ	[°]	3 ÷ 5	diameters of 40 - 150mm, hollow drills
	Centre angle φ	[°]	approx. 100	should be used; for holes < 40mm
	Cutting speed	[m/min]	50 ÷ 100	diameter, use a normal SS-twist drill.
	Feed	[mm/Umdreh.]	0,1 ÷ 0,3	

Transport and Storage - Liners

In house the AGRU Liner rolls are handled carefully with adequate equipment to avoid deformation or damage to the rolls after manufacturing
The rolls are wrapped in PE-protection film and stored on plane ground, so that no damage can occur.
A stapling of the rolls can be permitted to a maximum of five layers for long term storage.
The authorized installer has to take care on site to store the liners adequately to avoid any damages.

- width defined by roll size plus 0.4m each side
- even, stonefree or protected (e.g.:geotextile or sand) ground
- protected against mechanical damages
- unopposed acces for delivering of Rolls per truck

The AGRU in house transportation of the rolls are executed by using special equipped fork-lifts or cranes, so no punctual forces can occur to the rolls respectively no damages.
The transport to the prefabricator or on site is executed by adequate trucks (lorries) or in containers.
The transport on site or the deloading of a container has to be performed by equipment capable to deload without damaging the liner rolls.
Therfore every roll is delivered with lashing points(loading belts).
For deloading the rolls out of a box container only mandrel (dorn) lifters shall be used to avoid deformation and damage to the rolls.

Truck charging with Fork Lifts and loading belts

Liner stock Agru Bad Hall

Deloading on site

Liner stock on site

Installation Guidelines Liners Introduction

This manual addresses the Quality Control Program developed and utilized by AGRU Company's Installation partners to assure the quality of workmanship and the installation integrity of geo-membranes and other geo-synthetic products.

All geo-synthetic components of lining systems will be addressed in this manual, including geo-membranes, geotextiles, geonets, geo-composites, and geo-synthetic clay liners. AGRU Company recognizes that careful and specific documentation of the installation is required to substantiate this Quality Control Program.

Material delivery

A third Party QA Representative should be present, whenever possible, to observe and assist in material delivery and unloading on site. The Third Party QA Representative should note any material received in damaged state and take any necessary conformance samples. Upon mobilization to site, a Representative certified by AGRU shall:

- Verify the equipment used on site is adequate and does not risk damage to the geomembrane or other materials.
- Mark rolls or portions of rolls which appear damaged.
- Verify that storage of materials ensure adequate protection against dirt, theft, vandalism, and passage of vehicles.
- Ensure that rolls are properly labelled and that labelling coresponds with Quality Control documentation.
- Complete roll numbers, date, roll size and any damage will be logged on the AGRU Material Delivery Checklist (See Appendix A).

Geomembrane installation

Earth Work

The General and/or Earthwork Contractor shall be responsible for preparing and main taining the subsoil in a condition suitable for installation of the liner unless specifically agreed otherwise.

Subsoil preparation for the following day`s lining progress

In cases where no site specific earthwork quality control guidelines exist, the following general guidelines shall comply to the following general specifications

Surfaces to be lined shall be smooth and free of debris, roots, and angular or sharp rocks. All padding shall consist of well-graded material, free of organics, trash, clay-balls, or other non adequate material that may cause damage to the geo-membrane. Unless otherwise required by design specifications, the upper six inches (6") of the finished subsoil shall not contain stones or debris larger than one-half inch (1/2"). The subsoil shall be compacted in accordance with design specifications, but at least in a quality to provide a firm subbase sufficient to allow the movement of vehicles and welding equipment over the subsoil without causing demage to the prepared surface (eg. wheel tracks). The subsoil should consist of homogenious material and none abrupt changes in grade.

The Earthwork Contractor shall protect the subsoil from desiccation, flooding, or freezing. Protection, if required, may consist of a thin plastic foil (or other material as approved by the engineer) placed over the prepared completed subsoil until the placement of the geo-membrane begins. Prepared subsoil with cracks greater than one-half inch (1/2") in width or depth shall be replaced or reworked by the General and/or Earthwork Contractor toremove those defects.
The moisture content of the subsoil should not exceed 20%.If the moisture content exceed 20% then the Contractor should prepare a sufficient dewatering system and in addition to it spraying some bentonite to ensure the subsoil condition for a proper installation of the geomembrane.

Surface Acceptance. Upon request, the Site Supervisor will provide the Owner's and/or Contractor's representatives with a written acceptance of the surface to be lined. This acceptance will be limited to an amount of area that the Installer is capable of lining during a particular work shift. Subsequent repairs to the subsoil and the surface shall remain to the responsibility of the Earthwork Contractor. An example of Installer`s subsoil Surface Acceptance form is included in Appendix A.

Crest Anchorage System

The anchor trench shall be excavated by the General and/or the Earthwork Contractor as specified in the design drawings prior to geo-membrane placement.

Anchor trenches should be excavated only the distance required for that days liner placement to minimize the potential of collapsing

Corners in the anchor trench shall be constructed with a sufficient radius to avoid sharp bends or overfolding of the geomembrane.

anchor trench

Preparation for Geomembrane Deployment

Panel Layout
Prior to start the liner deployment, layout drawings shall be drafted to indicate the panel configuration and general location of field seams for the project.

Identification
Each panel used for the installation will be given a number which will correlate to a batch or roll number. This panel identification number shall be related to the Installer`s Panel Placement Form, which will be used when required.

Field Panel Placement

Weather Conditions
Geo-membrane deployment will generally not be done during any precipitation, in the presence of excessive moisture, in an area of flooded water, or during heavy winds or rainfall.

Location
AGRU`S installation partner will attempt to install field panels as indicated on the layout drawing. If the panels are deployed in a location other than indicated on the layout drawings, the revised location will be noted in the field. These notes will be maintained and submitted by AGRU`S partner and/or third party QA Consultant as determined on a site specific basis.

Documentation of Panel Placement
Information relating to geo-membrane panel placement including date, time, panel number, and panel dimensions may be maintained on a site specific base, on the Panel Placement Form as attached in Appendix A.

If a portion of a roll is set aside to be used at another time, the roll number will be written on the remainder of the roll in several places.

Method of Deployment

The method and equipment used to deploy the panels must be choosen as not to damage the geo-membrane or the prepared subsoil surface.

No personnel working on the geo-membrane will wear shoes that can damage the geo-membrane or engage in actions which could result in damage to the geo-membrane.

Adequate temporary loading and/or anchoring, (i. e. sandbags, tires) which will not damage the geo-membrane, will be placed to prevent uplift of the geo-membrane by wind or underflooding by rain.

The geo-membrane will be deployed in a way that typical thermal expansion can take place

Any area of a panel seriously damaged (torn, twisted, or folded) will be marked and repaired in accordance with later description in this document.

Geomembrane Field Seaming

General Requirements
Temperature and humidity
seaming shall only be performed at temperatures above +5°C ambient temperature
In an Environment where the humidity exceeds 80% special care shall be taken that the difference to the dewpoint is minimum 3K

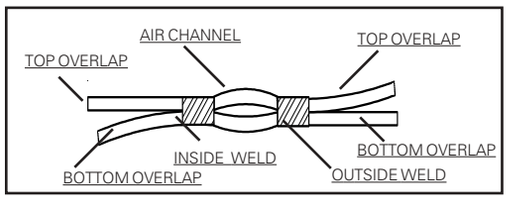
Layout
In general, seams shall be oriented parallel to the slope, i. e., oriented along, not across the slope. Whenever possible, horizontal seams should be located on the base of the cell, not less than 1,5m (five feet) from the toe of the slope or when the guidance of the wedge welder is assured. Each seam made in the field shall be numbered. Seaming information to include seam number, welder ID, machine number,temperature setting, and weather conditions may be maintained on Installer`s Panel Seaming Form as attached in Appendix A.

Personnel
All personnel performing seaming operations shall be trained in the operation of the specific seaming equipment, being used and will qualify by successfully welding a test seam as described in chapter "Trial weld"

Equipment

Fusion Welding
Fusion welding consists of placing a heated wedge, mounted on a self propelled unit, between two (2) overlapped sheets such that the surface of both sheets are heated above the polyethylene's melting point. After being heated by the wedge, the overlapped panels pass through a set of pressure wheels which compress the two (2) panels together to form the weld. Those machine is equipped with a sensor which continuously monitors the temperature of the wedge and the speed of the machine.

Figure 1 – double track fusion weld (hot wedge weld)



Seam Preparation
Hot wedge welding

Overlap the panels of geo-membrane approximately 10 - 15cm (4" to six 6") prior to weld Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, or debris of any kind. No grinding is required for hot wedge welding.
Adjust the panels in a way that seams are aligned with a minimum number of wrinkles or "fish-mouths".A piece of sliding liner may be used, directly underness the overlap of the geo-membrane which will be be seamed to prevent build-up of dirt or moisture between the panels.

Weather Conditions
The Installer relies on his and the experience of the Project Superintendent and the results of test seams to determine whether seaming is restricted by weather. Many factors, such as the geo-membrane temperature, humidity, wind,
precipitation, etc., can effect the integrity of field seams and must be taken into account when deciding whether or not seaming should proceed. Test seams, as described in Paragraph 3.5.3, are required prior to daily production seaming to determine if the weather conditions will effect the Installer's ability to produce quality seams.

Additional non-destructive and destructive testing of production seams substantive the decision made by the Project Superintendent to seam on any given day.The daily protection of the placed geo-membranes has be done by the responsibility of customer. Important is the protection against wind and storms.

Extrusion Fillet Welding

Extrusion welding is used beside the hot wedge welding method as standard method for welding the liner where hot wedge welding cannot take place. For joining the liner according DVS 2209-1 only the process variant II, manual continous Hot Gas Extrusion Welding method has to be considered. This welding technique is characterized as follows:

- Welding process is performed with welding filler being pressed out of a compounding unit.
- The welding filler is homogenous and completely plastified.
- The joining surfaces have been heated up to welding temperature.
- Joining is performed under pressure.

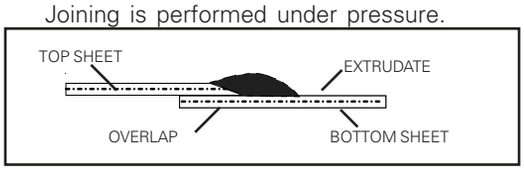


Figure 2 – Extrusion seam

Extrusion Fillet Welding

Whenever possible, the edge of the to be welded patch will be bevelled prior to perform the weld.

Overlap the panels of geo-membrane a minimum of 8,0cm (three inches 3").

Using a hot-air gun, tackweld the panels or patches to be welded, taking care not to damage the geo-membrane.

Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt and debris.

Grind seam overlap prior to welding properly with not damage the geo-membrane. Grind marks should be covered with extrudate whenever possible. In all cases grinding should not extend more than 8,0mm (1/4") past the edge of the area covered by the extrudate during welding (recommended disc grid 80 - 100)

Whenever possible, Welding Technicians will cut a 25mm (one inch) peel specimen at the end of every seam. Prior to welding the next seam, the specimen will be tested for peel.

In the case of non-complying seam, more specimen will be cut out, the welding machine will be taken out of service until a passing trial weld is obtained, and additional peel specimens will be taken to localise the reason for the failure.

The CQC Co-ordinator may, after consulting the Installer's Site Superintendent, to take destructive samples from any seam, if defects are suspected.

Seaming Documentation

Welding Technicians will mark on the liner with permanent markers, such as Mean Streak, at the start of all seams information regarding, date, time Welding Technicians ID, machine number and set temperature. CQC Coordinator or Assistant will record date, time, seam number, Technician ID, machine ID, set temperature speed and weather conditions on the Installer`s Panel Seaming Form (attached in Appendix A)

Welding Technicians will periodically check operating temperature and speed and mark the information along the seam.

CQC Co-ordinator will make periodically checks on welding operations to verify overlap, cleanliness, etc.

Seam Testing - Geo-membranes

Non-Destructive Seam Continuity Testing

The Installer shall non-destructively test, field seams over their full length using a vacuum test unit or spark tester (for extrusion seams only) and air pressure test (for fusion seams). The testing shall be carried out to the accepted standards of the industry. The purpose of non-destructive tests is to check the continuity of seams. It does not provide any information on seam strength. Continuity testing shall be carried out on 100 percent of the seams as the seaming work progresses. The Installer shall complete any required repairs in accordance with the Specification. A typical Non Destructive Seam Testing and Repair form is shown in the Annex A.

Procedure for Air pressure Testing

The general air pressure testing procedure used by the Installer shall be as follows: Seal both ends of the test channel with a heat gun or other acceptable clamping method. Insert a hollow needle with attached pressure gauge into the test channel. Inflate the test channel to 300 kPa (43 PSI), close valve, and observe initial pressure after approximate air temperature and pressure have stabilized (see detailed graph in Appendix A).Observe and record the test pressure 10 minutes after reading the initial test pressure. If pressure loss exceeds 30 kPa (4,3 psi), or if the pressure does not stabilize, locate the faulty area and repair.At the conclusion of the pressure test, the end of the seam opposite the pressure gauge shall be cut to verify seam channel continuity. A decrease in a gauge pressure must be observed or the air channel will be considered "blocked" and the test will have to be repeated after the blockage is corrected.Remove needle or other approved pressure feed device and seal the resulting hole. Test results will be recorded by the Installer.

recommended test pressure by DVS standard for HDPE

up to 20°C	5 bar
20 to 40° C	4 bar
40 to 55° C	3 bar.

For flexible materials like VLDPE/PP-flex/FPO the test pressure shall be reduced 2 bar (28 psi) less than HDPE

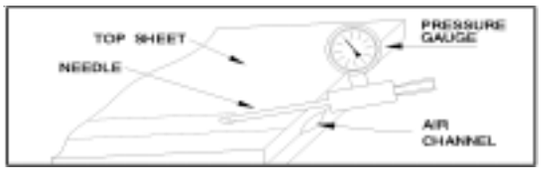


Figure 3 – Air-Pressure Testing

Non-Complying Air Pressure Test:

In the event of a non-complying air pressure test, the following procedure shall be followed:
Check the seamend, seal and retest the seams.
if the seam fails air pressure testing, the Installer may isolate the failing zone, air pressure test the seam outside the failing zone, then repair the failing zone by the methods listed below. Alternatively, the Installer may repair the entire seam by the methods listed below:
Cap-strip the suspect area
When sufficient overlap exists 50 mm, heat tack the overlap and extrusion weld the entire seam;

- Further isolate the air pressure failure
- Test the entire length of the repaired seam by vacuum testing.

All needle holes in air channels, within the boundaries of the active cell, will be repaired (closed) by extrusion bead.

Air Pressure Testing Documentation

All information regarding air-pressure test (date, initial time, temperature and pressure, final time and pressure, pass/fail designation and Technicians number) will be written on one end of the seam, or portion of seam tested. All of the above information will also be logged on the Installers Non destructive Testing Form as attached in Appendix A.

Vacuum testing

Unless otherwise specified, the general vacuum testing procedure used by the Installer shall be as follows:

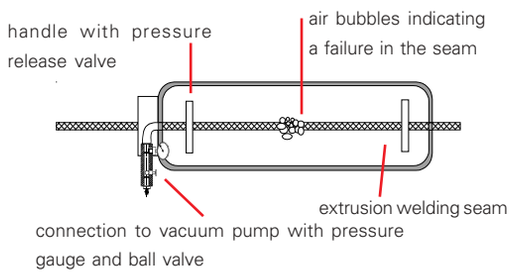
- Turn on the vacuum pump to reduce the vacuum box.
- Apply a generous amount of liquid soap and water solution to the area to be tested.
- Place the vacuum box over the area to be tested and apply sufficient downward pressure to "seat" the seal strip against the liner.
- Close the release valve and open the ball valve.
- Ensure that a leak tight seal is created.
- For a period of not less than 15 seconds, examine the geomembrane through the clear top view for the presence of soap bubbles.
- If no bubbles appear after 15 seconds, open thevacuum release valve and move the box over the next adjoining area with a minimum of 75 mm overlap, and repeat the process.

Vacuum Testing Documentation

Vacuum testing crew will use Mean Streak permanent markers to write on liner indicating tester's ID number, date and pass/fail designation on all areas tested.
Records of vacuum testing will be maintained by the CQC Co-ordinator or testing crew on Installers Non-Destructive Testing Form or Installer`s repair Report Form as attached in Appendix A.

All cuts through the liner, as a result of testing, will be repaired by extrusion welding (patching).

Figure 4. Vacuum Inspection box with transparent top and soft rubber base



Destructive Testing

Concept
The purpose of destructive testing is to determine and evaluate seam strength. These tests require direct sampling and thus subsequent patching. Therefore, destructive testing should be executed to a minimum in the field area to reduce the amount of repairs to the geo-membrane exept remaining liner in the trench.

Procedure for Destructive Testing

Destructive test samples shall be marked and cut out randomly at a minimum average frequency of one test location every 150m (500 feet) of seam length, unless otherwise specified or agreed.

Location of destructive samples will be selected by CQC Co-ordinator (or the third party QA Representative), with samples cut by Installer`s welding Personnel.

Destructive samples should be taken and tested as soon as possible after the seams are welded (the same day), in order to receive test results in a timely manner.

Installer`s qualified personnel will observe all field destructive testing and record date, time, seam number, location, and test results on Installer`s Destructive Testing form- attached in Appendix A.

All destructive test locations with pass/fail designation will be marked on liner with permanent markers, such as „Edding".

Sample Size

The sample should be 300mm (twelve inches) wide with a seam 400mm (sixteen inches) long with the seam in the center. The sample may be increased in size if an independent laboratory testing shall make at Client`s request or as specified in the project specifications.

A 25mm (one inch,1") specimen shall be cut from each end of the choosen seam for field testing.The two specimens shall be tested on a field tension-meter for peel strength. If either field specimen does not pass, it can be assumed that the sample would also not pass specified destructive testing. The procedure mentionedshall be followed to locate passing samples for specified testing.

Procedure for Non-Complying Destructive Test

Cut additional field samples out of the seam where tested specimen failed at peel testing. The distance should be approximately 3.0m in each direction from the location of the initial non-complying sample. Perform a field test for peel strength. If those field samples pass, then all sampling material can be cut for specified testing. If all specimen of the full sample length pass, then repair should be carried out in the area between the two passing sample locations according to procedures described.

If either of the samples are still in non-compliance, the additional samples are taken in accordance with the above procedure until two passing samples are located to establish the zone where the seam should be reconstructed.

All passing seams must be bounded by two locations wherefrom full samples, passing specified destructive test, have been taken.

In cases of repaired seams exceeding 45m (150 feet), a sample must be taken out and pass destructive testing within the zone where the seam has been reconstructed. Each part must be considered as an independend seam.

All destructive seam samples shall be numbered and recorded on Installation Company's Destructive Test Form as attached in Appendix A.

Specified Testing of Destructive Seam Samples

Full Destructive Seam Testing

Full destructive test on samples will be performed by the Installer when required by the site specific QC plan or in the event that third party destructive testing is not being performed. Full samples will be tested under appropriate conditions on site unless off site laboratory testing is required by the specifications or the site Supervisor`s request of laboratory testing.

Destructive samples will be tested for "shear strength" and "peel adhesion" (according to DVS 2226-1/2/3). Five specimen shall be tested for each test method and results shall be considered in accordance to the tables shown in the above mentioned DVS standard

Defects and Repairs

The Installation Company's CQC Co-ordinator and/ or project Superintendent shall carefully after completion of seams visually check all seams and areas of the geo-membrane for defects,holes, blisters, or any signs of damage

All other installation personnel shall, at all times, be on the lookout for any damages on the geomembrane. Damaged areas shall be marked and repaired.

Repair Procedures

Any part of the geo-membrane seam showing a defect, or having a destructive or non-destructive test in non-compliance shall be repaired. Several procedures exist for repair and the decision as to the appropriate repair procedure shall be made by Installer Company's project Superintendent.

Procedures available for repair include the following:

Patching
In general to repair large holes, deep notches or cut outs where destructive samples where taken. All patches shall extend at least 8.0cm (three inches 3") all the edges of the defect and all corners of patches shall be rounded.

Grinding and Welding
Used to repair sections of extruded fillet seams.

Spot Welding or Seaming
Used to repair small tears, pinholes, or other minor localized flaws.

Cap strips
Used to repair length of extrusion or fusion welded seams.

Welding of overlap along the fusion welded seams.

Removal of a seam and replacement with a strip of new material seamed into place.

Verification of Repairs

Every repair shall be non-destructively tested. Repairs which pass the non-destructive test shall be considered acceptable. Repairs exceeding 50m in length (150 feet) require a destructive test. Non-destructive testing of repair shall be logged on a Installer Repair Report Form when specified as attached in Appendix A.

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Geo-textiles

Handling and Placement

All geo-textiles shall be handled in a manner to ensure that they are not damaged. The following special handling requirements shall be considered as:

- On slopes, the geo-textiles shall be secured in the anchor trench and then rolled down the slope if practical. In any case it should be deployed in such a manner that no waves, wrinkles or overfolding can take place.
- In presence of wind, all geo-textiles shall be secured by weight with sandbags or tyres.
- Geo-textiles shall be cut using an approved cutter. Once the material is cut in place, special care has to be taken to protect other geo-synthetic materials from damage.
- Care shall be taken not to entrap stones or any type of debris what could damage the geo-membrane, especially gravel which is mainly used as filter material.

Seams and Overlaps

Geo-textiles may be seamed by thermal bonding or by sewing. No horizontal seams shall be allowed on slope sections.

On slopes steeper than ten horizontal to one vertical, it is recommended that geo-textiles be continuously sewn along the entire length of the seam. Geo-textiles shall be overlapped a minimum of 10cm (four inches 4") prior to sewing.

On sections lower than ten horizontal to one vertical, geo-textiles can be either sewn as indicated above or thermally bonded. If thermally bonded, the geo-textile shall be overlapped a minimum of 10cm (four inches 4")prior to seaming.

Repairs

Any holes or other defects in the geo-textile shall be repaired as follows:

On Slopes

- A patch made from the same geo-textile shall be seamed into place. Should any defect exceed 10% of the width of the roll, those roll shall be removed from the slope and replaced.

Horizontal Areas

- A patch made from the same geo-textile shall be spot-seamed in place with a minimum of 300mm (twelve inches 12") overlap in all directions.

Geo-nets

Handling and Placement

The geo-nets shall be handled in such a manner as to ensure the geo-nets are not damaged in any way.

- On slopes, the geo-nets shall be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the geo-net sheet in low tension to avoid waves or overfolding.If necessary, the geo-net shall be positioned by hand after being unrolled to minimize wrinkles. Geo-nets can be placed in the horizontal direction (i.e., across the slope) in some special locations (e.g., where extra layers are required or where slope is less than 10:1). Such locations shall be identified by the Design Engineer in the project drawings.
- Geo-nets shall not be welded to geo-membranes. Geo-nets shall be cut using approved cutters, i.e., hook blade knives, scissors, etc. Care should be taken to prevent damage to material layers beyond.
- Care must be taken not to entrap dirt in the geo-net that could cause clogging of the drainage system, and/or stones that could damage the geo-membrane.

Placing andTying of Geo-net

When several layers of geo-nets are installed, care should be taken to prevent the strands of one layer from penetrating the channels of the next layer. Adjacent geo-nets shall be joined according to the following requirements.

Adjacent rolls shall be overlapped by at least 10cm (four inches 4") and securely tied.

Tying can be achieved by plastic fasteners. Tying devices shall be of bright color for easy inspection. Metallic strips are not allowed.

Tying shall be 1.5m - 3.0m along the base/slope section, every 1.5m along the slope every 60cm across the slope and at top of berm and into anchor trench at least with 30cm intervals.

In the corners of the slopes where overlaps between perpendicular geo-net strips are required, an extra layer of geonet shall be unrolled along the slope, on top of the previously installed geo-nets, from top to bottom of the slope.

If more than one layer of geonet is installed, overlaps must be staggered and layers tied together.

Repairs

Any holes or other defects in the geo-net shall be repaired by placing a patch extending 60cm (two feet) of the damaged area beyond in each direction. The patch shall be secured to the existing geo-net by tying every 300mm (twelve inches 12"). If the width of the damaged area across the roll is more than 50% of the roll width, the damaged area shall be cut out and the two separated parts of the geo-net shall be joined.

Geo-composites

Handling and Placement

All Geo-composites shall be handled in a manner to ensure that they will not be damaged. The following special handling requirements shall be considered:

- On slopes, the geo-composites shall be secured in the anchor trench and then carefully unrolled down the slope when practical.
  In any case it should be deployed in such a manner as to continually keep the geo-composite sheet in sufficient tension to reduce folds and wrinkles.
- In the presence of high wind, all geo-composites shall be weighed with sandbags or equivalent.
- Geo-composite shall be cut using an approved cutter, i.e. hook blade knives. If the material is being cut in place, special care must be taken to protect other geo-synthetic materials from damage.
- Care shall be taken not to entrap stones or other debris that could damage the geo-membrane, or generate clogging of drains or filters.

Seams and Overlaps

Geo-composites may be seamed by thermal bonding or by sewing. No horizontal seams shall be allowed on side slopes greater than 4:1.

On slopes steeper than ten horizontal to one vertical, it is recommended that geo-composites be continuously sewn. The geo-composite must be overlapped by at least 8cm (three inches 3") the geo-net overlap by at least 10cm (four inches 4").

On base and slopes with more than ten horizontal to one vertical, geo-composites can be either sewn as indicated above or thermally bonded.

Tying of the geo-composite will be with plastic fasteners. Tying devices shall be of bright color for easy inspection. Metallic strips are not allowed.

Tying shall be 1.5m - 3.0m along the base/slope section, every 1.5m along the slope every 60cm across the slope and at top of berm and into anchor trench at least with 30cm intervals. End to end joints on the base will be overlapped 30cm with no tying.

Repairs

The repair will be observed and if smaller than 1.0m x1.0m the geo-composite will be repaired. If the defect is larger, then the roll will be cut and a overlap joint is placed.

In case if the geo-net is undamaged, and the geo-textile is damaged, a patch of geo-textile shall be placed. The geo-textile patch shall be thermally bonded in place with a minimum of 300mm (twelve inches 12") overlap in all directions.

If the geo-net is damaged, the damaged geo-net shall be removed. A section of geo-net shall be cut to replace the removed section. The geo-net shall be tied to the existing geo-net using plastic fasteners placed at least every 15cm (six inch 6") overlap. A geo-textile patch shall be placed over the repaired geo-net section. The geo-textile patch shall be thermally bonded in place with a minimum of 300mm (twelve 12") inch overlap in all directions.

Geo-synthetic Clay Liners

Storage

Geo-synthetic clay liner rolls must always be stored in a location where they will not be exposed to excessive moisture.

Handling & Placement

- On slopes, geo-synthetic clay liners should be placed with overlap oriented parallel to the maximum slope (i.e. down the slope, not across the slope).
- Joining panels of geo-synthetic clay liners the overlap should be a minimum of 15cm (six inches 6").
- Geo-synthetic clay liners never should be installed in remaining pits of water or during rainfall.
- Geo-synthetic clay liners should always be installed with appropriate side up.
- Rolls should be pulled tight to smooth out any creases or irregularities.

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- Precautions should be taken to avoid damage to any underlying geo-synthetic materials while placing the geo-synthetic clay liners.

  Cover geo-synthetic clay liners with geo-membrane or other cover materials after placement to avoid damage from penetration.

- **Repairs**

  Repairs to cuts or tears at installed rolls should extend a minimum of 15cm(six inches 6") beyond the area in need of repair. Repair pieces should be held in place until cover material has been placed.

- **The Procedures described herein are those in effect of AGRU lining technology reserves the right to deviate from these procedures in order to keep abreast of changes in technology.**

Liner with geotextile protection and backfilling of gravel

Drawings at following pages

- Corner sections
- Corner section and drainage detail
- Drainage Detail
- Retaining Trench
- Slope/Base Section
- Welding Seams
- Dam Penetrations
- Mechanical Attachment
- Attachment Details

retaining trench

corner section

extrusion weld

dam penetration

mechanical attachement

slope-base section

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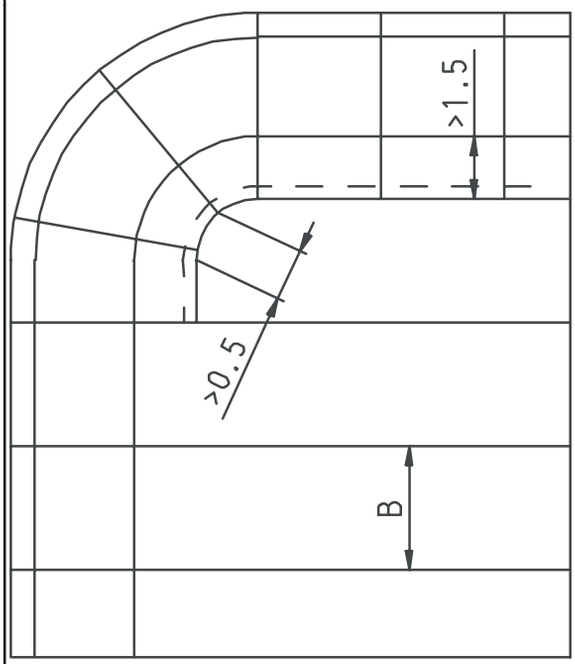
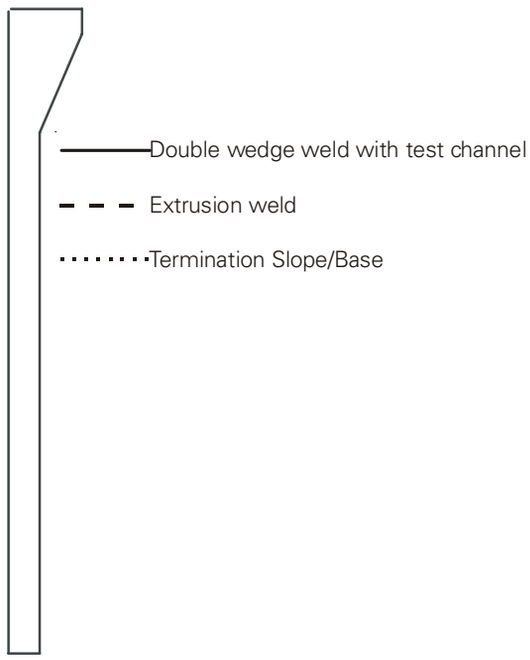
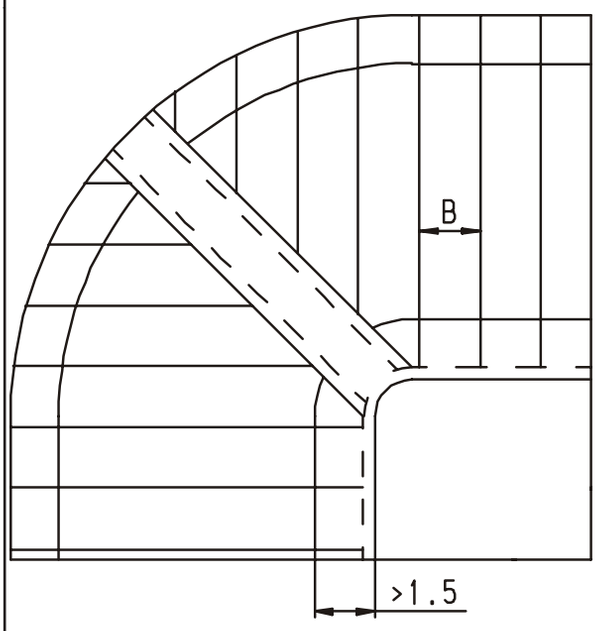
Typical corner section:
measurements in mm
all figures shall be considered as minimum

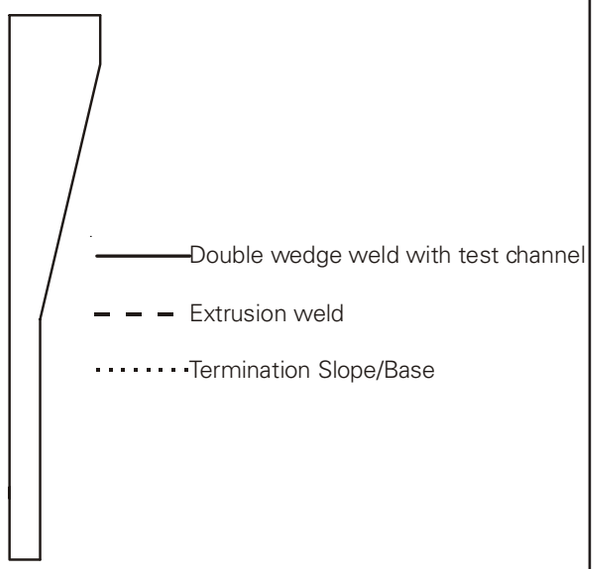




cut view

Typical corner section:
measurements in mm
all figures shall be considered as minimum requirements





cut view

Detail corner section and drainage detail

Typical corner section:
measurements in mm
all figures shall be considered as minimum requirements

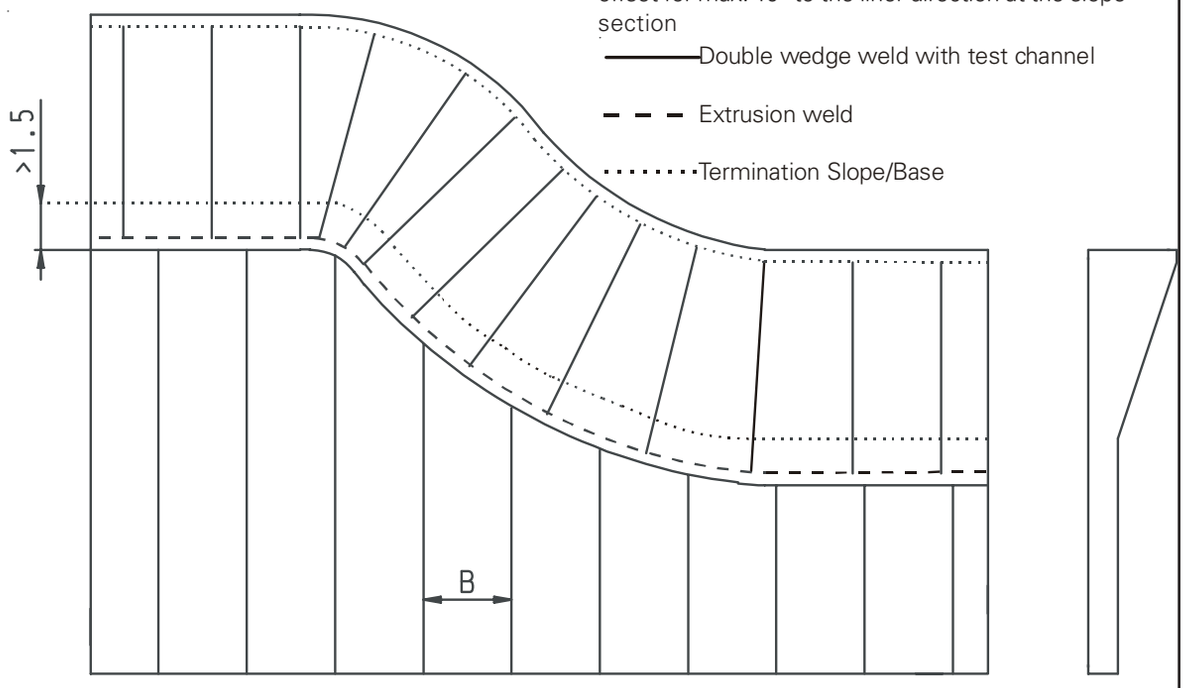
1.the welding seam at slope/base transition may be executed either as hot wedge double fusion or as extrusion welding seam.

2. the liner direction at transition section may be offset for max. 10° to the liner direction at the slope section

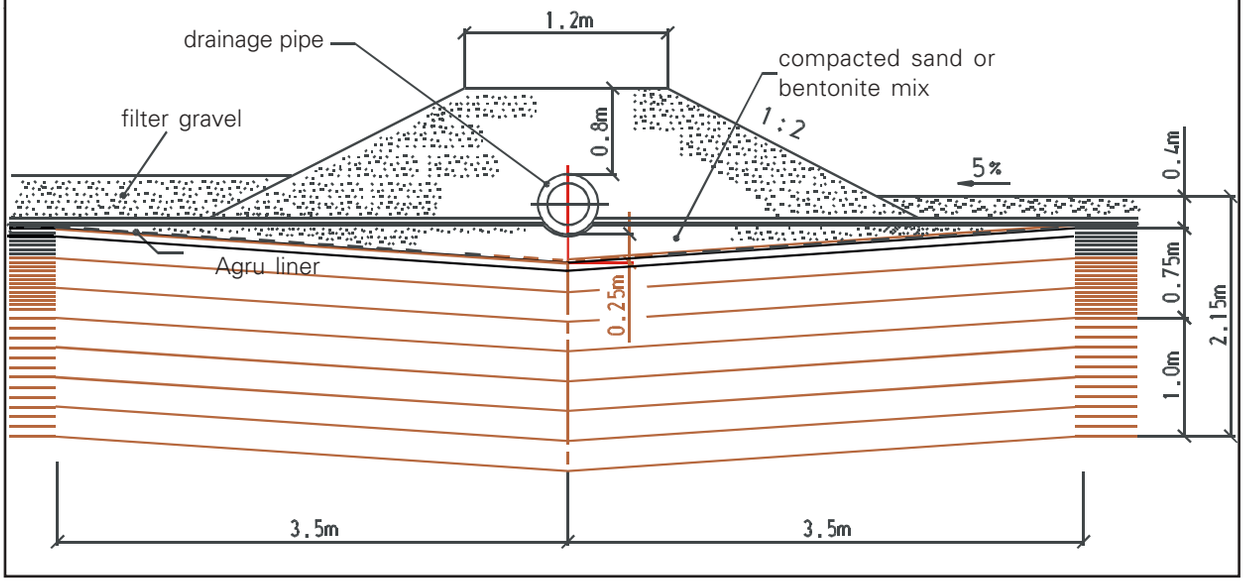
Double wedge weld with test channel

Extrusion weld

Termination Slope/Base



typical drainage detail



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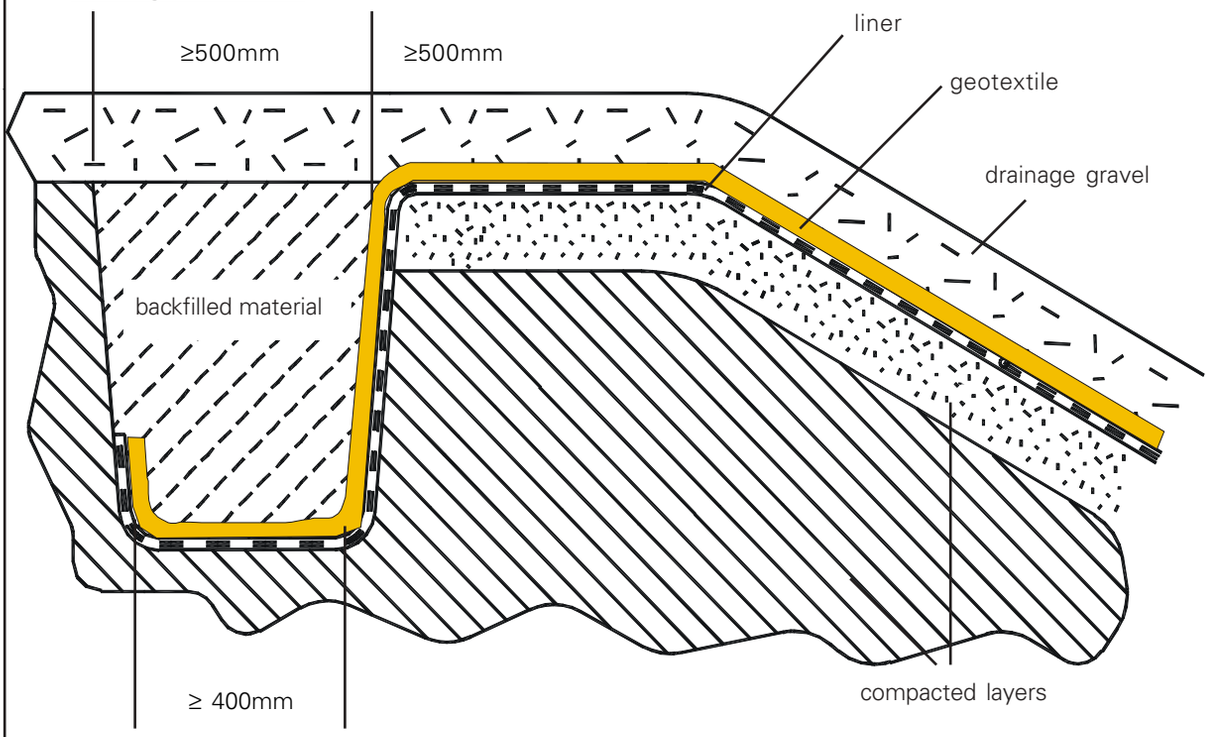
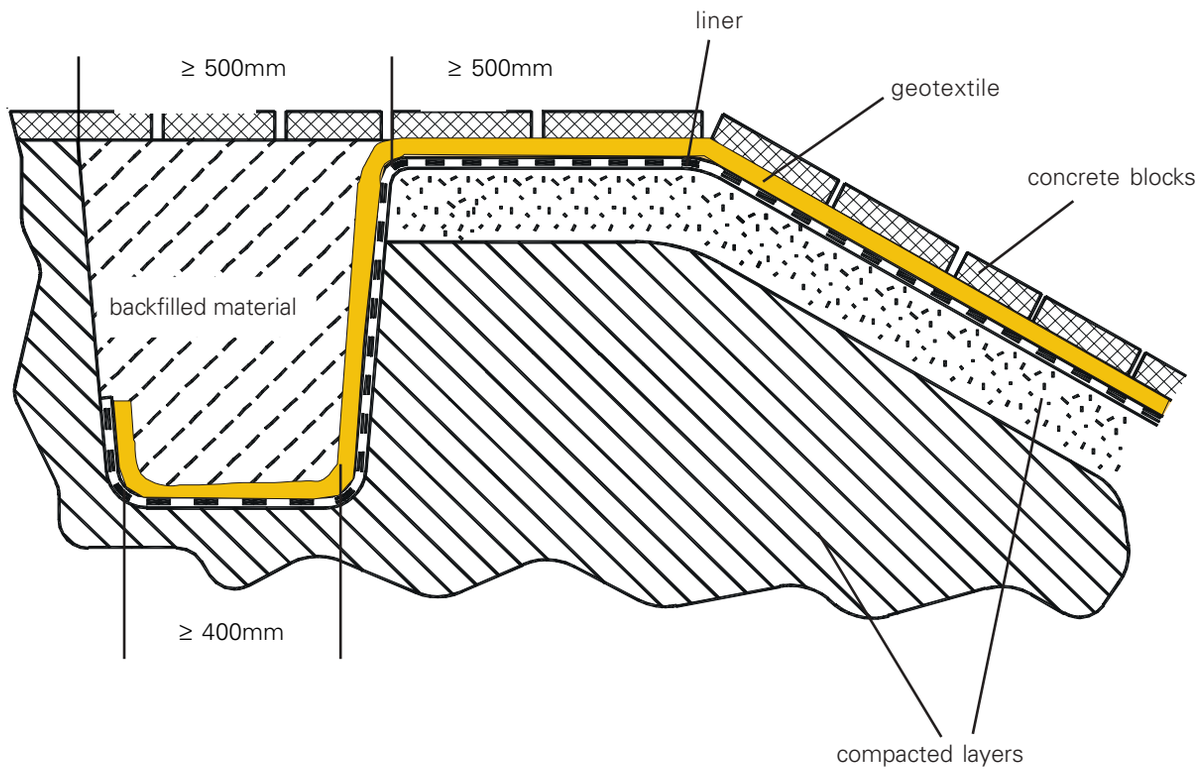
Detail retaining trench

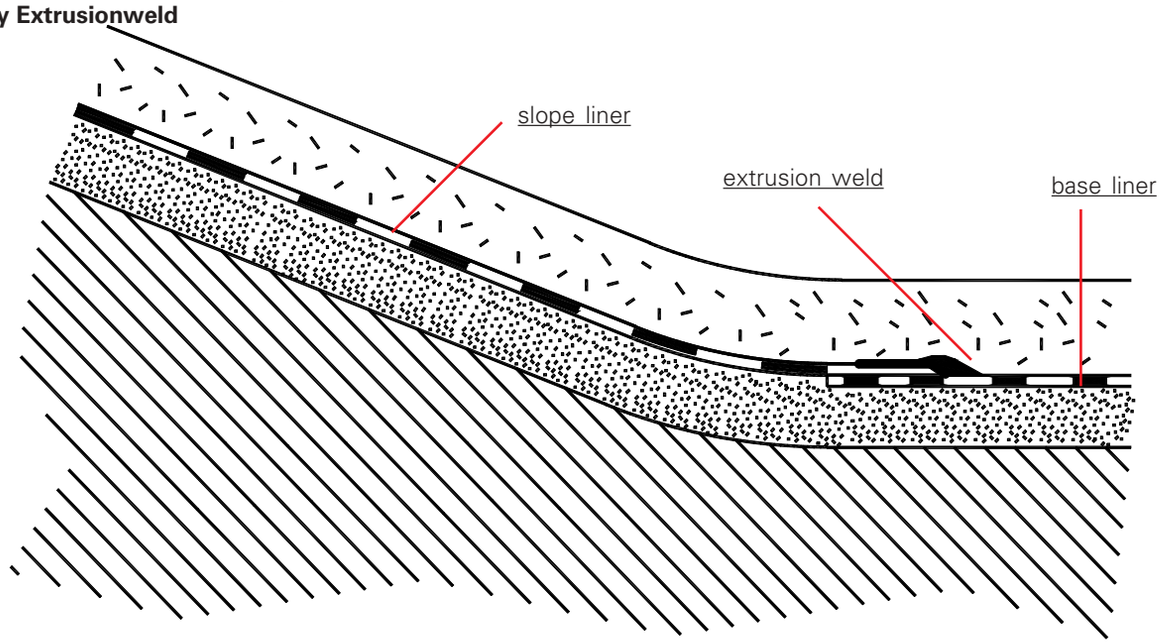
retaining trench (liner)



retaining trench (liner and geotextile covered by concrete blocks)

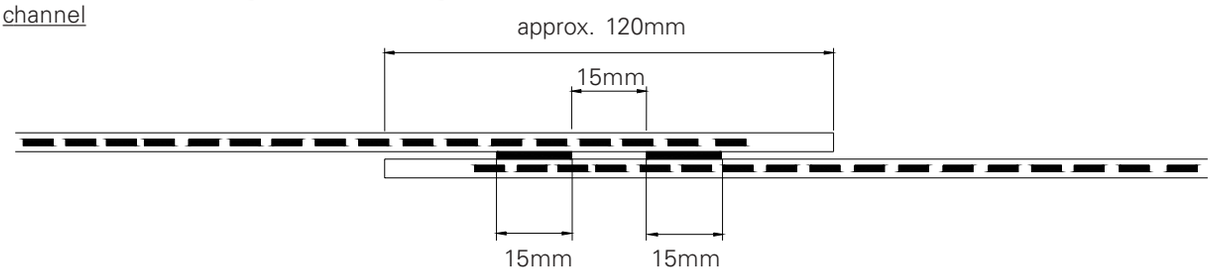


Detail Slope/Base Section joined by Extrusionweld

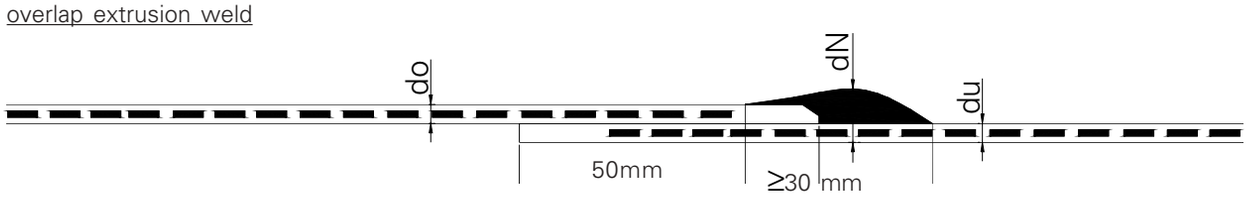


Detail Welding Seams

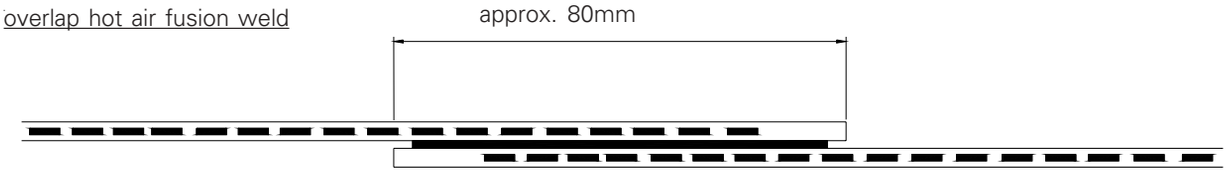
double fusion hot wedge weld with integrated test channel



overlap extrusion weld



overlap hot air fusion weld



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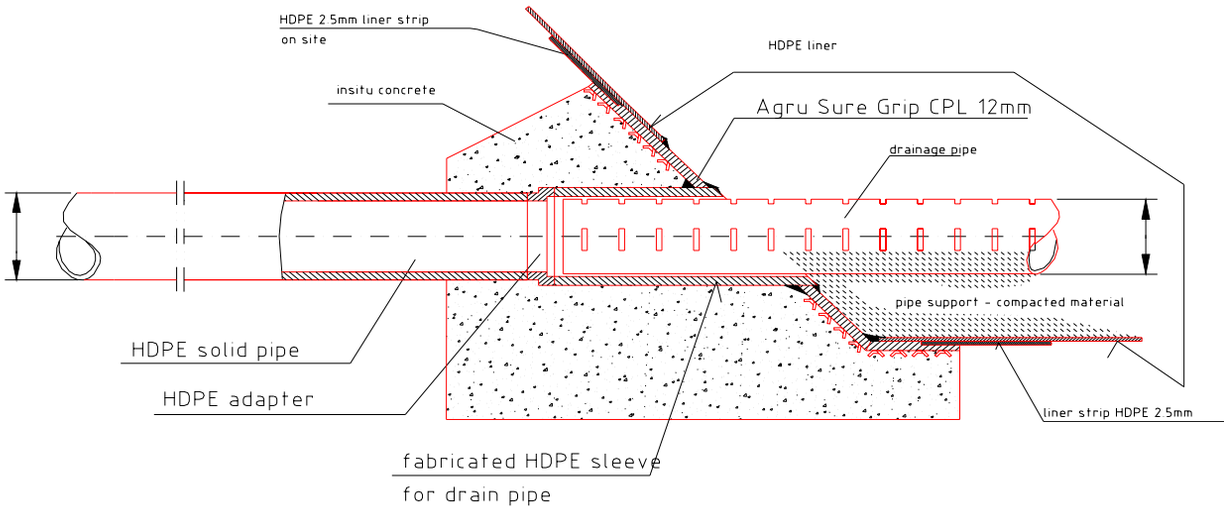
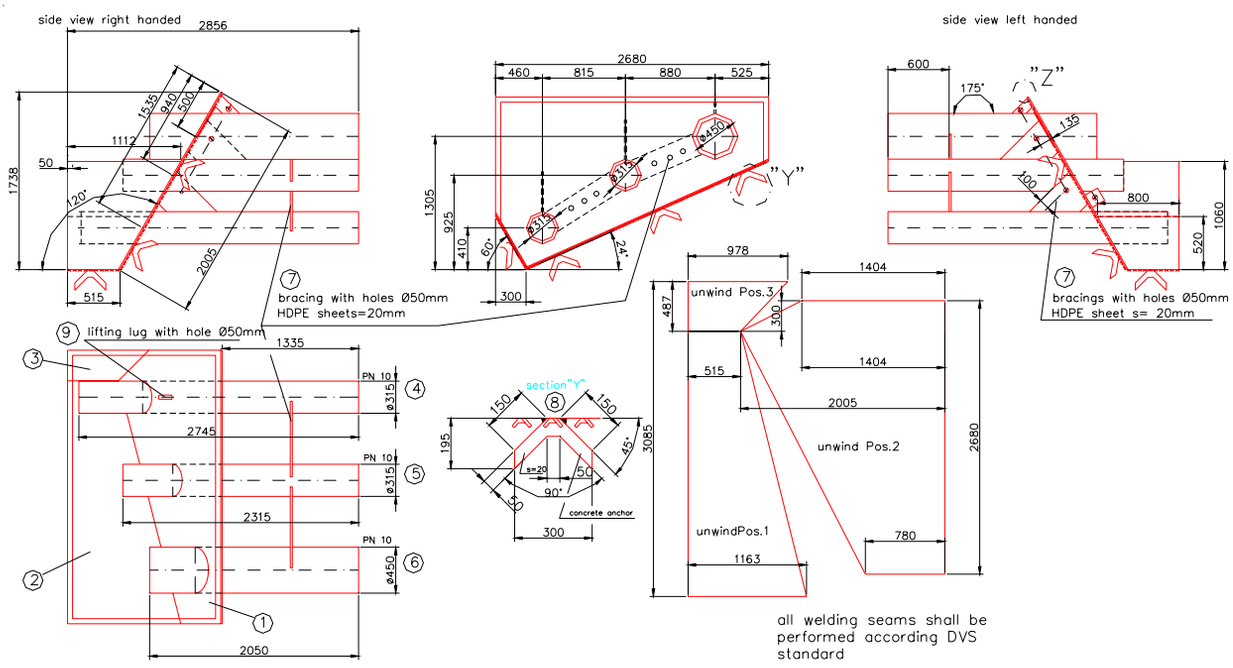
Dam Penetrations

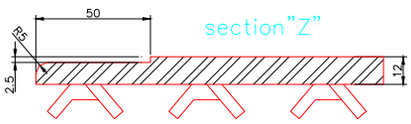


pipe dimension

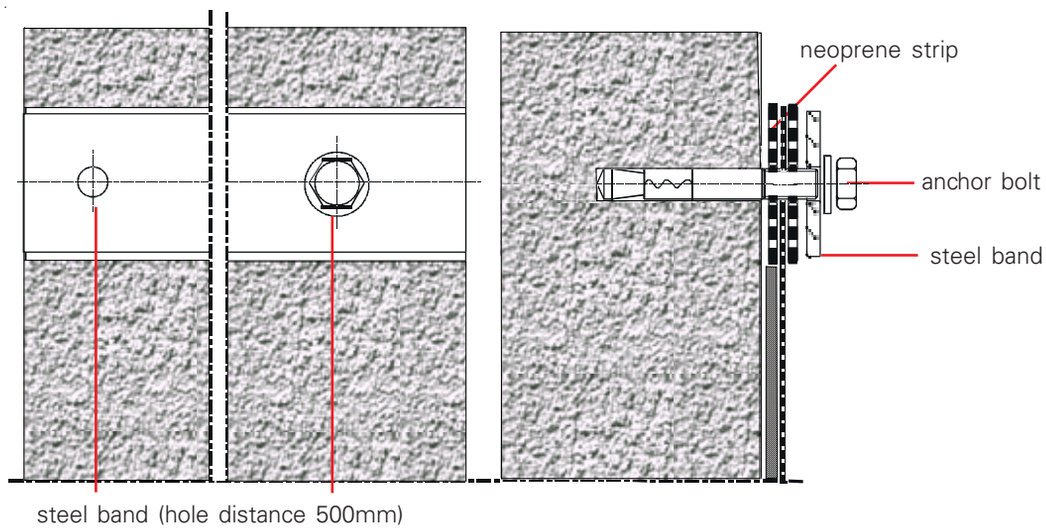
slope

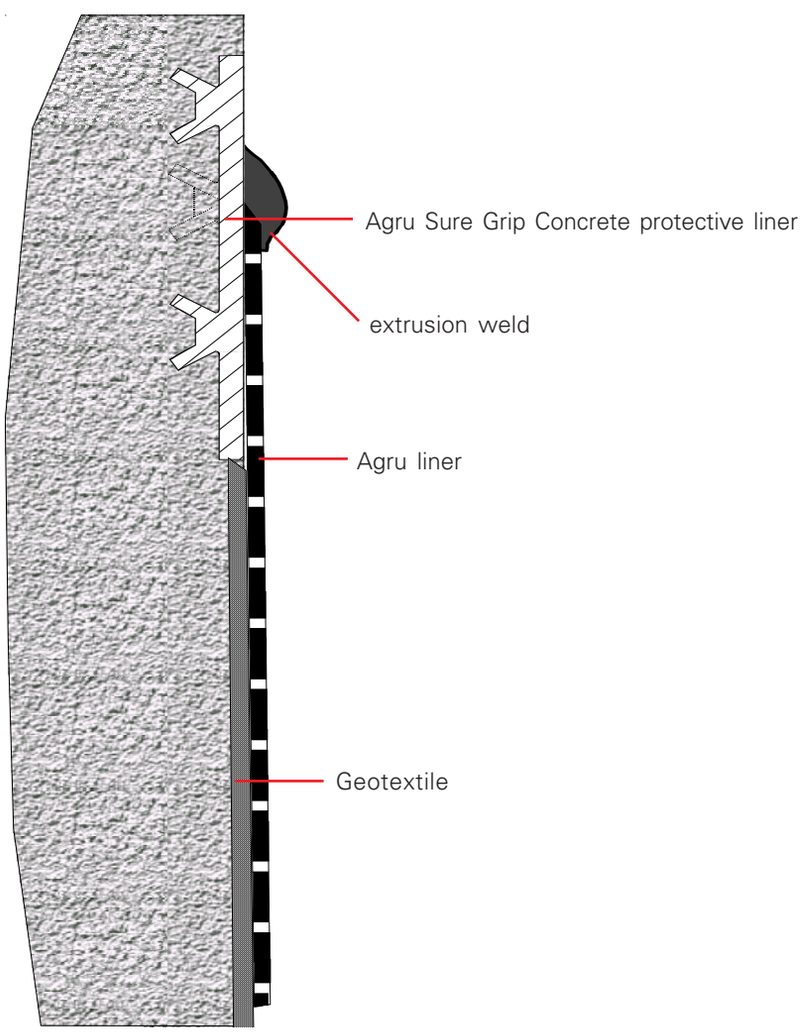
dam penetration structure
drawing A4-2066-99





Mechanical Attachment





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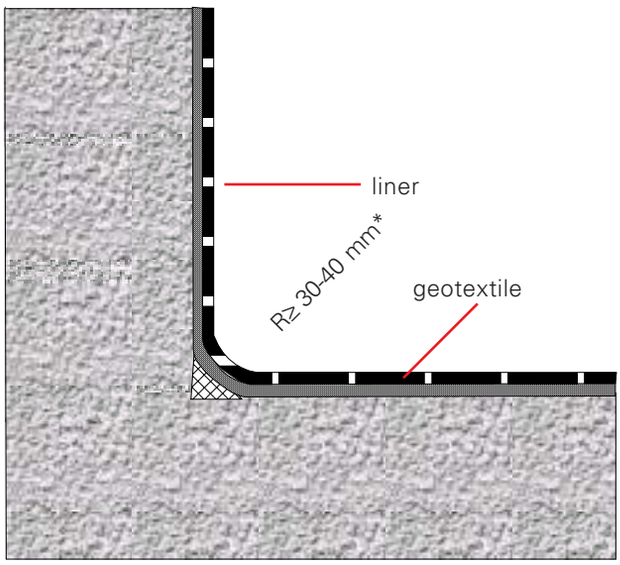
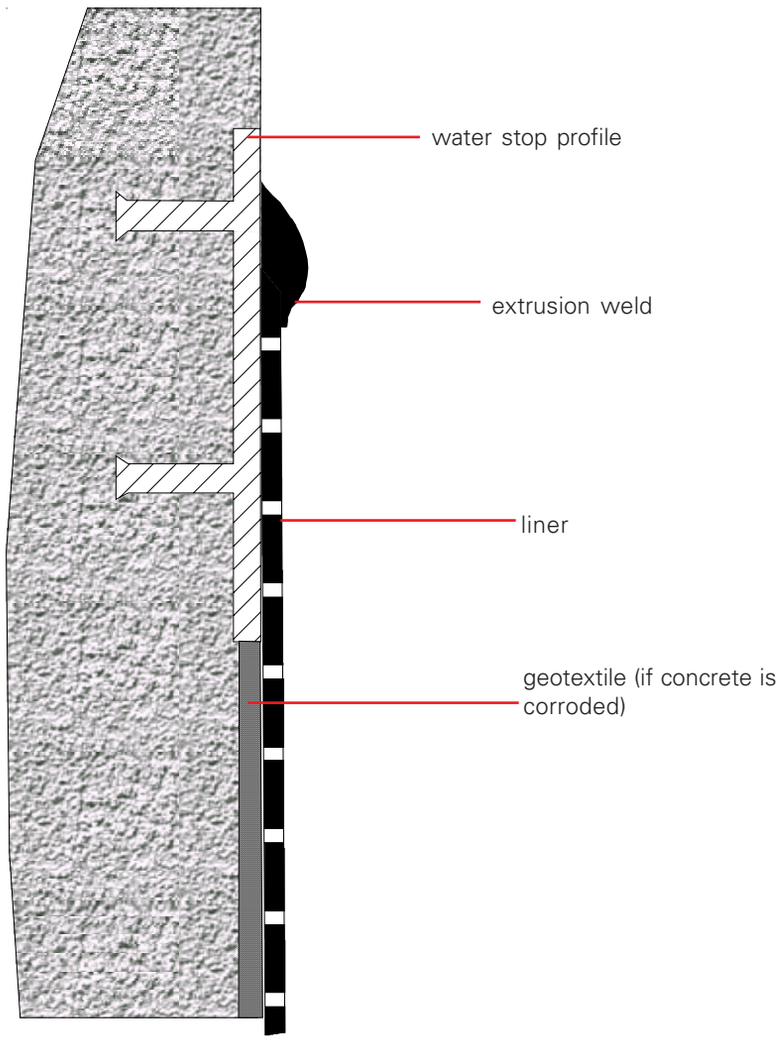
Attachment Details



*edges formed by lean concrete or PU-foam



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AGRU Seam Log

Project Name ____________________ Site Manager ____________________

Location ____________________ Material ____________________

Job Number ____________________ Sheet Thickness ____________________

Q.A. Tech. ____________________ Smooth _______ structured/textured _____

Seam Number	Time of Weld	Date of Weld	Type of Weld	Length of Seam	Machine Number	Technician ID Number

HOME

Welding Protocol for Hot Wedge Welding (Double Seam) (following DVS 2225 part 4)	**Prot.N°:**

Project:	Installation Company:
Liner/Sheet:	Nominal Thickness : [mm]
Welding Machine:	Welder:

Material-Description	
Liner/Sheet Manufacturer:	Roll-/Serial N°
Type of Sheet Material:	

	Measurement		1	2	3	4	Remarks
	Seam N°						
Time	Begin						
	End						

Weather Conditions		
General (Clouds/ Wind)		
Air Temperature	[°C]	
Relative Atmospheric Humidity	[%]	

Liner Conditions		
Surface		
Welding Area		
Surface Temperature	[°C]	

Welding Parameters								
Wedge Temperature	Setting	[°C]						
	Measurement		Begin					
			End					
Preheating Temperature	Setting	[°C]						
	Measurement		Begin					
			End					
Welding Speed	Setting	[m/min]						
(for automatic welding)	Measurement	[m/min]						
Welding Force	Setting	[N]						
	Measurement	[N]						

Welding Seam Test in accordance with DVS 2225-1 / ÖNORM S 2076		
Test Weld (Seam)	N°	
Weld - Specimen	N°	

Notes:

	welder	supervision of construction	3rd party quality control
Date			
Signature			

HOME

Test Protocol for Hot Wedge Welding (following DVS 2225 part 4)	**Prot.N°:**

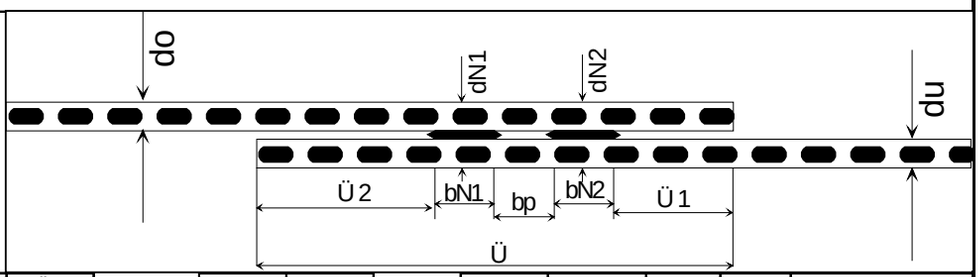
Project:	Installation Company:
Liner/Sheet:	Nominal Thickness : [mm]
Seam Design	Seam N°

Outer Appearance

station	weld path	bulging	notches and grooves	Remarks

Measurements [mm]

D dn1=(do+du)-dn1
D dn2=(do+du)-dn2



station	Ü1	Ü2	bN1/bN2	do	du	do+du	dn1	dn2	D dn1	D dn2	Remarks

Test of mechanical seam properties ¡ with graphic display ¡ without graphic display

station	specimen width [mm]	maximum force [N]	deformation and failure behaviour	Result	Remark

Imperviousness-Air Pressure Test

station	Liner Temperature °C Test pressure bar Test time	Pressure Loss < 10%	Remark

Weld - Specimen N°

Notes:

	welder	supervision of construction	3rd party quality control
Date Signature			

HOME

Welding Protocol for Extrusion Welding (following DVS 2225 part 4)	**Prot.N°:**

Project:	Installation Company:
Liner/Sheet:	Nominal Thickness : [mm]
Welding Machine:	Welder:

Material-Description	
Liner/Sheet Manufacturer:	Roll-/Serial N°
Type of Sheet Material:	
Type of Filler Material:	

	Measurement		1	2	3	4	Remarks
	Seam N°						
Time	Begin						
	End						

Weather Conditions		
General (Clouds/ Wind)		
Air Temperature	[°C]	
Relative Atmospheric Humidity	[%]	

Liner Conditions		
Surface		
Welding Area		
Surface Temperature	[°C]	

Welding Parameters								
Extrudate Temperature	Setting	[°C]						
	Measurement		Begin					
			End					
Preheating Temperature	Setting	[°C]						
	Measurement		Begin					
			End					
Welding Speed	Setting	[m/min]						
(for automatic welding)	Measurement	[m/min]						

Welding Seam Test in accordance with DVS 2227-1 / ÖNORM S 2077-1		
Test Weld (Seam)	N°	
Weld - Specimen	N°	

Notes:

	welder	supervision of construction	3rd party quality control
Date Signature			

HOME

Test Protocol for Extrusion Welding (following DVS 2225 part 4)	**Prot.N°:**

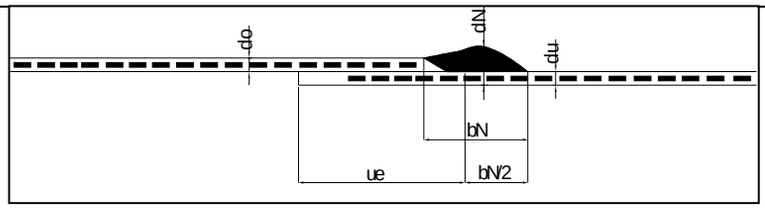
Project:	Installation Company:
Liner/Sheet:	Nominal Thickness : [mm]
Seam Design	Seam N°

Outer Appearance

station	weld path	bulging	notches and grooves	Remarks

Dimensions [mm]

ue =overlap ≥ 40mm
do = top liner
du = bottom liner
bN ≥ 30mm
bN2 = offset 5mm
dn = seam height ≥ 1,25x(do+du)
≤ 1,75x(do+du)



station	do	du	bN	bN2	dn	ue		Remarks

Test of mechanical seam properties ¡ with graphic display ¡ without graphic display

station	specimen width [mm]	maximum force [N]	deformation and failure behaviour	Result	Remark

Imperviousness-Vacuum/pressure test

station	Vacuum Vacuum Pressure bar Test time	High Voltage Spark Test Type Voltage kV	Remark

*for fillet welds

Weld - Specimen N°

Notes:

	welder	supervision of construction	3rd party quality control
Date Signature			

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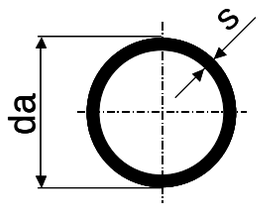
System of units

Size	Technical system of units	SI - unit (MKS-system) Legal unit	ASTM - unit
Length	m	m 1m = 10dm = 100cm = 1000mm 1000m = 1km	ft 1,609km(statute) = 1Meile = 1,852km (naut.) = 1Meile 0,9144m = 1yd = 3ft 25,4mm = 1 inch
Area	m^2	m^2 $1m^2 = 100dm^2 = 10000cm^2$	yd^2 $0m836m^2 = 1yd$ $1yd^2 = 9ft^2$
Volume	m^3	m^3 $1m^3 = 10^3dm^3 = 10^6cm^3$	yd^3 $0,765m^3 = 1yd^3$ $1yd^3 = 27ft^3$
Force	kp 1N = 0,102kp 1kp = 9,81N	N $1N = 1kgm/s^2 = 10^5$ dyn	lb 1lbf = 4,447N = 32poundals
Pressure	kp/m^2 $1N/cm^2 = 0,102kp/cm^2$ 0,1bar = 1mWS 1bar = 750Torr 1bar = 750 mmHg 1bar = 0,99atm	bar $1bar = 10^5Pa = 0,1N/mm^2$ $10^6Pa = 1MPa = 1N/mm^2$	psi 1bar = 14,5psi = 14,5lb/sq in
Mechanical stress	kp/mm^2 $1N/mm^2 = 0,102kp/mm^2$	N/mm^2	psi $1N/mm^2 = 145,04psi$ = 145,04lb/sq in
Velocity	m/s	m(s	ft/sec. 1m/s = 3,2808ft/sec.
Density	g/cm^3	g/cm^3	psi $1g/cm^3 = 14,22x10^{-3}psi$
Volume	m^3	m^3	cu ft $1m^3 = 35,3147$ cu ft = 1,3080 cu yd $1cm^3 = 0,061$ cu in
Temperature	°C	°C 1°C = 1°K	°F °F = 1,8 x °C + 32

SDR - Standard Dimension Ratio



$$SDR = \frac{da}{s}$$

Example:
da = 110 mm
s = 10 mm

$$SDR = \frac{da}{s} = \frac{110}{10} = 11$$

SDR ... Diameter - wall thickness relation
da ... outside diameter [mm]
s ... wall thickness

S - series

$$S = \frac{SDR - 1}{2}$$

Example:
SDR11

$$S = \frac{SDR - 1}{2} = \frac{11 - 1}{2} = 5$$

SDR ...Diameter - wall thickness relation

Component operating pressure

$$p_B = \frac{20 \cdot \sigma_v}{(SDR - 1) \cdot C_{min}}$$

Example:
PE 100, 20°C, 50 years, wather (d.h. σ_V=10)
SDR11
Cmin=1,25

$$p_B = \frac{20 \cdot \sigma_v}{(SDR - 1) \cdot C_{min}} = \frac{20 \cdot 10}{(11 - 1) \cdot 1{,}25} = 16$$

p_B ... Component operating pressure [bar]
σ_v ... Reference strength [N/mm²]
(see the pressure curve for each material)
SDR ... Standard Dimension Ratio
C_{min} ... Minimum safety factor
(see following table)

Material	Temperatur		
	10 bis 40°C	40 bis 60°C	über 60°C
PE 80	1,25		
PE 100	1,25		
PP-H	1,6	1,4	1,25
PP-R	1,25		
PVDF	1,6		
ECTFE	2,0		

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Drainage system

Demands:

A very important part of the landfill site is a good functional drainage system of the waste. The function of the drainage system is determined by the individual components of the sealing system.

Function of a base drainage system:

- Avoidance of uncontrolled backwater at landfill base
- Collection and transport of the leachate to the collecting and treatment facilities.
- Controlled drainage of the filter systems.

Those tasks are fulfilled only by a overall functional system of the individual components such as base sealing, drainage pipes, collecting pipes and manholes. Those requirements are met by appropriate dimensions, weldability of material components and/or material equality of the individual components out of HDPE or PP.

Pipes and manhole constructions are subjected to the same chemical requirements as the liners. Usually the pipelines in the landfill are controlled by Video cameras once per year. If strong incrustations appear the pipes should be cleaned by high pressure cleaning. The smooth, anti-adhesive surface of HDPE / PP favours the cleaning of the pipes.

Because of the high chemical resistance and the excellent weldability of HDPE / PP the requirements are fulfilled better than by any other material . The calculated stabililty of pipes and manholes is therefore given. If manhole construction works inside the landfill area are unavoidable, all criteria confirm to the application of HDPE / PP material.

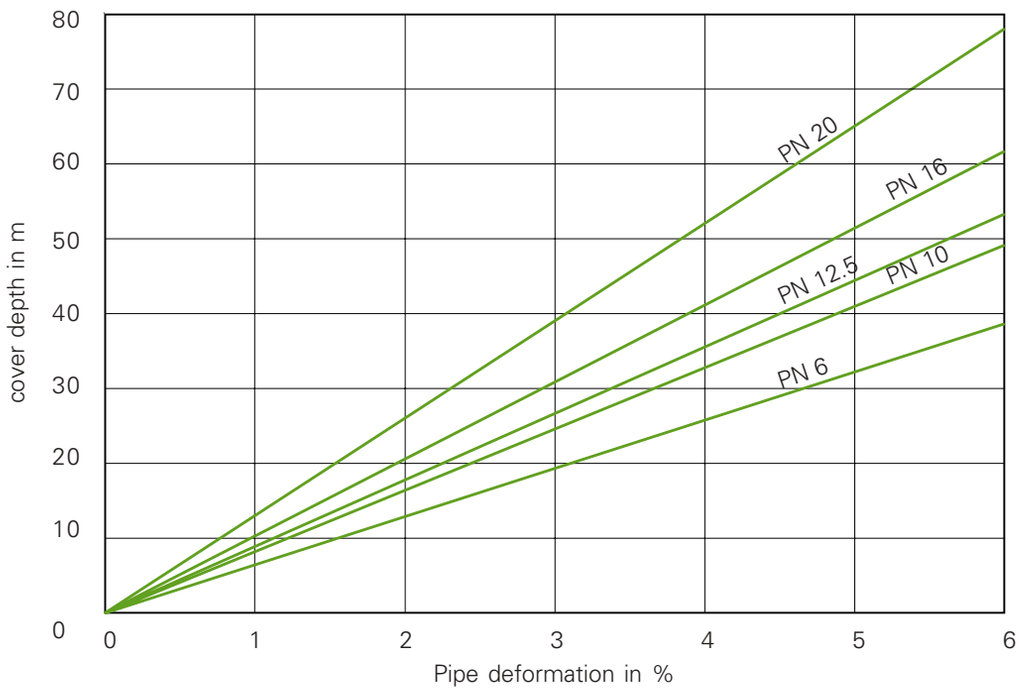
Our engineering department is pleased to support you by statical calculations according to ATV A 127 for leachate pipes at any time.

Strain Diagram for slotted HDPE Pipes

This diagram is a general information. As in each assembly case changed Values can occur, thes values are only guide values.
So a calculation is for each project is to do.

Calculation basis:ATV A 127

- ❑ Garbage Density: 15 kN/m²
- ❑ Pipe support Material: Gravel 16/32
  Clay
- ❑ Temperature: 30° C
  Reduction: 15 %
- ❑ Reduction (Slots): 25%
- ❑ Density of Proctor: 97%
- ❑ E-Modulus of the base soil
  next to and beyond the pipe: 23 N/mm²
- ❑ E-Modulus of the base soil: 6 N/mm²
- ❑ Load Case: Dam



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Calculation of buried piping systems

A stress and deformation proof according to ATV, instruction sheet A 127, has to be furnished for buried piping systems (e. g. drainage channels). But there can also serve other basis for calculation, such as ÖVGW (guideline G 52) or results of research projects.

There is a software program for the surcharge calculation according to ATV 127 at disposal in our technical engineering department in order to furnish the demanded proof.

Please fill in the following questionnaire as completely as possible. We will promptly prepare a corresponding statics after receipt of the questionnaire.

1. Generally	Project:					
	Site:					
	Principal:					
2. Details for pipe	Pipe material:			Pipe inside diameter:		[mm]
	Pipe outside diameter:		[mm]	Wall thickness:		[mm]
	Nominal width:		[mm]			
3. Soil		Zone	1	2	3	4
	Group	G (1,2,3,4)				
	Kind of soil	(gravel, sand, clay, loam)				
	Specific gravity	[kN/m³]				
	Proctor density	[%]				
	E-Modulus of the soil E_B	[N/mm²]				
4. Installation	Dam ☐	Trench ☐				
	Gravel surcharge above pipe summit (min.2xda)	h =	[m]	Width of trench	b=	[m]
				Gradient of slope	β=	[°]
5. Surcharge	Soil ☐	Waste ☐		Traffic load	without ☐	
	Surcharge height	h =	[m]		LKW12 ☐	
	Specific gravity	γ_B =	[kN/m³]		SLW30 ☐	
	Weight on surface	F =	[kN/m²]		SLW60 ☐	
6. Operating conditions of the pipe	Unpressurized discharge piping system			Pressurized piping system		
	Operating temperature	T =	[°C]	Operating temperature	T =	[°C]
	Entry cross section at drainage systems	A_E =	[%]	Operating pressure	p =	[bar]

Calculation of buried piping systems

Comments to some points of the questionnaire

1. Generally:
These general statements are only necessary to enable an easy assignment of the different projects.

2. Details for pipe:
The most important statement is the determining of the pipe material (polyethylene or polypropylene), as normally the pipe dimensions are given.

3. Soil / 4. Installation:
There are four different groups of soil

Group	Specific gravity γ_B [kN/m³]	Angle of internal friction φ'	Deformation modulus E_B in [N/mm²] at degree of compaction D_{Pr} in %					
			D_{Pr}					
			85	90	92	95	97	100
G1	20	35	2,0	6	9	16	23	40
G2	20	30	1,2	3	4	8	11	20
G3	20	25	0,8	2	3	5	8	13
G4	20	20	0,6	1,5	2	4	6	10

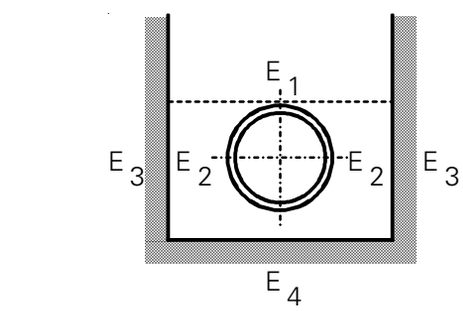
The at the calculation applied deformation modulus of the soil has to be distinguished by the following zones:

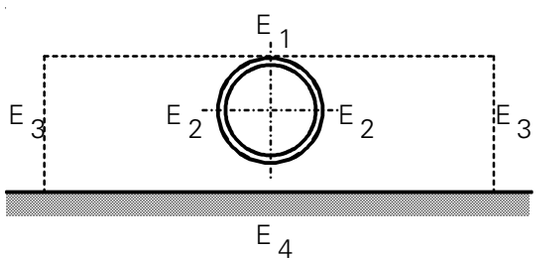
E_1 .... Surcharge above pipe summit
E_2 .... Conduit zone at the side of the pipe
E_3 .... Adjoining soil beside the conduit zone
E_4 .... Soil below the pipe (site soil)

5. Surcharge:The surcharge height is at the trench embedding condition the installation depth of the pipe (referring to the pipe summit) and at the dam embedding condition the waste surcharge.

6. Operating conditions of the pipe: You only have to fill in the corresponding operating parameter for each application.

Dam embedding condition





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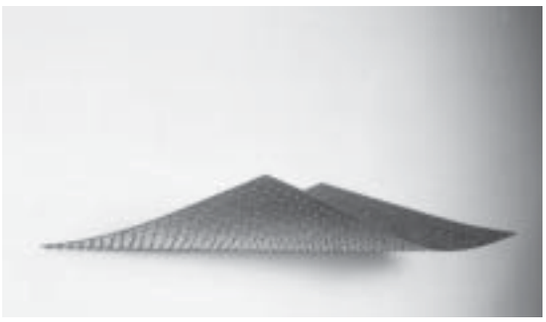
Description of AGRU Structure Types

AGRU offers different structure types and combinations on request if a combination of chosen layers construction requires a special structure combination for the geomembrane.

The **AGRU MICRO-SPIKE MST/MSB** Liner was developed to create one structure type with two different structures:
Top = MST
Bottom = MSB
which can be used for most of typical layer constructions and slope designs.



The enclosed diagrams show the shear interaction of different combinations of sands, soils and non woven protection geotextiles which are based on geotechnical reports performed at the BOKU-University for Agricultural Sciences of Vienna Institute for Geotechnical Engineering are summarized to be able to predetermine a liner - structure for the specific project design.

Also AGRU structure types canbe combined with one side smooth (G).
Please see in our actual price list or contact our technical department for possible structures.

AGRU MICRO SPIKE MST/MSB

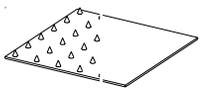
The surface structure is formed by calendering process during one production run and is different each surface side to support the chosen layer combination by increasing of the internal shear interaction from top side to bottom side by having two different structured surfaces:

MSB-down side surface:
Textured base surface manufactured with a defined formed structure by calendering process with additionally a minimum of 32 000 MICRO SPIKES per m² and a minimum average height of 0,60 mm.

MST-top side surface
Textured sandrough surface manufactured with a defined structure by calendering process with a minimum of 60 000 small spikes having an average height of 0,40mm.

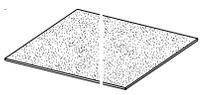
Other structures available at AGRU

S-Spikes



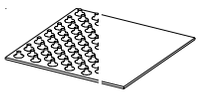
having large Spikes of 6mm height each 25x25mm
Application:
For very steep soil slopes as clay or coarse clay.

T - Textured



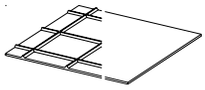
sandrough sprayed on particles
Application
For highest interface friction to geotextiles

D-Drainage



having one side drainstuds, height of the studs 4,5mm, 10mm between the rows of studs and staggered arranged
Application:
In combination with smooth liner a double layer can be installed without using a geogrid

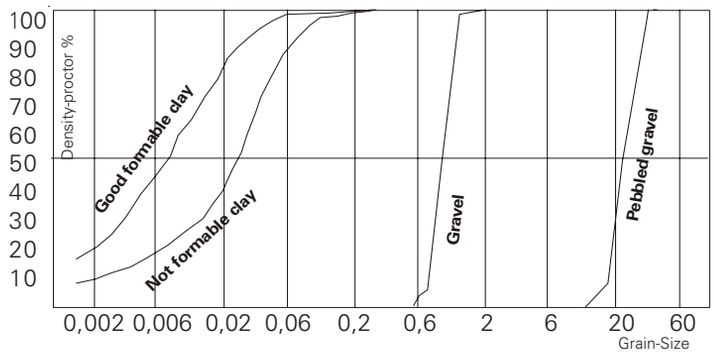
R50 (on request)



grid pattern 50x50mm with 2mm high grids
Application:
Good for sand or coarse send

Various combinations of the structures can be chosen in dependence of the slope-layers design

Shearing Diagrams
Graphic determination of the stability at slopes with structured AGRU HDPE liners



Stability

To approve the stability of slopes it is necessary to investigate the mechanical properties of the subsoil which will be in contact with the membrane. The shear strength of the different soil types, geotextiles and plastic membranes can be determined by the analytical method of "Coulomb or Mohr" (breakcondition).
The therein containing shear parameter will be determined by the use of a shear box or tilting table.
With the choosen soil (clay, coarse clay) the sealing layer will be simulated as well as the filter material (sand,gravel).
Practically for bigger landfill projects a test area (approx. 500m²) will be executed to determine the actual site conditions.

Basic of the diagram

a.) soil types

- pebbled gravel
- coarse sand
- coarse clay
- clay

surface structures

- smooth (G)
- Spike (S)
- Grid pattern 50x50mm (R50)
- Grid- Spike pattern (RS12) (no longer available old structure for comparison purposes)
- MICRO SPIKE top (MST)
- MICRO SPIKE bottom (MSB) (tests performed on 1.5mm liners)
- textured (T)

b.)soil condition
The cohesive soil types clay and coarse clay have been compacted with a standard proctor density and a standard proctor moisture content.
The cohesless soils coarse sand and pebbled gravel have been compacted with medium density.
All soil types are homogenous.
For the combination with various geotextiles, the test has been executed under wet conditions.

c.shape and surface of tested contact surfaces:

The contact surfaces of the various tested combinations were even and the clay material has been planed.

d.) cut-and-try method:

the shear strength of the various combinations has been determined with various methods in dependence to determine the standart stress.

Basic of the diagram-calculation of slope angles

a.) The stated angles of the slope are valid for the case of failure of a sliding down parallel to the slope.

b.) The stated angles of the slope resp. ratio of inclination are valid for a typical load of s`= 10 kN/m².
This is approximately equivalent to the load of the mineral drainage body at a waste disposal.

c.) The values are valid for large slope heights; at small slope heights no continuous gliding surface is forming parallel to the slope and a certain supporting effect appears at the base of the slope.

d.) For the calculation of the slope angles no pore-water pressure was considered.

The graphics enclosed show in summerized form the interface friction behaviour for different AGRU liners and structures against common component layers of landfills and are based upon results of the test reports of the University for Agriculturing Sciences Viennna (Universität für Bodenkultur"BOKU") performed at the Institute for Geotechnical Engineering Univ.Prof.Dr.Otto Pregl.

AGRU assumes no liability in connection with the use of this data.

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Using the shear graphics - Choice of a stable combination

Case 1:

If the chosen angle of slope cuts the red bar of a considered combination and if it is in the white area, this angle of slope will be practicable.

Case 2:

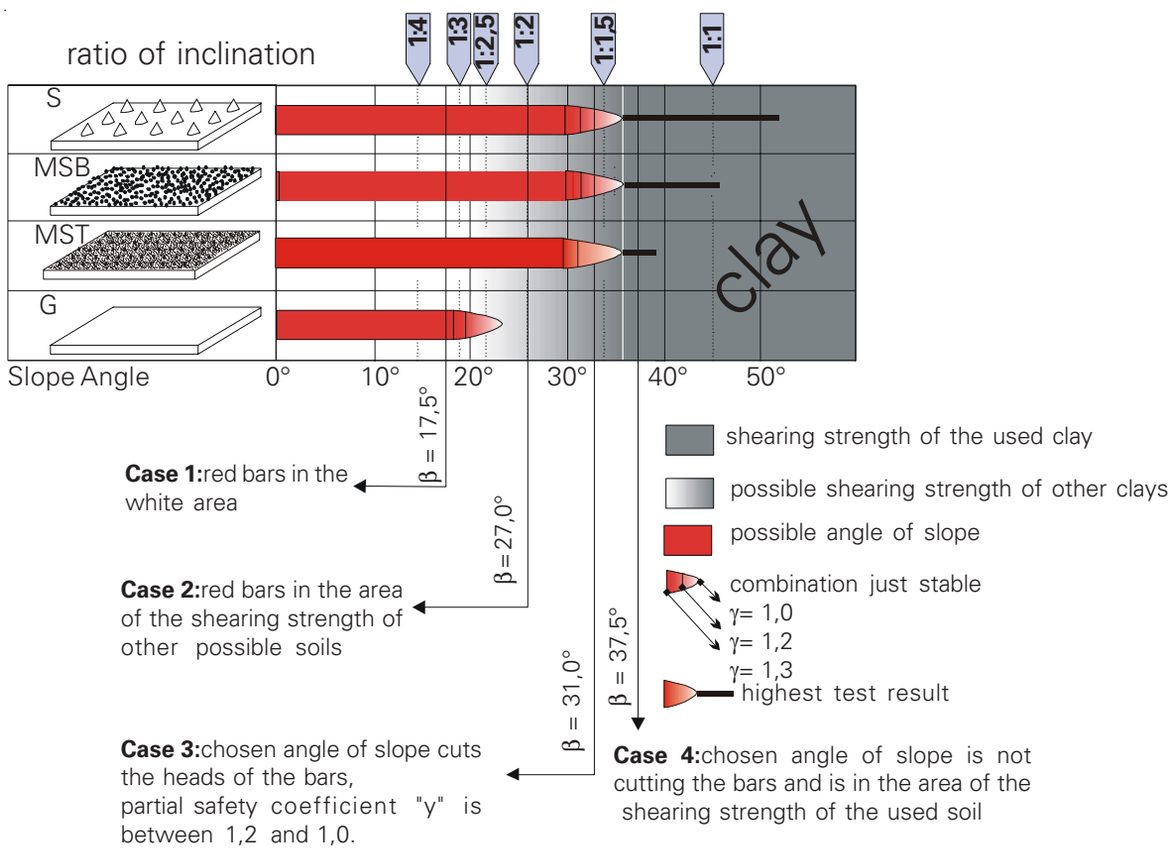
If the chosen angle of slope is in the area of the shearing strength of possible similar soils (not in the white area anymore), the shearing strength of the soil will be the criterion and special investigations should be carried out.

Case 3:

If the chosen angle of slope is cutting the partially red head of a red bar and if it is in the white area of a combin-ation, the partial safety coefficient will be between 1 and 1,3 and this angle of slope will just be stable (it should be considered, how to increase the security). If the partially red filled head is at the same time in the area of the shearing strength of possible similar soils (not in the white area anymore), the shearing strength of the soil will be the criterion and special investigations should be carried out, compare with case 2.

Case 4:

If the angle of slope is not cutting the red bar resp. its



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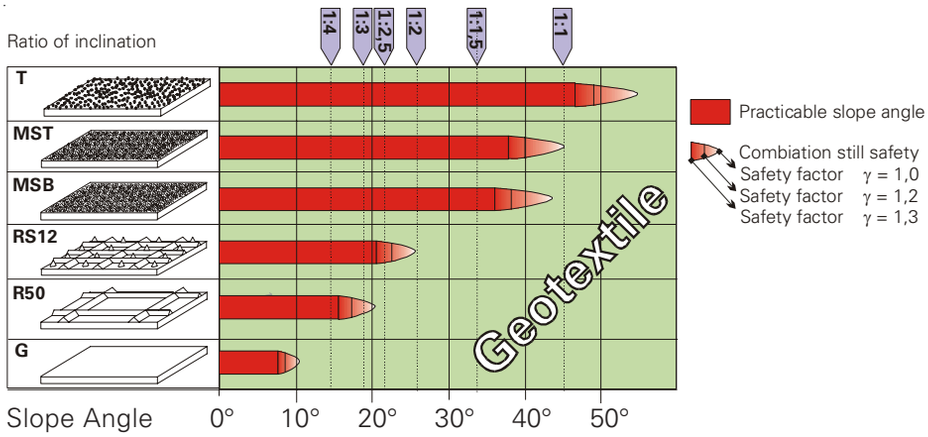
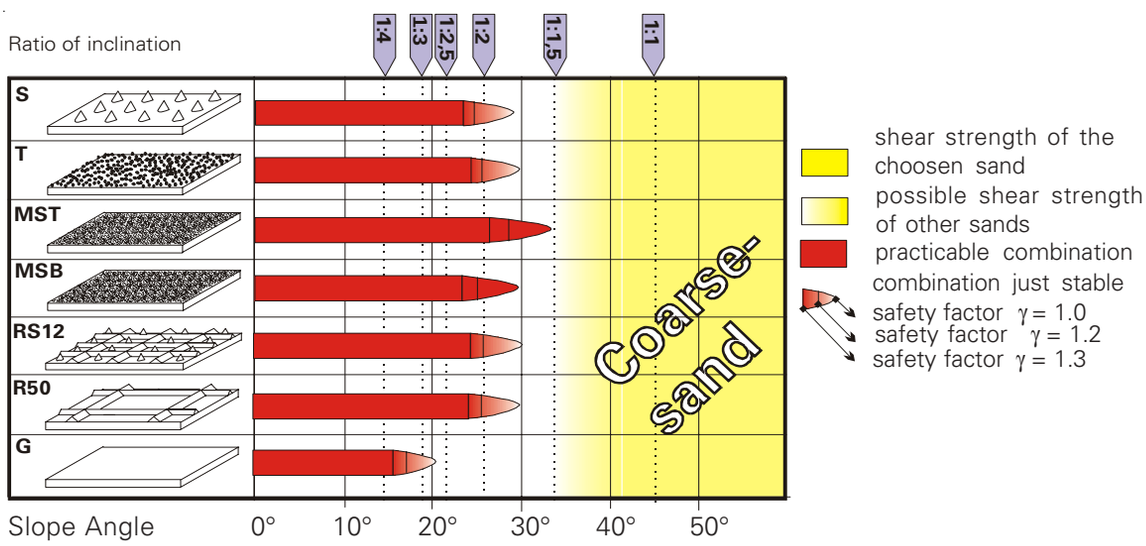
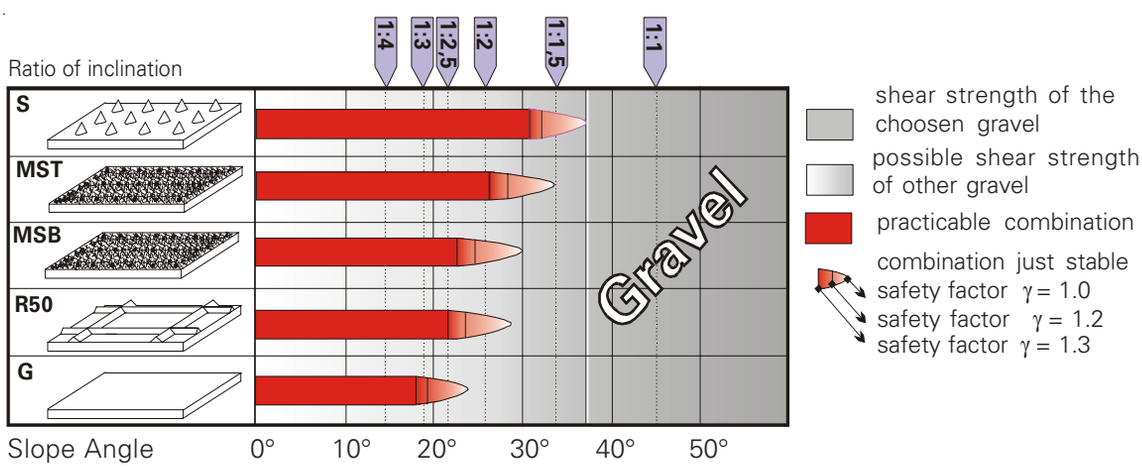
To take a look to a combination of a geomembrane and a geotextile no white area at the end of the red arrow occurs because the internal shear strength of the geotextile is not decisive in this case. Therefore the reflection of annex 2 and second part of annex 3 can be neglected.
In addition also the slope angles are determined in a way that no tensile stress can effect the geotextile.



shearing diagram
drainage materials





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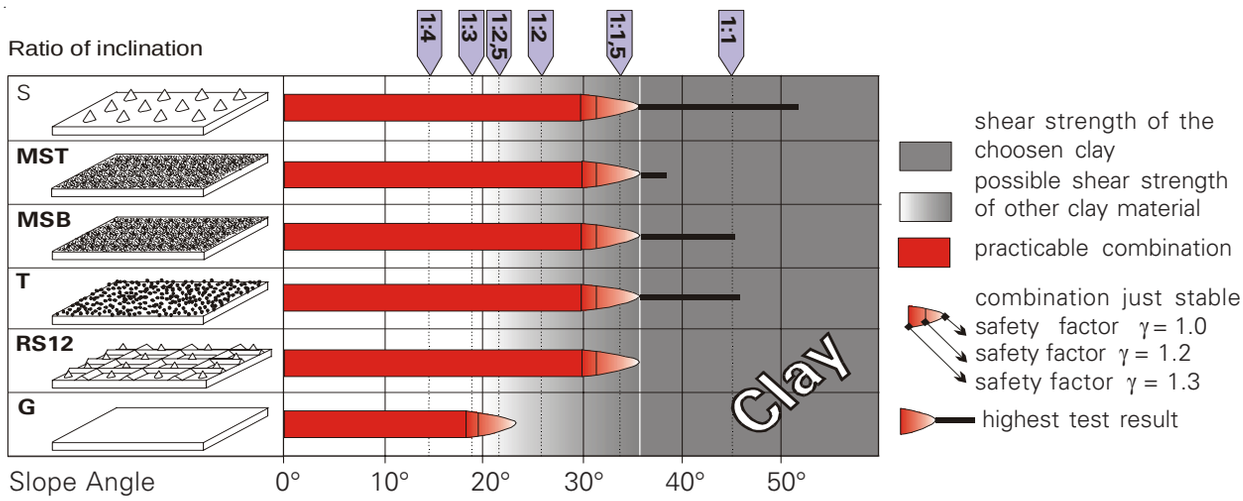
shearing diagram
soil and sealing materials



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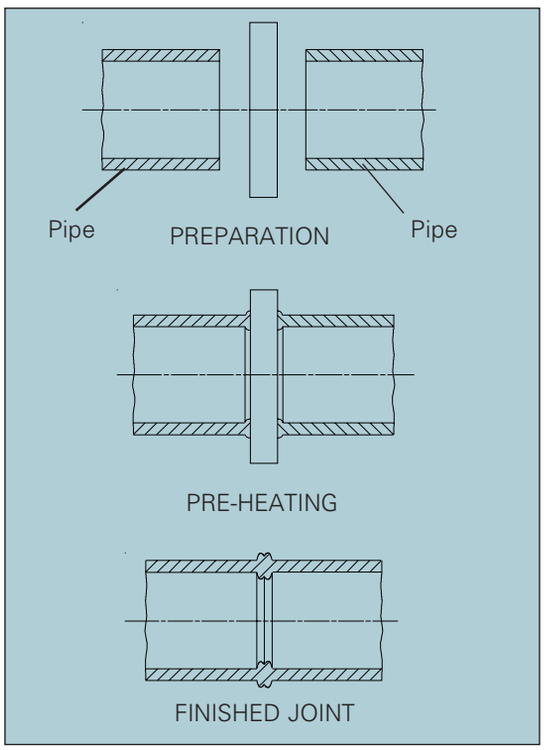
Heating element butt welding

(following to DVS 2207, part 1 for PE-HD and part 11 for PP)

Welding method discription

The welding faces of the parts to be joined are aligned under pressure onto the heating element (alignment). Then, the parts are heated up to the welding temperature under reduced pressure (pre-heating) and joined under pressure after the heating element has been removed (joining).



Principle of the heating element butt welding illustrated by a pipe.

All welding must be practised with machines and devices which correspond to the guidelines of the DVS 2208 part 1.

Preparations before welding

Control the necessary heating element temperature before each welding process. That happens e.g. with a high speed thermometer for surface measurements. The control measurement must happen within the area of the heating element which corresponds to the semi finished product. That a thermal balance can be reached the heating element should be used not before 10 minutes after reaching the rated temperature.

For optimal welding clean the heating element with clean, fluffless paper before starting of each welding process. The non-stick coating of the heating element must be undamaged in the working area.

For the used machines the particular joining pressure or joining power must be given. They can refer to e.g. construction information, calculated or measured values. In addition during the pipe welding process by slow movement of the workpieces ocurs a movement pressure or movement power which can be seen on the indicator of the welding machine and should be added to the first determined joining power or joining pressure.

The nominal wall thickness of the parts to be welded must correspond to the joining area.

Before clamping the Pipes and fittings in the welding machine they must be axial aligned, The ligh longitudinal movement of the parts to be welded is to ensure for exsample through adjustable dollies or swinging hangings.

The areas to be welded should be cleaned!

Pipe outside diameter [mm]	die gap width [mm]
≤ 355	0,5
400 ... < 630	1,0
630 ... < 800	1,3
800 ... ≤ 1000	1,5
>1000	2,0

Together with the control of the gap width also the disalignment should be checked. The disalignment of the joining areas to one another should not overstep the permissiple degree of 0,1 x wall thickness on the pipe outside or on the table respectively.
Not worked welding areas shouldn´t be dirty or touched by hands otherwise a renewed treatment is necessary. Shavings which are fallen in the pipe should be removed.

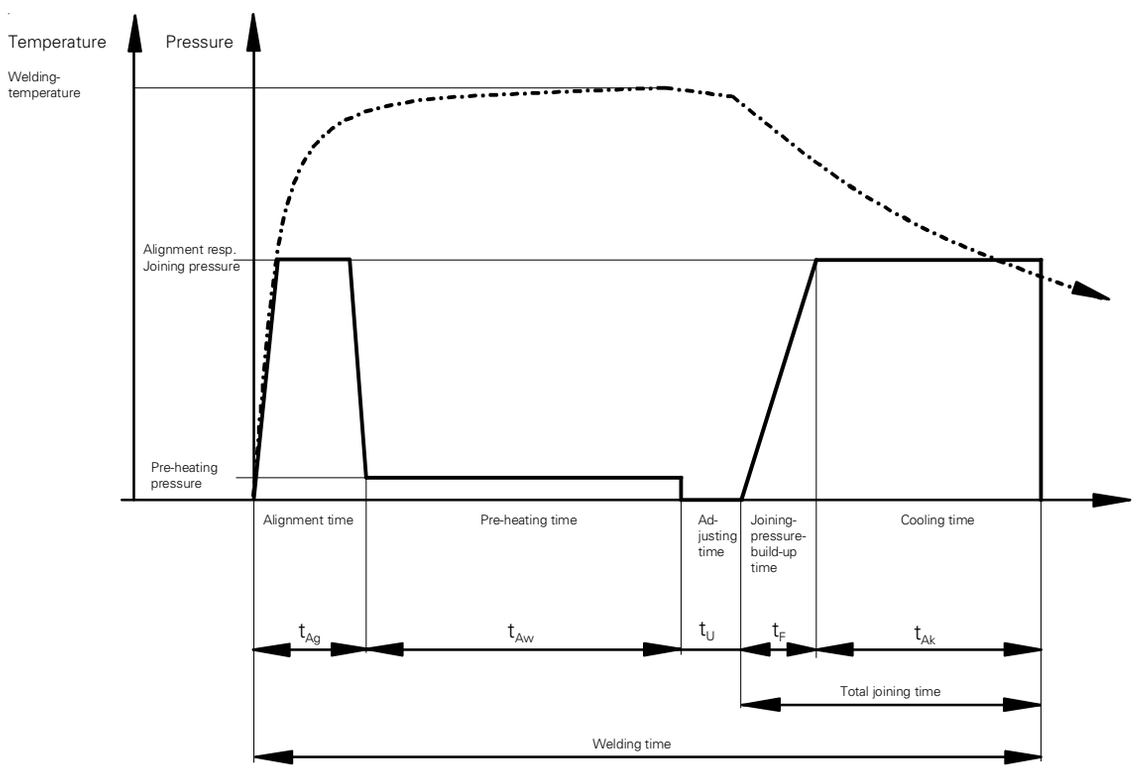
Heating element butt welding

Performing of the welding process

On heating element butt welding the areas to be joined get warm up to the requested welding temperature with heating elements and after the removal of the heating element they join togehter under pressure. The heating element temperatures are listed in the following table.Generally the aim is to use higher temperatures for smaller wall thicknesses and the lower temperatures for larger wall thicknesses

	PE	PP	PVDF	ECTFE
Heating element temperature [°C]	200 up to 220	200 up to 220	232 up to 248	275 up to 285

The gradually sequences of the welding process



Heating element butt welding

Welding parameters

Reference values for heating element butt welding of PP, PE, PVDF and ECTFE pipes and fittings at outside temperatures of about 20°C and low air-speed rates.

Type of material	Wall thickness [mm]	Bead height [mm]	Pre-heating time t_{AW} [sec]	Adjusting time t_U [sec]	Joining pressure build-up time t_F [sec]	Cooling time t_{Ak} [min]
		P=0,15 N/mm²	P≤0,02 N/mm²		P=0,15 N/mm²	
PE80 PE100 PE-el	 4,5	0,5	 45	5	5	6
	4,5 7,0	1,0	45 70	5 6	5 6	6 10
	7,0 12,0	1,5	70 120	6 8	6 8	10 16
	12,0 19,0	2,0	120 190	8 10	8 11	16 24
	19,0 26,0	2,5	190 260	10 12	11 14	24 32
	26,0 37,0	3,0	260 370	12 16	14 19	32 45
	37,0 50,0	3,5	370 500	16 20	19 25	45 60
	50,0 70,0	4,0	500 700	20 25	25 35	60 80

Specific heating pressure

In most cases, the heating pressure [bar] or the heating force [N], which have to be adjusted, may be taken from the tables on the welding machines. For checking purposes or if the table with pressure data are missing, the required heating pressure has to be calculated according to the following formula:

When using hydraulic equipment, the calculated welding force [N] has to be converted into the necessary adjustable hydraulic pressure.

Calculation of the welding area:

$$A_{Pipe} = \frac{\left(da^2 - di^2\right) \cdot \pi}{4}$$

or

$$\approx d_m \cdot \pi \cdot s$$

Calculation of the welding force:

$$F = p_{spec} \cdot A_{Pipe}$$

Heating element butt welding

Alignment

Here adjusting surfaces to be joined are pressed on the heating element until the whole area is situated plane parallel on the heating element. This is seen by the development of beads. The alignment is finished when the bead height has reached the requested values on the whole pipe circumference or on the whole sheet surface. The bead height indicates that the joining areas completely locate on the heating element. Before the welding process of pipes with a larger diameter (>630mm) the sufficient bead development also inside the pipe must be controlled with a test seam. The alignment pressure works during the whole alignment process.

	PE	PP	PVDF	ECTFE
Specific heating pressure [N/mm²]	0,15	0,10	0,10	0,08 up to 0.09

Pre-Heating

During the pre-heating process the areas must abut onto the heating element with low pressure. At which the pressure will fall nearly to zero (<0,01 N/mm²). On pre-heating the warmth infiltrate in the parts to be welded and heat upto the welding temperature.

Adjustment

After the pre-heating the adjusting surfaces should be removed from the heating elements. The heating element should be taken away from the adjusting surfaces without damage and pollution. After that the adjusting surfaces must join together very quickly until immediately prior to contact. The adjusting time should be keept as short as possible, otherwise the plasticised areas will cool down and the welding seam quality would be influenced in a negative way.

Performing of pressure test

Before the pressure testing, all welding joints have to be completely cooled down (as a rule, 1 hour after the last welding process). The pressure test has to be performed according to the relevant standard regulations (e. g. DVS 2210 Part 1, DIN 4279).

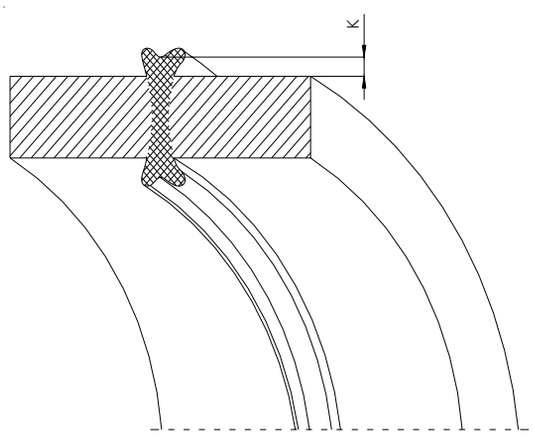
The imposed maximum test pressure is 1,5 x PN, whereby during the test period (10 minutes at least) no pressure drop is allowed. The piping system has to be protected against changes of the ambient temperature (UV-radiation).

Joining

The areas to be welded should coincide by contact with a velocity of nearly zero. The required joining pressure will rise linear if possible.

During cooling the joining pressure must be maintained. A higher mechanical use is only after prolongation of the cooling permissible. Under factory circumstances and insignificant mechanical use the cooling times can be remain under espacialy by parts with a thick wall during the clamp removal and storage. Assembly or mechanical treatment is allowed after the whole cooling.

After joining, a double bead surrounding the whole circumference must have been created. The bead development gives an orientation about the regularity of the weldings. among each other. Possible differences in the formation of the beads may be justified by different flow behaviour of the joined materials. From experience with the commercial semi finished products in the indicated MFR-field can be assumptioned from the welding tendency, even when this can lead to unsymetrical welding beads. K must be bigger than 0.



Heating element butt welding

Requirements on the welding device used for heating element butt welding
(following to DVS 2208, part 1)

Clamping device

In order to avoid high local stresses in the pipe and deformations, the clamping devices should surround at least the pipe casing as parallel as possible to the welding plane. By their high stability, it must be provided that the geometric circular form of the pipes will be maintained. They must not change their position in relation to the guide elements, even under the highest working forces. For fittings, such as stub flanges and welding neck flanges, special clamping devices which prevent deformations of the workpiece have to be used.

The pipe clamped at the mobile machine side has eventually to be supported and exactly adjusted by means of easy-running dollies so that the working pressures and conditions required for welding can be maintained.

It is recommendable to use clamp elements adjustable in height to allow a better centering of the workpieces.

Guide elements

Together with the clamping devices, the guide elements have to ensure that the following maximum values for gap width (measured on cold joining surfaces) are not surpassed due to bending or beaming at the least favourable point in the respective working area of the machine at max. operating pressure and with wide pipe diameters (see table on page 59).

The gap width is measured by inserting a spacer at the point opposite to the guide while the plane-worked pipes are clamped. Guide elements have to be protected against corrosion at the sliding surfaces, e. g. by means of hard chrome plating.

Heating elements

The heating element has to be plane-parallel with its effective area.
Permissible deviations from plane-parallelity (measured at room temperature after heating the elements to maximum operating temperature at least once):

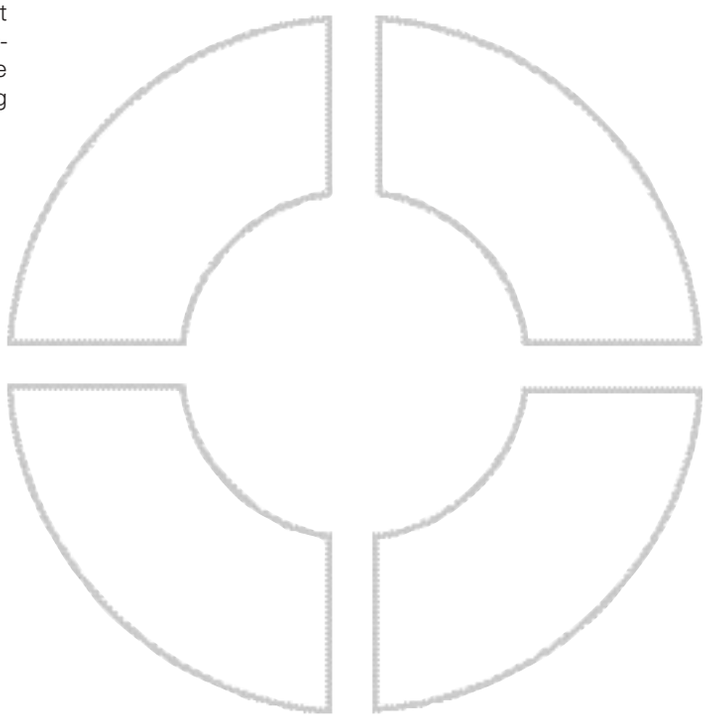
Pipe outside Ø resp. edge length	admissible deviation
÷ 250 mm	≤ 0,2 mm
÷ 500 mm	≤ 0,4 mm
> 500 mm	≤ 0,8 mm

For processing in a workshop, the heating element is in general permanently mounted to the device. In case of a not permanently attached heating element, adequate devices have to be provided for its insertion (e.g. handles, hocks, links).

If the size and nature of the heating elements necessitates its machine-driven removal from the joining surfaces, adequate equipment has to be provided too.

The power supply has to be protected against thermal damage within the range of the heating elements. Likewise, the effective surface of the heating element has to be protected against damage.

Protecting devices are to be used for keeping the heating element during the intervals between the welding processes.



Heating element butt welding

Requirements on the welding device used for heating element butt welding
(following to DVS 2208, part 1)

Devices for welding seam preparation

An adequate cutting tool has to be prepared with which the joining surfaces of the clamped pipe can be machined in a plane-parallel way. Maximum permissible deviations from plane-parallelity at the joining surfaces are:

Pipe outside Ø da [mm]	deviation [mm]
< 400	≤ 0,5
≥ 400	≤ 1,0

The surfaces may be worked with devices which are mounted on or which can be introduced easily (e. g. saws, planes, milling cutters).

Control devices for pressure, time and temperature

The pressure range of the machine has to allow for a pressure reserve of 20 % of the pressure, which is necessary for the maximum welding diameter and for surmounting the frictional forces.
Pressure and temperature have to be adjustable and reproducible. Time is manually controlled as a rule.

In order to ensure reproducibility, a heating element with electronic temperature control is to be preferred. The characteristic performance and tolerance values have to be ensured.

Machine design and safety in use

In addition to meet the above requirements, machines used for site work should be of lightweight construction.
Adequate devices for transportation and introduction into the trench have be available (e. g. handles, links).
Especially if voltages above 42 V are applied, the relevant safety regulations of VDE and UVV have to be observed in the construction and use of the machines.

Machines used in workshops have to meet the following requirements:

- Stable construction
- Universal basic construction (swivelling or retractable auxiliary tools and clamps)
- Quick-clamping device
- Maximum degree of mechanization
- Indication of pressure transmission (hydraulic/ welding pressure) on the rating plate
- Possibility to fix working diagrams in the operating area
- In case of big machines, an undercarriage with locking device (stable, adjustable in height, built-in level) is recommended.

Electrofusion welding

(following to DVS 2207, part 1 for PE-HD

Welding method

On electric welding, pipes and fittings are welded by means of resistance wires which are located within the elektofusion socket. A transformer for welding purposes supplies electric power.

The expansion of the plastified melt and the during the cooling developed shrinking stress produce the necessary welding pressure which guarantee an optimal welding.

The method distinguishes itself by an extra-low safety voltage as well as by high automatization.

Welding systems

For the welding of AGRU-E-fittings the universal welding machine Polymatic should be used.
This welding device is a machine with bar code identification, it supervise all functions full automaticly during the welding process and stores them.

After feeding of the code for universal welding machines with magnetic code characteristic, the code is deleted which means that the card can only be used once.

Suitable welding machines

For the welding of electric weldable AGRU-fittings the following universal welding devices with bar code identification are suitable:

-Polymatic plus + top**
-Tiny Data M + Tiny M
-TWIN, LOGIC
**with componet pursuit acc. ISO 12176-4

General welding suitability

Only parts made of the same material may be joined with one another. The MFR-value of the E-fittinga out of PE is in the range of 0,3 ¸ 1,3 g/10min. They can be joined with pipes and fittings out of PE 80 and PE 100 with a MFR-value between 0,30 and 1,70 g/10min.

The weldable SDR-serie and the maximum ovality are listed in the following tabel.

The welding area has to be protected against unfavourable weather conditions (e. g. rain, snow, intensive UV-radiation or wind) The permissibel temperature range for PE is from
-10°C up to +50°C. The national guidelines must also be considered.

Welding parameters

The welding parameters are specified by the bar code, which is directly affixed on the fitting.

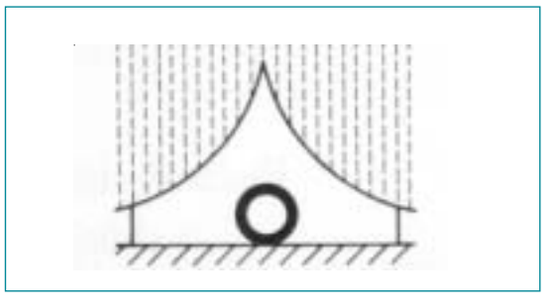
For PE the following datas are valid:

DIM	SDR 17	SDR 11	SDR 7,4	Ovality
20	-	+	+	1,5%
25	-	+	+	1,5%
32	-	+	+	1,5%
40	+	+	+	1,5%
50	+	+	+	1,5%
63	+	+	+1)	1,5%
75	+	+	+1)	1,5%
90	+	+	+1)	1,5%
110	+	+	+1)	1,5%
125	+	+	+1)	1,5%
140	+	+	+1)	1,5%
160	+	+	+1)	1,5%
180	+	+	+1)	1,5%
200	+	+	+1)	1,5%
225	+	+	+1)	1,5%
250	+	+	+	1,5%
280	+	+	+	1,5%
315	+	+	+	1,5%
355	+	+	+	1,5%
400	+	+	+	1,5%

+ Pipe weldable
+[1)] Pipe weldable; Code 077, 078 and 079 not suitable for borings of the pipe
- Pipe is not weldable

Electrofusion welding

Preparation of welding place



Preparation of the welding seam
(immediately before starting the welding process)

Cutt off pipe at right angles by means of a proper cutting tool and mark the insert length.

Insert length= socket length/2

Clean pipe of dirt with a dry cloth at insert length and carefull machine pipe by means of a peeling tool or scraper knife in axial direction (cuting depth min. 0,2mm). Remove flashes inside and outside of pipe ends.

If a fitting is welded instead of the pipe, the welding area of the fitting has to be cleaned and scrapped as the pipe.

Preparations before welding

Unpack the E- fitting immediately before welding.

Never touch the inside of the socket and the scrapped pipe end.

If a pollution cannot be excepted, clean the welding areas with PP- or PE-cleaner (or similar) and with fluffless paper.

The faces to be welded have to be dry before the socket is put over the pipe. At any rate, remove residues of clean-sing agents or condensation water with fluffless, absorbent paper.
Slide the socket into the prepared end of pipe right to its center stop until it reaches the marking.

Processing guidelines

Assemble welding equipment (prepare tools and machinery), control welding devices.

Install welding tent or similar device.

HOME

Electrofusion welding

Preparations before welding

Performing the welding process

Processing guidelines

The second part which has to be welded with the socket (pipe or fitting) should be prepared too.
Insert the second pipe end (or fitting) into the socket and clamp both pipes into the holding device, so that no forces can raise between welding area and the pipe (fitting) and that the socket can be turned smoothly.

Check:
If a marking does not flush with a socket end, the pipe has not been inserted right up to the center stop.

The clamping device has to be loosened and the pipe ends must be inserted until the markings are directly visible on the socket ends.

Observe the operating instructions for the welding device. Only the most significant steps of the welding procedure are described as follows.

Both plug-type socket connections should be turned upwards (however the axial position of the socket must not be changed) and connected with the welding cable. Position welding cable so as to prevent its weight from twisting the welding socket.

After the welding equipment has been properly connected, this is shown on the display.

The welding parameters are fed in by means of a reading pencil or a scanner. An audio signal will acknowledge the data input.

After the welding parameters have been fed in, the trademark, dimension and outside temperature are shown on the display. These values now have to be acknowledged. Then, for control purposes, you will be asked, whether the pipe has been worked.

Electrofusion welding

Performing the welding process

Visual control and documentation

Processing guidelines

Optional is a traceability bar code is marked directly on the fitting, so it is easy to read the code into the welding machine. The using of the traceabilitycode is not forcing. That means, if you don´t need the code nothing chance at your working process. So you can use your standard welding machine.

The welding process is started by pressing the green start key. This time on the display also the desired welding time and the actual welding time are given as well as the welding voltage

During the whole welding process (including cooling time) the clamping device shall remain installed. The end of the welding process is indicated by an audio signal.

After expiration of the cooling time, the clamping device may be removed. The recommended cooling time must be observed!
If a welding process is interrupted (e.g. in case of a power failure), it is not permissible to reweld the socket.

Minimal cooling times:

da 20	-	63 mm	6 min
da 75	-	125 mm	10 min
da 140	-	180 mm	20 min
da 200	-	250 mm	30 min
da 280	-	355 mm	45 min

Visual weld control is performed by the welding indicator on the socket. Moreover, all welding parameters are stored internally by the device and can be printed to receive a welding protocol.

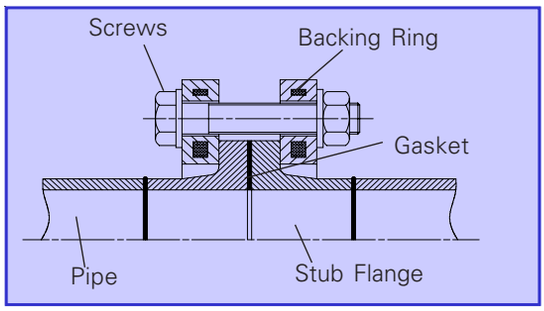
Detachable joints

Flange connections of piping systems

If pipe joints are connected by means of flanges, the following guidelines have to be adhered to:

Aligning of parts
Before applying of the screw initial stress, the sealing faces have to be aligned planeparallel to each other and fit tight to the sealing. The drawing near of the flange connection with the thereby occuring tensile stress has to be avoided under any circumstances.

Tightening of screws
The length of the screws has to be chosen this way that the screw thread possibly flushes with the nut. There have to be placed washers at the screw head and also at the nut.
The connecting screws have to be screwed by means of a torque key (torque values see supply program).



Generally

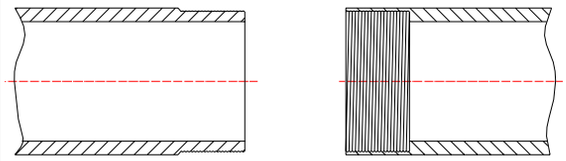
It is recommend to brush over the thread, e. g. with molybdenum sulphide, so that the thread stays also at longer operation time easy-running.
On choosing the sealing material, special attention has to be paid to chemical and thermal suitability.

Unions of piping systems

If pipe joints out of thermoplastics are connected by means of unions, the following regulations have to be adhered to:
For avoiding of unpermissible loads at the installation, unions with round sealing rings should be applied.

The union nut should be screwed manually or by means of a pipe band wrench (common pipe wrenches should not be used).

Prevent the application of unions at areas with bending stresses in the piping systems.



Adhesive joints

With polyolefines, adhesive joints are not applicable due to their proper chemical resistance.

The hereby achieved strength values range extremely below the minimum requirements made to adhesive joints in practice.

Hot wedge welding
(in accordance to DVS 2225 Teil 3 und Teil 4)

Welding method

A hot wedge welding equipment creates an overlap welding seam with a test channel.
Following characteristic features are typical:

- welding without welding filler
- the joining area is plastified by direct contact with the hot wedge.
- the welding force is applied just after the plastification of the joining
- the welding-equipment has two wheels for appearing the same pressureon both sides
- the setting of the different welding parameters is independent

Welding parameters

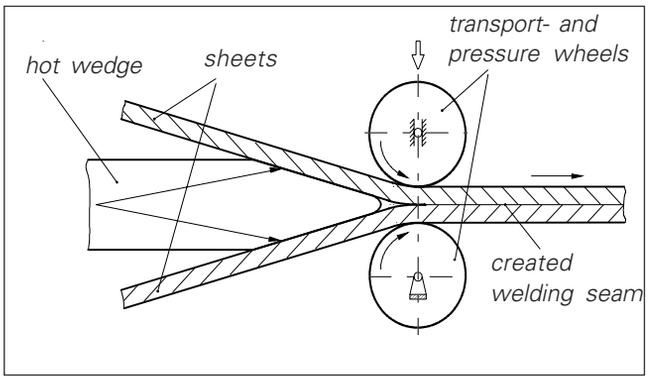
Hot wedge temperature
280 to 380° C
Welding pressure
20 to 40 N/mm wheel width
Welding speed
0.5 to 2.5 m/min

The welding parameter have to be determined depending on material, thickness, structure of the sheet and also on the ambient conditions like wind,humidity and temperature.
The quality of the welding seam depends on the right setup of all parameter of the equipment and therefore it is important to control the created seam on several test specimen to asure a constant quality for the ambient conditions on site. Change of condition cause a control of the seam and if necessary a new setup

Preparation of welding place

The welding area has to be protected from unfavourable weathering conditions (e.g. tent).

- temperatures below +5°C
- relative humidity higher than 80%
- wind
- sun radiation
- temperatures below dewpoint

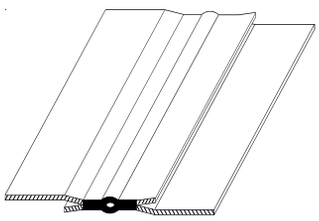


Preperation of welding seam

The joining area has to be free from impurity and moisture. Grind or scrape to remove oxidation zone if necessary.
The execution of T-crosses with welding machines requires a special treatment of the welding seam. the both existing overlaps and the behind section of the joint have to be worked off. The crossing from the above to the lower liner takes place in the front section of the joint. This section shall be in accordance to the thickness of the liner.

Execution of welding

To minimize the thermal expansion of the sheets it is important only to plastify thedefined surface area to be welded.
Thermal and mechanical stress of the sheets have to be controlled and minimized.
Assuring a high quality of the welding a permanent controlling and recording of the parameters is necessary.



for the dimensions please have a look at the installation guideline

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Hot wedge welding

Control of welding seam

Property	test intervall	Double Seam
seam condition	continuous	visual -pocket scriber
dimensions	spot checks	mechanical -ultra sonic
mechanical strength	spot checks	peeling test
tightness	continuous	air pressure test

Visual control

The control of a proper ewelding is performed visually. Therefore defects in the welding areasare checked by means of apocket scriber. The whole seam length has to be controlled.
The pocket scriber is manually guided along the welding seam: the scriber penetrates the seam at defect seam areas.

- Unevenless in small limited areas do not minimize the function of the seam
- bulgs on the front edge of overlap seams are not permitted.
- Permitted are bulgs with a thickness under 50% of the nominal thickness in the rim zone of the seam and only when appearing occassionally.
- Notches and scores can be permitted under 10 % of the nominal thickness
- failures have to be repaired in general

Mechanical control

Peeling tests are performed acc.DVS direct on site or in quality labs on tensile test equipment.
The short therm welding factor has to bedetermined

Tightness test

For testing the tightness following tests can be performed:

- pressure test
- vacuum test

The pressure test determines the tightness of the hot wedge double seam with control channel.The test is non-destructive and relevant for the complete seam.
One our after executing the welding one side of the channel is closed tight by means of a pressure equipment (with pressure gage or pressurecontrol unit) . The other side is also closed by means of hot air welding or by a clamping valve. The test- time is 10 min, afterwards the channel is opened and the pressure must decrease abrupt(pressure gage). The welding is tight when the pressure in the channel does not decrease more than 10% within the testing time .

For the vacuum test the overlap-seam is controlled sectionally by means of a bell jar .One hour after executing the welding seam a wetting agent with a high surface constraint is applied. Afterwards the bell jar is adjusted on the middle of the seam. The controlled sections have 10 cm overlap,the vacuum is 0,5bar /0.0345p.s.i., and the testing time is 10 seconds.
The seam is tight when the vacuum increases fast,stays constantduring 10 seconds and no bubbles appear.

Hot wedge welding

Requirements on the welding device (following to DVS 2225,part4)

General Requirements

- robust construction for no break downs during transport and processing
- Protection against moisture, dust and dirt
- Protection of the electronic parts against electrostatic magnetism
- easy handling and repairable

Welding device

The welding equipment for hot wedge welding comprises a basic device,the functional partsfor the setup of the parameter(temperature, welding pressure ,welding speed) and additional a unit for data control and print out.

Heating system

The heating system is designed to have a constant temperature distribution along a welding seam. The temperature appeared on the sheets has to be kept constant

Hot wedge system

The temperature of the wedge is adjustable infinitely variable up to 450°C. The hot wedge temperature is controlled where the liner has passed the wedge.The gap between the wedge and the contact surface of the sheet has to be protected against direct sidewind. For optimal heating up of the contact zonea the wedge has to be designed long enough.

Drive system

the drive system on a wedge welder is designed to run a constant speed(±5 cm/min) without any influence to the actual load of the maxhine

Wheel pressure system

The welding pressure should be adjustable infinitely variable or fine graded and hold constant. The setting tolerance is arround ±100 N. The system should equalize fluctuations of the liner thickness that much that the welding pressure during welding exceed not more than one third.

Data control and print out

The data control unit is used primary for supervision if the set up parameters are held in a defined tolerance range during processing.
The data have to be safed that these afterwards can exactly be determined to each welding seam and documented. The interval of measures is done according time (e.g.: 2 sek.) or according seamlength (e.g.: 3 cm). A summary about all the parameter has to be controllable directly and every time and there must be an akustic or visualsignal when tolerances go out of limitand also an information on the data print out and control unit. The datas which have to be controlled and safed are named as followed:

- welding temperature
- welding speed
- welding pressure
- temperature of the liner
- ambient temperature

Extrusion Welding
(following to DVS 2207, part 4 and DVS 2209, part 1)

Welding method

Extrusion welding is used as standard method for welding of thick-walled (Tanks, apparatus and pipe engineering), for welding of Liners (sealing of concrete structures, sealing of natural structures) and for welding of special parts.

This welding technique is characterized as follows:

- Welding process is performed with welding filler being pressed out of a compounding unit.
- The welding filler is homogenous and completely plastified.
- The joining surfaces have been heated up to welding temperature.
- Joining is performed under pressure

Qualification of welder and requirement on welding devices

The plastic welder must have obtained the knowledge and skill required for the performing of welding processes.
As a rule, this would mean that he is a qualified plastics worker and welder continuously practising or disposing of long-time experience.

Weldability of base material and welding filler

Liners and welding fillers have to be suitable for extrusion welding. Weldability of base material and welding fillers have to be in perfect processing condition. Assure weldability of parts to be welded according to DVS 2207, part 4.
The welding filler has to be adjusted to processing with the particular extrusion welding device and to the type of material used for liner product.The welding filler is being processed in form of pellets or rods. Pellets and welding rods of uncontrolled composition and unknown origin must not be processed. Do not use regenerated material for welding.
The welding filler has to be dry and clean (prevent moisture from falling upon cold pellets).

For extrusion welding, several kinds of devices may be used (see DVS 2209, part 1). The most common device is a portable welding device consisting of a small extruder and a device for generating hot air. The welding pressure is applied onto the teflon nozzle, directly fastened at the extruder, which corresponds to the welding seam form.
Depending on the type of device, the maximum capacity of the welding fillers is about 2,5 kg/h.

General important Note:

For fusion of different materials as e.g: PE80 sheet or PE80/PE100 pipe material to VLDPE - Liners by using extrusion welding technique it is strongly recommended to prove the compatibility of the used welding filler to the materials which needs to be welded together by performing a trial weld.

In general it is recommended to use welding rod having MFR-values suitable for that material to be welded together with the higher MFR.
So for welding pipes to liners also welding rod suitable for liners schall be chosen.
For evaluation of welding quality a trial weld has to be performed before welding different PE materials together.

Extrusion Welding

Preparation of welding place

Assemble welding equipment (prepare tools and machinery), control welding devices.

Preparation of welding seam
(at any rate immediately before starting the welding process)

The adjusting surfaces and the adjacent areas have to be prepared adequately before welding (e. g. by scrapping). Parts that have been damaged by influences of weather conditions or chemicals have to be machined until an undamaged area appears. This has to be considered especially on performing repair works.

Do not use cleansing agents affecting plastics thus by causing them to swell.

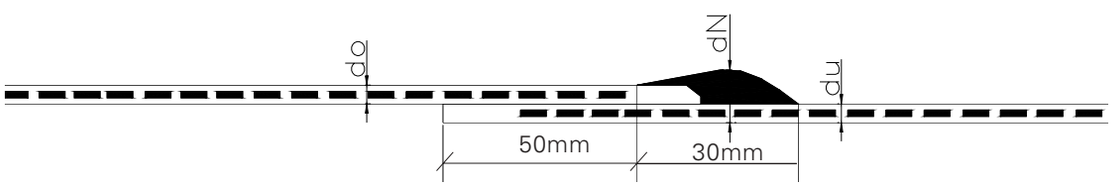
In order to equalize higher differences in temperature between the different workpieces, the workpieces have to be stored long enough at the working place under the same conditions.

Welding Sam design

Extrusion-overlap welding

do= thickness upper liner
du= thickness lower liner
dN= seam thickness

≥ 1,25 x (do + du)
≤ 1,75 x (do + du)



Performing of welding process

Due to the hot gas passing out of the nozzle of the welding device, the adjusting surfaces of the parts to be welded are heated up to welding temperature. The welding filler, continuously flowing out of the manually guided device, is pressed into the welding groove. The discharged material pushed the device ahead thus determining the welding speed. The heating of the adjusting surfaces must be coordinated with the welding speed.

Basically the welding seams have to executed in a way to assure that no re-working will be required. If necessary, it should, however, be performed only after acceptance so that eventual welding faults can be discovered on visual inspection. On performing re-working, avoid the build-up of notches.

Visual control of welding seam

On visual inspection, surface conditions of the welding seam, proper performance as to drawings as well as evenness are evaluated.

HOME

Seam Testing - Geomembranes

Non-Destructive Seam Continuity Testing

The Installer shall non-destructively test, field seams over their full length using a vacuum test unit or spark tester (for extrusion seams only). The testing shall be carried out to the accepted standards of the industry. The purpose of non-destructive tests is to check the continuity of seams. It does not provide any information on seam strength.

Vacuum testing

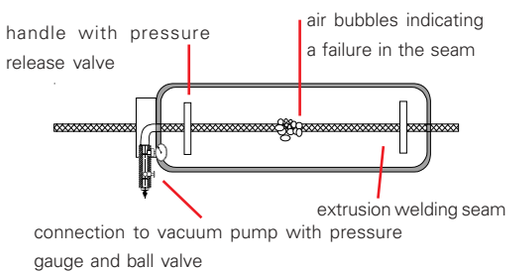
Unless otherwise specified, the general vacuum testing procedure used by the Installer shall be as follows:

- Turn on the vacuum pump to reduce the vacuum box.
- Apply a generous amount of liquid soap and water solution to the area to be tested.
- Place the vacuum box over the area to be tested and apply sufficient downward pressure to "seat" the seal strip against the liner.
- Close the release valve and open the ball valve.
- Ensure that a leak tight seal is created.
- For a period of not less than 15 seconds, examine the geomembrane through the clear top view for the presence of soap bubbles.
- If no bubbles appear after 15 seconds, open thevacuum release valve and move the box over the next adjoining area with a minimum of 75 mm overlap, and repeat the process.

Vacuum Testing Documentation

Vacuum testing crew will use Mean Streak permanent markers to write on liner indicating tester's ID number, date and pass/fail designation on all areas tested.
Records of vacuum testing will be maintained by the CQC Co-ordinator or testing crew on Installers Non-Destructive Testing Form or Installer`s repair Report Form as attached in Appendix A.

All cuts through the liner, as a result of testing, will be repaired by extrusion welding (patching).



Vacuum Inspection box with transparent top and soft rubber base

Destructive Testing

Concept

The purpose of destructive testing is to determine and evaluate seam strength. These tests require direct sampling and thus subsequent patching. Therefore, destructive testing should be executed to a minimum in the field area to reduce the amount of repairs to the geo-membrane exept remaining liner in the trench.

Procedure for Destructive Testing

Destructive test samples shall be marked and cut out randomly at a minimum average frequency of one test location every 150m (500 feet) of seam length, unless otherwise specified or agreed.

Location of destructive samples will be selected by CQC Co-ordinator (or the third party QA Representative), with samples cut by Installer`s welding Personnel.

Destructive samples should be taken and tested as soon as possible after the seams are welded (the same day), in order to receive test results in a timely manner.

Installer`s qualified personnel will observe all field destructive testing and record date, time, seam number, location, and test results on Installer`s Destructive Testing form- attached in Appendix A.

All destructive test locations with pass/fail designation will be marked on liner with permanent markers, such as „Edding

WELDING PARAMETERS (Guide Values) HOT WEDGE WELDING (ELECTRIC WEDGE)

Material	wedge temperature	Remarks	welding speed
HDPE	~ 360°C - 400°C	[2]	1,0 - 2,5m/min[1]
LDPE	~ 360°C - 400°C		1,0 - 2,5m/min[1]
LLDPE	~ 340°C - 380°C		1,0 - 2,5m/min[1]
VLDPE	~ 300°C - 370°C		1,2 - 3,0m/min[1]
HDPE-el	~ 360°C - 400°C		1,0 - 2,5m/min[1]
PP - flex	~ 300°C - 400°C		1,2 - 3,0m/min[1]
FPO	~ 300°C - 370°C		1,2 - 3,0m/min[1]

[1] depending on material thickness and wedge temperature

[2] 1000N welding pressure for sprayed on textured liner

specific joining force - welding pressure per mm roll width

HDPE//HDPE-el	20-40N/mm roll width
LDPE/LLDPE	20-40N/mm roll width
VLDPE	14-25N/mm roll width

PARAMETERS SHALL BE SET IN CONSIDERATION OF THE AMBIENT CONDITIONS AND IN ACCORDANCE WITH THE RELEVANT DVS - GUIDELINES.
A trial weld and test under site conditions must be performed to optimize parameter settings.

WELDING PARAMETERS (Guide Values)AUTOMATIC HOT WEDGE WELDING (hot air operated)

Material	wedge temperature	hot air temperature	welding speed
HDPE	~ 360°C - 400°C	360°C - 500°C	1,0 - 2,5m/min[1]
LDPE	~ 360°C - 400°C	360°C - 500°C	1,0 - 2,5m/min[1]
LLDPE	~ 340°C - 380°C	340°C - 450°C	1,0 - 2,5m/min[1]
VLDPE	~ 300°C - 370°C	300°C - 400°C	1,2 - 3,0m/min[1]
HDPE-el	~ 360°C - 400°C	360°C - 500°C	1,0 - 2,5m/min[1]
PP - flex	~ 300°C - 400°C	300°C - 400°C	1,2 - 3,0m/min[1]
FPO	~ 300°C - 370°C	300°C - 400°C	1,2 - 3,0m/min[1]

[1] depending on material thickness and wedge temperature

specific joining force - welding pressure per mm roll width

HDPE/LDPE/HDPE-el	20-40N/mm roll width
LDPE/LLDP	20-40N/mm roll width
VLDPE	14-25N/mm roll width
PP - flex/ FPO	15-30N/mm roll width

PARAMETERS SHALL BE SET IN CONSIDERATION OF THE AMBIENT CONDITIONS AND IN ACCORDANCE WITH THE RELEVANT DVS - GUIDELINES.
A trial weld and test under site conditions must be performed to optimize parameter settings.

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WELDING PARAMETERS (Guide Values) EXTRUSION WELDING

Material	Air temperature at preheating nozzle	extrudate temperature	welding speed
HDPE/LLDPE/HDPE-el	~240°C-280°C	~220°C	~ 0,4m/min[1]
PP	~240°C-280°C	~ 210°C-220°C	~ 0,4m/min[1]
PVDF	~260°C-280°C	~225°C-240°C	~ 0,4m/min[1]
VLDPE	~ 200°C - 240°C	~190°C-200°C	~ 0,4m/min[1]
PP - flex	~ 200°C - 240°C	~190°C-200°C	~ 0,4m/min[1]
FPO	~ 200°C - 240°C	~190°C-200°C	~ 0,4m/min[1]

1 depending on material thickness and extrusion gun capacity
Required air quantity ~ 300 l/min

PARAMETERS SHALL BE SET IN CONSIDERATION OF THE AMBIENT CONDITIONS AND IN ACCORDANCE WITH THE RELEVANT DVS - GUIDELINES.
A trial weld and test under site conditions must be performed to optimize parameter- settings.

WELDING PARAMETERS (Guide Values) HOT AIR STRING BEAD WELDING

Material	Air temperature at preheating nozzle	remarks	welding speed	
HDPE/LDPE/HDPE-el	~300°C-350°C		~ 0,4m/min[1]	
VLDPE	~240°C-300°C		~ 0,4m/min[1]	
PP - flex	~240°C-300°C		~ 0,4m/min[1]	
LLDPE	~ 200°C - 240°C		~ 0,4m/min[1]	
FPO	~240°C-300°C		~ 0,4m/min[1]	
PP	~ 280°C - 340°C		~ 0,4m/min[1]	
PVDF	~ 340°C - 370°C		~ 0,4m/min[1]	
ECTFE	~ 340°C - 380°C	recommended to use Nitrogen gas-50l/min		

1 depending on material thickness and extrusion gun capacity
Required air quantity ~ 300 l/min

PARAMETERS SHALL BE SET IN CONSIDERATION OF THE AMBIENT CONDITIONS AND IN ACCORDANCE WITH THE RELEVANT DVS - GUIDELINES.
A trial weld and test under site conditions must be performed to optimize parameter- settings.

WELDING PARAMETERS (Guide Values) OVERLAP HOT AIR WELDING

Material	air temperature	welding speed
HDPE	~ 360°C - 400°C	0,5m/min[1]
LDPE	~ 340°C - 380°C	0,5m/min[1]
LLDPE	~ 340°C - 380°C	0,5m/min[1]
VLDPE	~ 300°C - 370°C	0,5m/min[1]
HDPE-el	~ 360°C - 400°C	0,5m/min[1]
PP - flex	~ 300°C - 400°C	0,5m/min[1]
FPO	~ 300°C - 370°C	0,5m/min[1]

1 depending on material thickness and extrusion gun capacity
Required air quantity ~ 300 l/min

PARAMETERS SHALL BE SET IN CONSIDERATION OF THE AMBIENT CONDITIONS AND IN ACCORDANCE WITH THE RELEVANT DVS - GUIDELINES.
A trial weld and test under site conditions must be performed to optimize parameter- settings.

Application fields

The field of application for AGRU liners can be divided int below listed groups:

Ground water protection

- landfills for industrial and municipal waste
- basins for storage of oil and industrial sludge
- collecting ponds and reservoirs for groundwater endangering fluids
- Heap leach pads for mining industry
- manipulation areas, petrolstations, storage areas for petrochemical products
- Collecting basins for clean or polluted water
- road and railway constructions at environmental protected areas or natural reserves
- AGRULOCK Vertical Cut-Off Walls

Hydraulic engineering

- Lining of water reservoirs for potable water and Irrigation
- Sealing of dykes and ponds, embankments dams and river beds
- Lining of canals and channels
- Swimming Pond and Biotops

Building engineering

- Sealing of tunnels
- base sealing of buildings
- Lining of Concrete structures
- Protection of concrete structures against agressive medias
- Barrier against radon radiation
- Lining of roofs

Sealing of landfill (vevy lagoon2)

Sealing of water channel (ganez 22)

Tunnelliner

Lining technology present and past

The function of a landfill has changed with time foundamentally. While in former times waste exclusively were deposited that means the waste was stored indiscriminately, todays target is avoidance, reduction and utilization of waste. The landfill is the last terminal for residual substances which can not be used any more.

In each antipolution refuse disposal concept landfills are essential components either independent or supplementing as stockroom for remaining substances out of material (recycling) or energetic use.

In the past decades environmental impairments through old landfills had been raising and this lead to the fact that the requirements, which are made today on a modern landfill, are growing. Insufficient sealing of old landfills led to new solutions.

Today the municipal-, industrial- and hazardous waste is transfered to stock in perfectly sealed landfills. These must correspond in all details to the requirements of the water and Environment protection clauses. A main importance of the lining technology is to minimize emissions. In order to guarantee the reduction of emissions the landfill designers prefere the "multi-barrier concept".

Choosing
a suitable geological location

Base sealing
as barrier to the subsoil

Leachate drainage
for the safe disposal of leachate and gas

Drain of surface water
Due to various drainage systems, choosing of location, subbase drainage

Homogeneous structure of the landfill
to avoid back water, lateral uncontrolled outflow of the leachate and incomplete anaerobic degradation

Vertical wells
for gas collection, to increase the circulation and for heat depletion

Landfill capping
to avoid the rainfall water infiltration

Early gas collection
gas collectin is possible even during landfill operation

Treatment
of all hazardous emissions in reprocessing plants

Control
of all emissions in collectors even after reaching the final storage capacity and closing of the landfill operation.

Qualification of HDPE for landfill construction

HDPE is used for more than 25 years in the construction of landfills. This sealing membrane has been constantly improved in the past years .
HDPE (high density polyethylene) is a linear hydrocarbon resulting of polymerization from ethylene. It exclusively consists of the element carbon and hydrogen and after the polymerization it does not have any double bonds. Beyond that, this plastic does not possess any functional groups, which favour a potential chemical attack.
From the materials used at present for the sealing of landfills HDPE possesses the largest resistance against aggressive leachate (see annexe: chemical resistance list).

Besides the chemical influences further demands have to be considered

Weathering

Mechanical strain

Biological attack

It can be considered that in most cases all demand factors of the above mentioned groups will result. They can become effective at the same time or one after another.

Weather conditions

HDPE liners show an excellent resistance against UV radiation due to the stabilisation with carbon black. A period of 5000 h weathering in a xenontest device results in no reduction of the mechanical characteristics.
(L. Glueck, J. Zoehren; Liner sheets as sealing means in ground water protection, supplement to garbage and waste 22/85)

The examination of the thermal oxidative resistance is carried out by oven ageing at increased temperature.
Due to scientific investigations the life time of a HDPE liner was calculated with 300 years even if the leachate is saturated with oxygen. Oxygen is partially needed for the degradation of waste materials and therefore the strain is less to the liner,those result in a higher life times expectation of the liner, if in addition no substantial chemical attack is present.
(J. Hessel, R. Koch, E. Gaube und C. Gondro; "Long term strength of liners out of polyethylene", plastics 78/88).

Quality assured

The internal monitoring system, the certified QM-system according to ISO 9001 and the 3rd party inspections by independent state authorized institutes like SKZ or MPA-Darmstadt assure a continuously high quality of the AGRU liners.
The substantial quality control beginning with receiving of raw material till the inspection of the finished product guarantee a complete reliability of the raw material and the product.
This enables Agru to issue work certificates in accordance to EN 10204 (DIN 50049).

Easy Installation

The Installation and welding of the AGRU liners is of great importance because tightness and stable function are required. The jointing of the liners is mostly executed by hot wedge welding, whereby a double welding seam with integrated testing channal is created.

In principle only AGRU authorized and trained installers should be considered for the installation.

The AGRU liners are UV stabilized, resistant to rodents and root penetration. They consist of excellent chemical, mechanical and biological properties.

Permanent tight

The base sealing has to be a thight layer between the subsoil and the waste.
A clay sealing with k-value 10^{-8} m/sec. result in a permeability of **3150 m³/ha** per year in central Europe. The liner out of HDPE is absolutely tight against liquids.

A combination, consisting of clay sealing and AGRU liners, offers an optimal sealing solution and appropriate security.

The leachate and especially the condensate in combination with the biogas is very aggressive. The liner must therefore show a high chemical stability. The possible load and tension of settings require a tearproof, tough material.

Furthermore a good weldability of the liner must be given.

The AGRU liner comply all those requirements. The qualification is comfirmed by appropriate approvals (e.g. DIBT, Asquale our BAM).

Advantages

Compared to PVC - PE characterizes in the following points:

- better chemical resistance
- common use of PE in the food sector (drinking water)
- no dangerous HCl steams at welding process or in case of fire
- no brittlement of HDPE liners because they do not contain volatile additives

To get the biggest possible volume for waste storage on small areas, landfill design will consist in steep slopes, which exceed the shear strength of smooth liners. To fulfill the stability and to avoid the tearing off of the slope-downwards installed liners, we recommend to use AGRU structured liners.

AGRU offers to it`s customers various literature (approved calculations of the shear strength for the different surface structures in dependence to the most common contact materials tested by specialized institutes) in order to get the best solution for the selection of the liners
(annexe: shear diagram).

Sealing of extremly steep slopes with AGRU liners.

General requirements to the liner system

The lining system must conform both, as an overall and individual part to the following requirements:

- excellent and long term safety function
- insensitiv against subsidence
- toughness with regards to the requirements during the installation and later in operation of the landfill to ensure apropriate collection and discharge of the leachate

Further the lining system must also meet the following general requirements:

- permanent tightness of the liner and the welding seams
- state of the art welding technology also with regards to unfavorable weather
- conditions during the installation efficient technology for a 100 % reliable documentation of the examination for the welded joints on the liners

Design engineered Details

Reasonable care should be taken to the design of the lining systems for following items:

- penetration of the liners (e.g. piping systems)
- connection to the liners (e.g. on inspection manholes for leachate,
- preinstalled liner parts, concrete foundations)
- integration of the liners (e.g. at the crest)
- pipe bedding of leachate pipe collection systems
- Foundations of concrete structures (e.g. leachate collection ducts)

In the area of penetrations and connections different settings shall be considered.
Due to preparative engineering details, which essentially aim in a sufficient flexibility of the installed liners, it should be guaranteed that the liners will not be damaged in case of a setting process.
The penetration of the pipes through the liners must be designed in a way that a perfect welding is guaranteed.

control of the welding seam by air pressure test (Bacci 1602)

installed liners on prepared subsoil (KAT_Tulln 01)

Pipe Penetration (Frank/Sansenh_04)

HOME

Base Sealing

The base sealing is the technical barrier between the subsoil and the waste. Base sealings are mainly designed as combination sealing system. This system offers a double safety and therefore the system is state of the art at most projects (reference to general regulations).

The AGRU liners out of HDPE fulfill those requirements. The qualification is confirmed by appropriate test certificates.

Base sealing as combination

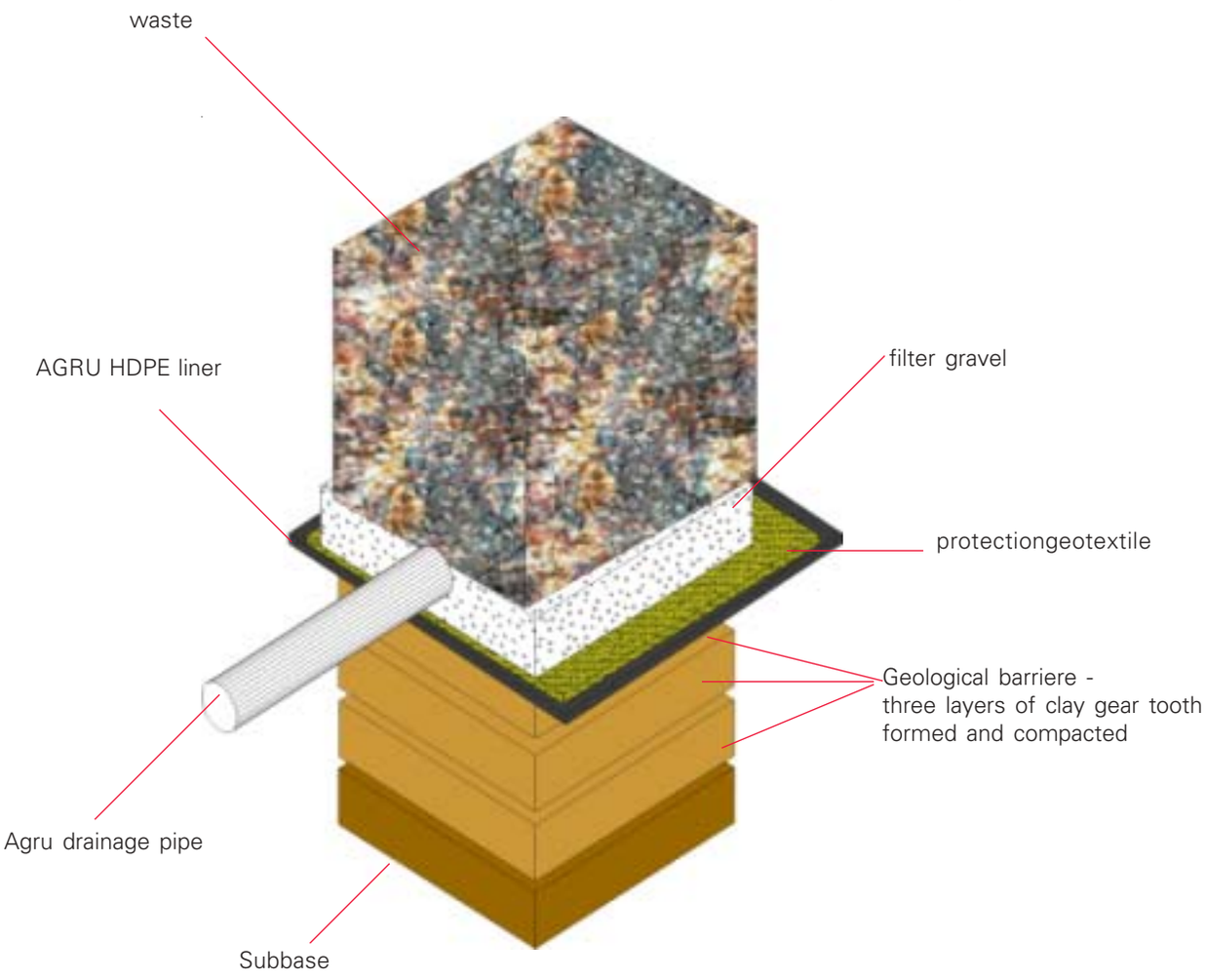
The base sealing system consists mainly out of the following components:

- Subgrade
- Geological barriere
- Agru Geomembrane
- Geotextile
- drainage layer (filter gravel)

Mineral sealing

The landfill will be isolated with a water impermeable, clay layer (Geological barriere) and AGRU liners.

The subsoil and the Construction of the Geological barriere is specified in country specific regulations and is constantly modified according to state of the art technology.
Before starting the construction the individual components are examined for there suitability in accordance to the design and project data and will be released if they fulfill the Specification.



Graphic: Construction details

Landfill technology

With reference to the latest developments in the lining technology the multi barrier concept is mainly applied.
The target is to have a accurate protection against environmental harmful emissions from the landfill and especially to ensure a durable protection of the groundwater.
In the state specific regulations the combination sealing system is the technical barrier of the landfill, indicated as state of the art system according to the latest technology of the preferable lining systems.

The combination sealing system:

This system consists of a geomembrane, joined by preferably 2,5 mm thick liners (HDPE), which should be, if possible, in contact to a multi clay-layer. Protection layers (e.g. geotextiles on the liner) protect them against waste disposal, drainage- or recultivation layers.

Depending on the concept of the waste treatment and landfill design the following media flows are possible:

Immissions:

- waste (organic, inert, pollutants) (to the landfill)
- water (rainfall,surface water, waste moistness)
- air transmissions
- water (in the landfill)
- gas
- pollutants

Emissions:

- water (surface water, evaporation, drainage water (from the landfill)
- leachate, gas condensate, groundwater)
- gas (surface emission, soil migration, dilution in leachate)
- dust
- noise

The particular sealing is due to the liquid proof geomembrane (AGRU liner) and the combination of liners and multi-layer of clay. Additionaly the combination of both sealing elements prevent the failure of the single components and creates a interacting protection.

The leachate and gasemissions are regulated as follows:

- A landfill capping with surface drainage prevents principally the infiltration of rainfall water into the waste
- All water flow to the landfill will be prevented due to crest and surface drainage and sufficient distance to those trenches.
- The waste is sorted homogenious to avoid accessorily humidity, leachate and uncontrolled aerosis and to ensure a complete anaerobic decomposition.
- Wells support the vertical flow in the landfill. Principally those wells are installed to collect the bio gas of the waste, and to increase the gas flow
- A base sealing separates the waste from the subsoil and avoid infiltration of leachate and gas penetration into the Subgrade.
- The leachate drainage pipes in adequate dimensions reduce the static load to the base of the landfill and collect leachate and gas from the surrounding area.
- The biological pollutants in the landfill are collected and treated that no harmful emissions can pollute the environment.
- The overall function of the landfill can be permanently monitored on its operation condition by special control devices.

Drainage system

Demands:

A very important part of the landfill site is a good functional drainage system of the waste. The function of the drainage system is determined by the individual components of the sealing system.

Function of a base drainage system:

- Avoidance of uncontrolled backwater at landfill base
- Collection and transport of the leachate to the collecting and treatment facilities.
- Controlled drainage of the filter systems.

Those tasks are fulfilled only by a overall functional system of the individual components such as base sealing, drainage pipes, collecting pipes and manholes. Those requirements are met by appropriate dimensions, weldability of material components and/or material equality of the individual components out of HDPE or PP.

Pipes and manhole constructions are subjected to the same chemical requirements as the liners. Usually the pipelines in the landfill are controlled by Video cameras once per year. If strong incrustations appear the pipes should be cleaned by high pressure cleaning. The smooth, anti-adhesive surface of HDPE / PP favours the cleaning of the pipes.

Because of the high chemical resistance and the excellent weldability of HDPE / PP the requirements are fulfilled better than by any other material . The calculated stabililty of pipes and manholes is therefore given. If manhole construction works inside the landfill area are unavoidable, all criteria confirm to the application of HDPE / PP material.

Our engineering department is pleased to support you by statical calculations according to ATV A 127 for leachate pipes at any time.

Drainage pipe out of PE

Leachate collecting manhole out of HDPE

Leachate collecting pipe systems out of HDPE

Slope sealing

Slope sealing systems have to prevent the landfill from water entrance. A further point which should be considered is that in the slope area mostly shear forces appear, which can result in a sliding of the protection layer.

The friction angle between the bottom side of the liner and the subsoil must be bigger than the friction angle between the top side of the liner and the Geotextile/sand. The friction angle between the top side of the liner and the drainfilter must be greater than the friction angle of the filtermaterial in itself. In order to fulfill those requirements, AGRU offers liners with different structures. The different structures result in differnt friction values. To meet a project-related Specification AGRU has tested its different liner types with the most common structures and materials by specialized institutes to facilitate the selection of the correct structured liner type (detailed report is availabe on request).

Slope sealing with structured liners

Slope sealing France (france n11)

Anchor trench

Liners at the slope area are fixed in the anchor trench. Usually this anchor trench is backfilled with the stored excavated material, which is well compacted. Depending on the length of the slope the dimensions of the anchor trench varify. If the slope lenght is 10 m a anchor trench depth of 50 cm, a width of 40 cm and 50 cm distance from the anchor trench to the slope break point is sufficient.
For Example:

Slope length	trench width	crown width
< 10m	>0,5m	>0,5m
10 - 40m	>0,8m	>0,6m
> 40m	>1m	>0,8m

Purpose of the anchor trench

- wind and slide protection during Construction phase
- anchoring of the liner at crest after completion of Constuction

crest anchorage (Lichtenw. 03)

Anchor trench (Laibach)

Landfill capping

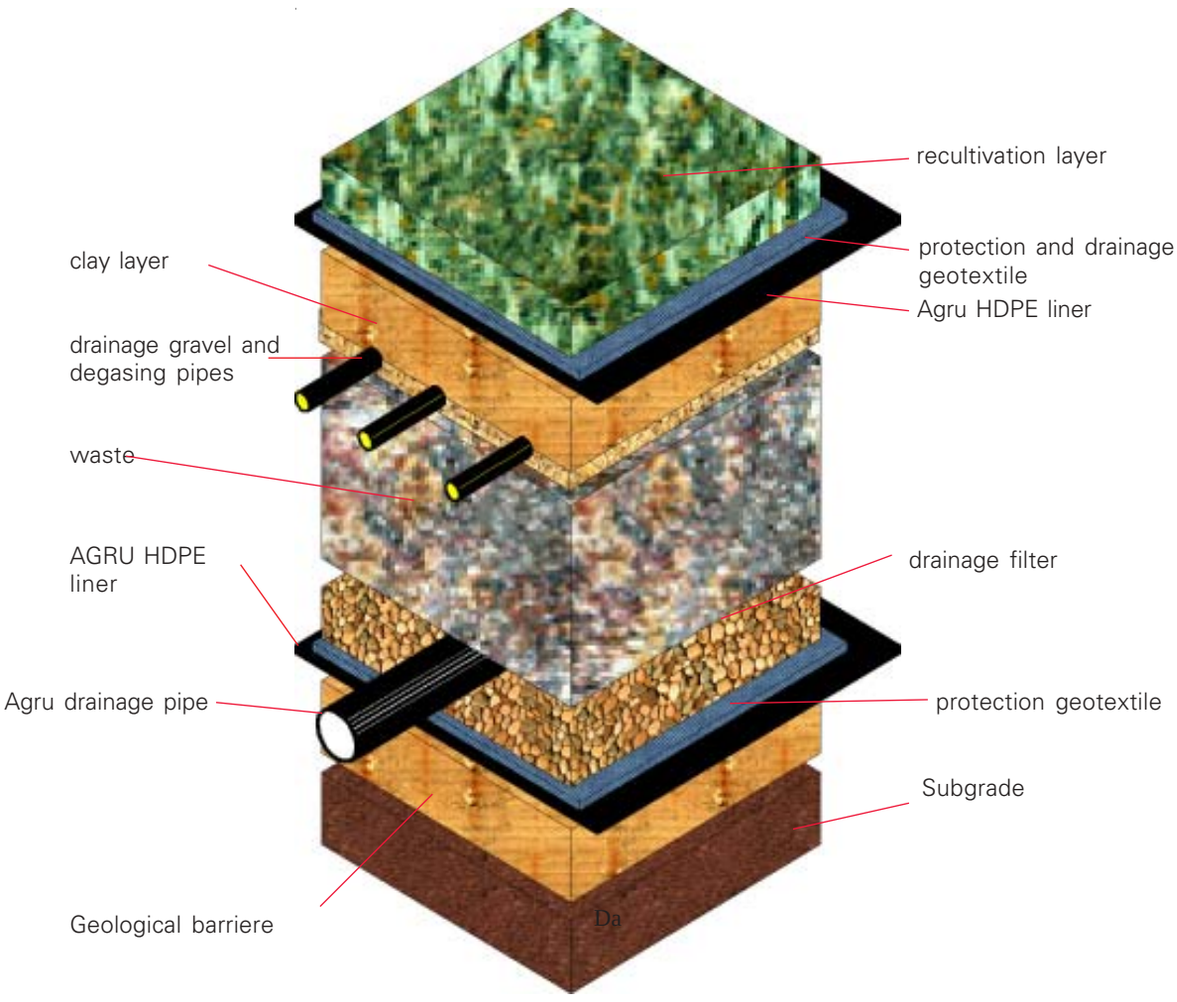
Those systems are designed to prevent the infiltration of rainfall into the waste or the uncontolled release of biogas from the waste. Technically cost efficient Systems can be obtained with Agru geomembranes. The capping shall meet following requirements:

- prevention of leachate due to infiltration of surface water
- uncontrolled streams in the landfill should be prevented and deriveted by an active surface gas collecting system
- recultivation of the landfill area and reintegration into the surrounding landscape

A single clay sealing without liners is simply relative qualified. During long dry periods the danger of dehydration in connection with soil cracking exists. Additionally the danger of root penetration and attack of rodants appear. A clay sealing should therefore be completed with an AGRU -HDPE-LLDPE or VLDPE liner.

A homogeneous welded liner is able to take over the required sealing functions. In Addition the liner is restistant against root penetration and rodents. The installation of the AGRU liner without any further mineral sealing is cost reducing and additional landfill volume is resulting. Due to the high disposal costs per m^3 waste this increases also the economy of a landfill. After reaching the final height of the waste capacity a landfill capping out of HDPE and a substrate layer is usually applied. AGRU has developed structured liners, which ensure a derivation of the shear forces into the subgrade, so that the drain and substrate layer can not slip and the liner will not be damaged.

The respective design of a landfill capping and the choice of the material (e.g. HDPE-LLDPE-VLDPE-FPP) depends on the state specific regulations and the type of stored waste (e.g. landfill for solid material)



Graphic: Cross-section of a landfill

Geotechnique for landfill construction

Stability
The entire landfill construction has to be considered as stable. Possible cause of risk the stability are:

- break of the subbase
- break of the slope base
- sliding of berms
- sliding of clay layers
- sliding of waste layers
- base break of storage layers
- constant tensile stress applied to the liner

To avoid above mentioned risk potentials, a proper design and approved calculation concerning all materials which will be used for the construction have to be provided by evidence of the design office.

- a sliding of the filter material at the liner must be avoided.
- liner and filter material may not slide together
- the protection geotextile for the liner may not be overstrained by tensions
- the stability of the clay sealant must be given
- improper stress applied to the liner must be avoided

Base sealing

The general definiton of the stability means that the sum of restrain forces must always exceed the sum of driving forces

Driving forces are:

- weight of sliding elements
- constantly load / load changes on the sliding area (construction units, traffic load)
- water pressure, pore water overpressure,
- flow pressure
- soil pressure

Detaining forces are:

- shear strenght of the soil and waste
- combined shear strength of the soil or waste and components like liners, geotextiles and so on.
- reactance in the sliding plane (textured liners)

Base sealing

Gas vent system

vertical gas vent
Due to multiple layers in the landfill the horizontal gas flow is normally stronger than the vertical. Therefore the vertical gas capacity is more efficient than the surface gas vent.

Gas wells at new landfills

The construction of the gas wells start directly above the filter material. Underneath the vertical gas well pipe increased load has to be considered. This load is eliminated by applicative supporting elements (e.g. base plates, gravel, etc...) .

vertical gas wells

The gas well exceeds with the waste storage. The drilled or slotted gas pipe, preferably of 160 mm diameter, may be extended by rising waste volume. The surrounding gravel column of the gas vent pipe will be dropped into the approx. 6 m long shaft pipe. This pipe will be pulled upwards in proportion to the waste storage.The gas tight top cover will be removed and the gas vent pipe will be extended. Gravel is filled up and the top cover will be replaced After reaching the maximum waste capacity the shaft pipe will be removed and a proper well head will be installed

Gas wells

Prior to the installation of the drainage layer and recultivation layer a gas well head will be installed. The gas well head consists of an inspection opening and a gate valve. The conncetion of the well head and gas collecting pipe system will be constructed under consideration of different settings in the waste by flexible HDPE-corrugated pipes

Surface drainage with connecting pipe prior to landfill capping

Gas wells for existing landfills:

The supplementary installation of a gas well will be executed without a shaft pipe. The gas vent pipe is pushed downward to the before calculated depth by means of special jacks.Then the gas well head will be connected

An obligatory statement concerning optimal well distances under consideration of economy and a collection rate as high as possible, can be made only after several gas emission measurement at the respective landfill.

Afterwards the installation of the first wells probes are inserted in defined distances around those wells. Following that simple steel pipes are pushed into the soil. If CH_4 is measured the distance to the next well must be accordingly shorter. It has shown that the final, optimal definition of the well distance takes place after approximately a half year test run. During this time the colecting pipe system should layed open on the top, that the installation of additional connections can be carried out without any problems.
Such exposed gas collecting pipes should be out of HDPE electroconductve material to avoid static loading and the associated danger of explosion. In particular its valid for incompleted landfills. HDPE electroconductive material should also be considered for all with in air in contact remaining parts such as well heads, shaft pipes and distribution systems.

Horizontal gas vent system

Gas vent at landfill base:
Heavy gases such as CKW are collected direct across the base sealing.The appropriate drainage and base collecting system will be used

Gas collecting below the landfill capping:
A drain layer (gravel) is installed when the landfill site has reached it`s Capacity. Embedded in this layer the gas collecting pipes will be installed. The surface area is parcelled in approx. 1 ha (2.5acre) large sections. The gas collecting pipes of the respective section are connected to the main collector. The main collector should be installed with a sufficient slope (transport of condensate) and ends in a manhole where all the regulation valves are placed.

Modulation of gas quantity:

Gas measurements are carried out regularly by the operator. Depending on gas quantity and concentration the landfill is parcelled into fields.Those fields can be monitored by several control valves at the gas regulator station. Pipes and Fittings installed at those stations are basically of HDPE electroconductive material.

An alternative of those economical and state of the art system is the gas collection with a separate pipe to each well. The disadvantage is a trimendous quantity of installed pipes which will increase the cost of the System.
By consideration to the necessary slope needed for the gas pipes, the collector stations will be either located at high-points or low-points.

Picture: Gas well collecting system

Engeneering requirements

Maintenance and control requirements:

For the maintenance and inspection works the entired main drainage system must be accesible for inspection by Video camera and high pressure cleaners. Those cameras can cover a distance of 150 m. Pressure cleaning devices can cover a pipe lenght of 300 m in one direction.

Landfill where the arrangement for inspection and collecting manholes are located beside the landfill base

Engineered design of base drainage::

The designer shall take into consideration that a minimum slope of >2% in longitudinal and cross direction is given.
Those design guarantee a optimized collection of the accumulating waste water.
Dimensions of the drainage pipes and distance from one to the other will be calculated proportional to the average yearly rainfall.
The pipe penetrations shall be designed for easy and safe connection to the liner.

Surface drainage:

Landfill cappings consist mainly of slope sections one to each other. If there is any slack flow, the friction coefficient will be reduced which can result in a slide even for structured liners.
Therefore a proper designed drain system above the capping will be necessary. The surface water will be collected in trenches at the toe of the landfill. HDPE pipes will transport the water to a catch basin.

surface drainage at landfill capping

Geotextiles

Requirements:

- separation, protection, drainage.....
- protection of the HDPE liner against mechanical damage
- filtration in contact with drainage layers at the landfill base and cap
- drain of the leachate above the base sealing
- separation of filter layers

Geotextiles are used to protect the high-quality HDPE liner against mechanical damage. Depending on the loads and filter materials geotextile with a weight from 800g/m² up to approximately 2000g/m² should be used.

According to the state of the art technology mainly geotextiles out of HDPE and PP are used.

The production of the Geotextile takes place in as large as possible dimensions to minimize the necessary overlap. The installation should be carried out by the liner installer.

Requirements according to the proposal consist mainly of:

- test certificate for chemical resistance of the geotextile
- product specification
- material specification of the manufacturer
- data of executed internal controls

In principle the choosen materials have to be verified according to the project related data. Test certificates of 3rd party institutes confirm in detail the achievment of the specified characteristics.

Installation
The geotextiles are placed either with a overlap of at least 0,5 m or they are thermally bonded (overlap >10cm).

The advantages of a thermal bonding:

- saving of material
- danger of wind attack during the installation will be minimized
- the creeping of the filter gravel will be avoided

Landfill

HOME

- Ground water protection
- Project: Municipal Landfill
- Location: Paris; Frankreich
- Product: AGRU HDPE Liner 2,0 mm
- Project data: 600 000 m²
  both sides smooth G/G

- Ground water protection
- Project: Landfill base sealing
- Location: Pisecna; Tschechien
- Product: AGRU HDPE Liner2,5 mm
- Project datea: 85 000 m²
  both sides smooth G/G
  Leachate collecting basin lined with
  sure grip concrete protective liner

HOME

- Ground water protection
- Project: Farmland
- Location: Bartow/Florida USA
- Product:AGRU/Am HDPE Liner 1,5mm
- Project data: 430 000 m² both sides smooth
  745 000m² MICROSPIKE™ Liner

- Ground water protection
- Project: Landfill base sealing
- Location: Bruneck; South Tyrol Italy
- Product: AGRU HDPE Liner 2,0/2,5mm
- Project data: 65 000 m²
  controllable double sealing system drainage liner D/G and both sides smooth coextruded liner with signal layer on D/G

HOME

- Ground water protection
- Project: Temporary landfill capping
- Location: Augsburg; Germany
- Product: AGRU PHDPE Liner 1,5 mm co-extruded
- Projektdaten: 65 000 m²
  both sides smooth G/G natogreen/black acc. BAM-Recommendation

- Ground water protection
- Project: Landfill capping
- Location: Oldenburg; Germany
- Product: AGRU HDPE Liner 2,5 mm
- Project data: BAM approved
  70 000 m² both sides smooth G/G
  100 000m² MICRO SPIKE MST/MSB

- Ground water protection
- Projekt: Landfill base sealing
- Location: Biffa Cour; Belgium
- Product: AGRU HDPE Liner 2,5 mm
- Project data: 150 000 m²
  Structur grid pattern/spikes R50/S and both sides smooth G/G

- Ground water protection
- Project: Landfill base sealing
- Location: Mount Saint Guibert Belgium
- Product: AGRU HDPE Liner 2,0 mm
- Project data: 160 000 m²
  textured T/T for slopes and both sides smooth for base

HOME

- Ground water protection
- Project: municipial landfill
- Location: United Kingdom
- Product: AGRU HDPE Liner 2,0mm
- Project data: 45 000 m²
  both sides smooth G/G

- Ground water protection
- Project: Harzardous waste disposal
  Base Sealing
- Location: Gabon, Africa
- Product: AGRU HDPE Liner 2,0 mm
- Project data: 100 000 m²
  both sides smooth G/G

- Ground water protection
- Projekt:Hazardous waste disposal base sealing
- Location: Lichtenwoerth; Austria
- Product: AGRU HDPE Liner 2,5 mm with Aluminium Barrier
- Projektdaten: 7 000 m²
  both sides smooth G/G with CHC/CFC-Barrier
  Leachate collecting basin lined with
  Sure Grip concrete protective liner

- Ponds for storage of potassium and phosphate sludge
- Project: Kemapco
- Location: Jordania
- Product: AGRU HDPE Liner
- Project Data:
  150 000 m² G/G 1,0 mm
  150 000 m² MST/MSB 1,0 mm
  130 000 m² G/G 1,5 mm
  130 000 m² MST/MSB 1,5 mm

HOME

- Mining industry heap leach pads
- Project: Telfer heap laech pad
- Location: Telfer Goldmine; Australia
- Product: AGRU HDPE Liner 1,5 mm
- Project data: 100 000 m²
  both sides smooth G/G

- Mining industry heap leach pads
- Project: Eldorado Goldmine
- Location: Sonora; Mexiko
- Product: AGRU/AM PEHD Liner 1,5 mm
- Projektdaten: 60 000 m²
  both sides smooth G/G

- Groundwater protection
- Project: Foundation sealing of Petrol stations
- Location: Most; Czech Republic
- Product: AGRU HDPE Liner 2.0 mm
- Project Data: 1 000 m²
  both sides smooth G/G

- Secondary containment
- Project: Oil - Tank farm sealing
- Location: Middle East
- Product: AGRU HDPE Liner 2.0 mm
- Project Data: 6 000 m²
  both sides smooth g/g

HOME

- Sealing of Roadworks for groundwater protection (selected objects)

Austria:	A9 Phyrnautobahn	HDPE G/G 1,0mm 63 000m ²
	A8 Wels / Westspange	HDPE G/G 1,0mm 20 000m²
	A8 Wels / Westspange	PPflex G/G1,5mm und 2,0mm 20 000m²
	Umfahrung Neustift	HDPE G/G 2,0mm 3000 m²
Germany:	B426	HDPE T/T 2,0mm 37000m²
Croatia:	Highway Split	HDPE G/G 1,0mm ca.:60000m²
France:	diverse Objekte	HDPE G/G 1,0mm und 1,5mm Type > 200 000m²; PPflex G/G 1,5mm ca. 30 000m²

Project:	Base sealing of a highway
Location:	Middle East-Coastal highway
Product:	AGRU HDPE Liner 1,0mm
Project data:	~138 000 m² both sides smooth G/G

- AGRULOCK Vertical Cut Off Walls
- Projekt: Ground water protection
- Ort: Venice; Italy
- Product: AGRU HDPE Liner 2,0 mm
- Project data: 40 000 m²
  AGRULOCK profile and both sides smooth G/G

- AGRULOCK Vertical Cut Off Wall
- Project: Monte Scherbelino Landifll
  Vertical Sealing
- Location: Frankfurt; Germany
- Product: AGRU HDPE Liner 2,5mm
- Project data: 43 000 m²
  AGRULOCK profile and boths sides smooth G/G

HOME

Hydraulic Engineering

Water is in the present an already very valuably element and will be even more in the future . Agru has developed products especially for those field of applications to preserve the main water resources like

- Lining of water reservoirs for potable and service water
- Sealing of dam`s, dykes, embankments and river`s.
- Sealing of canals and river bed`s.
- Lining of fish and shellfishfarm ponds
- Sealing of rainwater collecting basins
- Lining of detention basins for highways.
- Sealing of reservoirs for artificial snow production.
- Sealing of biotopes, golf ponds and artificial lakes.
- Sealing of agricultural areas for greenhouses, tree farms and vegetable beds.

Citrus tree farming
(System Holloway)

The use of polymere materials in the field of aquaculture is of significant importance due to it`s excellent properties like:

- Reduction of maintainance and valuable costs of lined ponds and reservoirs
- Absolute tightness of the system
- Establish erosion control
- Prevent the hollow out and backwash of dams
- Prevent the contamination of groundwater
- Eases Fish/Shellfish harvesting
- Simplyfying the preservation of water quality
- Reduces the desease risk at fish farms
- Guarantees long life performance and benefits
- prevent for unexpected habit of predators

Fish/Shellfish farm basins

Pond Construction

Fact finding at existing ponds resulted in a way that the choice of sealing material is a key fact concerning the expectation of life.
Liners produced of polyolefine materials like HDPE, LDPE, LLDPE, VLDPE and FPP have proven those requirements.
Agru Kunststofftechnik offer a variety of products and therefore the possibility of choosing the most suitable material to fulfill the project requirements.
A smooth hard substrate is the base of a easy and cost effective maintenance at pond constructions.
The remaining waste of a season periode just can be flushed away by high pressure water cleaners and be drained.
The lifetime of such a system is much higher than a convential system with clay or clay composite lining materials.
Liners produced out of polyolefin materials are resistent against rodents, that means that no predator attack will happen.
Therefore a long term sealing system is granted.
The use of Agru Liners prevent any soil erosion or slope deterioration.
It maintains pond bank integrity and keeps the original system design.
It eliminates muck and soft soil conditions around the pond.
It prevent the potentiall loss of water and fish/ shellfish from a pond bank breakthrough.

field of application: Lining of fish pond

Agru liner under tough condition

Water reservoirs in exponated areas

Over the years Agru Liners have prooved their ability to work as an excellent sealing material especially in a tough environment as for example the use at storage ponds in the Alpine climate for artificial snow production.
For the Winter Tourism managers it is a aim to get a longest as possible winter season.
To achieve those target the production of artificial snow is essential and in combination with the use of Agru Liners with its excellent material properties as a Sealing component in those water storage ponds.
Agru Kunststofftechnik GmbH as a leading manufacturer of Polyolefin materials provide those requirements for a long term sealant.
Together with the Biophysicist Dr. Hans Ellmauer a developement of a new generation liner took place - the so called "**Agru Bio plus Liner**"
It consists of a energetic loaded membrane which is produced in a particular manufacturing process and highlights in following properties

- Neutralisation of algae growth
- improved water quality
- Environmental performance evaluation
- improved efficiency in snow production
- Seasonal periode of extension at Ski tracks
- improvement of vegetation

pond in Construction phase

field of application: sealing of waterstorage pond for artificial snow production

Sealing of Concrete structures

field of application: Sealing of a concrete dam for power generation

field of application: Sealing of a concrete dam for power generation

A further aspect with the use of Agru liners is the application in combination with Concrete. The quality and the excellent properties of the liner guarantee a absolute tightness and a protection in case of concrete corrosion due to attack of (for example: desalinated water for cooling purpose in caloric power plants)
The advantage to complement one another like the concrete for structural strength and the liner as sealing and corrosion protection element guarantee a optimized solution for long term application with reference to tightness of the structure.

Waterreservoirs for potable water and Irrigation

field of application: Sealing of a water reservoir for potable water

field of application: Sealing of a flood water reservoir for Irrigation

In regions where the yearly rainfall is only a fraction of the european average AGRU Liners as a sealing element for water storage has been approved. They are the guarantee that during the hot summer periods enough water for the tourism or for agrucultural irrigation can be stored.

Detention basins

A very important factor is the groundwater protection along roads, highways, rail tracks and manipulation areas at railway stations.
At certain locations like above mentioned, those basins will be constructed to collect any spillage of groundwater endangering liquids and transport it to capable treatment facilities.
To construct those detention basins according state of the art technology Agru liners are an important factor to fulfill those requirements with reference to tightness and the function of a chemical barriere.
The proper installation guarantees a optimized solution for long term use and Environmental protection.

Retention pond

Retention pond

Evaporation ponds

- field of application: waste water settling pond
- The appropriate disposal of industrial waste water is very cost-intensive.The huge amount of especially from mining or chemical industrie accumulating waste water will be stored in huge ponds.
A big amount of the stored waste water will evaporate and the contaminated solids will remain and settling at the base.
To avoid infiltration into the subsoil Agru liners as a impermeable membrane guarantee the tightness of the structure and prevent therefore the surrounding area of any contamination.
At certain cycles the remaining sludge will be harvested and dewatered in industrial presses.
The filter cake will be either stored at landfills or incinerated.
Those treatment facilities consists mainly of several basins for liquids and one for solids, whereby all of them are sealed with Agru liners to fulfill the requirements of Environmental protection.

- Kemapco evaporation pond

Fire fighting basins

field of application: Sealing of fire fighting pond

To fulfill the safety requirements at industrial plants, the mandatory water supply must be given. Therefore basins with sufficient water quantity are built.
In the past those basins where built of concrete and sealed with epoxy coatings or FRP lining.But based on experience over the years weak points occured concerning tightness, and resulted in a hudge amount of water loss.
The solution was developed with the application of Polymere materials, like Agru liners due to their excellent material properties.
Agru liners are an important part of the facilities and assure a long term permanent tightness.
The proper installation of the liner in the basins will give confidence to a functional fire fighting sytem and assure therefore the production and safety of the employees.

field of application: Sealing of fire fighting pond

Irrigation Canals

field of application: Sealing of Irrigation Canal with Agru liners in the desert-Sandwich Construction

In areas where water is very rare the Agriculture need Irrigation.Man made water Canals transport the valuably water over hundreds of Kilometers to the agricultural areas. The loss of water in those unlined Canals is tremendous due to leakage and Billions of m^3 valuable water are lost. Agru offers a perfect solution by lining of those Canals with application prooved lining materials.
Depending on the project requirements the installation will be done either as a convential lining which means compacted subsoil - Liner or as sandwich Construction which means subbase-Liner-Concrete cover.
Both systems guarantee a 100% watertight Construction with a very minimized water loss due to evaporation.

field of application: Sealing of Irrigation Canal with Agru liners-conventional system

- Water Reservoir for Irrigation
- Project: Tirza
- Location: Jordan Valley
- Product: AGRU HDPE Liner 1,5 mm
- Project data: 285 000 m²
  both sides smooth G/G

- Water Reservoir for Irrigation
- Project: Cadiz
- Location: Cadiz, Spain
- Product: AGRU HDPE Liner 1,5 mm
- Project data: 15 000 m²
  both sides smooth G/G

HOME

- Fire fighting basin for a phosphate refinery (furtilizer plant)
- Project: Kemapco
- Location: Jordanien
- Product: AGRU HDPE Liner 2 mm
- Project data: 10 000 m²
  both sides smooth G/G

- Water reservoires for ski resorts for artificial snow production
- Project: Ski Resort Rohrmos
- Location: Ramsau; Austria
- Product: AGRU HDPE Liner 2,0 mm
- Project data: 10 000 m²
  both sides textrued T/T

- Water reservoires for ski resorts for artificial snow production
- Project: Ski resort Hochzeiger
- Ort: Jerzens; Austria
- Product: AGRU HDPE Liner 2,0 mm
- Project data: 8 400 m² + 4 200 m²
  both sides smooth for base and both sides textured T/T for slopes

- Water reservoires for ski resorts for artificial snow production
- Project: Ski resort Obersdorf
- Location: Obersdorf, Germany
- Product: AGRU HDPE Liner 2,0 mm
- Project data: 8 000 m²
  both sides smooth G/G

HOME

- Water reservoires for ski resorts for artificial snow production
- Project: Ski resort Reiteralm
- Location: Schladming; Austria
- Product: AGRU HDPE Liner 2,0 mm
- Project data: 6 300 m²
  one side smooth, one side textured T/G

- Ponds and Streams at Golf Courses for Irrigation
- Project: Golf course Fontana
- Location: Ebreichsdorf; Austria
- Product: AGRU HDPE Liner 1,5 mm
- Project data: 80 000 m²
  both sides smooth G/G

HOME

- Ponds and Streams at Golf Courses for Irrigation
- Project: PGA Golf course Catalunya
- Location: Catalunya; Spain
- Product: AGRU HDPE Liner 1,5 mm
- Project data: 37 000 m²
  both sides smooth G/G

- Ponds and Streams at Golf Courses for Irrigation
- Project: Jade dragon golf club
- Ort: Province Yunnan; China
- Produkt: AGRU HDPE Liner 1,0 mm
- Project data: 110 000 m²
  both sides smooth G/G

HOME

- Waterstorage for Industrial Applications
- Project: cooling water reservoir for electric power plant
- Location: Italien
- Product: AGRU HDPE Liner 2,5 mm
- Project data: 5 000m²
  both sides smooth G/G with
  co-extruded blue signal layer

- Waterproofing of canal constructions
- Project: Gaber Canal Phase II
- Location: Sinai; Egypt
- Product: AGRU HDPE Liner 1.0 mm
- Project data: 600 000m²
  both sides structured
  micro spike MST/MSB liner
  sandwich system : 15cm concrete layer
  HDPE MICRO SPIKE liner
  25cm concrete layer

HOME

- Rehabilitation of corroded Concrete Water Canals
- Project: Badajoz Water Canal
- Location: Distrikt Orellana; Spanien
- Product: AGRU HDPE Liner 2,0 mm
- Project data: 40 000m²
  both sides smooth G/G for rehabilitation of 2 km canal length

- Ponds for Sports- and Recreation Centers
- Project: water sport resort graf harrach
- Location: Bruck an der Leitha; Austria
- Product: AGRU HDPE Liner 1,5 mm
- Project data: 10 000 m²
  both sides smooth G/G with co-extruded UV-stabilized green signal layer

HOME

- Natural ponds and swimming ponds
- Product: Agruflex Pondliner
- VLDPE Liner with co-extruded olive-green UV-stabilized signal layer
- Thickness: 1,5 mm
  Width: 2 m

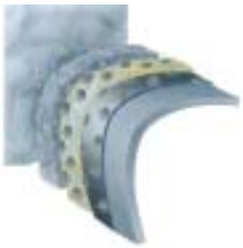
- Ponds for Sports- and Recreation Centers
- Project: Watersport resort
  Greifensee
- Location: Greifensee
  Switzerland
- Product: AGRU FPP Liner 1.5 mm
- Project Data: 5 000 m²
  both sides smooth with glass fibre reinforcement
  colour similar to ral 6000

Tunnel Construction

Since the early 50´s of the last century trial installations of geotechnical synthetic products for underground constructions were performed to achieve sealing and draining of tunnel constructions against agressive mountain water to extend life time.
The New Austrian Tunneling Method NÖT introduced around 1970 and also at this time newly applied gesynthetic products as ECB/bitumineos-, PVC liners and geotextiles a steady development and new polyolefin based geomembranes with improvement of physical properties, installation and welding techniques has occured.

Underground construction work requires high demands on design, construction, logistical chains and safety considerations.
Therefore the design life of such constructions is a minimum of 100 years.
One important premise for achieving such design life is the insulationof the structure against mountain- and ground water.
The proper sealing for underground construction therefore is an inherent part of the design.
The lining protects the structure and the interior equipment against corrosion, avoids utilization discontinuities and prevents malfunction of sensitive electronic and technical equipment.

Drilled Tunnel constructions...
are typically designed in a double shell construction of primary shot concrete layer and a load bearing inner shell construction with waterproofing lining insulation in between.



Cut and CoverTunnel constructions..
are typically easier to install in comparison to drilled tunnels as the geotexiles and liners will be layed on the already finished load bearing inner shell so no fixation or over head- work and over head welding is required.

Design Criterions

The proper design of the tunnel lining system is in dependence of operational demands as water backpressure and of the corrosion grade of the aggressive mountain water. The thickness is accordingly regraded from 4mm thickness for full tight 360° lining bearing high back pressure to 2mm thickness for umbrella sealing systems .

To protect the tunnel liner against mechanical damage and for eventually area drainage purposes protection geotexiles typically out of nonwoven PP up to 1000g/m² are installed.

The proper surface quality of the shot concrete layer is of paramount importance for the long term tightness of the geomembrane asits function is to take the fixation forces and bearing support of the liner. The installled liner and protection geotexile shall be smoothly applied to the shotcrete surface not to overstrain the liner or to create wrinkles to the lining.

In addition the poured inner shell shall be fully form-closed with the tunnel lining.To ensure this requirement also in the top injection using cementeous mortar or supension is perfomed

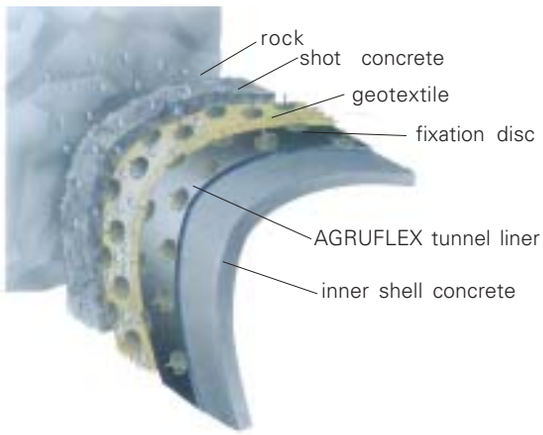
The drainage piping system for tunnels also has to be designed for right material , dimensioning on stiffness and entry area of holes or slots.
AGRU offers special coextruded PE and PP pipes with bright inside colour and smooth surface for better monitoring and against lime sintering.

Projects without drainage system of mountain water needs a design of the waterproofing and teh construction for the full scale water pressure. In this respect a „undrained tunnel“does not mean only not to install a drainage system, the total design needs to be adopted.

Undrained pressurized tunnel sealing systems with increased water pressure require special adoptions. Functional waterstop sections by using jointing profiles designed to the actual water pressure are installed in case of a leak to avoid water flows over several meters up to some 100 meters.

As Leakings for structures with outside water pressure can cause extensive repairs without any precautions, there is the possibility to integrate an injection system for located repair work. Systematic installation of injection pipes is done in the interface of sealing membrane and inner shell concrete to tighten located leaks by backfilling with special expanding concrete or synthetic resin.

Installation of AGRUFLEX VLDPE Tunnel liners



After the tunnel surface is shotcreted to achieve a smoothened surface suitable for installation of the waterproofing membrane the installation of protection geotextile and AGRUFLEX tunnel liner can be started.

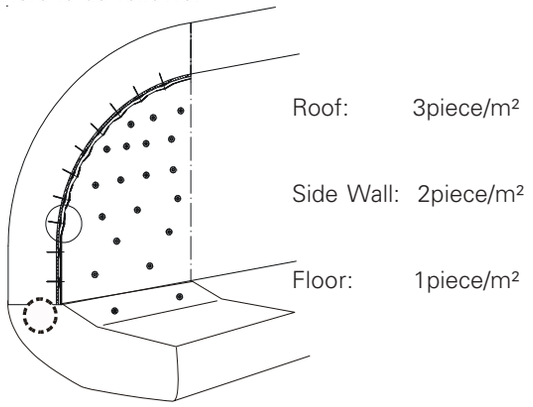
General Description of Installation Process:

The protection geotextile typically having 1000g/m²
is fixed to the shotcrete surface by means of discs out of PEVLD which are also the fixation points by means of manual hot gas welding for the AGRUFLEX PEVLD tunnel liner.

The AGRUFLEX tunnel liners are thermally bonded by using manual hot gas welding to this discs for temporary fixation to keep in place.
The fixation discs are designed to have a preset cracking ability so that after the inner shell of the tunnel structure is built the lining can not be damaged by settlements.
The AGRUFLEX tunnel liners are welded by using hot wedge welding technology acc. DVS 2225 and tested for tightness.
Smaller areas and the welding of waterstop profiles is performed by combined manual hot gas welding for tacking and extrusion welding technique.
After testing of all welding seams the concreting of the inner shell is performed.

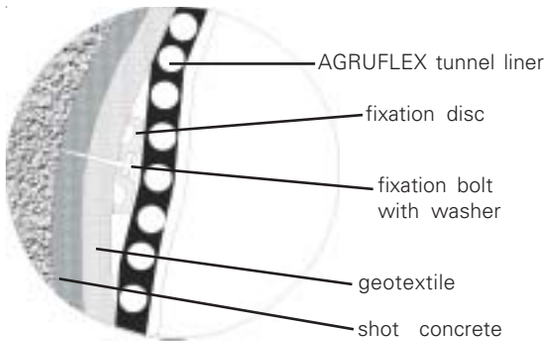
Layer Installation

The recommended arrangement of the fixation discs for the welding of the AGRUFLEX tunnel liners is as follows:



Installed Section

Detail of layers



Steps of Installation

Front: Geotextile, mounted to the shotcrete surface

View on scaffolding for installation and welding of the AGRUFLEX tunnel liners

The geotextile is mounted by fixation discs shot into the concrete

The AGRUFLEX tunnel liner is manually welded to the discs by hot gas welding

Fusion technique

Welding of liners is executed by hot wedge double seam technology

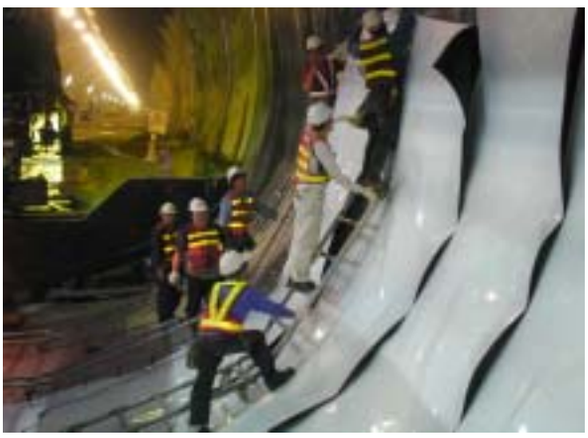
Seam Testing using air pressure for double seams and vacuum box for extrusion seams

Installation of waterstop profiles at bulkhead sections

View on finshed tunnel section
(prior to installation of inner shell concrete)

HOME

- Civil Engineering - Tunnel Sealing
- Project: Linkou Tunnel
  Taiwan High Speed Rail Project C210
- Location:Taipei/Taiwan
- Product: AGRUFLEX VLDPE Tunnel-Liner 2.5mm
  Thickness including signal layer (0.2mm)
- Project Data: 290 000 m²
  both sides smooth G/G with
  coextruded white signal layer



- Civil Engineering - Tunnel Sealing
- Project: Rappode Tunnel
- Location:Rappode/Germany
- Product: AGRU VLDPE Tunnel-Liner 2.5 mm
  Thickness excluding signal layer (0.2mm)
  acc. requirements of ZTV-Tunnel / D
- Project Data: 6000 m²
  both sides smooth G/G wit coextruded white
  signallayer and geotextile backed for installation
  using hook and loop fixation system

- Civil engineering tunnel sealing
- Project: Underground Athens
- Location: Athens; Greece
- Product: AGRU VLDPE Tunnelliner 2,2 mm
- Project data: 10 000 m²
  both sides smooth G/G with co-extruded blue signal layer

- Civil engineering tunnel sealing
- Project: Highway tunnel
- Location: Voitsberg; Austria
- Product: AGRU HDPE Liner 2.5 mm
- Project data: 15 000 m²
  both sides smooth G/G

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3rd party control

In addition to internal controls, regular tests on products, performed by inepen dently accredited test institutes, are of prime importance. This external control is one element of product approvals in several application ranges and countries, where the modalities of the external control are regulated in registration and approval certificates.
Presently following institutes are commissioned for the production:
TUV Bayern
MPA-Darmstadt
Hessel Ingeneurtechnik GmbH
SKZ-Wuerzburg
TGM-LKT-Wien
OFI-Wien

The high quality standard of our products is documented by a series of approvals.

- HDPE Geomembranes are approved according the **DIBt** requirements and are certified with the following numbers:

  HDPE Liners Z 59-21251
  G/G; 2,0 - 3,0mm; 5 and 7m width
  MST/MSB; 2,0 - 3,0mm; 5,15 and 7m width
  G/MSB 2,0 - 3,0mm; 5,15m width

  further Approvals:

- **BAM (Germany)**
  HDPE Liner 06BAMIV30299
  G/G; 2,5mm; 5m width

  HDPE Liner 06BAMIV30499
  G/G; 2,5mm; 7m width

  HDPE Liner 06BAMIV30199
  MST/MSB; 2,5mm; 5,15m width

  HDPE Liner 06BAMIV30599
  G/MST; 2,5mm; 5,15m width

  HDPE Liner 06BAMIV30699
  G/MSB; 2,5mm; 5,15m width

  HDPE Liner 06BAMIV30699
  R50/S; 2,5mm; 5,15m width

- **OENORM (Austria)**
  HDPE Liners ONN20009
  all structure types and widths; 2,5 - 5,0mm

- **ASQUAL (France)**
  HDPE Liner Asqual4701CQ02
  G/G; 2,0mm; 5 and 7m width

  HDPE Liner Asqual4700CQ02
  G/G; 1,5mm; 5 and 7m width

  HDPE Liner Asqual4702CQ02
  T/T; 2,0mm; 5 and 7m width

- **KIWA (Netherlands)**
  HDPE Liners KIWA K11680-04
  G/G; 1,5 - 2,0mm; 5 and 7m width
  G/T; 1,5 - 2,0mm; 5 and 7m width
  T/T; 1,5 - 2,0mm; 5 and 7m width
  G/T; 1,5 - 2,0mm; 5 and 7m width
  MST/MSB; 2,0mm; 5,15 and 7m width
  G/MSB 2,0mm; 5,15 and 7m width
  G/MST 2,0mm; 5,15 and 7m width

  Further approvals for standard liners

- **GRI-GM13 (USA)**
  HDPE Liner GRI_GM13
  G/G; 1,5 and 2,5mm; 5 and 7m width

- **ZIK (Croatia)**
  HDPE Liner ZIK699-04
  G/G; 2,5m; 5 and 7m width

- **ITC Zlin (Czech Republic)**
  HDPE Liner ITC030062V-A0-a
  G/G; 0,75 - 5mm; 5 and 7m width
  T/T; 0,75 - 5mm; 5 and 7m width
  S/R50; 0,75 - 5mm; 5,15m width

  VLDPE Liner ITC040216V-A0
  all structure types, thicknesses and widths

- Other Approvals are available on request

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Standards

AGRU Geomembranes are manufactured out of standardized moulding materials and produced according tot the relevant international standards.

Hereafter a summary of the most important standards for geomembranes:

ISO 1133
Kunststoffe; Bestimmung des Schmelzindexes (MFR) und des Volumen-Fließindex (MVR) von Thermoplasten
ISO 527
Kunststoffe - Bestimmung der Zugeigenschaften
OENORM S 2073
DIN 16 726
Kunststoff Dachbahnen; Kunststoff Dichtungsbahnen; Pruefungen
DIN 53 370
Bestimmung der Dicke durch mechanisches Abtasten
DIN EN ISO 34-1
Rubber, vulcanized or thermoplastic - Determination of tear strength - Part 1: Trouser, angle and crescent test pieces
ASTM D 792
Test Methods for Specific Gravity (Relative Density) and Density of Plastics by Displacement
ASTM D 1238
Tst Method for Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D 1204
Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting for Film at Elevated Temperature
ASTM D 1004
Test Method for Initial Tear Resistance of Plastic Film and Sheeting
ASTM D 6693
Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
ASTM D 4833
Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
ASTM D 746
Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
ASTM D 570
Test Method for Water Absorption of Plastics
ASTM D 543
Test Method of Resistance of Plastics to Chemical Reagents
ASTM D 1693
Tst Method for Environmental Stress-Cracking of Ethylen Plastics