12 PROJECT WORK

12.1 Rigid Compound Systems

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12.1.1 General / Compound System / Laying Technology

General

The preinsulated jacket-pipe (PJP) is proved practically since decades. In comparison with other conventional laying systems it offers essential advantages concerning **eco**nomical, **eco**logical and technical aspects.

An exact knowledge of the functional properties of the PJP-system will be necessary in order to use these advantages, because extensive special knowledge will be required for the project work.

Corresponding technical working resources have to be provided for the designing engineer, in order to develop economical useful and efficient district heating net works. In the following sections an introduction into the static knowledge will be given. This will however not cover the total extent of all projection work situations.

Therefore the **isoplus**-design engineers will be additionally available at each phase of construction, from tender up to execution and documentation, in order to work out all kind of information and required calculations for any individual problem.

The **eco**nomical situation of the district heating requires to check the limits of pipe static calculations as well as the part-safety correction values [γ_M] of the used materials to a large extent. Therefore the design criteria have to be considered with high attention. This will be guaranteed only by using the latest EDV computing programs.

Compound System

Carrier- and PEHD-jacket-pipe are non-positive connected with each other via the PUR-hard foam as a compound (compound system). Therefore this pipe system respectively laying technology will differentiate essentially compared to conventional procedures.

These special characteristics have to be considered during design and also during pipe laying, in order to guarantee a safe operation and a long lifetime of the PJP-pipeline.

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In case of thermal load all three components carrier pipe, PUR-foam and PEHD-jacket-pipe will expand axial constant, in the opposite to other pipe systems. Therefore all occurring external forces from soil and traffic loads as well as friction between jacket-pipe and surrounding soil (sand bed), will be transmitted on the carrier pipe. Due to the combined effect of these external as well as internal forces, caused by thermal expansion, several tensions will occur, which have to be taken from the compound system.

Because of this limiting values will occur, which have to be considered at design and assembling. The **isoplus**-PJP-systems may be used up to temperatures at minimum acc. to EN 253. On request a corresponding test certificate from an official material test authority (AMPA) can be seen.

Detailed and extensive static calculations will be required at higher temperatures as in EN 253 because this temperatures will cause enormous axial expansions and forces. Therefore the type of burden has to be checked exactly before beginning of the design, because admissible material parameter may reach their limit.

Laying Technology

Pipe laying procedures will be differentiated essentially between Cold Laying and Hot Laying. These two main groups will be characterised again by five different technologies. According to the local regulations respectively restrictions of the pipeline which has to be designed as buried pipeline, among the following five laying procedures can be chosen:

Cold Laying

1) Cold Laying
   without limitation of admissible laying length but with limitation of temperature to max. 85 °C for single pipes and max. 70 °C for double pipes

2) Conventional Laying
   with limitation of admissible laying length
   and temperature according EN 253

3) Operative Self Prestressing
   without limitation of admissible laying length
   but with limitation of temperature to maximum 130 °C

Hot Laying

4) Thermal Prestressing
   without limitation of admissible laying length
   but with prestressing in **not** filled pipe trench and limitation of temperature according EN 253 (preheating temperature = average temperature)
   Attention: Thermal prestressing with electric power is not allowed at isoplus double-pipe!

5) One-Time-Compensator-System
   without limitation of admissible laying length
   but with prestressing in filled pipe trench with limitation of temperature according to EN 253 (preheating temperature according to static calculation)

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12.1.2 Survey Ad- and Disadvantages

Laying Technology		Advantage	Disadvantage
Cold Laying	1) Cold laying	- Slight axial tension from heat extension - Pipe trench may be filled immediately	- Admissible operating temperature max. 85 °C for single pipes and max. 70 °C for double pipes
	2) Conventional laying	- The maximum admissible axial tension will not exceed - Pipe trench may be filled immediately	- The maximum admissible laying length has to be kept by placing of the required expansion sides (L, Z, U)
	3) Operative Self Prestressing	- Pipe trench may be filled immediately - Saving of expansion sides - also possible in the gliding area	- Extremely axial expansion movements - Danger of buckling - Axial tension exceeding the yield point of steel - Tapping branches will be not possible later on
Hot laying	4) Thermal Prestressing	- Limitation of axial tension - any desired laying length - Low axial expansion - Saving of expansion sides	- Pipe trench has to be kept open until prestressing will be finished - Depending from method an adjustable operational medium or a 380 V supply connection will be necessary
	5) One-Time-Compensator-System	- Pipe trench may be filled immediately, except of the one-time-compensators - Saving of expansion sides	- The higher the temperature, the more compensators will be required - The assembling pits have to be kept open until preheating

12.1.3 Admissible Laying Length L_{max} Single Pipe at convent. Laying

Dimensions Carrier Pipe				Jacket-Pipe Outside-Ø D_a in mm			L_{max} at a covering height [$Ü_H$] from upper edge, upper-edge-Jacket pipe (JP) up to upper-edge-terrain								
Nominal Diameter in		Outside-Ø d_a in mm	Wall-thickness acc. to isoplus in mm				$Ü_H$ = 0,80 m			$Ü_H$ = 1,20 m			$Ü_H$ = 1,60 m		
				Insulation Class			Insulation Class			Insulation Class			Insulation Class		
DN	Inches			Standard	1x reinf.	2x reinf.	Standard	1x reinf.	2x reinf.	Standard	1x reinf.	2x reinf.	Standard	1x reinf.	2x reinf.
20	¾"	26,9	2,6	90	110	125	56	45	40	38	31	27	29	23	20
25	1"	33,7	3,2	90	110	125	87	70	61	59	48	42	45	36	32
32	1¼"	42,4	3,2	110	125	140	90	79	70	61	54	48	47	41	36
40	1½"	48,3	3,2	110	125	140	104	90	80	71	62	55	54	47	42
50	2"	60,3	3,2	125	140	160	114	101	88	78	69	60	59	53	46
65	2½"	76,1	3,2	140	160	180	129	111	98	89	77	68	67	59	52
80	3"	88,9	3,2	160	180	200	131	115	102	90	80	71	69	61	54
100	4"	114,3	3,6	200	225	250	148	130	115	103	91	81	79	70	62
125	5"	139,7	3,6	225	250	280	159	141	124	111	99	88	86	76	68
150	6"	168,3	4,0	250	280	315	187	165	145	132	117	103	102	91	80
200	8"	219,1	4,5	315	355	400	210	183	159	150	131	115	116	102	90
250	10"	273,0	5,0	400	450	500	218	190	167	158	138	123	124	109	97
300	12"	323,9	5,6	450	500	560	249	220	192	182	162	142	144	128	112
350	14"	355,6	5,6	500	560	630	240	210	181	177	155	135	140	123	108
400	16"	406,4	6,3	560	630	670	266	231	214	198	173	160	157	138	128
450	18"	457,2	6,3	630	670	710	257	238	222	193	179	168	154	144	135
500	20"	508,0	6,3	670	710	800	262	244	210	198	185	160	159	149	130
600	24"	610,0	7,1	800	900	1000	278	240	209	214	185	163	173	151	133
700	28"	711,0	8,0	900	1000	-	309	270	-	240	211	-	196	173	-
800	32"	813,0	8,8	1000	1100	-	332	294	-	261	232	-	215	192	-
900	36"	914,0	10,0	1100	1200	-	368	329	-	292	262	-	242	218	-
1000	40"	1016,0	11,0	1200	1300	-	359	324	-	287	260	-	239	217	-

The values given in the table are based on the AGFW guideline FW 401 Part 10 and apply to soils with a specific weight of 19 kN/m^3, a maximum permitted shear stress [τ_{PUR}] of ≤ 0.04 N/mm^2 and an angle of internal friction [φ] of 32.5°, and for black carrier pipes, material P235GH (welded or seamless), No. 1.0345, wall thickness in accordance with **chapter 2.2.2** or **2.2.3**.

Maximum permitted axial stress [σ_{zul}] in a straight pipe = 190 N/mm^2, with a maximum operating temperature [T_B] of 130° C and a nominal pressure of PN 25. Depending on the T_B and depth of cover [$Ü_H$] a laid length of ≥ 120m can cause an axial elongation [ΔL] of >80 mm. This ΔL causes an expansion pad thickness [DP_s] of > 120 mm.
The PEHD casing pipe temperature is limited to a maximum of 60° C according to AGFW FW 401, which in turn means a maximum permissible DP_s of 120 mm. If there is then an ΔL von > 80 mm, the expansion leg or pad should be pre-tensioned.

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12.1.4 Admissible Laying Length L_{max} Double Pipe at convent. Laying

Dimensions Carrier Pipe				Jacket-Pipe-Ø D_a		Spread	L_{max} at covering height [$\ddot{U}_H$] from upper edge upper-edge-Jacket Pipe (JP) up to upper edge-terrain					
Double Pipe Type		Outside-Ø d_a	Wall-thickness isoplus	in mm		[K]	$\ddot{U}_H$ = 0,80 m		$\ddot{U}_H$ = 1,20 m		$\ddot{U}_H$ = 1,60 m	
				Insulation Class			Insulation Class		Insulation Class		Insulation Class	
DN	Inches	in mm	in mm	Standard	1x reinf.		Standard	1x reinf.	Standard	1x reinf.	Standard	1x reinf.
20	3/4"	26,9	2,6	125	140	20 K	63	57	43	39	33	30
25	1"	33,7	3,2	140	160		78	69	54	48	41	36
32	1¼"	42,4	3,2	160	180		86	77	60	54	46	41
40	1½"	48,3	3,2	160	180		97	87	68	61	52	47
50	2"	60,3	3,2	200	225		96	86	68	61	52	47
65	2½"	76,1	3,2	225	250		106	95	75	68	58	53
80	3"	88,9	3,2	250	280		108	97	77	69	60	54
100	4"	114,3	3,6	315	355		119	106	86	77	68	60
125	5"	139,7	3,6	400	450		108	96	80	71	63	56
150	6"	168,3	4,0	450	500		123	111	92	83	73	66
200	8"	219,1	4,5	560	630		134	119	102	91	82	73

Type	Spread [K]	$\ddot{U}_H$ = 0,80 m		$\ddot{U}_H$ = 1,20 m		$\ddot{U}_H$ = 1,60 m	
		Insulation Class		Insulation Class		Insulation Class	
		Standard	1x reinf.	Standard	1x reinf.	Standard	1x reinf.
20	30 K	58	52	40	36	30	27
25		72	63	50	44	38	33
32		79	71	55	49	42	38
40		89	80	62	56	48	43
50		88	79	62	56	48	43
65		97	88	69	62	53	48
80		99	89	71	64	55	50
100		110	97	79	71	62	56
125		100	88	73	65	58	52
150		114	102	84	76	67	61
200		124	109	94	83	76	67

Type	Spread [K]	$\ddot{U}_H$ = 0,80 m		$\ddot{U}_H$ = 1,20 m		$\ddot{U}_H$ = 1,60 m	
		Insulation Class		Insulation Class		Insulation Class	
		Standard	1x reinf.	Standard	1x reinf.	Standard	1x reinf.
20	40 K	53	48	37	33	28	25
25		66	58	45	40	35	31
32		72	65	50	45	39	35
40		82	73	57	51	44	39
50		81	72	57	51	44	39
65		89	80	63	57	49	44
80		91	81	65	58	50	45
100		100	89	73	65	57	51
125		91	81	67	60	53	47
150		104	93	77	70	62	56
200		113	100	86	76	69	62

Type	Spread [K]	$\ddot{U}_H$ = 0,80 m		$\ddot{U}_H$ = 1,20 m		$\ddot{U}_H$ = 1,60 m	
		Insulation Class		Insulation Class		Insulation Class	
		Standard	1x reinf.	Standard	1x reinf.	Standard	1x reinf.
20	50 K	48	43	33	30	25	23
25		59	52	41	36	31	28
32		65	58	46	41	35	31
40		74	66	52	46	40	36
50		73	65	52	46	40	36
65		81	73	57	52	44	40
80		82	74	59	53	46	41
100		91	81	66	59	52	46
125		83	73	61	54	48	43
150		94	84	70	63	56	50
200		103	91	78	69	63	56

Type	Spread [K]	$\ddot{U}_H$ = 0,80 m		$\ddot{U}_H$ = 1,20 m		$\ddot{U}_H$ = 1,60 m	
		Insulation Class		Insulation Class		Insulation Class	
		Standard	1x reinf.	Standard	1x reinf.	Standard	1x reinf.
20	60 K	43	39	30	27	23	20
25		53	47	37	32	28	25
32		59	52	41	37	31	28
40		66	59	46	41	35	32
50		66	59	46	41	36	32
65		72	65	51	46	40	36
80		74	66	53	47	41	37
100		81	72	59	53	46	41
125		74	65	54	48	43	38
150		84	76	63	56	50	45
200		92	81	70	62	56	50

If the double-pipe is being thermal stressed, the three components carrier pipes, PUR foam and PEHD jacket pipe, in contrast to others pipe systems, stretch axially on the effective average temperature between forward and reverse.
For the **isoplus** double pipe the maximum laying length [L_{max}] is depending on the depth of cover [$\ddot{U}_H$] and spread [K].

The values given in the table are based on the AGFW guideline FW 401 Part 10 and apply to soils with a specific weight of 19 kN/m³, a maximum permitted shear stress [τ_{PUR}] of ≤ 0.04 N/mm² and an angle of internal friction [φ] of 32.5°, and for black carrier pipes, material P235GH (welded or seamless), No. 1.0345, wall thickness in accordance with **chapter 2.3.2** or **2.3.3**.
Maximum permitted axial stress [σ_{zul}] in a straight pipe = 190 N/mm², with a maximum operating temperature [T_B] of 130° C and a nominal pressure of PN 25.

Further information to project work is available in our download area **www.isoplus.org**

12.2.1 General / Admissible Laying Length

For flexible pipe systems as well as for rigid PJP-compound systems a high degree of conversion of special know-how will be required. The following examples will show proved pipe laying technology of **isoplus**-flexible pipes.

Flex Pipe		**isoflex**						**isocu**						
Type		**20**	**28**	**28 v**	**28+28**			**22**	**28**	**22+22**			**28+28**	
Dimensions		20x2,0/75	28x2,0/75	28x2,0/90	2 • (28x2,0)/110			22x1,0/65	28x1,2/75	2 • (22x1,0)/90			2 • (28x1,2)/90	
spread in **K**		- -	- -	- -	**20**	**30**	**40**	- -	- -	**20**	**30**	**40**	**20**	**30**	**40**
depth of cover [U_H]	0,40 m	47	67	56	74	67	59	29	38	27	23	20	40	35	30
	0,60 m	31	45	38	53	47	42	20	26	19	16	14	28	24	21
	0,80 m	24	34	28	41	37	32	15	20	14	13	11	21	19	16
	1,00 m	19	27	23	33	30	26	12	16	12	10	9	17	15	13

Spread [K] = Difference of temperature between flow and return line.
At operating temperatures < 60° C no effect on **isocu**-pipe laying lengths.
At operating temperatures < 85° C no effect on **isoflex**-pipe laying lengths.

The Values mentioned in the table are for soils with a specific weight of 19 kN/m^3 as well as a friction angle of 32,5°. Parameters which will differ from that will lead to other lengths, which will be calculated from **isoplus**-design engineers on request. For bridges class SLW 60 (33,3 kN/m^2 surface load; 100 kN wheel load) a minimum covering height of 0,40 m will be sufficient for all **isoplus**-flexible pipes.

isoflex: Maximum permissible axial tension [σ_{zul}] in straight pipe = 150 N/mm^2
isocu: Maximum permissible axial tension [σ_{zul}] in straight pipe = 110 N/mm^2

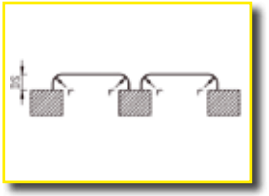
In case of pipe laying lengths > L_{max} **isoflex**- and **isocu**-pipelines should be thermal pre-stressed, or one of the following described first three application-technology (Loop-Technology, U-Compensation or Wave-Technology) has to be used. The axial expansion which will occur at every kind of technology has to be compensated by use of corresponding long expansion side legs and pads.

isopex-pipes are self compensating and may therefore be laid without limitation of laying lengths and without expansion pads. Due to the remaining tension and -bending after uncoiling, **isopex**-pipes may and will be laid similar like wave-technology.
isoclima-pipes will be installed generally without limitation of laying length and without expansion pads because of the maximum operating temperature of 30 °C.

12.2.2 Application isoflex and isocu

Loop-Technology

Flexible pipes will be laid from building to building resp. from house connection area to house connection area, L_{max} has to be considered. In front of the building additionally an expansion side leg [DS], of at least 1,00 m, or a minimum bending radius [r] has generally to be considered.



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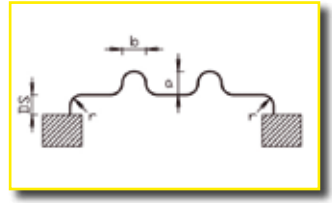
U-Compensation

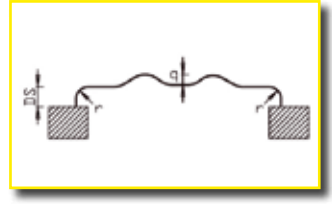
In case of pipe laying lengths longer than L_{max} U-compensation may be used. From U-elbow to U-elbow the corresponding maximum pipe laying length L_{max} has to be kept. The length [a] and the width [b] of the U-elbows should be at least the double of the minimum bending radius [r].



Wave-Technology

Pipe laying in wavy lines may be also used in case that L_{max} will be exceeded. The flexible pipes will be laid in wavy lines with a cross-measure [q] of at least 2,00 m.

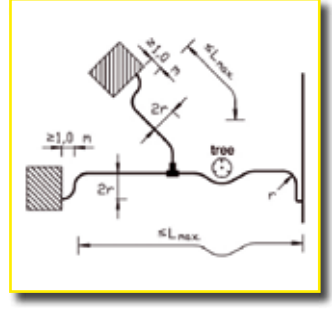
At the beginning and at the end of such a section a 90° angle with a corresponding minimum bending radius [r] has to be provided. Branches can be not installed in this kind of technology.



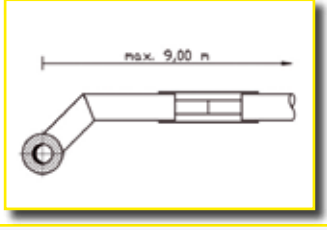
Branch-Technology

The connection of **isoflex**- resp. **isocu**-pipes will be made by use of pre-fabricated 45°- or parallel-branches.
It will be generally possible, to produce all kinds of branches, as described in **chapter 2.2** and **2.3**..

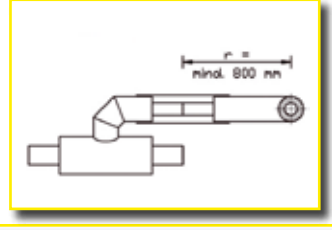
The connecting branch-pipe to the main pipe will be made by use of **isoflex** or **isocu**, depending from requirement, that means no additional carrier pipe and jacket-pipe reduction will be necessary.



45° T-Branch



Parallel-Branch

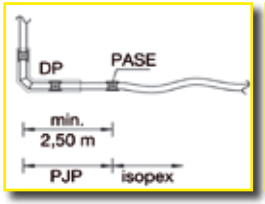


12.2.3 Application isopex

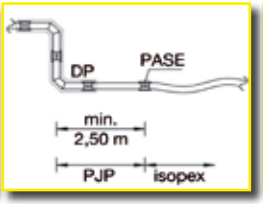
Transition PJP

Before connection of **isopex** on a axial or/and lateral expanding pipe system like **isoplus**-jacket-pipe (PJP), the expansion has to be compensated. That means, that before the transition of the PJP-pipe an L-, Z- or U-elbow has to be projected, or an anchor (FP) has to be provided.

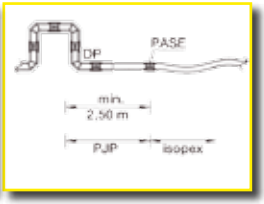
L-Elbow



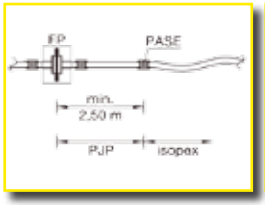
Z-Elbow



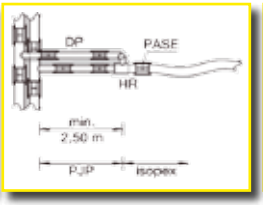
U-Elbow



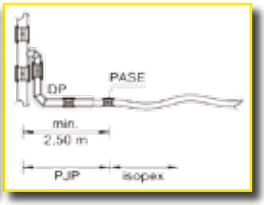
Anchor



45° T-Branch



Parallel-Branch



PASE = Press-Coupling with Welding-End **HR** = Bifurcated pipe

In case of a system-change within a PJP-branch-pipe, a rigid PJP-piece of pipe of at least 2,50 m lengths has to be provided between branch and transition for compensation of lateral expansion.

Expansion side legs of PJP-systems have to be provided with expansion pads (EP), according to the **isoplus** line-drawing.

Branch isopex

Alternatively it will be possible to carry out branches from several pipe systems with different kinds of connections and branches. The following **isopex**-branch technologies (possibilities A-D), see **following pages**, show the practically most used possibilities. In case of transitions to expanding pipe systems like i. e. **isoplus**-PJP (A-C), the pipe static has to be considered, see above.
In case of other applications please contact **isoplus**-application engineers.

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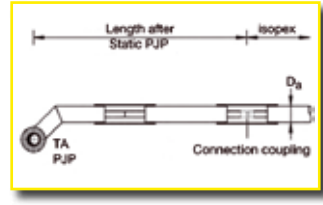
12.2.4 Possibilities / Examples

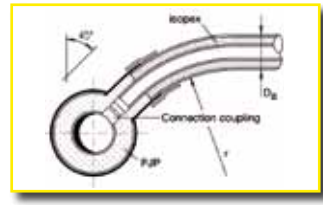
isoplus-PJP - isopex
Possibility A

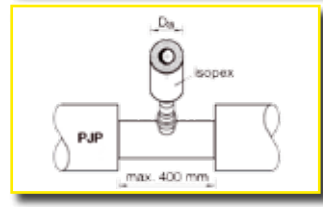


At the factory pre-insulated branch, according to the Design Manual, **chapter 2.2 and 2.3**, an **isopex**-connection coupling with unilateral welding end of steel will be welded to the corresponding branch-steel pipe of the prefabricated insulated branch, see **chapter 3.6.5**, and **10.2.17**.

The post-insulation at this spot will be made by use of a connection coupler or reducing coupler, according to Design Manual, **chapter 6** - Connection Technology Jacket-Pipe. Reducing couplers are only necessary if the outside diameter, [D_a] of the jacket pipe will be not the same as outside diameter of the **isopex**-pipe.

isopex - isopex
Possibility B





In case that house connections have to be installed later on into a pipeline which is still not in operation, the installation will be also made by use of a **isopex**-connection coupling with unilateral welding end of steel.

The insulation of the main pipe will be removed for a length of maximum 400 mm. The branch diameter of the carrier pipe will be tapped or burned out. Thereafter the connection coupling will be welded electrically or autogenously to the rigid **isoplus**-PJP-system, preferable in 45° angle. Connection coupling see **chapter 3.6.5**, assembling see **chapter 10.2.17.**

Post-insulation at this spot will be carried out by using half-shells, see **chapter 3.6.4**, or using an assembly branch. Informations concerning PEHD-assembly branches, see Design Manual, **chapter 6** - Connection Technology Jacket-Pipe!

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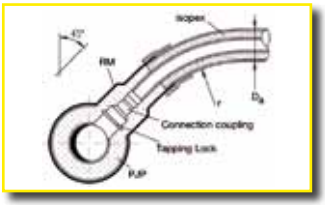
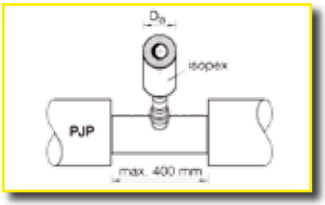
isoplus-PJP - isopex
Possibility C

In case that the rigid PEHD-jacket-pipeline will be already in operation, the connection has to be carried out by tapping procedure and by use of **isopex**-connection coupler with unilateral welding end made of steel.



The insulation of the main pipe will be removed for a length of maximum 400 mm. Thereafter the corresponding dimensioned tapping lock will be welded electrically to the rigid **isoplus**-PJP-system, preferable with an angle of 45°. Available tapping locks see Design Manual, **chapter 7.1.2**.

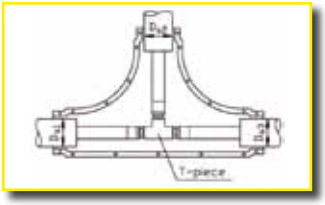
After the tapping has been carried out in accordance to Design Manual **chapter 10.2.11** also the connection coupling has to be welded electrically to the tapping lock. Connection coupling see **chapter 3.6.5,** assembling see **chapter 10.2.17**.



Post-insulation at this spot will be carried out by use of PEHD-assembling branch, see Design Manual, **chapter 6** - Connection Technology jacket-pipe. Due to the bigger nominal diameter of the tapping lock eventually an reinforced insulation thickness will be required at the branch, respectively a reducing coupler has to be provided.

isopex - isopex
Possibility D

Branches within the **isopex**-system will be carried out with **isopex**-T-pieces which should be preferable assembled with a branch-angle of 45°.



The flexible pipes will be cut right-angled and the insulation will be removed at all three ends to a length of maximum 150 mm. Thereafter the T-piece has to be fixed at the pipe ends, as described on **chapter 10.2.17**. Post-insulation of this branches will be carried out with GFK-assembly branches, see **chapter 3.6.4**.

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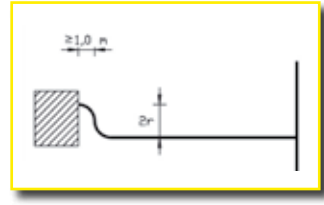
House Connection

with 45° T-Branch

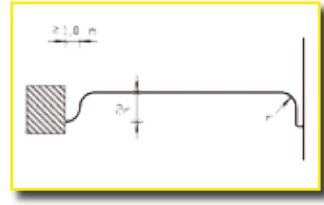


Buildings can be connected directly up to a distance of 9,00 m with **isoflex** and **isocu**, by using a 45°-branch.

Before the house-entry an expansion side-leg of a length corresponding to the double of the minimum bending radius [r] has to be provided. This will guarantee that inside of the building no expansion and no other strength have to be compensated.

In case of **isopex** and **isoclima** a limitation of length will be not necessary.

with Parallel-Branch



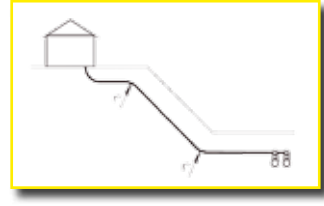
In case of parallel connections an expansion side-leg with a length according to the minimum bending radius [r] has to be provided for the exit pipe of the branch.

From this side-leg to the building the max. permissible pipe laying length [L_{max}], has to be considered in case of **isoflex** and **isocu** see **chapter 12.2.1**, or longer length one of the described pipe laying possibilities should be used, **chapter 12.2.2**.

In front of the house-entry a side-leg, preferable with the double length of the minimum bending radius [r] has to be provided, for the same reasons as at 45°-connection.

A limitation of the length is not necessary in case of **isopex** and **isoclima**.

at Sloping Terrain



In case that big height-differences i. e. terrain-embankments have to be overcome, **isoplus**-flexible pipes will be particularly suitable.

The connection to the main pipeline will be made as already described with 45°- or parallel-branch.

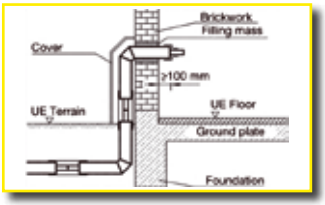
House Connection without Cellar

with Elbow - Outside

According to requirement PJP-elbows with standard side-legs or 1,00 • 1,00 m or 1,00 • 1,50 m length will be used, see Design Manual, **chapter 2.2.7** and **2.3.7** and **3.6.2**.

In connection with **isopex** connection couplers with one-side welding end will be required, see **chapter 3.6.5**, assembling see **chapter 10.2.17**.

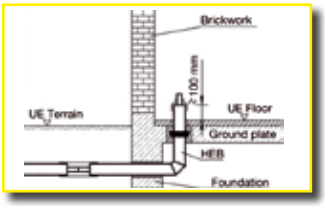
Post-insulation of the connection spots will be made by use of corresponding connection couplers, see Design Manual, **chapter 6** - Connection Technology Jacket-Pipe.



with Elbow - Inside

House-entry-elbows (HEB) with a standard delivery length of 1,00 • 1,50 m will be also used for houses without cellar, see **chapter 3.6.2**.

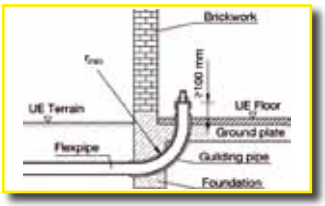
This solution will guarantee that there will be no connection coupler in the foundation and in the area of the ground-plate of the house. Post-insulation of the connection spots will be made by use of a connection coupler.



with Guiding Pipe

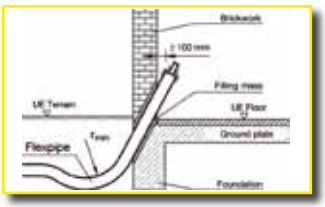
During construction of the house a suitable and flexible guiding pipe has to be installed into the foundation and into the ground-plate. The diameter of the protecting pipe should be at least 30 mm bigger than the PELD-jacket-pipe dimension of the flexible pipe.

ATTENTION: Minimum bending radius [r] of the used flexible pipe has to be kept absolutely.



Special

Special constructions for house connections of houses without cellar may be installed only after agreement and approval by **isoplus** design-engineers.



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