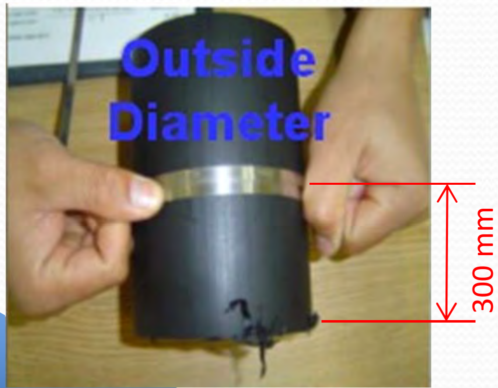
WIIK

Polyethylene Pipes Quality check

Visual check Pipe Quality

- Appearance → The internal and external surfaces of pipes shall be smooth and clean and shall have no scoring, cavities and other surface defects to an extent that would prevent conformity to pipe standard.
- Good smell → No disgust smell from recycle material.
- Dimensions and Tolerances should conform to relevant standard.
  - OD → pi-tape measured at 300 mm from pipe edge.
  - Pipe wall thickness → Vernier Caliper
  - Pipe length → Measuring tape
  - Pipe Ovality → Measuring tape/ Venier Caliper

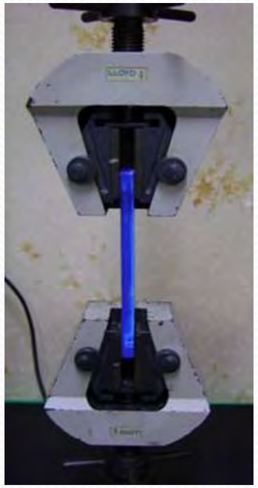


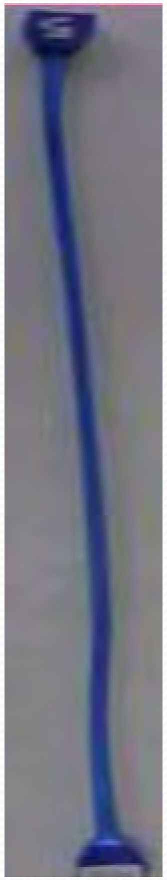
Laboratory check HDPE pipe

Item	Test parameter	Test method	Criteria
1.	Melt flow rate (190 deg C, 5 kg load)	ISO 1133	PE 80 (0.4-0.7 g/10 minutes) PE 100 (0.2-0.4 g/10 minutes)
2.	Oxidation induction time at 210 deg C	ISO 11357-6	≥ 35 minutes
3.	Carbon black content	ISO 6964	2.0%-2.5%
4.	Carbon black dispersion	ISO 18553	Grade ≤ 3
5.	Elongation at break	ISO 6259	≥ 350%
6.	Hydrostatic strength at 80 deg C	ISO 1167	≥ 165 hrs

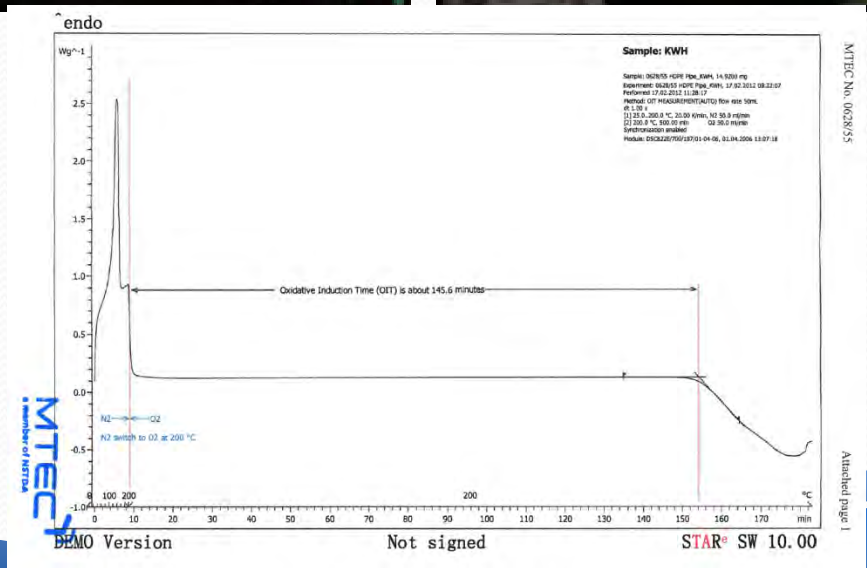
Melt flow rate tester

Tensile tester





Oxidation Induction time tester



Hydrostatic strength test

3^{rd} party laboratory

- 3^{rd} party laboratory in Thailand
  - DSS – Department of Science and Services

- 3^{rd} party laboratory in Singapore
  - TUV SUD

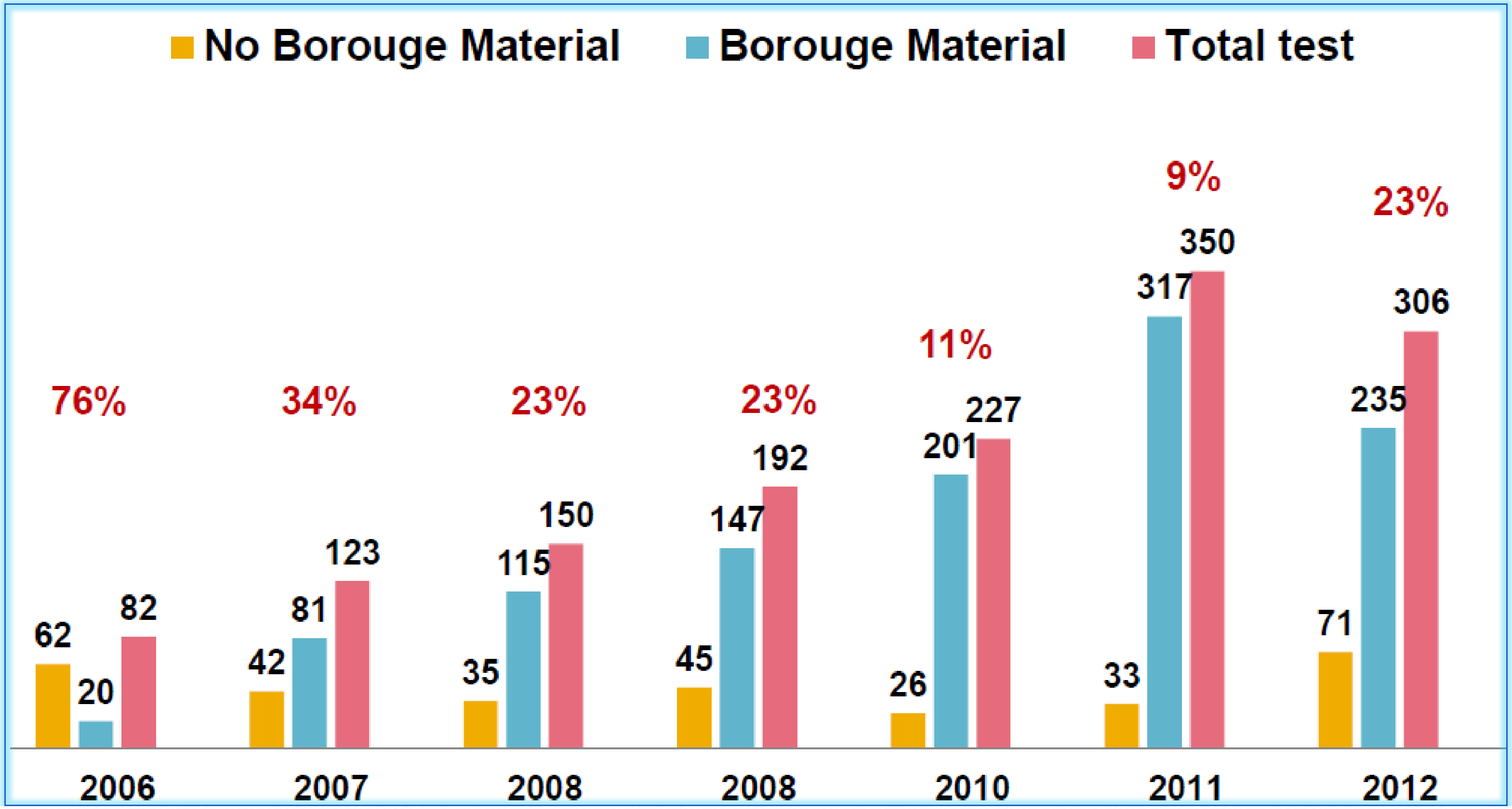
Quality check of China PE100 pipe

- High quality PE100 pipe resin producers offer a service of checking the **'finger print'** of material used to manufacture pipes and fittings.

- Involves laboratory measurement of key resin parameters and comparison against standard values for that company's material. Parameters include:
  - Melt flow rate and density
  - **Additive content by XRF (x-ray florescence)**
    Levels of zinc, calcium stearate (acid skavenger), IRGAFO 168 processing stabalizer and HALs anti-oxidant
  - Carbon black content and dispersion
  - Oxidation induction time

- The service is frequently offered free of charge but this would depend on the number of samples and how often they are submitted. It has been employed by Borouge in China with some success.

Material identification statistics in China (2006- Aug. 2012)



Source : Borouge

WIIK

Butt fusion welding

Butt fusion joint – a leak free

PLASTICS·PIPE·INSTITUTE

SEARCH

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1. Heat Fused Joints -- Benefits

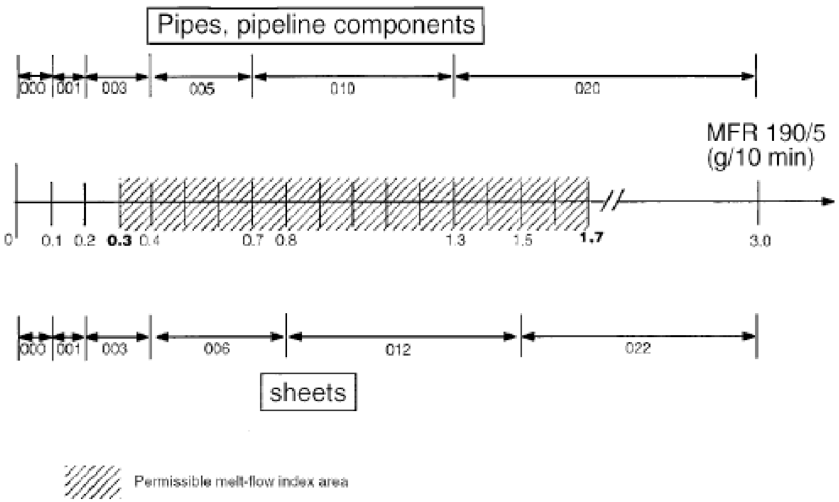
- HDPE pipe can be heat fused together to form a joint that is as strong or stronger than the pipe itself and is leak free.
  - This eliminates the potential leak points every 10-20 feet as found with PVC and Ductile Iron bell and spigot connections.
- The Life Cycle Cost of HDPE pipe differs from other pipe materials because the "allowable water leakage" is zero rather than typical leakage rates of 10 to 20% for PVC and Ductile Iron.
- HDPE pipe fused joints are self restraining and costly thrust restraints or thrust blocks are not required.
- HDPE pipe's fused joints simply do not leak, eliminating infiltration and exfiltration problems experienced with alternate pipe joints.

Welding cycle

- DVS 2207-1 Welding of Thermoplastics Heated tool welding of pipes, pipeline components and sheets made from PE-HD.

DVS – DEUTSCHER VERBAND FÜR SCHWEISSEN UND VERWANDTE VERFAHREN E.V.	**Welding of Thermoplastics** **Heated tool welding of pipes, pipeline components and sheets made from PE-HD**	**Direction DVS 2207-1** **(August 1995)** **DVS**

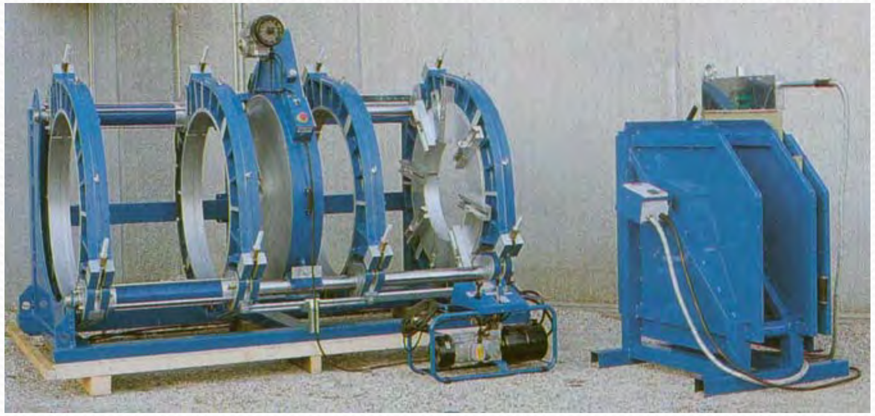
Content:



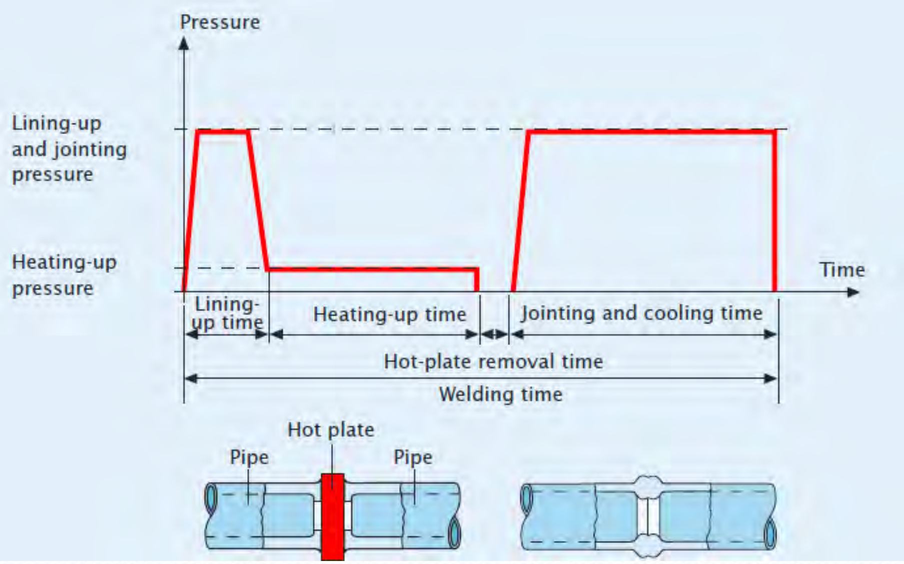
Component of butt fusion machine

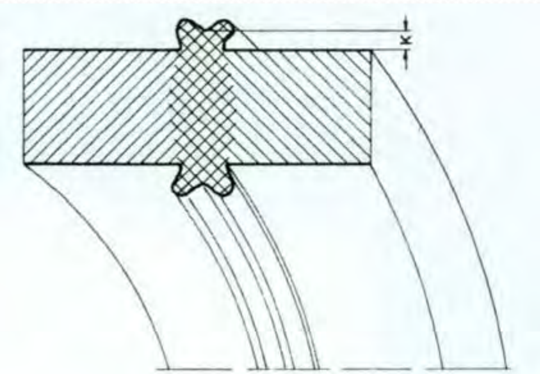
Model of butt fusion machine

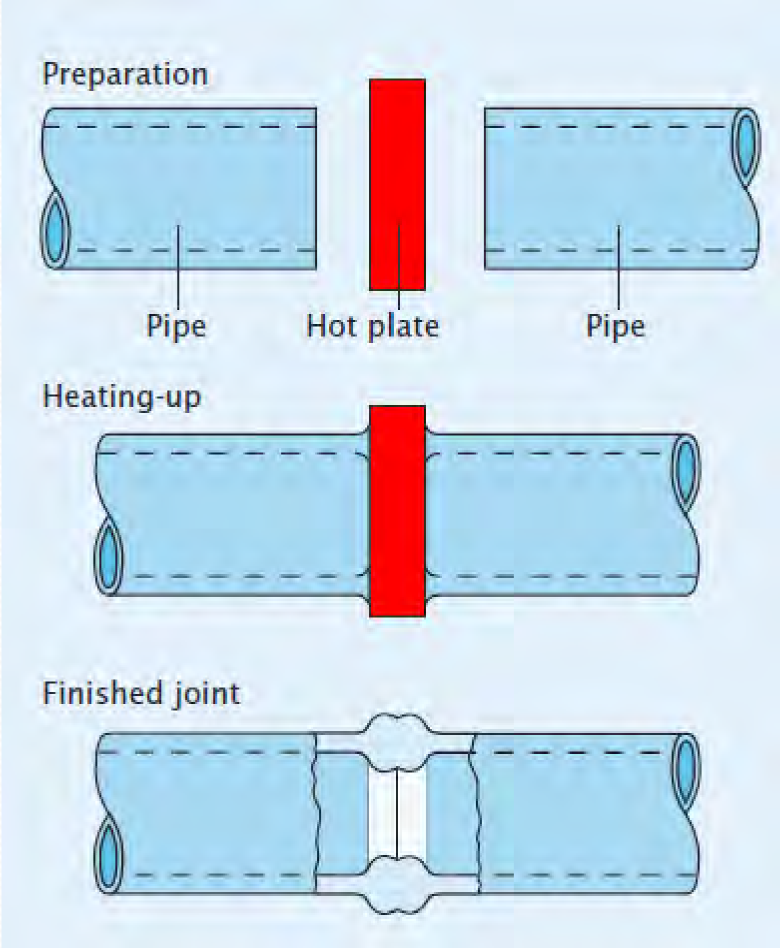
- PT 160
- PT 315
- PT 500
- PT 630
- PT 800
- PT 1000
- PT 1600



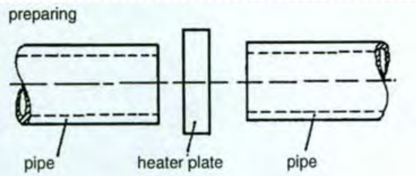
Welding cycle

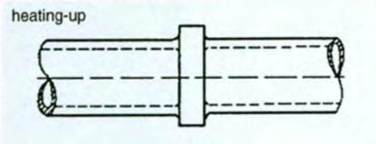


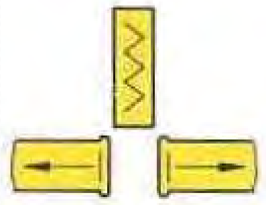


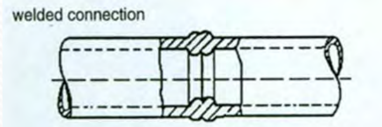


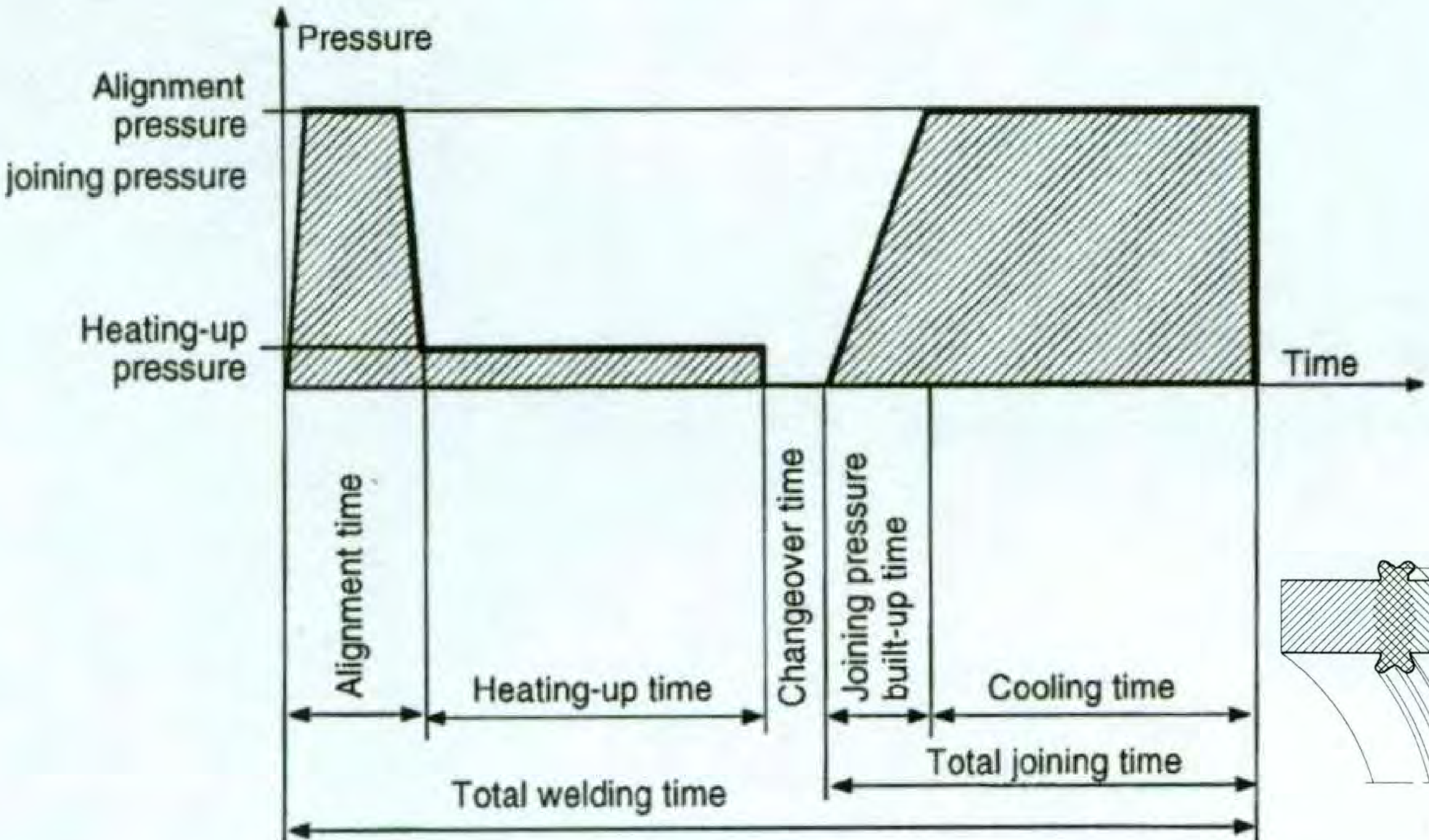
Welding cycle

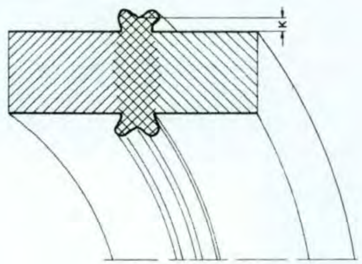








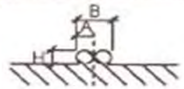




Butt fusion registration log sheet

PROJECT: PIPE: de = mm (ND) WELDING CONFIGURATION:

PN = ________



Weld no	Nom. Wall-thick.	Pipe length	Welding mirror temp.	Heating up pressure	Heating up time (to A)	Bead width A	Heating through time	Max. change over time	Max. press. raising time	Welding pressure	Min. welding time	Min. cooling time	Bead width (final) B	Welding accepted	
Welding Process No.			1	2	3	4	6	7	8	9	10	12	13	YES	NO
—	mm	m	°C	N / mm2	sec	mm	sec	sec	sec	N / mm2	minutes	minutes	mm		
	e =	L =													
Requirements = Tolerances =			210 ± 10	0,18 ± 0,01	—	Tab. 1	Tab. 1	Tab. 1	Tab. 1	0,18 ± 0,01	Tab. 1	Tab. 1	Tab. 1		

Butt Fusion Registration Log Sheet

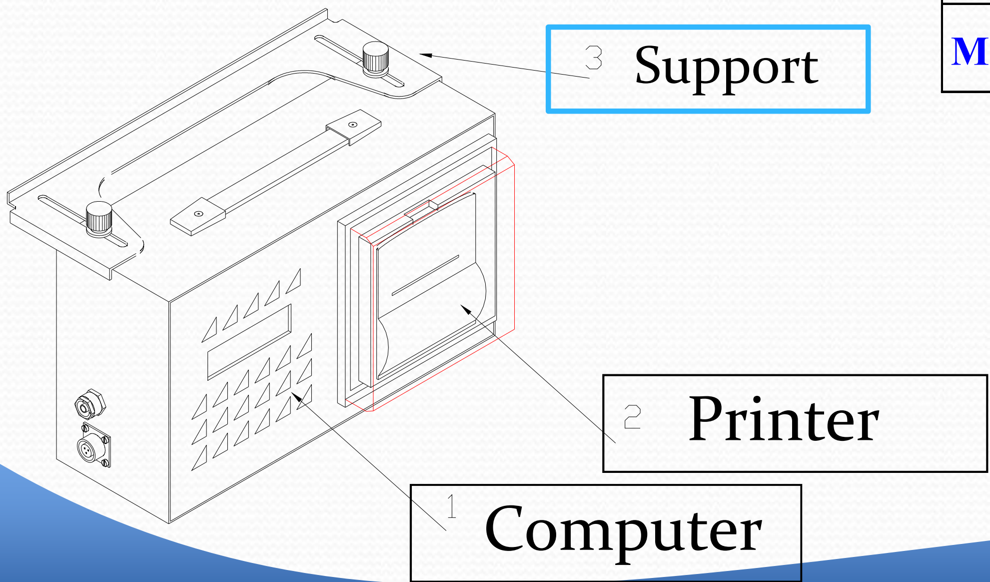
LDU Datalogger - printing data m/c

- The printing data machine has been designed and constructed for the measurement of the butt-welding parameters of PE 80,PE 100 and PP pipes and fittings.
- Showing on the display and advising by acoustic signal the pressure and time to be achieved during all the cycle welding phases.
- Once the operator has set up all the pipe's parameters, controls the heating mirror temperature. The possibility to print in advance all the welding parameters helps the operator avoiding the use of the welding tables.
- At the end of the welding the printing of a final report of the welding cycle will allow the operator to check if the welding cycle has been done correctly.
- The LDU can:
  - Survey the heating mirror temperature
  - Survey step by step the welding cycle
  - Calculate the welding parameters accordingly with a welding norm (pressure, times and temperatures)
  - Print the final report of the welding cycle
  - Store 400-1000 records concerning 400-1000 different welding cycles
  - Access to welding cycle database
  - Upload the welding cycle database to a pc or pen drive (usb flash drive)
  - Recognize the operator by an I-button probe

LDU Datalogger- printing data m/c

Electrical Data

Volatage	230 V
Frequency	50 Hz
Power	20 W IP44
Weight	5 Kg
Size	350 - 215 – 150 mm
Max. Pressure	0 -160 bar



Sample of site quality control

WIIK & HOEGLUND

LDU V2.0 - 7990
MACHINE MODEL PT500

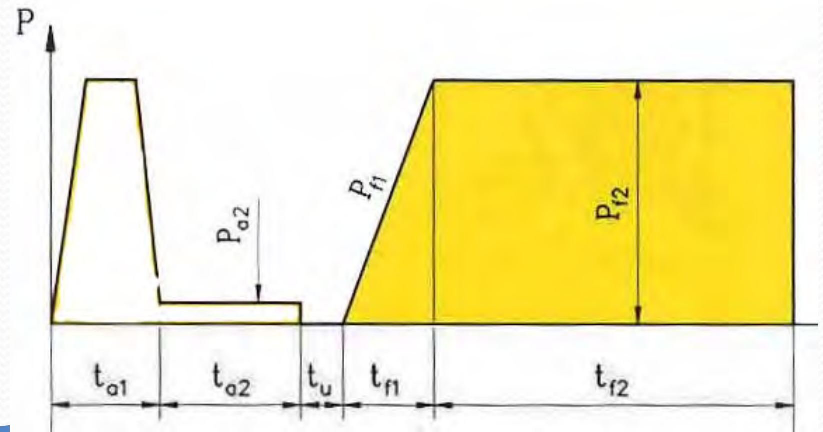
Serial Number	:	1	
Welding Date	:	8/ 8/ 1	
Welding Time	:	9: 8	
Project Name	:	CH 2250	
Operator Number	:	1	
Site Location	:	2	
Batch Order Number	:	3	
Material	:	PEHD	
Welding Standard	:	KWH Thailand	
Trust Factor (MPa)	:	.18	
Cylinders Section (cm2)	:	29.00	
Pipe Diameter (mm)	:	315.0	
Wall Thickness (mm)	:	15.0	
WELDING DATA		CAL.	MEAS.
Welding Number	:		14
Ambient Temperature (C)	:		29
Inertial Pressure(bar)	:		5.8
Welding Bead Time (sec)	:		24
Welding Bead Pres.(bar)	:	8.7	13.0
Heating Time (sec)	:	225	9 *
Heating Pressure (bar)	:	.4	.9
Heating Temperature (C)	:	210	209
Change Over Time (sec)	:	6	9 *
Ramp Time (sec)	:	12	2
Cooling Time (sec)	:	1575	21 *
Cooling Pressure (bar)	:	8.7	13.8

ATTENTION !!!
VERIFY THE PARAMETER *

ERROR NUMBER : 8

WELDING CYCLE NO CORRECTLY

Welder Identification



Parameters Control

Sample print out from LDU

LDU V2.0 - 625
MACHINE MODEL PT1600

Serial Number		72	
Welding Date		12/ 8/ 0	
Welding Time		11:13	
Project Name		R.O.O.	
Operator Number		17	
Site Location		1	
Batch Order Number		4130	
Material		PEHD	
Welding Standard		KWH	
Trust Factor	(MPa)	.18	
Cylinders Section	(cm2)	69.08	
Pipe Diameter	(mm)	1600.0	
Wall Thickness	(mm)	61.2	
WELDING DATA		CAL.	MEAS.
Welding Number			1
Ambient Temperature	(C)		26
Inertial Pressure	(bar)		17.1
Welding Bead Time	(sec)		198
Welding Bead Pres.	(bar)	77.0	95.3
Heating Time	(sec)	918	918
Heating Pressure	(bar)	4.2	18.2
Heating Temperature	(C)	210	209
Change Over Time	(sec)	35	13
Ramp Time	(sec)	51	2
Cooling Time	(sec)	2436	2437
Cooling Pressure	(bar)	77.0	93.8

WELDING CYCLE CORRECTLY

WIIK & HOEGLUND

LDU V2.0 - 7990
MACHINE MODEL PT500

Serial Number		1	
Welding Date		8/ 8/ 1	
Welding Time		9: 8	
Project Name		CA 2258	
Operator Number		1	
Site Location		2	
Batch Order Number		3	
Material		PEHD	
Welding Standard		KWH Thailand	
Trust Factor	(MPa)	.18	
Cylinders Section	(cm2)	29.88	
Pipe Diameter	(mm)	315.0	
Wall Thickness	(mm)	15.0	
WELDING DATA		CAL.	MEAS.
Welding Number			14
Ambient Temperature	(C)		29
Inertial Pressure	(bar)		5.8
Welding Bead Time	(sec)		24
Welding Bead Pres.	(bar)	8.7	13.0
Heating Time	(sec)	225	9 *
Heating Pressure	(bar)	.4	.9
Heating Temperature	(C)	210	209
Change Over Time	(sec)	6	9 *
Ramp Time	(sec)	12	2
Cooling Time	(sec)	1575	21 *
Cooling Pressure	(bar)	8.7	13.8

ATTENTION !!!
VERIFY THE PARAMETER *

ERROR NUMBER : 8

WELDING CYCLE NO CORRECTLY

Sample of welder certificate

คณะกรรมการส่งเสริมการพัฒนาฝีมือแรงงาน
Board of skill Development of Thai Government

หนังสือรับรองฉบับนี้ให้ไว้เพื่อแสดงว่า
This letter is to show that

นายบุญเยี่ยม จันทร์ดี
Name Surname

ได้ผ่านการทดสอบมาตรฐานฝีมือแรงงานแห่งชาติ
Certified the test of national skill standards.

สาขาอาชีพ ช่างเชื่อมท่อพอลิเอทีลีนความหนาแน่นสูง ระดับ ๑
Welder of High Density Polyethylene(HDPE) Level 1

ทดสอบโดย สถาบันพัฒนาฝีมือแรงงาน ภาค ๑ สมุทรปราการ เมื่อวันที่ ๒๘ สิงหาคม ๒๕๕๐
By Institution of skill development region 1 Samut Prakan
Date : DD / MM / YYYY

ให้ไว้ ณ วันที่ ๑๖ กันยายน ๒๕๕๐

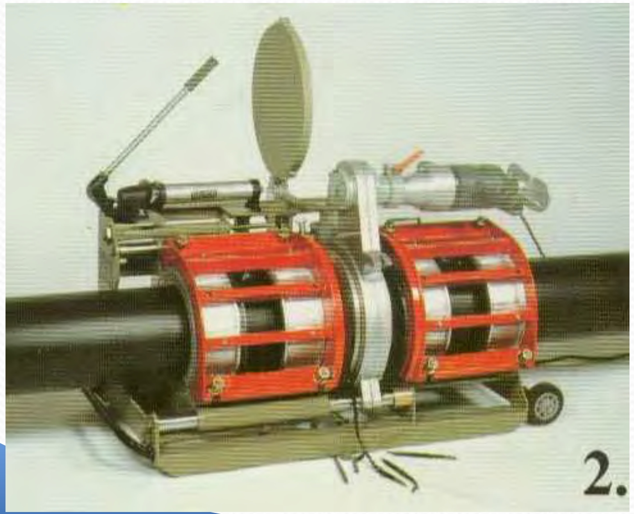
ผู้อำนวยการสถาบันพัฒนาฝีมือแรงงานภาค ๑ สมุทรปราการ
นายทะเบียน
Registrar

นักวิชาการฝึกอาชีพ 7ว รักษาราชการแทน
หัวหน้ากลุ่มงานพัฒนาฝีมือและศักยภาพแรงงาน
ผู้ดำเนินการทดสอบ
Tester

Welding procedure

Inserts are chosen for each pipe dimension. The bolts of the clamping shells are diagonally tightened to keep pipe in position. Max. 10% of pipe wall thickness misalignment has been allowed. Roller should be used to reduce drag force.

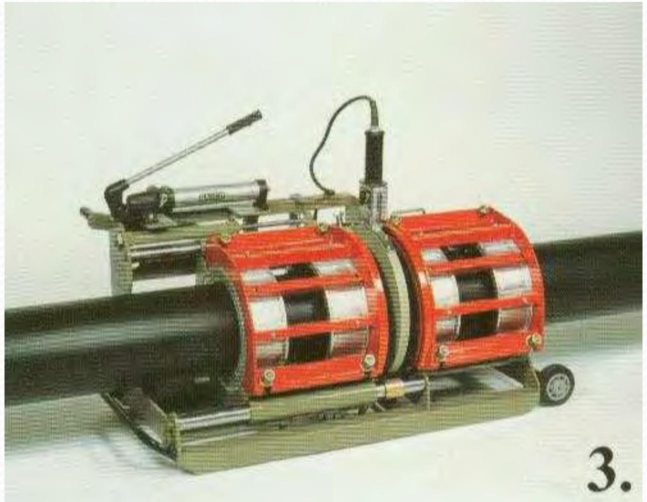
1.

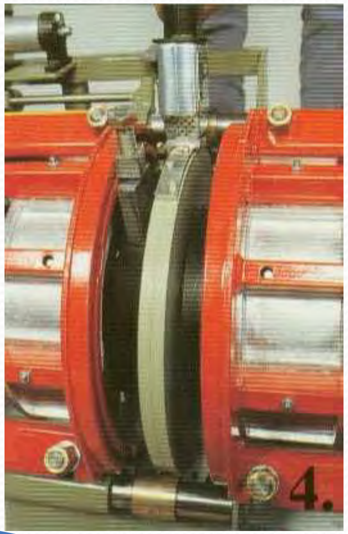


2.

The trimmer is inserted. The pipe ends are forced hydraulically against the cutter discs. To get an even trimming completion, the force is slowly decreased.

Welding procedure (cont'd)





The heater plate melts the pipe ends until a uniform bead depending on pipe diameter, is formed around the pipe.

The pressure applied for each machine is given in table, added with the "drag-force" pressure. When the bead is complete, the pressure is dropped to almost zero followed by a small pressure heat-soaking period.

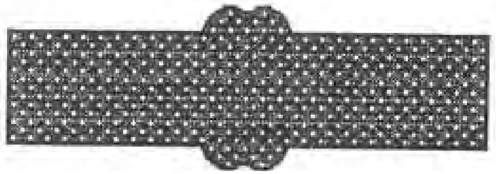
Welding procedure (cont'd)

The machine is opened and the heater plate carefully removes without touching the melted area. The pipe ends are joined carefully, but firmly. The welding pressure is to be applied within the pressure rising time, tf1, and is to be kept constant throughout the whole cooling period, tf2. Cooling must not be forced by applying water.

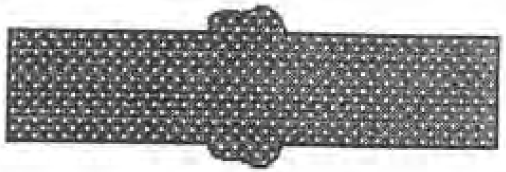
Welding procedure (cont'd)

When the cooling time is completed, the shells can be opened and the pipe moved out from the machine. Rough handling or pressure testing of the pipe before it has completely cooled to reach ambient temperature should be avoided.

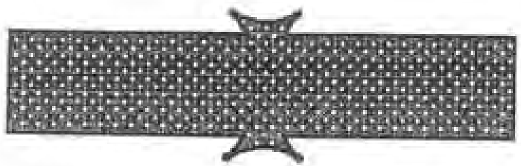
Weld shape appearance



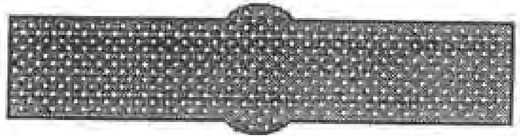
1. Correct weld joint



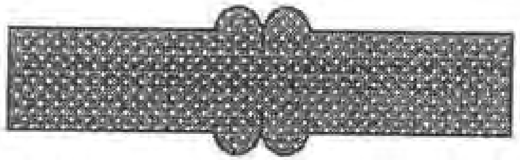
2. Non-uniform welding flash
→ Different MFR materials



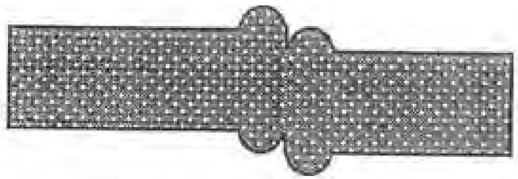
3. Narrow, excessive welding flash
→ Excessive welding pressure



4. Too small weld bead
→ Too low welding pressure



5. Brittle at the middle of weld joint
→ insufficient welding pressure or remove heating plate too slow.



6. Misalignment
→ The misalignment is more than 10% of wall thickness

Site Quality control

HDPE Pipe Welder Certification and testing of tensile strength

Witness of Qualified Testing

Tensile test at butt weld joint

- Test method : ISO 13953
- Criteria : ductile failure only

Tensile strength at butt-fusion weld joint

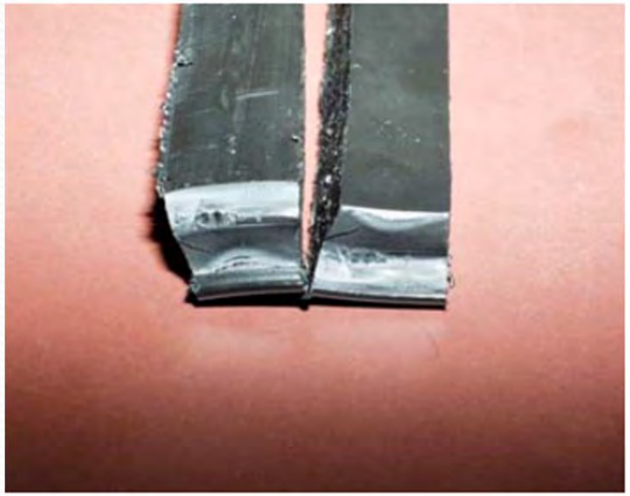
In-Field tensile tester

The new McElroy In-Field Tensile Tester gives contractors and pipe liners the ability to test high-density polyethylene (HDPE) butt fusion joints in the field. A hand-pump system safely tests coupons from pipes sized 2” IPS and larger. The tester also incorporates a template that is attached to the pipe to create a coupon through the use of a drill and reciprocating saw.

http://www.youtube.com/watch?v=3-yx1_sp57c

In-Field bending tester

- Site Bend Back Test
- Criteria : No brittle (if the joint crack → cold fusion)



An Example of a “Cold Fusion” Break

Reverse bend test

- http://www.youtube.com/watch?v=q-XgfxMS2A4

Fig. 1

Fig. 2

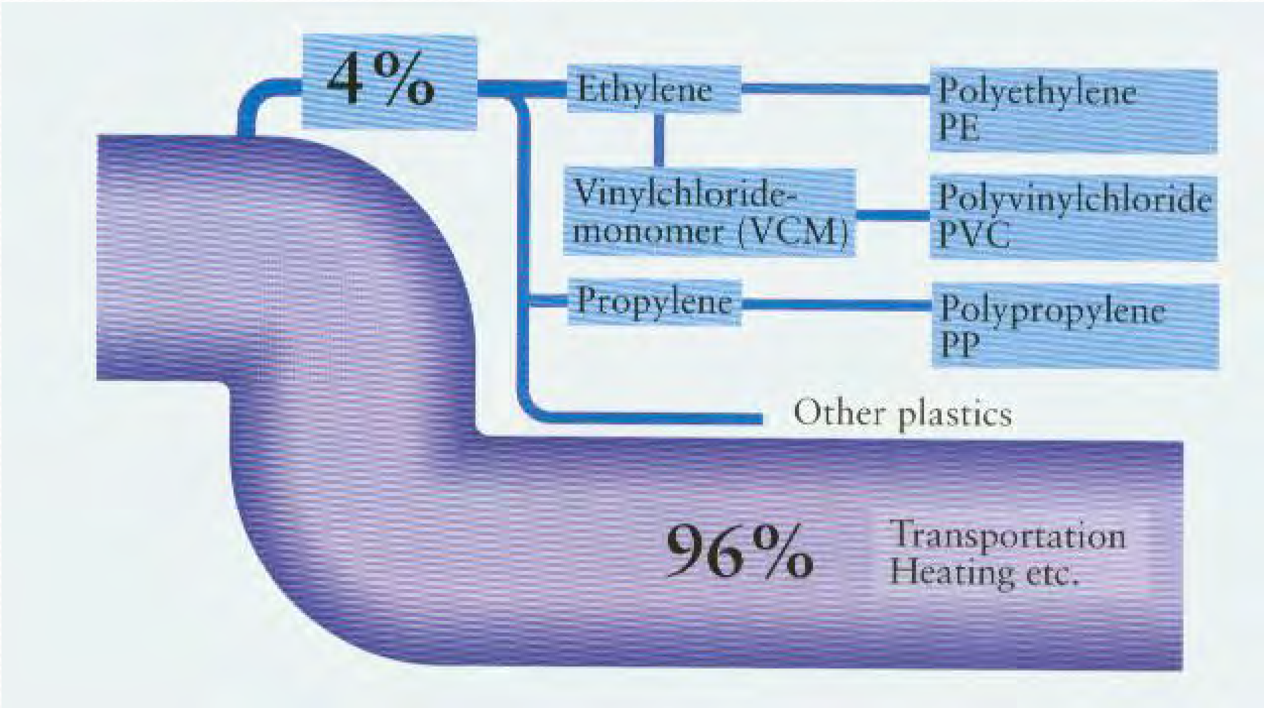
Fig. 3

Fig. 4

Fig. 5

Frequently asked questions

World application of oil



4% for manufacturing plastic

96% is burned as fuel in the fields of transportation, heating etc.

What is Polyethylene?

- Polyethylene is a thermoplastic. Thermoplastics can be re-melted upon the application of heat. Thermoplastics can be shaped during the molten phase and extruded or molded into a variety of shapes such as pipe, fittings, etc.
- There are four different grades of polyethylene based upon density.

Abbreviation	Density (kg/cu.cm.)	Full name
LLDPE	0.910-0.935	Linear Low Density PE
LDPE	0.915-0.925	Low Density PE
MDPE	0.926-0.940	Medium Density PE
HDPE	0.941-0.965	High Density PE

PE pipe development

PE32, PE40, PE63

1st generation (ปี1933) — PE 63 (σ = 5.0 MPa)

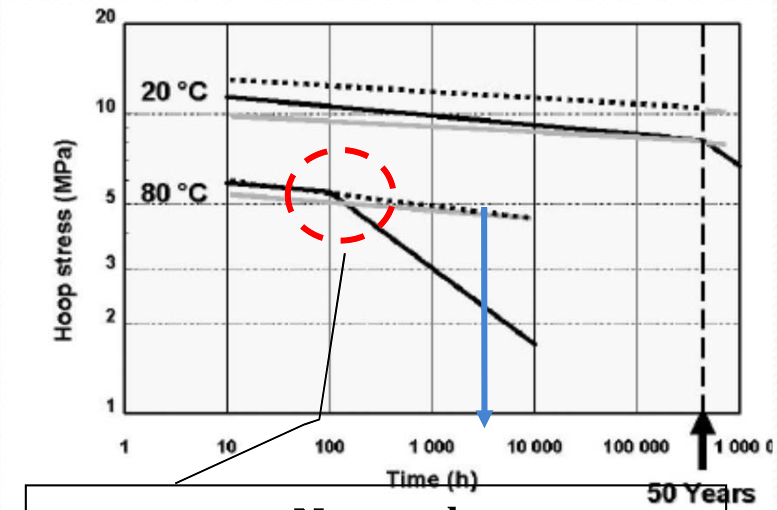
2nd generation (ปี1975) — PE 80 (σ = 6.3 MPa)

3rd generation (ปี1985) — PE 100 (σ = 8.0 MPa)

4rd generation (ปี1999) — **PE 100+ (σ >= 8.0 MPa) compound**

PE 100-RC (σ >= 8.0 MPa) compound

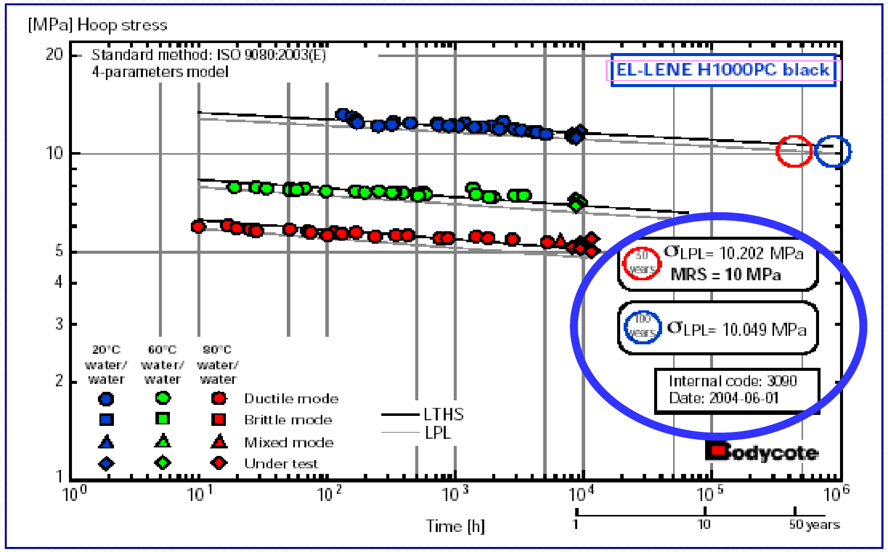
Regression curve of PE compound



Not good

Knee Point less than 5,000 hrs.

- The compound shall be evaluated in accordance with ISO 9080 from notify institute i.e. exova, studvik, bodycote etc.
- There shall be NO knee detected in the regression curve at time < 5,000 hrs.



มอก. 2559-2554

สำหรับคอมพาวนด์ชั้นคุณภาพ PE 100 นั้น ต้องพิจารณาผลทดสอบความทนแรงดันในระยะยาวตาม ISO 9080 ด้วยว่า ไม่พบการหักของเส้นกราฟ (knee) ดังรูปที่ 1 ที่การทดสอบ 80 องศาเซลเซียสก่อน 5 000 ชั่วโมง

Overall service factor

Pressure pipes (stress design based)

Minimum Required Strength (MRS)

The minimum required strength shall be classified according to EN ISO 12162. The classification shall be determined out of the lower confidence limit tangential stress, which divides the MRS values into ranges. In the pressure test according to EN ISO 9080 the LPL-value shall be determined for the pipe material. This LPL-value gives the classification for the MRS value. For classification reasons 50 year have been taken and the relevant design coefficient is applied. In practise the lifetime will be longer. Therefore also the remaining design factor 100 year is given. For the different thermoplastics materials used in buried pipes, the MRS values are given in Table 2.

Table 2 — Material properties relevant for pressure pipes at 20 °C

Material [a]	MRS σ classification [MPa]	Overall service design coefficient [b] C_{50} [-]	Overall design coefficient [c] C_{100} [-]	Allowable approximately one hour stress [MPa]
PE 63	6,3	1,25	—	10
PE 80	8,0	1,25	1,23	12,6
PE 100	10,0	1,25	1,23	16

[a] If values are needed related to specific products, these shall be acquired from the manufacturer or specific standards.

[b] The overall design coefficient is determined in EN ISO 12162 and the values shown in the table are minimum values. The values may be increased by users when specific fluids which are harmful for the environment or mankind.

[c] Based on regression curves it is shown that the C_{100} coefficients slightly differ from the C_{50} values.

NOTE At temperatures below 20 °C the values will be higher than those shown.

Definition

3.1.3 Definitions related to material characteristics

3.1.3.1
lower confidence limit of the predicted hydrostatic strength
σ_{LPL}
quantity, with the dimensions of stress, which represents the 97,5 % lower confidence limit of the predicted hydrostatic strength at a temperature θ and time t

NOTE It is expressed in megapascals.

3.1.3.2
minimum required strength
MRS
value of σ_{LPL} at 20 °C and 50 years, rounded down to the next lower value of the R10 series when σ_{LPL} is below 10 MPa, or to the next lower value of the R20 series when σ_{LPL} is 10 MPa or greater

NOTE R10 and R20 series are the Reynard number series conforming to ISO 3:1973 [3] and ISO 497:1973 [4].

3.1.3.3
design coefficient
C
coefficient with a value greater than 1, which takes into consideration service conditions as well as properties of the components of a piping system other than those represented in the lower confidence limit

Definition (cont'd)

3.1.3.4
design stress
σ_S
allowable stress for a given application at 20 °C, that is derived by dividing the MRS by dividing it by the coefficient C, i.e.:

$$\sigma_S = \frac{\text{MRS}}{C}$$

3.1.4 Definitions related to service conditions

3.1.4.1
nominal pressure
PN
numerical designation used for reference purposes related to the mechanical characteristics of the component of a piping system

For plastic piping systems conveying water, it corresponds to the allowable operating pressure (PFA) in bar, which can be sustained with water at 20 °C with a design basis of 50 years, and based on the minimum design coefficient:

$$\text{PN} = \frac{20 \times \text{MRS}}{C \times (\text{SDR} - 1)}$$

NOTE Research on long term performance prediction of PE water distribution systems shows a possible service life of at least 100 years, see Bibliography [10] and [11].

Definition

- Pipe series S

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

- Standard dimension ratio (SDR)

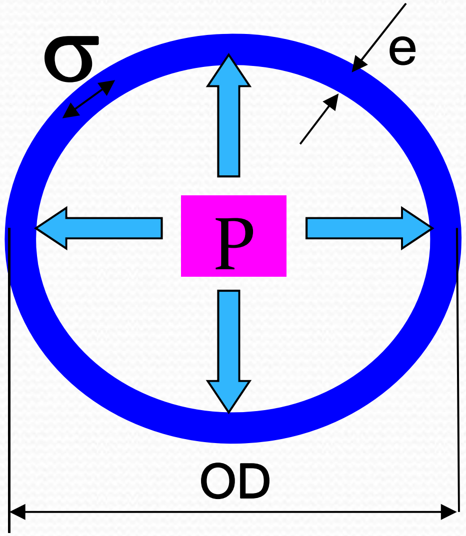
$$SDR = \frac{OD}{e}$$

Where:

SDR = Standard Dimension Ratio
OD = Outside Diameter, mm
e_{min} = Minimum Wall Thickness, mm

SDR	S
6	2.5
7.4	3.2
9	4
11	5
13.6	6.3
17	8
21	10
26	12.5
33	16
41	20

PE pipe classification



Designation	MRS (MPa)	Classification Number	σ_s (MPa)
PE63	6.3	63	5.0
PE80	8.0	80	6.3
PE100	10.0	100	8.0

PN, bar $= \dfrac{20\sigma_s}{[SDR-1]}$

σ_s, Design stress (MPa) $= \dfrac{MRS}{S.F.}$

SDR, Standard Dimension ratio $= \dfrac{OD}{e}$

e, mm $= \dfrac{OD}{SDR} = \dfrac{P \times OD}{20\sigma_s + P}$

S_R, Ring stiffness $= \dfrac{EI}{D^3}$

E = Elastic Modulus, kN/sq.m.
S.F. = Safety factor = 1.25 (water)
MRS = Minimum required strength, MPa
I = Moment of inertia = $e^3/12$, m^4/m
D = mean diameter, mm
OD = Outside diameter, mm
P = Pressure (bar)

Relationship between PN, MRS, S and SDR

Relationship between PN, MRS, S and SDR

The relationship between nominal pressure PN, design stress, σ_S, and the series S or SDR is given by the following equations:

$$PN = \frac{10\sigma_S}{S} \quad \text{or} \quad PN = \frac{20\sigma_S}{SDR - 1}$$

Examples of the relationship between PN, MRS, S, and SDR based on:

$$\sigma_s = \frac{MRS}{C}$$

are given in Table A.1, where C = 1,25.

Pressure ratings and pipe stiffness values for different SDR values PE Pipes

Very Flexible ↔ Flexible pipe

RM	σ (MPa)	SDR	41	33	26	21	17	13.6	11	9	7.4	6
PE100	8	PN (bar)	4	5	6.3	8	10	12.5	16	20	25	32
PE80	6.3		3.2	4	5	6.3	8	10	12.5	16	20	25
PE63	5		2.5	3.2	4	5	6.3	8	10	12.5	16	20
Ring stiffness (kN/m²)*			1.0	2.0	4.3	8.3	16.3	33.3	66.7	130	254	1042
ODmax-TIS 982-2013			2000					1600	1000	800	450	355
ODmax-ISO4427-2007			2000					1600	1000	800	450	355

*) Ring stiffness of pipe calculated from E-modulus = 800 MPa (3 minute, 20 deg C)

- Care should be taken when installation of HDPE pipe SDR ≥ 41 because the pipe is so thin.

Dimension table as per ISO 4427-2

Based on Safety factor = 1.25

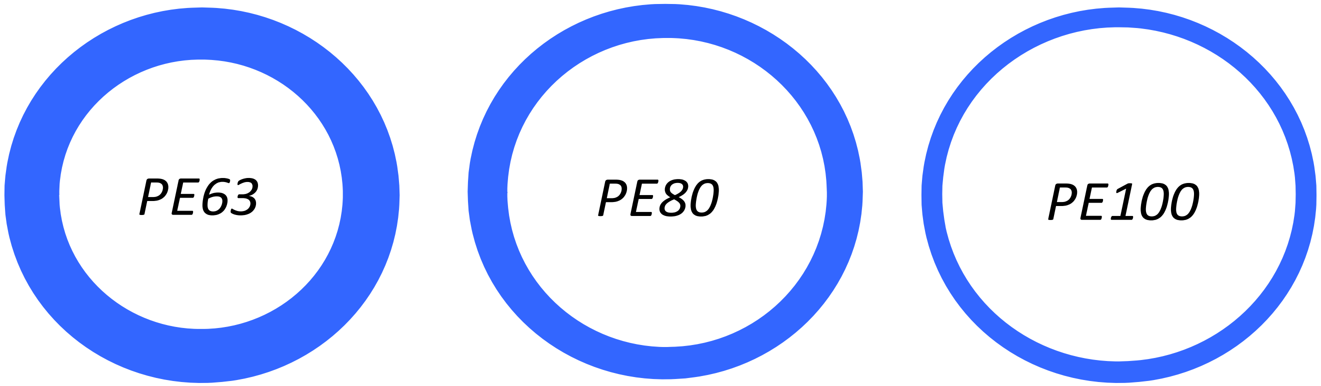
Table 2 (*continued*)

	Pipe series							
	SDR 21		SDR 26		SDR 33		SDR 41	
	S 10		S 12,5		S 16		S 20	
	Nominal pressure (PN) [a] bar							
PE 40	PN 3,2		PN 2,5		—		—	
PE 63	PN 5		PN 4		PN 3,2		PN 2,5	
PE 80	PN 6 [d]		PN 5		PN 4		PN 3,2	
PE 100	PN 8		PN 6 [c]		PN 5		PN 4	
Nominal size	Wall thicknesses [b] mm							
	e_{min}	e_{max}	e_{min}	e_{max}	e_{min}	e_{max}	e_{min}	e_{max}
400	19,1	21,2	15,3	17,0	12,3	13,7	9,8	10,9
450	21,5	23,8	17,2	19,1	13,8	15,3	11,0	12,2
500	23,9	26,4	19,1	21,2	15,3	17,0	12,3	13,7
560	26,7	29,5	21,4	23,7	17,2	19,1	13,7	15,2

PN vs SDR

PN (bar) at 20 deg C

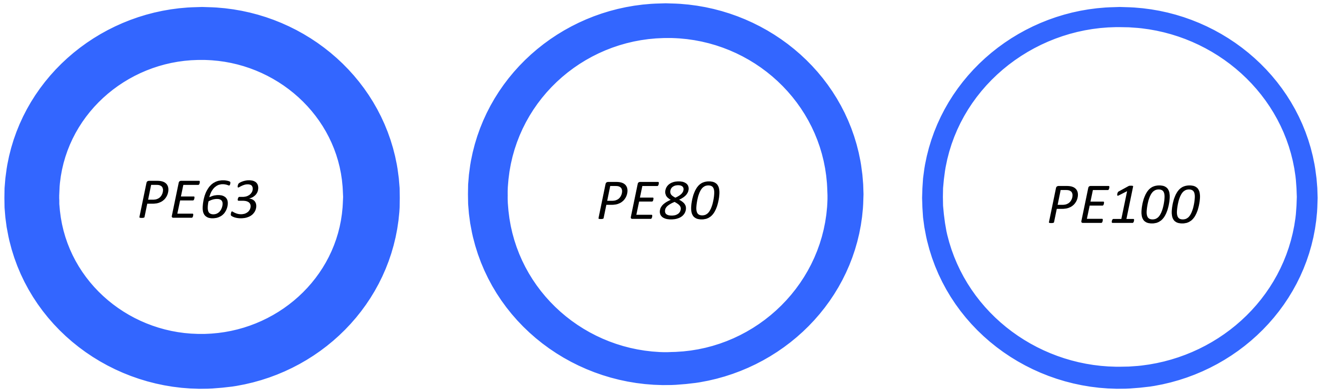
SDR = OD/e



PN	Standard Dimensions Ratio (SDR)		
	PE63	PE80	PE100
6	17	21	26
8	13.6	17	21
10	11	13.6	17
12.5	9	11	13.6
16	7.4	9	11
20	6	7.4	9
25	5	6	7.4

Comparison between PE80 and PE 100 PN 10

HDPE Pipe as per ISO 4427-2 Standard



PN10	Comparison between PE80 and PE100		
	PE63	PE80	PE100
OD	315	315	315
PN	10	10	10
SDR	N/A	13.6	17
e	N/A	23.2 mm	18.7 mm
			-19.40%
kg/m	N/A	21.39 kg/m	17.61 kg/m
			-17.67%

Pressure reduction coefficient

Pressure reduction coefficients for PE 100 and PE 80 piping systems

Temperature [a]	Coefficient
20 °C	1,00
30 °C	0,87
40 °C	0,74

[a] For other temperatures between each step, interpolation is permitted (see also ISO 13761:1996 [7]).

NOTE Unless analysis according to prEN ISO 9080 demonstrates that less reduction is applicable, in which case higher factors and hence higher pressures may be applied.

The allowable operating pressure (PFA) is derived from the following equation:

$$PFA = f_T \times f_A \times PN$$

where

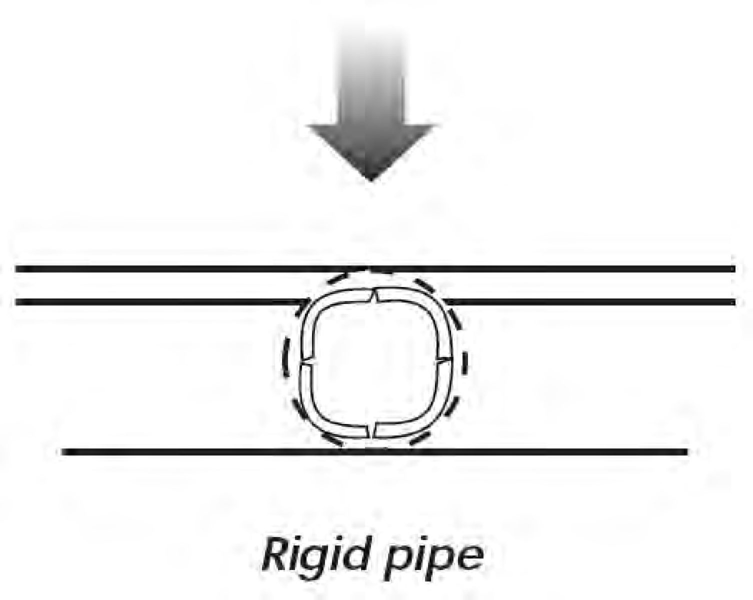
f_T is the coefficient in Table A.1;

f_A is the derating factor (or uprating factor) related to the application (for the conveyance of water f_A = 1);

PN is the nominal pressure taken as a value.

Type of pipe

- Rigid pipe

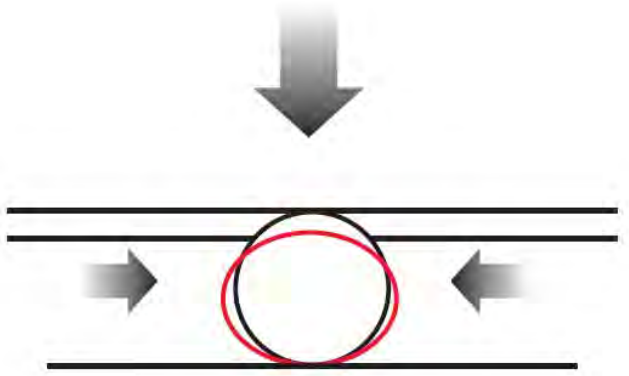


Source:

American Concrete Association

Type of pipe

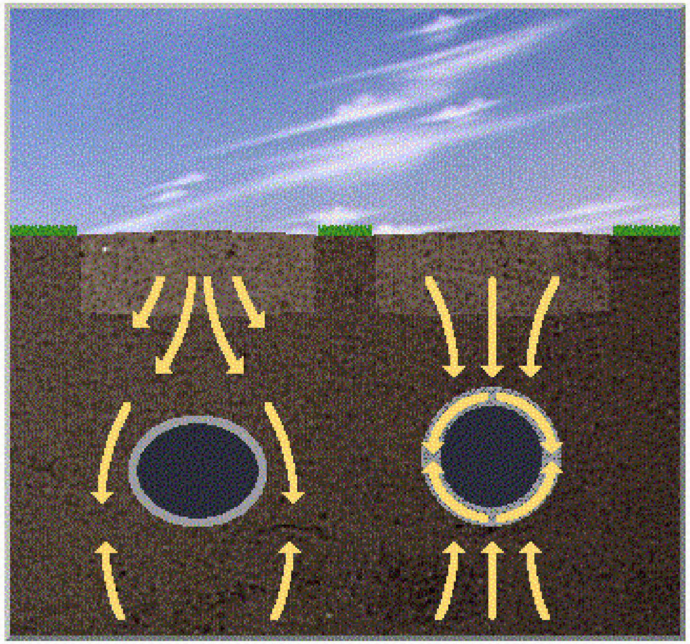
- Flexible pipe



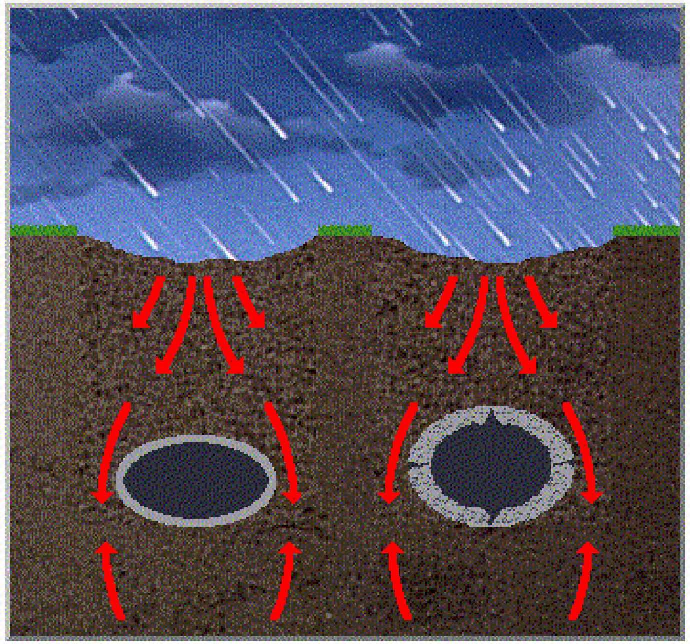
Flexible pipe

Rigid pipe vs Flexible pipe

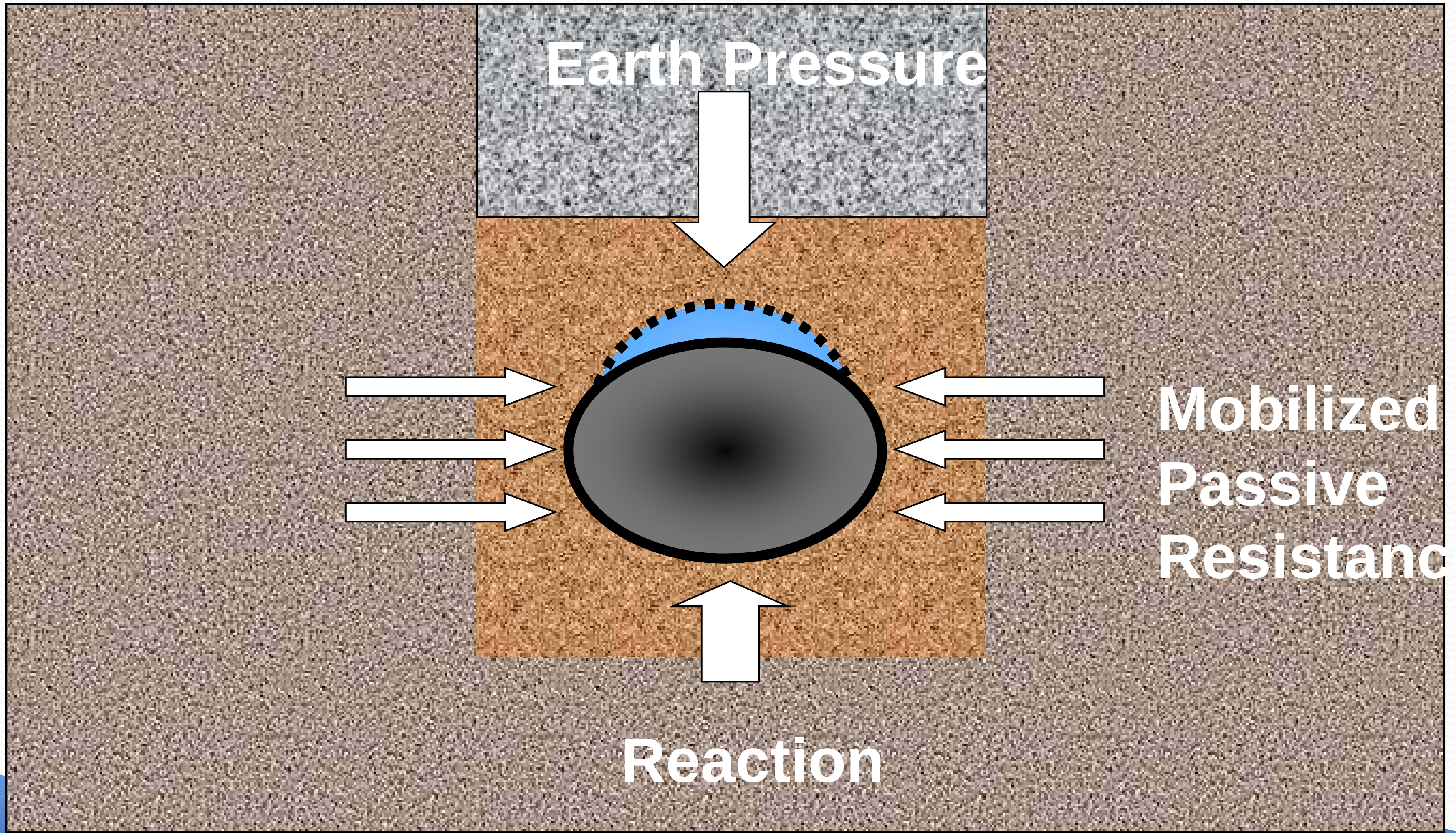
Rigid pipe



Flexible pipe



Flexible pipe load transfer



Roughness coefficient

Type of Pipes		k	C	M	n
Polyethylene (PE)		0.012	150	105	0.009
Weholite	- D > 550 mm - D < 500 mm	0.2 0.5	135	95	0.010
Steel pipe)	- New - Old	0.06 > 0.5	130 115	85 60	0.012 0.017
Ductile Iron pipe	- New - Old	0.06 > 0.5	130 90	80 60	0.013 0.017
Concrete pipe	- New - Old	0.03 > 2.0	135 90	75 60	0.013 0.017

Remark : k = Colebrook-white coefficient
C = Hazen-william coefficient
M = 1/n
n = Manning coefficient

Maximum velocity for PE Pipe

Q. 24 What is the maximum flow velocity for HDPE Pipe? In a pumped system the maximum operating velocity is limited by the surge pressure capacity of the pipe. The Plastics Pipe Institute's Handbook of Polyethylene Pipe states that "if surge is not a consideration, water flow velocities exceeding 25 feet per second may be acceptable."

Reference : PPI TN-27/2009 Frequently Asked Questions HDPE Pipe

Limiting velocity of PE pipe

APPENDIX I

LIMITING WATER VELOCITIES IN THERMOPLASTICS PIPING SYSTEMS

The maximum water velocity in a thermoplastic piping system depends on the specific details of the system, the character of the flow stream, and the system operating conditions.

In general, design velocities of 5 to 10 feet per second are being used and are considered normal. Higher flow velocities are common in certain applications including gravity and slurry flow. However, in all instances, careful consideration should be given to the effect that flow velocity will have on overall piping system performance in light of valve, pump, and system operation. Particular attention should be given to possible effects of excessive velocity on pipe abrasion rate and on pressure surges that may be generated by sudden or rapid changes in flow velocity.

Recommendations for pressure surge design, which are given in design standards or offered by piping manufacturers, should be followed.

Reference : PPI (Plastic pipe institute), TR-14, Appendix I

Surge pressure

In the case of a polyethylene piping system, the working pressure of the system plus recurrent surge pressure associated with a specific piping arrangement or operation should not exceed 150% of the pipe pressure rating. Occasional surge pressures in excess of this limit are allowable so long as the total of the expected surge plus the working pressure of the system does not exceed 200% of the pipe pressure rating.[1]

Reference : PPI (Plastic pipe institute), TR-14, Appendix I

Surge and water hammer

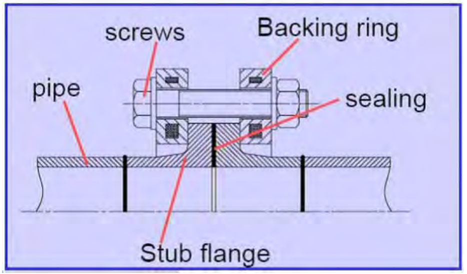
- Plastic pipe have a certain ability to withstand total pressure exceeding that indicated by their pressure class.
- The total pressure with regard to water hammer, may be permitted to reach a value 50% higher than the nominal pressure
- **Source : Plastics Pipes for Water Supply and Sewage Disposal by Lars-Eric Janson**

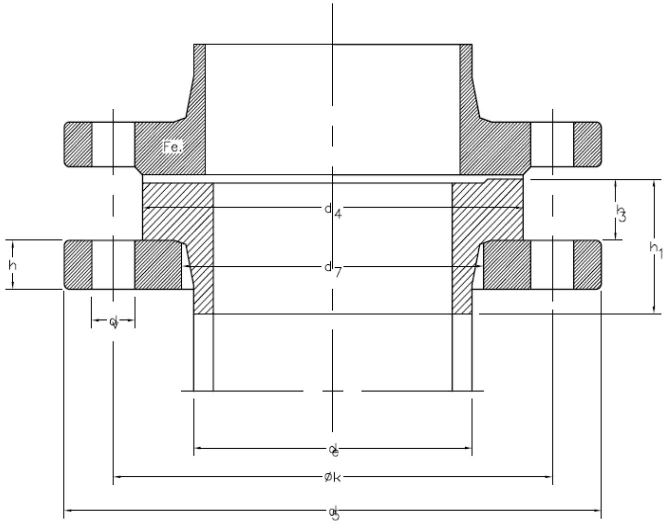
- Surge pressure allowances are applied above the Pressure class. For recurrent surges, the allowance is 50 percent of the pressure.
- **Source : AWWA M55 PE Pipe-Design and Installation**

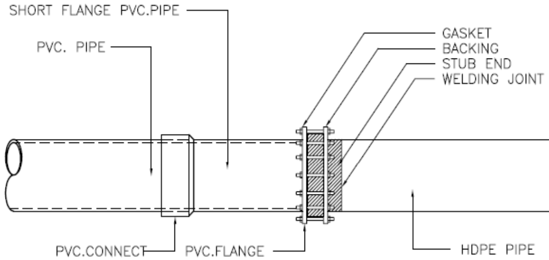
Connecting PE pipe to other pipe materials

- Using stubend joint

TYPICAL FLANGED CONNECTION FOR HEPE PIPE

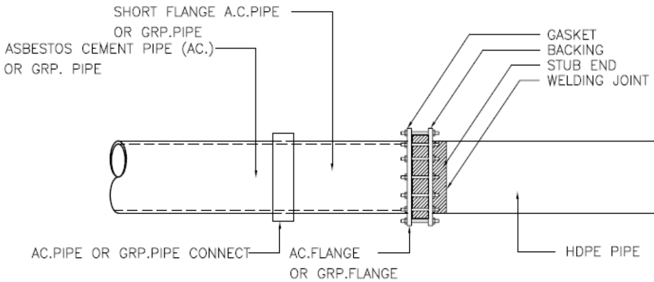




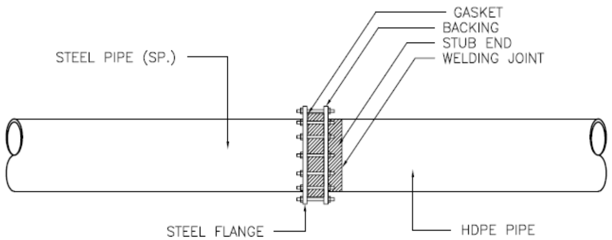


TYPICAL FLANGED CONNECTION FOR PVC.PIPE & HEPE PIPE

CONNECTION BETWEEN HDPE AND STEEL PIPE



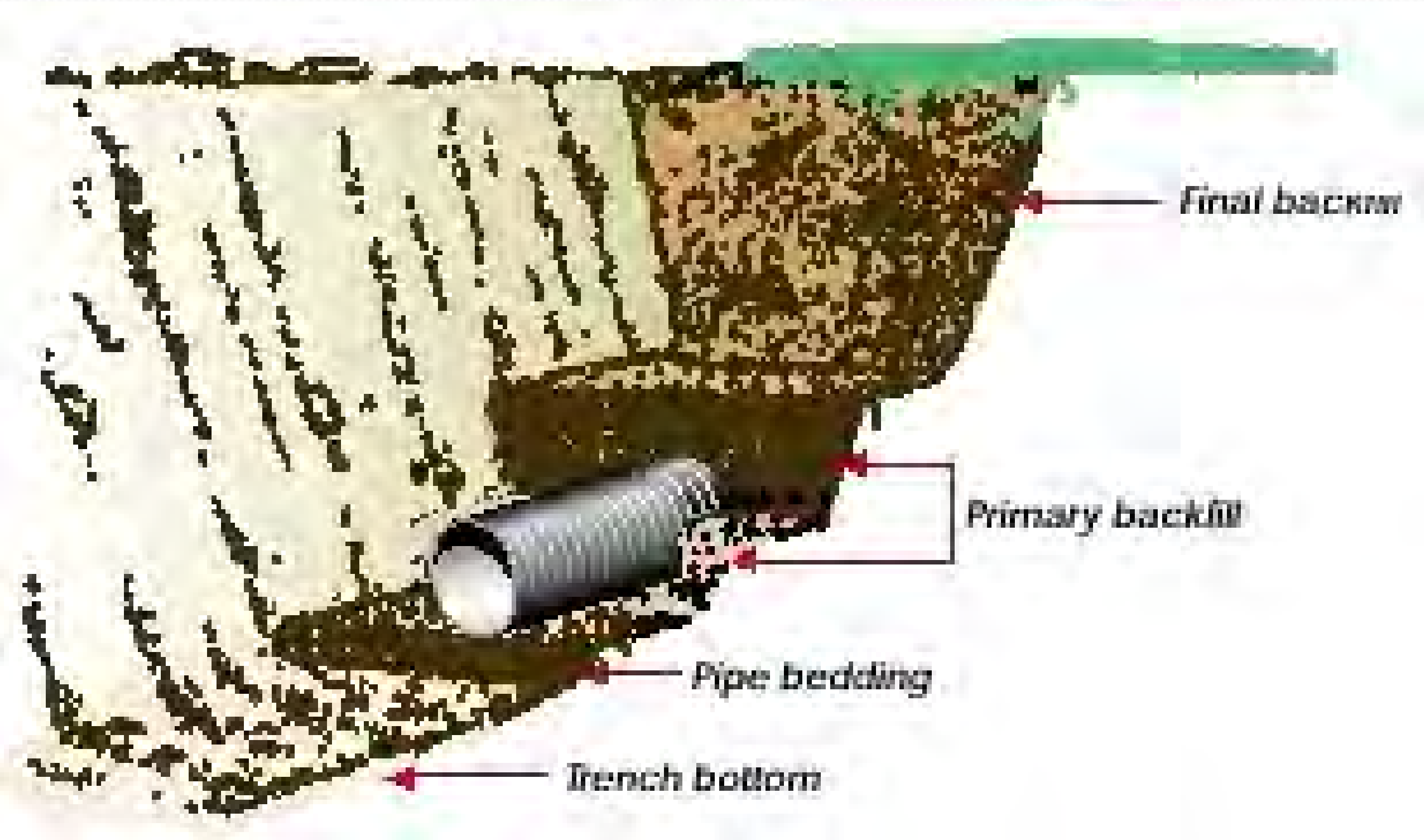
TYPICAL FLANGED CONNECTION FOR A.C.PIPE & HEPE PIPE



TYPICAL FLANGED CONNECTION FOR STEEL PIPE & HEPE PIPE

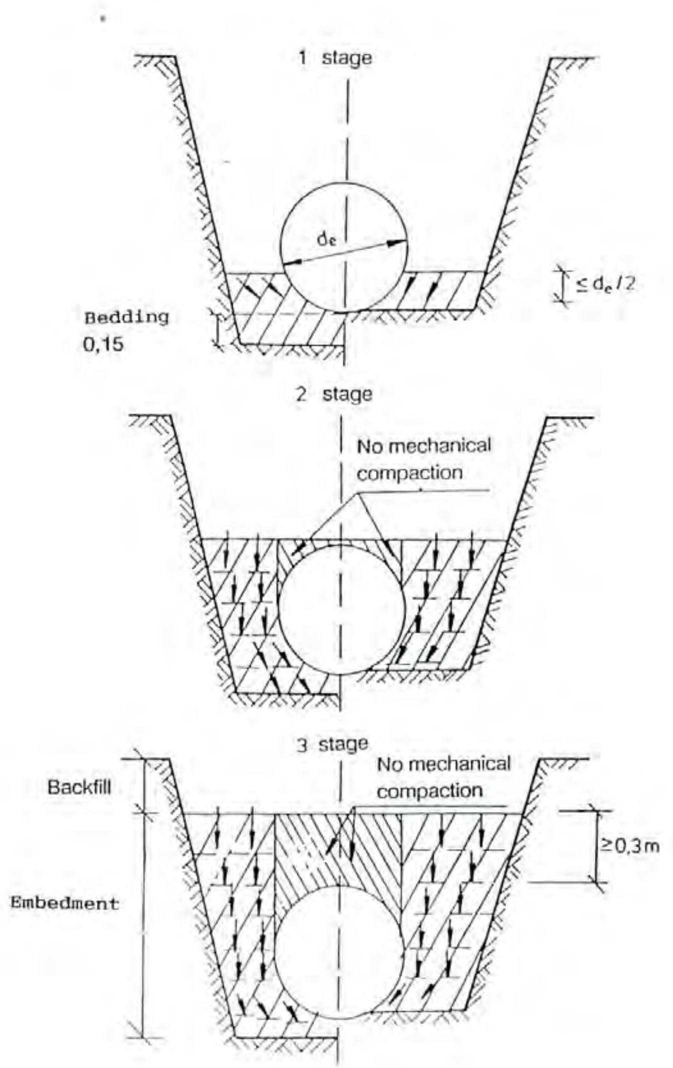
Trench configuration

- **Granular soil: Bedding and backfill**
  Compaction : 92-95% mod. Proctor



Trench

- The embedment material shall not be dropped on top of the pipe in such a manner that the pipe is moved or damaged. It shall be dropped as evenly as possible on both sides of the pipe and then packed under the pipe (haunches) and to the sides. The first layer can extend at the most up to half the pipe height.
- In the first stage the material is spread in the trench with a spade or other means and compacted so that the pipe laid at the planned level does not move from its place nor suffer damage.
- To prevent the pipe lifting it shall be pressed down or anchored during the compaction. If necessary the pipe can be filled with water during the compaction.
- The embedment is constructed and compacted as homogenous layers in the longitudinal direction of the pipe. The haunches supporting the lower half of the pipe is compacted with special care.

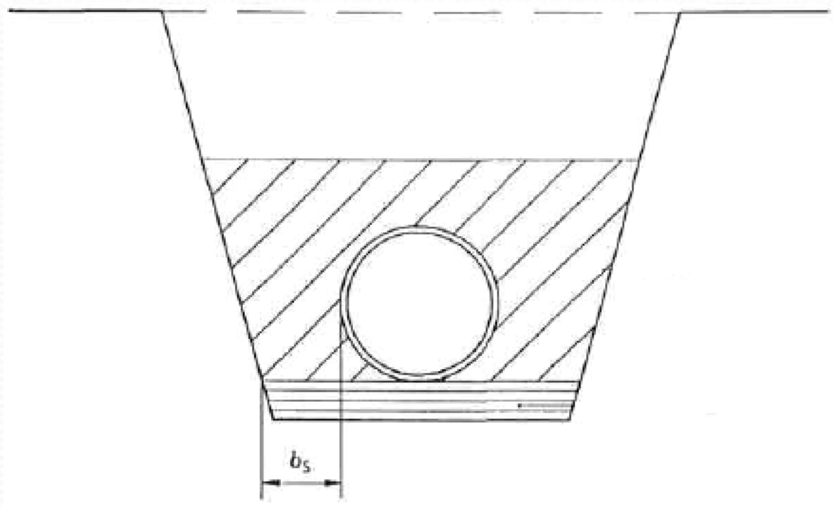


Stages in the construction of the surrounding layers in a trench for plastic pipes.

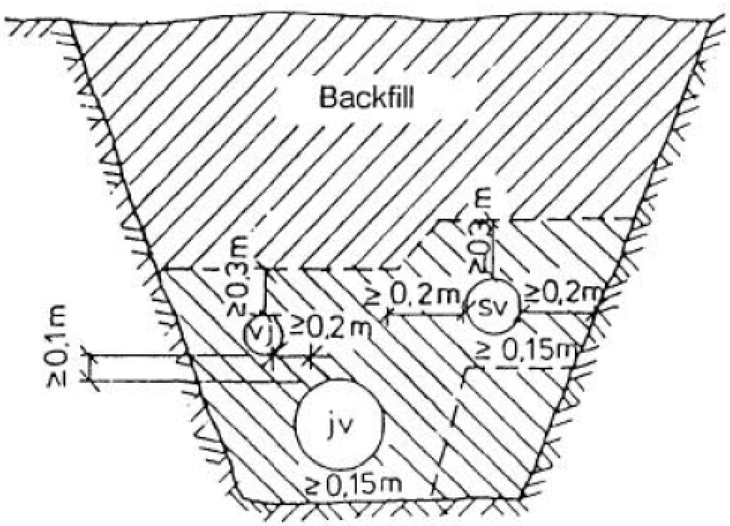
Suggested trench width

- In stable soil.

Nominal Pipe Size (mm)	Minimum Trench Width(bs) (mm)
75 to 400 Pipe	OD + 300
450 to 1000 Pipe	OD + 450
1200 and larger Pipe	OD + 600



Several pipes are laid in the trench



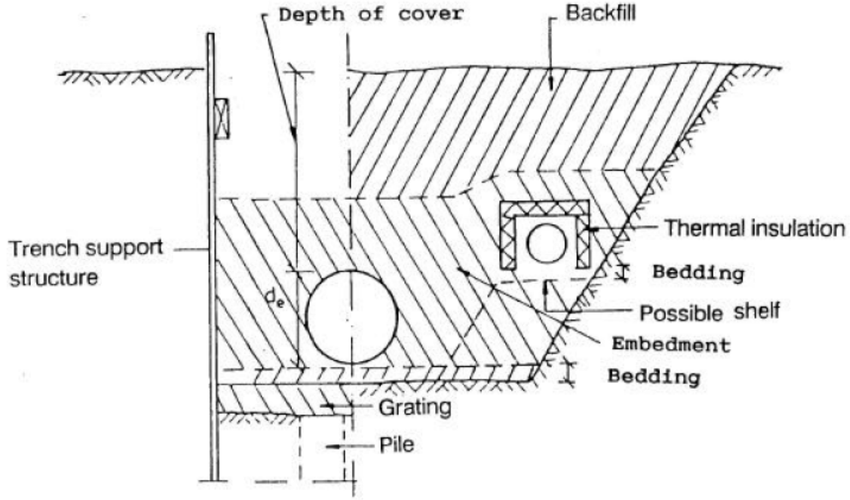
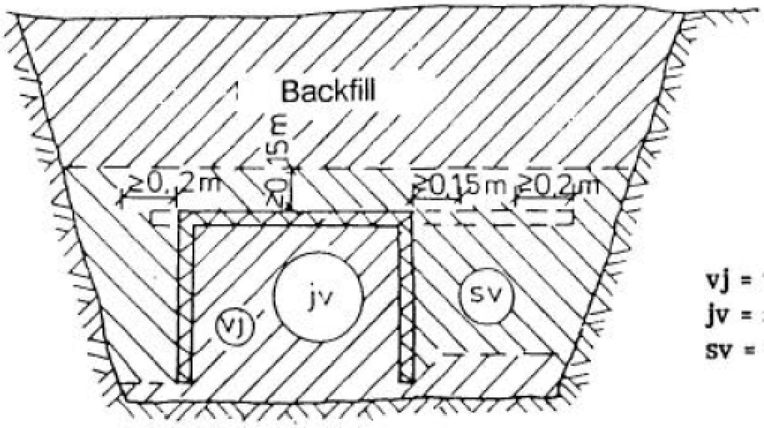
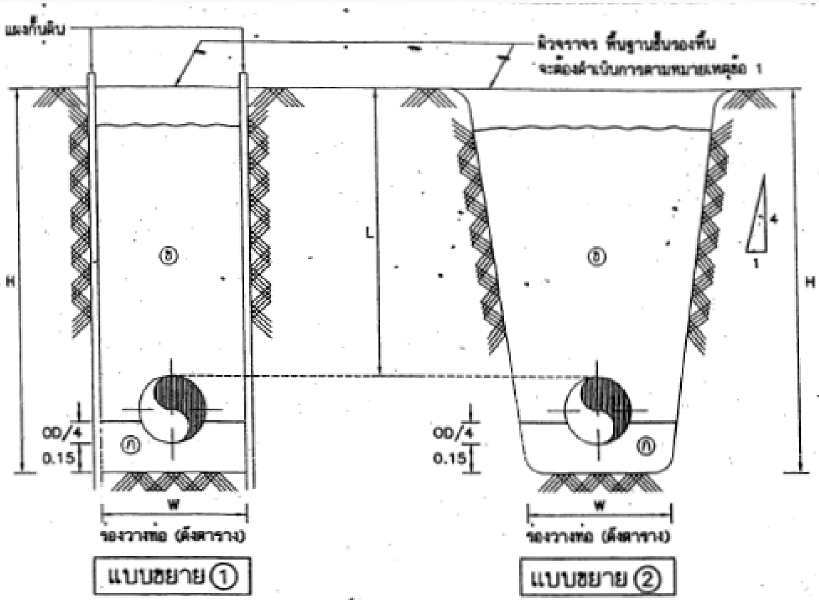


Fig. 1 The factors affecting the function of a pipe line and nomenclature of structural parts.



vj = water pipe
jv = soil and waste sewer
sv = rain water sewer

PWA suggested trench



สัญลักษณ์

(ก) วัสดุรองพื้นเป็นทรายบดอัดแน่น
(ข) วัสดุที่ใช้ถมเป็นทรายบดอัดแน่น

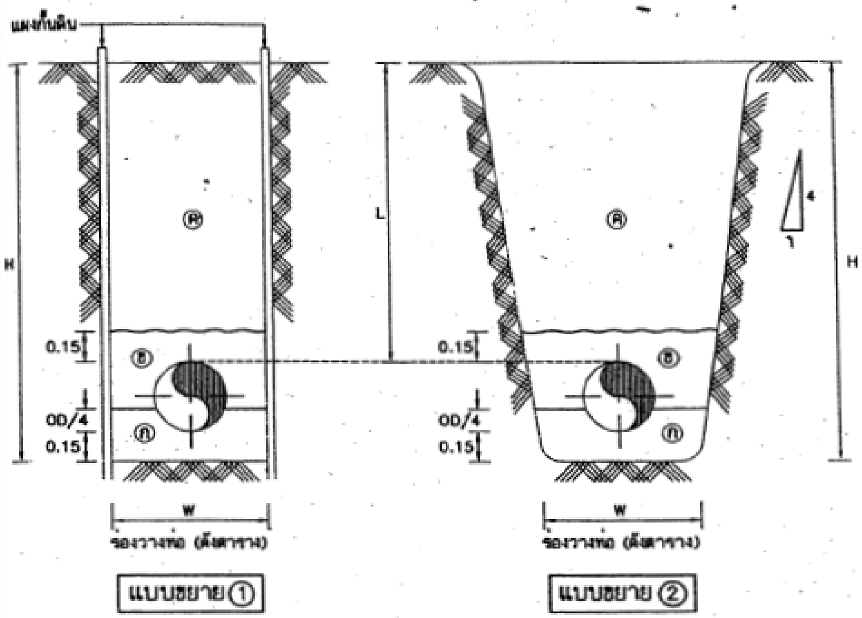
ตารางแสดงค่า "W" ขนาดร่องวางท่อ												
ขนาดท่อ (มม.)	100	150	200	250	300	400	500	600	700	800	900	1000
ค่า "W" ต่ำสุด (ม.)	0.40	0.45	0.50	0.55	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.35
ค่า "W" สูงสุด (ม.)	0.70	0.75	0.80	0.85	0.90	1.00	1.10	1.20	1.50	1.70	1.90	2.05
ค่า "L" ความลึกหลังท่อ(ม.)	0.80	0.80	0.80	0.80	1.00	1.00	1.00	1.00	1.20	1.20	1.20	1.20

หมายเหตุ

1. การวางท่อในถนนคอนกรีตหรือถนนราดยาง ร่องดิน วางท่อจะต้องกลบด้วยทรายบดอัดแน่นและซ่อมผิวจราจร ชั้นพื้นฐาน ชั้นรองพื้นฐานดังนี้
   1.1 ผิวจราจรที่อยู่ในความรับผิดชอบของกรมทางหลวง เทศบาล หรือเขตสุขาภิบาล ผู้รับจ้างต้องดำเนินการซ่อมตามหลักและวิธีประสานงานเกี่ยวกับการขุด และจัดซ่อมถนนระหว่างหน่วยงานสาธารณูปโภคและหน่วยราชการที่เกี่ยวข้องนั้นๆ
   1.2 ผิวจราจรที่อยู่ในความรับผิดชอบของเอกชน ผู้รับจ้างจะต้องดำเนินการซ่อมตามสภาพเดิม หรือดีกว่าสภาพเดิม
2. แบบขยาย ① ให้ใช้เมื่อค่า H > 1.50
3. แบบขยาย ② ให้ใช้เมื่อค่า H < 1.50
4. OD หมายถึง เส้นผ่าศูนย์กลางภายนอกของท่อ

–มิติต่างๆหน่วยเป็นเมตรเว้นแต่ระบุเป็นอย่างอื่น

Under traffic load



สัญลักษณ์

(ก) วัสดุรองพื้นเป็นทรายบดอัดแน่น
(ข) วัสดุที่ใช้ถมเป็นทรายบดอัดแน่น
(ค) วัสดุที่ใช้เป็นชนิดเดียวกับดินเดิมบดอัดแน่น

ตารางแสดงค่า "W" ขนาดร่องวางท่อ												
ขนาดท่อ (มม.)	100	150	200	250	300	400	500	600	700	800	900	1000
ค่า "W" ต่ำสุด (ม.)	0.40	0.45	0.50	0.55	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.35
ค่า "W" สูงสุด (ม.)	0.70	0.75	0.80	0.85	0.90	1.00	1.10	1.20	1.50	1.70	1.90	2.05
ค่า "L" ความลึกหลังท่อ(ม.)	0.80	0.80	0.80	0.80	1.00	1.00	1.00	1.00	1.20	1.20	1.20	1.20

–มิติต่างๆหน่วยเป็นเมตรเว้นแต่ระบุเป็นอย่างอื่น

หมายเหตุ

1. แบบขยาย ① ให้ใช้เมื่อค่า H > 1.50
2. แบบขยาย ② ให้ใช้เมื่อค่า H < 1.50
3. OD หมายถึง เส้นผ่าศูนย์กลางภายนอกของท่อ

Non-traffic load

Underground warning tape

TEXT/COLOURS

- CAUTION CAUTION CAUTION WATER PIPE BELOW
- CAUTION CAUTION ELECTRIC CABLE BELOW
- CAUTION CAUTION CAUTION GAS MAIN BELOW
- CAUTION CAUTION CAUTION STREET LIGHTING CABLE BELOW
- CAUTION CAUTION CAUTION STREET LIGHTING CABLE BELOW
- CAUTION CAUTION CAUTION FOUL SEWER BELOW
- CAUTION CAUTION CAUTION SEWERAGE PUMPING MAIN BELOW
- CAUTION CAUTION CAUTION FIBRE OPTIC CABLES

Underground protection

SIMONA® Protective Sheets

Perfect protection for gas pipelines

Processing SIMONA® Protective Sheets at the Ringsheim plant

- Good chemical resistance
- Extreme robustness, e.g. they will withstand the impact exerted by a 32 tonne excavator bucket

PE co-extruded
Coextruded SIMONA® PE-CoEx is available in yellow/black and coloured/black/coloured for highly effective warning. Labelling or the application of a wide coloured stripe can be performed during the extrusion process.

PE with anti-slip layer
SIMONA® PE-AR has an anti-slip layer and is ideal for efficient installation, depending on conditions and on the subsurface. A special coating reduces the risk of accidents when sheets are being laid on sloping or slippery

Figure 3: Protective sheets with studded panels

A regulation governing the safety of pipelines for gases and chemicals has been in existence in France since 2006.
Pipelines that convey dangerous substances (e.g. combustible gases) through public spaces must be protected against

SIMONA® Sheets made of the materials PE-CoEx and PE-AR are ideal for use as protective sheets that meet exacting requirements and comply with stringent quality specifications.

the fol-

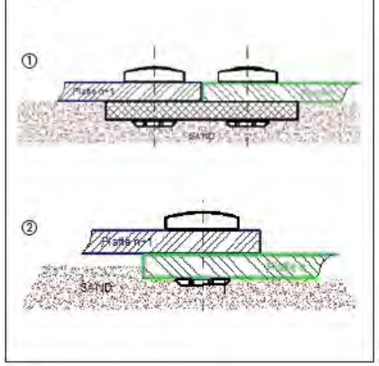
0 years

w

Figure 4: Protective sheets laid over a gas pipeline

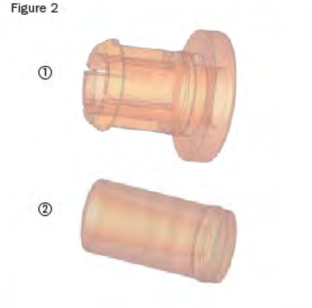
SIMONA® PE-CoEx protective sheets

Figure 1



① Laying with edge to edge
② Laying with overlap

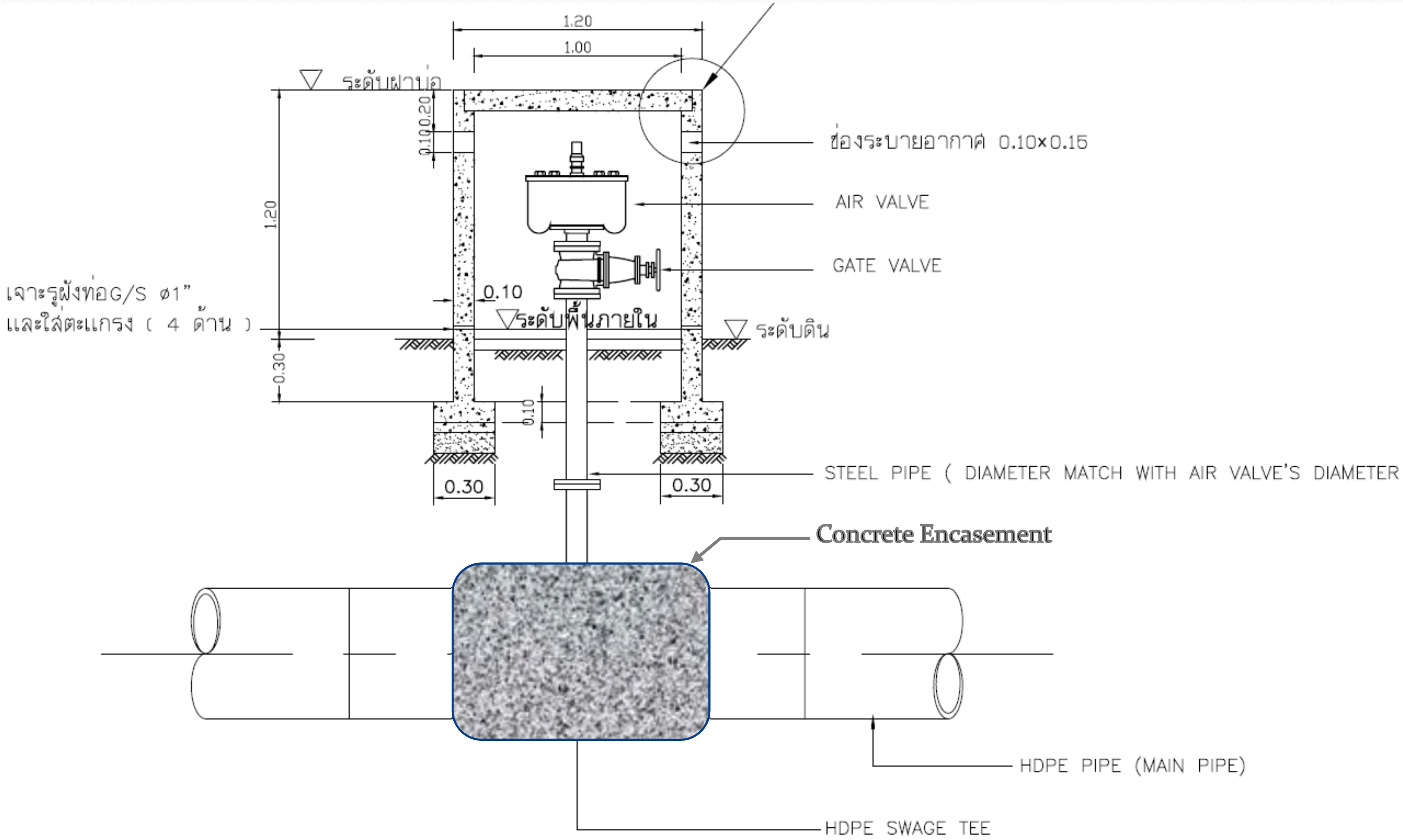
Figure 2



① PP rivet
② Locking pin

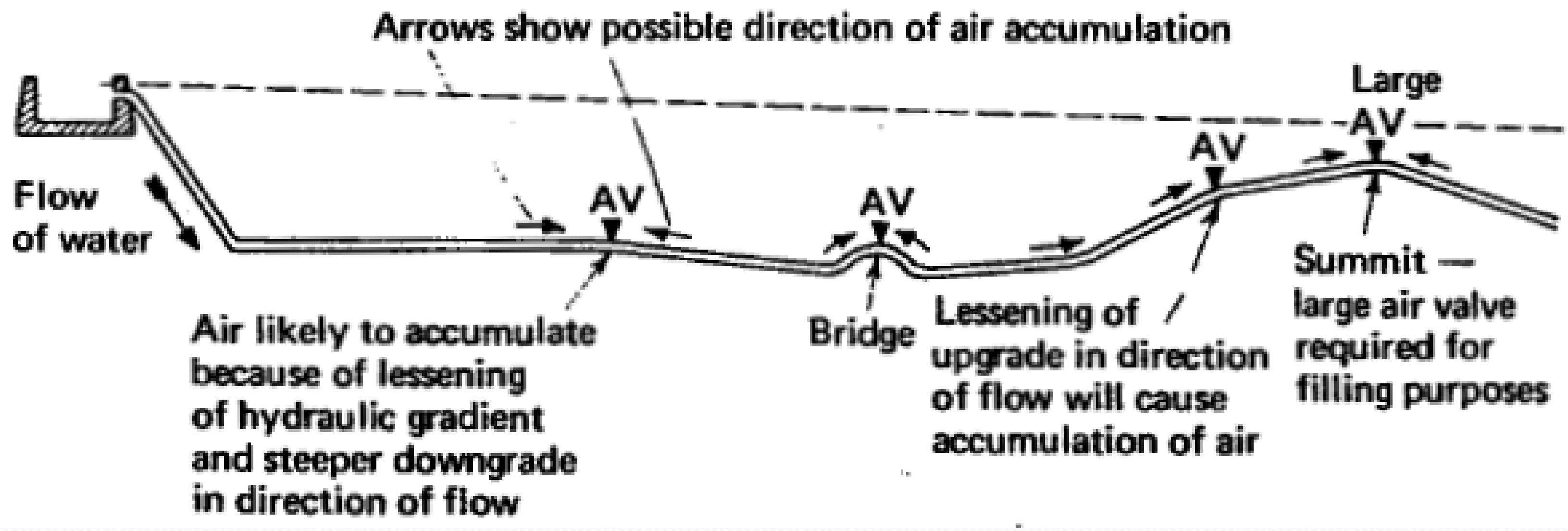
Branch connection

Connection to air valve



Air valve installations

- Please consult air valves suppliers on type, size, locations of air valves etc.



Guidance for size of air valve

Source : PWA

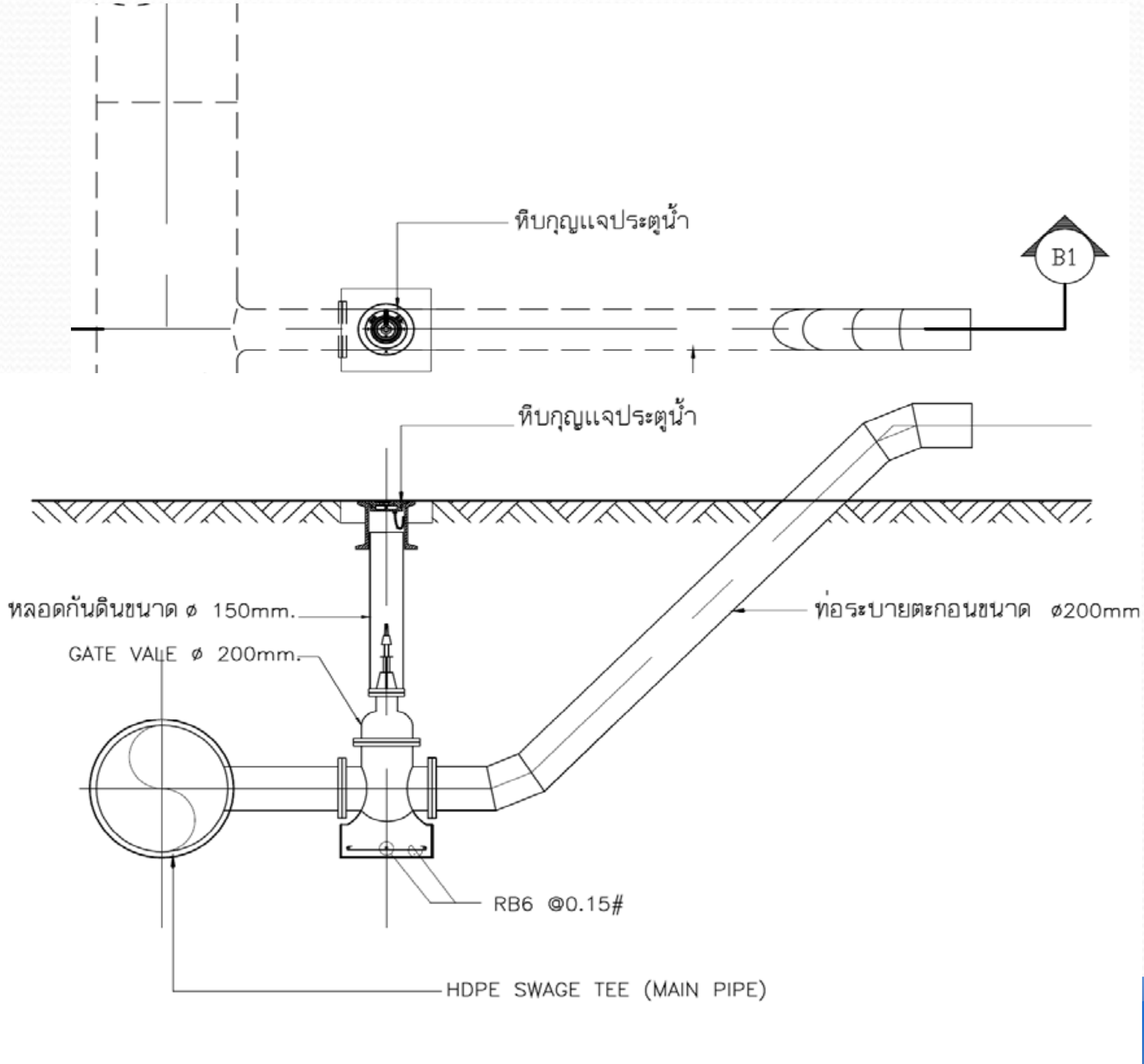
Pipe diameter (mm)	Air valve diameter (mm)
100 - 200	25
200 - 300	50
300 - 600	80
> 600	100

Source : Water supply,

Twort/Ratnayaka/Brandt

Pipe diameter (mm)	Air valve diameter (mm)
≤ 250	50 - 65
250 - 600	80 - 100
600 - 900	150
900 - 1200	200
1400 – 1800	2 @ 200

Blow off



หีบกุญแจประตูน้ำ
B1
หีบกุญแจประตูน้ำ
หลอดกันดินขนาด ø 150mm.
GATE VALE ø 200mm.
ท่อระบายตะกอนขนาด ø200mm
RB6 @0.15#
HDPE SWAGE TEE (MAIN PIPE)

Guidance for size of blow off

Source : PWA

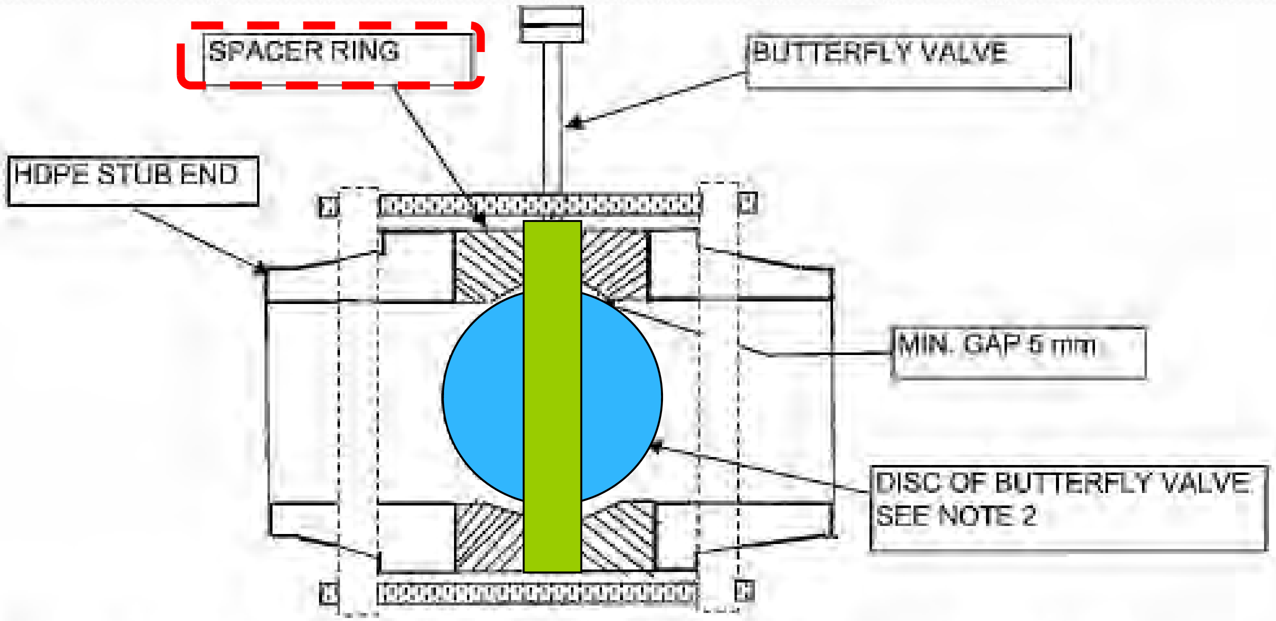
Pipe diameter (mm)	Blow off diameter (mm)
< 300	100
≥ 300	150

Source : Water supply, Twort/Ratnayaka/Brandt

Pipe diameter (mm)	Blow off diameter (mm)
≤ 300	80
400 - 600	100
700 - 1000	150
1100 - 1400	200
≥ 1600	250

Butterfly valve precaution

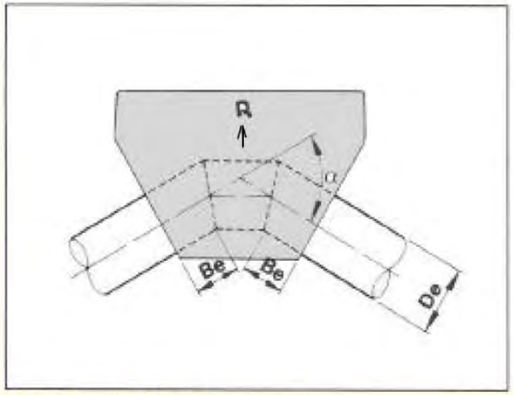
- It's a must to have 2 spacers ring placed between both ends of butterfly valve.



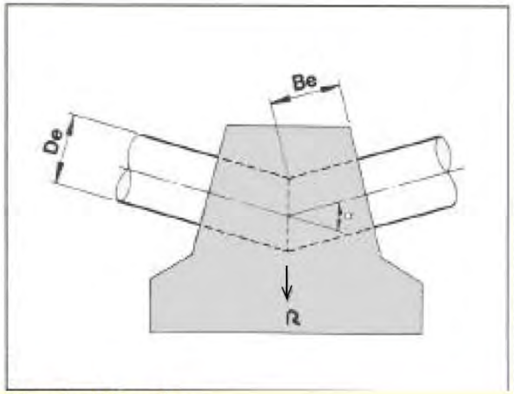
NOTE 1.Slope angle and thickness(t) should be adjustment following dimension body and length diameter disc of butterfly valve (Keep minimum gap between disc of valve and spacer ring 5 mm.lenght)
2 .See detail of butterfly valve from attachment

Fully encased fitting

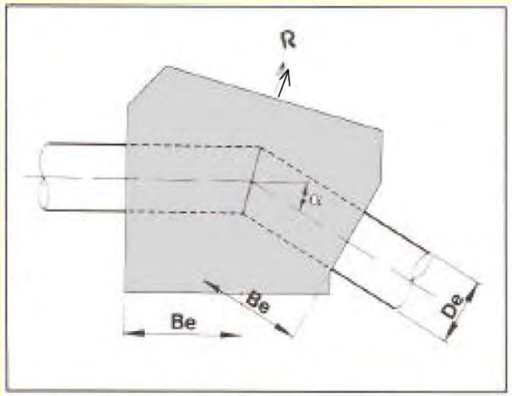
- Reinforced concrete



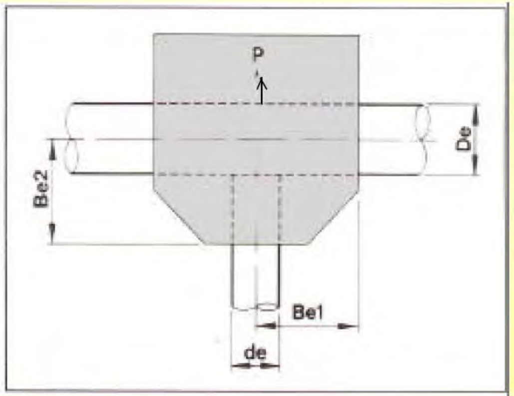
Horizontal bend



Vertical bend up



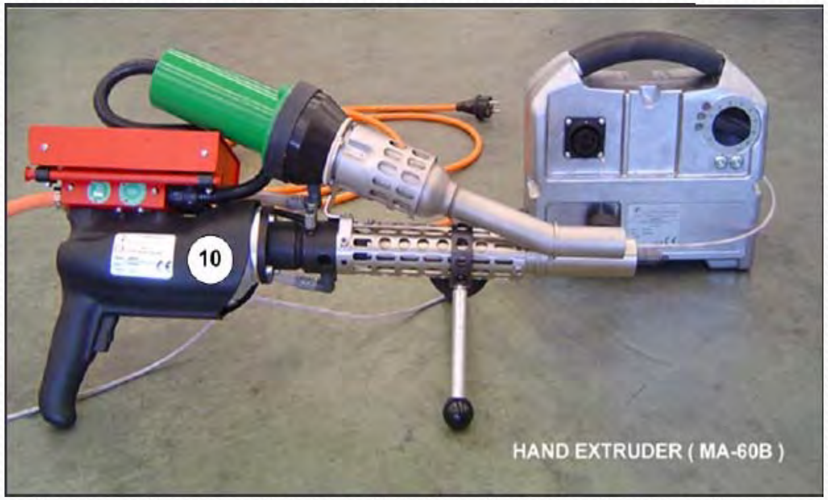
Vertical bend down

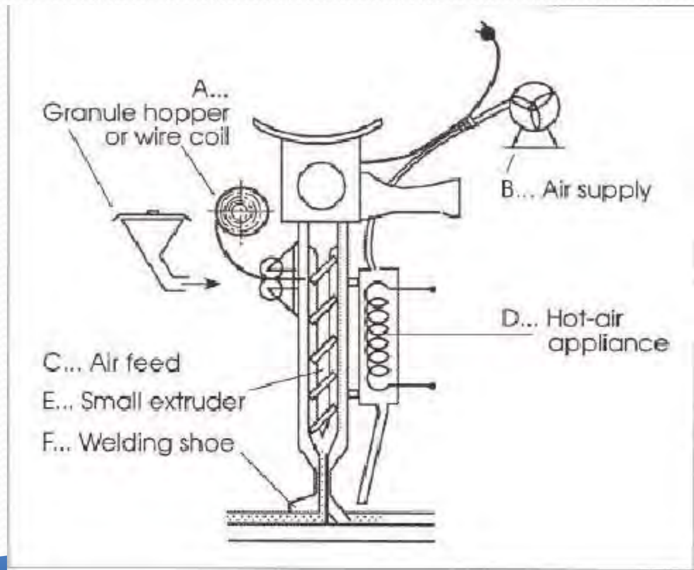


T-Branch

	At least
Be1 = De+de/2	Be1 = 200 mm+de/2
OR	
Be2 = de+De/2	Be2 = 200mm+De/2

Hand extrusion welding



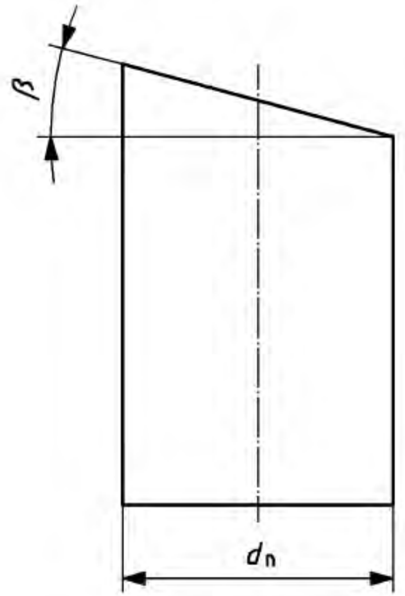


Derated fittings

Table B.3 — Derating factors for segmented bends

Cut angle β	Derating factor f_B
$\leq 7{,}5°$	1,0
$7{,}5° < \beta \leq 15°$	0,8 [a]

[a] In accordance with B.1 the test results of the manufacturer may demonstrate that a derating factor of 1,0 or another factor may be applicable.



Key

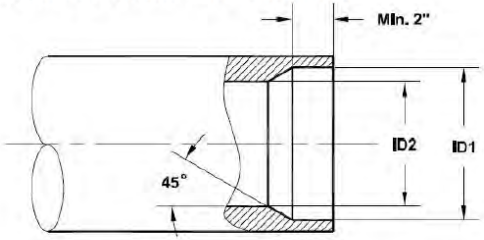
d_n nominal outside diameter

β cut angle

Figure B.2 — Segment design

The cut angle β, see Figure B.2, shall not be greater than 15°.

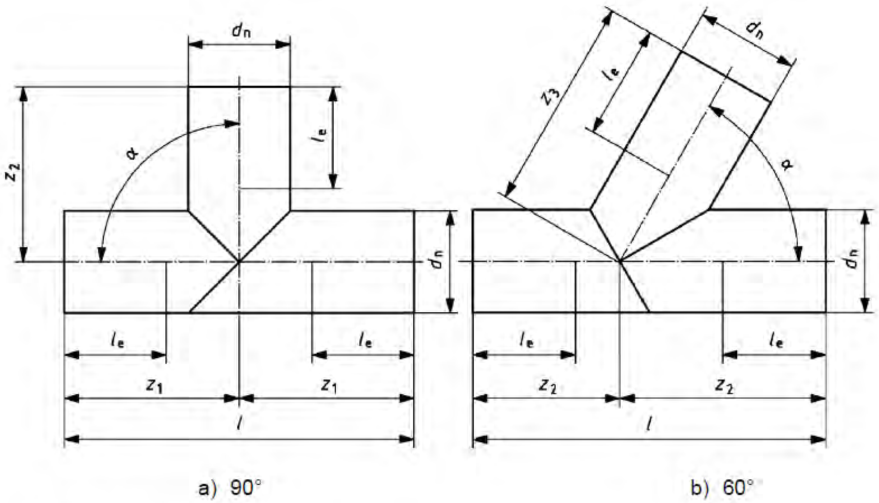
Figure 1: Counter bore end detail



ID1: Matches the adjoining pipe ID

ID2: Matches ID of the pipe feed stock for fitting

Derated fittings



Key

d_n nominal outside diameter

l_e tubular length of fusion end piece [a]

z_1, z_2, z_3 nominal lengths of fitting branch to axis

α nominal angle of fitting (± 2°)

[a] The length shall allow the following (in any combination): the use of clamps required in the case of butt fusion; assembly with an electrofusion fitting; assembly with a socket fusion fitting; the use of a mechanical scraper.

Figure B.4 — Segmented tees

For tees fabricated out of pipe segments, the following derating rules for the calculation of the PN shall apply:

$$[PN] = f_T \times [PN]_{pipe}$$

where

f_T is the derating factor for these tees, having a value of 0,6;

$[PN]_{pipe}$ is the nominal pressure of the pipe, taken as a value.

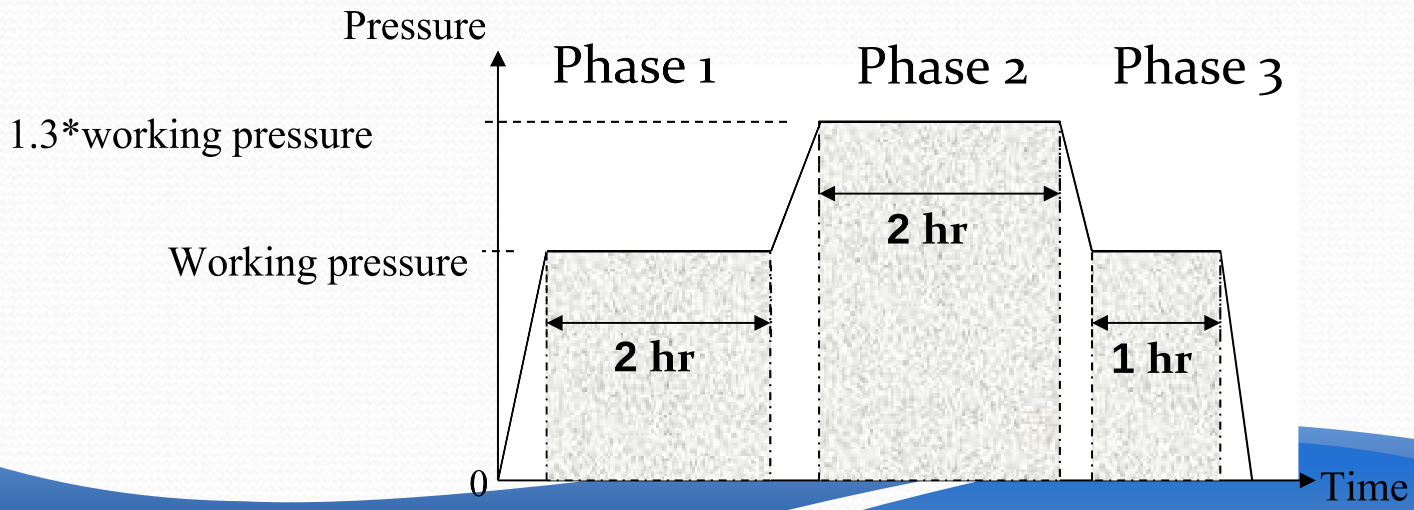
Practice has shown that these factors are applicable. Results of testing according to Table B.1 will determine the applicable factor f_T.

SFS : Hydro test (site)

- SFS 3115 “Plastic Pipes, Water tightness test for pressure pipelines

Step	Test pressure	Duration (hrs)
1	Working pressure	2
2	1.3*Working pressure	2
3*	Working pressure	1

*After one hour, measure the quantity of water, if any, which must be added to raise the pressure back to its initial value.



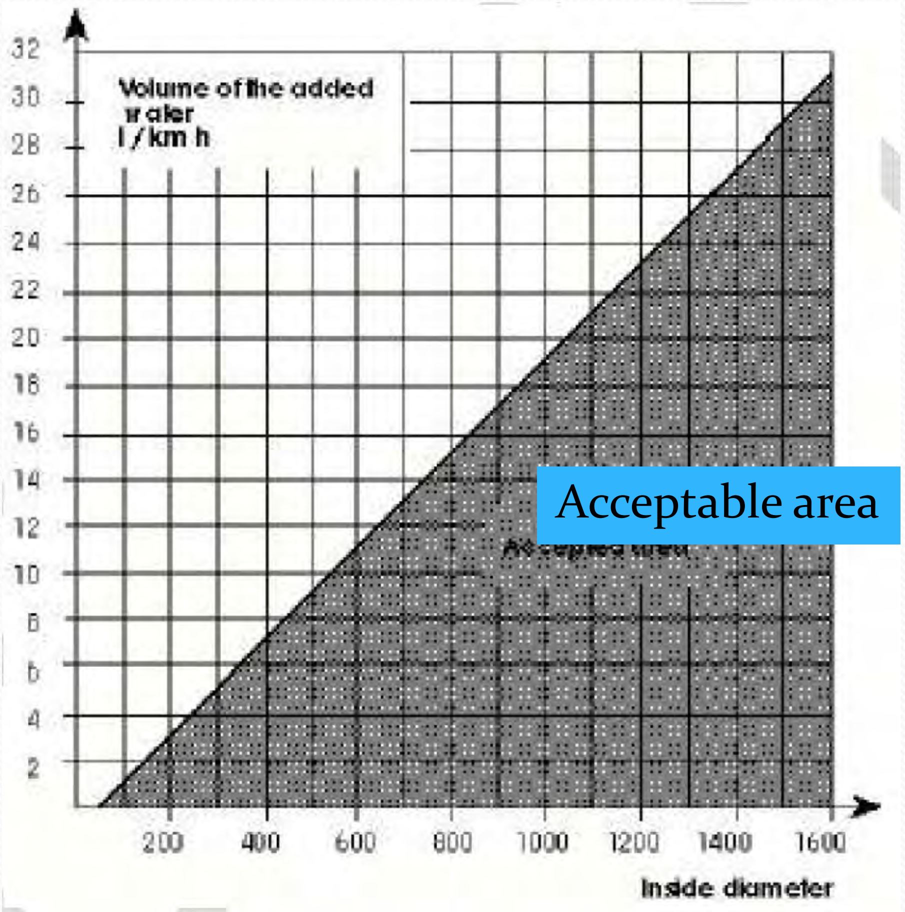
SFS : Site Hydro test (@40 deg C)

- Temperature reduction factor of 0.74 at 40 deg C

PN (bar)	Phase 1 Working pressure (bar)	Phase 2 1.3* Working pressure (bar)	Phase 3 Working pressure (bar)
6	4.4	5.7	4.4
8	5.9	7.6	5.9
10	7.4	9.6	7.4
12.5	9.2	11.9	9.2
16	11.8	15.3	11.8

SFS : Acceptance criteria

- The tightness test is acceptable if the quantity of additional water needed in the measurement made in stage 3 appears under the straight line of below figure.



Pressure test : Limit of approval/non-approval

Source :

SFS 3115 "Plastic Pipes, Water tightness test for pressure pipelines

AS/NZS – Site hydrotest

- AS/NZS 2033 “Installation of Polyethylene Pipe Systems”

Maximum test pressure shall be limited to 1.5 times the maximum design pressure for a maximum time of 15 minutes.

Maintenance of PE Pipe

- **Detection**
  - How can I verify the location of underground PE pipes?Is it possible to detect buried PE pipes from the surface?
- **Inspection**
  - Is it necessary to inspect periodically the PE pipe?
- **Water Jetting**
  - Can water jetting be used to clean PE pipe and are any special precautions necessary?
- **Flow Stopping**
  - What techniques are available for isolating sections of PE pipe for maintenance?
- **Repairs**
  - How can damaged PE pipe be repaired?
- **Leaks**
  - What is the typical expected frequency of leaks in a PE pipe network?
- **Damage**
  - Is PE more easily damaged than other pipe materials?

Detection

- How can I verify the location of underground PE pipes?
  - Construction Records held by the pipeline operator.
    - location, depth of burial, location of other underground plant and any other relevant information.
  - The information shown on the construction records should be verified on site.
    - Survey of appurtenances at the surface, such as chamber covers, as well as limited potholing to verify depth, may be necessary.
  - Remote pipe detection from the surface can also be used.
    - Electromagnetic methods as used to detect buried cables and metallic pipes are not suitable for detecting PE pipes.

Inspection

- **Is it necessary to inspect periodically the PE pipe?**
  - Periodic inspection of PE pipe is not normally required, but reference should be made to national or local codes of practice and preventative maintenance programmes.
  - In critical locations, e.g. above ground installations, it may be necessary to implement a periodic inspection programme to determine the condition of the pipe, pipe supports and other associated structures. The frequency of the inspection should be set by a risk-based approach.

Water jetting

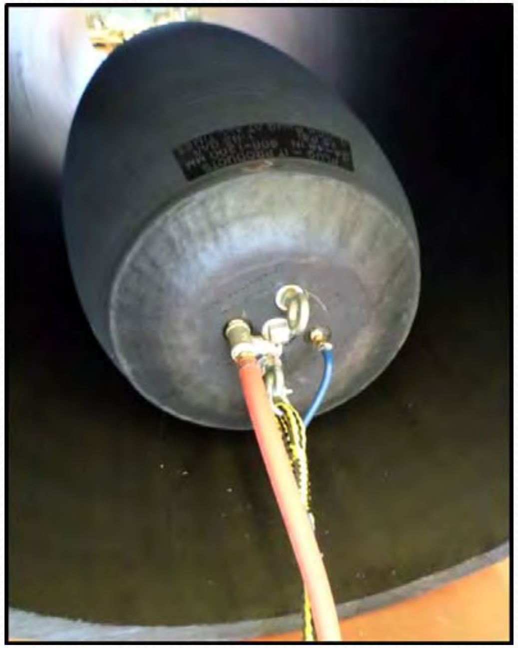
- **Can water jetting be used to clean PE pipe and are any special precautions necessary?**
  - Water jetting can be used for both routine cleaning of debris and also clearance of blockages. The normal practice would be to use low pressure/high volume for cleaning of debris and high pressure/low volume for clearing blockages.
  - Operational conditions for water jetting depend largely on pipe diameter and **SDR** and reference should be made to national or local codes of practice.

Flow stopping

- **What techniques are available for isolating sections of PE pipe for maintenance?**
  - The use of pipe ‘squeeze-off'. Squeeze-off is used in routine and emergency situations to stop or nearly stop flow in PE pipe by flattening the pipe between parallel bars.
  - Depend on pipe SDR, available for HDPE Pipe OD up to 125 mm

Squeeze-off (Fusion)
courtesy of Fusion plc

Inflatable bag flow stopping equipment



Leaks

- **What is the typical expected frequency of leaks in a PE pipe network?**
  - The frequency of repair to PE pipe depends upon a number of factors: above or below ground installation; direct burial or sliplined; location of other utility plant and pipework, etc.
  - Studies of leakage in Belgium and the Netherlands show that PE has a frequency of leaks as follows:
    - In mains: 0.0156 leaks/km/year
    - In services 0.071 leaks/km/year
    - This is comparable with steel and significantly lower than the data for iron pipes.

Damage

- **Is PE more easily damaged than other pipe materials?**
  - Damage to PE pipe most commonly arises from external impact on the wall of the pipeline.
  - If through-wall impact is sustained this results in immediate fluid loss and immediate repair needs to be carried out.
  - However damage to steel and iron pipes tends to damage the external pipe coating and only in extreme circumstances results in through-wall penetration. In such cases damage may not be apparent and the pipeline can remain in operation until failure occurs from pipeline corrosion at some point in the future. Such failures are both difficult to detect and expensive to repair.
  - During routine handling operations, due to its light weight, PE suffers little damage and where potential damage has occurred, for instance from scratches and scoring, guidelines are available from manufacturers to determine its fitness for purpose.
  - PE pipe does not have any coating that can be easily damaged leading to future corrosion.

Damage

- **Is PE more easily damaged than other pipe materials?** (cont'd)
  - During construction and operation most pipeline damage occurs from third party interference while operations are being carried out on other nearby utility pipework and plant, for instance from a mechanical digger. In such cases damage to PE pipe is immediately apparent and can be immediately repaired.
  - However third party damage to steel and iron pipes, in particularly the external coatings, cannot be immediately identified. The pipe can subsequently fail and need repairing at some point in the future incurring higher costs and disruption with little chance of identifying the third party offender with the costs being borne by the pipeline operator.

Static electricity

- **Are any special precautions suggested by customers and installers against the discharge of static electricity during maintenance works?**
  - PE pipe has a high electrical resistivity and static charge can accumulate on the surface of the PE pipe. Normal handling from pipe slings, cloths, etc generates the static charge, particularly in dry conditions.
  - High static electric charges can develop on PE pipes during squeeze-off, when repairing a leak, purging, making a connection, etc. Safety procedures have been developed by the major gas utilities to prevent static electricity igniting the flammable gas-air mixture.
  - Use an earthed wet tape conductor wound around, or laid in contact with, the entire section of the exposed piping.

Repairs

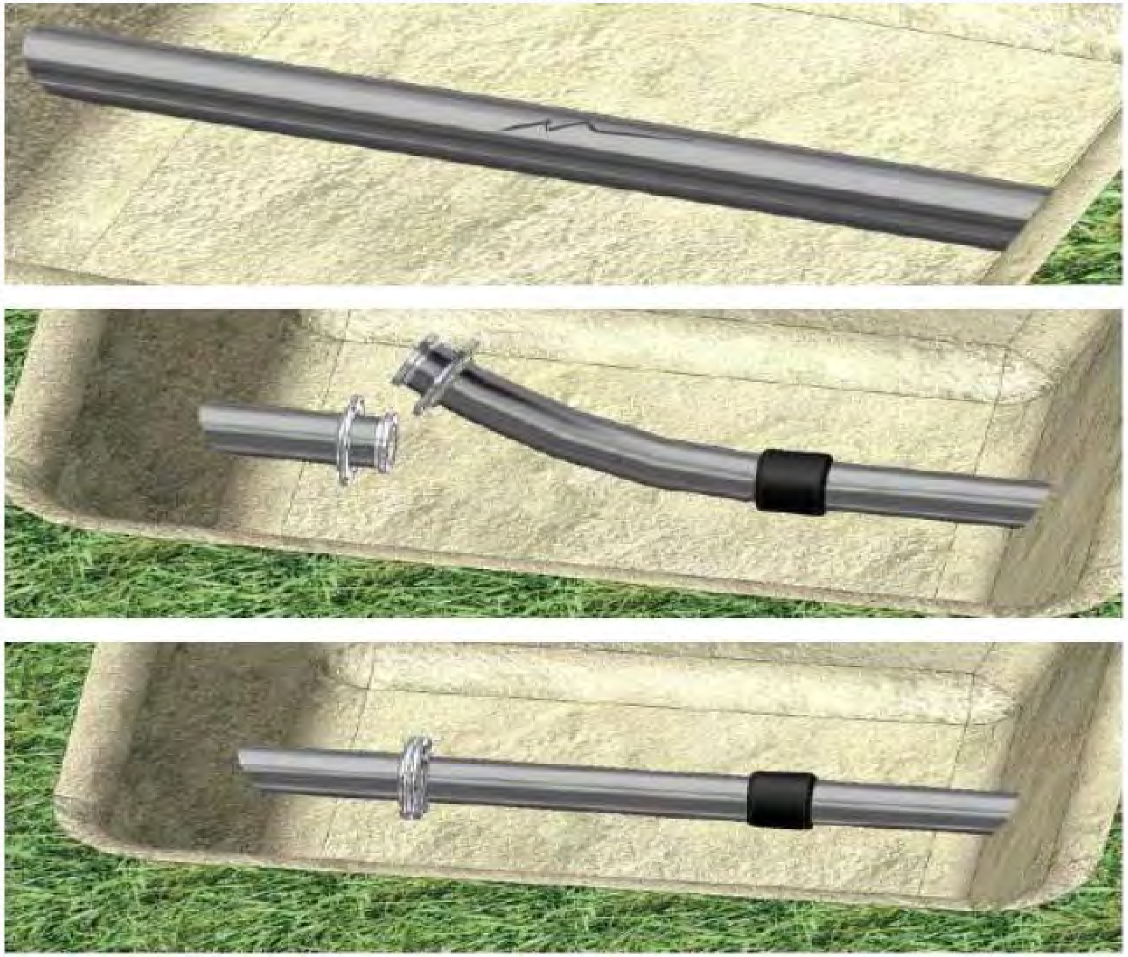
- **How can damaged PE pipe be repaired?**
  - The method of repairing damaged PE pipe depends upon the degree of damage sustained. Localised damage may be repaired by use of an electrofusion saddle or clamp fixed around the damaged area. Such a repair may not be suitable where gas or other flammable fluid is present in the pipe, due to the heat generated in the fusion process. PE encapsulation techniques have recently been developed and may be suitable for localised repairs. **Information on these techniques can be obtained from the pipe manufacturers.**
  - More extensive damage will require the section of pipe to be cut out and replaced. This is a relatively simple process, firstly isolating the damaged section by the use of squeeze-off tools, cutting out the section and replacing with new pipe using electrofusion couplers to tie-in the sections. It is important that the replacement section is of suitable diameter and pressure rating to maintain the integrity of the pipeline.
  - In all cases reference should be made to local or national codes of practice and all health and safety procedures should be closely followed.

Repairs of PE pipe

- Small pipe diameter
- Large pipe diameter
- Electrofusion fittings
- Compression fittings
- Mechanical fittings

Small pipe diameter repair

- HDPE Pipe OD ≤ 110 mm



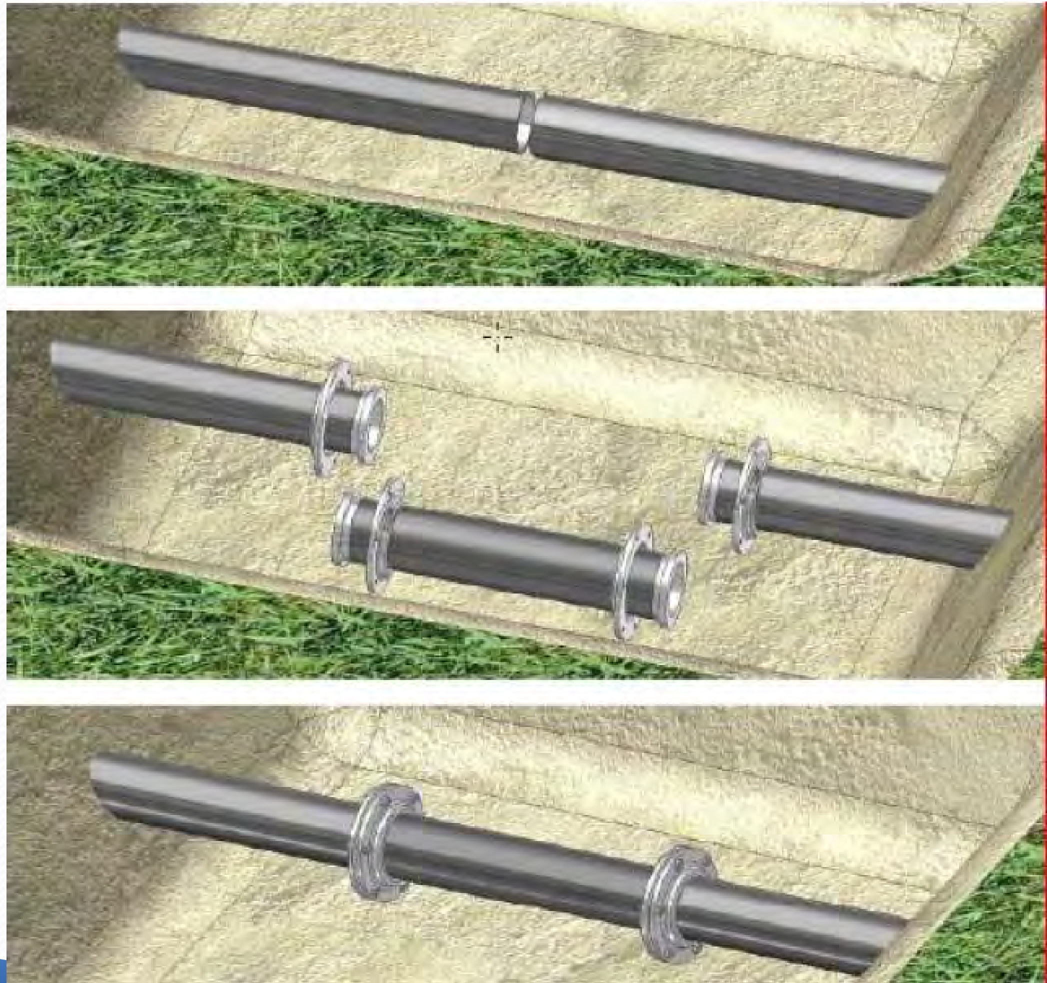
Normal butt fusion machine

- Butt fusion welding machine

Special welding machine

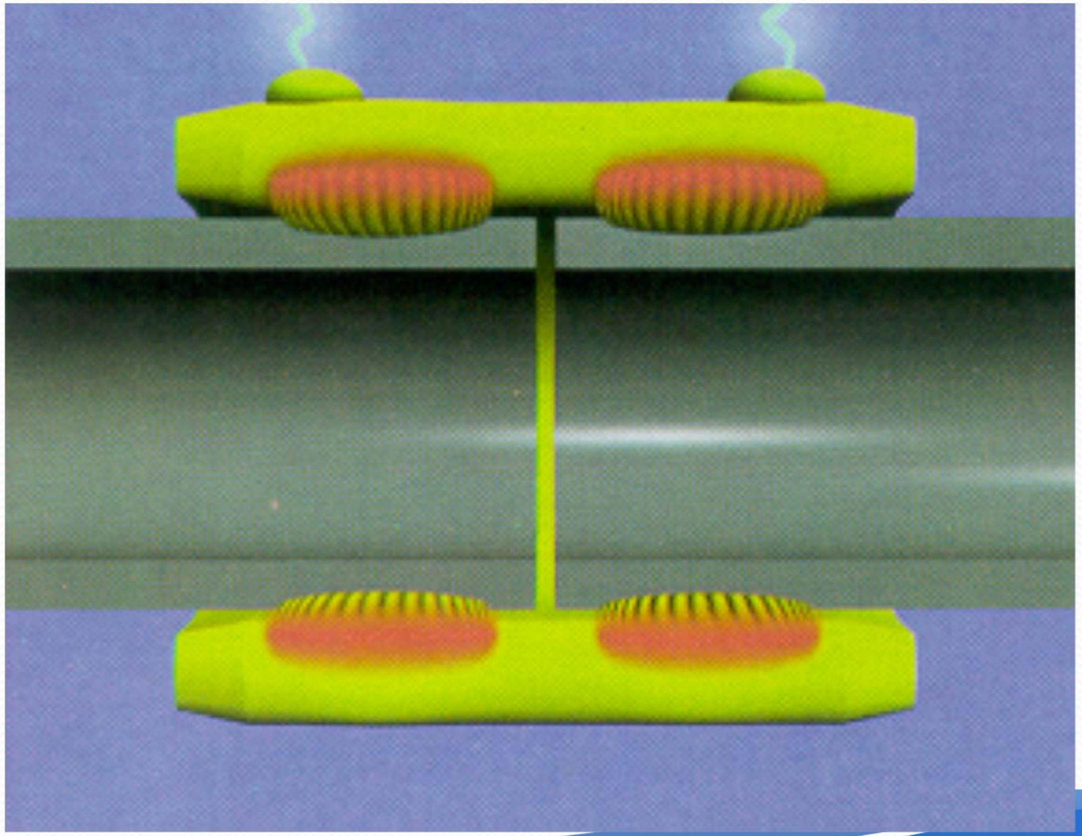
Large pipe diameter repair

- HDPE Pipe OD > 110 mm



Concept of Electrofusion

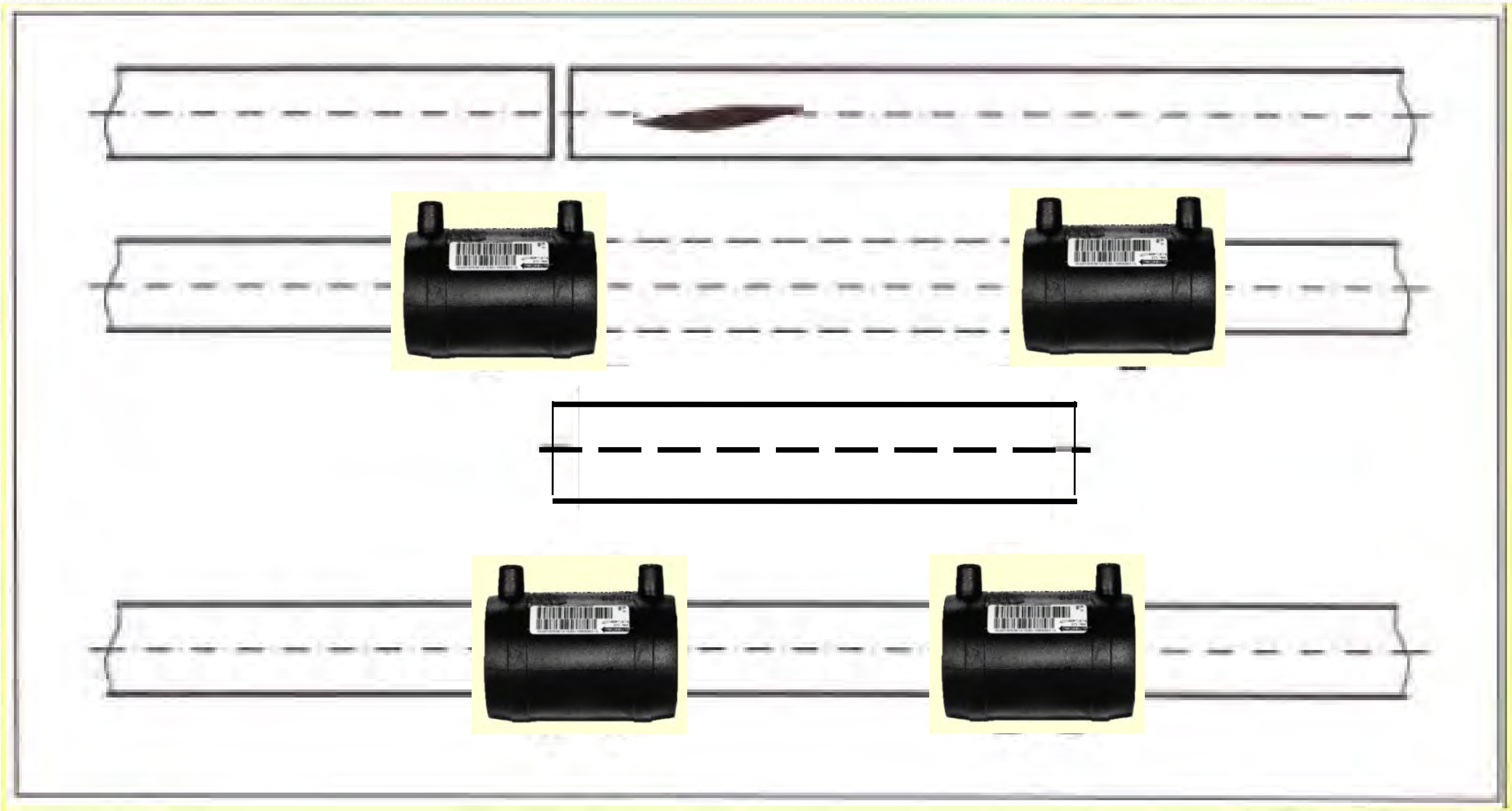
- The electrofusion joint is heated internally by a wire coil at the interface of the joint. Heat is created as an electric current is applied to the wire, in the fitting. The illustration above shows a typical electrofusion joint.



Electrofusion fittings

- Valid for PE Pipe PN ≥ 10 bars

Repair by using electrofusion coupler



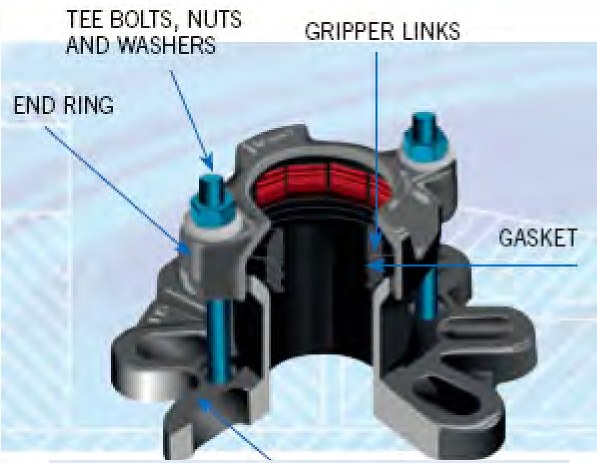
Compression fitting

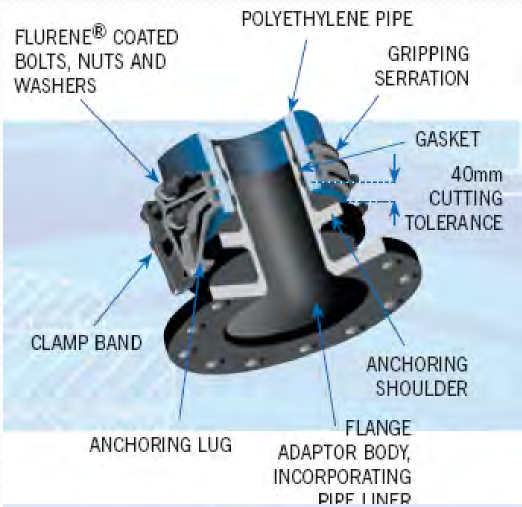
Flange Adaptor
*With optional PP, MS, PE Flange

CODE	SIZE	STANDARD PACK		FLANGE MATERIAL			
	D(mm)	NOS / BAG	NOS / CARTON	SIZE	PP	PE	MILD STEEL
FA 6300	63 mm	-	-	63 mm	PN 6	PN 10	PN 10
FA 7500	75 mm	-	-	75 mm	PN 6	PN 10	PN 10
FA 9000	90 mm	5	5	90 mm	PN 6	PN 10	PN 10
FA 1100	110 mm	5	5	110 mm	PN 4	PN 10	PN 10
				CODE	PPFA	PEFA	MSFA

Mechanical fittings

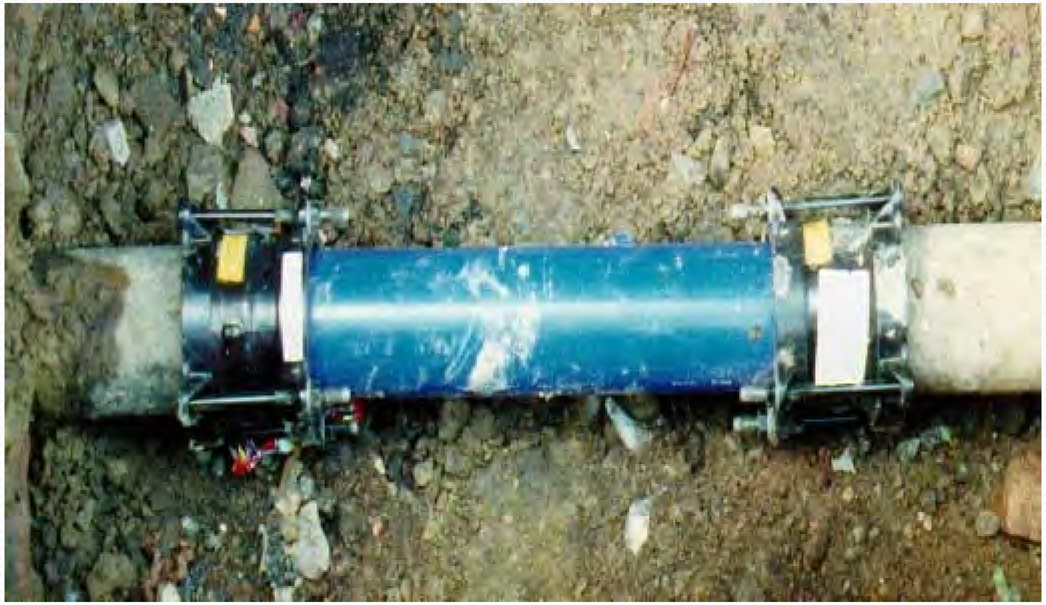
- Coupler → for HDPE pipe up to OD 315 mm
- Flange adapter →for HDPE pipe up to OD1600 mm

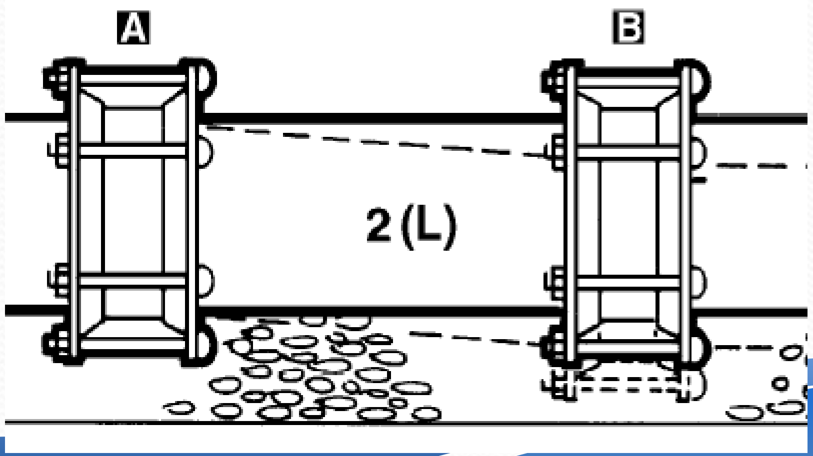




Viking Johnson coupler

Mechanical fittings





Special repair clamp

Plastlock

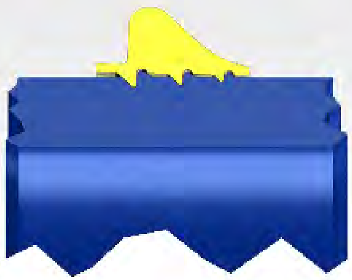
The Teekay Plastlock coupling is the easiest way to join plastic pipes together; designed and engineered to make a permanent connection.

Incorporating the Teekay multiple seal gasket, the design concept has been followed through to the pipe anchoring mechanism itself, which is also constructed with three progressive anchor rings.

These rings permanently hold and lock the two pipes together.

The progressive anchoring design features a single element at each end of the coupling, incorporating three individual pipe anchor rings at staggered heights. This allows for a dynamic locking of the pipe and ensures all three rings are in contact with the pipe wall. Each anchor ring incorporates a chamber which allows the pipe wall to be increased locally around the area where each anchor ring engages with the pipe.

This increases the effectiveness of the anchor rings and allows for a permanent end restraint solution on plastic pipes.



Material Selection

Type I
Casing:
AISI 304/ DIN 1.4301
Fasteners:
Alloy Steel, PTFE Coated
Gasket:
EPDM/NBR/HNBR/Viton

Type II
Casing:
AISI 304/ DIN 1.4301
Fasteners:
AISI 316/ 316L
Gasket:
EPDM/NBR/HNBR/Viton

Type IV
Casing:
AISI 316L/ DIN 1.4404

Q&A

THANK YOU FOR YOUR KIND ATTENTION!!