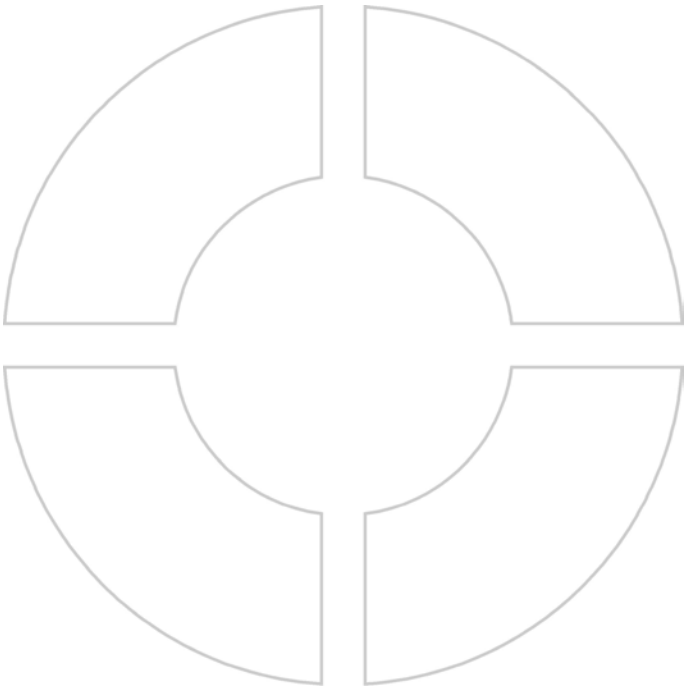
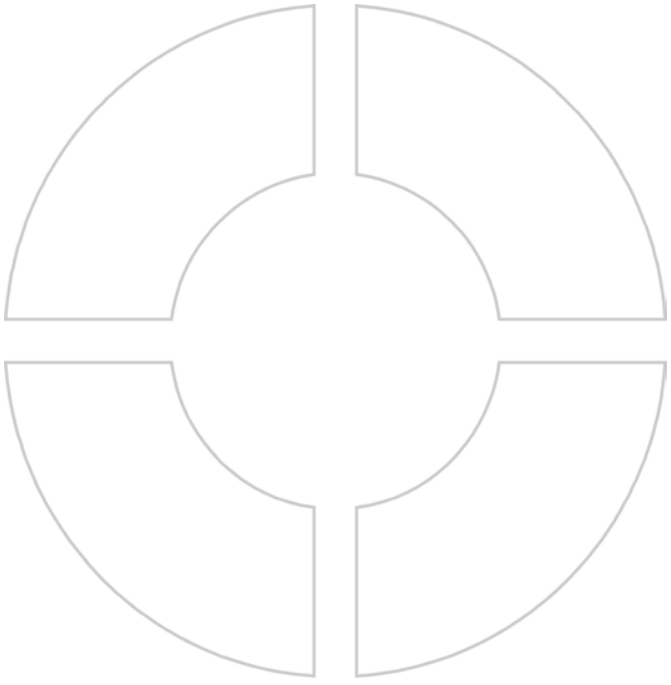




Material properties

Advantages of PE 100 in compressed-air supply

- excellent resistance to compressor oils and aggressive ambient air
- very good stress cracking resistance
- high creep rupture strength
- high pressure load resistance PN 16 at 20°C
- wide temperature range (between –30°C and +60°C)
- very good weldability
- easy, clean, rapid and safe installation
- corrosion resistant (compressed air not polluted by corrosive deposits from the piping)
- low frictional resistance resulting in decreased pressure drops and increased flowrates when compared to metal pipes of the same internal diameter
- lower flow noise level compared to pipes made from other materials

Other properties

- low specific weight of 0.96g/cm^3 (PVC 1.40g/cm^3, steel 7.86 g/cm^3)
- very good chemical resistance
- excellent resistance to rapid crack growth
- high weathering resistance
- no conductivity
- very good abrasion resistance
- no deposits nor growth
- frost resistant
- very good thermal insulating property
- rodent resistant
- resistant to any microbial corrosion

Chemical resistance

PE 100 basically provides an excellent chemical resistance to a multitude of media based on acids, alkalies and hydrocarbons.

As a result, polyethylene has been accepted as material used for industrial piping systems.

The humidity that often forms in a compressed-air system (which can cause considerable problems in metallic piping) has no negative impact on the above positive properties.

Special emphasis is to be put on the resistance to compressor oils which usually must be considered as serious problem for some other plastics (e.g. ABS).

There are of course some limitations such as contact with free chlorine or solvents at high temperatures.

In case of doubt, our technical engineering department are able to help you to assess the media and to support you in the planning and design process.

The resistance of any other sealing material is of great importance for the chemical resistance of a compressed-air piping system and it must be dimensioned appropriately.

We recommend to use gaskets made from NBR as a standard.

This applies to profile packing for flange connections as well as to gaskets in shut-off devices (ball valves and shut-off butterfly valves).

For thread adaptors we recommend the use of a PTFE tape on threaded connections.

Depending on the resistance required we are able to supply alternative sealing materials.

In the event that the ambient air contains aggressive media, it is required to carry out a separate testing of the sealing material.
In this case, please do not hesitate to contact our technical engineering department for further assistance.

Specific material properties of PE 100

	Property	Standard	Unit	PE100
	Specific density at 23°C	ISO 1183	g/cm^3	0,95
	Melt flow index MFR 190/5 MFI range	ISO 1133 ISO1872/1873	g/10min	 0,5 T003
Mechanical Properties	Tensile stress at yield	ISO 527	MPa	25
	Elongation at yield	ISO 527	%	9
	Elongation at break	ISO 527	%	>600
	Impact strength unnotched at +23°C Impact strength unnotched at -30°C	ISO 179	kJ/m^2	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	16 6
	Ball indentation hardness acc. Rockwell	ISO 2039-1	MPa	46
	Flexural strength (3,5% flexural stress)	ISO 178	MPa	24
	Modulus of elasticity	ISO 527	MPa	1100
Thermal Properties	Vicat-Softening point VST/B/50	ISO 306	°C	77
	Heat deflection temperature HDT/B	ISO 75	°C	75
	Linear coefficient of thermal expansion	DIN 53752	$K^{-1} \times 10^{-4}$	1,8
	Thermal conductivity at 20 °C	DIN 52612	W/(mxK)	0,4
	Flammability	UL94 DIN 4102	–	94-HB B2
Electrical Properties	Specific volume resistance	VDE 0303	OHM cm	$>10^{16}$
	Specific surface resistance	VDE 0303	OHM	$>10^{13}$
	Relative dielectric constant at 1 MHz	DIN 53483	–	2,3
	Dielectric strength	VDE 0303	kV/mm	70
	Physiologically non-toxic	EEC 90/128	–	Yes
	FDA	–	–	Yes
	Colour	–	–	blue

Permissible working pressures for AGRUAIR

AGRUAIR was designed for an acceptable operating pressure of 16 bar (at 20°C, compressed air and a service life of 50 years).

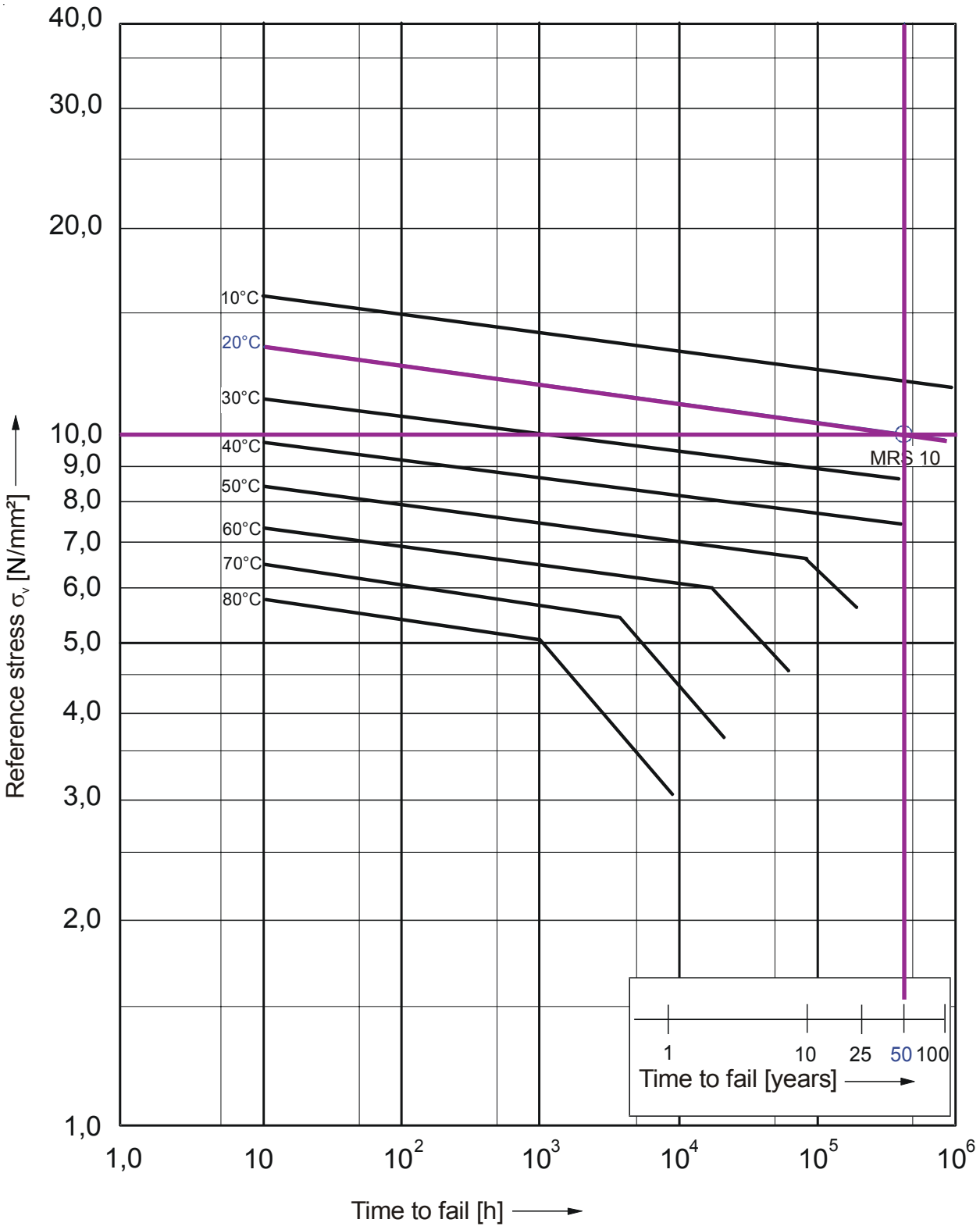
The values detailed in the table show the acceptable permanent stress of pipes and fittings of industrial compressed-air piping systems for a certain operating temperature and operating time.

Creep strength

The calculated service life of the pipes is based on the results of the creep rupture tests under internal compression carried out by the material manufacturers as per DIN 8075, and on long-term tests of the ageing stability in temperature controlled oxygenated fresh water.

Operating temperature [°C]	Service time [years]	Permissible Working pressure [bar]
20	50	16
30	50	14
40	50	12,5
50	15	11,4
60	5	9,8

Creep curve of PE 100



Transport and storage

Transport

Pipes are supplied as standard in 5 m lengths. AGRUAIR pipes are packed as bundles.

When transporting the pipes care should be taken of the following points:

- The loading area must be free from sharp objects (e.g. stones, metal parts etc.)
- The pipes should be supported on the loading area by at least ¾ of their length to prevent the pipes from being bent excessively.

Storage

The pipes are to be stored on level surfaces which must be free from sharp objects.

The maximum piling height amounts to 1,0 m. The pipe stacks should be secured on either side.

We recommend to leave the AGRUAIR pipes and fittings packed until installation commences.

If stored outside, protect the pipes against UV radiation.

NOTE:

UV stability
Due to the low UV resistance AGRUAIR is only recommended for indoor application. For outdoor installation ensure that sufficient UV protection is provided (use UV-resistant (black) insulation material).

Installation

Compared to the piping systems made from metal, the installation of the AGRUAIR piping system displays some significant differences.

Therefore, we recommend every installation specialist is trained in the correct techniques for laying and welding of the AGRUAIR products.

Prevent mechanical stress (bending and pushing) of the pipes during installation at temperatures of around 5°C.

Installations carried out at temperatures below 5 °C are not recommended.

The installation instructions should be complied with during installation.

Pressure testing

Any newly-installed piping system must be pressure-tested before being commissioned.

Before carrying out the pressure tests let the weld joints cool down completely (this takes usually 1 hour after the last weld).

The pressure test is to be carried out according to the relevant standards (e.g. DVS 2210, part 1, DIN 4279 or DVGW G 469).

The required test pressure amounts to 1.5 x PN (maximum PN+5). During the pressure test provide suitable protection to prevent ambient temperature changes (due to insulation).
As test medium we recommend water.

Supporting distances

The support distances normally depend on the mechanical properties of the pipe material, the pipe dimension, the specific weight of the flow media, the operating temperature and the piping layout.

The support distances shown in the tables refer to compressed air used as flow medium with a density of 1.3 kg/m³.

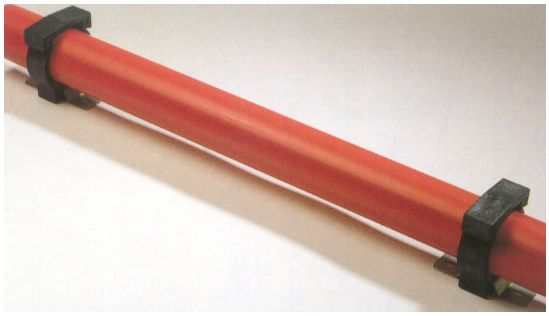
The calculation of the support distances is based on a maximum deflection between two pipe clips of L/500.

To achieve wider support distances especially in the case of smaller diameters (da 20 – 40mm) pipe holders for continuous pipe support can be used.

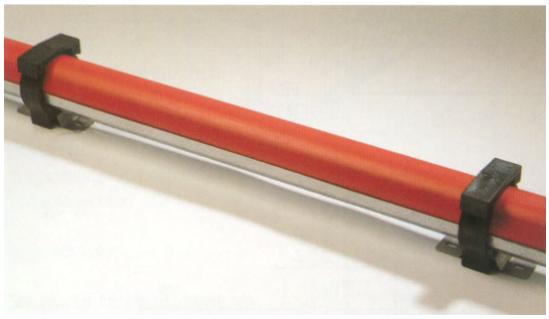
In the case of vertical pipings the specified distances can be increased by about 50%.

To achieve the optimum pipe support suitable for plastics we recommend the use of our pipe clips.

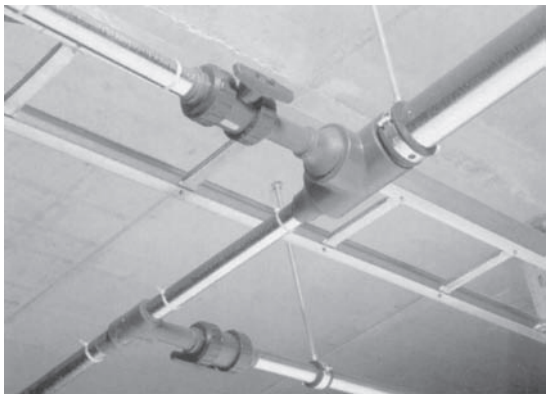
These are made from polypropylene and have been developed especially for plastic piping systems.



Supported by pipe clips



Continuous support by pipe holders



Practical example

Supporting distances for AGRUAIR pipes

Pipe outside diameter d [mm]	Thickness s [mm]	Support distance L in [cm] at				
		20°C	30°C	40°C	50°C	60°C
20	2,8	83	79	73	66	64
25	3,5	96	92	85	77	74
32	4,4	114	100	100	90	88
40	5,6	132	126	116	105	101
50	6,9	153	146	135	122	118
63	8,7	179	170	157	142	138
75	10,3	201	191	177	160	155
90	12,5	227	216	200	180	174
110	15,2	259	247	228	206	199

Change of length due to thermal expansion

Plastic has the property of expanding under heat.

The calculation of the change in length of AGRUAIR pipes is based on the following formula:

$$\Delta L = \alpha \cdot \Delta T \cdot L$$

ΔL	=	change in length due to the temperature change	[mm]
α	=	linear expansion coefficient [for PE 100 = 0.18 · mm/(m·K)]	
ΔT	=	difference in temperature	[°K]
L	=	pipe length	[m]

The temperature difference ΔT results from the difference between installation temperature and the maximum and minimum pipe wall temperature (installation, operation, shut down) .

Calculation of minimum straight length

(following DVS 2210, part1)

Changes in length are caused by a changing operating temperature.

Axial movement compensation should be provided at outside installed pipes.

In many cases the changes in direction of flow can be used to compensate changes in length.

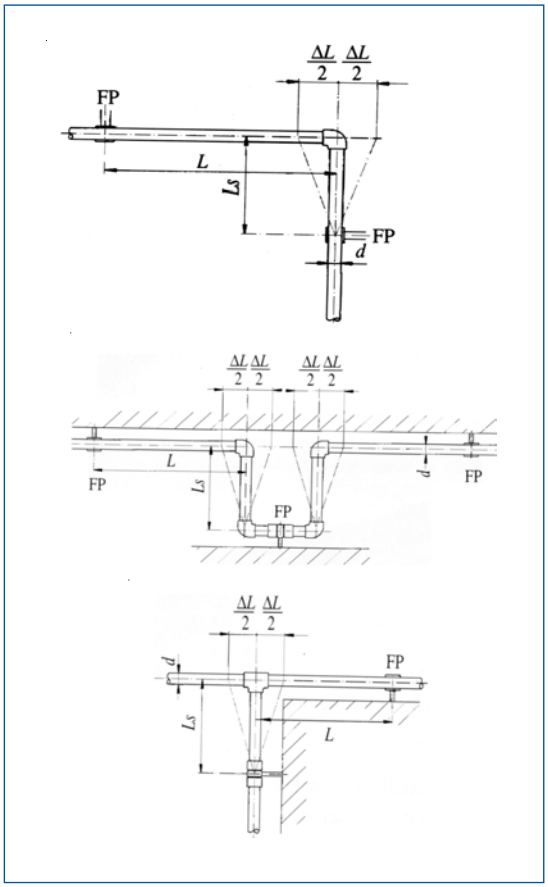
Prestressing method - Installation

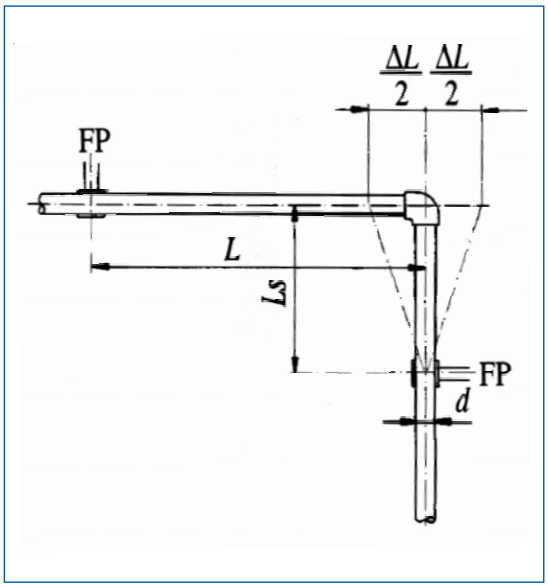
For this method it is required to enter $\Delta L/2$ to calculate the minimum straight length, as part of the change in length is compensated by prestressing by $\Delta L/2$.

This means that in practice the bent side is already prestressed by half of the change in length $\Delta L/2$.

Advantages of the prestressing method

- The minimum straight length can be reduced.
- Perfect installation during operation, as the expansion is hardly visible.





The minimum straight length is based on the following :

$$L_S = C \cdot \sqrt{da \cdot \Delta L}$$

L_S	=	minimum straight length	[mm]
da	=	pipe outside diameter	[mm]
ΔL	=	change in length	[mm]
C	=	material-based constant for PE 100 = 26	

Diagram showing minimum straight length L_S

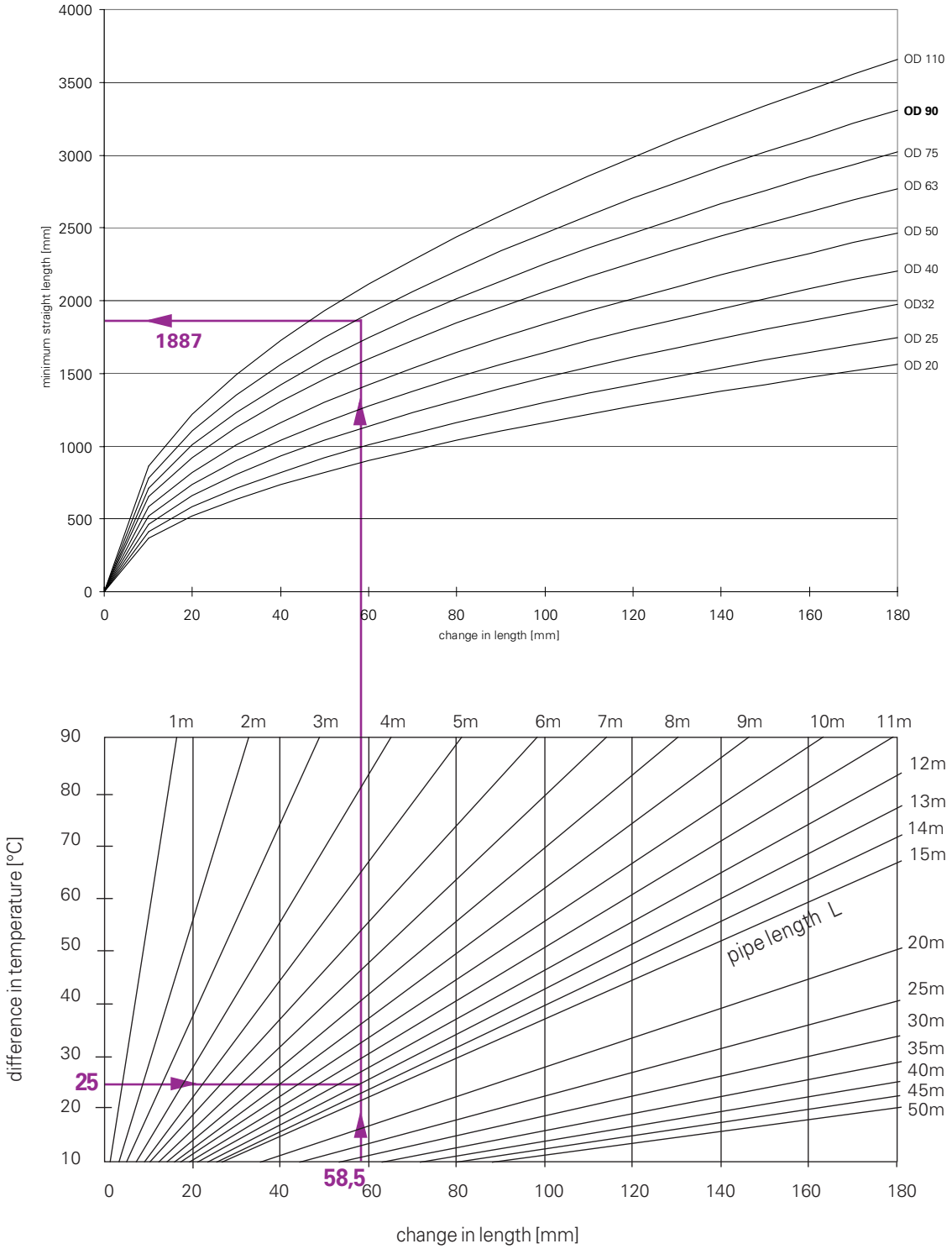
Example:
Temperature difference (operating and installationtemperature) ΔT: 25°C

Length of pipe: L = 13 m

Theoretical longitudinal expansion:
ΔL: 58.5 mm

For the minimum straight length of a pipe Ø 90 mm please start with diagram 2 to calculate the change in length. Afterwards please follow the vertical line to the diagram 1, up to the intersection of the pipe Ø 90 mm line and than turn to the left.

Minimum straight length:
L_S = 1887 mm



Condensate drainer

Apart from the minimum straight lengths and expansion bends required for changes in length, there are also flow deviations used which serve as consumer protection.

The so-called "goose-neck" is often used for the installation of tees from the ring-main piping to the point of use connections.

This prevents the condensate that is formed due to temperature and pressure changes (especially in the case of systems without effective air drying), from reaching the connections and thus from corroding and damaging the equipment.

Basically there are 2 possibilities of prevention:

Version 1 - goose neck

A possible installation is shown by the figure below. This version is the most cost-effective of the versions detailed and offers sufficient protection in most cases.

Version 2 - water drainer

This method offers a maximum of protection for the connected devices and should be installed in the case of complicated devices.

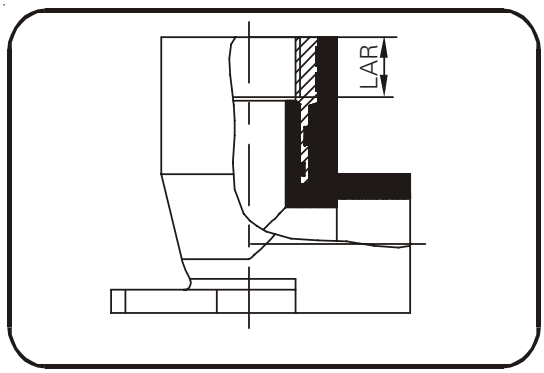
Example of goose-neck design

Screwed connections

Thread parts with metal insert

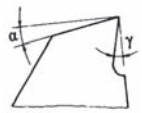
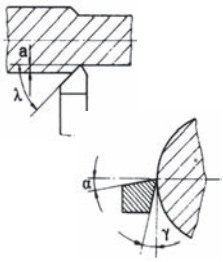
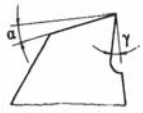
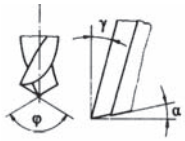
When connections to male or female threads are required, ensure that the full effective thread length is engaged and that an appropriate sealing material such as PTFE tape has been used.

Note:
The tightening torque must not exceed 40 Nm.



Thread depth (*LAR*)

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

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

The cutting speed, feed and cutting geometry should be designed in a way that any subsequent heat can mainly be removed through the shavings (too much pre-heating can lead to melting resp. discolouration of the processed surface).

All usual metal and wood processing machines may be applied.

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 $1m^3 = 10^3 dm^3 = 10^6 cm^3$	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 $1bar = 10^5 Pa = 0,1N/mm^2$ $10^6 Pa = 1MPa = 1N/mm^2$	psi 1bar = 14,5psi = 14,5lb/sq in
Mechanical stress	kp/mm^2 $1N/mm^2 = 0,102kp/mm^2$	N/mm^2	psi $1N/mm^2 = 145,04$psi = 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 = 1K	°F °F = 1,8 x °C + 32

Pipe Sizing

To correctly dimensioning a compressed-air line, it is necessary to define some parameters.

First of all, the pressure required by the consumer must be determined.

Many compressed-air distribution systems are supplied with excessive compressed air which results in significant extra costs based upon the yearly operating hours.

In order to avoid these costs, it is useful to exactly define the required pressure.

Furthermore, the length of the compressed-air piping system must be dimensioned accurately, and therefore it is useful to work out a pipe schematic.

Based on this schematic, the required piping and nominal lengths (including fittings) can be accurately calculated.

The piping system length is an important factor for calculating the pipe diameter.

Based on the nominal length it is possible to determine and calculate the flowrates, which are required when determining the diameters.

Fittings (such as 90° Elbows) increase the flow resistance and pressure drop of the complete system caused by the changed direction of flow.

The influence of the fittings can be calculated by means of equivalent lengths which can then be simply added to the pipe length. For the equivalent lengths please refer to the below table.

	Equal pipe length in [m]*								
Fitting	da 20	da 25	da 32	da 40	da 50	da 63	da 75	da 90	da 110
45°-Elbow	0,2	0,3	0,3	0,4	0,5	0,7	0,8	1,0	1,2
90°-Elbow	0,8	1,0	1,3	1,6	2,0	2,6	3,1	3,7	4,5
Tee main direction	0,3	0,3	0,4	0,5	0,6	0,8	0,9	1,1	1,4
Tee branch	0,9	1,2	1,5	1,9	2,4	3,0	3,5	4,2	5,2
Reducer	0,0	0,0	0,0	0,1	0,1	0,1	0,1	0,1	0,2
Ball valve	0,1	0,1	0,1	0,2	0,2	0,3	0,3	0,4	0,5

* approximate value based on the following formula

$$L_{equ.} = \frac{\zeta \times d_i}{\lambda \times 1000}$$

$L_{equ.}$ ... equivalent length [m]
d_i ... pipe inside diameter [mm]
ζ ... drag coefficient
λ ... coefficient of friction [bar]

Approximation formula for calculating the pipe inside diameter

The pipe inside diameter is normally calculated by means of an approximation formula assuming that the compressed-air temperature is equivalent to the intake temperature.

A suitable approximation can be achieved by the following equation:

A second and simplier method is the calculation of the pipe outside diameter by using a nomogram based on the approximation formula.

The nomogram shown is specially adapted to AGRUAIR pipes and relates directly to results in the required outside diameter.

The outside diameter can be calculated by entering the known parameters such as pressure drop, operating pressure, flowrate and length of piping system, through its created intersections .

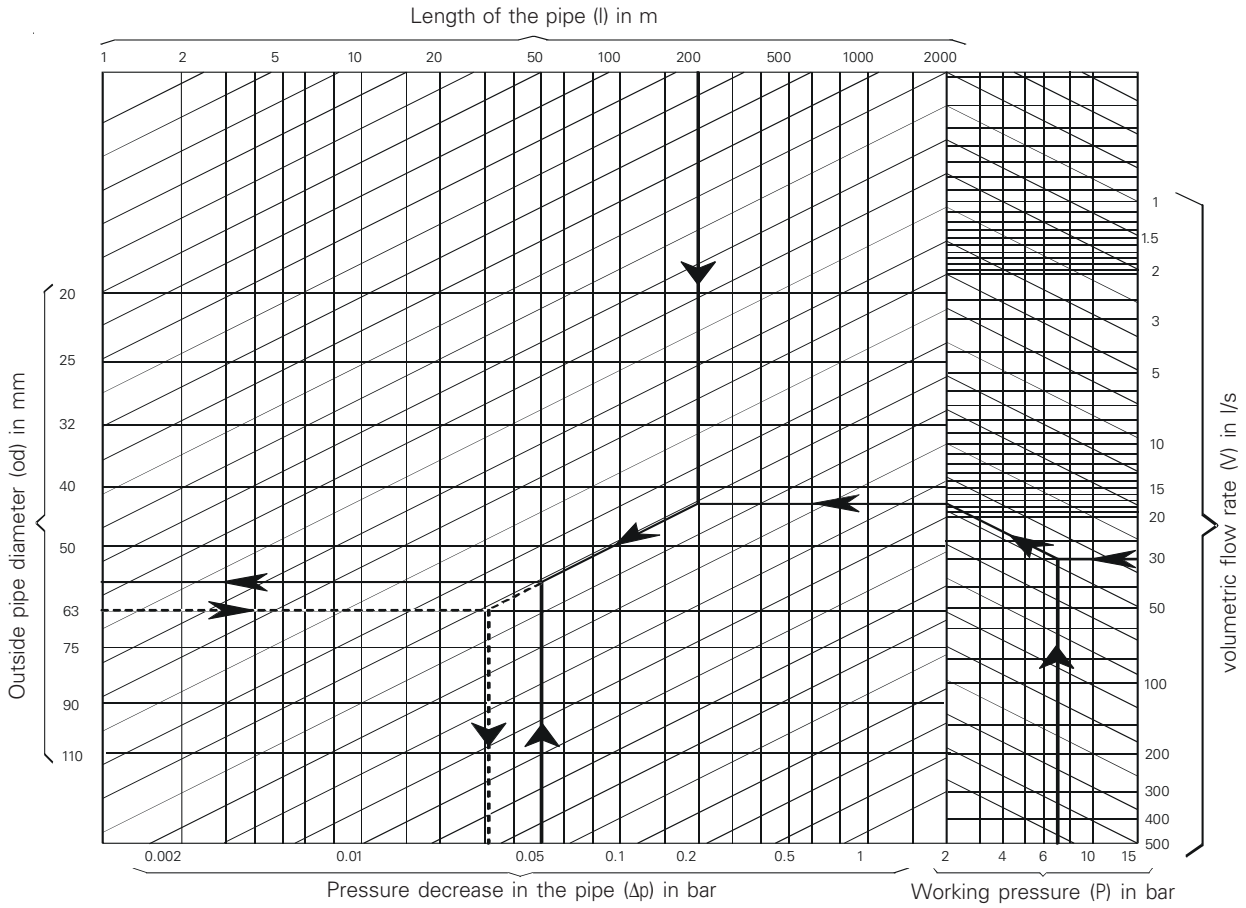
$$d_i = \sqrt[5]{\frac{450 \times L \times V^{1,85}}{\Delta p \times p}}$$

d_i	...	pipe inside diameter	[mm]
L	...	nominal length of pipeline	[m]
V	...	flowrate	[l/s]
Δp	...	pressure drop	[bar]
p	...	excess operating pressure	[bar]

The use of the outside diameter is advantageous as a subsequent conversion from inside to outside diameter is no longer required.

Another advantage of the nomogram is the fact that when four parameters are known, the fifth can easily be calculated.

Nomogram for calculating the pipe outside diameter



General requirements

The quality of the welded joints depends on the qualification of the welder, the suitability of the machines and appliances as well as the compliance of the welding guidelines. The welding joint can be checked through non destructive and / or destructive methods.

The welding process should be supervised. Method and size of the supervision must be agreed from the parties. It is recommended to document the method datas in welding protocols or on data medium.

Each welder must be qualified and must have a valid proof of qualification. The intended field of application can be determined for a type of qualification. For the heating element butt welding from sheets as well as for the industrial piping system construction DVS® 2212 part 1 is valid. For pipes >225mm outside diameter an additional proof of qualification is requirement.

The used machines and appliances must correspond to the standards of the DVS® 2208 part 1.

PE pipes from coils are oval immediately after rolling up. Before welding the pipe ends have to be adjusted for example by heating with a hot-air blower and usage of a suitable cut pressure or round pressure installation.

The joining areas of the parts to be welded must not be damaged or contaminated.
Immediately before starting the welding process, the joining areas have to be cleaned and must be free from e.g. dirt, oil, shavings.

On applying any of these methods, keep the welding area free of flexural stresses (e. g. careful storage, use of dollies).

The AGRU welding instructions apply to the welding of pipes and fittings out of the thermoplastics listed in the table (according to DVS® 2207).

Material designation	Weldability
Polyethylene PE 80, PE 100	MFR (190/5) = 0,3 - 1,7 [g/10min]

Measures before the welding operation

The welding area has to be protected from unfavourable weather conditions (e. g. moisture, wind, intensive UV-radiation, temperatures < 0°C). If appropriate measures (e. g. preheating, tent-covering, heating) secure that the required pipe wall temperature will be maintained, welding operations may be performed at any outside temperatures, provided, that it does not interfere with the welder's manual skill.
If necessary, the weldability has to be proved by performing sample welding seams under the given conditions.

If the semi finished product should be disproportionately warmed up as a consequence of intensive UV-radiation, it is necessary to take care for the equalization of temperature by covering the welding area in good time. A cooling during the welding process through draft should be avoided. In addition the pipe ends should be closed during the welding process.

Following connection methods are possible:

Type of connection	OD 20 - 63		OD 63 - 110		> OD 110	
Heating element socket welding	●	●	●	●		
Electric socket welding (Electro Fusion welding)	●[1)]	●[1)]	●[1)]	●[1)]	●[1)]	●[1)]
Flange joint	●	●	●	●	●	●
Heating element butt welding	●	●	●	●	●	●

●[1)] - This welding method is suitable for the installation of prefabricated piping system elements as filed welding

Heating element socket welding

Heating element socket welding (following to DVS® 2207, part 1 for PE-HD)

Welding method

On heating element socket welding, pipe and fittings are lap-welded. The pipe end and fitting socket are heated up to welding temperature by means of a socket-like and spigot-like heating element and afterwards, they are joined.

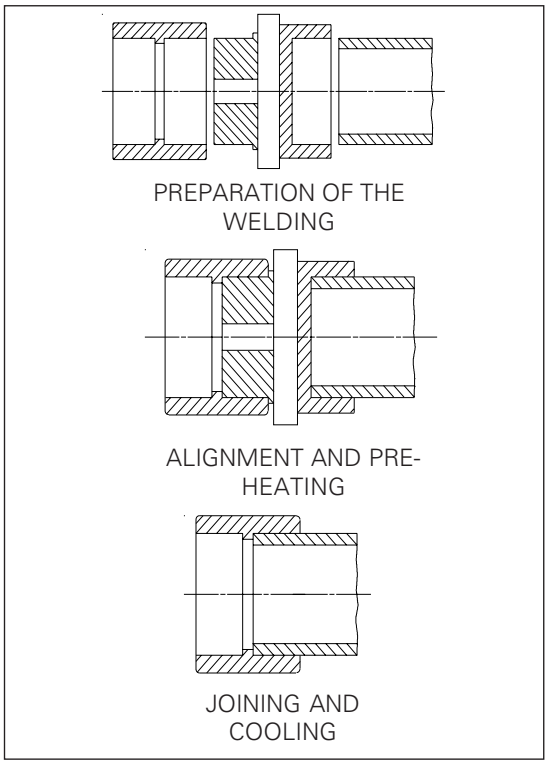
The dimensions of pipe end, heating element and fitting socket are coordinated so that a joining pressure builds up on joining (see schematic sketch).

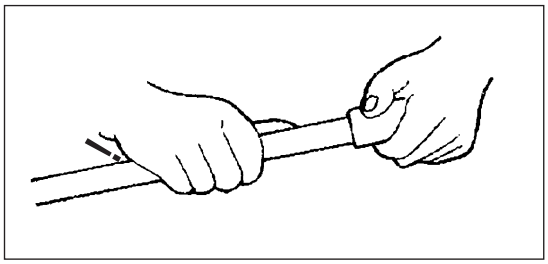
Heating element socket weldings may be manually performed up to pipe outside diameters of 40 mm. Above that, the use of a welding device because of increasing joining forces is recommended.
The guidelines of the DVS® are to be adhered to during the whole welding process!

Welding temperature (T)

PE-HD	**250 ÷ 270 °C**

Schematic sketch of the welding process





Fixing by hand

Welding parameters

Reference values for the heating element socket welding of PP and PE-HD pipes and fittings at an outside temperature of about 20°C and low air-speed rates:

Material-type	Pipe outside diameter OD [mm]	Pre-heating time t_{Aw} [sec]	Welding temperature [°C]	Adjusting time t_U [sec]	Cooling time t_{Ak} fixed [sec]	Cooling time t_{Ak} total [min]
PEHD	16	6	250 ÷ 270	4	6	2
	20	6		4	6	2
	25	10		4	10	2
	32	10		6	10	4
	40	20		6	20	4
	50	20		6	20	4
	63	30		8	30	6
	75	30		8	30	6
	90	40		8	40	6
	110	50		10	50	8

Processing guidelines
Heating element socket welding

Preparation of welding place

Assemble welding equipment (prepare tools and machinery), control welding devices, setuo tent or similar

Preparation of welding seam

(at any rate immediately before starting the welding process)

Cut off pipe faces at right angles and remove flashes on the inside with a knife.
The pipe-ends should be chamfered following to DVS® 2207; part 1 and the below table.
Work the pipe faces with a scraper until the blades of the scraper flush with the pipe face.
Thoroughly clean welding area of pipe and fittings with fluffless paper and cleansing agents (acetone or similar).
If peeling is not necessary, work the pipe surface with a scraper knife and mark the depth (t) on pipe.

Pipe diameter d [mm]	Pipe chamfer for PEHD b [mm]	Insert length for PEHD t [mm]
16	2	13
20	2	14
25	2	15
32	2	17
40	2	18
50	2	20
63	3	26
75	3	29
90	3	32
110	3	35

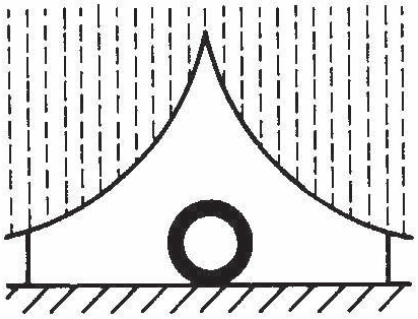
Preparations before welding

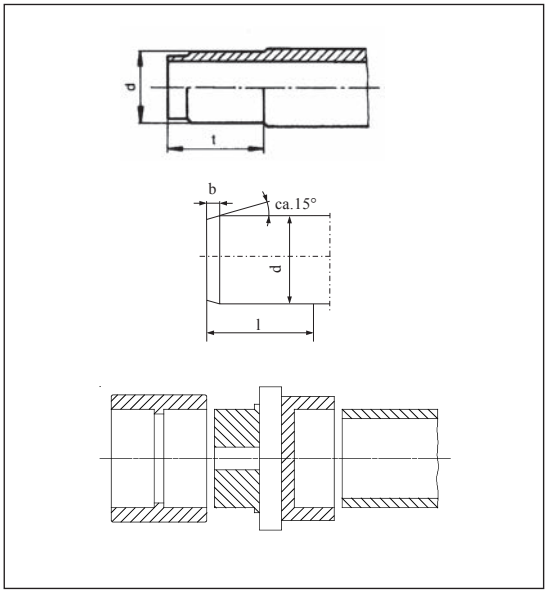
Check temperature of heating element (on heating spigot and on heating socket).
Thoroughly clean heating spigot and heating socket immediately before each welding process (with fluffless paper). At any rate, be careful that possibly clogging melt residues are removed.

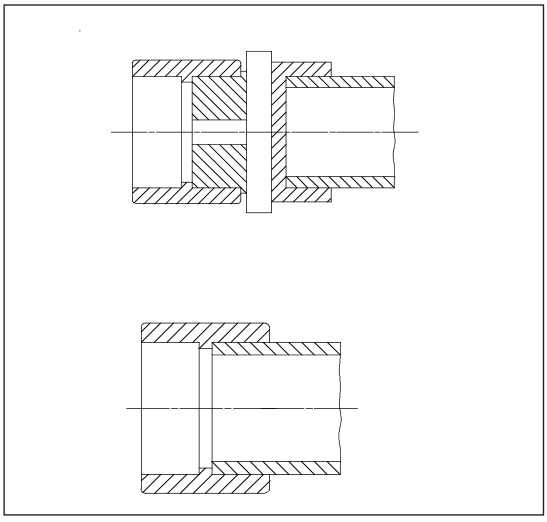
Performing of welding process

Quickly push fitting and pipe in axial direction onto the heating spigot or into the heating socket until the end stop (or marking). Let pass by pre-heating time according to table values.
After the pre-heating time, pull fitting and pipe off the heating element with one heave and immediately fit them into each other without twisting them until both welding beads meet.
Let the joint cool down, then remove clamps.
Only after the cooling time, the joint may be stressed by further installation processes.

On manual welding:
Adjust the parts and hold them fast under pressure for at least one minute (see table: page 15:fixed cooling time)







Processing guidelines
Heating element socket welding

Visual welding seam control

Check out bead of welding seam. It must be visible along the whole circumference of the pipes.

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 see table).
During the pressure test he piping system has to be protected against changes of the ambient temperature (UV-radiation).
For the pressure test we recommend water as test medium.

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

Devices for heating element socket welding are used in workshops as well as on sites. As single purpose machines, they should be designed for a maximum degree of mechanization of the welding process.

Clamping devices

Marks on workpiece surfaces caused by special clamping devices for pipe components must not affect the mechanical properties of the finished connection.

Guide elements

Together with clamping devices and heating element, the guide elements have to ensure that the joining parts are guided centrically to the heating element and to each other. If necessary, an adjusting mechanism has to be provided.

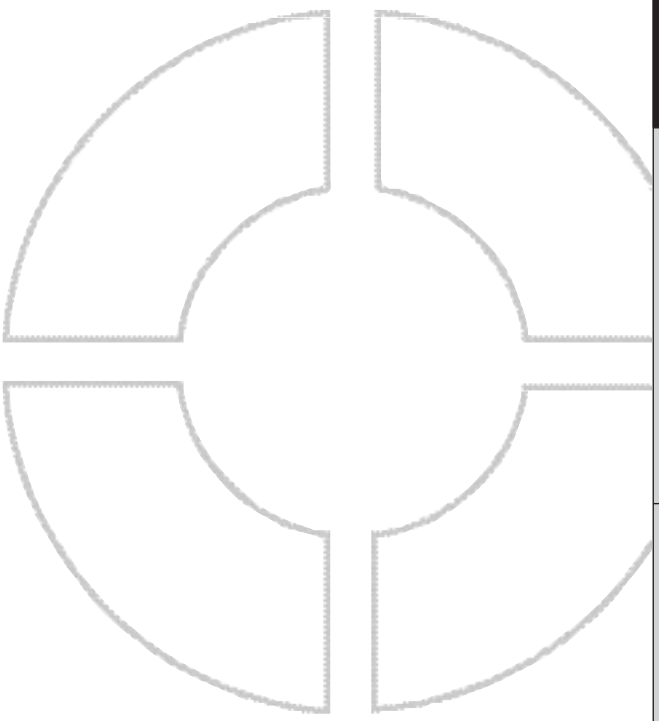
Machine design and safety in use

In addition to meet the above requirements in construction and design, the following points should be considered for the machine design:

- Stable construction
- Universal basic construction (swivelling or retractable auxiliary tools and clamps)
- Quick clamping device
- Maximum degree of mechanization (reproducable welding process)

Pressure test according to DVS® 2210 part 1:

Object		Pre-test	Main-test	Short-test
Test pressure		1,5 x PN max. PN + 5 bar	1,3 x PN max. PN + 3 bar	1,5 x PN max. PN + 5 bar
Test period	piping systems without branches compl. L ≤ 100m	minimum 3 h	minimum 3 h	minimum 1 h
	piping systems without branches compl. L ≥ 100m	minimum 6 h	minimum 6 h	minimum 3 h
Control during test procedure		each 1 h **with** restore of test-pressure	each 1,5 h **without** restore of test-pressure	each 1 h **without** restore of test-pressure
Material specific pressure drop (average value)		up to 0,8 bar/h	up to 0,8 bar/h	up to 0,8 bar/h
Note for the respective test		Standard		special case (agreement with client required)



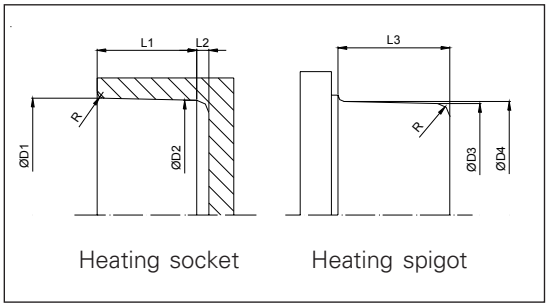
Heating element socket welding

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

Heating elements

The values contained in the table (correspond to the draft of ISO TC 138 GAH 2/4, document 172 E) apply to the dimensions of the heating tools.

Dimensions of heating elements for heating element socket welding fittings
Type B (with mechanical pipe working):



Heating socket Heating spigot

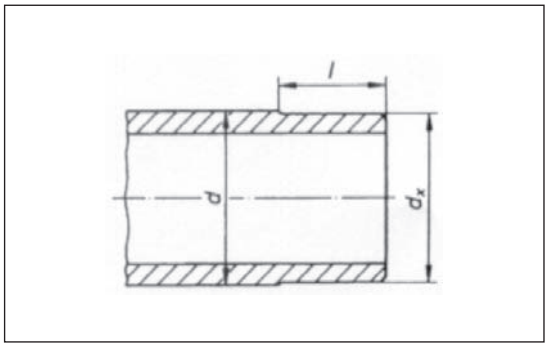
Pipe diameter [mm]	ØD1 [mm]	ØD2 [mm]	ØD3 [mm]	ØD4 [mm]	L1 [mm]	L2 [mm]	L3 [mm]	R [mm]
16	15,9	15,76	15,37	15,5	14	4	13	2,5
20	19,85	19,7	19,31	19,45	15	4	14	2,5
25	24,85	24,68	24,24	24,4	17	4	16	2,5
32	31,85	31,65	31,17	31,35	19,5	5	18	3,0
40	39,8	39,58	39,1	39,3	21,5	5	20	3,0
50	49,8	49,55	49,07	49,3	24,5	5	23	3,0
63	62,75	62,46	61,93	62,2	29	6	27	4,0
75	74,75	74,42	73,84	74,15	33	6	31	4,0
90	89,75	89,38	88,75	89,1	37	6	35	4,0
110	109,7	109,27	108,59	109	43	6	41	4,0
125	124,7	124,22	123,49	123,95	48	6	46	4,0

[1)]Dimensions are valid at 260 ÷ 270°C

Tolerances:
÷ 40mm ± 0,04mm
> 50mm ± 0,06mm

Tools for welding seam preparation

At heating element socket welding with mechanical pipe working (method type B), a scraper is required for calibrating and chamferring the joining surfaces of the pipe. The srcaper has to be adjusted to the heating element and to the fitting socket. It is adjusted with a plug gauge.



Pipe end prepared for the socket welding (dimensions see table)

Calibration diameter and length for the machining of pipe ends with method type B

Pipe outside diameter [mm]	Calibration diameter d_x [mm]	Calibration length l [mm]
20	19,9 ± 0,05	14
25	24,9 ± 0,05	16
32	31,9 ± 0,05	18
40	39,85 ± 0,10	20
50	49,85 ± 0,10	23
63	62,8 ± 0,15	27
75	74,8 ± 0,15	31
90	89,8 ± 0,15	35
110	109,75 ± 0,20	41
125	124,75 ± 0,20	44

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 electrofusion socket which effects in a smooth surface. A transformer for welding purposes supplies electric power.

The shrinking stress of the electro fusion fitting create the necessary welding pressure which guarantees 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 a universal welding machine should be used.
This welding device is a machine with bar code identification, it supervises all functions full automatically 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
- BEAT II

**with traceability acc. ISO 12176-4

General welding suitability

Only components made of the same material may be joined with one another. The MFR-value of the E-fittings 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 an MFR-value between 0,3 and 1,7 g/10min.

The weldable SDR-series 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 permissible temperature range for PE is from -10°C up to +50°C. The national guidelines must also be considered.

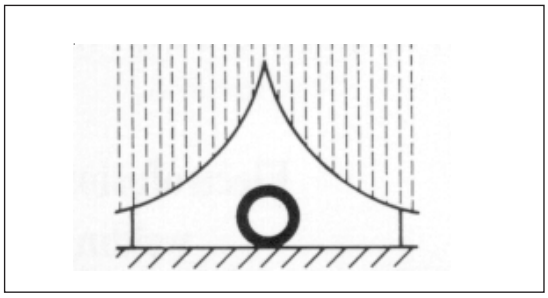
Welding parameters

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

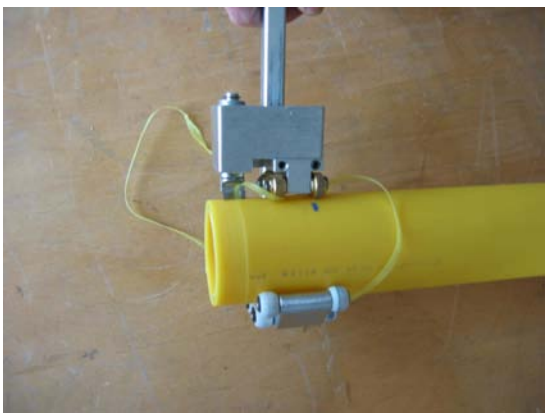
OD		SDR 17,6	SDR 17	SDR 13,6	SDR 11	SDR 9	SDR 7,4
20	max. Ovality 1,5%	no	no	no	yes	yes	yes
25		no	no	no	yes	yes	yes
32		no	no	no	yes	yes	yes
40		yes	yes	yes	yes	yes	yes
50		yes	yes	yes	yes	yes	yes
63		yes	yes	yes	yes	yes	yes
75		yes	yes	yes	yes	yes	yes
90		yes	yes	yes	yes	yes	yes
110		yes	yes	yes	yes	yes	yes
125		yes	yes	yes	yes	yes	yes
140		yes	yes	yes	yes	yes	yes
160		yes	yes	yes	yes	yes	yes
180		yes	yes	yes	yes	yes	yes
200		yes	yes	yes	yes	yes	yes
225		yes	yes	yes	yes	yes	yes
250		yes	yes	yes	yes	yes	yes
280		yes	yes	yes	yes	yes	yes
315		yes	yes	yes	yes	yes	yes

Electrofusion welding

Preparation of welding place



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



Preparations before welding

Processing guidelines

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

Install welding tent or similar device.

See environmental conditions and the environmental temperature (see page 19)

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 machine pipe carefully by means of a peeling tool or scraper knife in axial direction (cutting 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 scraped as the pipe.

Unpack the E- fitting immediately before welding.

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

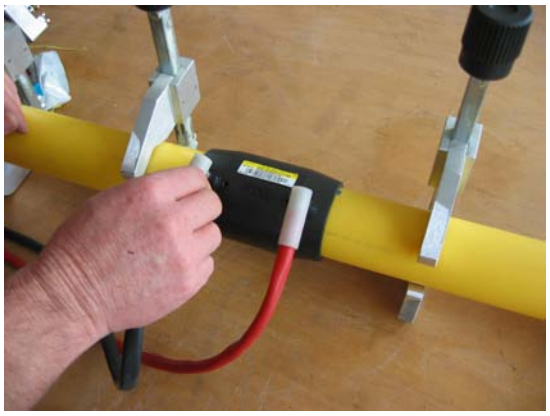
If a pollution cannot be excepted, clean the welding areas with a suitable PE-cleaner (or similar) and with fluffless paper.

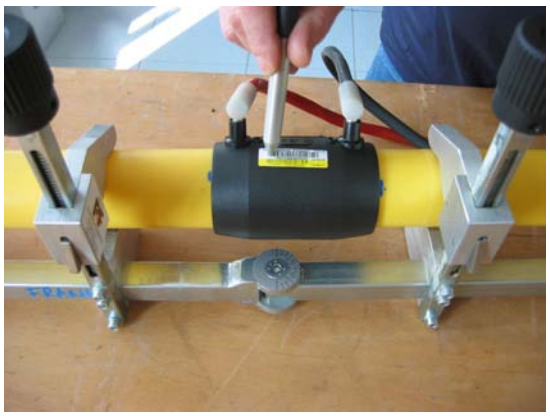
The faces to be welded have to be dry before the socket is put over the pipe. At any rate, remove residues of cleansing agents or condensation water with fluffless, absorbent paper.
Slide the socket into the prepared end of pipe right to its center stop until it reaches the marking.

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 are 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 have to be acknowledged. Then, for control purposes, you will be asked whether the pipe has been worked.

Welding without clamping device:
It is possible to weld AGRU electro fusion fittings without using a clamping device.
The working instructions must correspond to DVS® 2207 part 1 and to the AGRU welding requirements. Keep in mind that the installation situation must be stress free. Is it not possible a clamping device must be used.

Electrofusion welding

Performing the welding process

Visual control and documentation

Processing guidelines

Optional a traceability barcode is marked directly on the fitting. This barcode guarantees for an automatic electronical documentation of the component traceability. The use of the traceability code is not forcing. That means, if you don´t need the code nothing chances at your working process. So you can still 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 possible to reweld the socket after cooling down to ambient temperature (<35°C).

Minimum cooling time:

da 20 mm	-	63 mm	6 min
da 75 mm	-	125 mm	10 min
da 140 mm			15 min
da 160 mm	-	180 mm	20 min
da 200 mm	-	280 mm	30 min
da 315 mm	-	400 mm	45 min
da 450 mm	-	560 mm	60 min.

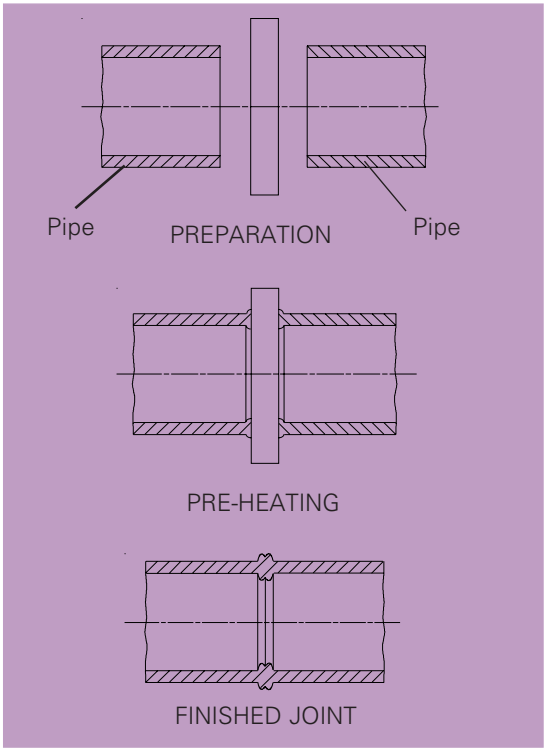
Visual weld control is performed by the welding indicator on the socket. Moreover, all welding parameters are stored internally by the device and can be printed to receive a welding protocol.

Heating element butt welding

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

Welding method description

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 welds 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 is done 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 not be used before 10 minutes after reaching the rated temperature.

For optimal welds 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 e.g. to 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 slight longitudinal movement of the parts to be welded is to ensure for example through adjustable dollies or swinging hangings.

The areas to be welded should be cleaned immediately before the welding process with a clean, fat-free oil, so that they are plane parallel in this clamped position. Permissible gap width under adapting pressure see following table:

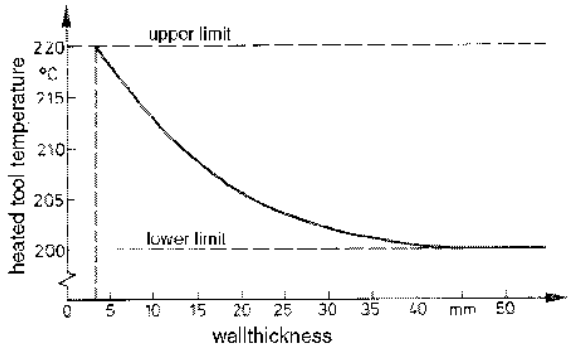
Pipe outside diameter [mm]	Gap width [mm]
≤ 355	0,5
400 ... < 630	1,0
630 ... < 800	1,3
800 ... ≤ 1000	1,5
>1000	2,0

Together with the control of the gap width also the misalignment should be checked. The misalignment of the joining areas to one another should not cross the permissile 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 fallen in to the pipe should be removed.

Heating element butt welding

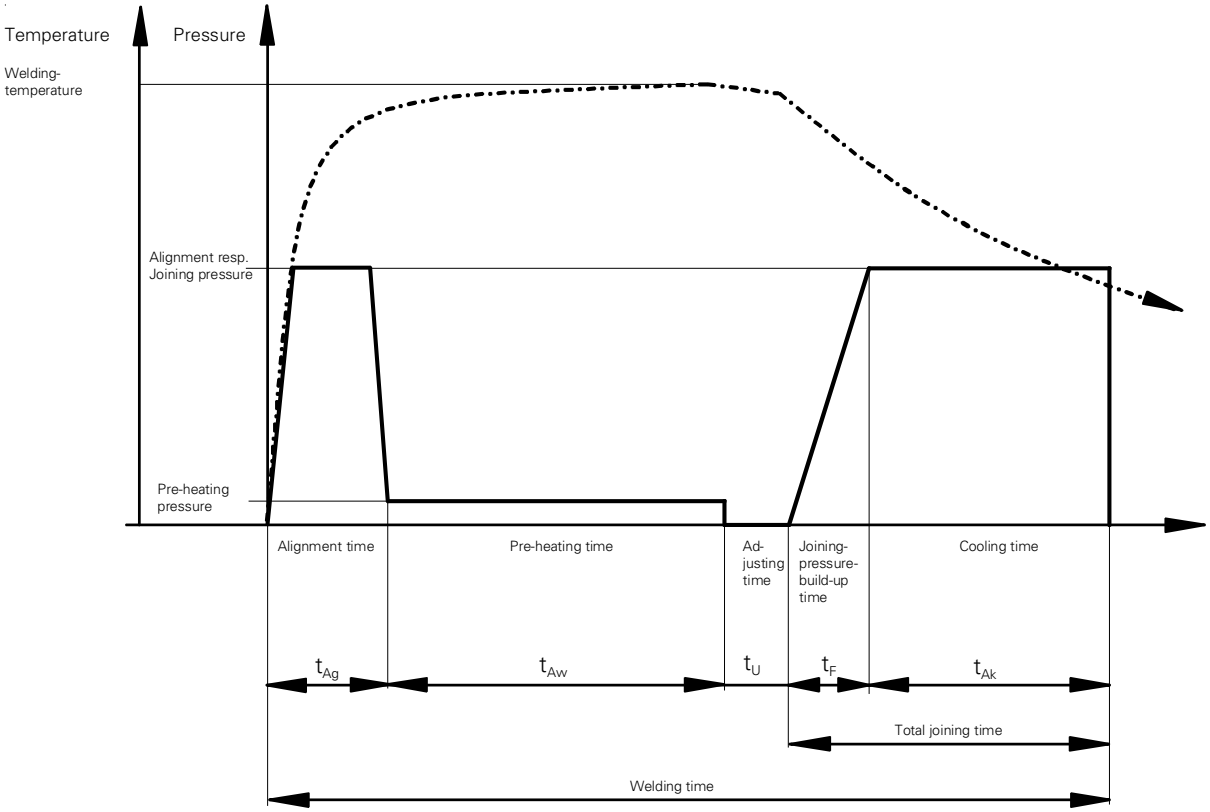
Performing of the welding process

On heating element butt welding the areas to be joined are heated up to the requested welding temperature with heating elements and after the removal of the heating element they are joined 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 (see chart).



	PE
Heating element temperature [°C]	200 up to 220

The gradually sequences of the welding process



Heating element butt welding

Welding parameters

Reference values for heating element butt welding of PE 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	 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:

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

oder

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

Calculation of the welding force:

$$F = p_{spez} \cdot A_{Rohr}$$

P_{spez} = 0,15N/mm² (PE 100)

Heating element butt welding

Alignment

The 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 effects during the whole alignment process.

	PE
Specific heating pressure [N/mm²]	0,15 N/mm²

Pre-Heating

During the pre-heating process the areas must abut onto the heating element with low pressure. For that purpose the pressure is reduced to nearly zero (<0,01 N/mm²). On pre-heating the warmth infiltrate in the parts to be welded and heat up to the welding temperature.

Adjustment

After the pre-heating the adjusting surfaces should be removed from the heating element. The heating element should be taken away from the adjusting surfaces without damage and pollution. After that the adjusting surfaces must be joined together very quickly until immediately prior to contact. The adjusting time should be kept 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

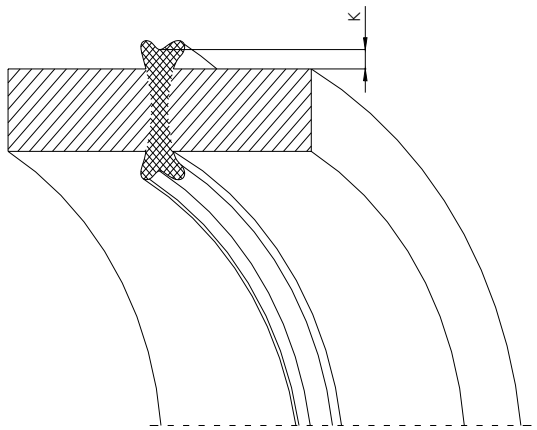
Before the pressure testing, all welding joints have to be completely cooled down (as a rule, 1 hour after the last welding process). The pressure test has to be performed according to the relevant standard regulations (e. g. DVS® 2210 Part 1 - see table pressure test).
During the pressure test the piping system has to be protected against changes of the ambient temperature (UV-radiation).
For the pressure test we recommend water as test medium.

Joining

The areas to be welded should coincide by contact with a speed 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 especially by parts with a thick wall during the clamp removal and storage. Assembly or mechanical treatment is allowed only 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 assumed from the welding tendency, even when this can lead to unsymetrical welding beads. K must be higher than 0.



Pressure test according to DVS® 2210 part 1:

Object		Pre-test	Main-test	Short-test
Test pressure		1,5 x PN max. PN + 5 bar	1,3 x PN max. PN + 3 bar	1,5 x PN max. PN + 5 bar
Test period	piping systems without branches compl. L ≤ 100m	minimum 3 h	minimum 3 h	minimum 1 h
	piping systems without branches compl. L ≥ 100m	minimum 6 h	minimum 6 h	minimum 3 h
Control during test procedure		each 1 h **with** restore of test-pressure	each 1,5 h **without** restore of test-pressure	each 1 h **without** restore of test-pressure
Material specific pressure drop (average value)		up to 0,8 bar/h	up to 0,8 bar/h	up to 0,8 bar/h
Note for the respective test		Standard		special case (agreement with client required)

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 as well as deformations, the clamping devices should surround at least the pipe casing as parallel as possible to the welding zone. 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 recommended 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 28).

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 fixed heating element, adequate devices have to be provided for its insertion (e.g. handles, hocks, links).

If the size and condition of the heating elements required 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 which allows the machining of the joining surfaces of the clamped pipe in a plane-parallel way. Maximum permissible deviations from plane-parallelity at the joining surfaces are:

Pipe outside Ø OD [mm]	Deviation [mm]
< 400	≤ 0,5
≥ 400	≤ 1,0

The surfaces may be worked with devices which are mounted 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 be designed 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 light-weight construction.
Adequate devices for transportation and introduction into the trench have to be available (e. g. handles, links).
Especially if voltages above 42 V are applied, the relevant safety regulations of VDE have to be observed in the construction and use of the machines.

Detachable joints

Flange or Unions connections of piping systems
If pipe joints are connected by means of flanges or unions 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 gasket. The drawing near of the flange connection with the resulting occurrence of tensile stress has to be avoided under any circumstances.

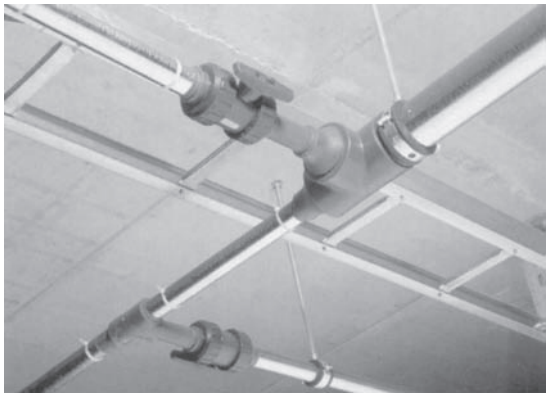
Tightening of screws
The length of the screws has to be chosen in such a way that the screw thread flushes with the nut. Washers have to be placed at the screw head and also at the nut.
The connecting screws have to be screwed by means of a torque key (torque values see supply program).

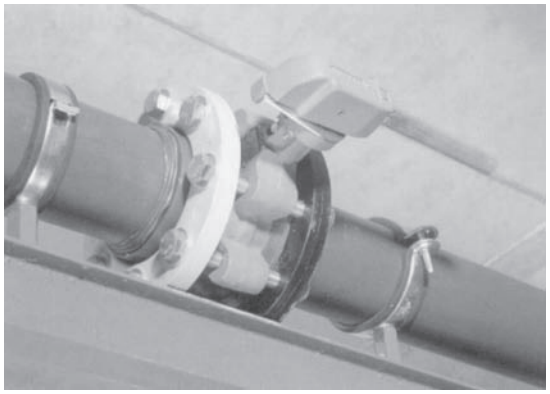
Unions of piping systems
To avoid of inadmissible loads at the installation, unions with round gasket rings should be applied.

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

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

Generally
It is recommend to brush over the thread, e. g. with molybdenum sulphide, so that the thread stays lubricated for a longer operation time.
On choosing the sealing material, special attention has to be paid to chemical and thermal suitability.

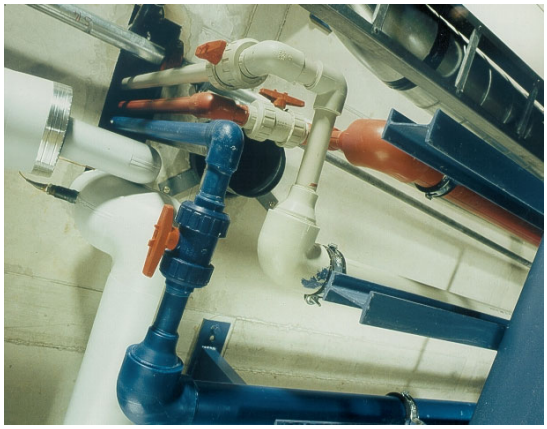




Reference projects

BMW engine factory in Steyr, Austria

The complete supply of compressed air in the largest engine factory of the BMW group has been done with AGRUAIR PE 100 blue pipes and fittings.
The delivered pipes and fittings from OD 20 up to OD 110 are tested and approved.
The complete piping system for the compressed air is designed for maximum operating pressure of 8 bar and a life time of > 50 years.
All pipes and fittings are welded together through heating element socket welding and electro fusion welding which results in a material conform and tight piping system.



Limestone factory Sermuth

Material:	PE 100 blue
Classification:	MRS 10 acc.ISO 9080
Dimension:	Ø 63 x 8,6 mm
	Ø 110 x 15,1 mm
Operating pressure:	up to 16 bar
Length:	500 m

The pipeline for compressed air of the different working stations has been done with AGRUAIR PE 100 blue pipes and fittings.
The delivered pipes and fittings from OD 63 up to OD 110 - SDR 7,4 are approved and tested.
The piping system for compressed air is designed for a maxiumum operating pressure up to 16 bar and life time of more than 50 years.
All pipes and fittings are welded together through heating element socket welding and electro fusion welding which results in a material conform and tight piping system.

Reference projects

BMW Leipzig, Germany

The complete underground pressure piping system for compressed air supply and also drinking water supply in the BMW factory has been done with AGRUAIR PE 100 blue pipes and fittings.

Following dimensions are installed for compressed air and drinking water supply.

Compressed air:	Ø 63 - Ø 180 mm - SDR 7,4
Water:	Ø 40 - Ø 315 mm - SDR 11
Total length:	8.400 m

All pipes and fittings are welded together through heating element butt welding, heating element socket welding and electro fusion welding which results in a material conform and tight piping system.

Referencelist

Austria:

Praher - Schwertberg
Landeskrankenhaus Steyr
Landeskrankenhaus Voecklabruck

Maldives:

Shangri-La - Male

USA:

Boeing - Seattle
Union Railways

Germany:

Dr. Oetker - Wittlich
Wacker Siltronic - Burghausen
ABB - Freidberg
VW - Wolfsburg
VW - Emden

3rd party control

In addition to internal controls, regular tests on products and of internal procedures, performed by independently 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 the following institutes are commissioned for the production:

Versuchsanstalt fuer Kunststoff- und Umwelttechnik am TGM - Vienna

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

AGRUAIR products are approved for the compressed air supply and also for the water supply according to ON B 5172 and ON EN 12201.

AGRU has also different approvals and registrations in USA and Canada.

Please contact our sales or technical departement regarding approvals.

Standards

AGRU pipes and fittings are manufactured out of standardized moulding materials and produced according relevant international standards.

Below please find a summary of the most important standards for PE.

OENORM B 5014, part 1
organoleptic and chemcial requirements and testing of materials in drinking water area

OENORM B 5172
Pipes out of high density polyethylene (PE-HD) for water supply

DIN 8074/8075
Pipes out of Polyethylene (PE)

DIN 16963, part 1 - part 15
Pipe joints and their elements for pipes of high density polyethylene (HDPE) under pressure

EN 12201, part 1 - part 5
Plastics piping systems for water supply - Polyethylene (PE)

ISO 1872
Plastic - Polyethylene (PE) - Material

ISO 4065
Thermoplastic pipes - Universal wall thickness table

ISO 4427
Polyethylene (PE) pipes for water supply - Specifications

BS 6920
Plastic pipes and fittings - Buried polyethylene (PE) pipes for the supply of gaseous fuels - Metric series - Specifications