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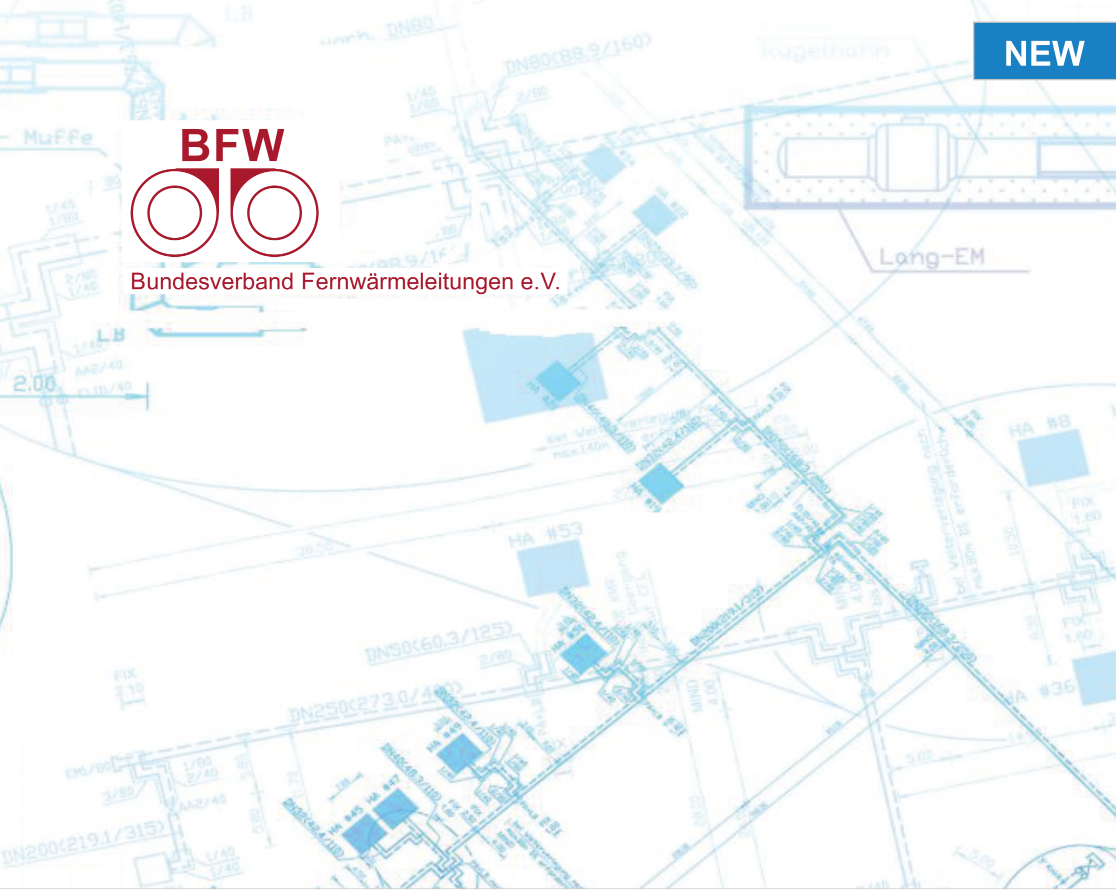

BFW

Bundesverband Fernwärmeleitungen e.V.

The practical assembly manual

For the installation of pre-insulated district heating pipes

Plan - Check - View

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Imprint

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Authors

Dr. Thomas Böhmer, Böhmer GmbH

Christian Ebert, ISOBRUGG Steel Casing Pipe GmbH.

Johannes Ellmer, isoplus Fernwärmetechnik Vertriebsgesellschaft mbH

Andreas Gräve, Lancier Monitoring GmbH

Christof Grieser-Schmitz, BASF Polyurethanes GmbH

Frank Hellmann, 4 pipes GmbH

Ralph Herzer, German Pipe GmbH

Jens Heyer, Chamber of Crafts Aachen

Gerd Moser, BRUGG Pipe systems GmbH

Ludger Tidde, Lancier Monitoring GmbH

Olaf Rickert, BROEN A/S

Ronald Schröder, IFW - Engineering Company for Heat Technology mbH

Jürgen Schütze, BRUGG Pipe Systems GmbH

Jakob Sørensen, isoplus Fernwärmetechnik Vertriebsgesellschaft mbH

Knud Strauchmann, Böhmer GmbH

Sebastian Vogt, Lancier Monitoring GmbH

Oliver Vollmann, STURM Isotech GmbH & Co. KG

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All contents and chapters have been prepared with the greatest care by the authors. Should you nevertheless discover an error, please send a message to: Anfrage@bfwev.de or directly to the Federal Association of District Heating Pipelines e.V. Kraftwerk Mitte 5-7, 01067 Dresden, Germany

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Foreword

"The truth is on the pitch..."

Even if this unforgettable sentence by Otto Rehhagel referred rather to the predictability of a soccer match, it also has a certain validity in district heating construction. Here, too, precise planning before kick-off is just as crucial as the ability to react to unplanned events later on the (construction) field with the help of the right resources and knowledge.

With every project, we are playing for a tight budget, our reputation, our jobs and, last but not least, a reliable heat supply for thousands of residential and commercial premises. Every action, therefore, must be as precise, efficient, and as sustainable as possible!

This is precisely where this book comes in. Because on the following pages you will find a lot of information that will help you to successfully implement your district heating project.

This book is made by practitioners for practitioners. It is intended to provide you with a practical illustration of the daily and not-so-daily facts for the planning and installation of district heating pipelines. This new edition was once again created with the help of a large number of authors, who often checked, updated and rewrote the contents in their free time and at weekends. I would like to take this opportunity to thank them on behalf of the BFW Board.

Thanks are also due to the companies involved, which financed the realization of the book through their advertisements.

Incidentally, these companies strictly refrain from product advertising within their articles and place their business interests behind a common motivation; namely that of preserving and expanding the importance of district heating among the technologies of the future. There are good reasons for this, because district heating is and will remain the most interesting heat source, especially from a CO^2 emission point of view.

As a network specialist, you know that your work will disappear into the ground for decades after completion. Perhaps you have already found yourself regretting this fact. But even if your achievement is hidden by asphalt and concrete, it still has a positive impact on the lives and well-being of many.

Isn't that a good reason to continue and perhaps even increase your commitment to district heating!

Sincerely yours

Dr. Thomas Böhmer

Chairman of the Board of Directors of Bundesverband Fernwärmeleitungen e.V.

The Federal Association of District Heating Pipelines e.V. - a network of strong partners.

The Federal Association of District Heating Pipelines e.V. (BFW) is an

association of numerous companies from Germany and neighboring European countries involved in the construction of district heating pipelines. Our goal is to ensure an intensive exchange of experience, to take up and expand technical developments and, above all, to qualify our members.

Within our topic-specific working committees, new ideas are constantly generated and comprehensive standards and working aids for planners and practitioners are developed. In particular, this is intended to sharpen and strengthen quality awareness.

This is because there is often a lack of understanding of the technical problems and challenges that those involved in district heating pipeline construction have to deal with. This is where the Federal Association comes in and provides support as a competence network with its comprehensive range of services:

- Qualification and further training measures
- (according to AGFW FW 603 and DVS 2212-4)
- BFW expert forum
- Interface for technical questions
- Provision of working aids
- Publisher of "The practical installation manual
- Publisher of the digital "Rohrpost
- Regular exchange of experience in the BFW working group and working committees
- Initiation of and participation in research projects
- Intensive exchange with the AGFW

The BFW's practical guide - The Practical Installation Handbook - now available to you structures basic and specialist knowledge relating to district heating pipeline construction and is already enjoying a positive response in its 4th edition.

Written by specialists, this basic work covers all important areas and regulations, taking into account international standards. The easy-to-understand guide is intended to serve as a valuable guide for those responsible for the planning, awarding and execution as well as installation and maintenance of local and district heating systems.

To expand your technical knowledge, we recommend participating in our annual BFW Expert Forum! In this series of events under the motto "From experts - for experts", the participants are provided with two days of innovative and technical expertise as well as assistance for error prevention and for systemic self-monitoring (of all construction steps). Dates can be found on our homepage www.bfwev.de.

The Federal association district heating registered association is however more than a specialized federation. The members of the federation stand already for many years in a close, partnership exchange. The quality-oriented level of our work is only made possible by the commitment that each individual volunteer makes to this association.

I am proud and very pleased that I have been given the trust to further develop and advise the BFW as working group chairman. I have been familiar with the topic of "district heating" on various levels since 1996 and I, too, learn something new every day.

I hereby cordially invite you to enter into an intensive dialog with me - and above all with the German District Heating Association e.V. - and to improve the quality of district heating pipeline construction together with you and your experience.

Yours, Oliver Vollmann

Chairman of the Working Group of the German District Heating Pipeline Association.

1.0 Planning - statics, laying and connection variants and design of expansion pads

1.1 Expansion paths

For all subsequent considerations, we consider the line length l to be the distance from a freely moving line end (change of direction or compensator) to the point under consideration, to a fixed point component, or to a natural fixed point (usually in the middle of a straight line).

1.2 Frictional force in the soil

Whenever the pipe moves in the soil, a frictional force F'R acts on the casing pipe in the opposite direction to the direction of movement. This frictional force depends on the diameter of the casing pipe, the coefficient of friction between the sand and the PE casing pipe, the average earth pressure around the circumference and the weight of the pipe (with or without water filling). The average earth pressure is influenced by the laying depth, the earth density and the degree of compaction. Good compaction in the pipe area requires void-free underfilling of the pipes and a trench bottom capable of compaction.

The effective friction coefficient depends on the grain shape and grain distribution as well as on the water content of the backfill sand. Particularly large scattering of the friction forces occurs if the sand adjacent to the pipe contains cohesive constituents.

1.3 Stress on the rigid polyurethane foam

For small and medium nominal diameters (up to approx. DN 200), the compressive strength of the PUR rigid foam is predominantly decisive for the permissible earth and live loads.

Larger pipes are deformed as a whole when overloaded, but they are increasingly strengthened with diameter due to the bond between the carrier pipe and the casing pipe. Up to DN 600, the load capacity is determined by the deformation capacity of the rigid PUR foam.

There is a high level of safety against overloading by earth and traffic loads in the usual applications in practice.

1.4 Stresses in the buried composite pipe

The frictional forces acting on the PE casing pipe are transmitted to the steel pipe through the composite. Here, depending on the direction of movement from the free end of the pipe, they accumulate as tensile or compressive stresses or change the stress ratios existing here from previous movements.

1.4.1 Basic rule

Along the pipe axis, without a fixed point, the longitudinal force can only increase or decrease by the effective frictional force per running meter.

Since the longitudinal forces do not change in the adhesion area, no frictional force and shear stress act here. Conversely, it follows that in protection tubes, even when they are arranged in the sliding area, the longitudinal forces in the tube do not change due to the lack of frictional force, but l and Δl do.

1.5 Laying without preload

The de-energized state existing during installation is never reached again after commissioning.

During heating, compressive stresses occur which reduce the length compared to the free expansion; during cooling, tensile stresses occur which increase the length compared to the previously stress-free state. At intermediate temperatures, completely different stress distributions may be present along the tube axis, depending on the preceding temperature profile. The actual elongation path cannot be calculated from a momentarily measured temperature alone, and the friction force (hysteresis) cannot be calculated from an elongation path measured at an intermediate temperature.

Unambiguous ratios are only present at the highest and lowest temperatures. The first expansion movement from the stress-free state is the largest. The expansion legs must be designed for this. They are only used to one side during operation. A mechanical prestressing of the expansion legs could result in a reduction of the required expansion zone thickness and a reduction of the expansion leg lengths. Since it is usually not possible to separate the bend to be prestressed at the optimum point, bending moments other than forces would have to be applied at the connection point, since otherwise the bend would not be stress-free after 50% expansion travel.

1.6 T - Branches

The steel parts of the T-pieces are to be designed in such a way that they do not represent an inadequate weakening either for the stress due to internal pressure or for the longitudinal forces.

In order to keep the bending stresses due to the height offset within the permissible limits, branch lines with a maximum length of 6 m may open directly onto the main line in the case of small and medium branch diameters. Longer branches require an expansion leg. Exceptions are possible if the main line can be made sufficiently transversely elastic by expansion zones when the difference in diameter is small.

1.7 Fixed point elements

In the case of buried composite casing pipes, fixed point elements are not normally required, irrespective of whether there is a bonding area or not. However, if fixed point elements are installed, they must usually be designed for very high forces. This must also be taken into account, for example, in the case of alternating installation in the buried area and in the duct.

The longitudinal force only drops to 0 or to the amount resulting from the internal pressure where unhindered expansion can take place. It is always easier to accommodate the residual expansion of the buried part in the channel than vice versa.

Fixed point elements are required in the buried pipeline if otherwise constant one-sided wandering of the pipeline would occur. This can be caused by a corresponding mode of operation or by special installation conditions.

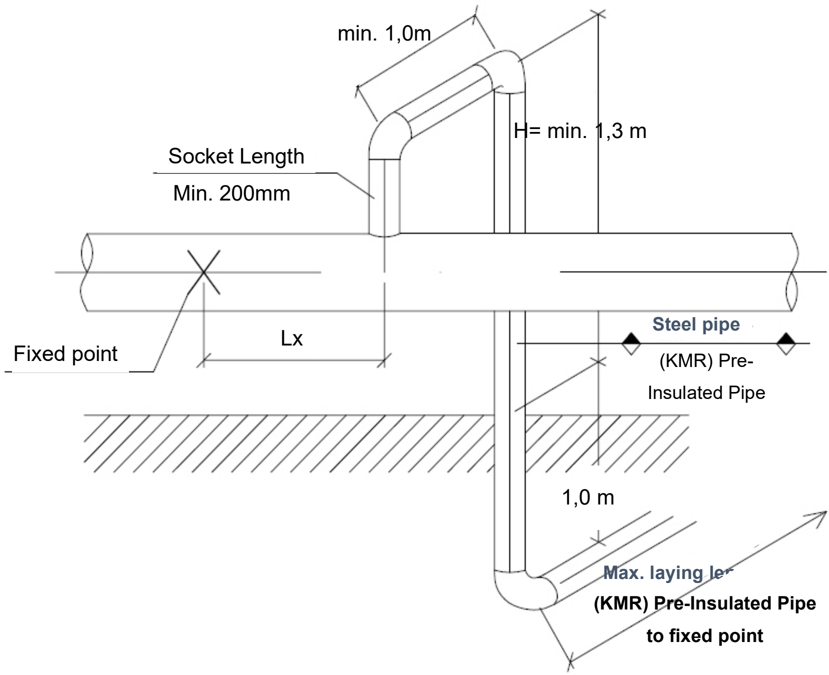
1.8 Bypass obstacles

If an obstacle has to be bypassed with the line, this can be done in the simplest case by a Z-jump. Here, it is necessary that the offset is either so large that it can elastically absorb the strain arriving from both sides, or it must be so small that it can transmit the frictional force added up from the next free end without exceeding the permissible bending stress. The latter is rarely possible in practice. In principle, this applies to horizontal, vertical or inclined offsets.

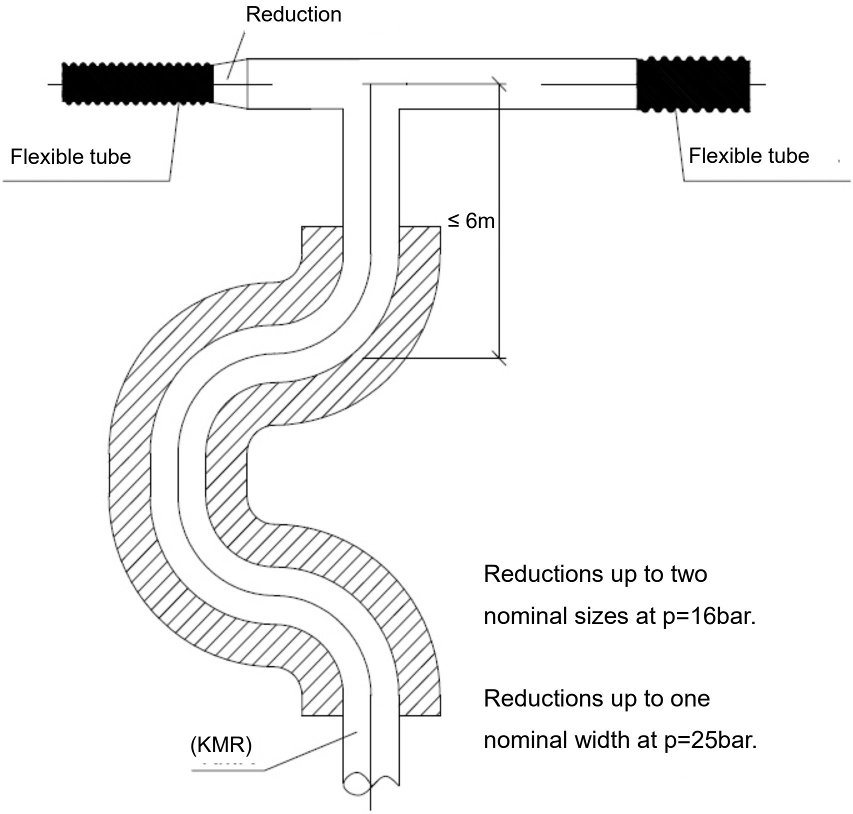
Height jumps are usually too small to accommodate stretching. In this case, it is advisable to combine the small height jump with a correspondingly large lateral jump.

A cost-effective solution is often to use an S-bend formed from several 3° kinks to get around the problem. For a 6 m bar, one 3° bend results in a lateral offset of more than 0.3 m, 2 bends of 3° at intervals of 6 m each already result in a lateral offset of more than 0.9 m, i.e. with 3 bars of 6 m each, a lateral offset of 1.25 m results.

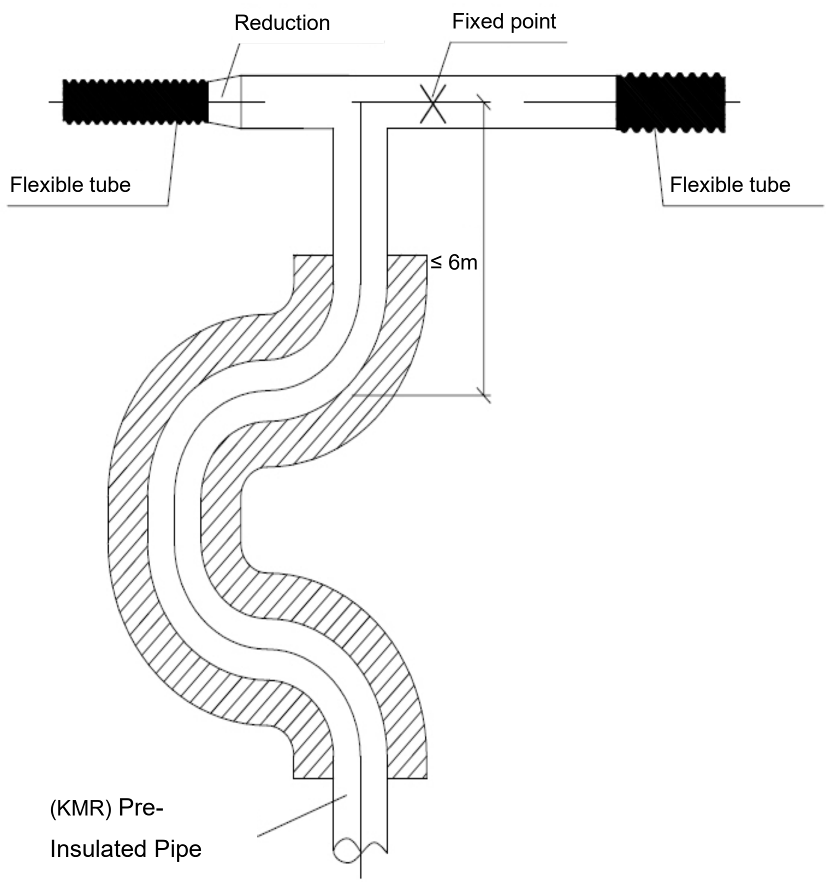
1.9 Laying and connection variants



Connection of (KMR) Pre-Insulated Pipe lines to existing overhead lines



Consideration of reductions without fixed point



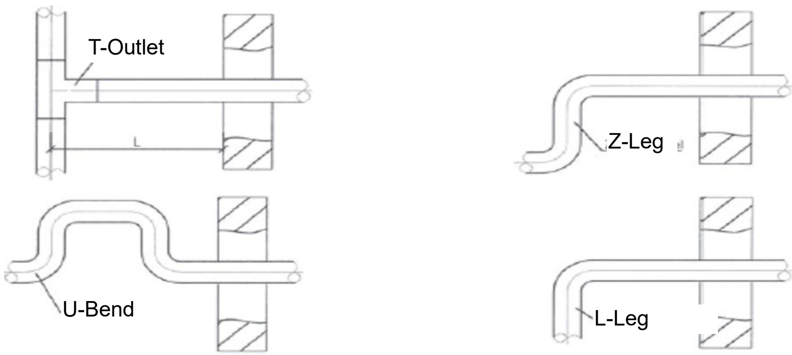
Consideration of reductions with fixed point

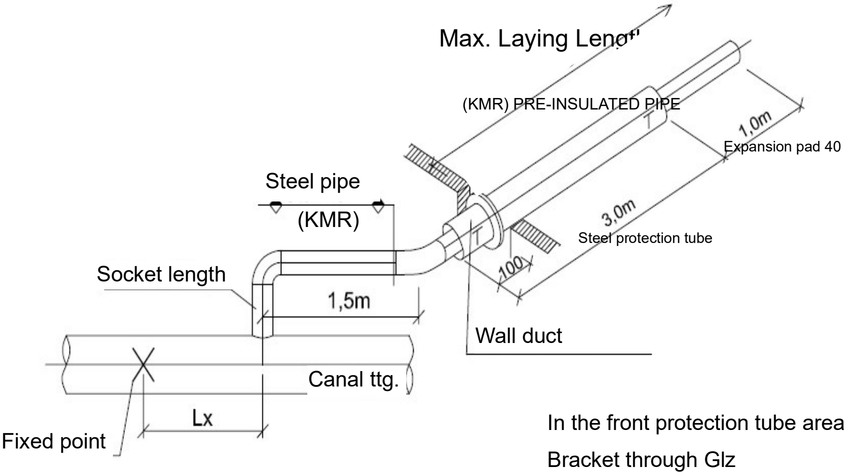
Stress-free buried systems when introduced into structures, ducts and house entries.

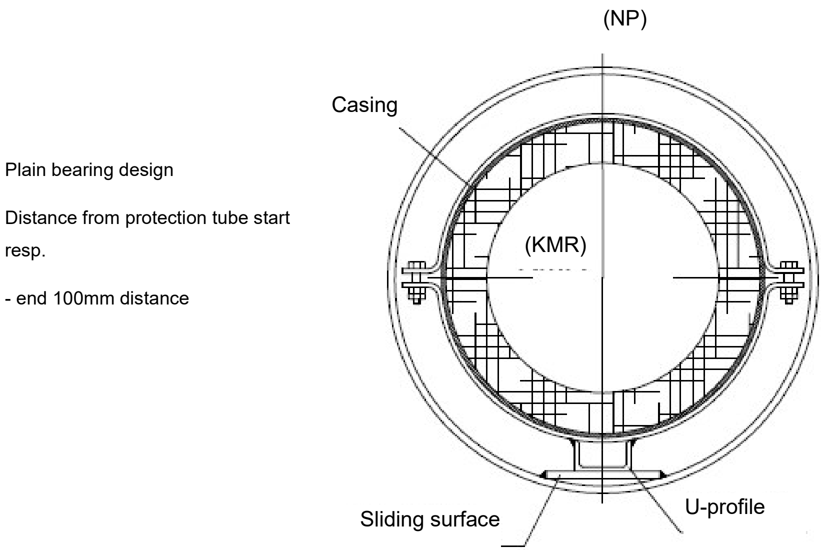
According to the static requirements and the local conditions, an expansion element must be arranged in front of the house entry, as a Z-leg, L-leg or U-expander.

For a T-entry, L is max. 6m, for larger distances an expansion element must then be provided.

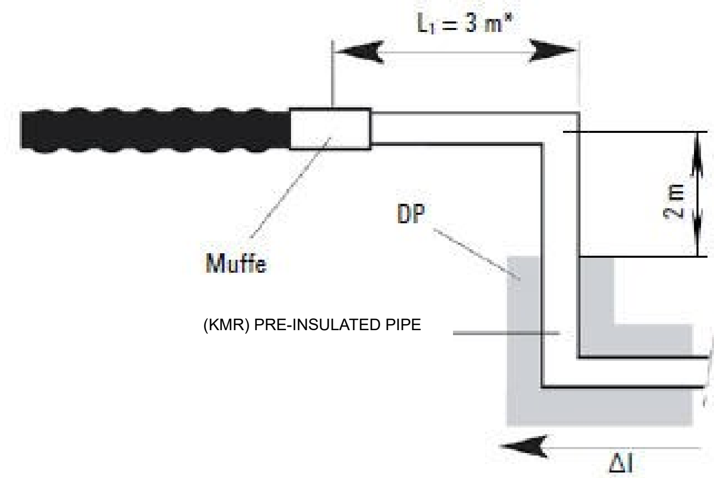
In the case of pressing water or stratified water, the annular space seal is Introduction of stress-free systems





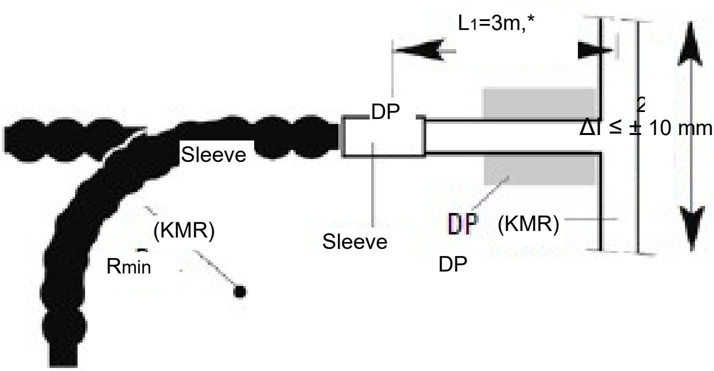


Connection of (KMR) Pre-Insulated Pipe lines to existing sewer lines

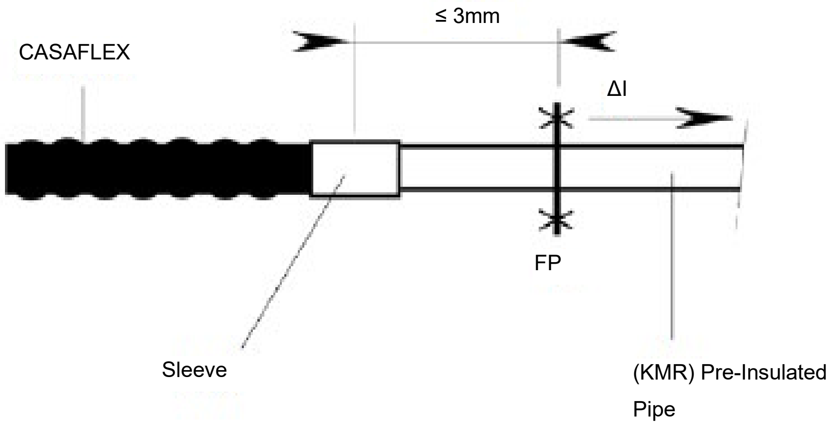


(KMR) Pre-Insulated Pipe interface with flexible pipe transition with Z-expansion bend

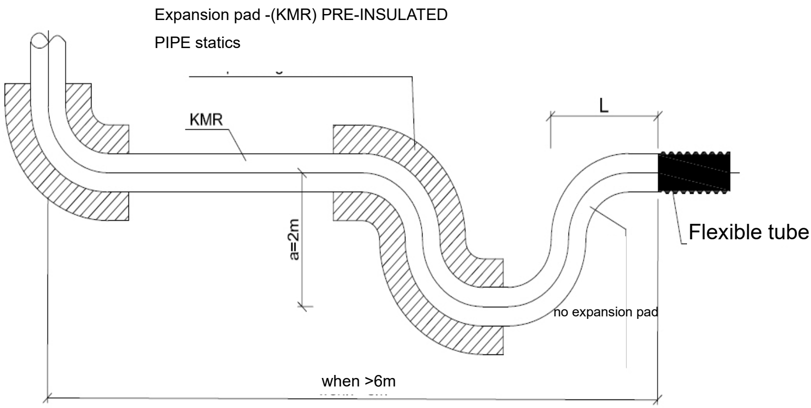
L1=3m*



(KMR) Pre-Insulated Pipe interface with flexible pipe - transition at T junction

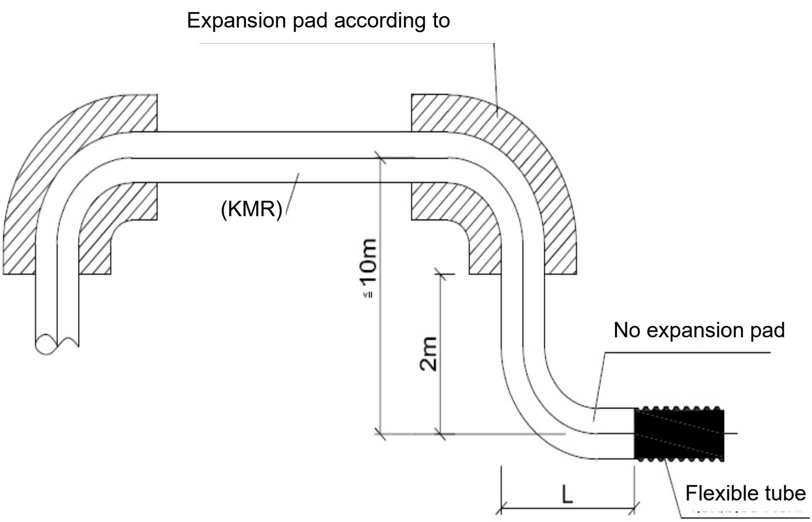


(KMR) Pre-Insulated Pipe -interface with flexible pipe transition with fixed point



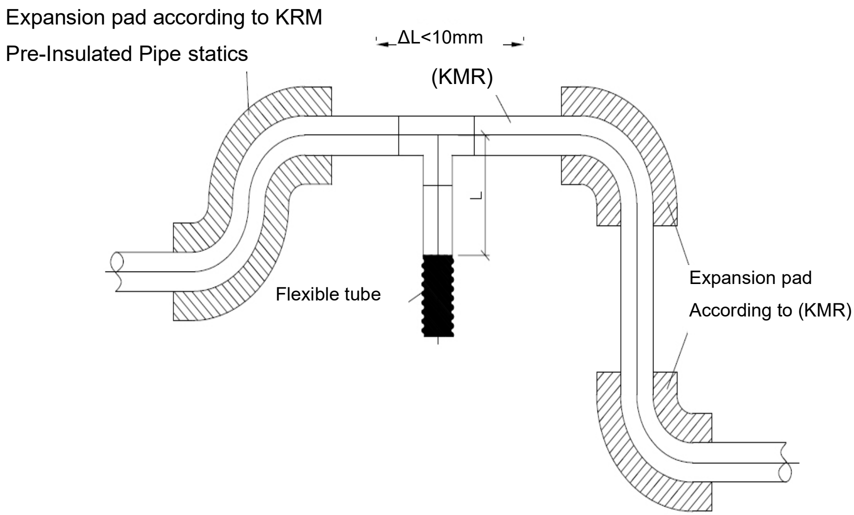
(KMR) Pre-Insulated Pipe -Interface with flexible Pipe U expansion bend

Dimension L = observe the system manufacturer's specifications



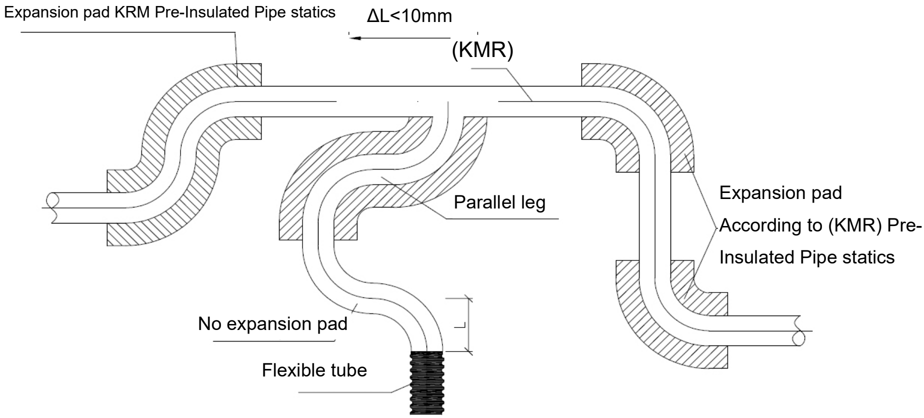
(KMR) PRE-INSULATED PIPE - Interface with flexible pipe Z expansion bend

Dimension L = observe the system manufacturer's specifications



(KMR) Pre-Insulated Pipe - Interface with flexible pipe - 45° T-branch

Dimension L = observe the system manufacturer's specifications



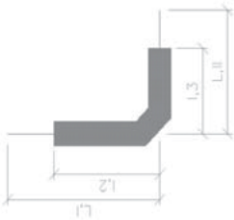
KMR Pre-insulated Pipe - Interface with flexible pipe parallel branch

1.10 Dimensioning tables for expansion pads

Thigh- L.	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250	DN 300	DN 350	DN 400	Expansion pad
	Expansion Pad Length l;2 = l,3											
10m	0,8 m	0,8 m	0,8 m	0,8 m	0,8 m	0,8 m	0,8 m	0,8 m	0,8 m	0,8 m	0,8 m	30 mm
15m	1,0 m	1,1 m	1,1 m	1,2 m	1,2 m	1,2 m	1,2 m	1,2 m	1,2 m	1,2 m	1,2 m	
20 m	1,1 m	1,1 m	1,2 m	1,3 m	1,4 m	1,5 m	1,5 m	1,5 m	1,5 m	1,5 m	1,5 m	40 mm
25 m	1,2 m	1,3 m	1,4 m	1,5 m	1,6 m	1,7 m	1,8 m	1,8 m	1,8 m	1,8 m	1,8 m	
30 m	1,4 m	1,5 m	1,6 m	1,7 m	1,8 m	1,9 m	2,1 m	2,2 m	2,2 m	2,2 m	2,2 m	50 mm
35 m	1,5 m	1,6 m	1,7 m	1,9 m	2,0 m	2,1 m	2,3 m	2,4 m	2,5 m	2,5 m	2,6 m	60 mm
40 m	1,6 m	1,7 m	1,9 m	2,0 m	2,1 m	2,3 m	2,5 m	2,5 m	2,7 m	2,7 m	2,8 m	70 mm
45 m	1,7 m	1,9 m	2,0 m	2,1 m	2,3 m	2,5 m	2,7 m	2,8 m	2,9 m	2,9 m	3,0 m	80 mm
50 m	1,7 m	1,9 m	2,1 m	2,2 m	2,4 m	2,6 m	2,8 m	3,0 m	3,2 m	3,2 m	3,3 m	90 mm
55 m	1,7 m	2,0 m	2,2 m	2,3 m	2,5 m	2,7 m	2,9 m	3,1 m	3,3 m	3,3 m	3,5 m	
60 m	1,8 m	2,1 m	2,3 m	2,4 m	2,5 m	2,8 m	3,0 m	3,2 m	3,5 m	3,5 m	3,6 m	
65 m	1,9 m	2,1 m	2,3 m	2,5 m	2,6 m	2,9 m	3,1 m	3,3 m	3,6 m	3,6 m	3,8 m	
70 m	1,9 m	2,2 m	2,3 m	2,5 m	2,7 m	3,0 m	3,2 m	3,4 m	3,7 m	3,7 m	4,0 m	100 mm
75 m	1,9 m	2,3 m	2,4 m	2,5 m	2,7 m	3,1 m	3,3 m	3,5 m	3,9 m	3,9 m	4,1 m	
80 m	1,9 m	2,3 m	2,4 m	2,6 m	2,7 m	3,1 m	3,4 m	3,6 m	4,0 m	4,0 m	4,2 m	120mm All-round P 60mm 45mm presp.
85 m		2,3 m	2,5 m	2,6 m	2,8 m	3,2 m	3,5 m	3,7 m	4,1 m	4,1 m	4,3 m	
90 m		2,3 m	2,5 m	2,6 m	2,8 m	3,2 m	3,5 m	3,8 m	4,2 m	4,2 m	4,5 m	
95 m			2,5 m	2,6 m	2,8 m	3,3 m	3,6 m	3,9 m	4,3 m	4,3 m	4,6 m	
100 m			2,5 m	2,6 m	2,8 m	3,3 m	3,7 m	3,9 m	4,3 m	4,3 m	4,6 m	All-around P 70mm 50mm presp.
105 m				2,6 m	2,9 m	3,3 m	3,7 m	4,0 m	4,4 m	4,4 m	4,7 m	
110 m				2,6 m	2,9 m	3,3 m	3,8 m	4,0 m	4,5 m	4,5 m	4,8 m	
115 m					2,9 m	3,4 m	3,8 m	4,1 m	4,6 m	4,6 m	4,9 m	
120 m					2,9 m	3,4 m	3,9 m	4,1 m	4,7 m	4,7 m	5,0 m	All-around P 80mm 60mm presp.
125 m						3,4 m	3,9 m	4,2 m	4,7 m	4,7 m	5,1 m	
130 m						3,4 m	3,9 m	4,2 m	4,8 m	4,8 m	5,1 m	
135 m						3,4 m	3,9 m	4,3 m	4,8 m	4,8 m	5,2 m	
140 m						3,4 m	3,9 m	4,3 m	4,9 m	4,9 m	5,3 m	
145 m							3,9 m	4,3 m	4,9 m	4,9 m	5,3 m	All-around P 90mm 65mm presp.
150 m							3,9 m	4,3 m	4,9 m	4,9 m	5,3 m	
155 m							3,9 m	4,3 m	4,9 m	4,9 m	5,4 m	
160 m								4,3 m	4,9 m	4,9 m	5,5 m	
165 m								4,3 m	5,0 m	5,0 m	5,5 m	
170 m									5,0 m	5,0 m	5,5 m	
175 m									5,0 m	5,0 m	5,5 m	
180 m									5,0 m	5,0 m	5,5 m	
185 m									5,0 m		5,5 m	
190 m											5,5 m	
195 m											5,6 m	
200 m											5,6 m	
205 m												

1.10.1 Dimensioning for 90° L- bend

Schenkel-L. L, l = L, ll	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250	DN 300	DN 350	DN 400	Expansion pad Thickness
					Dehnpolster-Länge		l,2 = l,3					
10m	0,8 m	0,8 m	0,8 m	0,8 m	0,8 m	0,8 m	0,8 m	0,8 m	0,8 m	0,8 m	0,8 m	30 mm
15m	1,0 m	1,1 m	1,1 m	1,2 m	1,2 m	1,2 m	1,2 m	1,2 m	1,2 m	1,2 m	1,2 m	
20 m	1,1 m	1,1 m	1,2 m	1,3 m	1,4 m	1,5 m	1,5 m	1,5 m	1,5 m	1,5 m	1,5 m	40 mm
25 m	1,2 m	1,3 m	1,4 m	1,5 m	1,6 m	1,7 m	1,8 m	1,8 m	1,8 m	1,8 m	1,8 m	
30 m	1,4 m	1,5 m	1,6 m	1,7 m	1,8 m	1,9 m	2,1 m	2,2 m	2,2 m	2,2 m	2,2 m	50 mm
35 m	1,5 m	1,6 m	1,7 m	1,9 m	2,0 m	2,1 m	2,3 m	2,4 m	2,5 m	2,5 m	2,6 m	60 mm
40 m	1,6 m	1,7 m	1,9 m	2,0 m	2,1 m	2,3 m	2,5 m	2,5 m	2,7 m	2,7 m	2,8 m	70 mm
45 m	1,7 m	1,9 m	2,0 m	2,1 m	2,3 m	2,5 m	2,7 m	2,8 m	2,9 m	2,9 m	3,0 m	80 mm
50 m	1,7 m	1,9 m	2,1 m	2,2 m	2,4 m	2,6 m	2,8 m	3,0 m	3,2 m	3,2 m	3,3 m	90 mm
55 m	1,7 m	2,0 m	2,2 m	2,3 m	2,5 m	2,7 m	2,9 m	3,1 m	3,3 m	3,3 m	3,5 m	
60 m	1,8 m	2,1 m	2,3 m	2,4 m	2,5 m	2,8 m	3,0 m	3,2 m	3,5 m	3,5 m	3,6 m	
65 m	1,9 m	2,1 m	2,3 m	2,5 m	2,6 m	2,9 m	3,1 m	3,3 m	3,6 m	3,6 m	3,8 m	
70 m	1,9 m	2,2 m	2,3 m	2,5 m	2,7 m	3,0 m	3,2 m	3,4 m	3,7 m	3,7 m	4,0 m	100 mm
75 m	1,9 m	2,3 m	2,4 m	2,5 m	2,7 m	3,1 m	3,3 m	3,5 m	3,9 m	3,9 m	4,1 m	
80 m	1,9 m	2,3 m	2,4 m	2,6 m	2,7 m	3,1 m	3,4 m	3,6 m	4,0 m	4,0 m	4,2 m	120 mm o. RP. 60 mm 45mm vorsp.
85 m		2,3 m	2,5 m	2,6 m	2,8 m	3,2 m	3,5 m	3,7 m	4,1 m	4,1 m	4,3 m	
90 m		2,3 m	2,5 m	2,6 m	2,8 m	3,2 m	3,5 m	3,8 m	4,2 m	4,2 m	4,5 m	
95 m			2,5 m	2,6 m	2,8 m	3,3 m	3,6 m	3,9 m	4,3 m	4,3 m	4,6 m	
100 m			2,5 m	2,6 m	2,8 m	3,3 m	3,7 m	3,9 m	4,3 m	4,3 m	4,6 m	RP. 70 mm 50mm vorsp.
105 m				2,6 m	2,9 m	3,3 m	3,7 m	4,0 m	4,4 m	4,4 m	4,7 m	
110 m				2,6 m	2,9 m	3,3 m	3,8 m	4,0 m	4,5 m	4,5 m	4,8 m	
115 m					2,9 m	3,4 m	3,8 m	4,1 m	4,6 m	4,6 m	4,9 m	
120 m					2,9 m	3,4 m	3,9 m	4,1 m	4,7 m	4,7 m	5,0 m	RP. 80 mm 60mm vorsp.
125 m						3,4 m	3,9 m	4,2 m	4,7 m	4,7 m	5,1 m	
130 m						3,4 m	3,9 m	4,2 m	4,8 m	4,8 m	5,1 m	
135 m						3,4 m	3,9 m	4,3 m	4,8 m	4,8 m	5,2 m	
140 m						3,4 m	3,9 m	4,3 m	4,9 m	4,9 m	5,3 m	
145 m							3,9 m	4,3 m	4,9 m	4,9 m	5,3 m	RP. 90 mm 65mm vorsp.
150 m							3,9 m	4,3 m	4,9 m	4,9 m	5,3 m	
155 m							3,9 m	4,3 m	4,9 m	4,9 m	5,4 m	
160 m								4,3 m	4,9 m	4,9 m	5,5 m	
165 m								4,3 m	5,0 m	5,0 m	5,5 m	
170 m									5,0 m	5,0 m	5,5 m	
175 m									5,0 m	5,0 m	5,5 m	
180 m									5,0 m	5,0 m	5,5 m	
185 m									5,0 m		5,5 m	
190 m											5,5 m	
195 m											5,6 m	
200 m											5,6 m	
205 m												



Erklärung:

T-Stücke **ohne** Verstärkung möglich

Beispiel: DN 65 **bis 55m**

RP - Rundumpolster

1.10.2 Dimensioning for 60° L-bend

Thigh - L L, I = L, II	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250	DN 300	DN 350	DN 400	Expansion pad Thickness
	Expansion pad length I,2 = I,3											
5 m	0,6 m	0,6 m	0,6 m	0,6 m	0,6 m	0,6 m	0,6 m	0,5 m	0,5 m	0,5 m	0,5 m	
10 m	1,2 m	1,2 m	1,2 m	1,2 m	1,2 m	1,2 m	1,2 m	1,2 m	1,2 m	1,2 m	1,2 m	40 mm
15 m	10,0 m	10,0 m	1,8 m	1,8 m	1,9 m	1,9 m	1,9 m	1,5 m	1,5 m	1,5 m	1,5 m	
20 m			2,3 m	2,3 m	2,5 m	2,5 m	2,5 m	2,5 m	2,5 m	2,5 m	2,5 m	60 mm
25 m			20,0 m	20,0 m	3,1 m	2,9 m	3,1 m	3,0 m	3,0 m	3,0 m	3,0 m	80 mm
30 m					3,7 m	3,4 m	3,7 m	3,5 m	3,5 m	3,5 m	3,5 m	90mm
35 m					30,0 m	30,0 m	4,3 m	4,0 m	4,0 m	4,0 m	4,0 m	100 mm
40 m							40,0 m	4,5 m	4,5 m	4,5 m	4,5 m	
45 m								5,0 m	5,0 m	5,0 m	5,0 m	120mm *)
50 m								5,2 m	5,2 m	5,2 m	5,2 m	RP. 80 mm
55 m								50,0 m	5,5 m	5,5 m	5,5 m	
60 m									5,9 m	5,9 m	5,9 m	60 mm presp.
65 m									6,2 m	6,2 m	6,2 m	
70 m									6,3 m	6,3 m	6,3 m	RP. 100 mm
75 m									70,0 m	6,5 m	6,5 m	
80 m										6,7 m	6,7 m	70 mm presp.
85 m										80,0 m	80,0 m	
90 m												
95 m												
100 m												
105 m												
110 m												
115 m												
120 m												
125 m												
130 m												
135 m												
140 m												
145 m												
150 m												
155 m												
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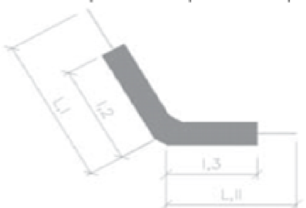
190 m												
195 m												
200 m												



*) 120mm, RP 60mm, preload 45mm

RP - Round cushion

Explanation:

xxx	max. laying lengths L,I: L,II

1.10.3 Dimensioning for 45° L- bend

Thigh - L L, I = L, II	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250	DN 300	DN 350	DN 400	Expansion pad Thickness
	Expansion pad length I,2 = I,3											
5 m	0,8 m	0,9 m	0,9 m	0,9 m	0,9 m	1,1 m	1,1 m	1,0 m	1,0 m	1,0 m	1,0 m	40mm
10 m	1,5 m	1,8 m	1,8 m	1,8 m	1,8 m	2,0 m	2,0 m	2,0 m	2,0 m	2,0 m	2,0 m	60mm
15 m	**10,0 m**	**10,0 m**	**10,0 m**	**10,0 m**	2,6 m	2,3 m	2,3 m	2,8 m	2,8 m	2,8 m	2,8 m	
20 m					**15,0 m**	**15,0 m**	3,5 m	3,8 m	3,8 m	3,8 m	3,8 m	80mm
25 m							**20,0 m**	4,8 m	4,8 m	4,8 m	4,8 m	100mm
30 m								**25,0 m**	5,7 m	5,7 m	5,7 m	120mm *)
35 m									**30,0 m**	6,6 m	6,6 m	RP. 70 mm,
40 m										7,5 m	7,5 m	
45 m										**40,0 m**	**40,0 m**	50 mm presp.
50 m												
55 m												
60 m												
65 m												
70 m												
75 m												
80 m												
85 m												
90 m												
95 m												
100 m												
105 m												
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115 m												
120 m												
125 m												
130 m												
135 m												
140 m												
145 m												
150 m												
155 m												
160 m												
165 m												
170 m												
175 m												
180 m												
185 m												
190 m												
195 m												
200 m												

*) 120mm, RP 60mm, 45mm presp

RP – Round cushion

xxx max. laying lengths L,I: L,II

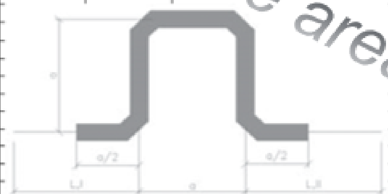
Adhesive area

1.10.4 Dimensioning for U-bend

Expansion pad len

Thigh - L	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250	DN 300	DN 350	DN 400	Expansion pad
L I = L II	Expansion pad length / height and width U-bend a											Thickness
10m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,6 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	30 mm
15m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,6 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	
20 m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,6 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	40 mm
25 m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,6 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	50 mm
30 m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,6 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	60mm
35 m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,6 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	80 mm
40 m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,6 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	
45 m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,6 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	90mm
50 m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,6 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	100mm
55 m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,6 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	
60 m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,6 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	
65 m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,6 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	dp=mm, RP 60mm 45mm presp.
70 m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,6 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	
75 m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,7 m	1,9 m	2,0 m	2,1 m	2,2 m	2,3 m	
80 m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,7 m	1,9 m	2,0 m	2,1 m	2,2 m	2,3 m	
85 m	1,4 m	1,4 m	1,4 m	1,5 m	1,7 m	1,8 m	2,0 m	2,0 m	2,2 m	2,2 m	2,3 m	RP 70mm, 50mm presp.
90 m	1,4 m	1,4 m	1,4 m	1,5 m	1,7 m	1,8 m	2,0 m	2,0 m	2,2 m	2,2 m	2,3 m	
95 m		1,4 m	1,4 m	1,5 m	1,7 m	1,9 m	2,0 m	2,0 m	2,3 m	2,2 m	2,3 m	
100 m		1,4 m	1,4 m	1,5 m	1,8 m	1,9 m	2,1 m	2,0 m	2,3 m	2,2 m	2,3 m	
105 m			1,4 m	1,6 m	1,8 m	2,0 m	2,2 m	2,1 m	2,3 m	2,2 m	2,4 m	RP 80mm 60mm presp.
110 m			1,4 m	1,6 m	1,8 m	2,0 m	2,2 m	2,1 m	2,4 m	2,2 m	2,4 m	
115 m				1,6 m	1,8 m	2,1 m	2,3 m	2,2 m	2,4 m	2,2 m	2,5 m	
120 m				1,6 m	1,8 m	2,1 m	2,3 m	2,2 m	2,5 m	2,2 m	2,5 m	
125 m					1,8 m	2,1 m	2,3 m	2,2 m	2,5 m	2,3 m	2,5 m	RP 90mm 65mm presp.
130 m					1,8 m	2,1 m	2,3 m	2,3 m	2,6 m	2,3 m	2,6 m	
135 m						2,1 m	2,4 m	2,3 m	2,6 m	2,3 m	2,6 m	
140 m						2,1 m	2,4 m	2,4 m	2,6 m	2,4 m	2,7 m	
145 m						2,1 m	2,4 m	2,4 m	2,7 m	2,4 m	2,7 m	RP 100mm 70mm presp.
150 m						2,1 m	2,4 m	2,4 m	2,7 m	2,5 m	2,7 m	
155 m							2,4 m	2,4 m	2,7 m	2,5 m		
160 m							2,4 m	2,4 m	2,7 m	2,5 m		
165 m							2,4 m	2,4 m		2,5 m		
170 m							2,4 m	2,4 m		2,5 m		
175 m								2,4 m		2,6 m		
180 m								2,4 m		2,6 m		
185 m										2,6 m		
190 m										2,6 m		
195 m												
200 m												
205 m												

Adhesive area



Explanation:

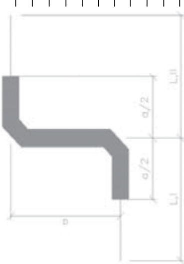
T-pieces possible without reinforcement
Example: DN 65 to 60m

RP - Round cushion

nt

1.10.5 Dimensioning for Z-bend

Schenkel-L.	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250	DN 300	DN 350	DN 400	Dehnpolster
L, I = L, II	Dehnpolster-Länge / Höhe Z-Bogen a											Dicke
10m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,6 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	30 mm
15m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,6 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	
20 m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,6 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	
25 m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,6 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	40 mm
30 m	1,4 m	1,4 m	1,4 m	1,5 m	1,6 m	1,6 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	50 mm
35 m	1,4 m	1,4 m	1,4 m	1,6 m	1,7 m	1,7 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	60mm
40 m	1,4 m	1,5 m	1,5 m	1,6 m	1,8 m	1,8 m	1,8 m	2,0 m	2,1 m	2,2 m	2,3 m	70 mm
45 m	1,4 m	1,6 m	1,6 m	1,7 m	1,9 m	1,9 m	1,9 m	2,0 m	2,1 m	2,2 m	2,3 m	80 mm
50 m	1,4 m	1,7 m	1,7 m	1,8 m	2,0 m	2,0 m	2,0 m	2,1 m	2,1 m	2,1 m	2,3 m	90mm
55 m	1,4 m	1,7 m	1,8 m	1,9 m	2,0 m	2,0 m	2,1 m	2,1 m	2,2 m	2,1 m	2,3 m	100mm
60 m	1,4 m	1,7 m	1,9 m	2,0 m	2,1 m	2,1 m	2,2 m	2,3 m	2,4 m	2,3 m	2,3 m	
65 m	1,4 m	1,7 m	1,9 m	2,1 m	2,2 m	2,2 m	2,3 m	2,4 m	2,4 m	2,4 m	2,4 m	
70 m	1,4 m	1,7 m	1,9 m	2,1 m	2,3 m	2,3 m	2,4 m	2,5 m	2,6 m	2,5 m	2,5 m	
75 m	1,4 m	1,7 m	2,0 m	2,2 m	2,4 m	2,4 m	2,5 m	2,6 m	2,7 m	2,6 m	2,6 m	dp=120mm, *)
80 m	1,4 m	1,7 m	2,0 m	2,2 m	2,4 m	2,4 m	2,6 m	2,7 m	2,8 m	2,7 m	2,8 m	
85 m	1,4 m	1,7 m	2,0 m	2,2 m	2,4 m	2,5 m	2,7 m	2,8 m	2,9 m	2,8 m	2,9 m	70mm 50mm vorsp.
90 m		1,7 m	2,0 m	2,2 m	2,4 m	2,6 m	2,7 m	2,9 m	3,0 m	2,9 m	3,0 m	
95 m		1,7 m	2,0 m	2,2 m	2,4 m	2,7 m	2,8 m	3,0 m	3,1 m	3,0 m	3,1 m	
100 m			2,0 m	2,2 m	2,4 m	2,7 m	2,9 m	3,1 m	3,2 m	3,1 m	3,2 m	80mm 60mm vorsp.
105 m			2,0 m	2,2 m	2,4 m	2,7 m	2,9 m	3,2 m	3,3 m	3,2 m	3,3 m	
110 m			2,0 m	2,2 m	2,4 m	2,7 m	2,9 m	3,2 m	3,4 m	3,2 m	3,4 m	Rundum-P. 90mm 65mm vorsp.
115 m			2,0 m	2,2 m	2,4 m	2,7 m	2,9 m	3,2 m	3,5 m	3,2 m	3,5 m	
120 m				2,2 m	2,4 m	2,7 m	2,9 m	3,2 m	3,6 m	3,2 m	3,5 m	
125 m					2,4 m	2,7 m	2,9 m	3,2 m	3,6 m	3,2 m	3,5 m	
130 m					2,4 m	2,7 m	2,9 m	3,2 m	3,6 m	3,2 m	3,5 m	
135 m						2,7 m	2,9 m	3,2 m	3,6 m	3,2 m	3,5 m	
140 m						2,7 m	2,9 m	3,2 m	3,6 m	3,2 m	3,5 m	
145 m						2,7 m	2,9 m	3,2 m	3,6 m	3,2 m	3,5 m	
150 m						2,7 m	2,9 m	3,2 m	3,6 m	3,2 m	3,5 m	
155 m							2,9 m	3,2 m	3,6 m	3,2 m	3,5 m	
160 m							2,9 m	3,2 m	3,6 m	3,2 m	3,5 m	Rundum-P. 100mm 70mm vorsp.
165 m							2,9 m	3,2 m	3,6 m	3,2 m	3,5 m	
170 m								3,2 m	3,6 m	3,2 m	3,5 m	
175 m									3,6 m	3,2 m	3,5 m	
180 m									3,6 m	3,2 m	3,5 m	
185 m									3,6 m	3,2 m	3,5 m	
190 m									3,6 m	3,2 m	3,5 m	
195 m									3,6 m		3,5 m	
200 m											3,5 m	
205 m											3,5 m	



Erklärung:
T-Stücke **ohne** Verstärkung möglich
Beispiel: DN 65 bis 58m

*) Rundump.: dp=60mm (45mm vorsp.)

Author of the chapter

Ronald Schröder, IFW Deuben

2. Occupational safety

2.1 Technical regulations

ArbSchG	Occupational Safety Act
BGI 5515	Personal protective equipment
BGI – GUV – 18524	Risk assessments
BGR 133	Fire protection equipment with fire extinguisher.
BGV A 1 :2005	Accident prevention regulations
BGV A 3:1997 (updated reprint 2005)	Electrical systems and equipment
BGV D 36:2006	Ladders and steps
BG RCI	Gis Chem Hazardous material information system
DIN 4124:2002	Construction of excavation pits
Safety Data Sheet	Polyol component
Safety Data Sheet	Isocyanate Component
TRGS 430	Technical rules for hazardous substances
VDS 2869: 2006-06	Handling liquid gas cylinders

2.2 General

2.2.1 Foam components

The substance used, polyol component A, is a hazardous substance as defined in the Ordinance on Hazardous Substances. The substance is highly flammable and harmful to health. During transport to and provision at the construction site, the packaging must always be kept tightly closed and protected against unauthorized access.

The safety instructions, safety data sheets and the specifications of the respective PU foam manufacturers for processing the foam components apply. The polyol component A in 5/10 liter containers is a hazardous material as defined by transport law (ADR/GGVSE). Component B (isocyanate) is a hazardous substance as defined by the Ordinance on Hazardous Substances, but not a dangerous good as defined by ADR/GGVSE.

2.2.2 Transport to the construction site

The storage/transport temperature recommended by the manufacturer for the polyol component is 5°C - 25°C. Even in the short term, the storage/transport temperature must be kept below 50°C (load limit of container reached). In the warm season, the vehicles must be parked in the shade or cooled by switching on the ventilation.

A 2 kg ABC fire extinguisher (easily accessible) and a high-visibility vest must be carried.

In the event of an accident, inform the emergency number 112, stating the respective UN number 1993 (polyol component A).

2.2.3 Provision on the construction site

The products are to be stored on site in a fixed location for a short period only (maximum 24 h) and protected against unauthorized access (in the case of fixed storage >24 h: application of the Water Resources Act and TRbF 20, storage for flammable liquids).

On the construction site, storage should be as cool as possible during the warm season. Unless otherwise stated in the respective data sheets, the components are usually stored at 15˚C - 25˚C. Even in the short term, the storage/transport temperature must be kept lower than 50°C (burst load limit container reached). (Storage therefore in the shade, cover with reflective aluminum foil).

To avoid cooling by direct contact with the ground, the containers should be stored on pallets.

The shelf life of the systems is noted in the corresponding technical data sheets. Polyol and isocyanate components are sensitive to moisture.

- The containers must be kept tightly closed until immediately before use.
- Opened containers must be resealed immediately after material removal.

2. Handling of the polyol component during hand foaming on the construction site

The responsible fitter must define the Ex areas: Within a radius of 3 m around both the mixing point and the foaming point (socket openings). Depending on the location, at least two warning signs (no smoking and explosion hazard) must be erected and, if necessary (in case of public traffic), a warning post must be set up.

Sparking operations such as welding, hammering, grinding and the use of cell phones during mixing and foaming are not permitted at the work sites.

The mixing process must be carried out outside the pipe trench in a closed-off hazardous area (in the well-ventilated open air) on sufficiently conductive ground (grown soil, uncoated concrete, no asphalt, plastic, etc.). The polyol component A must be filled into a container with a maximum capacity of 5 liters.

If a 10 liter bucket is required for the total foam quantity achieved, the isocyanate component must be filled into this bucket before the mixing process begins. The connection of the electric current for the foam whisk must be made in the area outside the cordoned-off area.

During mixing and foaming, "Personal Protective Equipment (PPE)" (at least safety goggles, face shield if necessary) must be worn. When foaming indoors, these rooms must be sufficiently ventilated.
Eating, drinking or smoking is not permitted during the work!

2.4 Waste disposal

Reacted polyurethane waste can usually be disposed of with household or commercial waste. In any case, the responsible authorities should be contacted regarding disposal.

2.5 Protective work clothing

Flame resistant closed work clothes with long sleeves and trouser legs, liquid-tight safety shoes, protective gloves, closed and face-fitting safety goggles and safety helmet.

2.6 Gas cylinders

Propane gas cylinders may only be transported upright, secured against slipping or falling over, with the cylinder valve closed and the valve protection cap screwed on. Pressure cylinders must be handled with care. The 5/10 liter propane gas cylinders represent dangerous goods in the sense of the transport law (ADR/GGVSE).

Regular instruction of employees regarding the transport of dangerous goods according to "ADR/GGVSE" and the storage of gases according to "TRGS".

2.7 Tool

Only tested electrical tools with a current inspection sticker may be used. (BGV A 3)

Authors of the chapter

Jürgen Schütze, BRUGG pipe systems GmbH

Johannes Ellmer isoplus district heating technology Distribution company mbH

3. Civil engineering - guidelines and dimensions

3.1.1 General

Earthworks are to be carried out in accordance with the generally applicable guidelines and standards for civil engineering work. At the same time, the additional regulations that vary from municipality to municipality as well as the AGFW1) guidelines of worksheet FW 401- Part 12 must be observed.

Pipe trenches are to be constructed by a competent civil engineering company in accordance with DIN 18300, DIN EN 805, the DIN 4124 section and backfilled in accordance with sections 3.09 and 3.11 of DIN 18300. The width of the pipe trench is governed by DIN 4124 Section 5.2..

DIN 4124 Sections 4.1 to 4.3 also specify whether pipe trenches must be sloped and at what depth. This also shows the required slope angles for different soil conditions.

The installation depth or pipe crown overlap height on which the project planning and pipe statics are based must be strictly adhered to. The condition of the trench bottom is specified in DIN EN 1610. The bottom must be load-bearing and free of stones along its entire length.

According to DIN EN 1610, the pipe layer must generally ensure that the pipe trenches are drained and kept free until all postinsulation work has been completed in order to safeguard the quality of the overall system.

Collapsed pipe trenches must be excavated by hand. The progress of installation and the quality of all work carried out, and thus the expected service life of a district heating pipeline, depend to a large extent on DIN-compliant trenching.

3.1.2 Rules and regulations

For all activities in pits and trenches, the following is specified and binding in the accident prevention regulation "Construction work BGV C 22":§ 28 (1) During earth, rock and excavation work, earth and rock walls must be sloped or shored in such a way that employees cannot be endangered by slipping masses. All influences that may affect the stability of the ground shall be taken into account.

§ 32 Working space widths
Excavation pits and pipe trenches in which work is carried out must have sufficient working space. The dimensions of the working space depend on the slope angle, shoring, installations, type of pipe and work sequence.

Furthermore, the earthworks must be carried out in accordance with the generally applicable guidelines and standards for civil engineering. At the same time, the additional regulations that vary from municipality to municipality and the AGFW guidelines of Worksheet FW 401 - Part 12 must be observed.

The pipe trenches are to be constructed by a competent civil engineering company in accordance with DIN 18300, DIN EN 805, DIN EN 1610 and DIN 4124 and backfilled in accordance with sections 3.09 and 3.11 of DIN 18300. Section 5.2 of DIN 4124 is decisive for the pipe trench width.

Sections 4.1 to 4.3 of DIN 4124 also specify whether pipe trenches are to be embanked and at what depth. This also shows the required slope angles for different soil properties.

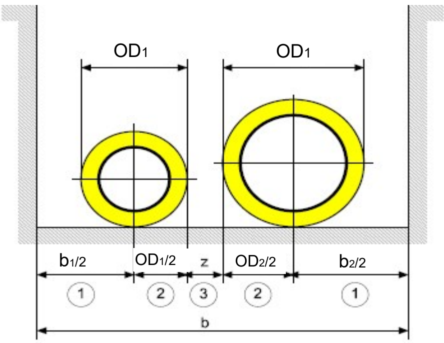
The installation depth or pipe crown overlap height on which the project planning and pipe statics are based must be strictly adhered to. The condition of the trench bottom is specified in DIN EN 1610. The bottom must be load-bearing and free of stones along its entire length.

The progress of installation and the quality of all work to be carried out, and thus the expected service life of a district heating pipeline, depend to a large extent on DIN-compliant trenching.

3.1.3 Minimum clear widths for pipe trenches with accessible working space

The minimum clear trench width - i.e. the available accessible width taking into account the trench shoring - can be calculated according to DIN 4124; see Figure 14

Schematic diagram for determining the minimum trench width according DIN 4124



Determination of the minimum trench widths

1. Half the minimum clear width b 1 /2 and b 2 /2 for each of the two lines corresponding to the outer diameter of the outer casing according to DIN 4124

2. Half outer diameter of sheath OD 1 /2 and OD 2 /2 of the two pipes.

3. The distance "z" between the pipes depends on the installation technique, the working procedures for pipe and socket installation, the pad thickness and the compaction requirements.3 If the interstitial space must be walked on, the minimum distance recommended in Table 1 must be used for "z".

For the distance "z" between the supply and return pipes, the minimum values given in Table 1 are recommended for the working space to be entered between the casing pipes (the larger value applies in the case of different casing pipe diameters).

The distance should also be greater in the area of expansion pads to ensure their proper embedding and the compaction of the bedding materials as well as their functionality.

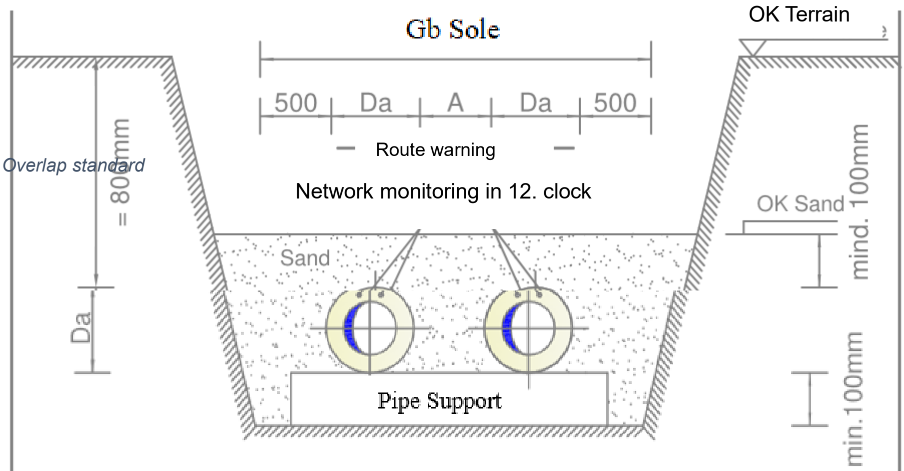
Nominal diameter of service pipe / outer diameter of casing pipe. DN [-] / Ds [mm]	**Minimum distance between the casing pipes** z [mm]
≤ 200 / 315	250
≥ 250 / 400	350

Depending on the design of the joints and, in particular, the installation design meeting the expected quality requirements, as well as the PE welding methods that may be used, the distance may have to be selected larger in accordance with the manufacturer's specifications.

3.1.4 Minimum trench dimensions

The trench widths listed in Table 2 must not be undercut. Distances Z are to be used according to the minimum dimensions in Table 2!

Scheme Trench cross section



The filling material in the line zone must comply with EN13941-2 and meet the following minimum requirements:

- friable round-edged sand-gravel mixture
- permissible grain size: 0...8mm
- maximum 10 mass percent ≤ 0.075 mm;
- maximum 3 mass percent ≤ 0.02 mm;
- non-uniformity number according to DIN EN ISO 14688-2 greater than 1.8
- proctor density min. 94%; optimum 97...98%

Minimum mounting distance in mm								
Da	A	Gb	Da	A	Gb	Da	A	Gb
90	250	1450	250	250	1750	500	350	2350
110-125	250	1500	280	250	1800	560	350	2450
140	250	1550	315	250	1850	630	350	2600
160	250	1550	355	350	2050	710	350	2750
180-200	250	1650	400	350	2150	800	350	2950
225	250	1700	450	350	2250			

Never underlay pipe supports (sleeves) at the connection point! Remove the squared lugs before sanding! Do not exceed the pipe support distance of 2.0 m!

Hard foam pipe supports are only permissible up to DN 150. For larger nominal diameters, alternative materials such as sandbags must be used or head holes created..

Support on support timbers (squared lumber) is not permissible!

3.1.5 Securing the excavation pits and pipe trenches

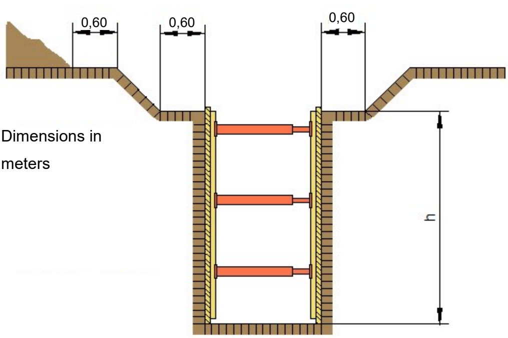
The trench protection is to be determined according to the accident prevention regulations as well as DIN 4124

The following safety measures must be observed:

- A protective strip at least 60 cm wide is to be arranged on both edges of a pipe trench, which is to be kept free of excavated material and unneeded objects. For trenches up to a depth of 0.80 m, the protective strip may be omitted on one side.
- Pipe trenches from a depth of 1.25 m to 1.75 m must be secured by embankment or shoring. From a depth of 1.75 m, access to the pipe trenches must generally be made safe by shoring. The access must be entered and exited using suitable equipment, such as a ladder.
- The shoring must be checked regularly and repaired or reinforced if necessary. An inspection must always be carried out after particular weather conditions (heavy rain, snow, etc.) or other external influences.
- There must be no cavities behind the shoring. Therefore, water (rainwater, etc.) must be prevented from flowing in behind the shoring at the surface by means of separate structural measures..
- The bottom of the pipe trench must be load-bearing and free of water and stones along its entire length.

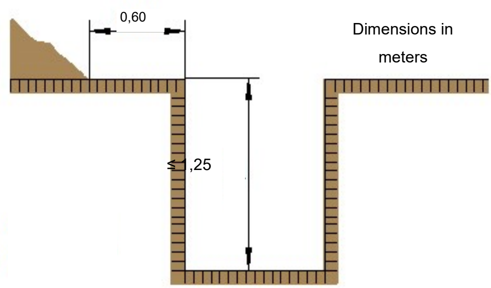
- The design of the pipe support must be coordinated in advance of the construction work so that the corresponding trench profile can be produced in accordance with the pipe support.
- To ensure the quality of the pipe and socket installation, drainage of the pipe trenches must be provided until all work has been completed. During the entire construction period, the civil engineering company must ensure that the construction site protection, drainage, etc. complies with the regulations and agreements.

3.1.6 Examples of pipe trenches and shoring



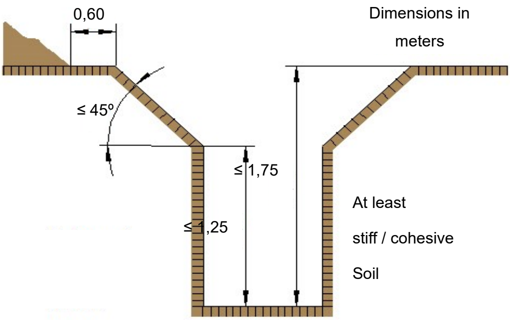
If an embanked advance structure is constructed to reduce the height of an excavation or trench shoring, a horizontal protective strip at least 0.60 m wide must be provided between the shoring and the base of the embankment if employees are working there..

Figure 16, Shored trench with embanked advance excavation



Here, too, a horizontal protective strip at least 0.60 m wide must be provided if employees are working there.

Figure 17, Trench with vertical walls



Pipe trenches without shoring - with at least stiff, cohesive soils - with a depth of 1.75 m must be sloped to a depth of 1.25 m with an inclination of 45°.

Figure 18, Trench with vertical walls and sloped edges

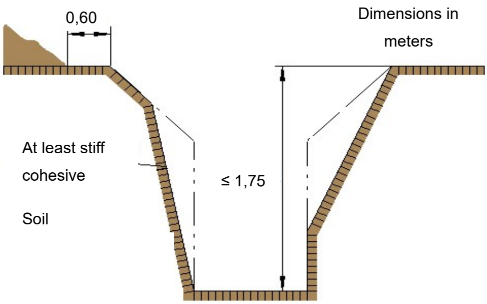


Figure 19, Variants to the minimum requirements according to Figure 18.

Figure 19 shows other permissible wall boundaries if additional soil is removed as a result. Permissible slope angles according to DIN

Soil class 3 and 4:

non-cohesive, soft cohesive soils

max. 45

Soil class 5:

stiff, semi-solid cohesive soils

max. 60°**.**

Soil class 6 and 7:

Rock max. 80

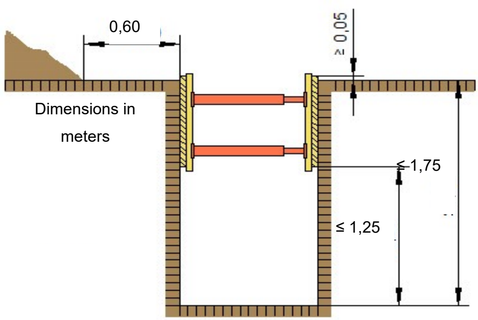


Figure 20, Partially obstructed ditch

Furthermore, in at least stiff cohesive soils and a depth of up to 1.75 m, it is possible to excavate vertically and shore the area lying more than 1.25 m above the bottom of the trench. The planks used for this must be at least 5 cm thick, the breast timbers at least 8 cm thick and 16 cm wide. The shoring must protrude at least 5 cm from the upper edge of the ground. The channel spindles must be secured against falling down.

3.1.7 Minimum dimensions of head holes

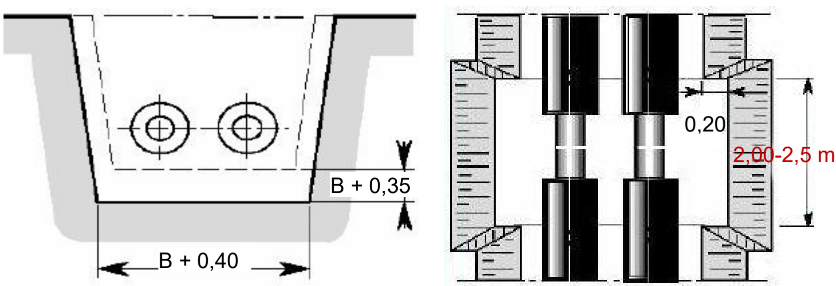


Figure 21, Head holes

To ensure that the service pipes are welded together properly and the socket joints can be installed in accordance with the quality specifications, head holes must be made at each pipe joint in the case of larger dimensions. When installing T-branches, bends, shut-off valves, etc., larger head holes are required in accordance with the manufacturer's specifications.

Depending on the design of the joints, the head holes may have to be enlarged.

3.1.8 Trench widening in the area of the expansion pads

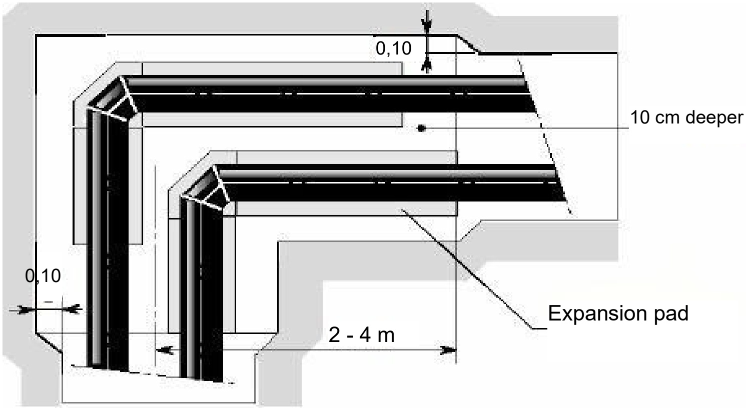


Figure 22, Trench widths for expansion pads

In the case of single-layer cushioning, the pipe trench must be widened by at least 10 cm on both sides to ensure proper installation. In the case of multi-layer cushioning, the trench dimensions must be adjusted in width and length according to the installation plans.

3.1.9 Closing the pipe trench.

After completion of all insulation and sealing work as well as the installation of the expansion pads, all the tests included in the scope of work must be carried out.

The following points must be ensured before sanding ensure:

- The pipe routing corresponds to the installation plan
- The cover heights on which the structural design is based are complied with
- Collapsed soil, stones and foreign objects have been removed from the area of the sand bed or the pipes
- The expansion pads have been installed in the specified lengths and thicknesses and secured against earth pressure
- All joints have been properly postinsulated and logged, and

penetrations to structures and buildings have been closed

- In the case of thermal prestressing, the specified expansion paths and the corresponding temperature have been achieved and recorded
- The monitoring system has been functionally tested and logged

Before the sand bed is created, the route must be approved by the site manager responsible for the construction project after checking the previously mentioned points.

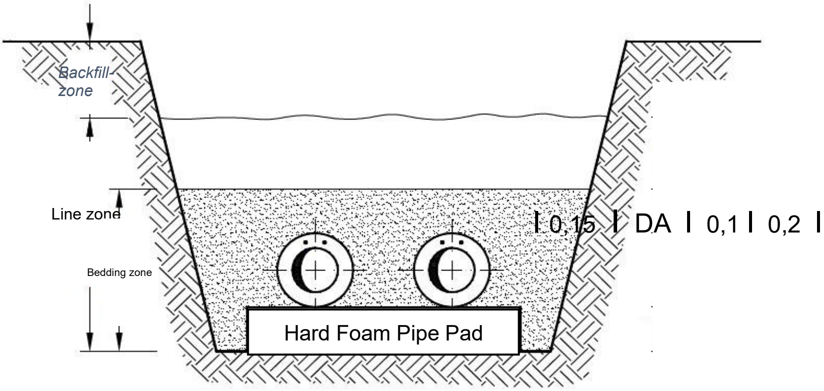
Afterwards, the plastic casing pipes (KMR) Pre-insulated Pipe are to be backfilled on all sides with at least 10 cm of sand with a grain size of 0-8 mm (filling material according to EN13941-2) in layers and extremely carefully and compacted exclusively by hand. In order to avoid cavities, special attention must be paid to the spaces or pipe gussets between the pipes. These spaces must be tamped and compacted separately.

This prevents later and unacceptable settlements and displacements. During this work, any auxiliary supports used must be removed at the same time, unless they are sandbags to be slit open or rigid foam supports.

A further possibility for backfilling is the use of "soil mortar" or "liquid soil". In this case, prior consultation between the planner, operator and system supplier is required.

The sand bed must not be slurried!

Figure 23, Backfill - sand bed



After completion of the sand bed, the trench can be backfilled with excavated material. Compaction in layers is necessary here. Large, coarse and pointed stones should be removed..

According to ZTV E - StB, coarse-grained soil up to a large grain size of 20 mm is to be used as backfill soil outside the pipeline zone. In general, according to DIN 18196, soil of compactability class V 1 is to be used as backfill material.

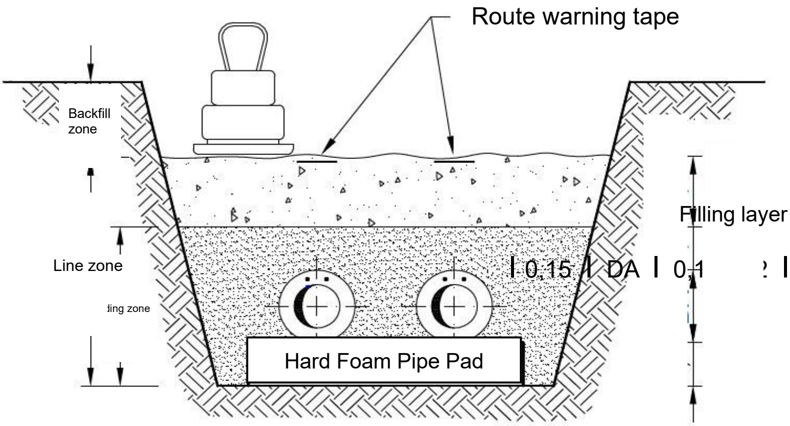


Figure 24, Backfill - pipeline zone

On top of the first layer, build another layers of 20-30 cm height and finish with the intended top layer

3.2 Transport, unloading and storage of materials

3.2.1 Transport

The plastic casing pipes and components as well as the accessories are delivered by truck to the construction site or the material warehouse. The access routes must be suitable for heavy goods traffic and for trucks with a 12 m or 16 m loading area.

The storage of the pipe rods on the truck has to be carried out with sufficiently wide wooden intermediate layers and thus ensures a safe and damage-free unloading.

The service pipe ends must be protected with plastic caps during transport and storage must be sealed. These must not be removed from the system components until the steel pipe weld joints are prepared. All couplings and shrink materials as well as all accessories such as end caps, sealing rings, etc. are delivered in protective sleeves or cardboard boxes which must not be removed or damaged until immediately before installation.

3.2.2 Unloading

The unloading of the truck is carried out on site by the pipe layer. Compliance with all relevant accident prevention regulations and safety conditions must be ensured. All pipes, construction and accessory parts are to be unloaded properly and carefully and must not be thrown from the loading area. Smaller dimensions and accessories should preferably be unloaded by hand..

For larger nominal diameters, unloading is carried out with a crane to be provided by the customer. For 12 m and 16 m pipe rods, two 10 - 15 cm wide textile or nylon belts with a load beam (traverse) at least 4 m long must generally be used for unloading

This prevents unacceptable deflection and damage to the pipes as well as possible damage to integrated systems such as the net monitoring system. Pulling and rolling of the pipes on the ground as well as the use of steel ropes or chains is not permitted

.

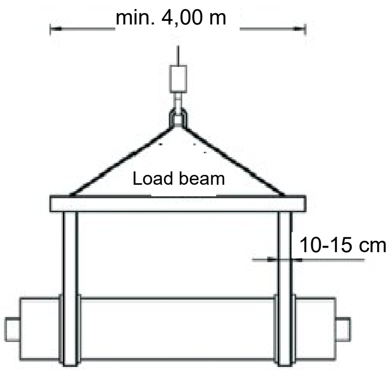


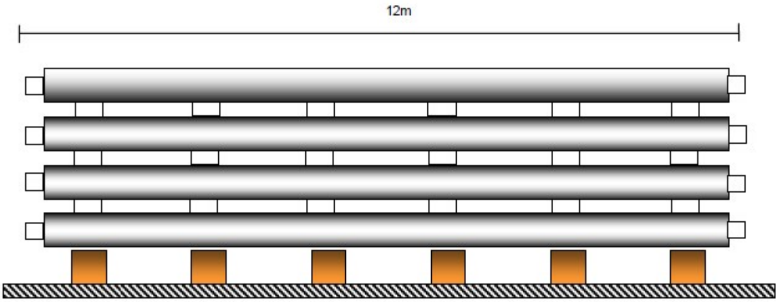
Figure 25, Unloading - load beam and belts

3.2.3 Storage

The pipe rods and components are to be stored on level, stone-free and dry surfaces, separated according to dimensions. Groundwater endangered and water damming soils are to be avoided for storage. Sand banks or appropriately wide squared timber shells serve as supports for the pipe rods.

Depending on the nominal size, these should be between 10 and 15 cm wide and evenly spaced at intervals of around 2.00 m (see Fig. 26).

For safety reasons, the stack height should be limited to a maximum of 2.50 m. The pipe stacks can be arranged either in pyramid or cuboid form (see Figs. 27 and 28). In any case, the pipes must be secured against lateral slipping by means of pegs, supports or wooden wedges. If the pipes are to be stored for a longer period, suitable protective measures must be taken against all weather influences.



Side view - storage of prefabricated pipes á 12m in cuboid shape. Position of wooden planks: 6 pieces - 1m from the end of the pipes and at a distance of 2m.

Figure 26, Bearing - side view

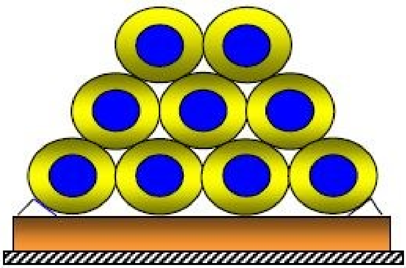


Figure 27, Storage as a pyramid

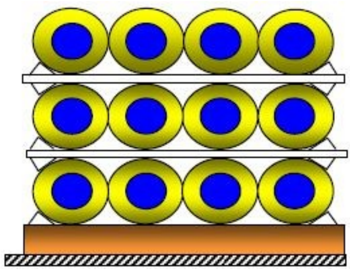


Figure 28, Storage as a cuboid

Precautions must be taken to avoid moisture penetration of the foam areas and contamination when storing all system components such as bends, T-branches, fittings, etc. Moisture penetration of the foam end areas and contamination are avoided.

Mechanical damage to the cores of the monitoring and fault location systems must be excluded.

Accessories such as sleeves, shrink sleeves, end caps, expansion pads, etc. must also be sorted, stored in a dry, frost-free place and protected from direct sunlight; all connection sleeves must be stored upright.

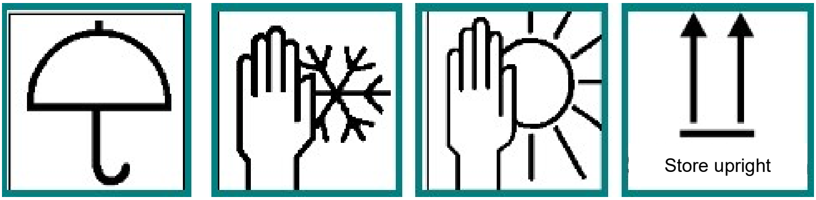


Figure 29, Storage indication sign

Figure 30, Improper storage

Figure 31, Proper storage

The PUR in-situ foam components, like the other accessories already mentioned, must be stored protected against theft in a lockable room or construction container at temperatures between +15° C and +25° C. It is essential to comply with the requirements of the safety data sheets.

Polyol

Figure 32, Warning and command signs for polyol

Isocyanate

Figure 33, Warning and command signs for isocynate

Authors of the chapter

Gerd Moser, BRUGG Pipe Systems GmbH

Ralph Herzer, BRUGG German Pipe GmbH

4. Pipeline Construction

4.1 General

Only companies that have proven their professional qualification according to FW 601 and are in possession of a valid certificate are to be commissioned with the pipeline construction work.

Prior to the start of installation, the pipe trench shall be handed over by the civil engineering company to the pipeline construction company.

Within the framework of the preparatory measures for the installation of the (KMR) Pre-insulated Pipe, the pipe-laying company must pay particular attention to and check the following points:

- Checking the installation plans for conformity with the local conditions.
- Consideration of special features in the installation plans (location of special components, location of T-branches, thermal prestressing, etc.).
- If thermal prestressing is planned, have the prestressing sections been defined and in what order should the line sections be installed and prestressed.
- Feasible solutions for overcoming any obstacles.
- If there are obstacles in the pipe trench that were not known during the planning phase and have to be built over or culverted, it is essential to contact the planner or system manufacturer before laying the pipe so that the route modification can be statically checked and approved.
- If the length and thickness of the expansion zones are specified in the installation plan and it is thus ensured that the center distances of the pipelines in these areas are increased accordingly.

4.1.1 Installation of the plastic casing pipes and components

The system components are to be placed in the pipe trench for further processing, in accordance with the installation and laying plans and in accordance with the manufacturer's instructions, and moved to the correct position without functional impairment of the sand bed or the pipe supports using suitable lifting equipment and support straps.

Sandbags or rigid PUR foam bars that do not damage the casing pipe and do not have to be removed after installation are to be used as support aids.

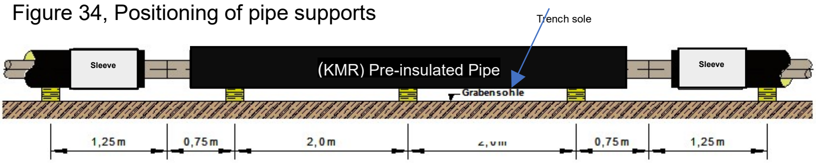
Squared lumber is not permitted as a support aid!

The size of the support aids must be such that a working space of at least 20 cm around the pipe is ensured. The positioning of the support aids must be selected so that they are outside the areas of expansion pads and casing joints.

In particular, in the case of pipelines to be prestressed, care must be taken to ensure that no components (valves, gate valves, T-branches, etc.) are hindered in their freedom of movement.

If the pipelines rest on the trench subgrade, the required sand bed must have a height of at least 10 cm.

Figure 34, Positioning of pipe supports



When installing pipes over head holes, care shall be taken to arrange the casing joints centrally above them. Sufficient working space for proper installation of the components and use of the tools, equipment and machinery for making the pipe and socket joints must be ensured by spacing the pipes sufficiently from each other and from the pipe trench walls.

During pipe laying - before welding the service pipes - the closed socket systems that are normally used are to be pushed onto one end of the pipe in a suitable manner, originally packed and undamaged, and placed far enough away from the welding point to be protected against overheating (see Figure 35).

Only careful handling of these materials during the pipe-laying phase (protection against damage, soiling, strong sunlight, etc.) will later ensure flawless workmanship and a high-quality sealing function.

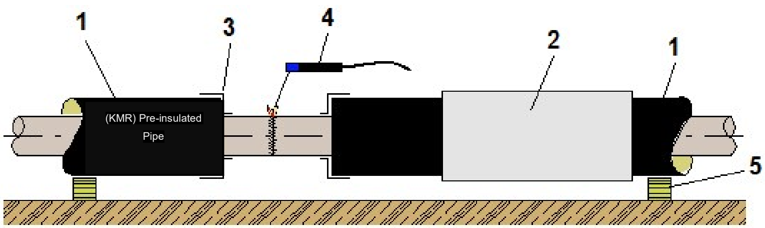


Figure 35, Welding of (KMR) Pre-Insulated Pipe

1. (KMR) Pre-insulated Pipe
2. Muff system (wrapped in protective film).
3. Flame protection mat (protection during the welding process)
4. Hand welder
5. PUR - rigid foam pipe support

To absorb the stresses in the pipeline resulting from thermal expansion and the end displacements at changes in direction, various compensation measures such as L-, Z- or U-bends are possible.

Furthermore, thermal prestressing of the piping or mechanical prestressing of the expansion pads is possible under certain conditions and structural circumstances. The installation of system components, such as T-branches, expansion joints, ground installation fittings, fixed points, etc., also requires special attention with regard to statics and installation regulations (see Chapter 1, Planning).

The distance between the pipes and the pipe trench wall or the trench shoring as well as between the supply and return pipes is based on the following aspects and regulations for installation in the pipe trench:

- safety during work in excavations and trenches in accordance with BGV C 22 in conjunction with DIN 4124
- the necessary clearances for pipe and system component laying
- the production of the carrier pipe weld seams
- the type of socket joints to be produced
- the possibility of compacting the bedding materials, especially in the lower pipe area
- the different displacement of the supply and return pipes in the bend areas
- the length and thickness of the expansion pads to be installed

4.1.2 Mounting fittings

Mounting fittings should only be used when no other alternatives are possible from a technical point of view.

Of course, there will always be cases where an installation fitting is justified, such as in the case of an unexpected obstruction in a busy road or a tapping of a district heating pipeline for a new branch. However, these are manageable individual cases for which the installation fittings were ultimately designed.

When deciding to use installation fittings, it must be taken into account that PE components manufactured on site are always subject to the site conditions, which rarely correspond to those of factory production.

4.1.3 Installation with monitoring and fault location system

If the LOCAs are equipped with a monitoring and fault location system, special attention must be paid to the following:

- The cores must not be mechanically and/or thermally damaged under any circumstances. Suitable protective measures must be taken when welding the carrier pipes (see Figure 35).
- The electrically conductive cores of the monitoring and fault location systems must be in the position specified by the manufacturer after pipe laying.
- Cores of the same type must generally be opposite each other (see Figure 36).
- Crossing of the cores in the socket areas is not permitted (if necessary, the pipes must be rotated during installation)!

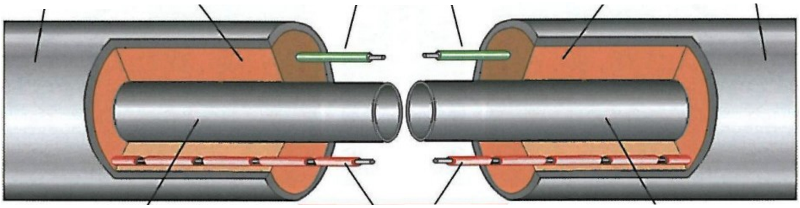


Figure 36, Wire position for monitoring system (example NiCr-Cu system)

4.1.4 Handover to socket installation company

After completion of its work, the pipeline construction company shall hand over the section to be reinsulated to the joint installation company in due form and on the basis of a report.

The report must show that all welds belonging to the postinsulation section have been inspected and approved.

Authors of the chapter

Gerd Moser, BRUGG Pipe Systems GmbH

Ralph Herzer, BRUGG German Pipe GmbH

5. Socket systems - socket assemblies-jacket joints

In order to achieve a friction-locked, gas and water-tight district heating pipe system, special socket constructions are required for the casing joints.

5.1 Muffle systems

According to the current state of the art, the following muffle systems are used in district heating:

- non-crosslinked shrink joints
- cross-linked shrink joints
- electric joints
- manufacturer-specific special joints

5.1.1 Non-crosslinked shrink joints

This type of joint represents a double-sealing joint system consisting of an undivided PEHD pipe with heat-shrinkable properties. The first seal is made by placing butyl rubber sealing tapes between the sleeve on the casing pipe. The second seal is made by two shrink sleeves at the joints of the sleeve to the casing pipe.

5.1.2 Cross-linked shrink joints

The cross-linked self-sealing shrink sleeve is a system consisting of an undivided PEHD pipe with heat-shrinkable properties. After extrusion, the sleeve is cross-linked. This radiation crosslinking gives the sleeve mechanical, thermal and chemical properties of high performance plastics. A sealing tape made of butyl rubber is inserted between the casing pipe and the sleeve for sealing before the shrinkage process, so that the shrinkage and sealing result in an very high annular strength is achieved and no additional sleeve is required.

5.1.2 Electrofusion sockets

The electric socket is a non-crosslinked socket system consisting of a split or unsplit PEHD pipe. By applying heating conductors or using sleeves that have already been equipped with heating grids during manufacture, the sleeve can be heated by microprocessor-controlled welding transformers to such an extent that the sleeve is bonded to the outer casing.

5.2 Working steps for non-crosslinked shrink joints

a) Removal of the foam skin at the ends of the adjacent foam areas.
b) Installation of the monitoring and fault location system in accordance with the manufacturer's instructions
c) Cleaning and drying of the sealing surfaces
d) cleaning and degreasing of the sealing surfaces with PE cleaner
e) Roughening of the shrinkage areas with emery cloth (grain size 40-60), + 50 mm on both sides in each case
f) Final cleaning of the sealing surfaces
g) Mark the center of the sleeve over the back cut
h) cut the sealing tape to size (circumference + 50mm)
i) Preheat the contact surfaces to approx. 40°C
j) Place the butyl rubber sealing tape approx. 20 mm from the marking with an overlap of approx. 50 mm.
k) Make vent holes at the edge of the sleeve (immediately after the end of the bearing surface).
l) Center the socket at the two centering marks.
m) Shrink socket pipe ends (supports on outer casing) with flame by moving burner continuously in circumferential direction and radially to pipe.
n) Allow socket to cool to below approx. 40°C
o) Leak test at 0.2 bar for a period of 3 minutes
p) Drill out vent holes
q) Prepare a test foam, at least at the beginning of daily foaming, for new containers of foam components or before starting a foaming series. The test foaming can be used to determine the reaction times and the quality of the PUR components.
r) Check the shelf life of the components and the component temperature (approx. 20°C).

s) Determine correct quantity dosage according to the volume of the socket cavity and the correct mixing ratio of the foam components according to the specifications of the foam manufacturers and mark it in the mixing cup.

t) Surface temperatures during foaming must be within a range of 15 to 45°C.

u) Foam components polyol and isocyanate must be mechanically mixed exclusively with a high-speed stirrer until no streaks remain and a uniform coloration is obtained.

v) Rapid filling of the foam mixture and insertion of vent plugs.

w) Tap the insulated joint and compare the sound with the factory-made (KMR) Pre-insulated Pipe pipe. A comparable sound indicates proper foaming.

x) Checking the monitoring system after the PUR foam has cured.

y) Permanent sealing of the foam openings

z) Thoroughly clean the transition areas of the sleeve to the casing pipe and degrease them with PE cleaner.

aa) Roughen the transition areas with emery cloth (sleeve width +50 mm on both sides)

ab) Heat the transition area to approx. 65°C

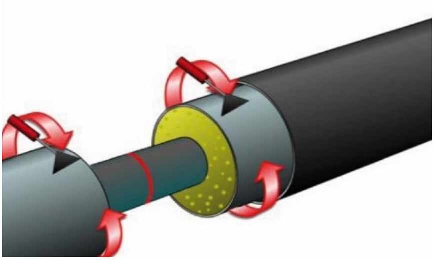
ac) Shrink the sleeve by moving the torch continuously in circumferential direction and radially to the pipe. During the shrinking process, the liquefaction of the hotmelt adhesive on the entire sealing surface must be determined by the fitter using the finger test. After completion of the shrinking process, the fitter must check the hot-melt adhesive leakage and a downward pointing shape of the adhesive by feeling the edges of the sleeve. A beak up of the adhesive is not okay.

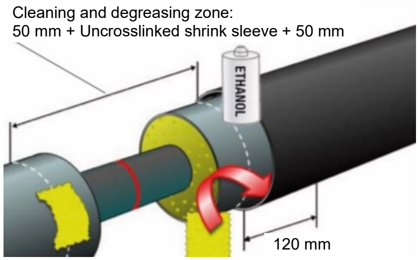
ad) Final inspection

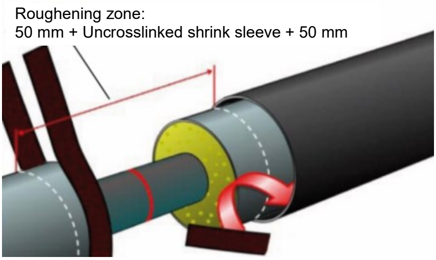
ae) Permanent visible marking of the sleeve on the upper side with

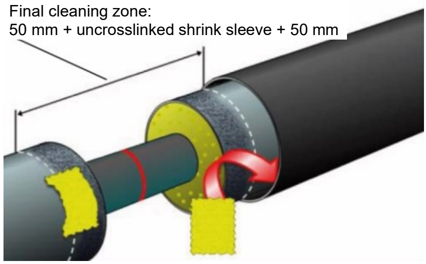
- Day of socket installation
- Socket fitter (abbreviation or number

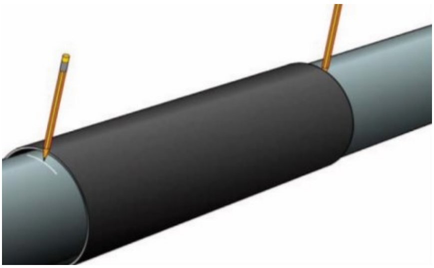
Measured values

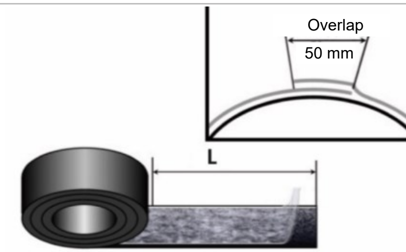


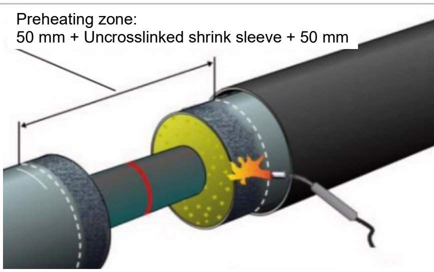

Cleaning and degreasing zone:
50 mm + Uncrosslinked shrink sleeve + 50 mm
ETHANOL
120 mm

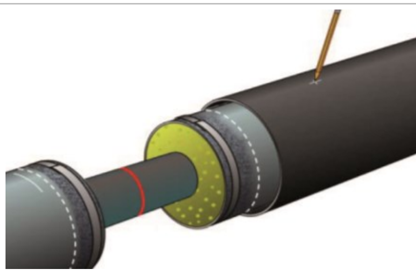

Roughening zone:
50 mm + Uncrosslinked shrink sleeve + 50 mm

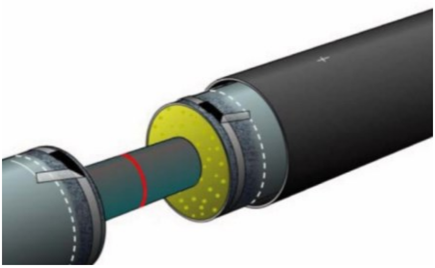

Final cleaning zone:
50 mm + uncrosslinked shrink sleeve + 50 mm

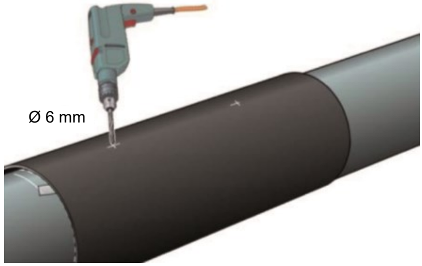


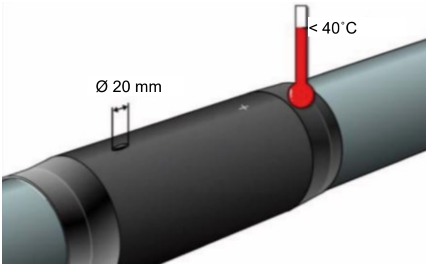

Overlap
50 mm
L

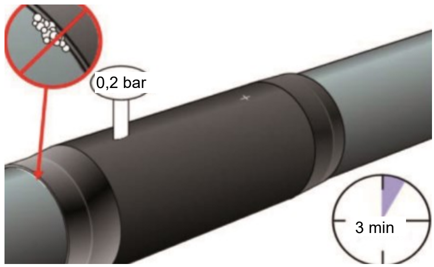

Preheating zone:
50 mm + Uncrosslinked shrink sleeve + 50 mm

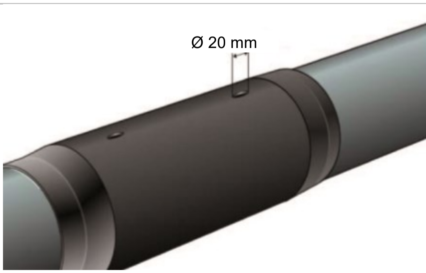


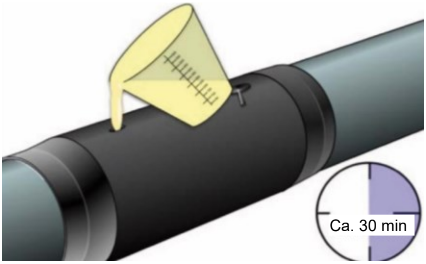


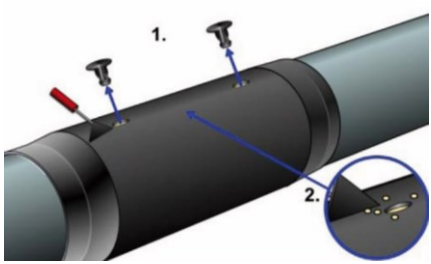

Ø 6 mm

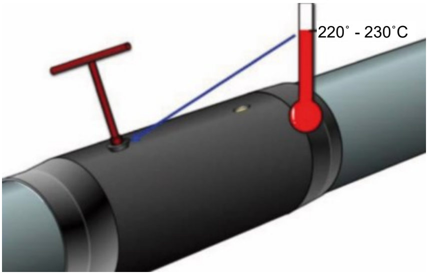

< 40˚C
Ø 20 mm

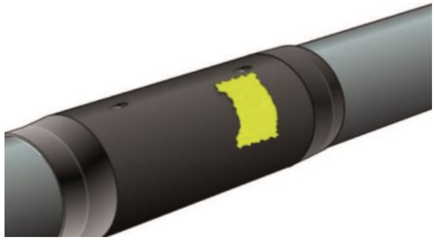

0,2 bar
3 min

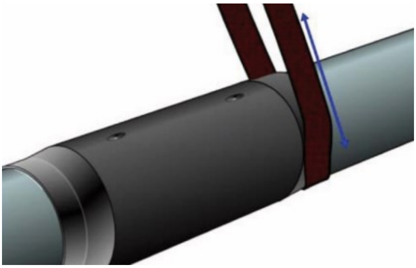

Ø 20 mm

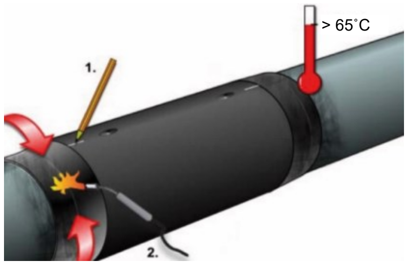

Ca. 30 min

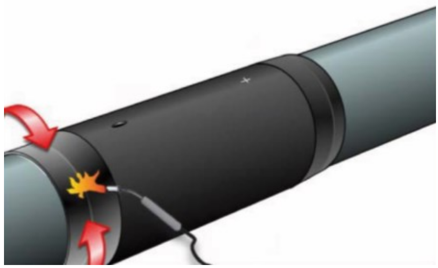

1.
2.


220˚ - 230˚C






> 65˚C
1.
2.



5.3 Working steps for crosslinked shrink sleeves

a) Removal of the foam skin at the ends of the adjacent foam areas

b) Installation of the monitoring and fault location system in accordance with the manufacturer's instructions.

c) Cleaning and drying of the sealing surfaces

d) cleaning and degreasing of the sealing surfaces with PE cleanere) Roughening of the shrinkage areas with emery cloth (grain size 40-60), on both sides +50 mm each

e) Roughening of the shrinkage areas with emery cloth (grain size 40-60) +50 mm on both sides

f) Final cleaning of the sealing surfaces

g) Mark the center of the sleeve over the back cut

h) Cut the sealing tape to size (circumference +50mm)

i) Preheat the contact surfaces to approx. 40°C.

j) Place sealing tape made of butyl rubber approx. 20 mm next to the marking with approx. 50mm overlap

k) Make vent holes at the edge of the sleeve (immediately after the end of the bearing surface)

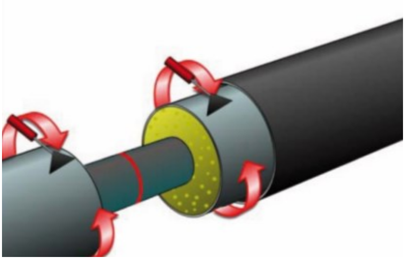
l) Center the sleeve at the two centering marks

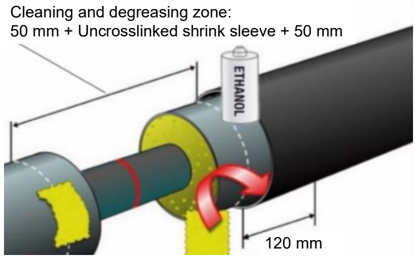
m) Shrink socket pipe ends (supports on outer casing) with flame by moving torch continuously in circumferential direction and radially to pipe.

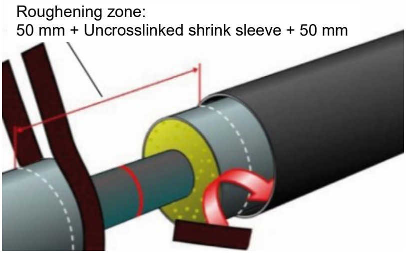
n) Allow the sleeve to cool to below approx. 40°C.
o) Leak test with 0.2 bar over the duration of 3 minutes
p) Drill out vent holes
q) Prepare a test foam, at least at the beginning of daily foaming, for new containers of foam components or before starting a foaming series. The test foaming can be used to determine the reaction times and the quality of the PUR components..
r) Check the shelf life of the components and the component temperature (approx. 20°C).
s) Determine the correct quantity dosage according to the volume of the socket cavity and the correct mixing ratio of the foam components according to the foam manufacturer's specifications and mark it in the mixing cup.

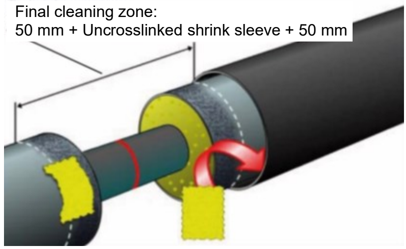
t) Surface temperatures during foaming must be in the range of 15 to 45°C..

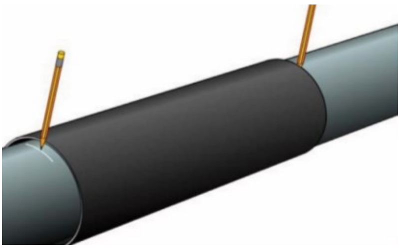
u) Foam components polyol and isocyanate are to be mechanically mixed exclusively with a high-speed stirrer until there are no more streaks and a uniform coloration is obtained..
v) Rapid filling of the foam mixture and insertion of vent plugs.
w) Tap the insulated joint and compare the sound with the factory-made (KMR) Pre-insulated Pipe pipe. A comparable sound indicates proper foaming
x) Checking the monitoring system after the PUR foam has cured.
y) Permanent sealing of the foam openings..
z) Final inspection.
aa) Permanent visible marking of the sleeve on the upper side with Day of socket assembly
bb) Socket fitter (abbreviation or number)
cc) Measured values

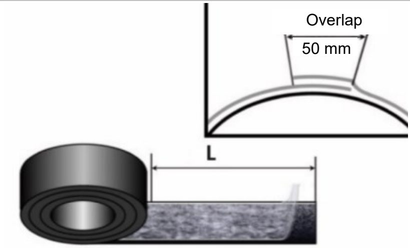


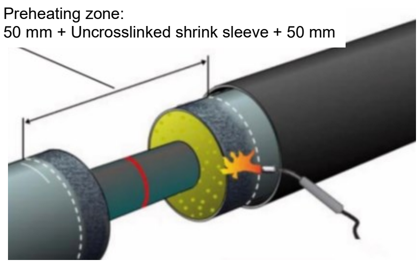

Cleaning and degreasing zone:
50 mm + Uncrosslinked shrink sleeve + 50 mm
ETHANOL
120 mm

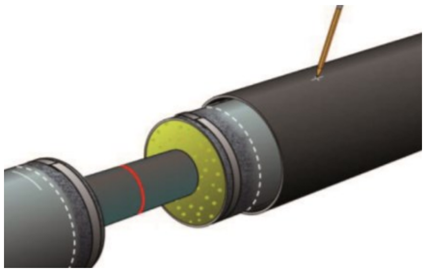

Roughening zone:
50 mm + Uncrosslinked shrink sleeve + 50 mm

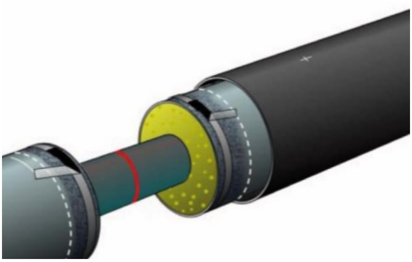

Final cleaning zone:
50 mm + Uncrosslinked shrink sleeve + 50 mm

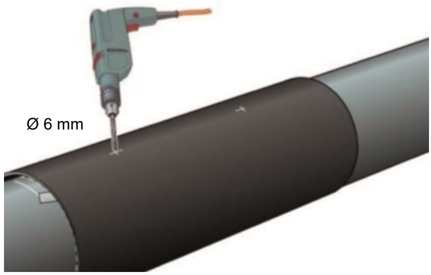


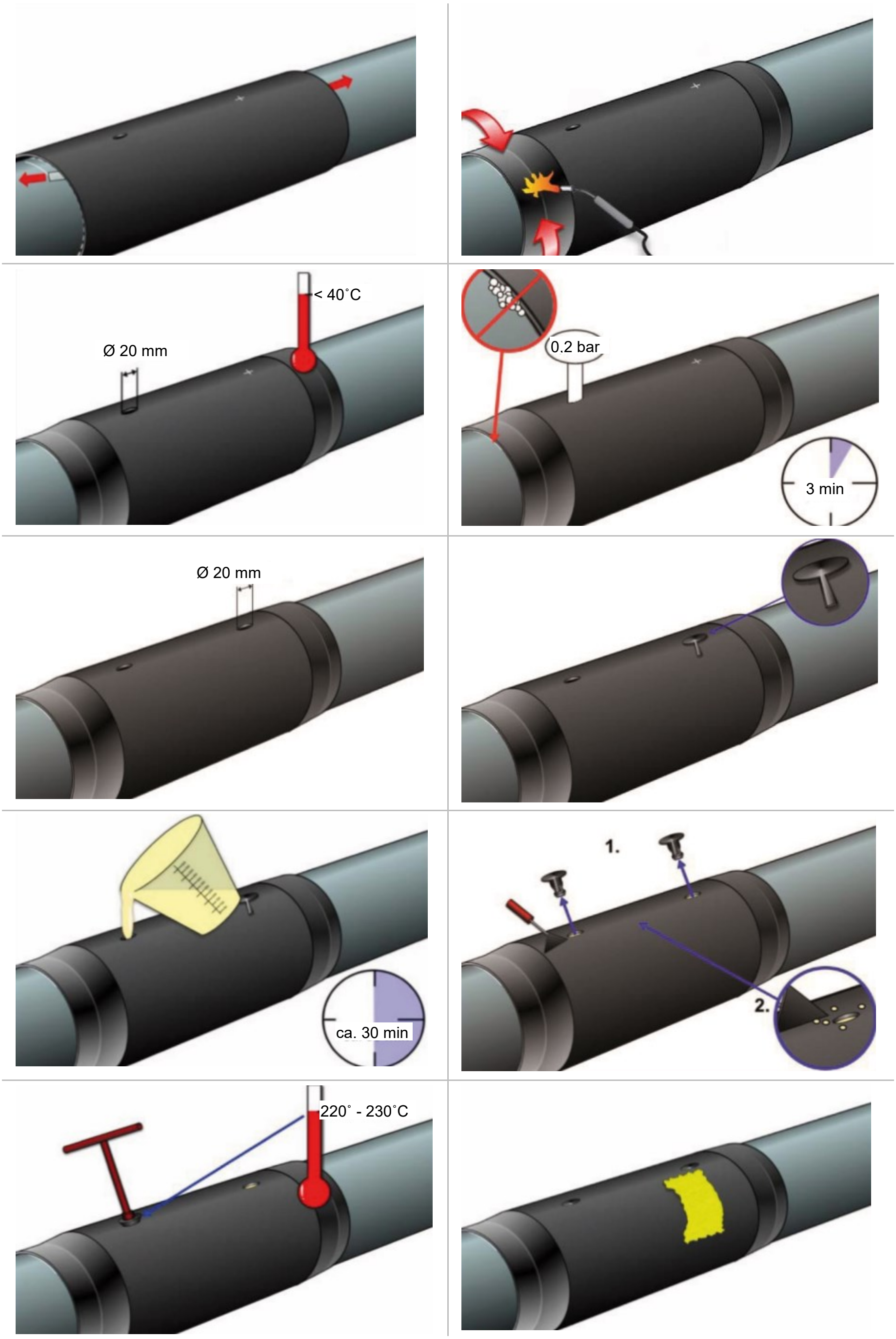

Overlap
50 mm
L

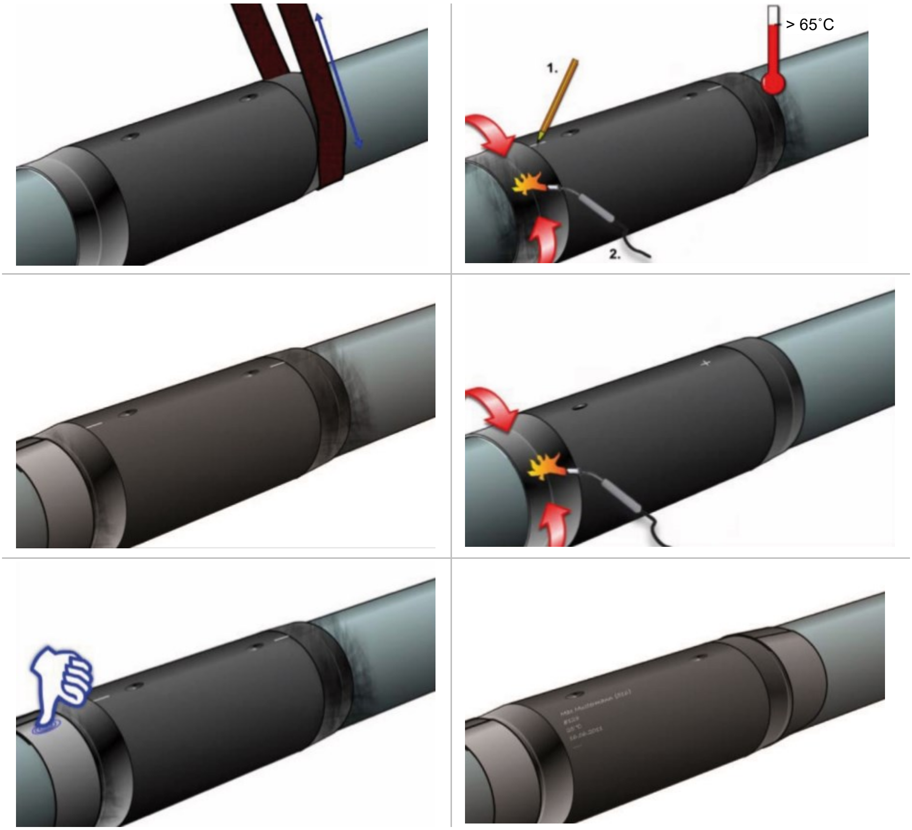

Preheating zone:
50 mm + Uncrosslinked shrink sleeve + 50 mm






Ø 6 mm


< 40°C
Ø 20 mm
0.2 bar
3 min
Ø 20 mm
1.
2.
ca. 30 min
220° - 230°C



5.4 Working steps for electric joints

a) Removal of the foam skin at the ends of the adjacent foam areas

b) Installation of the monitoring and fault location system in accordance with the manufacturer's instructions.

c) Cleaning and drying of the sealing surfaces

d) Cleaning and degreasing of the sealing surfaces with PE cleaner

e) Smoke the shrinkage areas with emery cloth (grain size 40 -60) + 50 mm on both sides.

f) Final cleaning of the sealing surfaces

g) Mark the center of the sleeve over the back cut.

Thoroughly degrease the copper heatsealing band. Place the copper heating cable around the outer casing 20 mm from the edge of the socket or the centering marks and position it at the 12:00 o'clock position. Fasten the copper heating cable tightly to the outer casing using the plastic staples. A distance of 3 - 5 mm must be maintained between the ends of the copper heating conductors due to expansion during heating.

h) Make vent holes at the edge of the socket (immediately after the end of the bearing surface).

i) Shrink the socket pipe ends (supports on the outer casing) with the flame by continuously moving the burner in the circumferential direction and radially to the pipe.

j) Allow the socket to cool to below approx. 40°C

k) Position the clamping bands flush with the socket ends directly above the copper heatsealing bands and screw them in place. Exclude electrical short circuits Tighten clamping bands firmly

l) Connect both welding guns to the loose ends of a copper heatsealing band. ignoring the polarity Secure the guns with a tensioning strap or adhesive tape. After a final inspection on sight of all joint components, the first automated electric welding operation is carried out. Proceed in the same way with the other side.

m) Allow the sleeve to cool to below approx. 40°C

n) Leak test with 0.2 bar over the duration of 3 minutes..

o) Drill out vent holes

p) Prepare a test foam, at least at the beginning of daily foaming, for new containers of foam components or before starting a foaming series. The test foaming can be used to determine the reaction times and the quality of the PUR components.

q) Checking the shelf life of the components, the component temperature (approx. 20°C)

r) Determine the correct quantity dosage according to the volume of the socket cavity and the correct mixing ratio of the foam components according to the foam manufacturer's specifications and mark it in the mixing cup.

s) Surface temperatures during foaming must be in the range of 15 to 45°C.

t) Foam components polyol and isocyanate must be mechanically mixed exclusively with a high-speed stirrer until there are no more streaks and a uniform coloration.

u) Rapid filling of the foam mixture and insertion of vent plugs.

v) Tap the insulated joint and compare the sound with the factory-made (KMR) Pre-insulated Pipe pipe. A comparable sound indicates proper foaming.

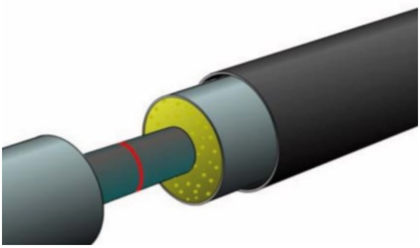
w) Checking the monitoring system after curing of the PUR-foam has cured.

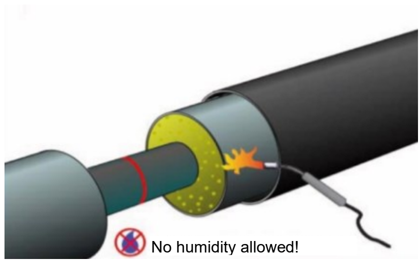
x) Permanent sealing of the foam openings.

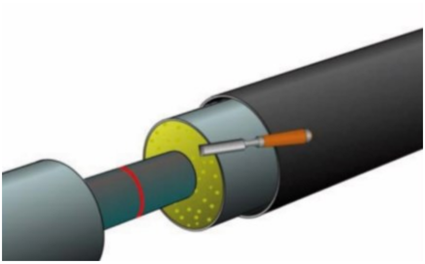
y) Final inspection

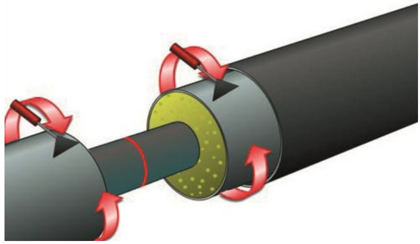
z) Marking of the sleeve on the upper side permanently visible with

- Day of socket installation
- Sleeve fitter (abbreviation or number)
- Measured values

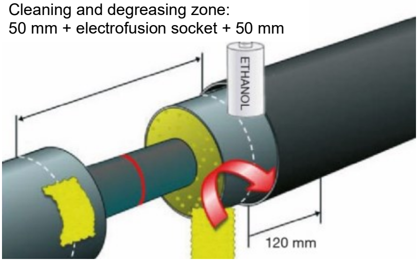




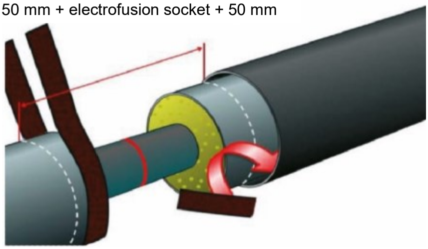




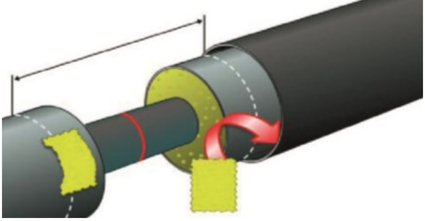
Cleaning and degreasing zone:
50 mm + electrofusion socket + 50 mm

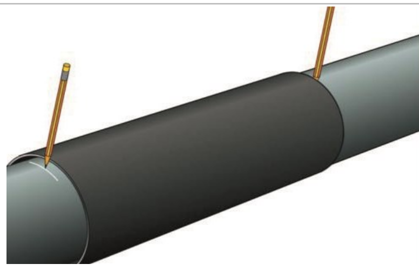


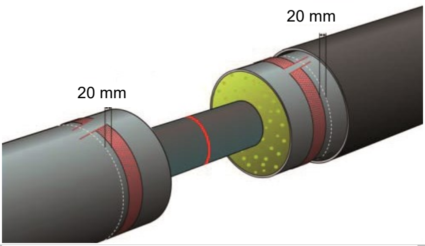
Roughening zone:
50 mm + electrofusion socket + 50 mm

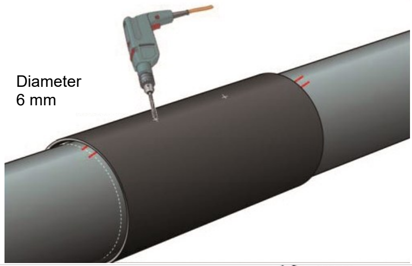


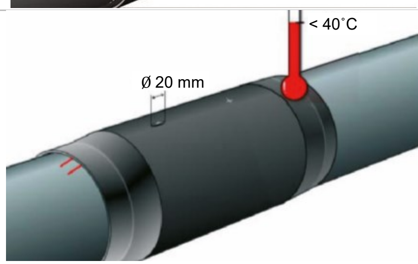
Final cleaning zone:
50 mm + electrofusion socket + 50 mm

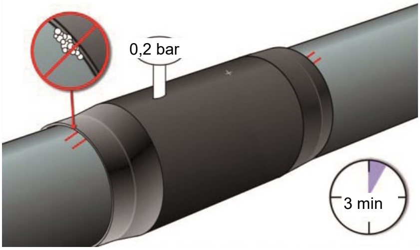


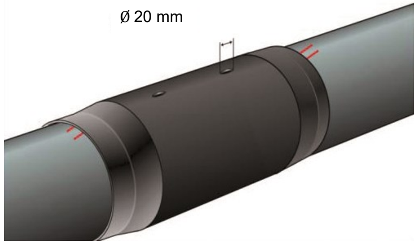


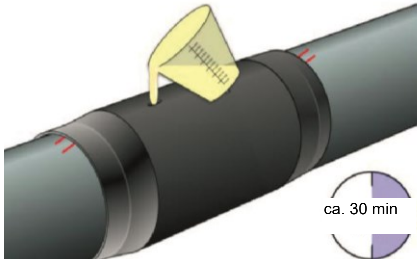


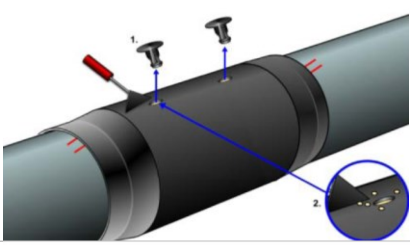


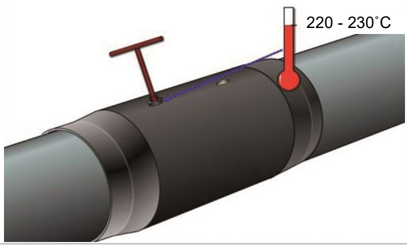



0,2 bar
3 min


Ø 20 mm


ca. 30 min


1.
2.


220 - 230˚C

Documents required for socket installation:

- Assembly tools & machines
- Assembly instructions
- Foam tables
- Operating instructions
- Protective equipment

5.5 Quality assurance

Faultless execution of insulation and sealing work on socket joints depends, among other things, on the prevailing weather conditions. While a sufficiently large working umbrella is sufficient in rainy weather, temperature is an extremely important factor for the quality of workmanship, in addition to cleanliness.

The standard range of temperature according to EN 489 is in the range between +15℃ and +45℃. This applies to both the air temperature and the surface temperature of the plastic casing pipe components. The ideal processing temperature of the foam components "polyol and isocyanate" is at 20 ℃.

For construction measures outside this range, it is necessary either to stop the construction site or to take special construction measures, which can be provided at the request of the client or the executing company.

In general, the surfaces of the steel pipe joints and the casing annulus of the socket joint must be safely maintained over the entire insulation and sealing phase at temperatures between

+15℃ and +45℃ must be maintained.

This can be achieved in the cold season by:

- Circulation of heating water
- Use of a construction blower
- Electric preheating of the steel medium pipes.

- Enclosure and light heating (up to approx. 15˚C) during PE welding operations.
- In the warm season:
- By shading the PUR foam components and socket areas, which must not be exposed to direct sunlight.
- Carry out foaming work in the early morning or late evening hours.

When repairing and tapping (KMR) Pre-insulated Pipe systems in operation, pay attention to:

- Pre-foaming
- Use of foam trays
- Wrapping the hot surface with closed-cell polyethylene wrapping strips

Other points that influence the quality:

- Precipitation - remedial action through appropriate protective measures, such as protective screens.
- Strong wind - remedy by appropriate protective measures, such as windbreaks
- Lack of space - sufficient space must be available (DIN 4142:2002)
- Cleanliness, dryness - the (KMR) Pre-insulated Pipe parts and pipes should be in a clean condition, the pipe trench in a relatively dry condition

Final work of the assembly personnel Final inspection

- Final measurement
- Documentation

Authors of the chapter

Johannes Ellmer, isoplus district heating technology Sales Company Ltd.

Oliver Vollmann, STURM Isotech GmbH & Co. KG

6 The use of valves in local and district heating networks

Valves make an important contribution to the safe and economical operation of local and district heating networks, regardless of whether they are used for controlling or shutting off material flows. In the following, however, valves for shutting off material flows will be dealt with in particular, since the control function is mainly used in systems for generation and pressure maintenance. In the rest of the text, the term district heating is used, although the explanations also apply to use in local heating and district cooling networks.

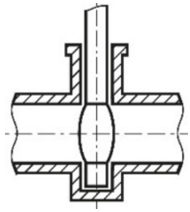
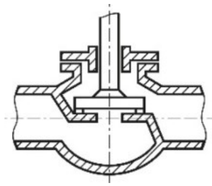
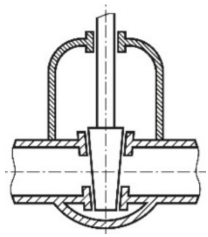
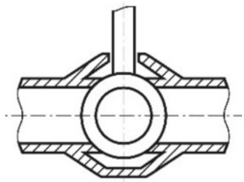
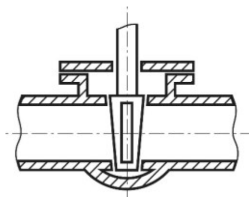
6.1 The correct selection of valve types

The various criteria for selecting valves already play a major role in the planning of plants and networks. Due to the focus on the application of shut-off valves in this chapter, the following characteristics will require special attention:

- Installation space
- Flow characteristics
- Maintenance requirements
- Costs for acquisition and operation

For the application of valves for the shut-off of material flows, the following valve types are mainly used in the plants:

Basic construction types according to EN736

Basic construction	Principle sketch
Butterfly valve	
Globe Valve	
Gate Valve	
Ball valve	
Rotary Plug Valve	

Based on the many years of experience of a wide range of energy supply companies in Europe with regard to reliability and safety, the use of ball valves has proven its worth, especially for directly buried pipelines. Of course, there are areas of application, especially in plant construction or in existing shaft structures, where the use of a compact shut-off valve also offers advantages due to cramped installation conditions.

The resulting disadvantages, such as the butterfly valve disc standing in the passage with its sealing elements flowing in the media flow and the resulting flow losses, do not weigh as heavily as possibly the costly conversion or even renewal of the structure in question.

Due to the positive experience gained in the use of ball valves over many years and the fact that they account for the largest proportion of the total number of valves used, the remainder of this chapter will focus in particular on this type of valve. However, comparisons, whether positive or negative, with other valves will be made at appropriate points and evaluated accordingly.

In addition to the general selection criteria, the many years of experience of the energy supply companies also play a decisive role in the selection of the valve types to be used. However, technical progress should be re-evaluated on a regular basis when planning new plants. Existing maintenance and repair infrastructure for certain valve types or even makes can be an argument for keeping old specifications, but makes little sense if there is general dissatisfaction, for example, with regard to reliability of the valve types or makes used so far.

Valve types that require considerable maintenance for the energy supplier should be replaced with valves that require as little maintenance as possible, or even better, maintenance-free valves in times of scarce personnel capacities.

Valves that require maintenance for safe and reliable operation must be serviced regularly according to the manufacturer's specifications. One example of this is the plug valves that were often used in earlier years, which usually had to be maintained by regularly injecting sealant. If regular maintenance is not carried out due to a shortage of personnel, operational safety is jeopardized. Which energy supplier would want to find a valve that can no longer be switched in the event of a scheduled or unscheduled shutdown of a network section?

Ball valves, which have been used successfully and reliably for many years, are used in district heating in two variants. On the one hand, ball valves with full bore are used. This variant offers a circular passage in the passage of the valve without constriction or narrowing in the area of the sealing seats in relation to the pipeline.

On the other hand, energy suppliers use ball valves with reduced passage for cost reasons. In this case, the passage in the area of the sealing seat and ball is usually constricted by one nominal size, which can contribute to additional noise development in addition to the flow losses that occur. Particularly in main pipelines with increased flow velocities, a ball valve with reduced passage can therefore lead to disadvantages, for example hydraulically.

Thus, all criteria for the selection of valves should be re-evaluated already during the planning of new plants or also for reconstruction measures.

The following overview serves as an aid in selecting the valve type depending on the criteria.

Selection of a fitting

Assignment of the criteria to the basic valve type

Criterion	Valve	Gate	Check	Ball-Valve	Comments
Tightness	+	+	+	++	Important, as long service life required
Pressure loss	−	+	+	++	with full bore like straight pipeline
Control characteristic	++	+	+	−	District heating applications less frequently required
Operating frequency	+	+	+	+	District heating rather low
Operating time	−	−−	++	++	Pressure differential is to be observed
Temperature range	+	+	+	+	mostly max. 120-130° C operating temperature
Pressure range	−	+	−	+	district heating PN 25
Operator	−	−	++	+	Remote heat important for the design of the drives
Installation space	−	−	++	+	Observe building design
Wear resistance	+	++	−	+	not relevant, since water is not clean
Repair incidence	−	−	++	++	Maintenance possible / not possible depending in design

6.2 The correct installation of the valves

After the selection of the best possible type of valves, correct storage and proper installation play an essential role for many years of reliable service in district heating. It is not uncommon for the service life of valves to be so limited during storage at the construction site or during installation that replacement was necessary before the plant or pipeline could be put into operation.

The storage of the valves must always be carried out according to the specifications of the respective manufacturer, which can be seen in the documents enclosed with the valve. The documents must be requested from the manufacturer if they are not enclosed with the valve when it is delivered.

Basically, the following points must be observed for storage:

- The storage must be carried out in such a way that contamination, especially inside the valve, can be ruled out. If protective caps are fitted by the manufacturer, these may only be removed shortly before installation.

- The permissible ambient conditions specified by the manufacturer, such as temperature, humidity and solar radiation, must be observed; in winter in particular, frost must be avoided.

- Ball valves should be stored and installed in the "OPEN" position, as in this position the sealing elements are properly protected. (Note: butterfly valves and gate valves, on the other hand, are stored in the "CLOSED" position).

When installing valves, the assembly and installation instructions of the respective manufacturers also apply, which can be found in the documents relating to the valve.

Some generally valid regulations also apply to the installation, which are to be listed for all manufacturers:

- Installation is to be carried out by suitable qualified personnel only. In the case of large valves, the attachment points specified by the manufacturer must be used.

- When installing flange connections, the specifications of the valve manufacturer and the specifications of the gasket manufacturer must be observed, and tightening torques for screws must be complied with.

- When welding, the maximum permissible temperatures of the valves must be observed; if necessary, cooling devices must be installed.

- Ball valves must always be installed in the open position and operated for the first time after the line has been cleaned/flushed.

Proper operation of the valve must be ensured in the installed state without danger to the operating personnel.

In general, all valid rules of technology must be observed in addition to the specifications in the respective manufacturer's documentation. In case of doubt, the respective manufacturer must be contacted.

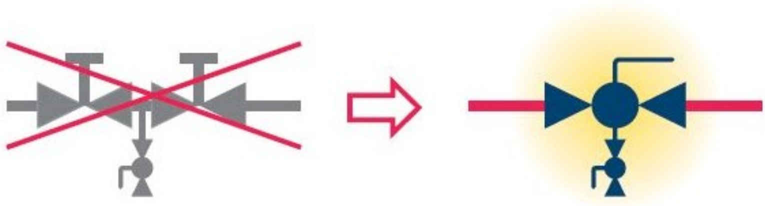
6.3. The correct operation of valves

In principle, the correct handling can also be found in the operating instructions of the respective manufacturer.
However, there are still special features for the application in district heating plants. For example, ball valves are often used because of the properties already described. However, due to their design, these have the limited application as pure open/close valves, which can lead to very long operating times for the ball valves in the case of longer transport lines, which means that the ball must be switched very slowly.
This can result in very high flow velocities with very slightly opened cross-sections, which can cause the ball seals made of PTFE (Teflon) used by all manufacturers to wash out and thus lead to leaks.
The intended operating time should always be selected in consultation with the valve manufacturer. When using electric actuators, it is usually also possible to provide a cycle which, according to a preset travel mode, dwells in intermediate positions in order to achieve a desired travel time from the fully open to the fully closed position, whereby no travel of the ball takes place in certain intermediate positions for a time to be defined. In any case, the manufacturer of the ball valve must be contacted for sizing.

A risk that should not be underestimated is the filling of pipeline sections, whether in newly built pipelines or during recommissioning after repair work. Very often, filling is carried out via ball valves located in the network. The opening of a small gap and the associated flow velocities can also damage the sealing system. A better solution here is to use drain and vent nozzles upstream and downstream of the main valve. Particularly safe is the filling of line sections via a bypass mounted between the two nozzles.

In order not to endanger the drain and vent fittings unnecessarily, it is advisable to use a so-called "wear fitting" to throttle the volume flow via the bypass. Any type of valve can be used for this wear valve. The filling process is controlled via this valve, taking into account the available replenishment quantity. Even with a normal ball valve, which is not intended for control functions due to its design, damage to the sealing surface does not play a role, since it is a so-called wear valve, which no longer has to fulfill a complete shut-off function.

In the case of plant or building valves, the requirements of DGUV 103-002 (double shut-off with intermediate venting) must be met. Here, ball valves offer the technical solution due to the two independently operating sealing elements in the passage. Two fittings, regardless of their design, are replaced by one ball valve.



The prerequisite for compliance with this regulation is a suitable sealing system and, of course, one that has been tested by an acceptance organization, as well as the existence of a test connection. A screw plug would be sufficient as a test connection, although it should be noted that the operating medium in district heating is hot water.

Removal of the screw plug may already result in injury to the operating personnel, and if a permanent leakage occurs, screwing in the screw plug will certainly no longer be possible. At this point, it is better to use a test ball valve of small nominal size, which ensures safe operation. The following pictures show examples of ball valves with a test connection.

The position of the test ball valve can be determined after consultation with the manufacturer. It should be borne in mind that the introduction of air into district heating systems is undesirable. Furthermore, it should be noted that at operating temperatures significantly above 100°C, steam formation is to be expected if water is present in the interior of the housing. In practice, this can quickly produce incorrect results for assessing ball valve tightness. Training of the operating staff by the manufacturer can be helpful for safe and reliable operation.

Appropriate safety instructions must be observed when using the double shut-off system. When opening drain ball valves, there is a danger from escaping medium, which in district heating is usually water at over 100°C. Therefore, it must be ensured that either the escaping medium is discharged via hose or pipe lines or the danger of steam formation is reduced by lowering the temperature.

In the leak test, it should also be noted that the expansion process can take some time and this must be taken into account in the evaluation.

6.4. Maintenance and repair of valve

For the maintenance and repair of valves, the manufacturer's specifications in the respective operating and maintenance instructions must be observed. These specifications must be observed within the scope of the warranty. In the case of valves requiring more maintenance, it is advisable to use a valve requiring less maintenance. The required maintenance work must be carried out in compliance with the safety requirements of the Occupational Health and Safety Act, the employers' liability insurance associations, the operators and other applicable regulations.

All maintenance and repair work should be carried out by qualified personnel, who are known

- the operating instructions of the plant operator
- the regulations of the valve manufacturer
- the general rules of technology
- the dangers of the plant

When work is carried out by external personnel, be it a third party company or just the service personnel of the valve manufacturer, personnel of the plant operator should always be permanently on site. Only the plant operator's personnel can guarantee safe working on plant components. In addition, for safety reasons, the external personnel must be instructed before starting work. In this context, the current operating situation should be explained and the general hazards of the operating medium and the environment should be pointed out.

6.5. Valves for direct burial

Finally, some special features must be mentioned for the area of valves intended for direct buried installation.

The regulations for the pre-insulation can be found in the corresponding chapters of this manual. These also apply to the areas of the valves.

Special mention should be made here of actuation from outside the pre-insulated system. This ensures that the actuation areas must also be protected from water entering the system and also from dirt. PE sleeve pipes with a sealing screw cap have proven to be a cost-effective and safe option here. These can be used in two versions:

1. **Sealed in the lower area.**

If there is a risk of a high groundwater level, the protective pipe should be sealed in the lower area. This prevents water from pressing into the protection tube from below when the groundwater level is high. However, if water penetrates from above, there is an increased effort to remove this water.

2. **Open in the lower area**

If the protective pipe is not sealed in the lower area, the water can seep downwards if it penetrates from above.

Basically, the use of a protection tube with a sealing cover is recommended, regardless of the design. This ensures that any contamination and also any water is kept away from the valve unit. This is absolutely necessary for a long-lasting valve. When selecting the thermowells, attention should be paid to the possibility of operation. Mobile planetary gear units are used for larger nominal sizes. The gearboxes ensure that the required breakaway and actuating torque is generated at the selector shaft by means of low input torques. In addition, the gear units allow controlled slow movement of the ball. It must be ensured that these gear units can be inserted into the protection tube.

Furthermore, when inserting expansion pads, it is imperative that the entire valve unit, and here in particular the extended control shaft of the valve, can perform the movement that occurs. Additional extensions for adjusting the overlap height must also be able to carry out the entire movement of the valve.

6.6 Conclusion of the Valves Working Committee

In the interest of a long-lasting plant or network that can be operated safely, it is advisable to install an employee of the operator with many years of experience as a "construction supervisor" already during construction. Defects, especially in directly buried LOCA lines, can no longer be detected or can only be detected with great difficulty during the final acceptance. In particular, faults that cannot be detected can lead to high maintenance costs after expiration of the warranty, which then have to be borne only by the operator.

Author of the chapter

Working Committee Valves of BFW

7 Equipment and tools for assembly of casing joints and assembly fittings

7.1 General information on the construction process

As part of the postinsulation work on the casing joints, it is essential that the installation personnel have suitable tools and equipment at their disposal.

It is recommended that the joint fitters carry the tools listed below in their installation vehicle and also work exclusively with these tools.

This is the only way to ensure that work is carried out in accordance with quality standards. This means that the fitters used and tested for reinsulation must also be equipped with these tools, which are of appropriate quality.

Adverse environmental conditions, time delays caused by other trades and seasonal peaks require close cooperation with the site management, the installing company and the civil engineering department.

Therefore, advance planning that is as accurate as possible is important, but binding detailed planning shortly before the start and then continuously during installation is even more important.

A satisfactory workflow on all sides can only be achieved by maintaining intensive contact between the installation department of the installation company and the construction management. This ensures that the preliminary work on site is in harmony with the assignment of the erectors.

Each joint installation team must have a fully equipped installation vehicle at its disposal. This naturally includes power generators, protective screens, tarpaulins, safety equipment and protective clothing. Each socket fitter must carry all materials, tools and equipment required for processing the selected socket system.

In the following list, all relevant tools for the qualitatively flawless execution of the work are listed. Special emphasis is placed on quality tools, because only then can quality work be performed.

7.2 Tools for the assembly of casing joints and assembly fittings

1) Propane gas cylinder

2) Propane connection set

3) Chisel

4) Hammer

5) Triangular scraper

6) Digital temperature meter

7) Wiring pliers

8) Crimping pliers

9) Measuring devices for monitoring systems.

10) Sealing tapes

11) Marking pens

12) Tape measure / Folding rule

13) Neutral cleaning paper

14) PE cleaner

15) Lubricating gel linen grain size

40 - 60

16) Twist drill set

17) Centering wedges

18) Cordless drill

19) Bead breaker set

20) Spray bottle

21) Cuff band

22) Foam components

23) Cable drum

24) Electric drill

25) 20 mm flat drill with depth stop

26) Foam measuring cup

27) Stirring rods

28) Safety goggles

29) Wedge drill with depth stop

30) Plug holder

31) Plug welder

32) Handsaw

33) PE deburrer

34) Jigsaw

35) Tension belts

36) Temperature measuring devices

37) Extruder welder

38) Hot air welder

39) Shim with groove

40) Generator set

41) Protective clothing

42) Protective gloves

43) Safety equipment

44) Protective screen

45) PE welding wire

46) Eye wash bottle

47) Folding ladder

48) Breathing filter

7.2.1 Required tool for socket installation according to FW 603

Tool	Tool number
Bead breaker set	19
Cordless drill incl. spare battery	18
Breathing mask	48
Eye wash bottle	46
Sealing tapes	10
Digital temperature gauge	6
Triangular scraper	5
Electric drill (at least 1000 rpm)	24
Flat drill 20 mm with depth stop	25
Hammer	4
Handsaw	32
Cable drum	23
Wedge drill with depth stop (normal and large version)	29
Ladder	47
Collar tape	21
Marking pens	11
Tape measure and folding rule	12
Measuring devices for different monitoring systems	9

Neutral cleaning paper	13
PE deburrer	33
PE cleaner	14
Propane gas bottle	1
Propane connection set consisting of: Safety valve,	2
Pressure regulator, double-walled hose, bell, pipe and handle	
PUR foam components (polyol and isocyanate)	22
Crimping tongs	8
Stirring rods	27
Foam measuring cup	26
Lubricating gel cloth (grain size 40 - 60)	15
Safety goggles	28
Protective gloves	42
Protective clothing	41
Protective screen	44
Safety equipment	43
Twist drill set	16
Spray bottle with leak detector	20
Chisel	3
Jigsaw	34
Plug holder	30

Plug welder	31
Generator	40
Wiring pliers	7
Centering wedges	17

Separate tools, in accordance with the manufacturer's specifications, must be used for all joints with a material bond, such as welding joints, fitting joints, etc., for postinsulation. These joints may also only be processed by fitters who have received training and certification from the manufacturer of the respective joint and can prove this by means of a certificate. See also notes chapter 5.

7.2.2 Additional tool for socket installation according to DVS 2212 - 4

Hand extruder with welding shoes for V- and fillet weld	37
Hot air welder with tacking and welding nozzle	38
PE welding rod	45
Temperature measuring devices up to at least 300 °C	36
Tension belts	35
Support rail with groove for assembly fittings (welding aid)	39

According to the specifications of the system manufacturers, additional tools may be required, especially for force-locking joints (welding joints, induction joints, fitting joints, etc.).

Authors of the chapter

Gerd Moser, BRUGG Rohrsysteme GmbH

Johannes Ellmer, isoplus Fernwärmetechnik Vertriebsgesellschaft mbH

8 Monitoring and fault location systems

8.1 General

Moisture ingress due to e.g. welding seam defects, leaking socket joints ordamage from the outside can lead to major damage. Heat losses due to insulation defects, corrosion on pipelines and interruptions in operation would be the result.

Today, district heating pipelines are predominantly equipped with operational or leakage monitoring. The advantage lies in the early detection of damage and its localization. Monitoring wires foamed into the thermal insulation at the factory with appropriate monitoring devices increase operational reliability, limit damage costs and extend the service life of the district heating network. In other words, they serve to protect the investment and the security of supply.

Depending on the monitoring system used, not only the joint area but the entire pipeline section is monitored. Even minor moisture penetration due to leaking weld seams, construction moisture or damage to the PEHD casing pipe or a joint can be detected and reported.

Two basic pipe monitoring systems have become established on the market.In addition to the standard Nordic system used by most pipe manufacturers, in which two copper wires serve as sensor wires, the resistance wire system with a nickel-chromium and a fully insulated copper wire as a return wire has also become established. Other systems offered on the market, such as HDW or JR-Isotronic, play a rather minor role.

In addition to the selection of a suitable sensor wire system, the integration and adaptation of the monitoring devices into the operator's existing infrastructure and correct, up-to-date documentation are extremely important for a functioning monitoring system that is accepted by the network operator.

8.2 Nordic system (EMS system)/Cu wire system (transit time measuring method)

The KM pipes and fittings prefabricated at the factory are equipped with two copper wires as standard. These are color-coded for differentiation (bare copper, electro-tinned copper). After connecting the pipes and fittings, the monitoring wires protruding from the polyurethane composite insulation are connected by crimp sleeves and then soldered with soft solder. To form a measuring loop, both wires are connected at the end points. Branches are directly integrated into the monitoring loop, taking into account the wiring guidelines. This creates a complete control of the entire network.

8.2.1 Structure

Figure 37, Nordic system
- Components

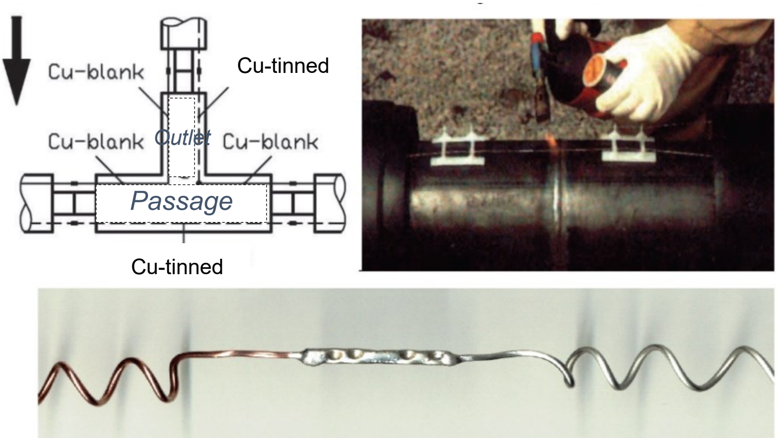


Figure 38, Nordic system - schematic structure

- One copper wire bare 1.5 mm²
- One copper wire electro-tinned 1.5 mm²
- Complete surface of both wires serves as sensor surface
- Resistance 0.012 Ohm/m
- Impedance value typically 270 Ohm
- Pulse delay typically 274 m/µs

8.2.2 Functionality

Monitoring is usually carried out via ohmic resistance measurement (DC voltage) between the wire pair and the electrically conductive carrier pipe. Since the insulation made of PUR foam is an electrical insulator, it has a high insulation resistance between the wire and the carrier pipe when the composite jacket is intact. Moisture penetration lowers the resistance between the carrier pipe and the wire system.

The so-called pulse delay method is used to locate the damaged area.

In contrast to the resistance measurement, the AC voltage behavior of the arrangement is evaluated here. Due to the geometrical arrangement of the copper wires and the carrier pipe, certain impedance values (typ. 270 Ohm) are set in this arrangement. The impedance values depend, among other things, on the distance between the wire and the carrier pipe and the AC voltage properties of the interstitial space (dielectric). Changes in the interstitial space and thus a change in impedance, e.g. due to moisture, can be detected as a function of location. For this purpose, pulses are applied to the array by a time domain reflectometer (TDR).

The measuring pulses cover a certain distance within a certain time. The speed of the measuring pulse (here typ. 270 m/μs) depends like the impedance value on the structure of the arrangement. At points where the impedance value of the arrangement changes, parts of the pulse are reflected (so-called echo). By measuring the time interval between sending the measuring pulse and the arrival of the pulse echo, an unambiguous localization is possible.

This technique can be used not only for pure localization, but also for preventive monitoring. An advantage over resistance monitoring is the independence from the conductivity of the penetrating medium. This means that the system can also be used for poorly or non-conductive media. Another advantage is the possibility to locate several faults in a measuring section in a differentiated and location-dependent manner.

A disadvantage is that in the case of insulation faults, a clear and detectable echo is only recognizable from a resistance insulation value in the kiloohm range. In contrast, wire breaks are clearly detectable.

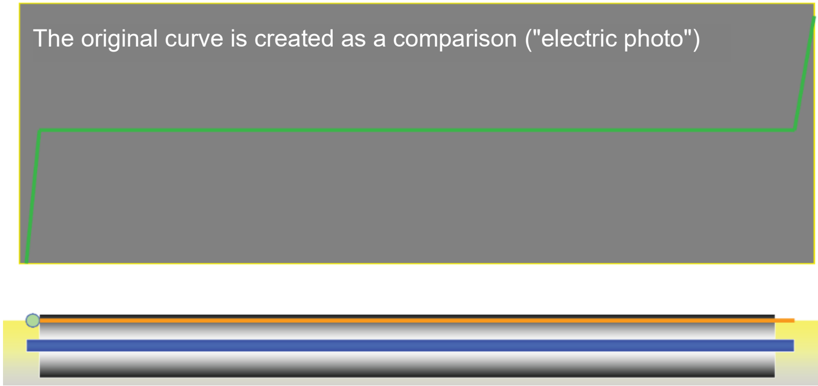


Figure 39, Nordic system - original image, good measurement

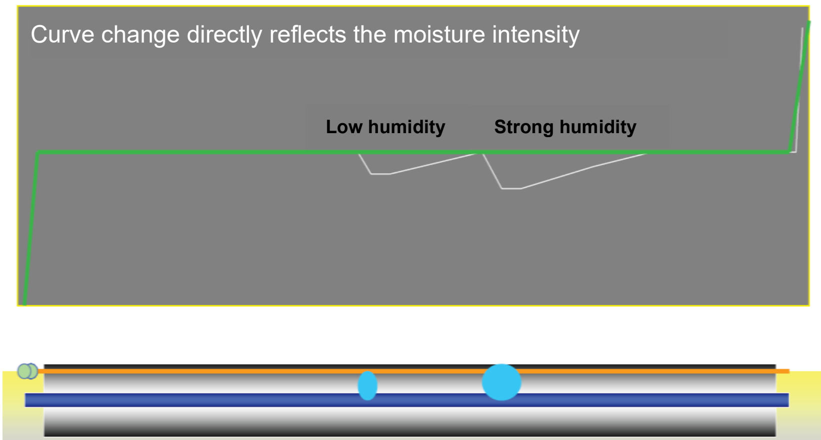


Figure 40, Nordic system - Curve change with humidity

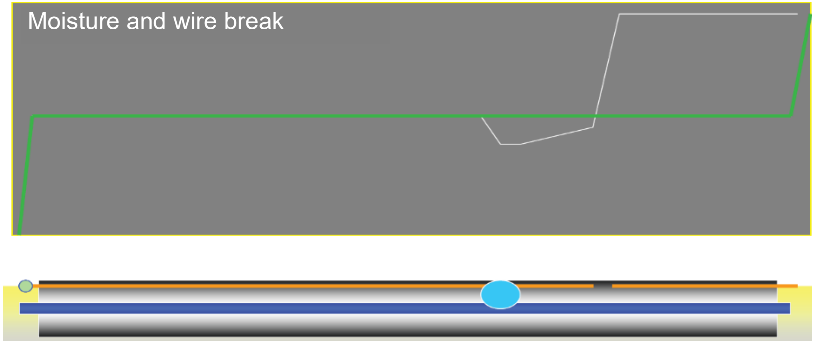
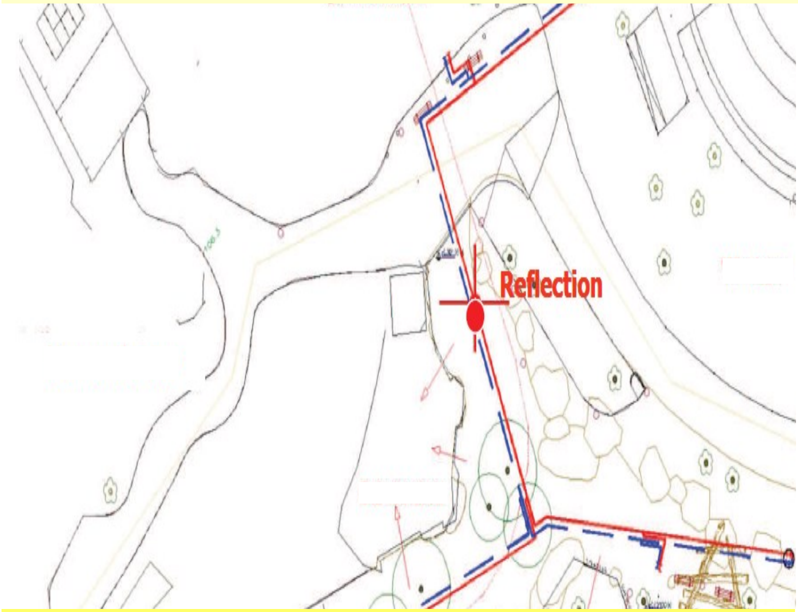


Figure 41, Nordic system - Curve change with moisture and wire breakage

Electrical impulses are transmitted into the



Error points cause reflections

Figure 42, Nordic System - Determination of Multiple Errors

8.2.3 Conclusion

Advantages:

- Monitoring of the entire pipe system
- Detection of faults over both cores
- Simple socket installation due to crimping sleeves and soldering
- No electronic components
- Sensor loop monitoring over the entire network
- Locatability of multiple faults
- Detection of non-conductive media

Disadvantages:

- Fault location only possible with larger damage areas, stronger moisture penetration

8.2.4 Review Cu wire system

- Continuity measurement of the wire loop low impedance value between 1-50 Ohm Values in the flow and return should be the same Insulation measurement between wire loop and media pipe high impedance value approx. 10 MOhm / 1000 m pipe.

Measurements must be performed with a special insulation measuring device, e.g. LANCIER Monitoring "PipeCheck", isoplus "IPS-HST" or similar.

8.3 Resistance wire system/NiCr wire system (resistance measuring method)

The typical feature and eponym of this technology is the resistance wire, which is installed in the tube as a sensor (sensor wire). Today, a NiCr wire with 5.7 Ohm/m (rarely also 4 Ohm/m) is used almost exclusively. This NiCr wire has a perforated insulation. In addition, a fully insulated loop wire (feedback wire) is installed. This serves to form a measuring loop and has no significance for the actual monitoring.

Important: Here, care must be taken during assembly to ensure that all joints are permanently insulated by using heat-shrink tubing.

8.3.1 Structure, components

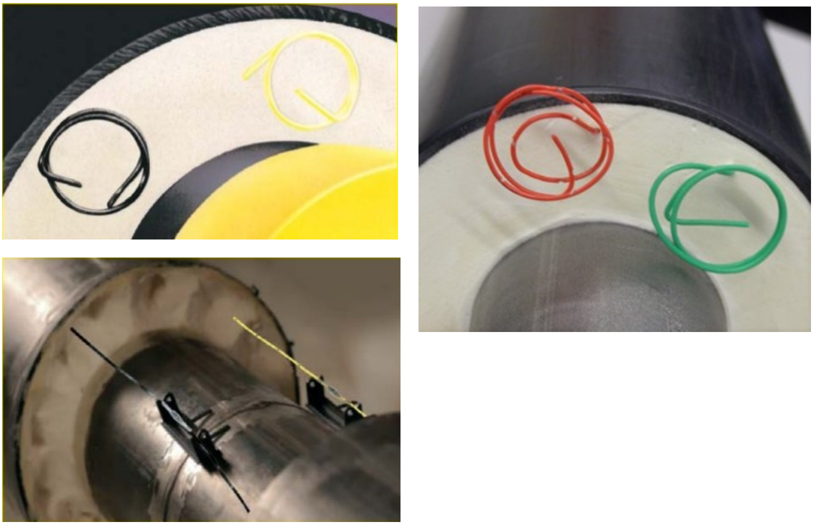
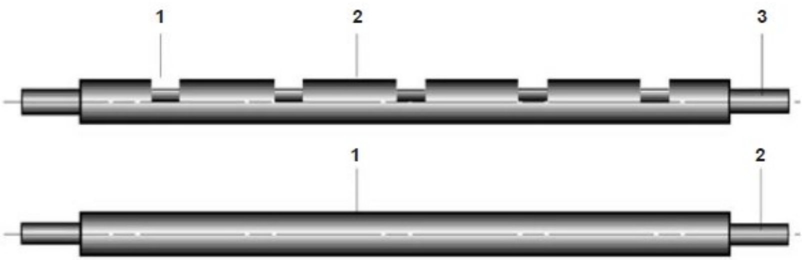


Figure 43, Resistance wire system – components



Structure of the sensor wire (top):

1. Perforations at regular intervals for moisture contact.
2. PTFE insulation,

   Color yellow, Fa. Isoplus

   Color red, Fa. Brandes
3. NiCr 8020 wire, Ø 0.5 mm

   5.7 Ohm/m

Structure of the feedback wheel:

1. FEP insulation,

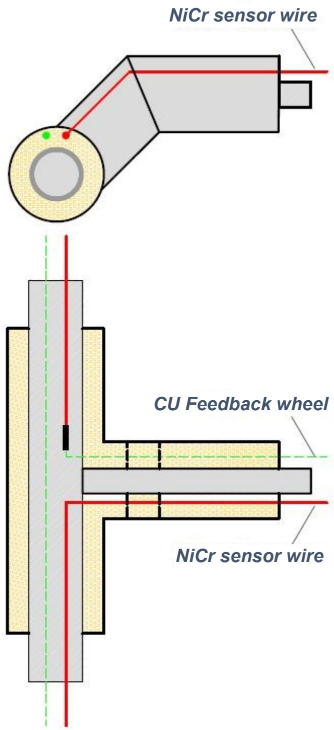
   Color black, Isoplus

   Color green, Brandes company

2. Cu wire, Ø0,8mm

   0,036 Ohm/m

Wire run

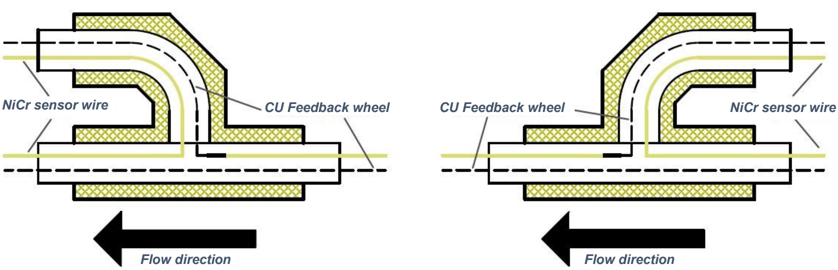


In the case of 45° branches, it is important to note whether these branches go up or down. The documentation of the installation situation is required for the later wire run recognition or the loop plan.

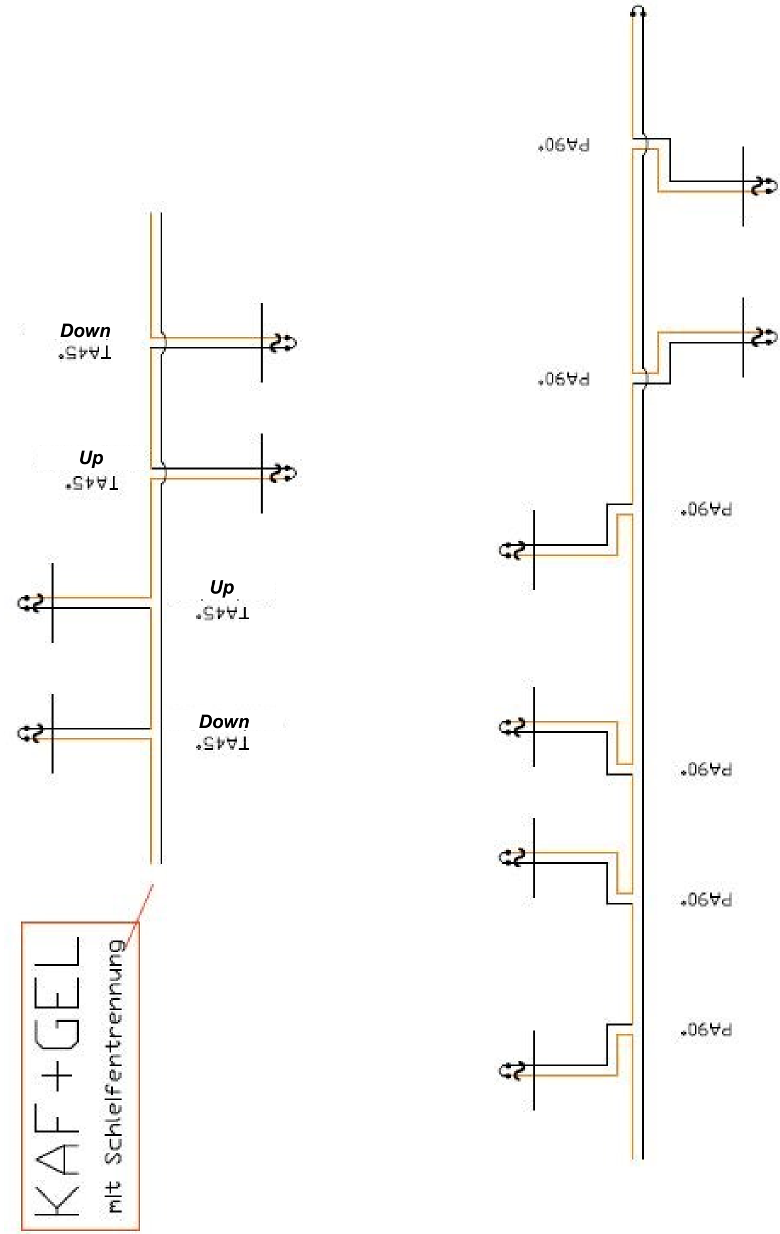
The installation of the parallel branches must be documented in such a way that it can be seen whether the branch was installed in or against the direction of flow. This has an influence on the wire run and the possibility of later, precise fault location.

Sensor and feedback wheels can be yellow/black or red/green, depending on the manufacturer.

45° Branch



Parallel branch in and against the flow direction



Parallel branch Wire run

8.3.2 Mode of operation

Similar to the Nordic system, monitoring is made possible by an ohmic resistance measurement, in this case between the perforated sensor core and the carrier pipe. Since the PUR foam insulation is an electrical insulator, it has a high insulation resistance between the sensor core and the carrier pipe when the composite jacket is intact. The perforation of the sensor wire is wetted by penetrating moisture. The resistance between the carrier pipe and the sensor wire is lowered. The location of the damaged area is carried out according to the principle of the unloaded voltage divider. (Connections of the return wires must be insulated, see 7.3).

Between the beginning and the end of the pipe, the resistance wire forms a longitudinal resistance [loop resistance, R(ges)], the magnitude of which is ultimately determined by the pipe length and the wire resistance installed in it. A defect (moisture) in the pipe system represents a connection between the sensing wire and the carrier pipe and divides the loop resistance into the sections R(x1) from the beginning of the pipe (0% of the length) to the defect and the section R(x2) from the defect to the end of the pipe (100% of the length). Both partial resistances R(x1) and R(x2) are directly dependent on the location of the moisture penetration. If a voltage is applied to the sensor loop, in the event of a fault the conductive moisture transfers a partial voltage value, which depends on the location, to the carrier pipe. From an electrical point of view, the carrier pipe takes over the function of the third connection, similar to the wiper connection of a potentiometer. The measured partial voltage (x% of the total voltage) is directly proportional to the location of the moisture penetration (x% of the total length).

In practice, however, one hardly finds idealized conditions, but has to deal with additional disturbance components. These include the element voltage (Ux), which is formed as a chemical stress element due to the metals used (NiCr wire, steel pipe).

Most of the locating instruments used today can compensate for interference components relatively well, so that very good locating results are achieved even with high-impedance faults in the MOhm range.

Due to the physical principle of the unloaded voltage divider, only single moisture faults can be located. In contrast to the Nordic system, multiple faults cannot be located. Here, with suitable device technology, the first fault location can be stored in order to then move from here to further faults.

For locating wire breaks, other locating methods must be used.

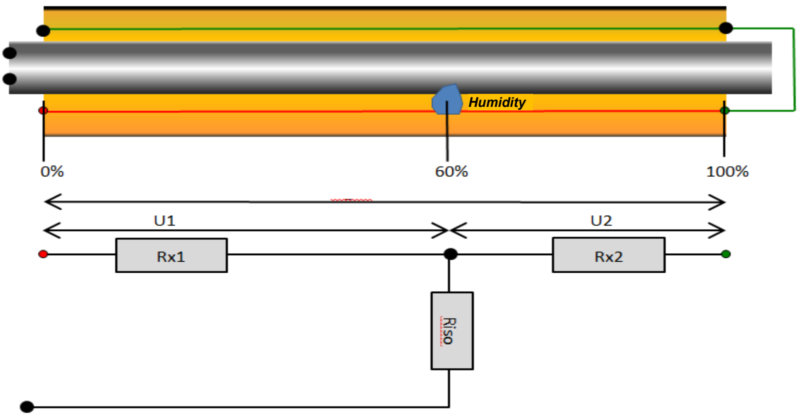


Figure 44, Resistance wire system - locating a single fault

8.3.3 Conclusion

Advantages:

- Monitoring of the entire pipe system
- Simple socket installation due to crimping sleeves
- No electronic components
- Sensor loop monitoring over the entire network
- Detection even at small damage points, high response sensitivity
- Reliable and simple location of initial faults
- Simple determination of pipe length by loop measurement
- Disadvantages:
- No direct locating of multiple errors.

8.3.4 Review NiCr wire system

- Continuity measurement of the wire loop
- Value between 0.1-10 kOhm
- Measured value must be converted to match the path length
- Values in the flow and return should be approximately the same
- Insulation measurement between wire loop and media pipe
- high impedance value > 10 MOhm / 1000 m pipe

Measurements must be performed with a special insulation measuring device, e.g. LANCIER Monitoring "PipeCheck", isoplus "IPS-HST" or similar.

8.4 Systems with indicators - also called hierarchical system

A typical feature of the systems, apart from the moisture indicators (HDW) or locating switches (JR-Isotronic) placed in the joint connections, are the separating switches (T-switches) installed in pipe branches. In this way, the monitoring system obtains its namesake hierarchical structure. The pipe network behind a branch belongs to the next higher hierarchy. The district heating network can be divided into up to four hierarchies. Moisture indicators and dividers are electrically connected via the twisted pair of wires foamed into the pipe at the factory. The systems operate potential-free, since a measurement is made wire against wire..

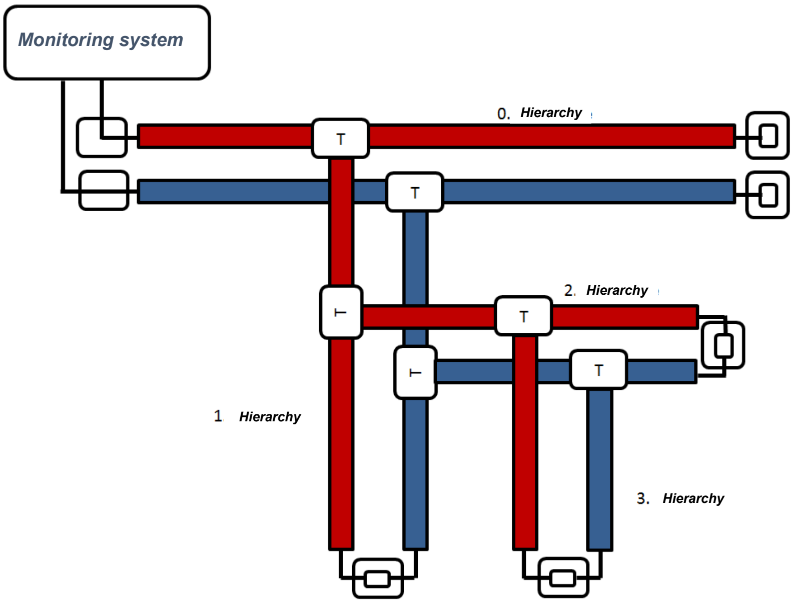


Figure 45, Hierarchical system - principle representation

8.4.1 Structure, components

Humidity indicator

Pair of cores, foamed in

T-switch

Figure 46, Hierarchical system - components

8.4.2 Functionality

The system monitors the indicators or locating switches installed in the joints. The indicator essentially consists of two copper plates that are insulated from each other by an inorganic fleece. When moisture enters the fleece, the resistance between the copper plates decreases.

The locating switch is based on a reversible switching function. In the event of moisture ingress, a switching contact is actuated via a source disc. The monitoring principle is based - as already with the Nordic and resistance wire system - on the measurement of the ohmic resistance, in this case the insulation layer of the moisture indicator or the switching state of the locating switch. In the event of moisture ingress, the resistance value decreases in each case. By installing an end termination, the continuity in the first hierarchy can also be monitored. Loop continuity in the other hierarchies must be checked manually at regular intervals. In the event of a fault, the location of the fault can be determined by measuring the pulse transit time.

8.4.3 Conclusion

Advantages:

- Simple socket installation due to crimp sleeves
- Reliable and unambiguous location of triggered moisture indicators
- Locatability of multiple faults

Disadvantages:

- No monitoring of the entire pipe network, pure socket monitoring
- Use of electronic components in the pipe network
- No loop monitoring over the entire network

8.5 Monitoring and tracking systems

8.5.1 Manual monitoring

In Manual Monitoring, or Passive System, the monitoring wires are led to a measuring point accessible in buildings or field cabinets. As required or at specified intervals, the condition of the district heating network is checked manually using mobile measuring equipment. In this case, the longer the time interval between control measurements is selected, the greater the risk that moisture faults may spread and cause major damage. When using the resistance wire system, there is a risk that multiple faults will not be detected and thus misinterpreted in the locating case.

Figure 47, Measuring devices for manual monitoring

8.5.2 Stationary monitoring

After standards have been established and consolidated in the sensor wire sector over the past decades, the further development of monitoring devices continues to progress, especially through adaptation to the changing IT infrastructure of the network operators. This must be taken into account in the function and design of the monitoring devices and systems.

8.5.2.1 Alarm systems

Alarm systems are mostly simple devices that monitor train paths and trigger an alarm when preset limit values are reached. The alarm is usually forwarded to other systems, e.g. control room or signaling device, via a relay contact. There is no further integration into the network operator's existing IT infrastructure. It is not possible to assess the development of the damage or the course of the damage. A simple good/bad message is generated. These solutions are mostly used by smaller network operators with few devices.

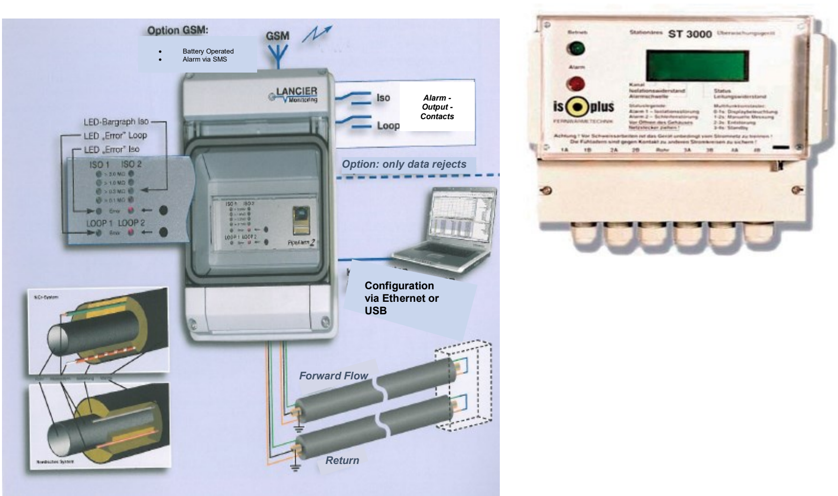


Figure 48, Measuring devices for automatic monitoring

8.5.2.2 Monitoring systems

In a monitoring system, monitoring devices are connected to a central computer via a network. In the simplest case, the central computer can be a normal PC or - depending on the expansion stage - a separate server or the control room of the network operator. The entire network is monitored centrally. Measured values and events are visualized and stored as history values in a database. On the basis of the history values, a damage progression can be assessed and causes can be concluded. By setting several alarm thresholds, preventive warnings and alarms can be issued at an early stage. werden.

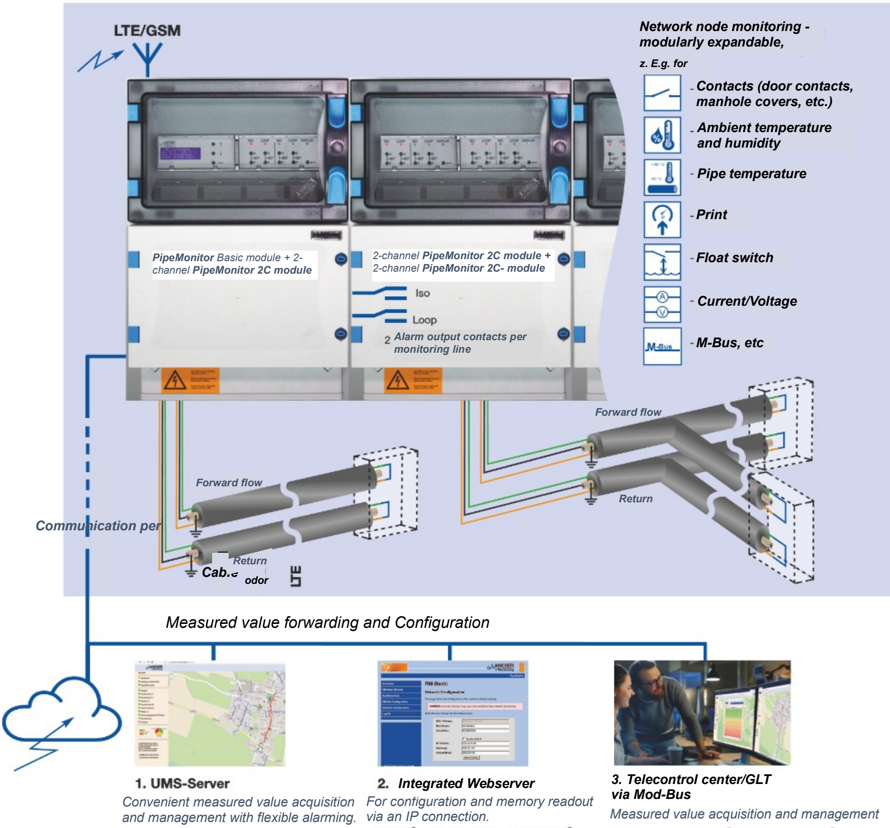
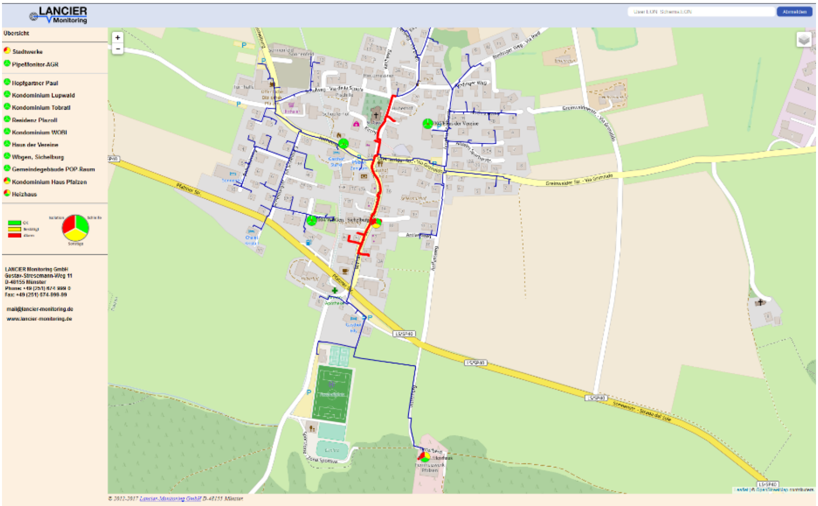
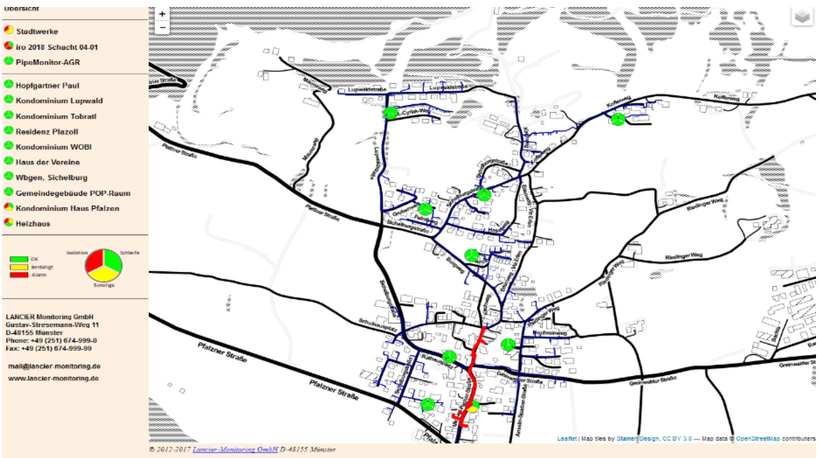


Figure 49, Example system overview for automatic monitoring

Modern systems allow connection to a geographic information system (GIS), so that routes, equipment locations and damage sites can be displayed graphically in a map system. Depending on the system, construction, network and wiring plans can be stored and are directly available in the event of a fault.





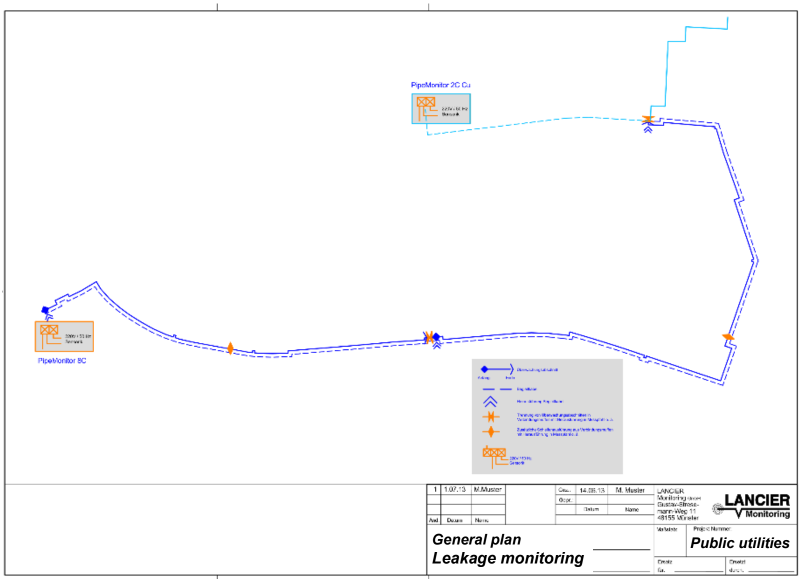
8.6 Planning and documentation

Good system planning and clean, error-free documentation of the district heating, monitoring network are essential for operation and damage repair.

8.6.1 Planning

The pipe monitoring system is planned in good time, i.e. as early as the pipe network planning stage. Here, the network has to be divided into sections that can be monitored and suitable equipment locations have to be determined. Cable designs, wiring guidelines, connection diagrams must be planned and documented - if not already specified by the pipe or system manufacturer.

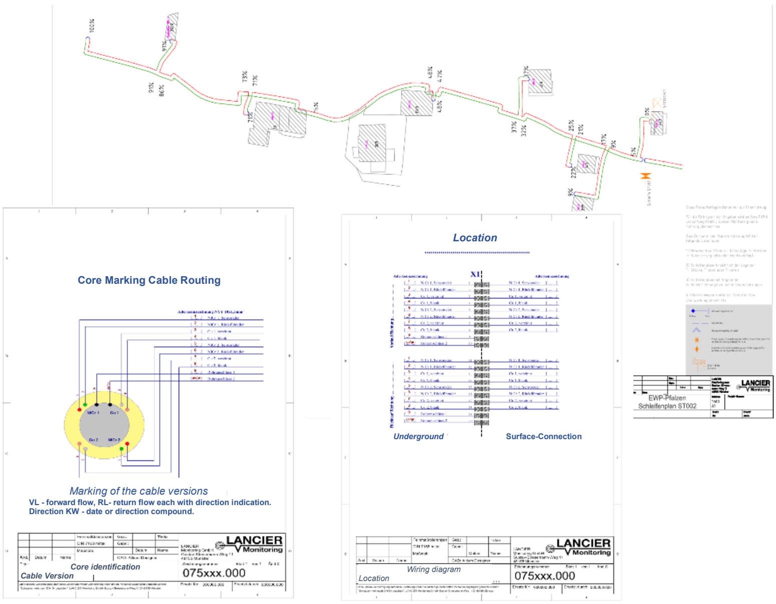
The network size and IT infrastructure of the operator must be taken into account when selecting the device. This is the only way to ensure that the operator accepts and uses the monitoring system**.**



8.6.2 Documentation

For exact fault location in the event of damage, regardless of whether it is a moisture fault or a wire break, binding, error-free documentation of cable laying and cabling is essential.

Each cable design and interconnection must be planned and documented exactly before execution. Every change on the construction site must be recorded. Every meter of wire that is installed, whether as a feeder or in pipe sleeves, is important here. Only in this way is it possible to locate the fault exactly to the meter.



Authors of the chapter

Johannes Ellmer, isoplus district heating technology Sales Company Ltd.

Ludger Tidde, Andreas Gräve u. Sebastian Vogt, Lancier Monitoring GmbH

9 Principles of polyurethane chemistry

9.1 Principles of polyurethane chemistry

Rigid polyurethane foam (PU foam) is formed by reacting polyols with diisocyanates. Two-component systems consisting of a polyol and a polymeric isocyanate component (PMDI) are usually used for foaming pipe joints. Polyols are molecules consisting of several hydroxyl groups (OH groups), which with polymeric isocyanates (substances with at least two isocyanate groups) form a rigid cross-linked foam.

9.1.1 Polyol

The basic substances of a polyol component are polyetherols and polyesterols, whose hydroxyl groups bond with the isocyanate groups of the PMDI to form the urethane group. As a result of their molecular length and degree of branching (functionality), they have a major effect on the foam's properties. Polyols are not the only ingredients of a polyol component as the chemical reaction is supported by:

- **Stabilizers**
- **Catalysts**
- **Blowing agents**
- **Other additives**

9.1.1.1 Stabilizers

Stabilizers affect the physical processes during the foaming process and stabilize the actual cells of the foam. They have an effect on cell size and structure. Their other important properties include increasing the solubility of the blowing agent in the liquid polyol component and improving the homogeneity of the polyol mixture.

Figure 54: Drums with colors indicating their contents

Blue = polyol; red = isocyanate

9.1.1.2 Catalysts

Catalysts affect the foam's reaction process. The more catalyst the system contains, the faster the foam reacts. Catalysts have a selective effect on the various reactions that take place during foaming. The important reactions include that of water with isocyanate to form carbon dioxide (blowing effect) and the base reaction of polyol with isocyanate to form the polyurethane matrix.

In some cases, special catalysts are also employed to accelerate the isocyanate's own reaction. This results in the formation of polyisocyanurate (PIR) structures in the foam, which are noted especially for their enhanced temperature stability.

9.1.1.3 Blowing agents

The blowing agent is responsible for the formation of the foam itself. The reacted foam's free, non-compacted density can be affected by the content of blowing agent. Physical blowing agents (e.g. cyclopentane) are added to the liquid component and evaporate due to the reaction heat generated during polyurethane formation (exothermic reaction).

By comparison, chemical blowing agents (e.g. water) generate the blowing gas (e.g. carbon dioxide) by reacting with the isocyanate during the chemical reaction of the two substances.

9.1.1.4 Other additives

Frequently used additives include flame retardants, which reduce the foam's flammability. This is particularly important for pipes in the industrial sector.

9.1.2 Isocyanate

The isocyanate for joint infill usually consists of a single component without further additives. To fill joints standardized PMDI (polymeric diisocyanate) is used, which not only enables the production of temperature-stable polyurethane foams but is also easy to process due to its low viscosity.

9.2 Processing and properties of polyurethane components

9.2.1 Mixing ratio

The mixing ratio refers to the shares of the polyol and isocyanate components used for the production of an ideal, standard-compliant polyurethane foam. The mixing ratio is expressed either by mass (gravimetric) or by volume (volumetric). It can be calculated from the number of hydroxyl groups of the polyol component and the number of isocyanate groups of the isocyanate component. As a rule, the gravimetric mixing ratio is significantly higher than the volumetric mixing ratio.

Example

A volumetric specification of 100 : 138 means that 100 : 138 parts by volume (expressed here in liters) of polyol and isocyanate respectively yields the desired foam quality. For the same polyurethane foam system, the gravimetric mixing ratio is significantly higher. This is due to the higher specific density of the isocyanate component. The corresponding gravimetric specification of 100 : 160 for the same polyurethane foam means that 100 : 160 parts by weight (expressed here in kilograms) of the polyol and isocyanate respectively yield the desired foam quality.

Calculation:

$$100 : mass\ (iso) * \frac{density(poly)}{density\ (iso)} = 100 : volume\ (iso)$$

$$\rightarrow 100 : \mathbf{160} * \frac{1.07}{1.24} = 100 : \mathbf{138}$$

where polyol density is 1.07 g/ml and isocyanate density 1.24 g/ml

The mixing ratio is a material-related specification that must be taken from the **technical data sheet** for each polyurethane foam system.

9.2.2 Reaction times

During the reaction of the components, different characteristic reaction times can be measured.

Start time

Time from the start of mixing until initial volume increase.

Gel time

Time from the start of mixing to the point at which threads can be drawn from the rising reaction mixture by immersing a rod (thread-drawing time).

Rising time

Time from the start of mixing until the foam achieves its maximum volume.

9.2.3 Density

Another important parameter is foam density. The density (g/l or kg/m³) is the mass of a piece of foam in relation to its volume. A distinction is made between three different densities: cup density, core density and overall density.

9.2.31 Cup density

Cup density is usually measured in the laboratory and is used in particular for checking incoming and outgoing goods. To determine the density, a certain amount of reaction mixture is poured into a cup of known volume.

The mixture foams and fills the cup right up. The excess foam is cut off precisely at the rim of the cup. From the mass of foam remaining in the cup and cup volume, cup density can then be calculated:

$$cup\ density\ = \frac{foam\ mass\ in\ cup\ (g)}{cup\ volume\ (l)}$$

Example

80 g of component mixture is poured into a 735 ml cup. After cutting off the excess foam, 47 g of reacted foams remain in the cup. This yields a cup density of 64 g/l.

9.2.3.2 Core density

The core density describes the density of a piece of foam from the interior of the joint and is calculated as follows:

$$core\ density\ = \frac{foam\ mass\ (g)}{foam\ volume\ (l)}$$

Jacketed pipe joints for district heating networks conforming to EN 13941 are subject to DIN EN 489-1:2020-03, which in turn refers to DIN EN 253:2020-3 and specifies that the core density must exceed 55 kg/m³ throughout.

In general, to determine the foam density, the joint must be opened so that a test specimen can be taken. For quality monitoring, a sample can also be taken from inside the joint using a hollow cylinder drill after foaming but before the welding plug is inserted.

The volume of a block-shaped piece of foam can easily be determined by measuring the edges. For irregularly shaped bodies (e.g. drilled-out cylinders), the water displacement method can be used. For this purpose, the foam body is pressed under water with a thin rod. The force required is proportional to the volume of the piece of foam (more detailed description in 9.6.2).

9.2.3.3 Overall density

The overall density is calculated to determine the quantities of liquid component required to at least fill a joint completely and in conformity with the standard.

In this case, the totality of the core density and edge zone compaction within the joint cavity is included in the calculation. The total density is therefore always higher than the core density in question.

The overall density is the basis for calculating the foaming table used on site. Depending on the size of the joint (diameter, cut-back length) and the foam system used, it states the quantities of the individual liquid components that must be used:

$$overall\ density\ = \frac{mass\ of\ foam\ filling\ (g)}{joint\ cavity\ volume\ (l)}$$

9.3 Typical characteristics of a joint foam

The typical, material-specific parameters of a standard joint foam are listed below. The polyurethane joint foam system Elastopor® H 2130/38 serves as an example here:

Blowing agent: cyclopentane
Mixing ratio: 100 : 138 ± 4 parts by volume
Mixing ratio: 100 : 160 ± 5 parts by mass
Reaction parameters (laboratory, 20°C):

- Start time: 52 s
- Gel time: 252 s
- Cup density: 50 kg/m³
- Polyol component viscosity: 950 mPas

Correctly processed, such a system is sure to meet the requirements of DIN EN 489-1:2020-3.

9.4 Processing conditions and influences

When processing polyurethane systems, it is essential to consider a number of important factors that have a major effect on foam quality. In the following, the various control variables are presented, with pictures of foam cups showing the effect on the foam. The adjacent picture of an ideal foam cup serves as a comparison (Fig. 55).

Figure 55: PU foam with ideal characteristics

9.4.1 Effect of component temperature

Component temperature has a major effect on the characteristics of the polyurethane system. The following two graphs show the effect of temperature on viscosity (Fig. 56) and reaction times (Fig. 57) of the above-mentioned standard polyurethane system.

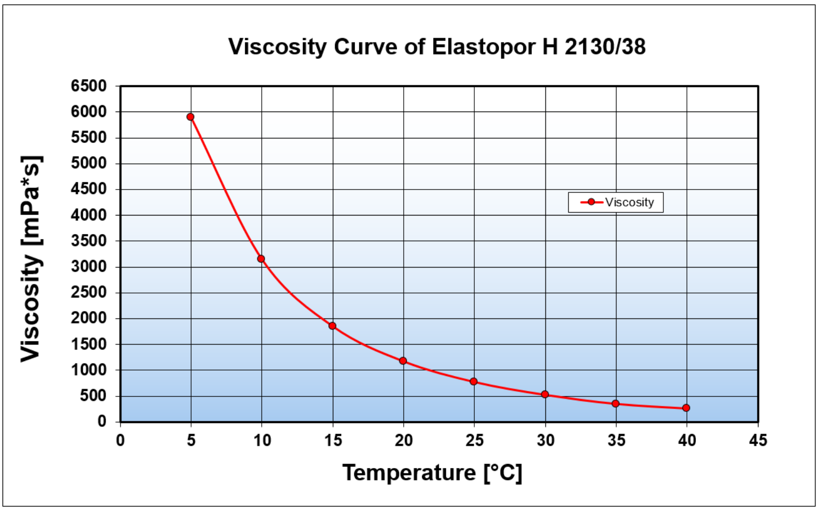


Figure 56: Curve of viscosity of a polyol component over component temperature

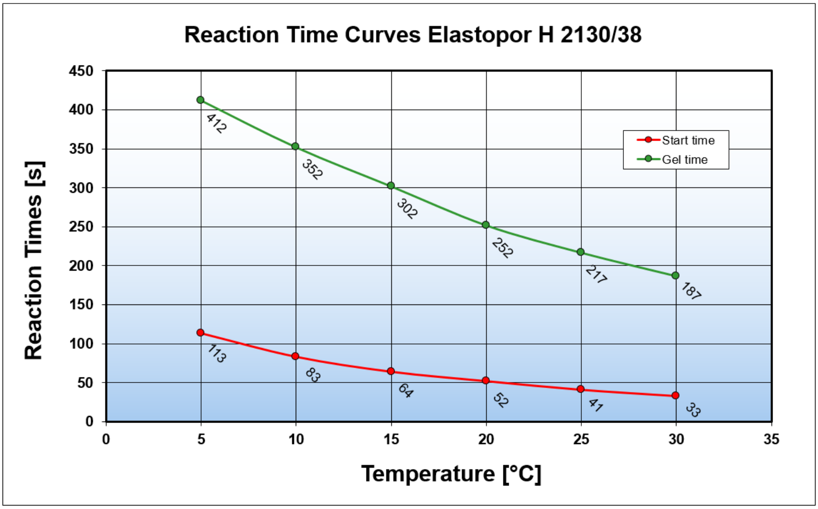


Figure 57: Curve of reaction times of a joint foam system over component temperature

9.4.1.1 Polyol and/or isocyanate component too cold (<20°C)

If the component temperature is too low, the viscosity of the liquid increases significantly, so problems can arise during mixing. A reduction in component temperature from 20°C to 10°C, for example, causes the viscosity to roughly triple (Fig. 56).

Excessively cold components also significantly prolong reaction times (Fig. 57). This results in a higher free rise density, as the rising polyurethane foam is still too liquid to retain the evaporating blowing agent in the cells. Under certain circumstances, the joint may not be completely filled. Overall, the foam reacts more slowly, causing curing to take longer and delaying subsequent installation work.

9.4.1.2 Polyol and/or isocyanate component too warm (> 20°C)

At elevated component temperatures, the reaction mixture reacts much faster (Fig. 57). Depending on the amount of foam required, there may not be enough time for thorough mixing and subsequent filling of the joint cavity with the liquid polyurethane mixture. At highly elevated component temperatures, the joint may be insufficiently filled with cyclopentane-blown polyurethane foam because of the early loss of blowing agent due to evaporation before the polyurethane reaction proper takes place.

The superimposition of the two graphs yields the ideal processing temperature of 15°C to 25°C. Within this window there is sufficient time to fill the joint and the viscosity is within a range that also ensures good mixing.

9.4.2 Surface temperature

Surface temperature is a major factor in joint foaming. In the cold season, the entire joint area must be heated using a burner or radiator heater or by induction. This applies in particular to the steel pipe, as steel's high thermal conductivity causes a large outflow of the reaction heat essential for a flawless polyurethane reaction process. In the summer months, exposure to direct sunlight should be prevented with suitable shading, as direct sunlight can easily heat the PE jacket to temperatures of more than 70°C.

9.4.2.1 Medium and/or jacket pipe too cold (< 15°C)

Excessively low pipe temperatures slow the reaction on the pipe surface, thus seriously impairing adhesion between the foam and pipe. The slow reaction also results in an increased free rise density due to insufficient evaporation of the physical blowing agent.

In some cases, this may result in insufficient filling of the joint. Below a temperature of 5°C, joint foaming with a polyurethane foam system is impossible without preheating. For winter pipe-laying projects, taking into account the maximum conceivable foaming pressure, the foaming table can be adjusted and a higher overall density (up to 10%) can be calculated in order to prevent incomplete joint filling.

9.4.2.2 Medium and/or pipe jacket too warm (> 50°C)

The pipe's higher temperature accelerates the reaction on its surface, which can also result in adhesion problems. This is due to the abrupt loss of blowing agent when the liquid comes into contact with the hot surface, resulting in a poor foam structure. An excessively fast reaction can result in a lower free rise density, causing significant overfilling and increased pressure build-up in the joint. Such excessive pressure build-up must be prevented, otherwise the joint may burst.

When repairing a hot pipe, an inorganic fleece (e.g. mineral wool) can be placed on the steel pipe as a practical solution to protect the (still liquid) foam from the maximum temperature. However, since this prevents adhesion between foam and steel pipe, it must be limited to exceptional cases.

9.4.3 Mixing ratio

Another important factor is the mixing ratio of the two components. The inaccuracy must not exceed +/- 4 parts by volume. As a rule, excess isocyanate is less detrimental than excess polyol.

9.4.3.1 Mixing ratio too high (excess isocyanate component)

Figure 58: PUR foam with excess isocyanate

Excess isocyanate results in a brittle foam structure characterized by poor physical properties, with a significant deterioration in adhesion, flexibility and water absorption in particular. The resulting excessively high free rise density causes insufficient filling of the joint. Fig. 58 shows that, with the same quantity as that in the original cup, the cup is only just filled and the foam is darker in color. In addition, the foam shows pronounced shrinkage.

9.4.3.2 Mixing ratio too low (excess polyol component)

Figure 59: PUR form with excess polyol

Excess polyol results in a soft foam structure and a significantly lower density. This is caused by the excessive quantity of blowing agent added with the polyol. The foam cup in Fig. 59 shows the marked effect on foam quality. Here too, as with excessively high temperatures (see above), overfilling and bursting of the sleeve can occur.

9.4.4 Effect of mixing quality (poor mixing)

Figure 60: Poorly mixed PUR foam

The mixing of the polyol and isocyanate components has a huge effect on foam quality and the properties of the entire joint. It is absolutely essential to mix the two components thoroughly. Poor mixing results in streaks in the foam and – due to the uneven foam quality – often in coarse, open cells.

This brittle foam shows impaired physical properties, including enhanced water absorption and increased thermal conductivity coupled with seriously impaired temperature stability and shear strength. Fig. 60 shows the coarse cell structure and the brown, unreacted isocyanate at the bottom. A poorly mixed foam does not meet the requirements of DIN EN 489-1:2020-3.

9.4.5 Effect of water, oil, grease, dust and dirt

9.4.5.1 Effect of water

In general, the uncontrolled penetration of water can be said to be the worst enemy when processing polyurethane systems. Since water actively interferes with the reaction process of the polyurethane system, the joint cavity must be protected from rain, condensation and trench water. To prevent condensation from forming overnight, joints should be prepared and foamed on the same day. Water on the pipe surface reacts with isocyanate as described above (9.1.1.3) to form carbon dioxide. This results in insufficient adhesion and an increased number of open cells.

Water in the polyol component results in a lower free rise density – with the consequences already described. Furthermore, this also changes the calculated mixing ratio. Since the amount of isocyanate required for the reaction of the additional water is disregarded when calculating the mixing ratio, the total amount of isocyanate added is too low with the effects described in 9.4.3.2.

If water is present in the isocyanate component, the two substances react and skin and lumps form. The isocyanate becomes unserviceable and must be disposed of.

9.4.5.2 Effect of dust and dirt

If there are dust and dirt on the pipe surface, there is often insufficient adhesion between the foam and the pipe. Dust in the components causes processing problems, especially during mechanical processing (clogged filters). Good mixing is more difficult to achieve.

9.4.5.3 Effect of oil and grease

Oil and grease on the pipe prevent adhesion between the foam and the pipe. Oil and grease in the components result in a coarse, flexible cell structure and significantly impair the physical properties.

9.5 How to achieve the ideal foam

Fig. 61 is a "fine" example of how joint foam should not look. Dust and rust residues from the obviously uncleaned steel pipe are visible in areas (1) and (2). The ragged appearance of the (here soft) foam in area (3) reveals a clear excess of polyol. The brownish-yellowish (rigid) foam in area (4) shows an excess of isocyanate. Glossiness (5) is also a sure sign of poorly mixed foam. Overall, the mixing of two components was obviously totally inadequate before the joint was filled.

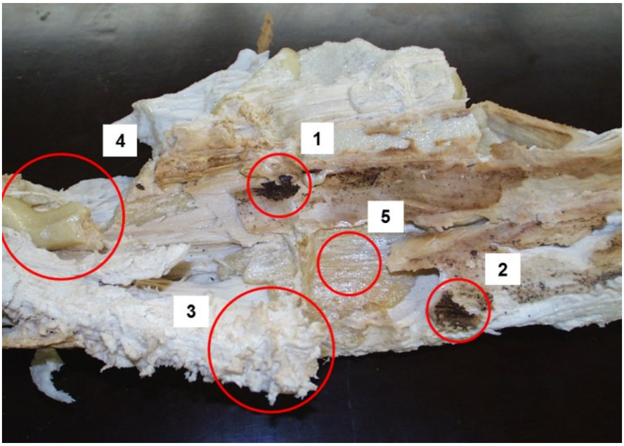


Figure 61: Original piece of foam from a failed pipe

Fig. 62 shows an original joint. Components in their pure liquid state are visible in the joint: crystallized isocyanate (6) and partially liquid polyol (7). In area (8) the two components have evidently reacted with each other, but the "foam" is flexible and still partially viscous. The two liquids were obviously poured unmixed into the joint cavity in the trench.

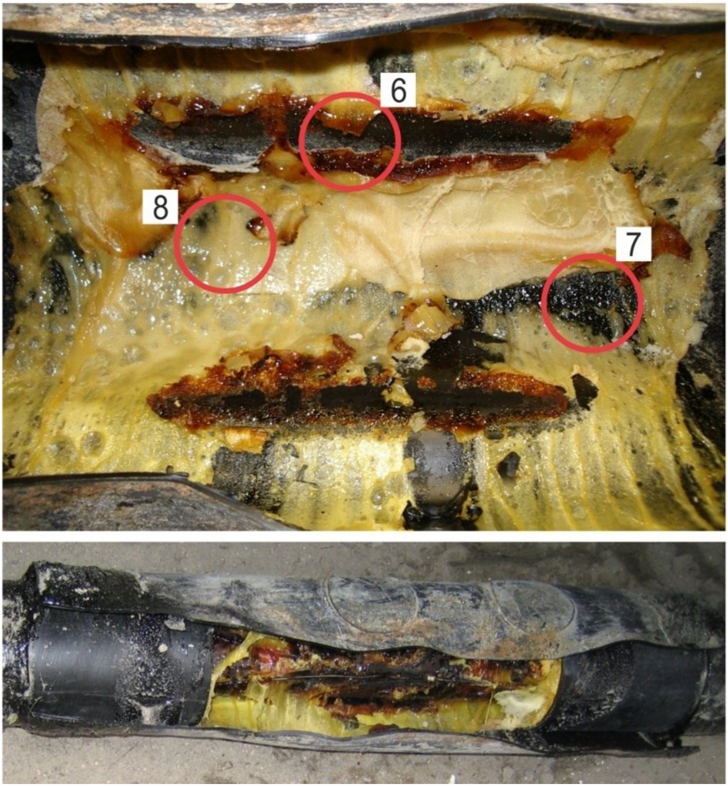


Figure 62: Original joint

By following the simple rules listed below, it is possible to obtain a joint that fully complies with the requirements of DIN EN 489-1:2020-03 without any difficulty.

The ideal foam

- **Correct mixing ratio**
- **Thorough mixing**
- **Correct component temperature**
- **Correct filling quantity (foaming table)**

The ideal pipe

- **Preheated**

- **Dry**
- **Clean**

9.6 Quality monitoring

The foaming of joints calls for great care and the allowance of sufficient time. Before starting work, a foam sample must be produced and labelled with the batch number of the PU material used, date, time and fitter's number.

9.6.1 Practical inspection in the field

9.6.1.1 Foam discharge

The amount of foam discharged from the openings (spill over) must not be too large (no bigger than a fist), as otherwise the overall density in the joint may be too low. If no foam is discharged, the joint can generally be assumed to be insufficiently filled. If this is the case, adding extra foam should be avoided at all costs, as this results in a sub-standard joint. After identifying and remedying the cause of the incomplete filling, the joint must be removed and replaced.

9.6.1.2 Heating

If completely filled, the joint becomes warm all over. Large air pockets immediately beneath the pipe surface, however, remain cold. This can easily be checked by feeling the surface with one's hand.

9.6.1.3 Knocking the joint

Any largish cavities can be detected by knocking the surface creating a hollow sound.

9.6.2 Foam testing to DIN EN 489-1:2020-3

In general, to determine the inner foam density, the joint must be opened so that a test specimen can be taken. For quality monitoring, a sample can also be taken through the filling hole using a hollow cylinder drill. This may happen after foaming but before the welding plug is inserted.

The following tests are mandatory:

Foam appearance: Streak-free

Core density: > 55 kg/m³. To determine the density of a foam body (of any shape), there is a simple method that can be quickly performed on site. Required for this are portable scales, a vessel containing water and a thin rod. The piece of foam is weighed (unit: g). The vessel filled with water is placed on the scales and the scales set to zero. The piece of foam is skewered on the rod and fully immersed. The value indicated by the scales in kg corresponds to the volume of the foam piece in liters. Dividing the foam weight by the volume yields the density. The advantage of this method is that foam pieces of any shape can be checked easily and quickly.

Water absorption (boiling test): < 10 vol. % (laboratory test)

Closed cells: > 88 % (laboratory test)

Cell size: < 0.5 mm (laboratory test)

9.7 Storage and safety

The information given below is in itself incomplete and must be supplemented with the relevant national regulations, technical bulletins and the safety data sheets of the component manufacturers. In particular, the current safety data sheets must be available on the construction site in legible form and in the national language and must therefore be available in the installer's vehicle. Persons handling chemicals must be familiar with the safety regulations and accident procedures. This responsibility to instruct lies with the employer and must be based on the currently applicable regulations.

Components must always be prevented from penetrating into the ground in the event of leakage. This makes special storage necessary. Storage must be on a sealed floor (e.g. steel lattice pallets with integrated drip tray, asphalt or concrete surface, thick sheeting, sealed hardwood boards of sufficient thickness). Spilled liquids must be immediately absorbed and/or removed with suitable cleaning material.

If the components are stored on the pipe-laying site, the containers must be safeguarded against theft. Unauthorized persons and especially playing children must be prevented from gaining access to the liquids.

As all contact with the components must be prevented, appropriate protective clothing must be worn when handling polyurethane systems (gloves, closed safety shoes, safety goggles, long-sleeved work clothes).

The storage and processing area for polyurethane system components must be well ventilated. In the case of blowing agents with explosion limits (e.g. pentane), smoking is strictly prohibited, all potential ignition sources must be eliminated, and the use of certified explosion-proof equipment is mandatory.

9.7.1 Polyol component

Ideal storage temperature: 15°C to 25°C

The storage container must be kept tightly closed to prevent the penetration of moisture and dirt.

Figure 63: Warning symbol for polyol components containing pentane, for instance

Storage at lower temperatures can cause segregation, particularly of the blowing agent.

Storage at higher temperatures can result in the degradation of the catalyst contained in the system. The vapor pressure of the propellant can also increase and cause the drum to swell and burst.

In the case of blowing agents used that can form **explosive mixtures**, sufficient grounding must be ensured to prevent the electrostatic charging of the containers. The equipment and tools employed must have a certified explosion-proof design.

9.7.2 Isocyanate component

Ideal storage temperature: 15°C to 25°C

Figure 64: Warning symbols for isocyanate (PMDI) used in general in pipe insulation

The storage container must be kept tightly closed to prevent the penetration of moisture and dirt.

Prolonged storage at higher temperatures results in an irreversible increase in viscosity.

Prolonged storage at below -10°C can cause crystallization.

Residues in containers must be treated with care. Penetrating moisture causes the formation of carbon dioxide and can cause the container to burst if venting is inadequate. Therefore, empty containers into which the penetration of water cannot be ruled out must not be tightly closed.

Isocyanate (PMDI) is a hazardous substance as defined by the Ordinance on Hazardous Substances (GefStoffV). Regulations must be strictly observed (see, among others, the current safety data sheet and TRGS 430). The employer is obliged to provide special training when materials containing isocyanates are handled. It is strongly recommended to consult further safety instructions under: *http://www.isopa.org/walkthetalk/MDI_de.pdf*.

Author of the chapter

Christof Grieser-Schmitz, BASF Polyurethanes GmbH

10 Plastic welding in district heating technology

10.1 Introduction

Plastic welding is an essential component in the construction of district heating pipelines. Professional welding of the individual components contributes to a long-lasting and efficient district heating supply. However, in order to perform this professional welding, some basic knowledge of plastics and their behavior is required.

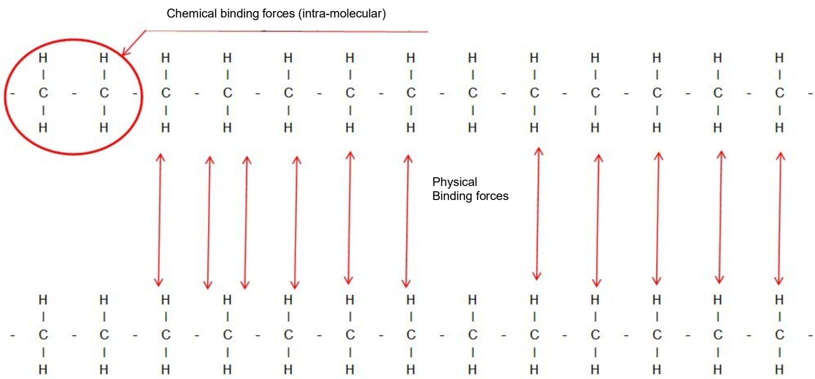
10.2 Basics

Polyethylene (PE, $C2H4$) is generally used for plastic casing pipes (CMP). Polyethylene is a thermoplastic, semi-crystalline plastic that is basically characterized by a high elongation at break, high toughness and good resistance to external influences such as chemicals or mechanical stress. In addition, PE has a low thermal conductivity. Thermoplastics consist of macromolecules, i.e. at least 1000 molecules are linked together. Therefore, they are also called thread or chain molecules**.**

These molecular chains are held together by two important forces: Chemical bonding forces,

- These are forces that are effective within the molecules and must not be influenced by the welder. If welding is carried out at too high temperatures, the molecular chains and thus the plastic are destroyed and it smells like candle wax. If the temperatures are too low, the welding partners are not joined together.

- Physical bonding forces, these bonding forces can and must be influenced by the welder. By heating, the molecular chains become mobile and can be connected under pressure. Cooling causes the chains to become immobile again and become hooked/knotted together**.**



However, this process just described presupposes that the three parameters

- Temperature
- Time and
- Pressure

be coordinated with each other. They influence each other and are more or less individual for each welder. All three variables are different for each thermoplastic and must lie within certain limit values. These limit values, and further information, are listed in the DVS 2207 regulations.

10.3 Welding procedures

10.3.1 Hot gas drawn arc welding (HAW)

In hot gas drawn arc welding, the welding equipment and filler metal are guided by hand. Dry and oil-free air is used as the hot gas. Hot-gas drawing welding is used wherever confined areas, small wall thicknesses or complex geometries have to be welded. In the field of district heating technology, this process is frequently used to produce root passes in preparation for hot gas extrusion welding.

To prepare the weld, both the base material and the filler metal must be machined immediately before welding to remove the oxide layer on the surface, the seam opening angle is between 50° - 70°. The prepared weld surfaces must be:

- **Be free from nicks**
- **Be dry**
- **Be free from dirt, oil and grease**
- **Be free from chips**

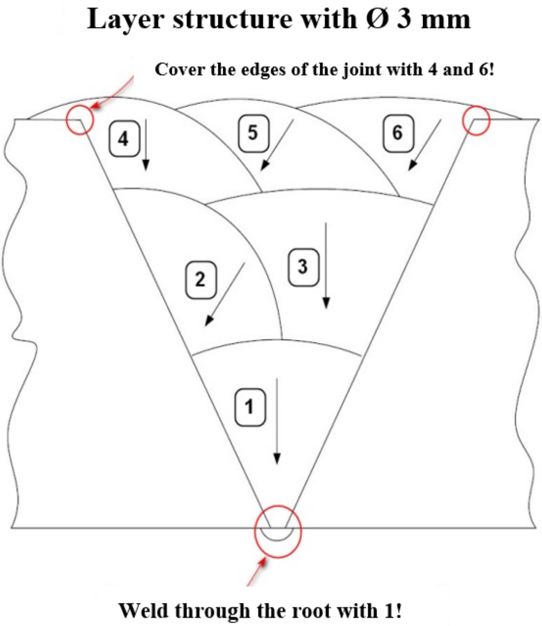
Furthermore, the welder must observe the following:

- the correct temperature of the hot gas, for PE-HD in the range of 300 - 350° C, measured 5 mm inside the nozzle.
- sufficient application of pressure by means of the welding nozzle
- a guide of the nozzle as parallel as possible to the base material. If the distance is too great, the base material will not be heated sufficiently and the molecular chains will not become hooked/knotted. If the distance is too small, the base material can already be thermally damaged.

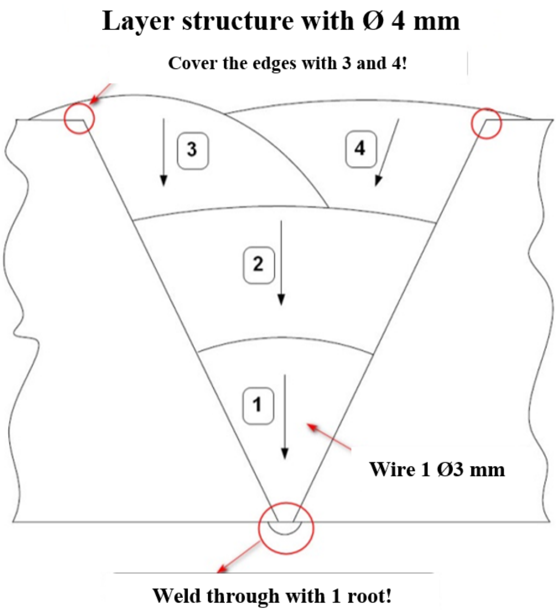
Already during the welding process it is possible for the welder to check the quality of the weld and to correct errors.
A good weld can be recognized by the following criteria:

- a smooth double bead on both sides of the weld bead
- a slight flattening of the welding rod
- a non-discolored, non-speckled shiny surface

The structure of weld seams is based on that of steel and is described in DVS 2207-3.



Layer construction with wire Ø 3 mm, for 5 mm V- and 10 mm X-seam

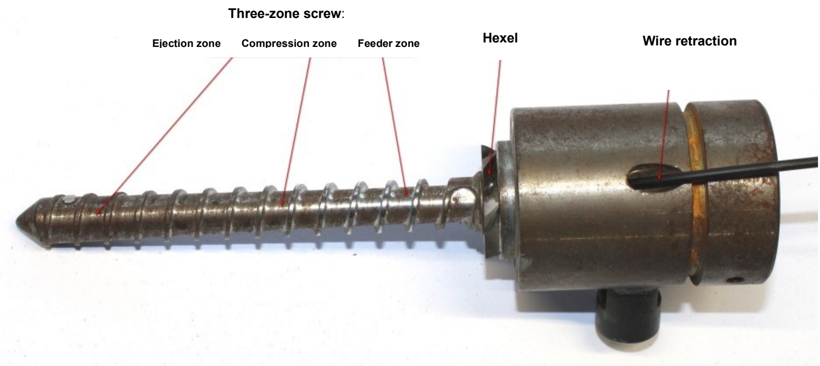


Layer construction with wire Ø 4 mm, for 5 mm V- and 10mm X-seam

When welding X-grooves, care must be taken to ensure that the weld beads are applied alternately to avoid stresses and distortion in the material. In the top layer, notches at the transition between the base material and the filler metal as well as between the individual beads must be avoided. These notches lead to premature failure of the welds due to stress peaks in the material.

10.3.2 Hot gas extrusion welding (HA)

In hot gas extrusion welding, the welding wire is drawn in by the extruder and crushed. It is then conveyed to the welding shoe via the extruder screw.



Extruder screw

During this transport the plastic is:

- completely melted
- mixed and homogenized
- degassed
- and pressed through a welding shoe, which gives the new shape.

After leaving the mold, the artificial material cools slowly and thus solidifies to its final shape. The welding shoe is responsible for shaping the weld seam. The welder has to observe more welding parameters in extrusion welding than in hot-gas drawing welding, these being:

- Temperature of the filler metal (approx. 210°C - 230°C)
- Temperature of the base metal (observe dew point)
- Hot gas temperature (250°C - 300°C)
- Mass flow rate of the filler metal (Kg/h)
- Hot gas flow rate (approx. 300 l/min)
- Welding speed (cm/min)
- Welding pressure (0.15N/mm2)

Welding shoes are usually made of Teflon (PTFE). This is a relatively inexpensive plastic that has all the necessary properties such as low thermal conductivity, good machinability and good temperature resistance. It is also anti-adhesive to the base material..

V-Sew Shoe

Fillet weld shoe

The welding shoes must be adapted for each seam shape and size. The nose at the front of the welding shoe helps to introduce the filler metal into the seam, builds up the necessary melt pressure, generates the feed of the extruder and specifies the seam shape. Important factors in the manufacture of the welding shoe include the required edge overlap as well as the maximum seam projection; these are specified in the DVS 2202-1 regulations, Table 5.

In extrusion welding, too, seam preparation is an essential part of the weld and contributes significantly to high seam quality.

As in hot gas drawing welding, the weld joint must be machined to remove the existing oxide layer, and the top of the seam is machined laterally approx. 3 mm (z dimension, edge overlap) beyond the joint edge to ensure a perfect bond between the base material and the filler metal.

The opening angle of the joint depends on the material thickness and is between 45° and 90°. The thicker the material, the smaller the angle. In addition, if possible, a root gap of approx. 2 mm should be maintained to ensure through-welding in the root. The weld projection must be between 10% and 30% of the material thickness and must not exceed 6 mm. After welding, the weld seam should be covered to prevent it from cooling too quickly and thus preventing the formation of vacuoles. These vacuoles do not form until after welding, when differences in temperature occur between the surface of the seam and the center of the seam. The material on the surface cools faster than in the center, 3-axial stresses are created and the material is torn open in and around the center of mass.

10.3.3 Plug welding (socket welding/ HD)

10.3.3.1 Uncrosslinked sleeve

- Preparation
- Drill out the foaming and venting holes using a conical drill bit with depth stop, to match the PE weld-in plugs
- Cutting out the foam immediately below the holes

- Removing the foam residues
- Peel off the oxide layer on the surface in the area of the hole
- Clean the welding area with PE cleaner

Welding in the plugs

- Check the temperature of the preheated PE plug welder (250°C - 270:C).
- Press the PE welding plug with a suitable plug holder into the heating bushing matching the PE welding plug after approx. 10 seconds simultaneously press the heating mandrel into the prepared conical bore for approx. 10-15 seconds.
- When the correct preheating temperature is reached (silky matte PE weld plug and a PE bead formation on the edge of the bore as well as on the PE weld plug), within 3 seconds transfer the weld plug from the weld socket into the conical bore, press it in with uniform pressure and then leave it in the weld for at least 30 seconds to cool down.

Important!

Do not tilt the welding plug and do not press it too deeply into the bore. The surface of the plug should end approx. 1 mm above the surface of the socket. The welding bead must not be removed.

10.3.3.2 Cross-linked socket

Preparation

- Drill out the foaming and venting holes using a conical drill with depth stop, to match the PE weld-in plugs

- Do not cut out the foam below the holes, there must be counterpressure
- Removing the foam residues
- Peel off the oxide layer on the surface in the area of the hole
- Clean the welding area with PE cleaner

Welding in the plugs

- Check the temperature of the preheated PE plug welder (270 °C).
- Press PE welding plug with suitable plug holder into the heating bushing matching the PE welding plug and at the same time press the heating mandrel into the prepared conical bore for approx. 45 seconds..

When the correct preheating temperature is reached (silky matte PE welding plug and a PE bead formation on the edge of the bore as well as on the PE welding plug), within 3 seconds the welding plug is transferred from the welding bush into the conical bore, pressed in with uniform pressure evenly over the surface and then left for at least 45 seconds to cool down in the weld.

10.3.4 Summary

The procedures described in this chapter, if followed, help to produce durable and resilient welded joints.

This in turn contributes to the reliable supply of district heating and minimizes the cost of repairs and maintenance of existing pipelines.

Author of the Chapter

Jens Heyer, Aachen Chamber of Crafts

11 Expansion pad

11.1 General

Expansion pads (DP), see Fig. 78, are a component of the plastic casing pipe system that requires special attention. They have the task of absorbing the changes in length of the CMR that occur due to the temperature expansions**.**

When selecting the expansion pads, care must be taken to ensure that no impermissibly high stresses occur in the components of the composite system..

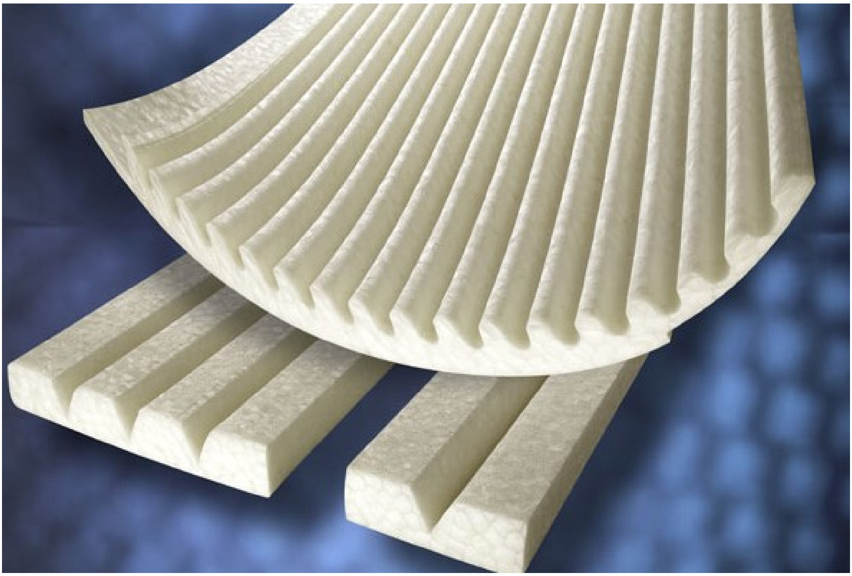


Figure 74, Expansion pad

Expansion pads are mounted at the following system points to accommodate the changes in length:

- at L-, Z- and U - bends
- on branches
- on reducing and end sleeves
- on shut-off valves
- at aeration and end venting
- at high and low points

The expansion pads used today (Fig. 78) consist mainly of Neopolen E.

11.1.1 Properties of Neopolen E

Neopolen E is a closed-cell, physically crosslinked particle foam made of polyethylene (EPE), which is supplied as sheet material in various thicknesses in white and black. Due to its excellent processability and versatile properties, Neopolen E is suitable for a wide range of applications.

11.2 Dimensions of the expansion pad elements

The dimensions of the expansion pad elements may vary depending on the system manufacturer or supplier. Fig. 79 shows an example of the range of dimensions of the expansion pad elements of a system manufacturer.

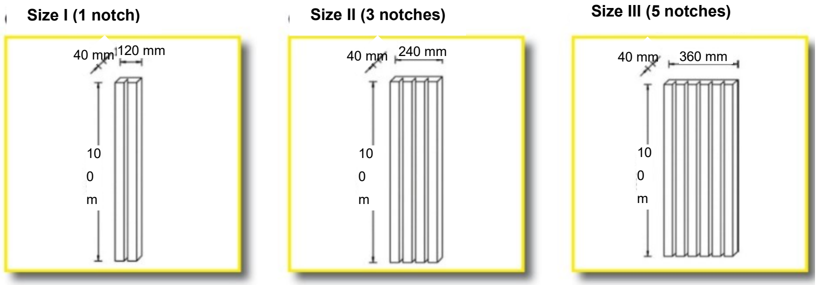


Figure 75, DP strip dimensions

As standard, the expansion pads are manufactured in three sizes of different widths and a thickness of 40 mm and a length of 1000 mm. If cushion thicknesses of > 40 mm are required, two or more cushions must be placed on top of each other by flaming.

11.3 Arrangement of the expansion pads

The arrangement of the expansion pads on the outer casing can be designed differently depending on the requirements. The following figures show different design variants for the arrangement of the expansion pads.

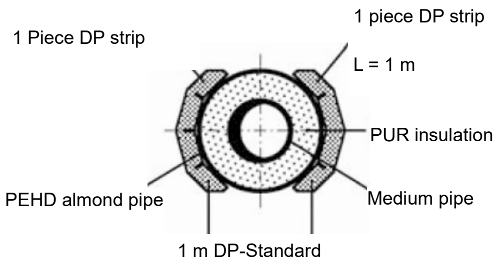


Figure 76, design as expansion pad strip

Design as oval-shaped expansion pad with protective sheathing

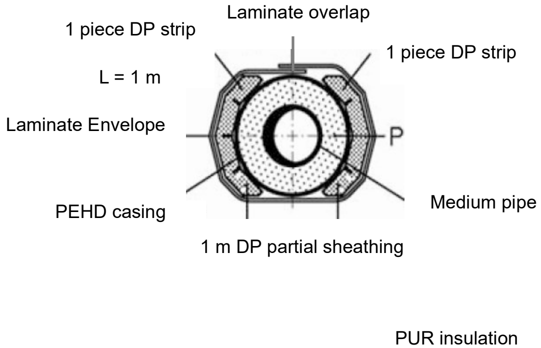


Figure 77, oval expansion pad with protective cover

Design as fully encapsulating expansion pad with protective sheathing

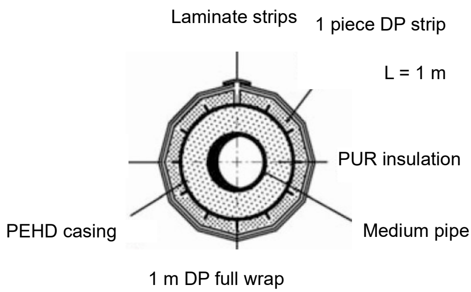


Figure 78, Fully encased expansion pad with protective sheathing

The expansion pads are to be arranged in layers around the pipe in such a way that the change in length - determined in accordance with the static verification and the expansion pad plan - can be completely absorbed.

The number of expansion pads in the axial direction depends on the expansion distance determined and documented in the expansion pad plan.

The following figures show the arrangement of the expansion pads with single-layer padding (Fig. 83) and with double-layer padding (Fig. 84).

Single-layer padding (40 mm) with equal expansion from both directions

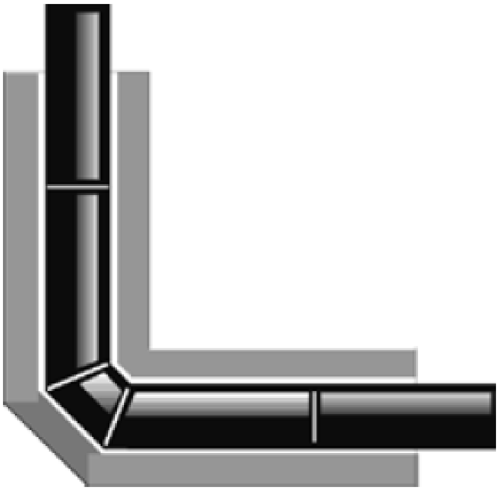


Figure 79, Single-layer padding

Two-layer padding (80 mm) with equal elongation from both directions

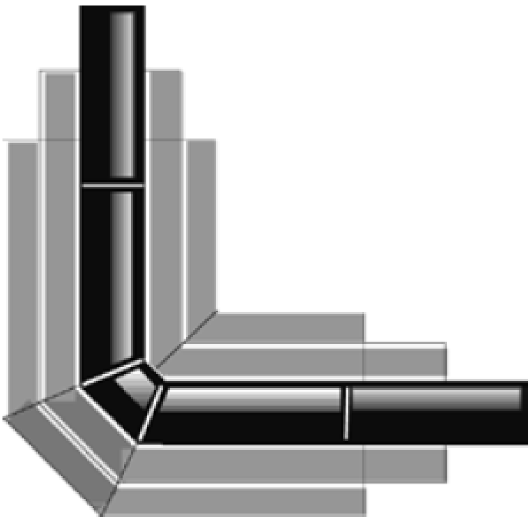


Figure 80, Two-layer padding

11.3.1 Assignment of the individual elements to the outer casing dimension

Depending on the design variant and the outer casing dimension, the expansion ranges may have to be composed or combined from several different individual elements (see Table 1).

Mantelrohr – Ø in mm	Größe	Kombination
Jacket Pipe – Ø in mm	Size	Combination
180 – 280	II	- - -
315 – 355	III	- - -
400 – 500	IV	II + II
650	V	II + III
630 – 670	VI	III + III
710	VII	III + II + II
800	VIII	III + III + II
900	IX	III + III + III
1000	X	III + III + II + II
1100	XI	III + III+ III + II
1200	XII	III + III + III + III
1300	XIII	III + III + III + II + II

Combination of expansion elements

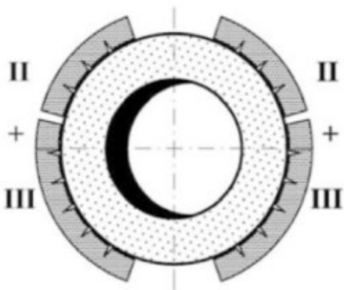


Figure 81, Combination example of expansion elements at size V

11.4 Requirements

11.4.1 Functional requirements

The expansion pad materials must meet the following requirements:

- Adequate reset behavior
- Sufficient elasticity during the entire service life
- Thermally conductive to minimize heat buildup between the expansion zone and the cladding tube
- Dimensionally stable against sand compaction and earth pressure
- Sufficient compressive strength against external loads
- Safety against inadmissible consolidation due to silting and sand penetration
- Non-rotting
- Rodent safety

Manufacturers must ensure that the aforementioned properties are met by means of evidence.

11.4.2 Stiffness

The expansion pads available on the market can vary considerably in terms of their stiffness. However, they must meet the following parameters in their property characteristics:

- under the laterally acting earth pressure, the expansion pads should not compress by more than 10 %.
- the expansion pad must allow a transverse movement of the pipe of at least 50 % of the original thickness without exceeding the radially permissible compressive stresses. In other words, the hardness (stiffness) of the expansion pad has a decisive influence on the bending moment and thus on the stress occurring in the bend. Consequently, expansion zones with hard expansion pads in the

arch area should be designed thicker than expansion zones with soft expansion pads.

11.4.3 Expansion pad thicknesses

The required expansion pad thickness depends on the thermally induced change in length of the pipe. Already during planning and static design, care must be taken to limit the associated heat buildup on the PE jacket due to the insulating effect of the expansion pads..

The following criteria must be ensured:

- **the temperature at the PE casing pipe must not exceed the maximum value of 50°C.**
- **It must be ensured that the fatigue strength of the PE casing and, in particular, the long-term function of the socket seals and casing weld joints are not impaired.**

The following maximum pad thicknesses are permissible without verification / recalculation:

- **maximum pad thickness with full wrapping: 100 mm**
- **maximum pad thickness with lateral expansion pads: 120 mm**

11.5 Mounting the expansion pads

In accordance with the planning specifications - from the cushioning plan and the structural analysis of the system manufacturer - the expansion cushions must be properly installed in terms of stiffness, thickness and length.

The installation must be carried out in such a way that the expansion pads are firmly attached to the PE casing pipe after installation. When backfilling the pipe trench and compacting the bedding material, the expansion pads must not change their position.

Preferably, the expansion pads should be protected against sand penetration by suitable measures. This can be done, for example, by a laminate wrapping. Sealing of the wrapping in the overlap area must be achieved by bonding/welding.

At the end of the expansion zone, it is essential to ensure that the laminate wrapping is led up to the outer casing and overlappingly welded there.

Oval-shaped expansion pads must be arranged in such a way that the center axes of the plastic cladding tubes and the expansion pads are parallel to each other and extend in height at least to the apex of the cladding tube.

The directions of action of the expansion pads must correspond to the direction of displacement of the LOCA (observe the specifications in the cushion plan).

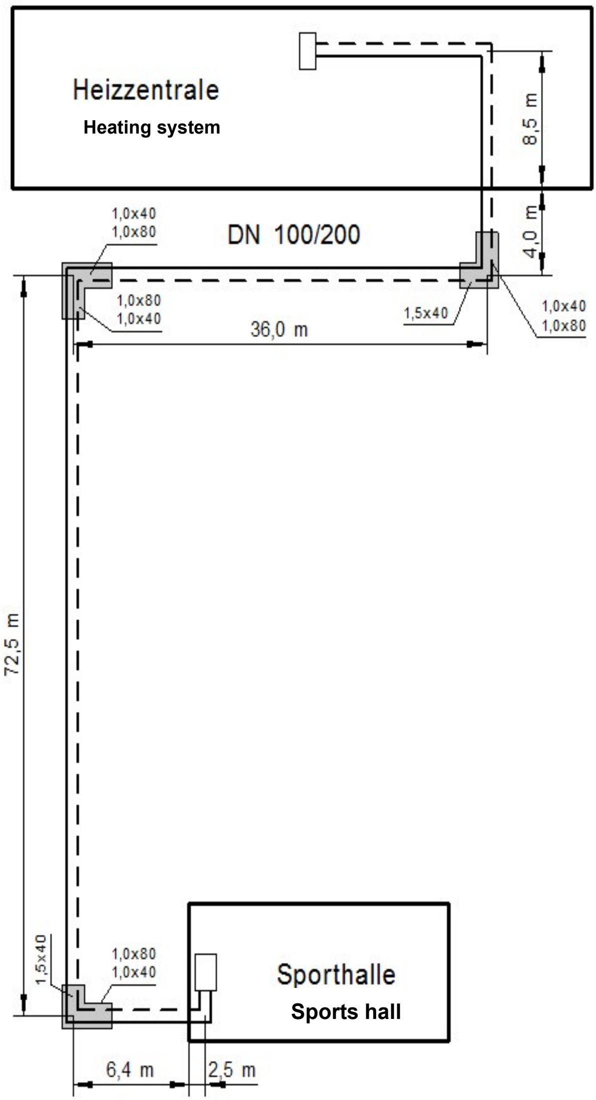


Figure 82, Example of an expansion pad plan

11.5.1 Examples expansion pad assembly

Figure 83, Multilayer oval-shaped padding of an L-leg with full wrap.

Figure 84, Single-ply cushioning with full encasement

Author of the chapter

Johannes Ellmer, isoplus district heating technology Sales Company mbH

12 Wall penetration sealing systems

12.1 General information and arequirements for preinsulated pipes

Seals for wall penetrations on insulated pipelines, especially district heating pipelines, require the utmost care when selecting the seal suitable for the particular application and when installing the seal. The PE jacket of district heating pipes, which is partly soft compared to gas or water pipes, for example, requires specially adapted sealing systems..

The general conditions relating to the pipe, the wall, planning, installation, pipe operation, the medium present, but also the installation options and the price of the components must be taken into account in their entirety when selecting a sealing system for the wall duct that is suitable for the individual application.

Figure 85, Constricted plastic jacket

Expert and early planning of the application in its entirety is essential to avoid structural damage in the long term.

Typical damage to wall ducts is mainly leakage due to deformed pipes (see Fig. 89) or crushed rubber seals.

Figure 86, Jacket deformation due to incorrect selection of the annular seal

12.1.1 Selection of the appropriate gasket - what to consider!

The following checklist provides an overview of the most important aspects to be considered when selecting and evaluating a sealing system for wall penetrations. It does not claim to be complete.

New construction or renovation?

- What is the condition of the masonry or wall sleeve?
- Need to take measures to seal the wall or coat the hole in the wall?
- Must be inserted with a wall sleeve into the wall?

Selection of a closed sealing system or a product that allows subsequent installation?

Particularly in the case of PE casing pipes (KMR) Pre-insulated Pipe with an outer diameter of more than 315 mm, it makes sense to first lay the pipe through the wall and then measure the annular space due to the pipe tolerances. In this case, the annular space seal to be produced individually must be suitable for subsequent installation.

Is the pipe shifting, especially with temperature fluctuations? Exactly how much pipe movement in millimeters is to be expected?

- Are there pipe movements, especially with temperature fluctuations?
- How often does this happen?
- Exactly how many pipe movements in millimeters are to be expected?

Only with precise information, the selection of the suitable seal is possible!

Is the pipe jacket dimensionally stable?

Which kind/ type of pipe is being used exactly?

Are seals to be activated with low tightening torque necessary?

In particular, the casing pipes of the flexible, insulated pipe systems are soft and require special care when determining the compatible seal in each case.

What are the tolerances of the pipe diameter (EN 253 allows plus

approx.3 - 5 %) for (KMR) Pre-insulated Pipe?

In dimensions larger than 315 mm outside diameter, a standard wall penetration seal can no longer reliably cover the possible tolerances. In most cases, the standard seal no longer fits on the pipe shell and a new "special seal" must be measured in and manufactured. It is recommended to work exclusively with individually measured and split gaskets for later assembly in these bigger pipe dimensions. Delivery time for these individual gaskets must be planned into the construction sequence.

Ovalities are to be expected in particular with ring bundles of flexible, pre-insulated pipe systems.

By choosing wall penetration seals type FW, which have been specially developed for district heating, the ovalities and tolerances of the ring bundles are optimally covered up to a casing pipe diameter of 200 mm. A standard seal, e.g. from the water pipe sector, should never be used for flexible insulated pipelines.

Is a centric position in the wall opening feasible?

Who installs the sealing system?

An experienced specialist company or the end user?

Depending on the expected level of expertise, the gasket must be selected accordingly for safe, site-appropriate installation. Even a high quality gasket can cause damage in the hands of an untrained person.

Is "pressing water" pending? This term is very sweeping..

- How many meters of water column can really be expected?
- Which load according to DIN 18533-1 is pending on the seal?

Especially in the interaction of pressure and temperature at the seal, it is important to select the right material and, if necessary, to take special measures. Seals against "pressing water" also have their limits - it should be clear where these are and whether these properties are sufficient for the respective application.

- Does the pipe come through the wall under tension?
- Can the seal absorb and withstand the stress?
- Are additional measures to be taken to relieve the stress on the seal?
-

If necessary, the pipe can be centered with a plastic casing spacer ring so the tension can also be taken from the seal in this way. It is also possible to place a second, simple seal in the wall, so that one seal can take the stresses on the inside and the second can seal on the outside (with 2x40mm width).

If it becomes necessary to manufacture a Pressio-individual seal with an asymmetrical structure, all the concerns of a factory-insulated pipe must also be taken into account here.

ATTENTION! A rubber wall penetration seal can only seal!

NEVER bear the loads that the pipe transmits to the gasket or even hold them for a long time.

- Is angling to be expected in the wall penetration?
- Is later structural or soil settlement to be expected?
- Will my gasket allow for later angular deflections?

It should be noted that corresponding structural settlements of e.g. only 10mm can squeeze a press seal to the point of leakage and can equally lead to pipe deformation.

Is buoyancy due to high water level to be expected?

PE casing pipes have a high buoyancy. Especially before commissioning, the still unfilled pipe can develop strong buoyancy forces due to accumulating rainwater or high groundwater. Insulated pipes of larger dimensions then press on the annular space at the 12 o'clock position, which can lead to leaks at the bottom at the 6 o'clock position. In these cases, buoyancy protection or weights are the solution for a functioning wall penetration.

Which medium is pending (water, biomass...?)

If necessary, pay attention to the media resistance of the gasket rubber material! Resistance tables for the most important substances can be found on the pages of the gasket manufacturers e.g. www.4pipes.de

If the gasket is exposed to UV radiation?

Plan additional protective measures if necessary.

For example, rubber seals installed above ground can be covered with sheet metal half-shells to protect the elastomers against UV light. The choice of elastomer material can also improve the resistance of an above-ground sealing system to UV radiation. EPDM, for example, is more advantageous here than NBR rubber.

What temperatures occur at the seal?

Elastomers, which are typically used as sealing elements, belong to the group of plastics. With increasing temperatures, elastomers lose their strength and correspondingly their pressure tightness.

Consideration of the interaction of pressure and temperature and the resulting reduced pressure tightness is importand.

12.2 Common sealing systems for wall penetration on the district heating pipe

The following sealing systems are available for various applications on district heating pipelines. The sealing systems considered are those specially developed for pre-insulated pipes. A complete overview of all wall penetration systems traditionally used on the market for pipelines, including those of other trades, is not provided.

12.2.1 Labyrinth - wall sealing rings

Labyrinth wall sealing rings witch serve as a water stop, are concreted or mortared into the wall and are suitable for wall penetrations without extraordinary load with "non-pressing" water.

The sealing system is characterized by quick assembly, simply sliding it onto the pipe with tension, and a favorable price/performance ratio.

In case of leakage, the wall must be opened. Retightening of this sealing system is not possible. The wall supports the pipeline, which usually helps not to deform the seal after pipe settlement.

Figure 87, Labyrinth wall sealing ring

12.2.2 Wall penetration seals, special district heating

Wall penetration seals in district heating design are developed for use against pressurized water. Their dimensions are matched to the tolerances and ovality of common district heating pipe systems. The 2 x 40 mm wide, extra-soft rubber sealing rings (Shore A hardness 40±) distribute the contact pressure of the seal in a protective manner over as wide a surface as possible. A low tightening torque enables safe assembly. Stainless steel pressure plates allow use in soil without hesitation. Pressio annular space seals can reliably seal pressures of up to 3 bar.

Pressio Individual wall penetration seals can can be manufactured for special applications in freely selectable dimensions and contours. Oval seals or seals with several additional pipe or cable penetrations, as well as seals in split design are possible.

Figure 88, Pressio wall penetration seal - district heating version

To the standard material EPDM- rubber, alternative qualities such as Nitrile rubber or Viton are available for special seal applications. The Pressio Individual seal in a spliced version is the first choice when (KMR) Pre-insulated Pipes are already installed and the annular space is individually dimensioned.

Pressio wall penetration seals are also available with a fixed loose flange for use on structures with geomembranes in the special district heating version (DIN 18533 must always be observed).

Figure 89, Example of house connection with Pressio FW

12.2.2.1 Assembly of Pressio wall penetration seals - what to consider

- Avoid heavy mechanical loads on pipe surface
- Avoid brittle fracture due to point and line loads
- Avoid stress cracks and deformation caused by excessive force
- Use correct installation tools (torque wrench)

For the tightening torque, it is essential to observe the specifications of the individual manufacturers with regard to ambient temperature and rubber quality (manufacturer-dependent rubber hardness of the sealing elements)!

It should be noted in particular that elastomers become softer with increasing temperatures and rapidly harder with decreasing temperatures. The manufacturer's specifications of the recommended tightening torques generally refer to a temperature of 23°C..

At low temperatures, the recommended tightening torque can be increased by up to 50% if necessary, and possibly reduced by up to 50% at elevated temperatures.

12.2.3 Pression Elements seals

Pressio Elements in link chain design are only suitable to a very limited extent for soft pipe systems like pre-insulated with PE jacket. There is a risk of pipe deformation. Extra soft rubber qualities (commercially available in blue) are available for use on plastic pipe systems. Professional installation is essential for successful sealing, especially on insulated piping systems.

.

Figure 90, Pressio Elements seal - extra soft version

12.2.4 Heat-shrink sealing from the casing pipe to the PE-jacket pipe

Shrink sleeves in high-shrink design, e.g. type Canusa - K60 HS70, provide high-quality sealing from a casing pipe to district heating pipe. The technology, which is equivalent to sleeve sealing PIP-joints, is suitable for small annular spaces and water pressure from outside. The installation is carried out by hot-shrinking, subsequently and with little contact pressure on the pipe jacket..

The integrated hotmelt adhesive in the sleeve provides the safe seal. The low pressure on the pipe jacket makes the sealing system practical even for very fragile insulated pipe systems. Seals with heat-shrink materials are available as a tubular shrink sleeve or as a split open sleeve.

The prerequisite for using this system is an existing sleeve pipe that protrudes at least 150 mm and the experience of the installer in handling heat-shrinkable products in district heating.

Figure 91, Heat-shrink sealing from the wallsleeve to the PE-Jacket pipe

12.2.5 Sealing sleeves

KMR sealing sleeves have been specially developed to ensure a pressure-tight seal between the wallsleeve and the outer pipecasing. The sleeves are made of high-quality elastomer, very dimensionally stable and pressure-tight up to 1 bar due to their high wall thickness compared to commercially available rubber sleeves. Due to their high flexibility, the sleeves allow large axial and radial movements between the wallsleeve and the DH-pipes. To ensure pressure tightness, the annular space should not exceed 70 mm.

Before backfilling the pipe trench, the sealing sleeves must always be wrapped with sufficient expansion padding towards the ground.

When mounting the sealing collars, it is essential to observe the manufacturer's specifications. Depending on the design of the wall duct - with or without sleeve pipe - different elastomeric sealing sleevers are used.

12.2.5.1 Sealing collar for direct wall connection

Compenseal sealing collars allow pipe movement and pipe settlement. Pressure tightness is given up to 1 bar, provided that the annular space between pipe and wall opening does not exceed 70 mm. The seals should always be installed with an expansion pad towards the ground.

The gasket is flanged or doweled to a smooth, clean wall (Fig. 97) and sealed on the pipeline and to the wall with special PU sealing adhesive and clamping straps. The pressure flange to the wall is made of stainless steel.

The maximum values with regard to axial and radial movement absorption - in accordance with the manufacturer's specifications - must be strictly observed.

Figure 92, Compenseal for direct well mounting

Figure 93, Example of a manhole wall penetration with Compenseal in front of the wall

12.2.6 Sealing sleeve from a the sleeve pipe to the preinsulated pipe

(Special (KMR) Pre-insulated Pipe sealing sleeves also allow pipe movement. They are applied to sleeve pipes (prerequisite) and medium pipes with special sealing adhesive and double clamping straps. Compared to commercially available rubber collars, the material thickness of the special district heating sealing collars is at least 5 mm. Furthermore, the KMR-sealing-sleeves are particularly long in order to fit two clamping straps and sealing adhesive each. Pressure tightness up to 1 bar is guaranteed for annular spaces up to 70 mm.

Larger annular spaces reduce the pressure tightness of the KMR-sealing-sleeve, smaller annular spaces can reduce wrinkling and thus the sleeve's ability to move. Sealing systems that should be able to withstand pipe movement and settlement must be encased to the ground with sufficient expansion padding and laminate.

Figure 94, Example of a (KMR) Pre-insulated Pipe structure insertion

Figure 95, KMR-Sealing sleeve pipe to casing pipe with havy duty steel straps

12.2.7 Wall sleeves

Wall sleeves form a perfect hole in the wall and thus provide the optimum basis for the use of an annular space seal. Likewise, with the use of a wall sleeve, the tightness between the wall and the seal is beyond doubt.

Wall sleeves are available in plastic up to an inner diameter of 300 mm and in fiber cement up to an inner diameter of 800 mm.

Steel wall sleeves can also be used to realize very large diameters and special dimensions.

To avoid structural damage in wall penetrations, it is essential to take a holistic view of all the components involved, such as pipe, seal, assembly and wall. A perfect wall penetration is the foundation for the quality of the subsequent steps and products.

Author of the chapter

Frank Hellmann 4 pipes GmbH

13. Documentation and acceptance

Checklist - Documentation for district heating systems

Any reader is welcome to copy this checklist for their own control purposes.

Construction Project: Part 100 – Technology

No.	Designation	Required	Available
101	Completion message and flowchart for integration		
102	Acceptance protocol EVUH/installer		
103	Protocol: "Release for filling and trial operation"/ installer declaration		
104	Welding documentation		
105	Welding instruction		
106	List of employed welders with test certificate		
107	Confirmed weld inspection records		
108	Protocols of the review by RU representatives		
109	Welding seam location plan		
110	Isometry		
111	General plan		
112	Circuit diagram		
113	Measuring point plan		

114	Measuring point plan				
115	Labeling scheme				
116	Labeling list				
117	Revised project documents				
118	Detailed drawings				
119	Laying plans				

No.	**Designation**	Required		Available	
		Yes	No	Yes	No
121	Protocol: "Pressure test" (with writing strip)				
122	Cleaning protocol				
123	Function and adjustment protocols of the valves				
124	Loop diagram leak monitoring system				
125	Protocol: "Insulation and continuity test leak monitoring system - cold -".				
126	Sleeve protocols				
127	Joint location plan				
128	Material BOMs				
129	Manufacturer documentation of the individual components (type sheets, dimension sheets, brochures, operating and maintenance instructions)				
130	Certificates for the individual components (sorted by items in the bill of materials)				

131	Site plan (M 1:500, excerpt from city map, hand-revised)				
132	Installer declaration/documentation thermal insulation				
133	Installer declaration/documentation Corrosion protection				
134	Erector declaration steel construction				
135	Steel construction documentation				
136	Acceptance protocols Elt plant				
137	Documentation Elt plant				
138	Acceptance protocols MSR plant				
139	Documentation MSR plant				
140	Other acceptance protocols such as e.g. land piece owner				

Attachments

No.	Designation	Required		Available	
		Yes	No	Yes	No
A1-1	Weld seam test films				
A1-2	Static proof of the pipe system				
A1-3	Operating instructions				
A1-4	Dimensions				
A1-5	Construction diary				
A1-6	Photo documentation				

Checklist - Documentation for district heating systems

Any reader is welcome to copy this checklist for their own control purposes.

Construction project: Part 200 - Construction

No.	Designation	Required		Available	
		Yes	No	Yes	No
201	Acceptance protocol EVUH/installer				
202	Protocol: "Release for trial operation"/ Installer declaration				
203	Documentation of the component				
204	Construction drawings				
205	Detailed drawings				
206	Acceptance protocol civil engineering office				
207	Other acceptance protocols such as property owner, green space office, etc.				
208	Compaction proof				
209	Verification of paving density for all base courses				
210	Verification of the grain size of the backfill sand installed				
211	Concrete test results				
212	Formwork and reinforcement plans				
213	Documentation drainage				
214	Documentation Components (e.g. manhole covers,				

	Ladders etc.)				
215	Documentation of the building entry (waterproofing system)				

Checklist - Documentation for district heating systems

Any reader is welcome to copy this checklist for their own control purposes.

Construction Project: Part 300 - Handover/Takeover Documents

No.	Designation	Required		Available	
		Yes	No	Yes	No
301	District heating acceptance/transfer protocol				
302	Inventory data sheets district heating				
303	Acceptance protocols of the installers				
304	Proof of the legal safeguarding of the pipeline				
305	Proof of warranty periods				
306	Final revised project documents technology				
307	Final revised project documents construction				
308	Final revised project documentation Elt plant				
309	Final revised documentation technology (3-fold)				
310	Final revised documentation construction (2-fold)				
311	Final revised documentation Elt plant (2-fold)				
312	Surveying documents (cadastral by publicly appointed surveyor)				
313	Site and elevation plans (M 1:500, excerpt from city map, foil)				

314	Detail plans (M 1: Detailed plans (M 1:250, foil)				
315	Protocol: "Insulation and continuity test Leakage monitoring system - warm -"				
316	Acceptance protocols FM system				
317	Approval documents (planning approval / shaft certificates)				
318	Permit documents (e.g. discharge permit HWA, EBA)				
319	Completion notification for the construction project				
320	Scrapping protocol				
321	Site plan (M 1:500) with marking of decommissioned and scrapped plant components				
322	Equipments created in SAP				
323	Plant inventory transferred to "district heating tray				

Checklist No. ....

Any reader is welcome to copy this checklist for their own control purposes..

Documentation for buried district heating pipelines

Construction project: ______________________ **Order No.** ____________

Part B (Contractor)

	Present Yes	Present No	Not Required
1. Civil Engineering	☐	☐	☐
1.0 Acceptance protocol civil engineering office	☐	☐	☐
1.1 Acceptance protocol property owner or green space office	☐	☐	☐
1.2 Compaction proof	☐	☐	☐
1.3 Proof of installation density for all base courses	☐	☐	☐
1.4 Verification of the binder content of asphalt base courses	☐	☐	☐
1.5 Verification of the grain size of the backfill sand installed	☐	☐	☐
1.7 Construction diary	☐	☐	☐
1.6 Photo documentation	☐	☐	☐
2. Pipe Construction	☐	☐	☐
2.0 Acceptance protocol pipe construction	☐	☐	☐
2.1 Preload protocol	☐	☐	☐

	vorhanden ja	vorhanden nein	nicht erforderlich
	Present Yes	Present No	Not Required
2.4 Tools okoll			
2.3 Cleaning protocol 'akuumbrille, Schweißnähte abgeseift ohne Protokollierung durchgeführt	☐	☐	☐
2.6 Pressure tests with air/vacuum goggles, welds soaped without logging performed	☐	☐	☐
2.2 Welded products	☐	☐	☐
2.5 Tools ›ckwarnsystem	☐	☐	☐
2.7 Mefl protocol leak warning system	☐	☐	☐
2.6 Isometrics	☐	☐	☐
2.10 Pipe Book geplan)	☐	☐	☐
2.9 Statics (laying plan)	☐	☐	☐
2.8 Construction diary			

geprüft: ____________ Datum / Unterschrift ______________________________

Audited: ____________	Date/Signature: ______________________________________

14. Standards and technical regulations

Valid standards and regulations at the time of going to press

The most important rules and regulations to be observed for

- the safety during the assembly work
- Requirements for the pipe systems
- notes on planning
- preparatory measures for the execution of the casing pipe connections
- the execution of the assembly work
- test procedures
- required execution qualities are listed in the following table.

The user must always make sure of the current status of the available elaborations.

Technical rules	Title
Rules and regulations of the employers' liability insurance association	
BGV A 1:2005	Principles of prevention
BGV A 3:1997	Electrical installations and equipment
BGV C 22:11997	Construction work
BGV D 36:2006	Ladders and steps
BGV 500:2004	Operation of work equipment
DIN and DIN EN standards	
DIN 4124:2002	Excavation pits and trenches - slopes, shoring and working widths
DIN EN 253:2006 + Supplement A2:2006 E DIN EN 253:2007	District heating pipes - Factory-insulated composite pipe systems for directly buried district heating networks - Composite pipe system consisting of steel service pipe, polyurethane thermal insulation and polyethylene outer casing.

IN and DIN EN standards	
DIN EN 448:2003 E DIN EN 448:2007	District heating pipes - factory-insulated composite pipe systems for directly buried district heating networks Composite fittings consisting of steel service pipe, polyurethane thermal insulation and polyethylene outer jacket
DIN EN 488:2003	District heating pipes - Factory-insulated composite pipe systems for directly buried district heating networks - Composite pipe system consisting of steel service pipe, polyurethane thermal insulation and polyethylene outer casing.
DIN EN 489:2003 E DIN EN 489:207	District heating pipes - factory-insulated composite pipe systems for directly buried district heating networks -pipe joints for steel service pipes with polyurethane thermal insulation and polyethylene outer casing.

Technical rules	Title
DIN EN 13941:2004	Calculation and installation of factory-insulated composite jacket pipes for district heating
DIN EN 14419:2004	District heating pipes - Factory insulated bonded pipe systems for direct buried district heating networks - Monitoring systems
E DIN EN 15632	District heating pipes - factory insulated flexible pipe systems
Part 1:2007	Classification, general requirements and tests
Part 2:2007	Composite pipe systems with carrier pipes made of plastic, requirements and tests
Part 3:2007	Non-composite pipe systems with carrier pipes made of plastic, requirements and tests
Part 4:2007	Composite metal service pipes; requirements and tests
E DIN EN 15689-1	District heating pipes - factory insulated composite jacket pipes For directly buried district heating networks - Part 1: Composite double containment pipe system consisting of two steel service pipes, polyurethane thermal insulation and an outer casing of polyethylene

AGFW Rulebook	
FW 401	Laying and structural analysis of plastic casing pipes (KMR)Pre-insulated Pipe for district heating networks
Part 2:2007	System description
Part 3:2007	Components; straight composite casing pipes
Part 4:2007	Components; composite moldings
Part 5:2007	Components; earth installation fittings
Part 6:2007	Components; pipe connections
Part 7:2007	Components; compensation elements and other system components
Part 8:2007	Monitoring and fault location systems
Part 9:2007	Design and implementation planning
Part 12:2007	Construction and assembly; organization of the construction process, civil engineering
Part 13:2007	Construction and assembly; organization of the construction process, pipe construction
Part 14:2007	Construction and assembly; organization of construction processing and socket assembly
Part 15:2007	Operation
Part 16:2007	Test method for casing joints

Technical rules	Title
Part 17:2007	Quality assurance
FW 420	District heating pipelines from flexible pipe systems
Part 1:2004+ Amendment 1:2006	Components for polymer medium pipe (PMR) systems
Part 2:2004	Systems with smooth steel medium pipes (steel flex)
Part 3:2007	Systems with corrugated stainless steel service pipes (corrugated metal pipes)
FW 420-5:2004 + Amendment 1:2006	District heating pipelines with flexible pipe systems - planning, construction and operation
FW 603:2007	Socket installation on plastic casing pipes (KMR) Pre-insulated Pipe and flexible pipe systems; testing of socket installers.
FW 605:2003	Joint installation on plastic casing pipes (KMR) Pre-insulated Pipe and flexible pipe systems; requirements for companies carrying out joint installation work

DVS Guidelines	
DVS 2207-5:1993	Welding of thermoplastic materials; welding of PE casing pipes - pipes and pipeline parts
Supplement 1:1997	Welding of thermoplastic materials; welding of PE casing pipes - fittings and shut-off valves
DVS 2212-4:2004	Testing of plastic welders; welding of PE-jacket - pipes - pipes and pipeline parts.
DVS 2284:2004	DVS course for plastics welders - PE casing pipes; Preparation for the welder examination according to DVS 2212-4

Technical rules	Title
Part 17:2007	Quality assurance
FW 420	District heating pipelines from flexible pipe systems
Part 1:2004+ Amendment 1:2006	Components for polymer medium pipe (PMR) systems
Part 2:2004	Systems with smooth steel medium pipes (steel flex)
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FW 605:2003	Joint installation on plastic casing pipes (KMR) Pre-insulated Pipe and flexible pipe systems; requirements for companies carrying out joint installation work

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DVS 2212-4:2004	Testing of plastic welders; welding of PE-jacket - pipes - pipes and pipeline parts.
DVS 2284:2004	DVS course for plastics welders - PE casing pipes; Preparation for the welder examination according to DVS 2212-4

15 Steel casing pipes Status 19.07.2021

Terms:

Steel casing pipe: steel in steel pipes = SIS pipes

Steel shell and tube assembly: steel in steel units = SIS units

Channels: concrete duct

District heating: district heating

Heating water: district heating water

Thermal oil: heat transfer oil

C - steel: carbon steel

Austenitic steel: stainless steel

Inner tube: inner pipe

Jacket tube: encasing pipe

Mineral wool shells: mineral wool shells

Anti-corrosion coating: anti-corrosion coating

Annulus: ring space

Stretch concept: expansion concept

Open laying: installation in trench

Trenchless laying: trenchless installation

Mechanical prestressing: mechanical prestressing

Thermal preload: thermal prestressing

Axial expansion joints: axial expansion joint

Joint compensator: lateral expansion joint

Length change, elongation: expansion

Burial: underground installation

Overhead installation, overhead line: above ground installation

Inner tube bearing: inner pipe supports

Special Insulation Material: special heat insulation

Roller bearing: roller bearing

Plain bearings: sliding support

Extended casing pipe: extented encasing pipe

Standard length: standard unit

SMR - Arc: SIS – elbow

SMR - Fixed point: SIS – fix point

SMR - axial compensator end closure: SIS – vacuum tight end closure

SMR - wall bushing: SIS – wall duct

SMR - Construction joints: SIS – connection on site

Puncture test: sparkling test

Mobile vacuum pump system: mobile vacuum pump

15.1 The development of steel casing pipe technology

Steel casing pipes have been used since the beginning of the 20th century for the transport of hot media and under difficult external conditions. Steel casing pipes have been installed in the USA since the 1930s, and their use in Europe began in the 1960s. In Europe, in Germany the first lines built with vacuum in the annulus. They set itself as a technical and economic alternative to the laying in concrete channels that had been common until then:

- Less space required
- Groundwater-tight with the welded casing pipes
- Operation with vacuum in the annulus

In this history, steel casing pipelines have proven to be reliable and technically - economically successful pipelines for media with higher temperatures and/ or difficult external conditions (source Merkblatt AGFW FW 410, preliminary remarks).

The changes in the district heating industry have also changed the structure and orientation of steel casing pipe projects - in addition to steel casing pipes in classic district heating networks, complex transport pipelines are being developed in primary networks and for industry.

The basic requirements for SMR pipelines are specified in the AGFW regulation FW 410.

Figure pipe bridge with steel casing pipe

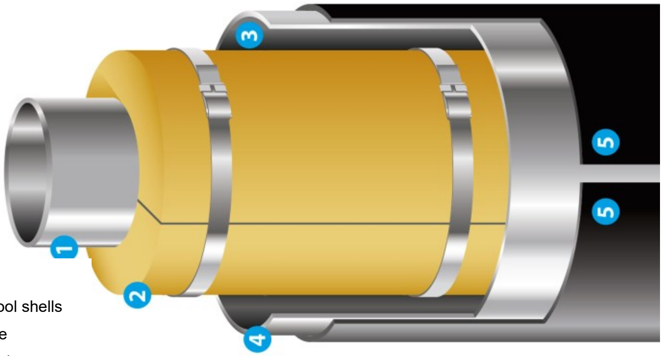
15.2 Steel casing pipe in district heating technology

Steel casing pipes can be used for all media, temperatures, pressures and pipe dimensions commonly used in district heating, district cooling and industrial applications.

With its technical focus on high temperatures and special external conditions, steel

casing pipe technology complements the other district heating systems widely used today.

Medium temperature	Up to 400°C
Media	Heating water, steam, condensate, thermal oil, environmentally hazardous media
Structure	
Inner tube	C - steel, austenitic steel
Thermal insulation	Mineral wool shells, Special insulation materials, Vacuum in the annulus
Jacket pipe	Steel pipe with external passive anti-corrosion coating
Mobility of the inner tube	Inner pipe freely movable in the outer casing only local coupling between inner pipe and outer casing at the fixed points Casing pipe friction in the ground, no external constructions, or concrete foundations at the buried fixed points
Jacket pipe connections	Usual pipe construction work such as welding and recoating on steel pipes
Planning and components	Project-related calculation, Planning and production, High degree of prefabrication
Leakage Monitoring	Monitoring of the vacuum in the annulus, during transport of environmentally hazardous media with a monitored annulus



1 - Inner pipe
2 - mineral wool shells
3 - Ring space
4 - Encasing pipe
5 – Coating

Figure: Structure steel casing pipe

Project-related technical and economic planning includes:

- Design, planning and construction of steel casing pipelines for buried installation, above-ground installation and culverts in open and trenchless installations
- Heat and pressure loss calculation of steam and heating water pipes
- Expansion concepts and strength calculations, selection of dimensions, material and casing coating
- Planning of prestressing techniques - thermal or mechanical
- Implementation of the expansion concept and the route in an installation plan with all construction units, details of the construction joints and details of the prestressing of the inner pipes.
- Planning of evacuation works, stationary vacuum pumps and vacuum monitoring systems.
- Planning of quality management, inspections and documentation, with monitoring by notified bodies if necessary.

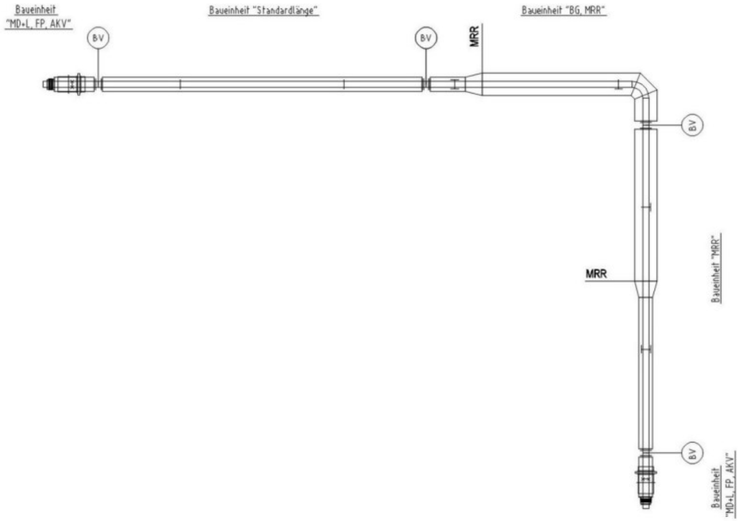


Figure: Planning of steel casing pipe construction units

Standard length 12m or 16m

Prefabricated SIS units with MD – wall duct, FP – fix point, AKV – vacuum tight end closure, MRR – encasing pipe reduction, SIS – elbow with extended encasing pipe.

Stretch concepts

- Natural compensation in the arches of the route
- Compensation with U - bends, axial compensators or joint compensators
- Reduction or suppression of the temperature-induced change in length of the inner tubes by thermal prestressing or a combination of thermal prestressing and natural expansion

Figure: U - bend with casing pipe extension

Thermal insulation

- Determination of the insulation thicknesses taking into account the heat losses and the maximum permissible temperature at the passive corrosion protection of the casing pipe
- Determination of single- or multi-layer insulation shells depending on nominal diameter and temperature
- Special solutions with reduced outer casing diameters in a combination of vacuum in the annular space and special insulation materials

Laying method

- Conventional burial in pipe trenches

Figure SMR - Construction units in the pipe trench

- Trenchless installation methods such as Horizontal Directional Drilling HDD even for long distances up to 1500 m

Figure: trenchless laying Horizontal Directional Drilling

- Above-ground pipelines or pipelines in buildings with supports on the casing pipes, e.g. in the case of great heights, restrictions on the number or distance between supports, and protection of the surroundings from the medium

- Pipe bridges with unsupported lengths with and without external support

- Also in case of settlement-prone soils and pressing groundwater

- Special custom-built units with a high degree of prefabrication

Figure: Special construction units

Operation with vacuum in the annulus:

- Reduction of heat losses by up to 30%.
- Monitoring of the pressure in the annular space and the tightness of the pipe.
- By removing air (oxygen) and moisture from the annular space, corrosion in the annular space is permanently prevented.
- At the ends and at all structural joints, the annular space between the carrier pipe and the outer casing is sealed vacuum-tight. No air, moisture or water can penetrate the annular space.
- Operation with vacuum monitoring with local display or remote data transmission
- Increased operating reliability with vacuum sections and vacuum bridges
- Length- and annulus volume-dependent operation with a stationary vacuum pump station

Innenrohr, DN inner pipe; DN	250		
Ringraum ring space	mit Vakuum with vacuum		
Berechnungstemperatur calculation temperature	250 °C		
Isolierdicke thickness heat insulation	Mantelrohr encasing pipe	Wärmeverlust heat losses	Mantelrohr-temperatur encasing pipe temperature
mm	DN	W / m	°C
90 + 0 = 90	**500**	**121,0**	**37,6**
100 + 0 = 100	**550**	**112,6**	**35,0**
110 + 0 = 110	**550**	**106,2**	**33,4**
120 + 0 = 120	**550**	**100,7**	**32,1**
130 + 0 = 130	**600**	**95,4**	**30,4**
140 + 0 = 140	**600**	**91,3**	**29,4**
150 + 0 = 150	**650**	**87,2**	**28,1**
160 + 0 = 160	**650**	**84,0**	**27,3**
170 + 0 = 170	**650**	**81,1**	**26,7**
180 + 0 = 180	**700**	**78,2**	**25,7**

inimum cover height

Stee asing pipe

Innenrohr, DN inner pipe; DN	250		
Ringraum ring space	ohne Vakuum without vacuum		
Berechnungstemperatur calculation temperature	250 °C		
Isolierdicke thickness heat insulation	Mantelrohr encasing pipe	Wärmeverlust heat losses	Mantelrohr-temperatur encasing pipe temperature
mm	DN	W / m	°C
90 + 0 = 90	500	150,8	45,1
100 + 0 = 100	550	140,7	41,8
110 + 0 = 110	**550**	**132,7**	**39,8**
120 + 0 = 120	**550**	**125,9**	**38,2**
130 + 0 = 130	**600**	**119,5**	**36,0**
140 + 0 = 140	**600**	**114,4**	**34,8**
150 + 0 = 150	**650**	**109,4**	**33,1**
160 + 0 = 160	**650**	**105,4**	**32,2**
170 + 0 = 170	**650**	**101,8**	**31,4**
180 + 0 = 180	**700**	**98,1**	**30,1**

Figure: Heat losses with and without vacuum

15.3 Steel casing pipe units and components

Due to the wide application of steel casing piping, all construction units and components are planned and supplied on a project-specific basis; there are no universally applicable designs.

All components such as bends, fixed points, etc. are not supplied as individual components, but are integrated into the construction units.

The important components are:

Standard lengths - ***standard unit*** **(short SL)**

- straight lengths 12 m or 16 m

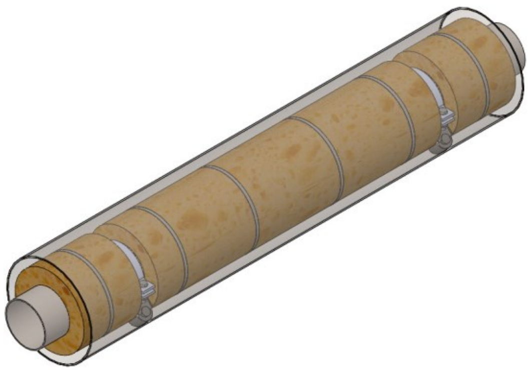


Image: Drawing standard length

- Fitting lengths: as standard lengths, but with adapted length.

- Inner tubes: seamless tubes according to EN10216 or welded tubes according to EN10217, materials P235GH to P355NH, for condensate or environmentally hazardous media austenitic steel

- Jacket pipes: welded pipes according to EN10217, materials P235TR1 to P355NH, in case of environmentally hazardous media austenitic steel, outer corrosion protection coating of PE according to DIN 30670 - N or S - n or v, PP - coating according to EN - ISO 21809, color coating

- Thermal insulation made of preformed mineral wool shells, special insulation materials, also in combination, fastening of insulation shells on the inner pipe with steel bands, protection at jacket pipe welds with glass fiber bands

- Inner pipe bearings as roller or sliding bearings with separation of the heat flow from the inner pipe to the outer pipe

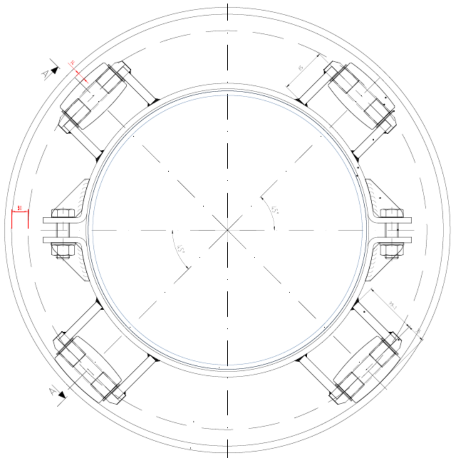


Figure: Section through the SMR with roller bearing

Illustration: Inner tube with roller bearing

SMR - bends - SIS - elbow

- with inner pipe bends or bends,

- outer casing bends made of segments
- resulting from the expansion concept: with extended jacket pipe
- prefabricated on a straight unit

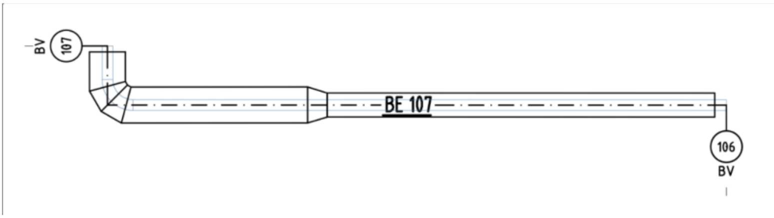


Figure: SMR - assembly unit with bend

SMR - fixed point - SIS - fix point (sometimes anchor point) (short FP)

- Transfer of axial forces from the inner pipe to the outer pipe
- Reduction of heat flow from the inner tube to the outer tube with heat insulating intermediate layers
- Vacuum-tight design or with annular passage
- For buried pipes: Transfer of forces via jacket pipe friction, no external structures or concrete foundations

SMR - axial expansion joint end closure - SIS - vacuum tight end closure (short AKV)

- vacuum tight end closure of the annular space
- suitable for relative movement between inner - or outer casing pipe
- At the end of a steel casing pipeline or in the route as a vacuum bulkhead

SMR - Wall duct- SIS - wall duct (short MD - L)

- For decoupling of casing pipe and structure
- Suitable for the small movements of the casing pipe on structures
- Sealing with force fit or lens compensator between casing pipe and building wall

Figure: SMR - fixed point, SMR - axial expansion joint end closure, SMR - wall penetration.

Jacket reduction - encasing pipe reduction (short MRR)

- **Concentric reduction of the outer casing**

SMR - T-branch - SIS - T - branch

- **T - piece or nozzle in or on the inner pipe**
- **Jacket pipe socket**

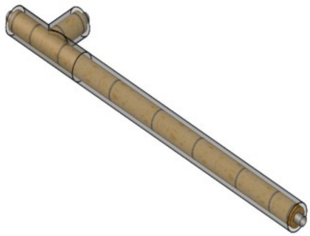


Figure: SMR - branch prefabricated in one unit

15.4 Transport, unloading and storage of steel casing pipes

Steel casing pipe construction units are transported on trucks.

Textile straps must be used to lift the units in order to protect the PE coating from damage.

Steel casing pipes shall be stored on padded timbers without touching the ground.

It is customary and advantageous to transport the steel casing pipe construction units following the construction sequence without intermediate storage, if possible close to the pipe trench.

The inner pipes are secured against the casing pipe with transport locks. The transport locks are not removed until the pipes are connected in the pipeline.

Figure: Transport SMR

15.5 Laying the construction units

The laying of steel casing pipes is described in detail in a laying guideline.

The steel casing pipe construction units are marked on the laying plan and on the casing pipe:

- Number of SMR - construction unit
- Number of SMR - construction joints
- Position of the 12:00 o'clock position with "above".

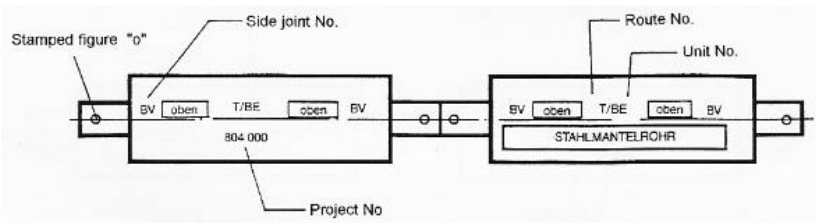


Figure units with marking

The project-related planning, length and assignment of the components results in a clear identification of all structural units and structural connections with numbers. Their position and direction is thus determined. The assembly of the steel casing pipe follows these specifications. Route modifications involving changes to the steel casing pipe are checked by the supplier.

Important steps during installation are:

- Vertical and horizontal alignment of the structural units on the pipe base (sand).
- Welding and testing of the inner pipe joints
- Post-insulation with mineral wool insulation shells
- Making, welding and testing casing joints with half-shells or by pulling in the casing pipe
- Note: The aim should be to close the outer casing joints quickly with a rapid assembly sequence. The reason: a closed structural connection provides reliable protection against the ingress of water or contamination into the annular space
- Recoating the passive corrosion protection and checking with the sparkling test
- The material for the construction joints such as casing pipe for half shells, thermal insulation shells with steel straps, glass fabric tape and post coating material for passive corrosion protection are part of the manufacturer's delivery.

Illustrations: Building connection with half shells

15.5.1 Preload

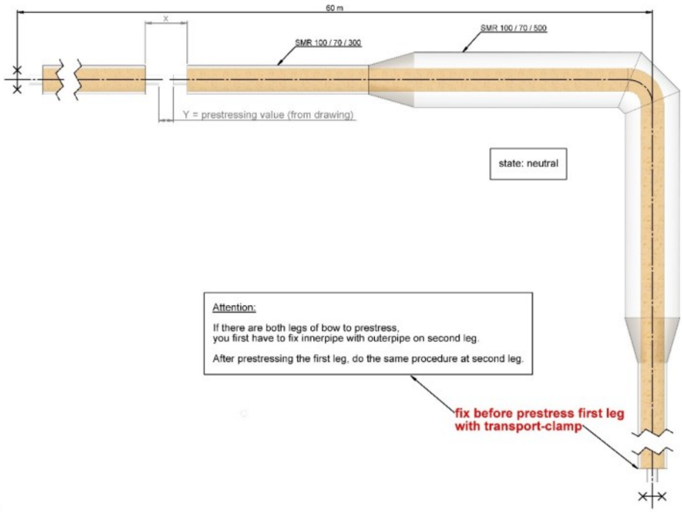
Two types of preload are distinguished:

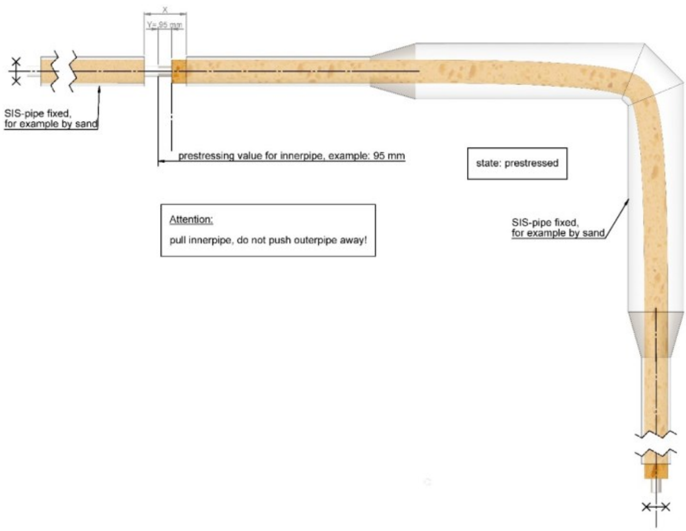
Mechanical preload

This prestressing, also known from overhead lines, is used for natural compensation of the inner pipe in the bends of the route or U-bends. The inner pipe bend is pulled into an eccentric position against the direction of expansion in the outer casing. This provides the path for the temperature-induced length change in the annular space.

The outer casing of the prestressing sections must be secured against displacement by at least partial backfilling.

All details such as prestressing point, prestressing direction and prestressing path are given in the installation plan.


60 m
X
SMR 100 / 70 / 300
SMR 100 / 70 / 500
Y = prestressing value (from drawing)
state: neutral
Attention:
If there are both legs of bow to prestress,
you first have to fix innerpipe with outerpipe on second leg.
After prestressing the first leg, do the same procedure at second leg.
fix before prestress first leg
with transport-clamp


X
Y=95 mm
SIS-pipe fixed,
for example by sand
prestressing value for innerpipe, example: 95 mm
state: prestressed
Attention:
pull innerpipe, do not push outerpipe away!
SIS-pipe fixed,
for example by sand

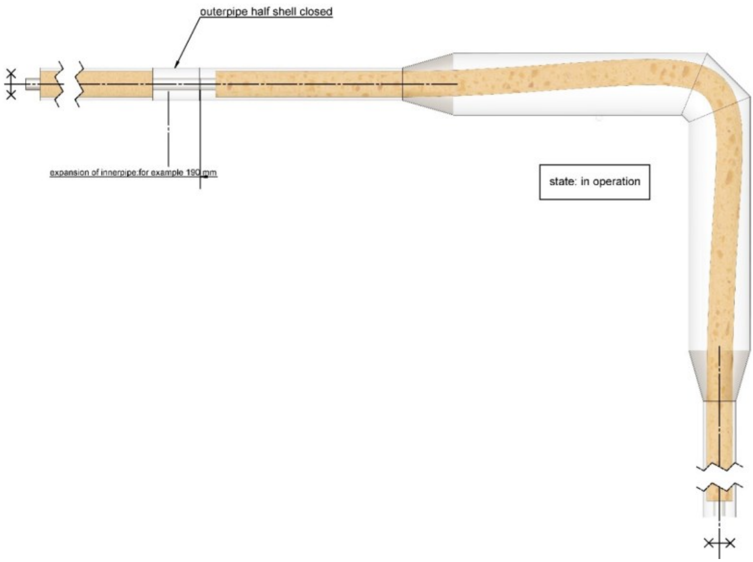


Figure: Mechanical prestressing of sheets

Thermal prestressing of the inner pipe against the outer casing:

This form of pre-stressing prevents or reduces the temperature-induced elongation of the inner pipe. In the cold state, tensile stresses prevail in the inner pipe and compressive stresses in the hot state, with the opposite stresses prevailing in the outer casing.

Up to a calculation temperature of 140°C, one hundred percent pre-stressing is possible, and up to a calculation temperature of 220°C, a combination of thermal pre-stressing and natural expansion is possible.

Thermal prestressing is a proven principle for straight, trenchless installations in HDD processes.

15.5.2 Evacuation of the annulus

During commissioning, the annular space is evacuated using a mobile vacuum pump system. The air and humidity are removed from the annular space. This process relies on a heated inner tube.

With evacuation prior to start-up - "cold evacuation" it is not possible to remove the moisture from the annulus and achieve an acceptable final pressure and leakage rate. By removing the air with the oxygen, the annulus is conserved.

The mobile vacuum unit consists of a vacuum pump, a water separator with chiller, a liquid collector and an oil separator. A 380 V three-phase connection is required for operation.

The development of the annulus pressure and the amount of liquid from the condenser are monitored and documented. Depending on the length, temperature and structure of the line, the annulus is evacuated in several sections and with saturation phases.

A pressure rise measurement is used to check the drying and tightness of the annulus.

Figure: Mobile vacuum pump stand

Author: ISOBRUGG Stahlmantelrohr GmbH

16 Introduction of flexible pipes

Working groups in TC107 under CEN (European Committee for Standardization) have produced the following standards for pre-insulated flexible pipe systems.

EN 15632-1 concerning classification, general requirements, and tests.

The EN 15632-2 and EN 15632-3 for composite systems with medium pipes made of plastic and non-composite systems with medium pipes made of plastic, respectively.
EN 15632-4 for composite systems with medium pipes made of metal.

EN15632-1 states that:
Depending on the pipe assembly (see Table 4), this European Standard applies to maximum operating temperatures from 95 °C to 140 °C and operating pressures from 6 bar to 25 bar.

The pipe systems are designed for a service life of 30 years. For pipe systems with medium pipes made of plastic, the corresponding temperature profiles are specified in EN 15632-2 and EN 15632-3 set.

This section focuses on the composite systems according to EN 15632-1, EN 15632-2 and EN 15632-4, describes four common media pipe types and gives a brief introduction to pipe design, installation techniques and available jointing systems.

Pre-insulated flexible pipe systems with medium pipe types made of:

- Flexible corrugated stainless-steel pipes
- Thin wall flexible steel
- Cross-linked polyethylene (PEX)
- Aluminum and PEX (Alu Pex)

Other carrier pipe types such as Cobber or PE are available on market.

Utilization principle

Flexible pipes are the ideal choice without much pre-planning for House connections or as a continuation of existing pipes. The flexibility and possible conveying length allow quick and accessible laying of pipes. Installation costs are greatly reduced due to easy bypassing of obstacles in the ground and minimum excavation.

Bonded flexible pipe systems (EN 15632-1 and EN 15632-2) insulated with rigid polyurethane foam (PUR) and a PE jacket made of LLDPE are bonded together by a bonding agent force, and the continuously manufactured production process makes the pipe structure watertight in the longitudinal direction.

Flexible pipes can also be used for smaller complete district heating systems with lower temperatures and dimensions up to ø140 mm.
When using flexible composite pipes, the manufacturer's installation instructions should be followed.

17 Flexible steel casing pipes made of stainless spiral corrugated metallic materials.

Spiral corrugated chrome-nickel steel carrier pipes with spiral corrugated

Steel casing pipes and double corrosion protection jacket made of Polyment and PE-LD

The perfect alternative:

Safe and economical through simple efficient planning and construction cost reduction.

- Safety due to the spiral corrugated carrier pipe made of chromium-nickel steel (1.4301 or 1.4404)
- Safety due to the corrugated steel casing pipe made of stainless ferritic chromium steel

Corrugated steel casing pipe, in combination with the optimized pipe components, offers exceptional resistance to deformation and is suitable for large loads, such as very high earth and traffic loads.

Flexible spiral corrugated metallic pipe systems are easily bendable and, depending on the pipe dimension, are produced in lengths of more than 1000 m "endless".

Design and application

Quality and efficiency at their best

Structure Flexible steel casing pipe

1. Stainless steel medium pipe
2. Monitoring veins
3. PUR foam
4. Steel shell
5. Polyment corrosion protection
6. PE-LD sheath

17.1 Safety through multilayer corrosion protection

The outer three-layer corrosion protection consisting of a double polyment layer and the polyethylene protective jacket form a strong bond to the steel casing pipe and protect the pipe against mechanical effects and moisture.

This optimized corrosion protection safeguards against aggressive soils, water and stray currents. This corrosion protection structure has proven itself for many years in buried high-frequency and telephone cables.

Security through permanent monitoring capability

The flexible steel jacket pipes can be continuously and completely monitored using the resistance reference measuring method (CrNi wire) or the transit time measuring method ("Nordic" / EMS system). Moisture ingress into the insulation, i.e. damage to the inner pipe or jacket pipe, is reported as well as faults in the monitoring system itself, e.g. line interruption (see BFW manual chapter 7).

Operating range (temp.)

Operating temperature for steel jacket system with optimized PUR insulation, TBmax -170 to + 150 °C

Operating temperature for pipe systems without steel jacket with PIR insulation, TBmax 160 °C

Operating pressure PN 16 and PN 25 (depending on type of connection)

Application:

Heating water (steel service pipe X5 CrNi 18-10)

Drinking water (steel service pipe X2 CrNiMo 17-12-2)

Service water (steel service pipe X2 CrNiMo 17-12-2)

Connection joints - transition from flexible pipe system to rigid pipe system

- Flameless connection with graphite sealing ring (PN 25) can be mounted in a few steps, without special tools, and allows connection to conventional pipe systems.
- Flameless connection with Pb sealing ring (PN16) is mounted using special tools.
- CrNi welded connection by means of TIG process. For special cases and medium pipes DN 200.
- The manufacturer's assembly instructions must be observed and requested there if necessary.

Connection to other pipe systems

Flexible metallic pipe systems with the designated design features can be connected to existing district heating pipelines (e.g. to plastic jacket pipe, hood duct, etc.) without any problems and in accordance with the manufacturer's specifications.

Building introduction

For the watertight insertion of the flexible steel pipes into buildings and manholes, adapted wall bushings are available in each case (see manufacturer's installation instructions and BFW manual chapter 11).

House connections according to the one-loop method

The flexible steel pipe systems can be laid using the single-loop method, as practiced in cable technology. This means that the pipes are routed (supply and return) in each case along the shortest route from one building to another. Within the building, e.g. in a cellar room, the transition to the house installation is made on the one hand and the connection to the supply of the next building on the other hand. In this way, the flexible pipes are routed in the same way to further houses or heat consumers (see manufacturer's specifications).

17.2 The advantage of this laying technique:

- no connections in the ground, respectively no interruption of corrosion protection
- shortest possible pipe runs
- every pipe connection is accessible at any time
- no welding work and pressure tests on the buried pipeline sections
- T-pieces, expansion bends, expansion joints and fixed points are not required
- small trench dimensions and short construction time

- no additional joints and transition components in the ground
- all monitoring wire connections are freely accessible

The universal pipe system - suitable for almost all soil conditions

Plowing in with flexible steel casing pipes. Image source: Image X21.de-ReinerFreese

Safe for use in the horizontal directional drilling (HDD) method

The horizontal flush drilling method has now proven itself, is recognized and presents a common, environmentally friendly alternative to the open trench method of construction. The flexible steel casing pipe described is exceptionally well suited for trenchless pipe laying. This is due to the special flexibility and stable structure of the corrugated casing pipe in combination with the described multilayer outer corrosion protection jacket.

Following a prior soil survey and, if necessary, soil samples, the borehole can be drilled within a short time using a drill mount and the precisely controllable flushing lance as well as various borehole expansion heads. The traffic disturbance is kept very low. It should be emphasized that even greater laying depths are possible due to the stable pipe construction.

Tube reel with flexible tube

Pipe length 115 m

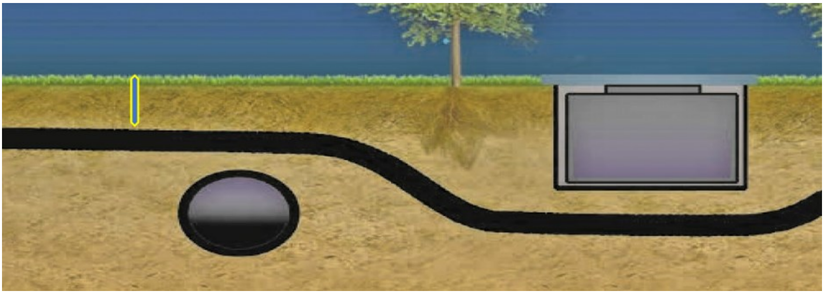
Pulling a flexible steel casing pipeline into the launch pit

Laying depth and overlap height

Due to its spiral corrugation, the outer corrugated steel shell in conjunction with the overall pipe design offers very high rigidity and is thus capable of absorbing high static loads. The expert opinion of the sworn expert Dr.-Ing-Veenker proves - quote: "For flexible steel casing pipe systems with the design features described, e.g.: the type series 22/55 - 200/310 (inner pipe diameter/outer pipe diameter), the required cover height under live load SLW 60 has been determined.

For all pipe types mentioned here, an effective covering height of 0.2 m is sufficient." For this purpose, the pipe crown must be secured against mechanical damage in the 12 o'clock position. This low cover height results in great advantages for planning and constructional implementation, especially in inner-city areas - e.g. when laying on existing hood sewers during renovations, etc.

Low overlap height



Twelve plus 1 good reasons for flexible stainless steel casing pipes

Diffusion-tight

- When using the welded connection joint 100 % diffusion-tight.
- No diffusion out of the thermal insulation or into the thermal insulation
- Therefore the lambda value is maintained for a longer period of time

Laying in continuous lengths without joints

- Laying in continuous lengths without joints
- Time saving due to shorter construction times
- No welding and post-insulation work in the trench

Trenchless laying "plowing in“

- The flexible pipe system can be laid with the help of a plow without trench excavation
- The flexible pipe can be connected to other pipes and ploughed in in one step

Repair of old or damaged pipe systems

- The flexible pipe system can directly replace district heating networks that are still in use and also other pipelines that are no longer in use or damaged
- New flexible pipelines can be laid in existing overdimensioned (KMR) Pre-insulated Pipe pipelines without additional financial expenditure


Flexible and stable construction

- No bend fittings in the ground
- Continuous factory corrosion protection
- Can also be used in ground settlement areas and on slopes without special precautions

Self-venting

- The spirally corrugated inner pipe is self-venting due to its design, even at high points.
- Venting components can be largely dispensed with

Low costs for dewatering

Safe installation even in wet soils and at high groundwater levels

For crossings of rivers and bodies of water (well suited for culvert construction)

Self-compensating

- No U-bends, expansion joints, expansion legs or fixed points in the ground required
- Low planning and construction management costs

Minimal civil engineering costs

- Smaller trench widths and shorter routes
- Less excavation
- Cost reduction for surface restoration
- Minimal installation depth
- Reduced costs for site safety, road and pedestrian bridges

Single-loop method instead of T-branches

- Increased safety - no interruption of corrosion protection
- Cost-effective and fast installation

Underground installation

- With horizontal flush drilling method
- By cable plow method
- In press and protective pipes

Bypassing obstacles and laying that protects the environment

- Passing under and over obstacles without additional costs
- No additional costs due to relocation of third-party pipelines
- Adaptation to local conditions - no groundwater lowering required
- Trees and shrubs can be bypassed over a wide area

Delivery and on-site measures

District heating pipes in general

Delivery to the construction site is made by truck free site collection warehouse. Please note any transport damage and any obvious defects immediately on the delivery bill and the consignment note and notify the driver.

All delivered parts must be stored at the collection point on a paved floor and protected from dirt and moisture. Buildings and shafts into which the pipes are inserted must be made watertight; any water that enters must be able to drain off again quickly.

Flexible steel casing pipes

On site, the supplier shall provide, free of charge, 5 m wide paved access roads for trucks, storage areas for materials, space for accommodation as well as power and water connections. When the pipe fitters arrive on the agreed installation date, the pipe trench must be completed in accordance with the manufacturer's specifications.

The UVV and relevant standards and the manufacturer's specifications described in the worksheets with regard to trench widths, trench depths, minimum bending radii, sand bedding and sand granulation must be observed.

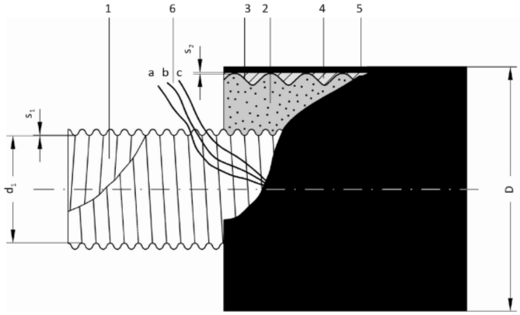
The continuing pipelines are to be designed free of stresses and strains.

This means that no expansion forces or bending forces may act on the flexible pipe or the connection joints from the outside!

Continuous laying and installation without waiting times and interruptions must be ensured. The pipe trench must be continuously accessible from at least one side (see UVV) and kept free of water during the entire laying and assembly time.

Assortment

Flexible steel casing pipe with spiral corrugated chrome nickel steel carrier pipe.



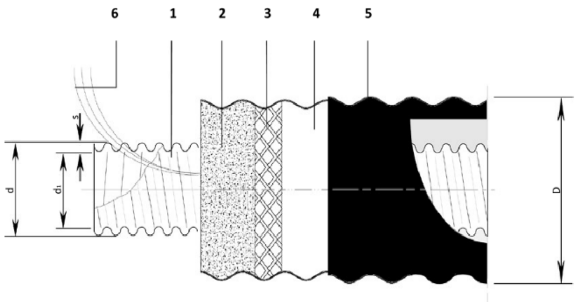
Structure

1. Stainless steel medium pipe
2. PUR foam
3. Steel jacket diffusion-tight
4. Corrosion protection
5. PE-LD jacket
6. Monitoring wires

Type	DN	Inner Tube Stainless Steel $d_1 \times s_1$	Outer Tube s_2	Outer Diameter D	Minimum Bending Radius	Volume Inner Tube	Weight	Maximum Delivery Lengths*
		mm	mm	mm	m	l/m	kg/m	m
30/ 91	**25**	30.0 x 0.3	0.6	94	1.0	0.81	3.9	1000
39/116	**32**	38.9 x 0.4	0.6	121	1.2	1.35	5.7	640
60/148	**50**	60.0 x 0.5	0.7	156	1.5	3.12	9.1	590
75/171	**65**	75.8 x 0.6	0.8	178	2.0	5.12	12.2	480
98/171	**80**	98.0 x 0.8	0.8	178	2.0	8.43	12.8	480
98/220	**80**	98.0 x 0.8	0.9	233	4.0	8.43	19.3	270
127/220	**100**	127.0 x 0.9	0.9	233	4.0	14.30	19.8	270
147/220	**125**	147.0 x 1.0	0.9	233	4.0	17.30	20.3	270
200/310	**150**	197.5 x 1.2	1.3	313	6.0	33.50	33.2	230

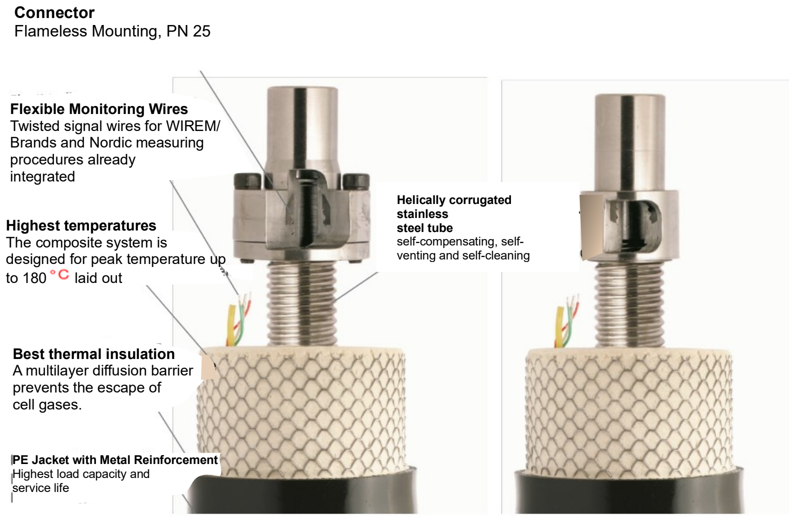
* according to maximum possible drum occupancy and normal production length

Flexible spiral corrugated CrNi steel medium pipe with and without stabilizing expanded metal grid



1. Stainless steel medium pipe
2. Pure foam (temp. load 160 C sliding)
3. Expanded metal grid
4. Barrier foil
5. PE-LD jacket 6. Monitoring wires

<u>**Assortment list see manufacturer**</u>



17.3 Specifications for civil engineering

Technical regulations, standards, execution instructions. When carrying out civil engineering work for FLEXIBLE steel casing pipes and flexible corrugated steel pipes, at least the following standards, regulations and guidelines must be observed:

DIN 1072	Road and path bridges, load assumptions
DIN 4033	Drainage channels and pipes made of prefabricated pipes, guidelines for execution
DIN 4124	Construction pits and trenches, embankments, working space widths, shoring
DIN 18300	VOB, Part C, General technical regulations; earthworks
DIN 18303	VOB, Part C, General technical regulations; excavation lining work
DIN 18304	VOB, Part C, General technical regulations; Pile driving work
DIN 18305	VOB, Part C, General technical regulations; dewatering work
DIN 18307	VOB, Part C, General technical regulations; underground gas and water pipeline work
DIN 18308	VOB, Part C, General technical regulations; drainage work
DIN 18320	VOB, Part C, General technical regulations; landscaping work
DIN 18330	VOB, Part C, General technical regulations; masonry work
DIN 18337	VOB, Part C, General technical regulations; Waterproofing against non-pressing water
DIN 18354	VOB, Part C, General technical specifications; asphalt pavement work

Leaflet "Securing of line trenches and excavation pits[1]

Leaflet on filling in pipe trenches[2]

Accident prevention regulations

The trench widths "B" given in the table are recommended values. However, they do not release the civil engineer from his duty of care with regard to the accident prevention regulations, the above-mentioned standards and regulations.

Design information

The minimum distances from external supply lines specified in the worksheet must be observed. See worksheets for civil engineering details for through connections and T-pieces.

1) Building trade association

2) Road Research Association, Subsoil Working Group, Maastrichter Str. 45, 50672 Cologne, Germany

17.4 Trench dimensions

Fig. 1: Trench layout

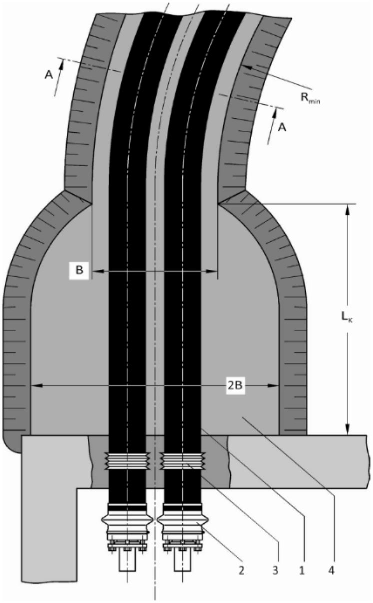
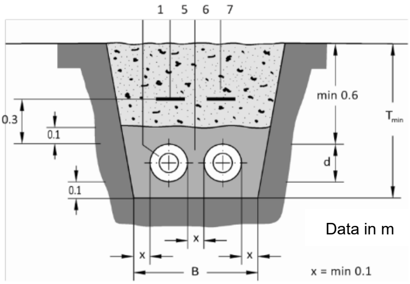


Fig. 2: Trench Cross SectionSection A-A



Structure

1. flexible corrugated steel pipe
2. connection
3. sealing bush (wall bushing)
4. working space in front of buildings and manholes
5. route warning tape
6. sand filling
7. backfill material (reused excavated material)

The backfill material in the pipeline zone must comply with EN13941-2 and meet the following minimum requirements:

-friable round-edged sand-gravel mixture
-permissible grain size: 0...8mm
-maximum 10 mass percent ≤ 0.075 mm
-maximum 3 mass percent ≤0.02 mm
-non-uniformity number according to DIN EN ISO 14688-2 greater than 1.8
-proctor density min. 94%; optimum 97...98 %

Trench and working space dimensions, excavation and sand filling quantity.

Example Pipe Type			30/91	39/116	60/148	75/171 98/171	98/220 127/220 147/220	200/310
Outer diameter tube	d	mm	94	121	156	178	233	313
Trench depth T min	*at* SLW 60[1]	m	0.80	0.85	0.85	0.90	0.95	1.05
Minimum overlap height	*at* SLW 60	m	0.60	0.60	0.60	0.60	0.60	0.60
Trench width B		m	0.50	0.55	0.60	0.65	0.75	0.95
Working space width 2B		m	1.00	1.10	1.20	1.30	1.50	2.00
Working space length L_k		m	0.50	0.50	1.00	1.00	1.50	2.50
Trench minimum radii[2] $R_{min.}$		m	1.00	1.20	1.50	2.00	4.00	6.00
Trench excavation[3]	*at* SLW 60	m³/m	0.40	0.47	0.51	0.59	0.72	1.00
Sand filling		m³/m	0.14	0.16	0.18	0.20	0.24	0.39

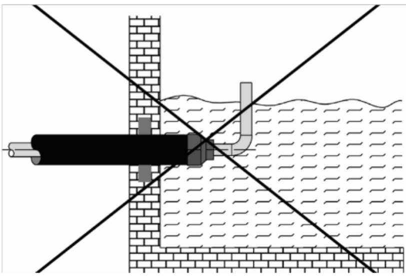
The trench widths „B“ are recommended values. Please observe generally applicable technical rules, guidelines and accident prevention regulations.

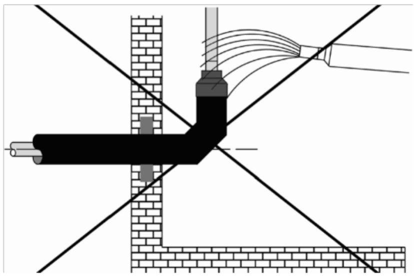
1) SLW 60 = 100kN wheel load according to DIN 1072
2) Smaller radii only after consultation with pipe manufacturer
3) Excavation quantities without consideration of slope inclination

Shaft structures and building entry

Planning and project engineering of shaft structures

Shaft constructions in local and district heating networks usually require a high effort for construction and maintenance. They must be ventilated, made watertight, and any day water that may have penetrated must be removed as soon as possible so that the shaft installations and the thermal insulation of the incoming pipelines (small and large-diameter pipes and flexible district heating lines) are not damaged.



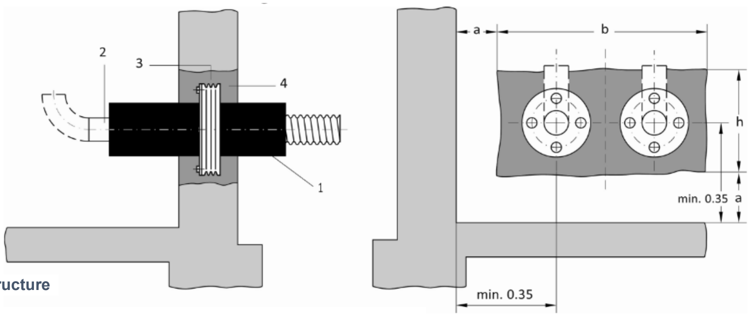


The pipe entries are to be provided with seals, depending on local conditions; in the case of non-pressing day water, the FLEX pipe wall bushing is usually sufficient; in the case of pressing ground water, an adjustable packing seal is usually necessary. The end terminations of the pipe ends are only designed as splash water protection. In principle, a design that is watertight during the day is also possible, but here, too, prolonged flooding, especially below operating temperature, must be avoided.

Because of these requirements, shaft structures are largely dispensed with today. Instead, pre-insulated tees and, if necessary, pre-insulated shut-off and drain/vent valves are used. In some cases, this avoids considerable construction and maintenance costs for manholes and increases the operational reliability of the plant.

Wall openings

Fig. 3: Wall breakthrough connection

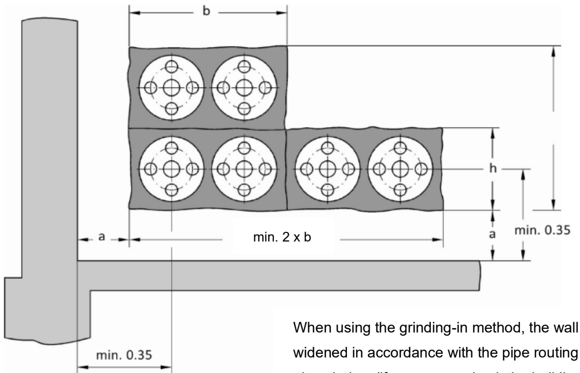


Structure

1) Flexible corrugated steel pipe
2) Connection joint
3) Wall bushing
4) Concrete (wall opening to be sealed watertight on site)

Data in m

Fig. 4: Wall penetration with single-grinding method



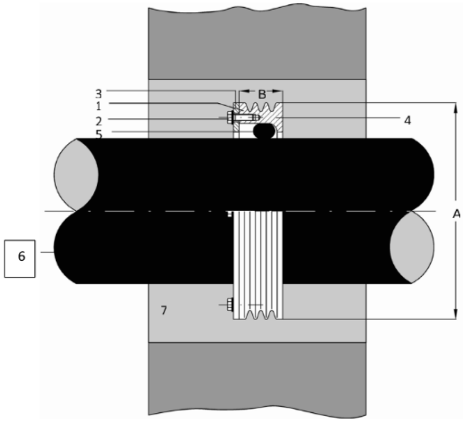
min. 2 x h

When using the grinding-in method, the wall openings must be widened in accordance with the pipe routing and the dimensions given below (if necessary, check the building statics on site).

Dimensions wall opening, wall spacing

Example pipe type	30/91	39/116	60/148	75/171 98/171	98/220 127/220 147/220	200/310
a	0.26	0.24	0.22	0.21	0.18	0.10
b	0.35	0.45	0.50	0.55	0.65	0.85
h	0.20	0.25	0.30	0.35	0.40	0.50

Wall duct



Structure

1. Fastening ring

2. hexagon head screw M6 x 20

3. washer

4. cast ring

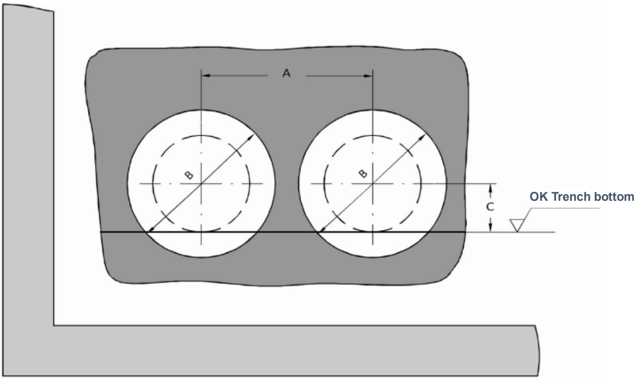
5. sealing ring

6. pipeline

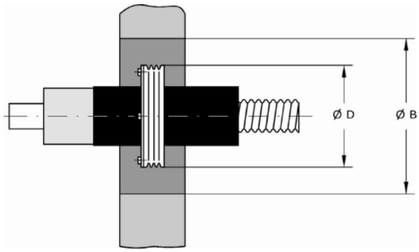
7. swelling mortar

Example pipe type	A mm	B mm	Sealing rings piece
30/ 91	160	40	1
39/116	186	40	1
60/148	221	40	1
75/171	243	40	1
98/171	243	40	1
98/220	298	40	1
127/220	298	40	1
147/220	298	40	1
200/310	378	75	2

Core drilling



Core drilling for annular space seals observe manufacturer's instructions for annular



Reference mass for core drilling

A. Center distance
B. Core hole diameter
C. Distance trench hole - pipe axis
D. Diameter of wall penetration

Core drilling dimensions*

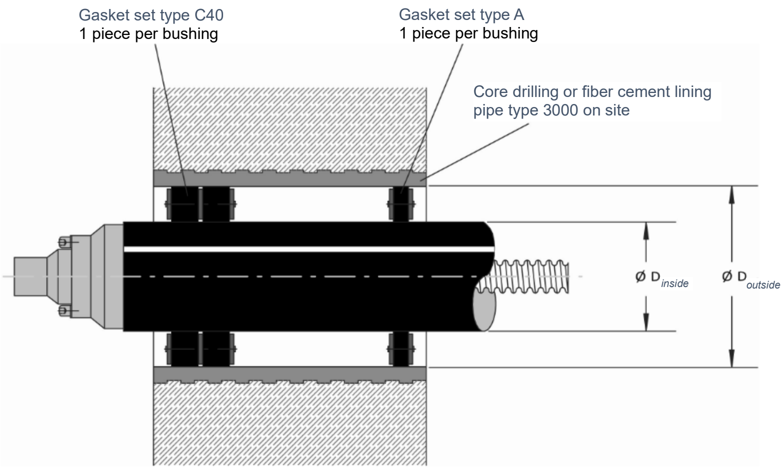
Example pipe type	A	B	C	D
30/ 91	260	250	50	160
39/116	310	300	60	185
60/148	310	300	80	221
75/171	360	350	90	243
98/171	360	350	90	243
127/220	410	400	120	298
147/220	410	400	120	298
200/310	460	450	155	378

*) only valid for standard wall bushing

Specifications in mm

Wall duct

With core boron or fiber cement lining pipe (pressure water-tight)



1 piece type C40 + 1 piece type A must be provided per pipe bushing!

Flex metal-Corrugated pipe type	DN	Ø Core drilling resp. Feed tube 3000	Gasket set Ø D inside	Ø D outside
Example		mm	mm	mm
30/ 91	**25**	150	94	150
39/116	**32**	200	121	200
60/148	**50**	250	156	250
75/171	**65**	250	178	250
98/171	**80**	250	178	250
98/220	**80**	350 / **300**	233	350 / **300**
127/220	**100**	350 / **300**	233	350 / **300**
147/220	**125**	350 / **300**	233	350 / **300**
200/310	**150**	400	313	400

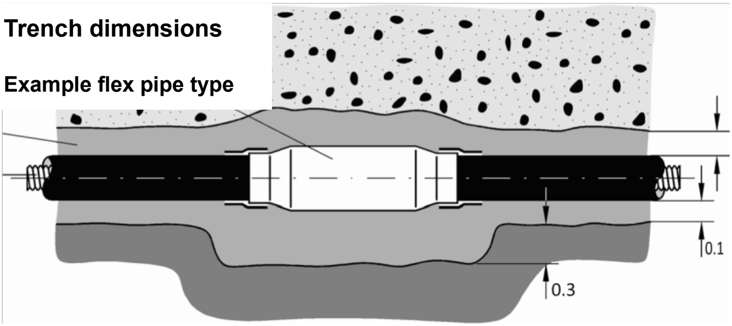
When ordering the sealing insert, the diameters "inside" and "outside" must be specified. Since hairline cracks may be present in the concrete or may be caused by machining, it is recommended that the borehole wall be sealed on site with a suitable sealant (e.g. AQUAGARD). Tightness can only be achieved if this recommendation is followed.

A prerequisite for the installation are perfect boreholes.

After installation of the sealing insert, the pipeline must not be moved axially.

Through connection

Fig. 1: Working space for the through connection (side view)



Structure

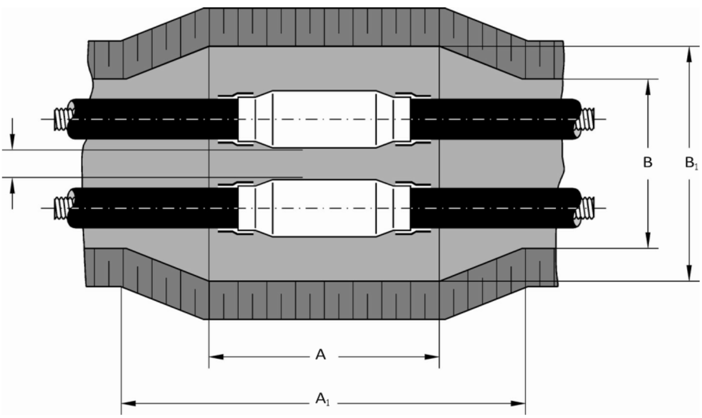
1. FLEX - corrugated metal pipe

2. Through connection

3. Sand filling (0-4 round grain)

4. Backfill material (reused excavated material)

Abb.2: Arbeitsraum für Durchgangsverbindung (Draufsicht)



Grabenmaße

Beisp. Flex-Rohr-Typ	A	A1	B	B1
30/ 91	1.5	2.5	0.5	1.5
39/116	1.5	2.5	0.55	1.55
60/148	1.5	2.5	0.6	1.6
75/171	2.0	2.5	0.65	1.65
98/171	2.0	4.0	0.65	1.65
98/220	2.0	4.0	0.75	1.75
127/220	2.0	4.0	0.75	1.75
147/220	2.0	4.0	0.75	1.75
200/310	2.0	5.0	1.00	2.00

Fig. 1: Working space for through connection (top view)

Data in mm. In case of repair, dimension A1 must be increased by 2.5 m for the deflection of the pipeline.

Flexible steel casing pipes made of stainless materials - T-pieces

T - connection, branch down

Fig. 1: T-joint, working space (top view)

Dimensions apply to all FLEX corrugated metal pipe types

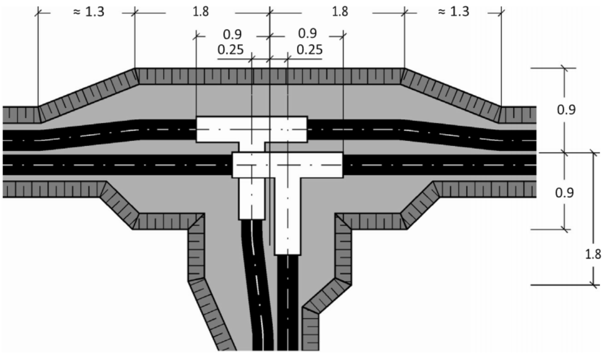
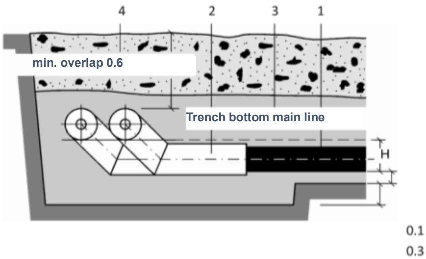


Fig. 2: T-joint, working chamber branch downwards (cross-section).



Trench dimensions, branch downwards (fig. 2)
Structure
1. corrugated FLEX metal pipe
2. T-joint
3. sand filling
The filling material in the pipe zone must comply with EN13941-2. and meet the following minimum requirements:
- friable round-edged sand-gravel mixture.
- permissible grain size: 0...8 mm
- maximum 10 mass percent ≤ 0.075 mm
- maximum 3 mass percent ≤ 0.02 mm
- Nonuniformity number according to DIN EN ISO 14688-2 greater than 1.8
- Proctor density min. 94%; optimum 97...98 %

4. backfill material (reused excavated material)

FLEX – corrugated metal pipe main line	**Branch Line**								
Example:	30/91	39/116	60/148	75/171	98/171	98/220	127/220	147/220	200/310
30/ 91	0.23								
39/116	0.23	0.25							
60/148	0.23	0.25	0.28						
75/171	0.23	0.25	0.28	0.30					
98/171	0.23	0.25	0.28	0.30	0.32				
98/220	0.23	0.25	0.28	0.30	0.32	0.34			
127/220	0.23	0.25	0.28	0.30	0.32.	0.34	0.36		
147/220	0.23	0.25	0.28	0.30	0.32	0.34	0.36	0.36	
200/310	0.19	0.21	0.24	0.26	0.28	0.30	0.32	0.32	0.36

H = Dimension of the height difference between the bottom of the trench of the main pipeline and the bottom of the trench of the branch pipeline. **Data in m**

T-connection, branch upwards

Fig. 1: T-joint, working space (top view)

Dimensions apply to all corrugated tube types

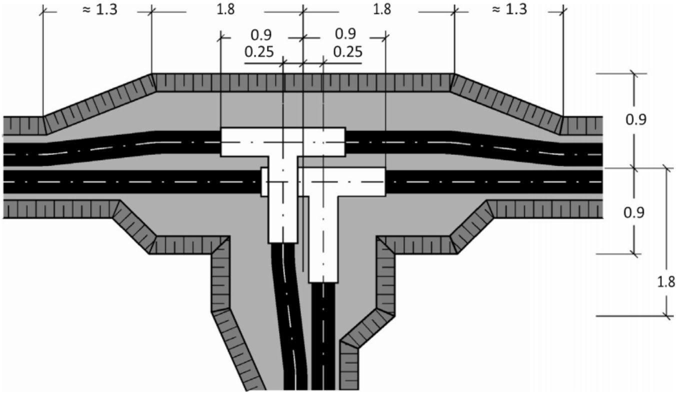
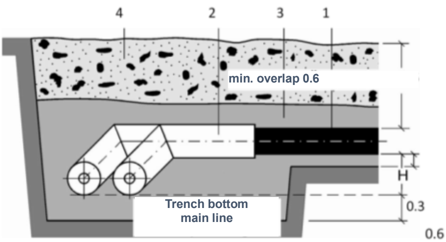


Fig. 2: T-joint, working space branch upwards (cross-section).



Trench dimensions, branch upwards (fig. 2)
Structure

1. corrugated FLEX metal pipe
2. T-joint
3. sand filling
The filling material in the pipe zone must comply with EN13941-2. and meet the following minimum requirements:
- friable round-edged sand-gravel mixture.
- permissible grain size: 0...8 mm
- maximum 10 mass percent ≤ 0.075 mm
- maximum 3 mass percent ≤ 0.02 mm
- Nonuniformity number according to DIN EN ISO 14688-2 greater than 1.8
- Proctor density min. 94%; optimum 97...98 %

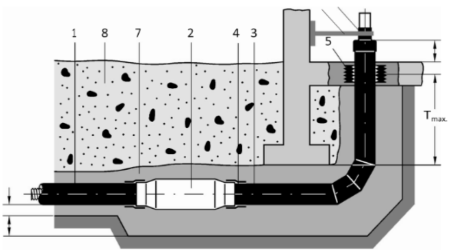
4. backfill material (reused excavated material)

FLEX – corrugated metal pipe main line	**Branch Line**								
Example:	30/91	39/116	60/148	75/171	98/171	98/220	127/220	147/220	200/310
30/ 91	0.23								
39/116	0.25	0.25							
60/148	0.28	0.28	0.28						
75/171	0.30	0.30	0.30	0.30					
98/171	0.32	0.32	0.32	0.32	0.33				
98/220	0.34	0.34	0.34	0.34	0.35	0.35			
127/220	0.36	0.36	0.36	0.34	0.38	0.38	0.36		
147/220	0.36	0.36	0.36	0.36	0.38	0.37	0.36	0.36	
200/310	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.36

H = Dimension of the height difference between the bottom of the trench of the main pipeline and the bottom of the trench of the branch pipeline. **Data in m**

House entries

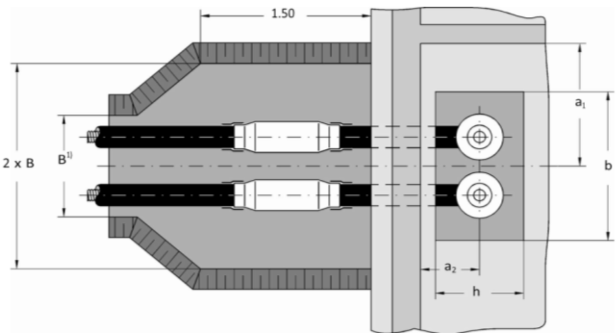
Fig. 1: House entry bend
Cross section



Structure

1. flex - corrugated metal pipe
2. HD-PE shrink sleeve
3. house entry bend, 1.5 x 1.5 m 90°
4. shrink sleeve
5. labyrinth seal
6. end cap
7. sand filling
The filling material in the pipe zone must comply with EN13941-2
and must meet the following minimum requirements
0.10 - friable round-edged sand-gravel mixture.
0.20 - permissible grain size: 0...8 mm
max. 10 mass percent ≤ 0.075 mm
max 3 mass percent ≤ 0.02 mm
Nonuniformity number according to DIN EN ISO 14688-2 greater than 1.8, Proctor density min. 94%; optim 97...98%
8. backfill material
9. pipe support

Fig. 2: House introduction sheet
Top View



FLEX – corrugated metal pipe type	**Minimum dimensions**					
	B	**a**	**a2 2)**	**b**	**h**	
Example:	**Trench-width**	**Lateral wall distance to center breakthrough**	**Wall distance to center breakthrough**	**Length of the Breakthrough**	**Width of the breakthrough**	**T max. Distance to lower edge foundation**
30/ 91	0.50	0.30	0.15	0.49	0.20	1.00
39/116	0.55	0.32	0.16	0.53	0.25	1.00
60/148	0.60	0.34	0.16	0.57	0.30	0.98
75/171	0.65	0.36	0.17	0.62	0.35	0.98
98/171	0.65	0.38	0.18	0.66	0.35	0.97
98/220	0.75	0.41	0.20	0.72	0.40	0.96
127/220	0.75	0.42	0.20	0.74	0.40	0.95
147/220	0.75	0.43	0.21	0.77	0.40	0.93
200/310	0.95	0.53	0.26	0.95	0.50	0.92

1) Measured on trench bottom. Data in m

2) Dimension a2 determined under the assumption that there is no obstruction of the arch fittings by foundations, etc.

17.5 Distance to other supply lines

Immediately in the area of buried district heating pipelines, the ground temperature is higher than normal.

The transmission performance of buried electrical lines can be affected as a result. Appropriate minimum distances between the supply and district heating lines are therefore required. (see also VDE 0100 and VDE 0101).

Fig. 1: Crossing lines

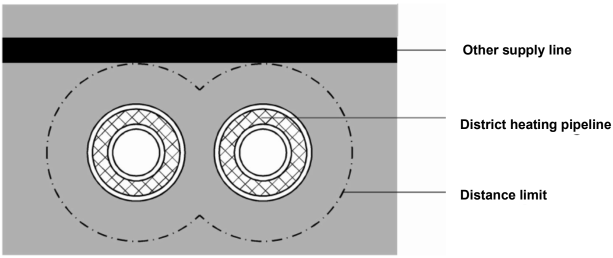
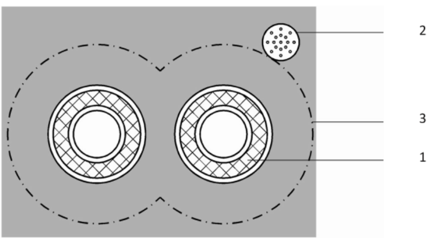


Fig. 2: Parallel lines



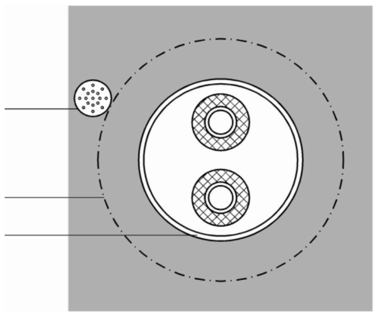


Table 1:
Minimum distance to crossing lines

Type of supply line	Minimum distance
1 kV, signal, measuring cable	0.3
10-kV or one 30-kV cable	0.6
several 30 kV cables or cables over 60 kV	1.0
Gas and water pipelines	0.2

Data in m

Table 2:
Minimum distance to parallel lines

Type of supply line	Minimum distance	
Parallel line Length	5 m	>5 m
1 kV, signal, measuring cable	0.3	0.3
10-kV or one 30-kV cable	0.6	0.7
several 30 kV cables or cables over 60 kV	1.0	1.5
Gas and water pipelines	0.4	0.4

Data in m

17.6 Laying through protective tubes

When laying flexible steel casing pipes through protective pipes, the following instructions must be observed.

1. One protective pipe is always required per pipe to ensure proper guidance during pulling-in. The protection tube must not have any bends. In addition, the protective pipes must not have any offsets at the joints which could severely impede or make it impossible to pull in the pipe or cause damage to the PE outer protective jacket.

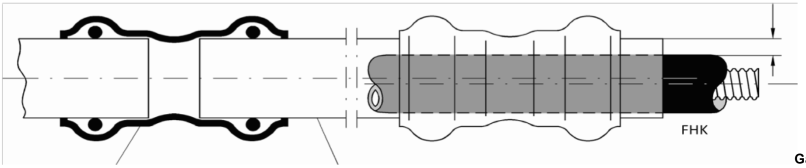
2. In the case of press-throughs, it is not always possible to insert protective pipes next to each other into the ground; instead, a large protective pipe is then pressed in. In this case it is necessary to contact us beforehand to agree on a constructive solution.

3. There must be enough working space at ground level in front of and behind the protective pipe so that the tractor with the cable trolley can maneuver without difficulty and pull the pipe into the protective pipe without bending it from the route axis.

4. Bends in the route directly in front of and behind the protective pipes must be avoided. If this cannot be ensured, the route must be discussed with the manufacturer in advance.

5. The pipes are pulled in without skids in the case of PVC, PE or fiber cement pipes, and with skids in the case of steel and concrete pipes. The inner diameter of the protective pipes should be at least 20 mm larger than the outer diameter of the flexible steel casing pipe or the skids.

Fig. 1: Laying pipe through straight, misalignment-free protective pipes without skids.
Max. Protection tube length > 50 m[1)]

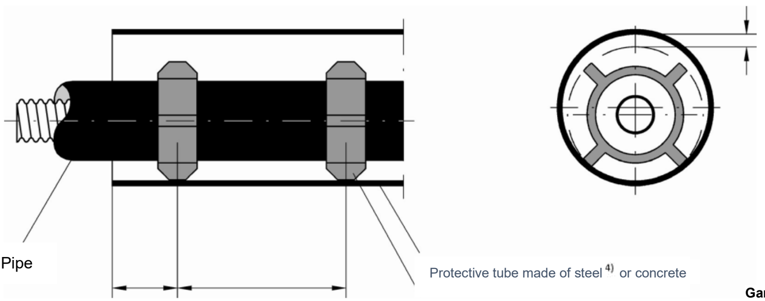


Game min. 40 mm

Socket for PVC sewer pipe
PE - sewer pipe
AZ - sewer pipe

PVC-/PE-/AZ sewer pipe

Fig. 2: Laying pipe through straight, misalignment-free protective pipes with skids.
Max. Protection tube length ≥ 50 m[1)]



Game min. 40 mm

max. 1.0 m from the end

Skid distance L

Plastic skid

Table for pipe laying

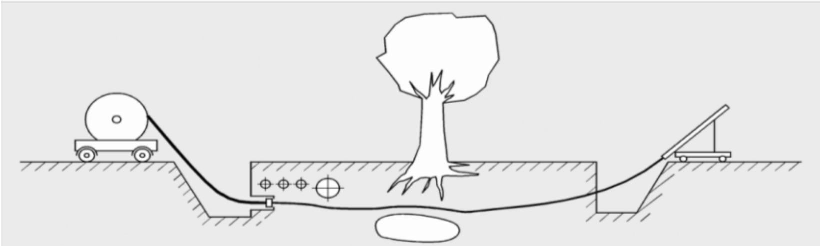
FLEX - corrugated metal pipe - type		30/91	39/116	60/148	75/171 98/171	98/220 127/220 147/220	200/310
Jacket pipe- Ø max.	mm	95	121	156	178	233	313
Skid distance L	m	2.00	2.00	2.50	3.00	3.00	4.00
		without skids					
PVC sewer pipe according to DIN 19 534[2)]	mm	125 x 3	160 x 3.6	200 x 4.5	250 x 6.1	315 x 7.7	400 x 9.8
Match wipe Fw-pipe & PVC pipe	mm	24	32	35	60	67	67
AZ sewer pipe according to DIN 19 850[2)]	mm	141 x 8	168 x 9	220 x 10	274 x 12	328 x 14	436 x 18
Pipe Interior - Ø	mm	125	150	200	250	300	400
Clearance between Fw-pipe and AZ-pipe	mm	30	29	44	72	67	87
		with skids					
Steel pipe according to DIN 2458 [3) 4)]	mm	168.3 x 4	219.1 x 4.5	219.1 x 4.5	273 x 5	323.9 x 5.6	406.4 x 6.3
Pipe Interior - Ø	mm	160	210	210	263	313	394
Skid (Frankenplastik company)		3 S19	4 S19	4 T19	2 F + 1 G25	3 F + 1 G25	4 F + 1 G25
Clearance between Fw-pipe and pipe	mm	27	51	20	35	30	31

1) After consultation with manufacturer

2) Min. cover height for SLW 60 = 0.80 m, for SLW 30 or under a road surface =0.60 m

3) Joints without root seam

Horizontal directional drilling method - Trenchless installation



No additional protective pipe required

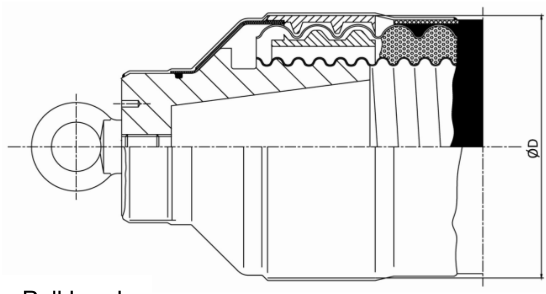
The horizontal flush drilling method was developed to lay supply lines without trenching. The horizontal flush drilling method is used wherever valuable surfaces (parks, landscape conservation areas, pedestrian zones, paved paths, front gardens, etc.) need to be protected or where difficult crossings (bodies of water, canals, roads with heavy traffic, railroad lines, dams, structures, etc.) have to be constructed.

Brief description of the process

The drilling tool consists of individually bolted hollow drill rods and a drill head equipped with nozzles. A water-bentonite mixture atomized under high pressure and in small quantities cuts and loosens the existing soil, stabilizes and lubricates the borehole. The special design of the drill head enables a targeted change of direction and precise control of the borehole.

At the end of the pilot hole, the drill head is exchanged for an expander head fitted with nozzles, and the flexible steel casing to be pulled in is coupled. Simultaneously with the retraction of the drill pipe, the pipe is pulled into the borehole expanded and supported by the water-bentonite suspension. System advantages: -no pipe trenches, earthworks only for installation pits -low damage to surfaces -no consequential damage, e.g. due to settling of the ground or the road surface -low obstructions or hazards to stationary and flowing traffic -consideration of tree and plant protection - largely independent of weather conditions - high working speed.

Trenchless laying

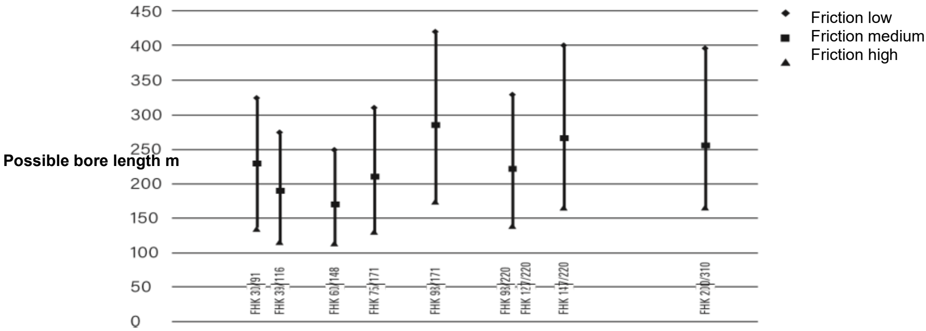


Pull head

Tube Type	Dmax mm	FZ kN	Recommended min. Borehole radius	Recommended Drill hole diameter	Normal Bore length
			m	mm	m
30/ 91	100	12	10	150	230
39/116	125	15	15	185	190
60/148	160	20	20	240	170
75/171	180	30	20	270	210
98/171	180	40	20	270	285
98/220	230	50	25	345	220
127/220	230	50	25	345	220
147/220	230	60	25	345	265
200/310	320	100	35	480	230*

FZ = permissible tensile force for flush drilling method

*= maximum delivery length without connection



The "Normal bore length" is a guide value for soil and installation conditions that do not present any particular difficulties.

The "Maximum bore length" can be achieved under particularly suitable soil and installation conditions (e.g. low friction values, large bore radii, etc.).

The "Minimum bore length" is a guide value for less favorable soil and installation conditions (e.g. high friction values, small bore radii, etc.).

In any case, the maximum permissible tensile force of the pipe must be observed.

It is recommended to have the local conditions determined in good time by a subsoil survey. For longer bore lengths or difficult subsoil conditions, an HDD expert should be consulted for evaluation.

Authors of the chapter

Jürgen Schütze, BRUGG Rohrsysteme Gmbh

Mario Meißner, LOGSTOR GmbH

Jakob Sørensen, isoplus Fernwärmetechnik Vertriebsgesellschaft mbH

Source reference: Brugg Rohrsysteme GmbH, System descriptions and functional descriptions for spiral corrugated flexible stainless steel pipes.

18. Preinsulated flexible steel pipes - Steel flex pipes

18.1 Applications

Preinsulated steel flex pipes are used in the district heating sector mainly for branch lines. Preinsulated steel flex pipes offer a number of advantages that allow considerable savings. The pipes are supplied in rolls of 50, 100 and 200 m and in fixed lengths, which means few joints, short installation times and thus low installation costs.

The pipes can be laid side by side and on top of each other. This requires a narrow pipe trench, which minimizes civil engineering costs.

Thanks to the rapid laying, installation and ongoing backfilling of the pipe trench, the normal condition is restored in a short time. In this way, obstructions for residents and road users are kept to a minimum..

Medium pipe			Changeover
Outside in mm	Wall thickness in mm	Outside in mm	Wall thickness in mm
20	2,0	75	
20	2,0	90	2,5
25	2,0	75	
25	2,0	90	
28	2,0	75	
28	2,0	90	2,5
28	2,0	110	
20/20	2,0	75	
20/20	2,0	90	
20/20	2,0	110	
25/25	2,0	90	
25/25	2,0	110	
25/25	2,0	125	
28/28	2,0	90	
28/28	2,0	110	
28/28	2,0	125	

18.2 Technical and mechanical properties

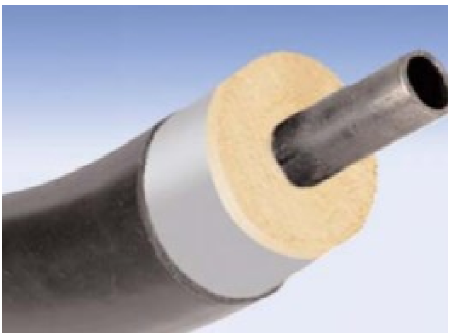
Medium tube	Welded steel pipes P195 GH+N, E195 or E155, + N, S2 according to EN 10305-3
Insulation:	Polyurethane foam (PUR) Blowing agent cyclopentane
Sheathing:	Polyethylene, PE-LD with internal Aluminum diffusion barrier
Pipe network monitoring:	nordic; Brandes
Continuous operating temperature:	120°C
Maximum temperature 100h/year:	130°C

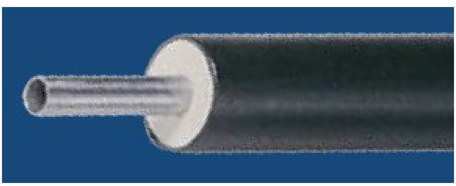
Mechanical properties:

Density		7850 kg/m^3
Tensile strength	>	290 N/mm^2
Yield stress	>	215 N/mm^2
E-modulus		2,1 – 10^5 N/mm^2

Thermal properties:

Coefficient of expansion	1,2 – 10-^{5} K^{-1}
Specific heat	0,48 kJ/kg K
Thermal conductivity	76 W/m K





18.3 Transport and handling

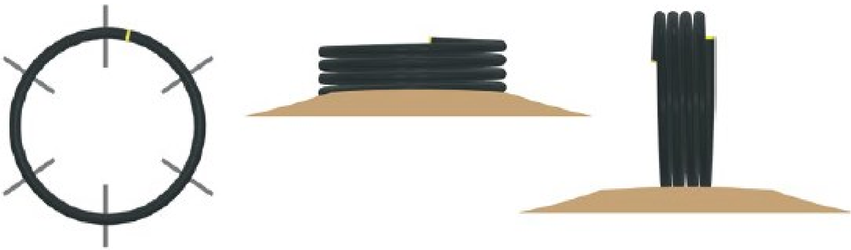
Storage

The tubes must be stored safely from damage.

Steel flex tubes can be stored either upright or lying down.

Tubes should be stored on a stone-free surface or on a flex tube trailer.

To prevent tube ends from being damaged, protective caps should not be removed prior to installation.



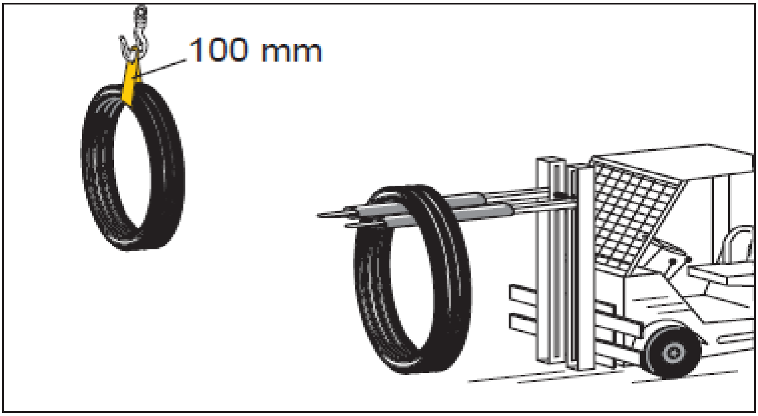
Handling

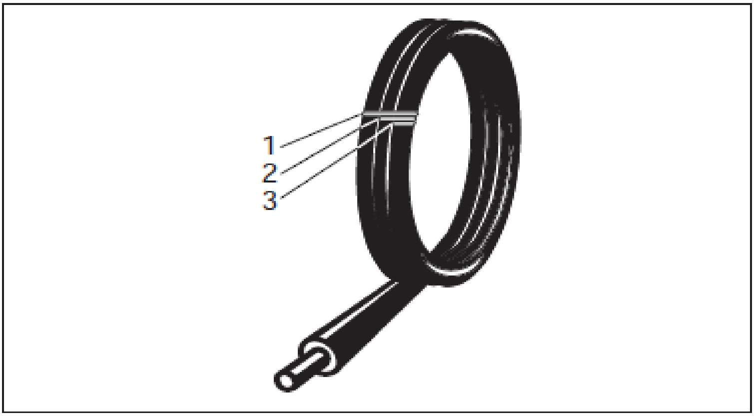
Only use belts with a width of min. 100 mm.

When handling with a forklift, protect the forks with a jacket tube, rubber cushion or similar.

Please do not cut all fixing straps at once.

Place the roll at the beginning of the line. Cut the first belt. Unroll the pipe roll to the next belt and cut it and so on.



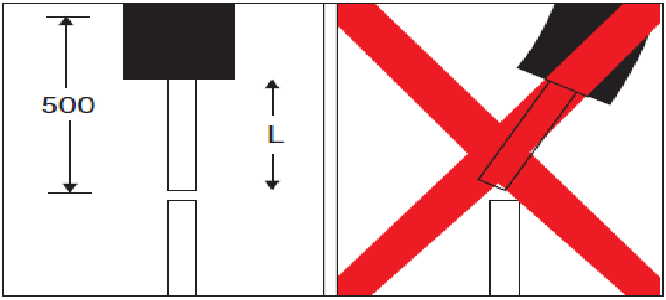


Alignment

Align the steel flex pipe end so that at least 500 mm of the pipe end is straight and parallel with the opposite pipe end.

This alignment is important and a prerequisite for proper installation of the sleeve.

When cutting, please observe the recoil effect of the free pipe ends.



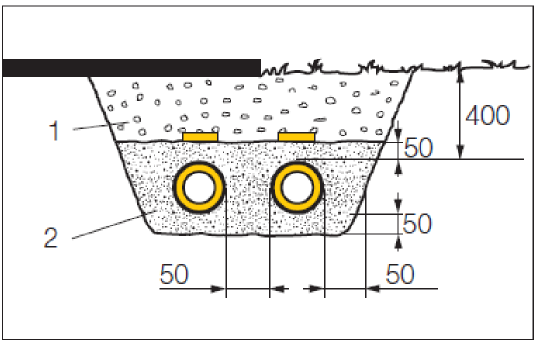
18.4 Pipe trench and friction material

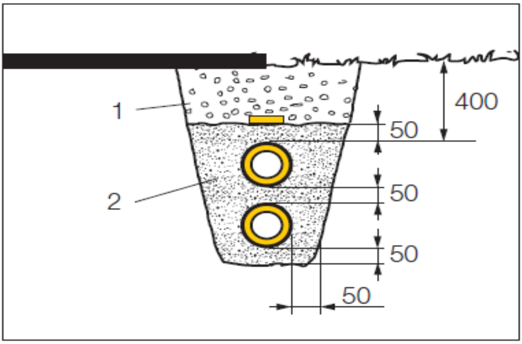
Pipe trench

Preinsulated steel flex pipes are installed in the pipe trench or by using HDD drilling methods.

Execute the pipe trench according to the following figures to ensure a cover of at least 400mm.

A minimum of 100mm compacted encasement with sand shall be provided. The distance between the casing shall be at least 100mm. The remaining backfill can be made with the existing excavation. Prior to this, a route warning tape is to be placed over each pipeline.





Friction material

When laid in a pipe trench, the steel braided pipes must be surrounded everywhere by at least 50mm of compacted friction material.

Max. Grain size: ⩽ 32 mm

Max. 10 weight percent: ⩽ 0.075 mm or

Max. 3 percent by weight: ⩽ 0.020 mm.

Coefficient of regularity, d60/d10 ⩾ 1.8

Degree of purity: the material must not contain harmful amounts of plant residues, humus, clay or silt lumps

Avoid large sharp-edged grains that can damage pipe and joints. Careful and uniform compaction is.

Water quality

To avoid internal corrosion, use only treated water. Water treatment depends on local conditions, but should meet the following minimum requirements:

pH 9.5 - 10 without free oxygen Total hardness < 3000 mg/l

18.5 Project planning guidelines

When the carrier pipe expands in a preinsulated steel flex pipe, stresses form in the steel pipe.

On straight sections, steel flex pipe can be laid cold without being overloaded, regardless of its length. It may be necessary to reduce stresses at the branch point and axial movements when entering buildings.

The stresses can be reduced by absorbing the expansion at bends and elbows, which are realized during the installation of the steel flex pipe.

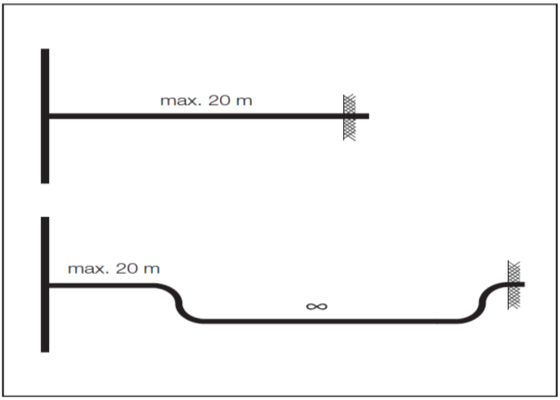
When branching with steel flex pipe from steel main lines, it must be ensured that movements in the main line are not transferred to the branch line.

Branches with steel braided pipe can be welded directly to the main pipe if he calculated axial movement of the main pipe is less than 10mm, and the length of the branch is less than Lmax:

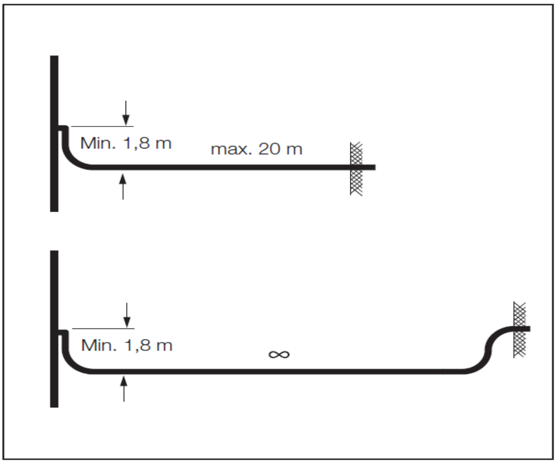
Cover Height, H				0,4 m		0,7 m		1,0 m	
d	s	A	D	F	L_{max}	F	L_{max}	F	L_{max}
mm	mm	mm^2	mm	N/m	m	N/m	m	N/m	m
20,0	2,0	113	77	703	24	965	18	1357	13
25,0	2,0	145	77	703	31	965	22	1357	16
28,0	2,0	163	77	703	35	965	25	1357	18
20,0	2,0	113	90	832	20	1137	15	1596	11
25,0	2,0	145	90	832	26	1137	19	1596	14
28,0	2,0	163	90	832	29	1137	22	1596	15

Please contact the pipe manufacturer regarding the creation of an expansion concept.

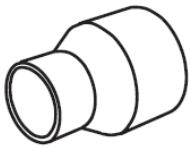
When branching with steel flex pipes perpendicular to the main line, the distance to a bend or house connection must not exceed 20m.



For parallel branching, the parallel steel flex pipe length must be at least 1.8m (2xRmin).



If the movement of the main pipe is greater than 10mm, a steel branch piece (26.9 x 2.6mm or 33.7 x 2.6mm) must be welded in between the main pipe and the steel flex pipe. An overhang piece is welded in between the branch pipe and the steel flex pipe.



<table>
<tr><th rowspan="2">Pipe end 1
Normal
Steel pipe</th><th colspan="2">Pipe end 2
Steelflex</th></tr>
<tr><th>20</th><th>28</th></tr>
<tr><td>26,9</td><td>x</td><td></td></tr>
<tr><td>33,7</td><td>x</td><td>x</td></tr>
</table>

In general, the movement in the branch must be secured according to the design rules for plastic casin g pipes single and twin with expansion pads.

Bends - Bending

Preinsulated steel flex pipes can be bent on site at temperatures of at least 5°C to the minimum bending radius R min - see table. For the exact bending radius, contact the pipe manufacturer..

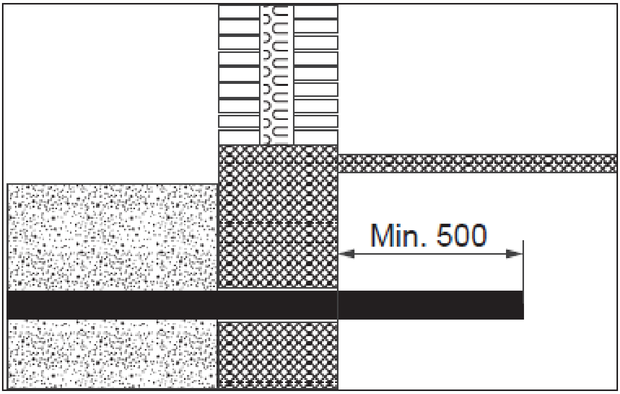
<table>
<tr><th rowspan="2">Jacket Pipe

D
mm</th><th colspan="3">Single Pipe</th><th colspan="3">TwinPipe</th></tr>
<tr><th>Smooth Coat
Flex
R_{min}
mm</th><th colspan="2">Wavy Coat
Flextra
R_{min}
mm</th><th>Smooth Coat
Flex
R_{min}
mm</th><th colspan="2">Wavy Coat
Flextra
R_{min}
mm</th></tr>
<tr><th></th><th>5°C und 23°C</th><th>5°C</th><th>23°C</th><th>5°C und 23°C</th><th>5°C</th><th>23°C</th></tr>
<tr><td>90</td><td rowspan="5">10 x D</td><td rowspan="4">8 x D</td><td rowspan="4">6 x D</td><td rowspan="4">10 x D</td><td rowspan="6">10 x D</td><td rowspan="2">7 x D</td></tr>
<tr><td>110</td></tr>
<tr><td>125</td><td>7 x D*</td></tr>
<tr><td>140</td><td rowspan="3">10 x D</td></tr>
<tr><td>160</td><td rowspan="2">10 x D</td><td>8 x D</td><td rowspan="2">-</td></tr>
<tr><td>180</td><td>-</td><td>10 x D</td></tr>
</table>

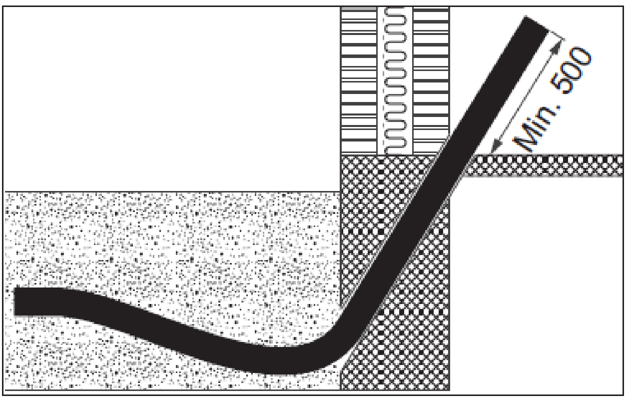
Medium Pipe Ø 32 mm and large: 9 x D

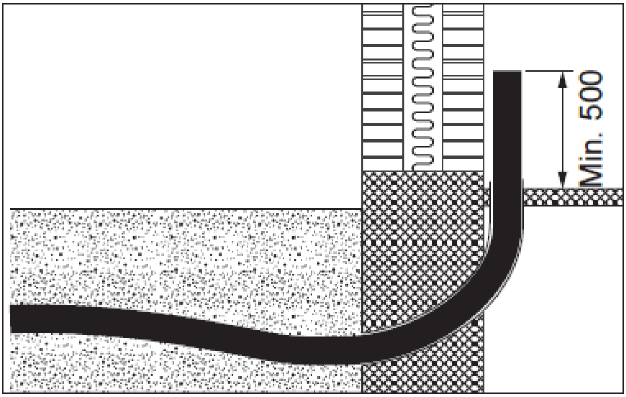
House entries

In the case of house connections, the pipe must be passed through the foundation wall and closed off at least 500mm from the inside. This ensures a sufficient length for the processing of the pipe end.



For new buildings, a lead-in pipe can be concreted in so that the steel flex pipe can be inserted later without affecting the building.





Authors of the chapter

Jürgen Schütze, BRUGG pipe systems

Mario Meißner, LOGSTOR GmbH

Jakob Sørensen, isoplus Fernwärmetechnik Vertriebsgesellschaft mbH

19 Preinsulated flexible PEX pipes

Applications

Preinsulated PEX pipes are used in district heating as main lines and branch lines.

The properties of PEX service pipe mean that expansion does not have to be taken into account, as the system is fixed by friction against the surrounding soil, and the expansion is absorbed into the flexible service pipes.

As a result of flexibility, low weight, and long lengths, the installation work becomes fast and economical.

Preinsulated PEX pipes are available as single and double pipes. The pipes are delivered in rolls. The lengths depend on the dimension of the sheathing - see the following table.

The pipes can be laid side by side and on top of each other. This requires a narrow pipe trench, which minimizes civil engineering costs.

Thanks to the fast laying, mounting and continuous backfilling of the pipe trench, the normal condition is restored in a short time. In this way, obstructions for residents and road users are kept to a minimum.

Single pipe

Medium pipe		Conversion
Outside in mm	Wall thickness in mm	Outside in mm
20	2,0	90
25	2,3	90
32	2,9	90
40	3,7	90
40	3,7	110
50	4,6	110
50	4,6	125
63	5,8	125
63	5,8	140
75	6,8	140
75	6,8	160
90	8,2	160
90	8,2	180
110	10,0	180
110	10,0	200
125	11,4	180
125	11,4	200
140	12,7	200

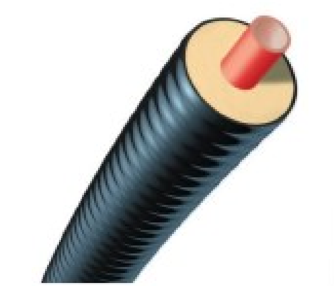
Double tube

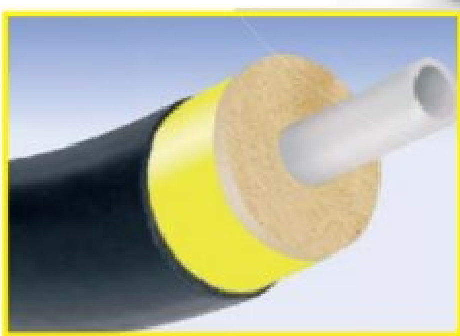
Medium pipe		Conversion
Outside in mm	Wall thickness in mm	Outside in mm
20/20	2,0	110
25/25	2,3	110
25/25	2,3	125
32/32	2,9	110
32/32	2,9	125
40/40	3,7	125
40/40	3,7	140
50/50	4,6	160
50/50	4,6	180
63/63	5,8	180
63/63	5,8	200
75/75	6,8	200

PEX pipes are also available in 10 bar pipes, single and double pipes. In dimensions from Ø 25mm to Ø 110 mm and up to 75/75 in double pipes.

19.1 Technical and mechanical properties

Carrier pipe:	PEXa with EVOH oxygen diffusion barrier according to EN ISO 15875
Insulation:	Polyurethane foam (PUR) with best thermal insulation properties
Jacket:	Corrugated/smooth polyethylene,PE-HD/PE-LDwith co-extruded diffusion barrier
Pipe network monitoring:	Without
Continuous operating temperature:	85°C
Maximum temperature 100h/year:	95°C
Operating pressure:	6 bar





19.2 Transport and handling

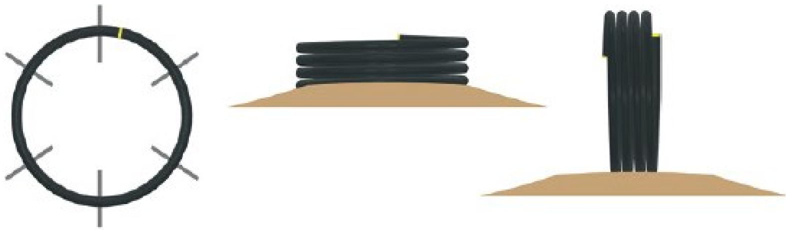
Storage

The tubes must be stored safely from damage.

Flex tubes can be stored either upright or lying down.

Tubes should be stored on a stone-free surface or on a flex tube trailer.

To prevent the pipe ends from being damaged, the protective caps should not be removed before installation.



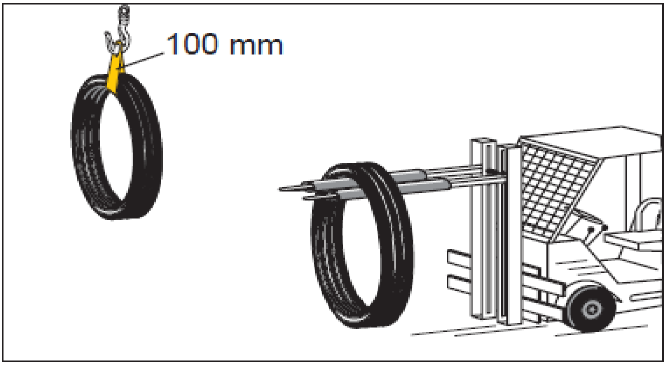
Handling

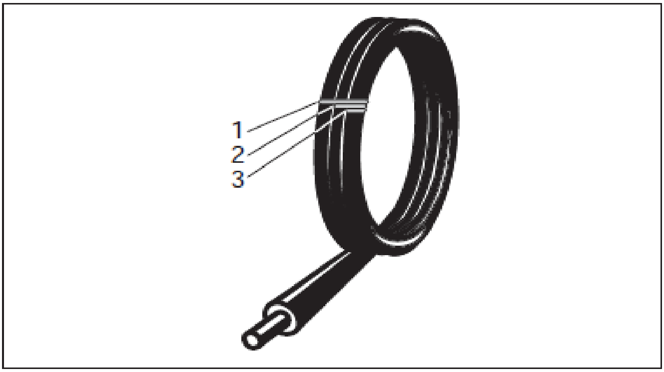
Only use belts with a width of min. 100 mm.

When handling with a forklift, protect the forks with a jacket tube, rubber cushion or similar.

Please do not cut all fixing straps at once.

Place the roll at the beginning of the line. Cut the first belt. Unroll the pipe roll to the next belt and cut it and so on.





19.3 Pipe trench and friction material

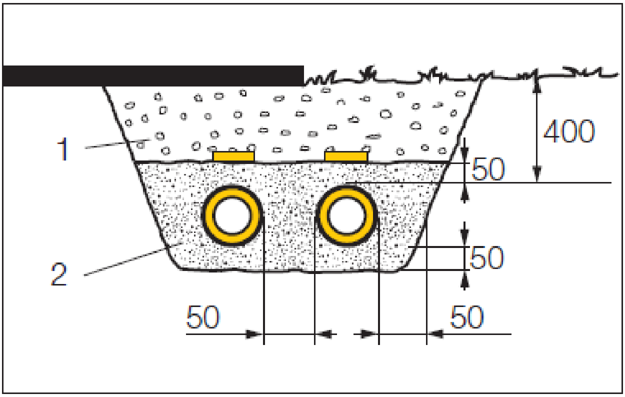
Pipe trench

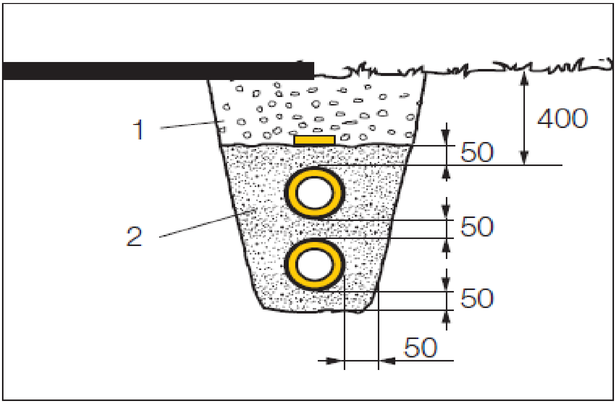
Preinsulated PEX pipes are installed in pipe trenches or by using HDD drilling methods.

When laid in trenches, the pipes must be surrounded by at least 50 mm of compacted friction material.

The pipe trench shall be covered with at least 400 mm of backfill material, measured from the top of the pipe to the bottom of the asphalt/concrete or unpaved terrain.

The distance between the casing should be at least 100mm. The remaining backfill can be made with the existing excavation. Prior to this, a route warning tape is to be placed over each pipeline.





Friction material

When installed in a pipe trench, the preinsulated PEX pipes must be surrounded everywhere by at least 50mm of compacted friction material.

Max. Grain size:	≤ 32 mm
Max. 10 Weight percent :	≤ 0,075 mm or
max. 3 Weight percent:	≤ 0,020 mm
Regularity coefficient, d60/d10	≥ 1,8
Degree of purity:	The material must not contain harmful amounts of plant residues, humus, clay or silt lumps

Large sharp-edged grains that can damage pipe and joints should be avoided. Careful and uniform compaction is required.

19.4 Project planning guidelines

Stretch

Preinsulated PEX pipe is a flexible pipe system that does not require special measures in buried systems.

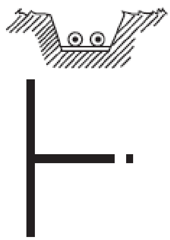
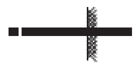
It is self-compensating, and due to the properties of the PEX medium pipe, it is not necessary to consider the expansion in buried systems.

When connecting preinsulated PEX pipes to a preinsulated steel pipe, it must be ensured that excessive movements are not transferred from the steel pipe to the preinsulated PEX pipe system.

This is ensured by the fact that the transition from the steel to the preinsulated PEX pipes takes place at a branch or after a bend. In case of a transition directly connecting to a steel pipeline, the length of the steel pipeline must not exceed 14 m.

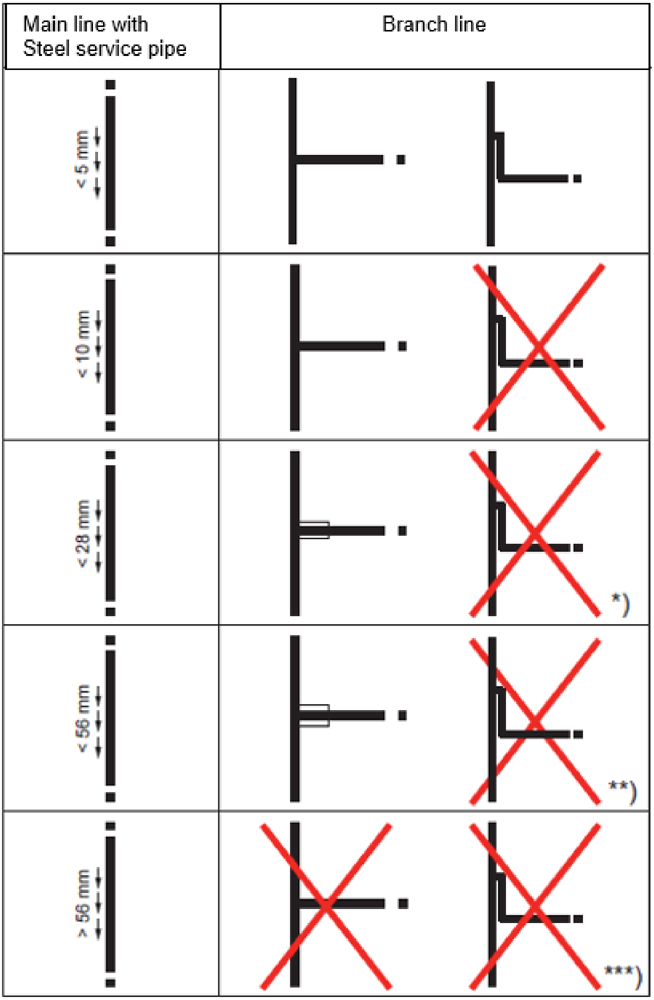
When branching with preinsulated PEX pipes from a steel pipeline, it must be ensured that movements in the main pipeline are not transferred to the branch pipeline. For more details on this, see the following figure.

Branch line lengths and introduction in buildings

Branch point	Branch Line	*Building Introduction*	
		Movement not allowed	*Movement allowed*
			

Please contact the pipe manufacturer for your project.

The main line



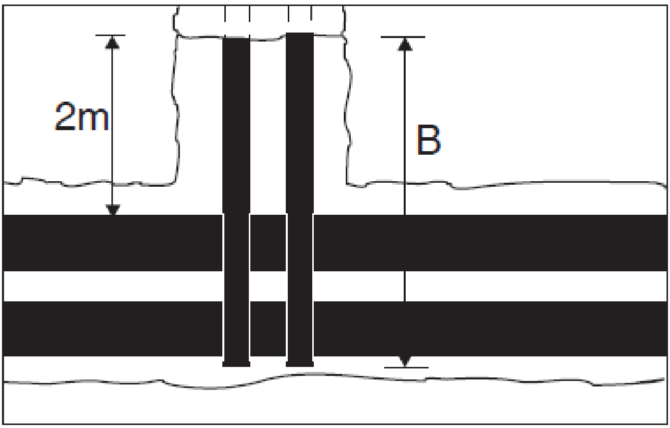
19.5 Connection to main line

Faultless installation of service pipe connections and installation fittings is best achieved when the Preinsulated PEX Pipes are straightened before installation begins.

Pipe ends are best aligned before cutting the desired length from the pipe reel.

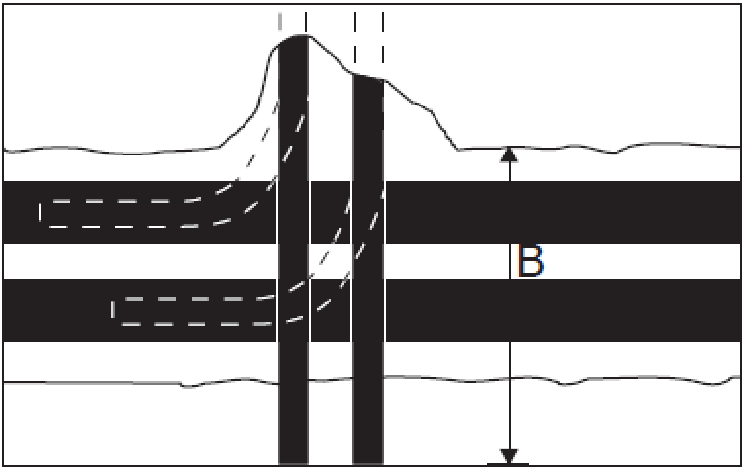
When connecting to a main pipe at an angle, at least 2 m of the pipe trench must be left open in consideration of the subsequent installation of the compression joints..

B = Minimum length of an aligned pipe end = 2 m + minimum width of the pipe trench.



Parallel connection to a main line. Due to the space available, preinsulated PEX pipes installed using the drilling method must always be connected to the main pipe in parallel.

B = Minimum length of an aligned pipe end = 2 m + minimum width of the pipe trench.



Bending

Bending radius

For changes in direction, the Preinsulated PEX Pipe can be bent on site to the minimum bending radius R using a bending tool.

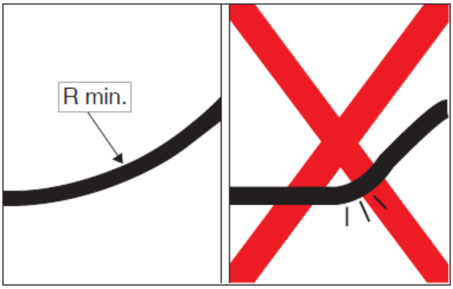
The flexibility of the Preinsulated PEX Pipe depends on the temperature of the pipe.

At temperatures below 5°C, the casing pipe should be heated to hand-hot with a gas burner before unrolling or bending.

Bend preinsulated PEX pipes in a soft curve.

The minimum bending radius depends on the dimension. Contact pipe manufacturer for exact bend radius.

Do not bend the pipes over a sharp edge.

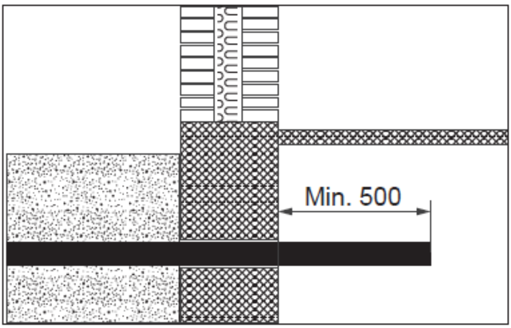


For the exact bending radius, contact the pipe manufacturer.

19.6 House connections

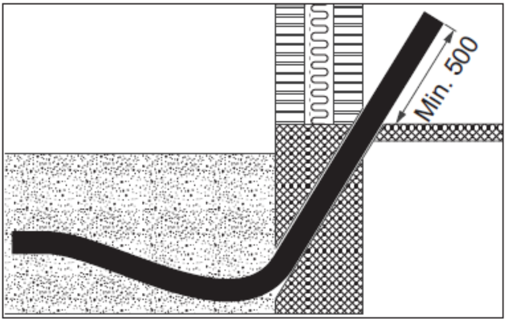
In the case of a house connection by means of a cast termination pipe or by straight or oblique perforation of the foundation wall, the termination of the Preinsulated PEX Pipe in the foundation wall is to be carried out in the same work step as the laying and sanding.

Thus, the drilling of the foundation wall takes place simultaneously with or before the laying of the pipes.



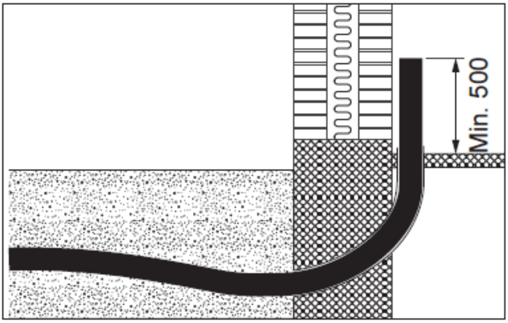
Oblique drilled introduction

A min. 500 mm long pipe end must be provided for all installations in the building


Min. 500

Cast end pipe

A min. 500 mm long pipe end must be provided for installation in the building.



For wall penetrations above ground in connection with a cabinet, a 2 m long open pipe trench must be available in front of the building wall for the subsequent pipe penetration.

NB! A pre-insulated PEX pipe of appropriate length must be provided for the later wall penetration and internal installation.

L min = 2 m + H + B + 0.5 m

Processing

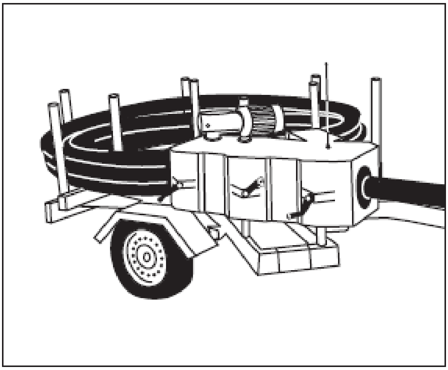
Shorten

Preinsulated PEX pipe is supplied in rolls.

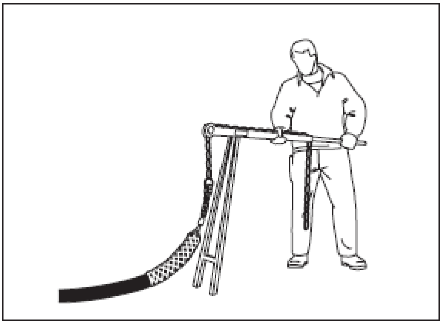
Cut the desired length with a suitable saw in an angular cut.

To simplify measuring, the outer casing of the Preinsulated PEX Pipe is marked with a continuous meter.

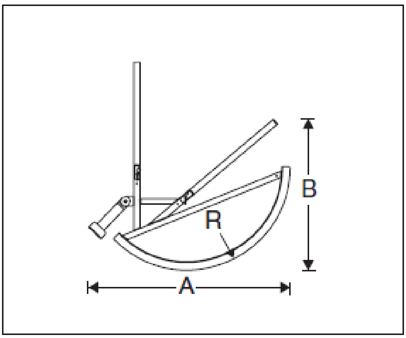
Assembly tools



Transport and unroll



Pulling tool



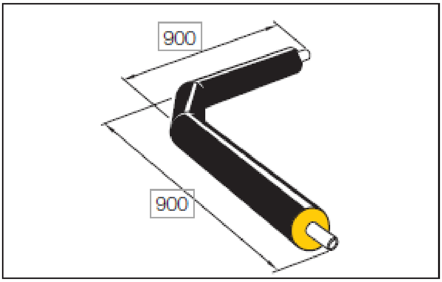
Bending tool

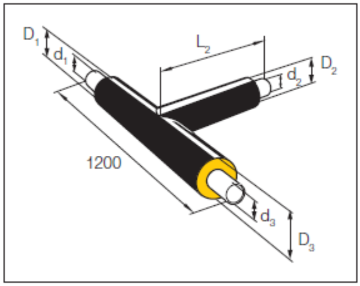
Molded parts

Preinsulated PEX pipes can use preinsulated fittings with PEX service pipe.

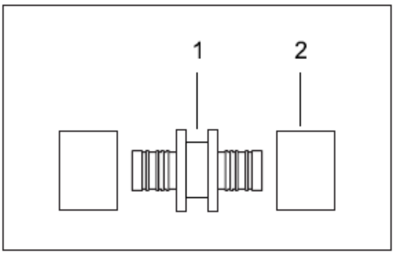
Bends; couplings; tees with PEX service pipe are made with press couplings embedded in the insulation.

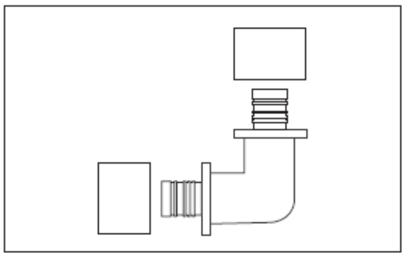
Press couplings with weld ends are purchased separately and welded on site.

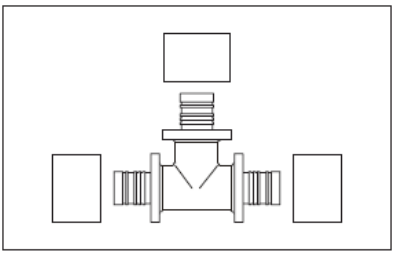


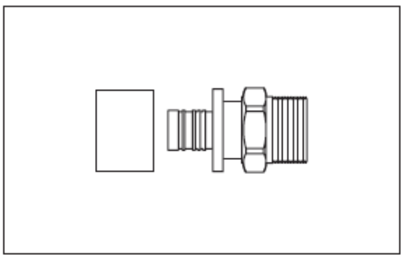


For current leg lengths, contact the current manufacturer.









Authors of the chapter

Jürgen Schütze, BRUGG pipe systems Gmbh

Mario Meißner, LOGSTOR GmbH

Jakob Sørensen, isoplus Fernwärmetechnik Vertriebsgesellschaft mbH

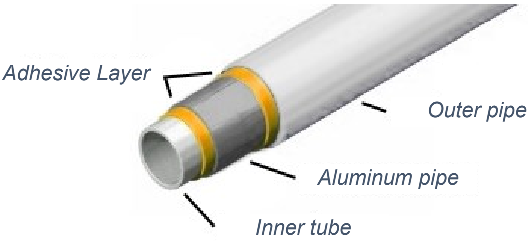
20 Aluminum and PEX (Alupex)

The pre-insulated flexible Alupex is a metal-plastic composite pipe system. The pipe consists of a Pex inner layer - aluminum layer - PE outer layer and a PE-LLD casing pipe.

A flexible layer of polyurethane foam connects them to form a solid sandwich structure.

The flexible insulation and PE-LLD casing pipe provide the flexibility while the multi-layer pipe remains dimensionally stable during installation. The pipe is therefore easily adjustable during branch line installation, making installation quick and efficient.

The carrier pipe is protected against oxygen and water diffusion. The integrated aluminum diffusion barrier between the casing pipe and polyurethane foam ensures optimal insulation and low heat loss, throughout the life of the system.



The structure of the metal-plastic composite pipe system "Alu Pex".
Alu Pex is also called MSR pipes = multilayer composite pipes.

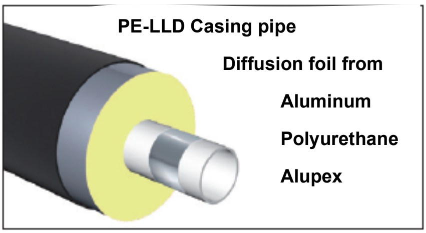
The pre-insulated Alupex pipes are manufactured with different types of sheaths. A smooth sheath as well as different types of sheaths with corrugations.

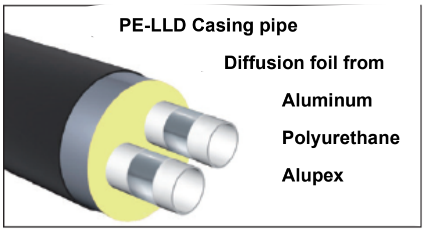
Due to its availability in small dimensions, it is ideal for house connections and withstands higher temperatures than that standard pex pipe without the built-in aluminum layer.

Alupex - Properties and Advantages

- Alupex is designed for a pressure of 10 bar and a continuous operating temperature of 95°C.
- The diffusion foil made of aluminum ensures optimal insulation and low heat loss during the entire life of the system.
- The carrier pipe is protected against oxygen and water vapor diffusion.
- The flexible insulation and PE-LLD casing pipe provide maximum flexibility, and the multilayer pipe is dimensionally stable.
- Fast and effective installation and easy adjustment of the pipe when laying house connections.

The construction of pre-insulated Alupex pipes





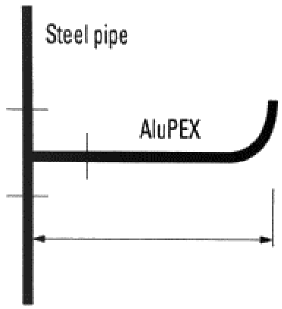
Alupex
Max. Working pressure: 10 bar
Diameter: 16 mm to 32 mm
Max. Continuous operating temperature: 95°C
Max operating temperature: 110°C

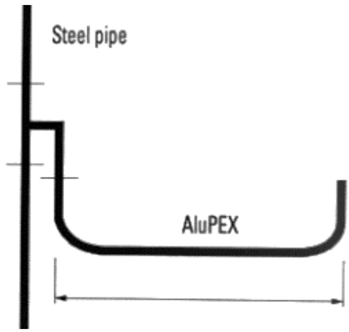
Installation instructions

When connecting Alupex to an existing network, precautions must be taken. It is recommended that you contact the manufacturer of the pre-insulated Alupex flexible pipe to ensure that proper installation instructions are followed.

Examples of connections to the existing steel network:

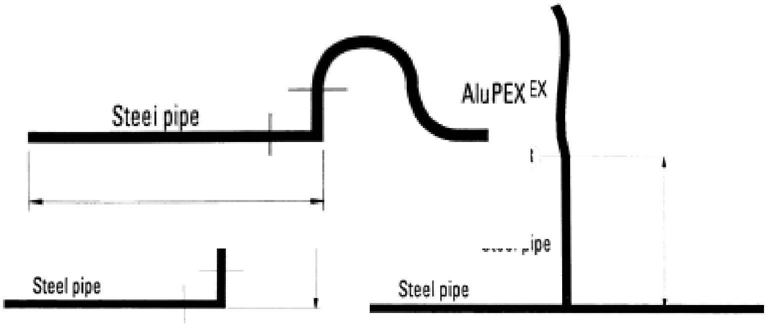
Connection to branch





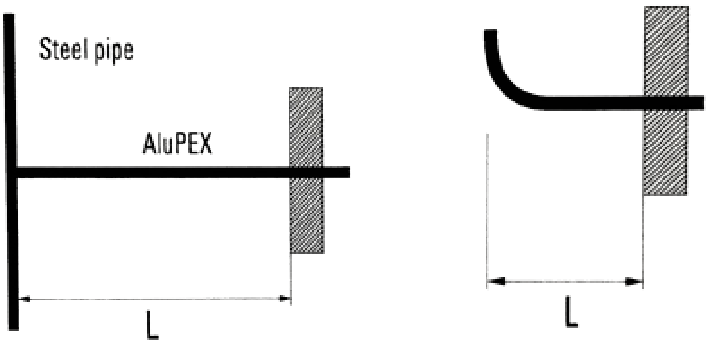
Where Alupex is connected to traditional steel pipes, as above with the prefabricated straight branches (Fig. 1), or parallel branches (Fig. 2). The installer should contact the respective pipe manufacturer for information on the allowable length of Alupex pipe.

Connection to steel pipes



When Alupex are connected in extension of traditional steel pipe systems as above with a steel pipe that is fixed (Fig. 3), with a steel pipe that is not fixed (Fig. 4), or when Alupex are connected with a longer steel pipe (Fig. 5). The installer should contact the respective pipe manufacturer to be informed about the permissible length of the steel pipes to which the Alupex are connected.

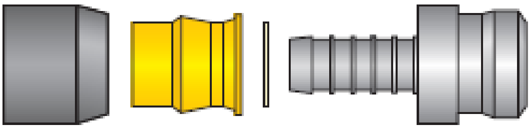
Service lines



Connection technology

Alupex pipes can be connected in various ways. In district heating, however, press couplings consisting of three parts are often used. A press ring is pressed axially over the Pex pipe, which is mounted on the support sleeve on the coupling body, and a crimp sleeve is pressed between the press ring and the Alupex pipe.

Example of a press-weld connection for Alupex



Press connections with a steel end to be connected by welding to the existing (KMR) Pre-insulated Pipe district heating system, are often used in connection with house connections and inside the house a press connection with external thread is preferred.

Otherwise the press connections are available in the standard types.

All types of press connections are approved to be used only with press tools approved by the manufacturer / supplier.

Jacket connection

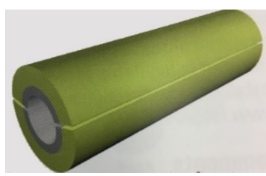
The various manufacturers of pre-insulated Alupex offer a wide range of sheathing solutions. It is always recommended to contact the relevant manufacturer to find the best jacket connection solution for the selected Alupex pipes and to ensure that the correct installation procedures are followed.

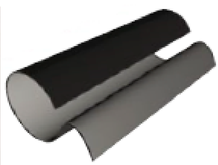
Types of joints

- PEHD + PEX joints, both of which are sealed (bitumen) with the use of mastic.
- PEHD joints sealed by electrofusion welding

.

All three of the above solutions for jacket connections have in common that they are either insulated with a liquid 2-component PUR foam solution (from canister or 2-component foam bag). Or insulating half-shells (PUR) with a soft core are used, which are sealed together with a heat-shrinkable film with mastic.





- Sandwich branches and bends made of fiberglass, sealed with adhesive tape (PIB-based mastic).
- Half shells with clip system and sealed with sealing rings.

All the above solutions for sheath joints have in common that they are insulated with either a liquid 2-component PUR foam solution (from canister or 2-component foam bag).

In case of more detailed questions about the exact data of the available pre-insulated Alupex pipes, precautions during installation, or general handling, it is always recommended to contact the manufacturer concerned.

Authors of the chapter

Jürgen Schütze, BRUGG Pipe Systems Ltd.
Mario Meißner, LOGSTOR GmbH
Jakob Sørensen, isoplus Fernwärmetechnik Vertriebsgesellschaft mbH

21 Member Companies of the BFW

3S Antriebe GmbH

Schichauweg 52

12307 Berlin, DE

www.3s-antriebe.de

4 pipes GmbH

Sigmundstrasse 182

90431 Nürnberg, DE

www.4pipes.de

BASF Polyurethanes GmbH

Elastogranstr. 60

49448 Lemfoerde, DE

www.polyurethanes.basf.eu

Böhmer GmbH

Gedulderweg 95

45549 Sprockhövel, DE

www.boehmer.de

Brugg Rohrsystem AG

Industriestrasse 3

5314 Kleindöttingen, CH

www.bruggpipes.com

BRUGG Rohrsysteme GmbH

Adolf Oesterheld-Str. 31

31515 Wunstorf

www.bruggpipes.com

BRUGG German Pipe GmbH
Darweg 43
99734 Nordhausen

www.bruggpipes.com

BROEN A/S
Skovvej 30
5610 Assens, DK

www.broen.com

Covalence / Seal For Live
Industries BVBA
Nijverheidsstraat 13
2260 Westerlo, B

www.sealforlife.com

HPW Industrievertretungs-company ltd.
Siemensstraße 27 a
67454 Haßloch/Pfalz*, DE*

www.hpw-fernwaerme.de

IFW Ing.-Gesellschaft für Wärmetechnik mbH
Karl Liebknecht Str. 19
06682 Teuchern/OT Deuben, DE

www.ifwdeuben.de

Isobrugg Stahlmantelrohr GmbH
Zum Hämeler Wald 21
31275 Lehrte-Arpke, DE

www.isobrugg.de

Isoplus Fernwärmetechnik GmbH

Schachtstraße 28

99706 Sondershausen, DE

www.isoplus.de

isoplus Fernwärmetechnik Vertriebsgesellschaft mbH

Aisinger Straße 12

83026 Rosenheim, DE

www.isoplus.de

KLINGER Fluid Control GmbH

Auf der Lind 10 A1

65529 Waldems-Esch, DE

www.klinger-kfc.de

(KMR) Pre-insulated Pipe Service GmbH

Gewerbepark 3

17039 Trollenhagen, DE

www.KMR Pre-insulated Pipe - fernwaerme.de

Lancier Monitoring GmbH

Gustav-Stresemann-Weg 11

48155 Münster, DE

www.lancier-monitoring.de

LOGSTOR Deutschland GmbH

Große Elbstr. 145C

22767 Hamburg, DE

www.logstor.com/de

PSI Products GmbH
Ulrichstrasse 25
72116 Mössingen, DE

www.psi-products.de

RAV Armaturen GmbH
Am Walzwerk 5
45525 Hattingen, DE

www.rav-valve.com

STURM Isotech GmbH & Co. KG
Benzstraße 21b
38446 Wolfsburg, DE

www.sturm-isotech.de

22 List of sources

22.1 Standards and regulations

Standards and regulations in force at the time of going to press

1] AGFW - The Energy Efficiency Association for Heating, Cooling and CHP e.V.

- AGFW - Adjustment frame FW 401

Certification of pipeline construction companies

- AGFW - Worksheet FW 601

Certification of pipeline construction companies

- AGFW - Worksheet FW 603

Joint installation on plastic casing pipes (KMR) Pre-insulated Pipe and flexible pipe systems, testing of joint installers

- AGFW - Worksheet FW 605

Certification of socket installation companies

[2] Laws and regulations

- BGV A 1, BGV A 3, BGV C, BGV D - accident prevention regulations
- BG RCI - Employer's Liability Insurance Association for Raw Materials and the Chemical Industry

[3] DIN standards

- DIN 18195 - Waterproofing of buildings
- DIN 18196 - Earthworks and foundation engineering - Soil classification for construction purposes
- DIN 18300 – Earthworks

- DIN 30672 - Organic coatings for corrosion protection of pipelines laid in soil and water for continuous operating temperatures up to 50 °C without cathodic corrosion protection tapes and shrinking materials DIN 4124 - Excavations and trenches - Embankments, shoring, working widths **[4]** DVS Guidelines
  - DVS - Guideline 2207-1 Welding of thermoplastics - Heating element welding of PE-HD pipes, pipeline parts and sheets
  - DVS - Guideline 2207-5 Welding of thermoplastics - Welding of PE casing pipes - Pipes and pipeline parts
  - DVS - Guideline 2212-4 Testing of plastics welders - Welding of PE outer casing pipes - pipes and pipeline parts

[5] European standards

- DIN EN 253 - District heating pipes - Factory insulated bonded pipe systems for directly buried district heating networks - Bonded pipe system
- DIN EN 448 - District heating pipes - Factory insulated bonded pipe systems for directly buried district heating networks - Composite fittings
- DIN EN 489 - District heating pipes - Factory insulated bonded pipe systems for directly buried district heating networks - Pipe joints
- DIN EN 12068 Cathodic protection - Organic coatings for corrosion protection of steel pipelines laid in soil and water in combination with cathodic protection - Tapes and shrinkable materials
- DIN EN 13941 Design and installation of factory-insulated composite casing pipes for district heating

6] VdS 2869 - Handling of liquid gas cylinders

7] TRGS 430 - Technical rules for hazardous substances

BFW

Bundesverband Fernwärmeleitungen e.V.

The practical assembly manual

For the installation of pre-insulated district heating pipes

Plan - Check - View

Bundesverband Fernwärmeleitungen e.V.
Kraftwerk Mitte 5-7
01067 Dresden
Germany

www.bfwev.de
E-Mail: Anfrage@bfwev.de