GSTT

rbv

Information

Nº. 20-1

Rehabilitation of pressurised pipelines

April 2020

Trenchless pipeline maintenance

Working group:
Rehabilitation of pressurised pipelines

NO DIG –why open up trenches when there's a better solution!

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Note: The titles of regulations and guidelines produced by the DVGW and other professional bodies are sometimes given in English for the reader’s guidance, although these are in fact German texts. However, the titles of DIN, DIN EN and DIN EN ISO norms cited in the Bibliography (§8) are always given in English, since these texts are available in English.

1 Preface

Large parts of our supply and disposal networks are many decades old and more. Because of both the standard of technology at the time of construction and the changing demands made on these pipes and networks during their service life, they have deteriorated or come to the end of the operating life for which they were designed.

The technical information presented here is intended to provide planners, builders, contractors and network operators with a guide to choosing between the various methods of restoring functionality to sections of pipework pressurised at between <0 and >16 bar.
Vacuum mains are principally used in vacuum sewerage systems as per DIN EN 1091 or DWA-A 116-1.

This guide is concerned only with techniques for the trenchless rehabilitation of existing networks along the same pipe route. Open trench construction or no-dig methods for laying pipes on a new route are not the subject of this technical information guide.

2 Causes and patterns of damage

2.1 Causes of damage

The type of damage will vary according to the network, its function and the material it is made from, with the following factors, singly or in combination, usually accounting for the overwhelming proportion of instances of damage.

- General ageing
- Leaking pipe joints
- Corrosive chemical attack on the pipe from the matter being transported or from the surrounding soil
- Mechanical load on the pipe resulting from operating conditions (internal pressure, pressure surges) as well as external stress (from soil load, traffic load)

Inappropriate choice of pipe, manufacturing defects, damage in transit as well as faults in installing pipework (unsuitable bedding material, sharp objects in the trench, insufficient covering) increase the stress and can be the actual cause of damage.

The age of the pipe and the changes in operational and environmental conditions over its working life are a further basic cause of damage occurring.

Depending on the pipe material and the loads involved, the causes of damage lead to different forms of deterioration. Below, the various patterns of damage related to the different types of pipe are described,

2.2 Types of damage

2.2.1 Cast iron and steel pipes

For cast iron and steel pipes there is a detailed set of regulations giving information on the historical development of pipes, fittings, jointing techniques and anti-corrosion protection, and evaluating them. This technical information is given in DVGW GW 19-1 (M) and GW 19-2 (M) as well as DVGW GW 22 (I)
For planning and executing rehabilitation, it is essential to make an expert survey of the existing pipe with reference to the type and causes of damage. The DVGW technical information leaflet provide the relevant basis for such a survey. Table 1 gives a summary of the developments in pipeline design.

Table 1: Summary of cast iron and steel pipeline design /DVGW GW19-1/

Base material: cast iron	Base material: steel
Grey cast iron (used in the old federal German Länder up until about 1965, in the new federal Länder up until about 1989)	Steel up until about 1950
Ductile cast iron (used in Germany since about 1964)	
Composite ductile cast iron pipes (used in the old federal German Länder from about 1980, in the new federal Länder from about 1990).	Composite steel pipes from about 1950 (from about 1980 in the new federal Länder).

When assessing grey iron pipes, one must look out for spongiosis, a material-specific corrosion phenomenon. Spongiosis in grey cast iron pipes is described in DIN EN 12502-5 and is also termed graphitisation on account of the selective dissolution of the material’s iron content. With this type of corrosion, the component’s original shape is largely maintained, and the surface may take on the appearance of graphite. The strength of the graphitised areas is severely reduced so that potential weak points develop, leading to a general increase in the risk of breakdown.

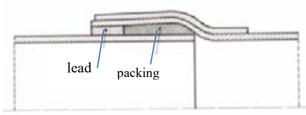
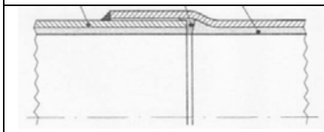
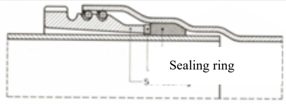
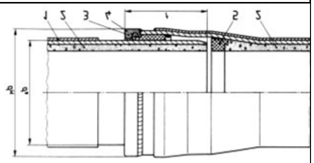
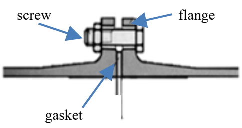
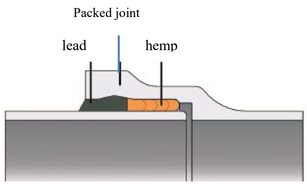
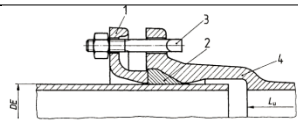
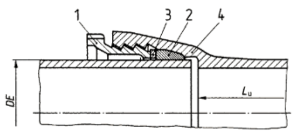
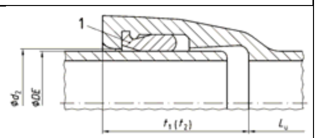
With steel and cast-iron pipes, where there is no, or inadequate, corrosion protection, there are basically two different corrosion phenomena to consider. On the one hand there is a fairly even surface corrosion that generally leads to an insignificant thinning of the pipe wall, and on the other hand uneven surface corrosion in the form of hollows and pitting that can lead to corrosion damage and a burst pipe. In the case of old designs of pipe with no, or inadequate, corrosion protection, an appropriate allowance had to be made for corrosion when designing the thickness of the pipe-wall.

Composite pipes have been used for decades now. Corrosive processes are only possible where there are external forces, as long the synthetic materials that are commonly used in thick film coatings, or cement mortar coating, do not lose their barrier properties.

External corrosive attack may be intensified by the effects of stray currents. These may occur where there is longitudinal electrical conductivity in welded steel pipes, but also in cast iron pipes with conductive axially force-locking socket connections (see Table 2, Cat.3). Consequently, special attention must be paid to connection techniques as well as to the effectiveness of corrosion protection.

For this reason, the historical development of connection technology is tabulated in the DVGW regulations in particular from the perspective of longitudinal electrical conductivity. The DVGW regulations differentiate between three categories of conductivity (Table 2).

Table 2: Examples of the classifications of typical socket connections /GW 19-2/

Property	Category 1	Category 2	Category 3
Electrical longitudinal conductivity at connections	Not interrupted, metallically conductive	neutral, not clearly conductive	Interrupted, not metallically conductive
Steel pipes	-		-
	-	Sockets up to 1930	-
			
	Welded socket	Screw-in socket joint	Push-in socket joint
Cast iron pipes			-
	Flanged socket (DIN EN 1092-2)	Packed socket joint up to 1930	-
	-		-
	-	Gland socket joint (DIN 28602)	-
	Screwed socket joints with contact elements inside socket		-
		Screwed socket joint (DIN 28601)	-
	Screwed socket joints with cable bridge	Examples in DVGW GW 368 supplementary sheet (withdrawn)	
		Force-locking push-in joints 1)	Push-in joint (DIN 28603)

1) Only for ductile cast iron pipes

When considering whether to rehabilitate or to replace, in the case of longitudinally conductive steel pipes where there are adequate static qualities, the decisive factor is the assessment of passive corrosion protection. If the quality of the sheathing permits the use of cathodic corrosion protection, the pipe can even continue to operate without rehabilitation, bearing in mind the indications given in DVGW GW 18(M). Coats of paint and the initial bitumen-based coatings with less rot-resistant carrier material are often no longer suitable for such supplementary measures. The DVGW information leaflet gives an overview of the historical development of coating materials (Table 3).

Table 3: Historical survey of sheathing materials for cast iron and steel pipes /GW19-1/

Coating materials for cast iron pipes	Coating materials for steel pipes
Corrosion protection systems without zinc coating usually made of bituminous compounds, or no corrosion protection (in the old federal Länder up to about 1974, in the new federal Länder up to about 1990)	No, or inadequate, corrosion protection (coats of paint) in use up until about 1940 (in the new federal Länder up until about 1980)
Corrosion protection systems with zinc coating that were installed in the period between 1974 and 1980	Corrosion protection systems with bituminous compounds on a jute or wool felt support up until about 1960 (in the new federal Länder until about 1980)
Corrosion protection systems that have been used along with thin coatings since about 1980, or multi-layer coatings or coatings applied on site (e.g. PE sheeting) (in the new federal Länder since 1990)	Corrosion protection systems with a bitumen/glass mat sheathing from about 1960 Compound pipe technology in the old federal Länder from about 1950.
	Polyolefin sheathing or multi-layered systems that have been in use since 1980 Compound pipe technology (in the new federal Länder since about 1990)

Internal corrosion in cast iron and steel pipes must be considered not only from the perspective of pipe statics where there is loss of wall thickness, but also with an eye to hygiene, in the case of water pipes, and perhaps even to operational issues. Incrustation has an impact on a pipe's hydrodynamics that should not be underestimated. For the first time, both corrosion and incrustation could be prevented in drinking water and wastewater pipes thanks to cement mortar coatings. One may refer to the tables in the DVGW's technical sheet for classification of existing pipes (Table 4).

Table 4: Types of coating for cast iron and steel pipes /GW19-1/

Cast iron pipe coatings	Steel pipe coatings
No, or insufficient, coating	Until about 1940 No, or insufficient, coating
Until about 1980 Coatings of bitumen or bituminous compounds	Until about1950 Coatings of bituminous compounds
From about1950 (occasionally from 1950; from 1970, normal as factory-applied coating) Cement mortar coatings	From about1950 (occasionally from 1950; from 1980, normal as factory applied coating) Cement mortar coatings

2.2.2 PVC / PE pipes

PVC pipes

Manufacture of PVC pipes began in the mid-1930's with rigid PVC for the chemical industry. After WW2 synthetic pipes made of rigid PVC only started to be used again at the beginning of the 1950's. In the following 15 years, PVC pipe installation increased steadily.

As no plasticisers were added to the material when manufacturing pipes and fittings, one uses the terms rigid PVC or PVC-U (unplasticised plastic). Rubber-sealed, elastic push-in connections, flanged connections (always adhesive-bonded), and adhesive-bonded sleeve connectors came into use.

PE pipes

The production of polymers was a prerequisite for the manufacture of plastic pipes from polyethylene (PE). In the mid-1930's it became possible to manufacture products of high molecular weight from low-molecular compounds, by various techniques involving polymerisation, polycondensation or polyaddition.

Connecting PE pipes was achieved by welding.

Plastic pipes, under normal load conditions, resist corrosion even in heavily aggressive soils. However, they are susceptible in extreme support conditions. Damage to laid pipes can particularly be caused by poor bedding-in and sharp or sharp-edged stones below or above the pipes, leading to an unacceptable concentration of load.

Ageing/ embrittlement

Pipes manufactured today are tested for creep rupture strength. In the case of older PVC and PE pipes, with increased duration of use, one must reckon on a loss of strength that can lead to partial premature embrittlement.

PVC pipes can also exhibit damage in the form of cracks caused by laying incorrectly (not free from tension), and weak points at connections due to poor bonding.

With PE pipes, damage occurs when they are incorrectly laid, leading to unacceptable stress (point load) and hence damage in the form of longitudinal cracks and rupture.

Damage is also seen to develop as a result of impurities trapped in the wall of a pipe during manufacture, and also from uneven cooling.

Ageing/ embrittlement of PE 63 (the first generation of PE up to 1979) is often the underlying cause of damage.

2.2.3 Asbestos cement pipes.

Asbestos cement pipes were manufactured and laid in Germany in the period 1930-1993. These pipes are made from an asbestos-cement mix that was applied seamlessly and under pressure around a steel core, in thin layers of about 0.1 mm until the required thickness of wall was achieved. In both West Germany (BRD) and former East Germany (DDR) long-fibred asbestos was used at first in the production of asbestos cement pipes. Pipes with a pressure rating of up to PN 16 were achieved in this way. In the 1980's only short-fibred asbestos was available for pipe manufacture in the DDR. Such pipes had lower strength but were used up to a pressure of PN 6.

Production and use of asbestos cement pipes have not been allowed in Germany since 1995. An exception is made for work involving demolition, rehabilitation or maintenance, subject to the provisions of TRGS 519 and DGUV-Information 201-012. Existing asbestos cement pipes may continue to be operated and repaired. During repair work, materials containing asbestos must be replaced with asbestos-free materials.

Asbestos cement pipes were produced from DN 50 in lengths of 4 to 5 metres and were noted for their lightness, workability and extensive corrosion resistance.

The danger of corrosion comes from lime-dissolving water or lime-aggressive soil. These pipes were protected from lime-dissolving attack by internal and external bituminous coats.

Diffusion of moisture through the pipe wall can lead to blistering and hence detaching of the bitumen coating.

Reduction in the strength of asbestos cement pipes occurred especially in areas where the supply of soft, not hardened water came from dams.

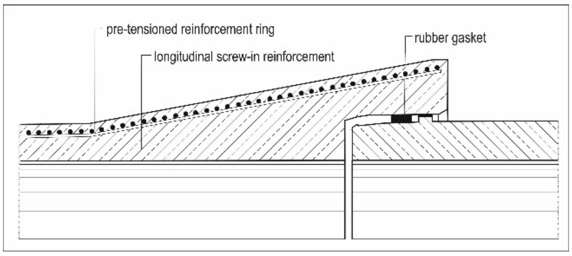
To connect pipes, rubber solution, rubber grommets and rubber seals were used (connectors by Kuas, Simplex, Gibault, Magnani, Reka etc). The ends of the pipes were not pushed completely together in order to protect the ends from damage and to ensure an angular tolerance of up to 6º for small nominal diameters and up to 3º for larger nominal diameters.

Fittings such as socket bends, junctions, transition pieces, adapter couplings or slip-on sleeves were not manufactured from asbestos cement. If fittings were needed for pipeline construction, then recourse was usually made to (welded) steel or cast-iron fittings without a cement coating. These fittings were joined to the asbestos cement pipes using (cast-iron) sleeves or transition pieces or slide-on couplers.

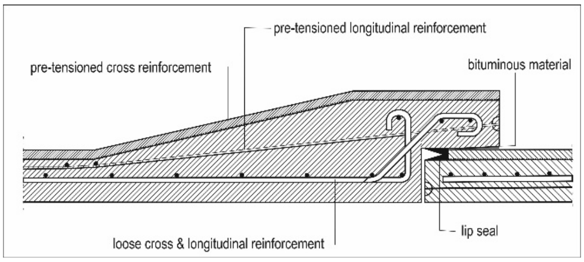
Laying asbestos cement pipes required perfect bedding conditions as these pipes are susceptible to shock and impact and have little flexural strength. In cohesive soils (clay, marl, silt) damage built up where frost and drought occurred over longer periods, leading typically to breaks in pipes.

2.2.4 Steel-reinforced concrete and pre-stressed concrete pipes

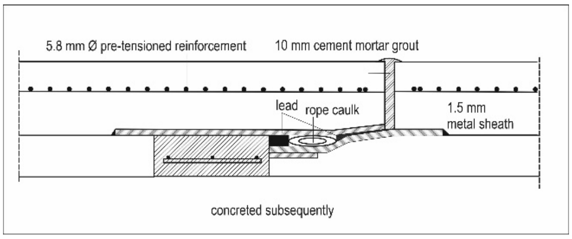
From the 1920's, steel reinforced concrete pipe was produced, with an inner case of sheet steel and an outer layer of reinforced concrete. Pressurised pipes of reinforced concrete in the 1930's had round iron bar inserts. Joints were sealed with hemp and lead, as in the case of cast-iron and steel pipes. Where the soil was aggressive, bituminous concrete protection was applied externally. The production of pre-stressed concrete pipes received a considerable boost in the 1950's with the construction of large water pipelines. Pipes were manufactured, from DN 500, up to 8 metres in length and able to withstand operating pressures of up to 35 bar. The longitudinal reinforcement was put into the mould under tension, and the single-layer concrete skin applied and compressed using high-frequency vibration. Damage may be caused by leaky joints (diagrams 1 to 4), carbonisation and corrosion of the reinforcement bars.



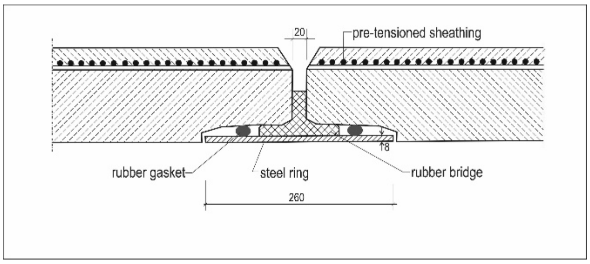
Diag. 1: DYWIDAG SENTAB type [DYWIDAG]



Diag. 2: Züblin type [Züblin]



Diag. 3: Bonna-Rohr type (Steel casing/ sprayed concrete pipe) [DYWIDAG]



Diag. 4: Straight sleeve type

2.2.5 GRP

Visible damage to GRP pipes usually occurs before commissioning. Damage caused by shock or impact before and during installation of the pipes or during transit to the site are the commonest causes of defects. These often appear as cracks in the inner protective coating. Occasionally one may come across dents.

Shock and impact damage in pipes is normally apparent as:

- Cracks running lengthwise from a point on the inner protective coat.
- Cracks radiating out from a point on an inner fibre-reinforced protective coat
- The inner protective coat coming away (delamination) in a ring around the point of damage and extending as a pale blotch beyond the length of the visible cracks
- Cracks in the inner protective coat running from the spigot end.
- Spigot ends dented in places

Damage to spigots may be caused when pipes are being installed using heavy machinery. Minor chips on the spigot should be assessed by the pipe's manufacturer.

Leaking sleeve connections may be caused when embedding, assembling or bending the pipeline.

Depending on the pipe system, the maximum permissible socket gap is 35 mm. When rehabilitating, a distinction must be made between pull-out resistant and not-pull-out resistant GRP pipe systems.

Disturbance to the bedding may be indicated, during a TV inspection, by:

- axial misalignment of consecutive pipes
- vertical or horizontal displacement of consecutive pipes (inner diameters are offset)
- too great a gap at the junction of two pipes

Disturbance to the bedding can be caused by uneven compaction when the pipe was laid, by construction work in the vicinity or by leaks flushing away material around the pipe.

3 Defining the problem

In order to re-establish a pipeline's functional efficiency professionally and economically, it is necessary to compile a complete picture of its condition and as accurate as possible a profile of the damage in the relevant section of pipe.

The first stage is to determine the causes of the damage and to investigate whether it is possible to (partly) eliminate them.

The next stage is to find answers to the following questions:

- Does using trenchless technology offer technical and economic advantages with regard to environmental requirements, taking into account area involved, construction time and costs?
- Can the existing pipe bear the static load, entirely or in part, required for the further service life that is planned, or is its renewal or replacement needed?

The following sections of this technical information leaflet describe the preconditions and possible applications of trenchless techniques for the renovation of existing pressurised pipes by rehabilitating them (i.e. working partly or completely with the existing pipe material) or by replacing them with new pipes.

It should be noted that rehabilitating drinking water pipes normally requires their replacement.

Differentiating between trenchless replacement and rehabilitation can also offer clear financial advantages. The former means laying new pipework, the latter refers to overhaul of an existing pipe. From the point of view of depreciation, the cost of remedial work can be either capitalised as a fixed asset or claimed as a direct expense.

In §5, as a decision-making tool, there is a selection matrix that can be consulted in order to make an initial choice of possible techniques. An evaluation is made as to the basic applicability of the different techniques in terms of both the type of medium transported and the type of damage.

4 Procedure descriptions

4.1 Cement mortar lining

This coating has already been described in DVGW worksheet W 343 in relation to drinking water pipes already in operation. Rehabilitating drinking water pipes with a cement mortar coating presupposes that the pipe continues to have stability with regard to internal and external static and dynamic loads, so that the rehabilitated pipe can expect to have a satisfactory operating life.

Cement mortar coating forms an inner protective layer that prevents corrosion and avoids the build-up of incrustations that have a negative effect on hydraulic characteristics.

For technical reasons only pipes with the same nominal width or the same diameter (along a section) can be cleaned and then coated.

Cleaning procedures
General

Cleaning procedures need to be chosen so that on the one hand the cement mortar makes a satisfactory bond, and on the other hand so that the pipe is not further damaged.

Incrustations and corrosion products must be removed. For pipes with a bituminous coating, any loose pieces must be removed, without exposing the surface of the metal. The choice of cleaning procedures depends on, among other things, the chemical composition of the incrustations, the presence of a (bitumen) coating, the nominal width and any deflections in the pipe (bends etc)

Mechanical cleaning

Cleaning nominal widths of from 80 mm to 1200 mm can be carried out using scrapers, brushes and rubber plungers. These pieces of equipment are pulled through the pipe by a winch and a steel cable, so that the spring steel scrapers loosen incrustations, corrosion products and loose coating. The rubber plunger clears the rubbish from the pipe. This process is repeated several times until the pipe reaches a satisfactory level of cleanliness.

Cleaning by hand

Where a pipe is wide enough to be accessed by an operative and where mechanical cleaning is not possible, short sections, fittings and bends can be cleaned by hand.

Hydraulic cleaning

Hydraulic cleaning can be used for long pipelines with constant diameter. Plungers can be pulled through them over several kilometres. Water pressure carries the cleaning apparatus through the pipe. Because of the large quantities of water involved in the case of larger pipes, this procedure is used principally for smaller diameters.

A pre-condition for hydraulic cleaning is that the pipe must have been designed to be piggable.

High pressure water jet cleaning

High pressure water jetting up to 150 bar is used only in pipes with easily dislodged incrustations and corrosion products, or else for follow-up cleaning.

Ultra high pressure water jet cleaning

Drinking water supply pipes are increasingly being cleaned with ultra high pressure jetting. This can be used between nominal diameters of from 80 mm to 3000 mm and even wider if required. Areas of incrustation, corrosion and coating that are difficult to dislodge are commonly loosened using water pressure up to 1000 bar.

Cement mortar coating techniques

Spray coating can be used for all of the usual diameters of water supply pipe from DN 80 to DN 3000. With this procedure, cement mortar is projected onto the pipe's inner wall by a spray head rotating at high speed. The surface can be smoothed by a rotating trowel or by a smoothing cone being pulled through. Once the pipe has been put back into service, the mortar coat combines with the ferrous material in the pipe wall. The barrier effect of the cement mortar provides passive corrosion protection for the wall of the pipe. The mortar's alkalinity hinders corrosion, giving active protection. Smoothing the coating is usually dispensed with, since on the one hand protruding laterals, angular offsets and bends may damage the smoothing cone and on the other hand smoothing will be made more difficult if the pipe is too ovoid.

Coating thickness and mortar strength

The required thickness of mortar coating when coating mechanically should be calculated as per DVGW worksheet W 343. There are various reasons, e.g. pipe geometry, hydraulics, why pipes might be given a significantly thicker coat, even double thickness. The mortar consists of cement, quartz sand and drinking water.

The prescribed mortar mix is a 1:1 ratio by weight of cement and quartz sand.

When tested as per DVGW W 343, the mortar should have a compressive strength of 50 N/mm^2 after 28 days, and a bending tensile strength of 5 N/mm^2. These values serve indirectly as quality criteria.

Cement mortar coating follow-up treatment

After coating, the ends of the pipe should be closed to protect the coating from drying out and to avoid the subsequent formation of cracks. After coating, care must be taken to ensure that there is sufficient moisture available and a minimum temperature of 5ºC for the fresh mortar to cure properly.

Returning cement mortar coated pipes to service
Flushing the pipe

After the pipe has been filled, pH value rises to 12.5. This is particularly problematic for drinking water pipes, as the boundary value laid down in the drinking water regulations is pH 9.5. An eye must be kept on an increase in pH value where there is a drop in the water's flow speed and hence longer retention time. It should also be noted that pH value rises more quickly with a decrease in the ratio of pipeline volume to inner surface area (in small nominal diameters). This rise, which also occurs during pressure testing, can normally be reduced by flushing the pipe. Once the pH complies with the boundary value laid down in drinking water regulations, the pipe can be returned to service.

Pressure testing

A pressure test should take place at the earliest 7 days after coating and involves saturating the mortar with water. The pressure test should be carried out following DVGW worksheet W 343, at a pressure above the pipe's normal operating pressure. The test is then carried out following DVGW worksheet W 400-2. This test is only appropriate for sections of pipe without laterals. It must be ensured that the uncoated pipe (i.e. before coating) can sustain the required pressure.

Quality assurance and certificates

Quality assurance is described in DVGW worksheet W 343. This worksheet can be used for conformity assessment of the contractors following DVGW worksheet GW 302, qualification-group R4.

References/ Regulations

DVGW W 343 (A) „Sanierung von erdverlegten Guss- und Stahlrohrleitungen durch Zementmörtelauskleidung – Einsatzbereiche, Anforderungen und Prüfungen“

DVGW W 346 (A), „Guss- und Stahlrohrleitungsteile mit ZM-Auskleidung - Handhabung“

DIN 2614 Cement mortar linings for ductile iron and steel pipes and fittings: application, requirements and testing

DIN 2880 Cement mortar linings for cast iron pipes, steel pipes and fittings)

DIN EN 196-1 Methods of testing cement: Part 1: Determination of strength

Roscher, H. u.a.: Sanierung städtischer Wasserversorgungsnetze, Verlag Bauwesen, 1. Auflage, 2000, S. 148

Technologiezentrum Wasser Karlsruhe (TZW): Information zur PAK-Problematik, TZW TAK-Info 09/2000 Karlsruhe

Schuchart, J. und Zech, H. Trinkwasser für München, Zementmörtelauskleidung bei Großrohren. 3R internat. 27 (1999) Nr. 3/4, S. 184-187

Naber, G.: Über die Zementmörtel-Auskleidung großer Stahlrohre, Beton (1971) Nr. 11, S. 441-444

4.2 Hose lining procedures

4.2.1 General

Hose lining is used to restore functional efficiency to an existing pipe by inserting hoses with or without bonding to the pipe wall. The various techniques have different structural designs for coping with internal and external loads. All hose-lining procedures require basic preparation in the form of inspection and cleaning of the existing pipe. Rehabilitation usually produces an improvement in roughness (k value). When working on pipes taken out of service, as well as when installing new ones, the manufacturer’s installation guidelines must be observed and the appropriate techniques must be used by skilled, i.e. qualified and trained specialist personnel.

Suitability for the intended area of application and operating life must be established, with regard to chemical, physical and in some cases thermal requirements, by type-examinations based on the relevant regulations.

For use in drinking water pipes, it must be demonstrated that the whole system is completely harmless, throughout the planned area of application, as regards drinking water hygiene, in accordance with the German Federal Agency’s KTW guidelines or coatings guidelines, and as regards microbiological characteristics as per DVGW worksheet W 270.

According to DIN EN ISO 11295, Table 17, hose liners (depending on their structural design) can be classified as independent, fully statically loadable Class A liners or as semi-structural liners of Class B or Class C. Straight sections of Class A liners can take all normal operational external and internal loads. In this case, a rise in nominal pressure in the rehabilitated host pipe is possible, as the latter is no longer required to fulfil the static load-bearing function.

In systems that are statically fully loadable (as per DIN EN ISO 11295, Table 17, Class A), care must be taken to ensure that these are independent of the host pipe and not bonded to it.

Where a pipe is classed as interactive, semi-structural (Classes B and C as per DIN EN ISO 11295, Table 17), care must be taken to ensure that the liner sits snugly against the host pipe both during installation and once operational load has been applied, so that the internal pressure can be transmitted radially to the host pipe. Class B systems have inherent ring stiffness. Bonding is possible but not necessary. Class C systems are based on obligatory bonding with the host pipe.

Structural design is described in GSTT information sheet 20-2.

4.2.2 Preparation

Inspecting the existing pipework

Suitability for rehabilitation as regards e.g. condition of pipe and pipe run as well as possible measures for removing obstructions must be established by an initial inspection (usually by sending down a camera).

The following must be established and recorded:

- length of pipe
- inner diameter tolerances (changes in diameter and offsets)
- incrustation, deposits and contamination
- obstructions affecting the cross-section (e.g. sharp-edged welds, screws, studs, plugs, connections and sacrificial anodes)
- incorrectly made or defective joints
- deformations, pre-deformations, changes in cross-section
- shifts in direction (bends)
- branches
- fittings (e.g. condensation traps, expansion compensators)
- valves

Apart from the range of tolerance allowed when inserting the hose liner, all changes to pipe cross-section along the pipe run, obstructions that might damage the liner and harmful contamination must be removed.

Freedom from obstructions (i.e. the free inner diameter of the pipe) must be established by a second inspection and recorded.

Cleaning

The aim of cleaning the pipe is to ensure that the inner diameter of the pipe to be rehabilitated is free of obstructions, by removing incrustations or harmful deposits. In most cases, pulling spring steel scrapers and rubber discs has proved effective. Fixed obstructions (as for example casting defects in the pipe, welds, projecting collars or screws, studs, plugs, connections and sacrificial anodes) protruding into the inner diameter of the pipe can be removed by dismantling the area of pipe with the obstruction, or dealt with by using a milling robot with the appropriate attachment. Welds should be worked on until the inner circumference is uniform and smooth.

For bonded systems, the inner surface of the pipe must also be free of deposits and loose areas of coating. The surface area is normally cleaned (metallic bright) by ultra high pressure jetting (up to 1500 bar) and/or sandblasted and then dried, in order to obtain a satisfactory base for full surface bonding.

4.2.3 Follow-up treatment

Installation and curing are followed by a final visual inspection to verify that the liner has been correctly installed.

A pressure test, a possible disinfection and sterility test, as well as re-connection to the pressurised pipe system, must be carried out by qualified technicians, as is the case with the open cut method.

4.2.4 Lining with cured-in-place pipes

4.2.4.1 Glass-fibre liners

GRP liners are available for pipes from DN 150 to DN 1500. Depending on their structural design, in accordance with DIN EN ISO 11295, Table 17, GRP liners can be classified as Class A self-supporting, fully static loadbearing liners, or Class B semi-structural liners.

GRP liners are therefore mainly suitable for rehabilitating generalised damage caused by exterior and interior corrosion, shell fractures, leaking couplings, individual holes, and longitudinal and transverse cracks, as well as sleeve misalignment that is within procedural or operational tolerances. Curved fittings cannot normally be rehabilitated by this method.

As a rule, the GRP liner used consists of an inner PE/PA film (which, after curing, may or may not be removed from the liner, depending on the manufacturer), GRP matting made of ECR glass fibres and UP or VE resin as well as a PE/PA outer film and a light-proof foil. It can be manufactured in individual lengths up to 600 metres, depending on the project.

Installation in the pipe to be rehabilitated involves drawing the liner by means of a winch from one excavation pit to another. To cure the GRP liner, it is first positioned using compressed air and then irradiated with UV light. For that, a UV light trolley with a defined lamp output is sent through the liner at a defined speed.

Connecting the GRP liner to the pipe system is achieved either by an inner sleeve in a new flanged spigot fixed to the host pipe, or by flanges (steel or hand-laminated GRP) that are fastened or laminated onto the liner after curing.

It may become necessary to clean the inserted GRP liner for operational reasons, and this can be carried out in accordance with the manufacturer’s instructions perhaps by high pressure flushing and/or a cleaning disc or a foam plastic pig.

4.2.4.2 Glass fibre reinforced needle felt liner

This composite material combines high strength glass fibre matting with the flexible characteristics of polyester needle felt.

Depending on how it is installed, it can be used for pipes of nominal diameter from DN 100 to DN 1600, in installation lengths up to 300 m. Rehabilitating bends is possible depending on situation, pipe route and radius. The pre-fabricated liners are inserted either by the inversion process using air-pressure (pressure drum) or water pressure (inversion tower, water column) or a combination of techniques, winching a pull-in-liner through and then inverting it with a calibration hose that positions the liner and presses it against the wall of the host pipe.

To insert the liner, a start pit and a target pit are essential. Warm water or steam are used to cure the resin system, whether epoxy resin (EP), unsaturated polyester resin or vinyl ester resin.

A glass fibre reinforced needle felt liner can be considered as a self-supporting, statically fully load-bearing solution, or as an interactive, semi-structural solution, depending on the extent of damage to the host pipe.

The liner used consists of glass fibre reinforced needle felt with a suitable inner layer of polyolefin or thermoplastic elastomer. Depending on the static conditions, the glass fibre reinforced needle felt liner is manufactured in thicknesses of from 3 mm to 24 mm.

Physical couplings, GRP flanges and/or standard rubber sleeves can be used to connect the glass fibre reinforced needle felt liner to the existing pipe network.

If it becomes necessary to clean the inserted liner for operational reasons, it is recommended to carry this out using suitable pigs in accordance with the manufacturer's instructions.

4.2.5 Lining with adhesive backed hoses

4.2.5.1 General

Quality assurance for bonding fabric hoses to the pipe wall is described in detail in DVGW worksheet GW 327 for gas and water pipes. Type examinations for use in gas pipes are carried out for pressures up to 4 bar in accordance with DIN 30658-1 and for from 4 bar up to 30 bar in accordance with DVGW testing specifications VP 404. For use in water pipes, DVGW worksheet W 330 contains the relevant requirements for pressures up to 10 bar and for from 10 bar up to 40 bar.

Contractors using the bonded fabric liner technique can give proof of their qualifications with Group R1 accreditation as per DVGW worksheet GW 302.

4.2.5.2 Fabric hose lining procedure

In this procedure, a fabric hose liner plastic-coated on the outside is impregnated on the inner fabric surface with a two-component adhesive. The fabric liner thus prepared is then inserted inside-out (inverted) into the previously cleaned pipe so that it adheres to the whole of the inner wall of the pipe. Depending on the adhesive used, internal pressure supports the liner during curing, which takes place

- cold, where the pipe is at ambient temperature
- warm by introducing thermal energy in the form of steam or water to heat the fabric liner, or
- by gradually irradiating the fabric liner with UV light by sending a lamp trolley along the pipe.

In this way a semi-static loadbearing inner lining is formed in the existing pipe equivalent to Class C as per DIN EN ISO 11295, Table 17. Variations on the procedure are available for rehabilitating domestic gas connections from DN 20, up to DN 1200 for gas, drinking water and wastewater pressurised pipes. It is possible to renovate bends depending on situation and pipe diameter.

Type tests and product certifications show that bonded fabric liners have an operational life of at least 50 years and are suitable for existing pipes working at pressures up to 40 bar.

The procedure is particularly suitable for pipes made of steel and cast iron. As long as they are shown to be suitable as regards cleanliness, bond strength and any breaks in the pipe, the procedure may equally be used with pipes made of concrete, fibre cement and PVC. While the usual lengths of fabric hose installed in urban supply pipelines range from 50 m to 250 m, for transport pipelines lengths of up to 600 m are possible. The technique is used in particular when rehabilitating fragile pipe material or pipes with localised damage that does not threaten its structural integrity for its projected service life.

Rehabilitating with bonded fabric hose liners is advantageous in the case of pipes with changes in direction and/or laterals. Apart from a start pit and target pit, no further excavation is necessary. With nearly all fabric liner techniques, laterals from DN80 (for gas pipes) or DN 150 (for water pipes) can usually be opened up from inside.

The following should be noted with regard to operating and maintaining pipes with bonded fabric hose liners:

- The pipe can be tapped into. A compass saw should be used, not a drill.
- No special connection techniques are required. Once the fabric liner has been cut from the end of the pipe, connection can be made with standard connectors or by welding on adapters.
- It is possible to weld gas pipelines as long as heat is discharged in a controlled way. Welding is not possible in the case of drinking water pipes for reasons of hygiene, since the heat has a localised effect on the lining.
- Because of the plastic lining, abrasive techniques cannot be used in any possible future cleaning operations. At best, the use of a foam pig should be considered.

Regulations

DVGW W 330 (A) „Einzuklebende Gewebeschläuche für Wasserrohrleitungen“ (Cured-in-place fabric hose-liners for water pipelines)

DVGW GW 327 (A) „Auskleidung von Gas- und Wasserrohrleitungen mit einzuklebenden Gewebeschläuchen“ (Lining gas and water pipes with cured-in-place fabric hose-liners)

DVGW VP 404 (P) „Rehabilitation von Gas-Hochdruckleitungen mit Gewebeschläuchen im Druckbereich über 4 bar bis 30 bar“ (Rehabilitating HP gas pipes in the pressure range 4 to 30 bar with fabric hose-liners)

DIN 30658-1 Materials for the subsequent sealing of underground gas mains -
Part 1: Plastic foil and fabric hose liners used to seal gas pipes already in place,
safety requirements and testing

4.2.5.3 Glass fibre reinforced fabric hose liners

A glass fibre reinforced fabric hose liner is a GRP composite liner that can cope with bends, for the trenchless rehabilitation of pressurised gas, drinking water and wastewater pipes made of all usual materials, with an operating pressure of up to 16 bar.

It consists of a glass-fabric reinforcement made of corrosion resistant ECR glass and an inner fabric hose-liner.

The liner is inserted by inversion, making the rehabilitation of pipe bends up to 45º possible.

Nominal diameter range is between DN 80 and DN 1000.

Depending on the statics requirements, the glass fibre reinforced fabric hose-liner is manufactured in wall thicknesses of up to 12 mm.

The liner is media-tight thanks to the inner plastic-coated fabric hose, can withstand all internal and external loads thanks to the GRP reinforcement, and is thus a complete replacement for the host pipe in terms of the latter’s static performance.

Depending on the design, the glass fibre reinforced fabric hose liner may correspond to Classes A, B or C according to the DIN EN ISO 11295 (Table 17) classification.

The rehabilitated pressurised pipe is reconnected using standard fittings.

These liners can usually be installed in lengths up to 150 m.

4.2.6 Lining with inserted hoses

Area of application

The fabric liner used normally consists of a PE outer coating, a fibre-reinforced fabric core (e.g. Kevlar) and an inner coating of PE or thermoplastic polyurethane (TPU). Depending on the desired pressure rating for the pipe being rehabilitated, non-bonded fabric liners are manufactured with a wall thickness of 6 mm to 8 mm (fabric core of 2 mm to 4 mm). The fabric liner is connected to the network using connectors (steel or cast iron) into which the liner is inserted.

Depending on the project, the hose liner is produced in lengths of up to several hundred metres, folded in a u-shape, wound on to drums and delivered to the site. There it is pulled by winch into the previously cleaned pipe and fitted loosely to the pipe leaving an annular clearance. Bonding to the host pipe is not necessary, since the fabric liner, though it is not bonded to the pipe wall, can completely absorb the internal operational pressure, and is independent of the host pipe. From now on, the rehabilitated pipe only has to withstand the external static load. Pulled-in fabric liners are thus pressurised pipe liners meeting DIN EN ISO 11295 definition 3.1.8. According to Table 17 note 1, this norm is still awaiting classification.

Systems are available for rehabilitating pressurised wastewater, water, gas and oil pipes from DN 80 to DN 500.

Given the relevant type-examinations and product certification, pulled-in fabric hose liners are shown to have a useful life of at least 50 years and to withstand operational pressures of up to 82 bar in accordance with DVGW test specification VP 643. The procedure is appropriate all types of pipe (steel, cast iron, fibre cement and plastic.) Pulled-in fabric hose liners can take bends of up to 45º.

Installation

The hose liner is pre-folded and held in shape by means of adhesive tape and then pulled in by means of a winch. It is restored to its circular cross-section with compressed air, the adhesive tapes coming away when the internal pressure reaches 0.5 bar.

Steel or cast iron couplings are then press-fit in place to secure the liner.

Tightness check, final inspection and re-connection

Pulled-in fabric hose liners can be tested for tightness like newly installed pipes, in accordance with the recognised rules for this technique (DVGW, DIN, DIN EN). The pressure test should be based on the pipe's normal operational pressure.

Re-connecting the rehabilitated section of pipe with the system once it has passed the pressure test and this has been signed off by the contracting authority. Re-connection is as described in the section "Operation & Maintenance"

Utilisation

Internal corrosion (e.g. pitting), leaking sockets, individual holes, longitudinal and transverse cracks and displacements are among the principal types of damage.

Pulled-in fabric hose liners cannot take external loads and negative pressure.

Operation and Maintenance

With pipes where the fabric hose liner is not bonded to the pipe wall, the following points concerning operation and maintenance must be noted:

It is not possible to drill into a non-bonded liner.

T-pieces or sockets can be integrated retroactively into the rehabilitated section by fitting new connectors.

A fabric hose liner may only be cleaned, when necessary, using a foam plastic pig.

Quality assurance and certificates

Fabric hose liners and connectors are factory made. Installation is carried out on site, following the manufacturer's guidelines. Approval for use at specific pressure ratings is authorised in accordance with DVGW testing specification VP 643

Regulations

DVGW VP 643 (P) "Flexible, gewebeverstärkte Kunststoff-Inliner und zugehörige Verbinder für Gasleitungen mit Betriebsdrücken über 16 bar (2004-2006)" ["Flexible fabric reinforced plastic in-liners and associated connectors for gas lines operating at pressures above 16 bar" (2004-06)]

4.3 Lining with continuous or discrete pipes, with annular space

Pipes made of PE, GRP, steel or GGG are available for these rehabilitation processes in nominal diameters from 25 mm to 3000 mm. Depending on the nominal size and pipe material, the pipes are delivered to the construction site as individual pipes, coils or drums. They can either be pulled into an existing pipe with a larger diameter by means of a winch or inserted using a pushing device.

Due to the process, an annular space remains between the inside diameter of the existing pipe and the outside diameter of the new pipe, which is filled depending on the requirements after the pressure test.

When pipes are pulled in, the new pipes are usually pulled in individually using a winch or as a pre-welded or pre-assembled pipe string. In the less common case of pipe pushing, individual pipes in the starting pit are connected to the already inserted pipe and are each pushed into the host pipe in turn, using a pushing device.

To reduce the insertion forces by minimizing friction, the installation can be carried out with spacers, skids or rollers that are attached to the new pipe string or by floating.

The host pipe to be rehabilitated does not have to absorb static loads when the external loads are transferred to the new pipe. As a rule, an annular space filling is required for this.

Depending on the type of host pipe, internal corrosion, leaking joints, single holes, longitudinal and transverse cracks as well as joint offsets are among the damage patterns in which rehabilitation by pipe insertion / pushing with annular space can be applied. Sharp and/or protruding obstacles must be removed before the new pipe is pulled in. It is essential to clean the host pipe in order to create the required cross-sectional clearance and to ensure that possible contaminants have been removed.

In larger man-entry pipes with spigot-and-socket connections, skids are generally used.

In the discrete pipe process, the transport takes place using pipe carts. The pipes are assembled and fixed within the host pipe by means of spacers and wedges. It is preferable to produce contact surfaces rounded to the outside diameter of the pipe.

Depending on the pipe material to be pulled in, the annular space must be filled in defined layers. When filling, inadmissible deformations, pipe offsets due to floating or local buckling at support points must be prevented.

In the case of the Sliplining procedure with annular space, fittings usually have to be removed.

With this procedure, pipes with additional mechanical protection are usually required. This mechanical protection prevents damage during installation. A connection to the host pipe in the non-rehabilitated section is made either with a special adapter or a flange connection.

The new pipe and the connecting parts are manufactured in the factory in compliance with the applicable regulations depending on the medium to be carried. The new pipe is installed on the construction site in accordance with the manufacturer's installation instructions and the DVGW GW 320-1 regulations. Pipes according to sections 5.1 to 5.4 are suitable for the process.

4.4 Lining with close-fit pipes

In the close-fit process, a pipe section with pipes made of thermoplastic materials with a reduced cross-section is pulled into the host pipe using winching technology and then reshaped so that the liner pipe fits tight against the wall of the host pipe (close-fit). These methods are also known as pipe string lining without annular space and can be used for the rehabilitation of pressure pipes in both the supply and disposal sectors. Liner pipes used are dimensioned according to internal pressure, external loads or buckling pressure.

There are two process variants:

1. **Reduction process**

With the reduction process, a pipe string is produced using the heating element butt fusion welding method and pulled into the host pipe by means of a suitable pulling device, the outer diameter of the liner pipe being reduced by up to 12% in a conical reducer (die), usually without applying heat. A minimum tensile stress must be observed during the entire pull-in process to avoid premature re-shaping.

After reaching the target pit and the strain relief, the liner pipe expands radially again and fits tightly against the host pipe.

A nominal size range from ND 100 to ND 1600 can currently be covered. The maximum liner pipe lengths depend on the permissible pulling forces and the local conditions. Depending on the design, single lengths of up to 1000 m are possible.

Thermoplastic materials (PE 100, PE 100-RC) are used as pipe materials. With these materials, pressure levels up to PN 16 can be covered in the reduction process.

2. Deformation technique

With the deformation technique, pipes are extruded with circular cross-section in the factory and pre-deformed there, wound on to drums and delivered to site. Pipe dimensions and length are determined in terms of the specific project but depend on the maximum pipe lengths for that size of cross-section and on the capacity of the drum. The pipes used are made of PE 80, PE 100, PE 100-RC (resistant to crack) or RT (raised temperature) materials and modified PVC. A range of nominal widths of from DN 100 to DN 500 (DN 500 up to PN 6) in insertion lengths of up to 600 metres is possible.

After insertion, the pipe resumes its original shape through a process specified by the manufacturer, combining steam and air-pressure, so that at the end the liner fits closely against the inner wall of the host pipe.

The material of the host pipe does not play a role in its rehabilitation, except that it must be strong enough to withstand forces during the insertion of the liner without suffering further damage.

If the host pipe is used exclusively as the route for the new pipe string (without having any structural function), then only SDR-rated pipes as listed in Table 6 are used.

Reduction and deformation lining techniques can be categorised as Class A or Class B following DIN EN ISO 11295, Table 17.

It should be noted that ancillary services to a section under rehabilitation will be interrupted. It should also be noted that time may be needed for pressure tests or decontamination measures and sterility checks.

The host pipe must be cleaned, obstructions affecting the cross-section must be removed, and free passage verified by TV inspection and calibration. It may be possible to rehabilitate bends, bearing in mind pipe design, local conditions and the procedure being used.

Renovating existing junctions, valves, castings, changes in dimension, house connections, and bends that cannot be rehabilitated must be carried out by the open-cut method. Once rehabilitation is completed, sections are joined together and the junctions are made good with special fittings and devices (e.g. reinforcing sleeves, expanders, adapters, lining sockets or standard welded sockets, stub flange and loose flange connections) and the pipe returned to service after pressure testing, flushing and hygiene approval.

Domestic laterals can be reconnected subsequently, using the various tapping saddles commercially available.

Quality assurance and the requirements to be met by the contracting firms are contained in regulations DVGW GW 320-2.

Firms and others can show their compliance with the pressurised pipe regulations with a certificate attesting Group 3 conformity as per DVGW GW 302.

4.5 Pipe bursting procedure

Pipe bursting is a trenchless replacement process for pipelines DN 50 - DN 1000 in the same route. The existing pipeline is burst using dynamic or static force and displaced into the surrounding soil. The process is characterized by the installation of new, factory-made pipes of the same or larger nominal size. The replacement takes place from pit to pit. Virtually all host pipe materials can be replaced in one piece using a bursting process up to a length of 200 m. Only small ductile cast iron pipes with cement mortar linings and old steel pipes with socket joints require a separate inspection.

In the dynamic bursting process, a winch rope is first pulled into the host pipe, which serves as a guide for the bursting device. During the retraction of the winch cable, the old pipeline is broken, the soil is displaced and the new line is pulled in at the same time by means of dynamic ramming energy, which is applied in the longitudinal direction of the pipe by a bursting device (modified pipe rammer). The dynamic bursting process is generally used only for host pipe made of brittle material.

With the static bursting process both ductile and brittle host pipes can be replaced. First, a rod is inserted into the host pipe by means of a hydraulic carriage, and when it arrives in the starting pit, a bursting tool that fits to the host pipe material is attached. As the rod string is pulled back, the host pipe is burst and displaced into the ground whilst the new pipe is installed at the same time. An advantage of the static bursting process is that no compressed air hose has to be pulled through the new pipe (to supply the rammer), so that the new pipe remains clean.

New pipes to be installed can be PE pipes with integrated or added protective coating, PP pipes, ductile cast iron (DCI) pipes with strain-resistant couplings, or welded steel pipes. Before insertion, PE and PP pipes are connected to the pipe string by means of butt fusion welding as per DVS 2207-1. Exterior welding beads should be removed. PE pipes up to ND180 can be used from coils.

If the current condition of the host pipe shows that obstacles may prevent or complicate the bursting process, they must be removed before the bursting process begins. The procedure does not require cross-sectional reductions due to incrustations, etc. to be removed, provided that a winch rope can be pulled in or the bursting rod can be pushed in.

Cleaning the host pipe may still be necessary if fragmentation releases substances (e.g. tar) to an extent that is environmentally significant (e.g. with gas pipes in some places). In this case cleaning must be carried out so carefully that the release of such substances does not occur.

Only straight pipe sections can be replaced using the bursting method. Bends, valves, hydrants or other internal parts must be removed before starting. Due to the displacement effect, minimum distances to longitudinal or crossing external lines must be observed.. The expansion dimension (difference between the outer diameter of the expansion minus the inner diameter of the host pipe) is important for maintaining minimum distances to the surface and to other pipes and structures (see DVGW technical sheet GW 323.) There must also be a minimum depth of cover. At the receiving pit, the permissible bend radii of the new pipe must be observed. During pulling in, the tensile forces affecting the new pipe must be measured and documented between the bursting expander and the new pipe using a tensile force measuring system. In practice, on-line measuring systems that use radio or cable to directly transmit figures for the pull-in forces that act on the new pipe to the operator of the pulling rig, have proven to be invaluable. This means that the pulling-in procedure can be stopped before the new pipe is damaged. Alternatively, a predetermined breaking point can be built in behind the bursting expander. All steps should be recorded in the bursting job site report. The companies to be commissioned with the pipe bursting work should have a certificate of conformity (a certification) in accordance with DVGW GW 302 in group GN 3 for gas and water pipes. The following regulations are to be applied for the bursting process: DVGW technical sheet GW 323, DVGW worksheet GW 325, DWA technical sheet 143-15 and RSV technical sheet No.8.

4.6 Press-pull procedure

The press-pull technique is used for the no-dig replacement of supply pipes of DN 100 to DN 400 laid in the same route, or for laterals from DN 25 to DN 65. The existing old pipe is pushed out and a new pipe is pulled in in its place, resulting in the equivalent of a conventionally laid pipe.

Requirements, Materials and Execution

The technique involves first disconnecting the pipe from the network at the launch and receiving pits. The new pipe is inserted at the launch pit and the pipe pulling device is mounted in the receiving pit. A traction rod is then passed through the old pipe string, attached to the end of the old pipe in the launch pit using an adapter, and in the receiving pit to the pipe pulling equipment. By applying traction to the rod, the old pipe string is forced towards the target pit and removed at that end. In the same operation new pipes connected to the adapter are successively fed into the pipe route as it is cleared.

The press-pull technique is appropriate for straight pipe runs. Laterals, junctions and other fittings must be dismantled in advance. To eject the old pipe, it may need to be divided up into several sections of from about 15 m to 50 m, depending on size and any bends. New pipe of up to 150 m in length can be installed. Increases in nominal dimension are possible – up to two sizes larger, depending on couplings and ground conditions. Tapered adapters have been designed for this.

The push-pull procedure is suitable for all old pipes made of pressure-resistant and brittle materials such as grey cast iron, PVC and asbestos-cement (bearing in mind TRGS 519). All new materials familiar from open pipe-laying can be considered that have exterior protection suitable for trenchless installation, as well as pipes with welded connections over an abrasion-resistant field coating.

Utilisation, operation and maintenance

With the press-pull procedure, standard pipes and connections are used that are suitable for the trenchless method. Hence, as far as their utilisation, operation and maintenance are concerned, they are in no way different from pipes installed conventionally by the open-cut method.

Quality assurance and certification

With the press-pull technique, as with any procedure that involves using force to insert new pipes into the ground, into an existing empty pipe or into an existing pipe route, the pull force limits and monitoring must be observed that are appropriate to the particular pipe material and its connections.

These and other quality assurance measures for this procedure are described in detail in DVGW worksheet GW 322-1 (A).

Executing companies using the press-pull procedure can show their compliance with the pressurised pipe regulations with a certificate attesting Group GN1 conformity as per DVGW GW 302 (A).

Regulations
DVGW GW 322-1 (A) No-dig replacement of gas and water pipework - Part 1: Using pushing or pulling procedures - Requirements, quality assurance and testing
DVGW GW 325 (A) No-dig construction methods for gas and water service pipework: Requirements, quality assurance and testing

4.7 Auxiliary pipe procedure

With the auxiliary pipe method, an existing old pipe is replaced by a new one along the same pipe route, in two stages. First, one pit is prepared for removing the old pipe and inserting the new one, and one pit for positioning the pipe replacement equipment. Depending on the soil and the condition and size of the old pipe, intermediate pits are usually created every 20 to 50 metres, spaced so as to take account of junctions, service pipes and fittings. As the first step, temporary pipes are coupled together and pushed forward by the pipe replacement equipment, forcing the old pipework gradually through the ground towards the receiving pit, where it is removed. Ideally, the old pipes are retrieved in complete sections. After the last of the old pipes has been completely removed, the temporary pipes are then re-used to line the pipe route. They now take the loads from the overlying ground and the traffic and ensure free passage for the new pipe.

As the second step, the new pipe is fastened to the temporary pipe with a pulling head and inserted into the pipe route as the temporary pipe is withdrawn. Steel and ductile cast iron pipes are usually assembled in the pit with the spigot end of socket pipes facing in the pulling direction.

This auxiliary pipe method is suitable for all rigid types of pipe material: grey cast iron, ductile cast iron, asbestos cement (taking into account TRGS 519), PVC and steel.

Utilisation, operation and maintenance

The procedures set out in §3.2.5 apply as appropriate.

Quality assurance and certification

On the lines of §3.2.5, the auxiliary pipe method requires limitation or monitoring of the tensile force operating on the new pipe string.

These and further quality assurance measures for this procedure are set out in detail in DVGW worksheet GW 322-2.

Regulations

DVGW GW 322-2 (A) „Grabenlose Auswechslung von Gas- und Wasserrohrleitungen – Teil 2: Hilfsrohrverfahren – Anforderungen, Gütesicherung und Prüfung“. [Trenchless replacement of gas and water pipes – Part 2: Auxiliary pipe method – requirements, quality assurance and testing]

5 Selection matrix

TABLE 5: SELECTION MATRIX

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Selection matrix**	**Rehabilitation**											
2		Cement mortar lining		Cured-in- place hose liner		Hose liner with adhesive on outside		Pulled – in hose-lining	Push/pull in with annulus	Close fit method		Pipe bursting	Push/ pull method with temporary pipe
3	**Media**	Drinking water pipes as W 343	With additives (not for drinking water	Glass- fibre liner	Glass–fibre needled felt liner	Fabric hose	Glass–fibre reinforced fabric			Reduction method	Deformation method		
4	**Gas**												
5	up to 1 bar	—	—	x	x	x	x	x	x	x	x	x	x
6	up to 4 bar	—	—	x	x	x	x	x	x	x	x	x	x
7	up to 10 bar	—	—	—	—	x	x	x	x	x	x	x	x
8	up to 16 bar	—	—	—	—	x	x	x	x	x	—	x	x
9	over 16 bar	—	—	—	—	x	—	x	x	—	—	x	x
10	**Water**												
11	< 0 bar	x	x	x	x	x	x	—	x	x	x	x	x
12	up to 10 bar	x	x	x	x	x	x	x	x	x	x	x	x
13	up to 16 bar	x	x	x	x	x	x	x	x	x	—	x	x
14	over 16 bar	x	x	x	x	x	—	x	x	x	—	x	x
15	**District heating**												
16	up to 10 bar	—	x	—	■	—	—	—	—	—	—	—	—
17	up to 16 bar	—	x	—	■	—	—	—	—	—	—	—	—
18	over 16 bar	—	x	—	—	—	—	—	—	—	—	—	—
19	**Wastewater**												
20	< 0 bar	x	x	x	x	x	x	—	x	x	x	x	x
21	up to 5 bar	x	x	x	x	x	x	x	x	x	x	x	x
22	up to 10 bar	x	x	x	x	x	x	x	x	x	x	x	x
23	up to 16 bar	x	x	x	x	x	x	x	x	x	—	x	x
24	over 16 bar	x	x	x	x	x	—	x	x	x	—	x	x
25	**Type of damage**												
26	Deposits/ incrustation	x	x	x	x	x	x	x	x	x	x	x	x
27	Internal corrosion	x	x	x	x	x	x	x	x	x	x	x	x
28	External corrosion	—	—	x	x	■	x	■	x	x	x	x	x
29	Leaks	■	■	x	x	x	x	x	x	x	x	x	x
30	Structural weakness	—	—	x	x	—	x	—	x	x	x	x	x
31	**Change in use**												
32	Operating pressure raised	■	■	■	■	■	■	x	x	x	x	x	x
33	Change in transport medium	■	■	■	■	x	x	x	x	x	x	x	x
34	**Change in cross–section**												
35	Reduction	■	■	■	■	■	■	x	x	x	x	x	x
36	No change	■	■	—	—	■	■	—	—	—	—	x	x
37	Increase	—	—	—	—	—	—	—	—	—	—	x	x
38	**Dimension in mm**												
39	from	80	80	150	100	20	80	80	25	100	100	50	25
40	to	2000	2000	1500	1600	1200	1000	500	3000	1600	500[1]	1000	400
41	Max. pipe length in m.												
42	up to	600	600	300/	300	600	150	1000	1000	1000	600	200	150
43				600									
44	Depends on procedure.						X Yes						
45	Depends on size						— No						
46	With intermediate pits						■ limited						

1) up to DN 500 only in SDR21

6 Properties of materials in pipes used

6.1 Ductile cast iron pipes

Ductile cast iron pipes may be used where they meet the following product norms, depending on the transport medium:

Drinking water:	DIN EN 545
Wastewater:	DIN EN 598
Gas:	DIN EN 969

When changing or renewing pipes, where this means installing the new pipe using traction, positive-locking couplings that can withstand longitudinal force must be chosen. Where the pipe is being pushed in, socket joints standardised as DIN 28603 may be used.

To protect the outer cladding from mechanical loads and damage during installation, pipes with a cement mortar cladding meeting DIN EN 15542 or a reinforced PE cladding meeting DIN EN 14628 must be used.

The area around couplings must be given appropriate protection, e.g:

- heat-shrinkable cladding meeting DIN 30672 for flexible socket joints
- rubber sleeves in conjunction with a physical cover e.g a metal cone

Pipes with a zinc coating and a protective finishing layer as per DIN 30674-3 may be used in agreement with the manufacturer.

Friction-type, thrust-resistant socket connections such as Tyton SIT should only be used in consultation with the pipe manufacturers.

Values for the permissible pulling forces and bends in alignment when pulling-in pipes can be obtained from DVGW regulations (GW 322-1, GW 322-2, GW 323). The permissible compressive strength loads for couplings must be checked with the pipe manufacturer.

In general, DVGW regulations DVGW G 461-1 (A) and G 461-2 (A) or W 400-2 (A) (GW 322-1, GW 322-2, GW 323) must be complied with.

6.2 Steel pipes

The essential characteristic of steel pipes is their balance of strength, wall thickness and outer coating that can be tailored to the respective intended area of application and method of laying.

Different types of steel pipe are supplied, depending on area of application. For steel water pipes and wastewater pipes, DIN 2460 along with DIN EN 10224 are usually stipulated. These pipes normally have cement mortar lining to DIN EN 10298. For gas pipes up to 16 bar, DIN EN 12007-3 requires pipes meeting PSL 2 technical specification level in compliance with DIN EN ISO 3183. For gas pipes above 16 bar, pipes as per Annex M in DIN EN ISO 3183 are required. Steel pipes for transporting oil and gas are supplied with a polyethylene casing as standard as per DIN EN ISO 21809-1. DIN 30670 covers pipe casings for water and gas distribution networks.

For additional external protection from mechanical stress during insertion, the following possibilities that meet DIN 30675-1 should be considered:

- reinforced PE coatings as per DIN 30670 or DIN EN ISO 21809-1

- PP coatings as per DIN 30678 or DIN EN ISO 21809-1
- cement mortar coating in the special S version as per DVGW GW 340 (A)
- polyethylene coatings with an additional corrugated PE layer extruded onto the surface
- polyethylene coatings with an additional GRP laminated surface
- polyethylene coatings with an additional polyamide or PP coating

Depending on the trenchless technique to be used, the procedure-specific requirements for external protection can be found in the relevant technical regulations.

For field coatings, heat-shrinkable or cold workable materials meeting DIN 30672 or DIN EN 12068 are available. For pipes with factory-made cement mortar cladding, these are supplemented with materials as per DVGW GW 340 (A). As an alternative, glass fibre reinforced laminates or grouts based on synthetic resin are available. These are used above all with pipes that have a thick or multi-layer coating.

In principle, for handling the pipe string on site, all the available figures for material strength are used to establish the bend radius of the pipe (e.g. in order to calculate the dimensions of the starting pit or of the bending curve). The bend radius of each pipe must be taken into account when calculating the maximum permissible pulling force (e.g. see DVGW GW 320-1 (A)).

S. Höhler, H.-J. Kocks, S. Zimmermann;
„Machbarkeitsstudie zur grabenlosen Verlegung von Stahlleitungsrohren; Rohrleitungen und deren Netzwerke – Lebensadern der Gesellschaft „ [“Feasibility study of trenchless laying of steel pipework: pipelines and networks – community lifelines“] Vulkan Verlag Essen, 2010, Schriftenreihe aus dem Institut für Rohrleitungsbau der Fachhochschule Oldenburg; Bd. 34, S. 268 – 280 (ISBN 978-3-8027-5333-6)

6.3 Polyethylene pipes

Semi-crystalline material polyethylene is used to manufacture pressurised supply and drainage pipes. Installation method and area of application determine the choice of the particular material, pipe wall construction and wall thickness.

For PE HP materials an operating life of 100 years has been scientifically determined on the basis of creep tests following DIN EN ISO 12612 and the extrapolation method set out in DIN EN ISO 9080. The various types of polyethylene for pipes are classified according to the material’s minimum required strength (MRS).

Following DIN 8075, polyethylene types are differentiated according to their MRS value:

- PE 80 (second generation PE MRS = 8 N/mm²)
- PE 100 (third generation MRS = 10 N/mm²)

New generations of PE 100 materials are PE 100 RC (Resistance to Crack, MRS = 10 N/mm²), and hence suitable for alternative installation techniques thanks to their higher resistance to crack formation.

PE HP pipes are classified in terms of their dimensions, wall thickness and tolerances in DIN 8074, DIN EN 122021-2 (drinking water and wastewater pipes) and in DIN EN 1555-2 (gas pipes).

Table 6: PE-HP-pipe classification as per DIN 8074

	Pipe series	PE 80	PE100
		Rating in bar	
Gas distribution	SDR 11	4	10
	SDR 17	1	4
Water distribution	SDR 5	32	40
	SDR 6	25	32
	SDR 7.4	20	25
	SDR 11	12.5	16
	SDR 17	-	10

PE pipes can be supplied in various lengths as straight lengths, coils or on drums, depending on pipe dimension.

Joining polyethylene pipes is carried out using heated tool butt welding or electro-fusion welding. The requirements of DVS 2207 Part 1 must be observed when welding. Welding may only be carried out by staff with the relevant training and certification (PE welding certificate as per DVGW GW 330). The welding technique used on site must be appropriate for the installation procedure. Heated tool butt welding is used for pipes being installed by the trenchless method.

Depending on the particular installation job, it is possible to use electro-fusion welding or mechanical connectors such as flanged couplings, grouted or push-in connections. These are normally limited to open trench sections of the operation because of the risk of damaging them during pulling-in or pushing-in.

For rehabilitating pressurised plastic pipes operating at > 10 bar, single-layer or multi-layer plastic pipes are used that can have an outer protective layer or sheathing made of polyolefin (PP/PE).

The existing regulations lay down various specifications for the material to be used, depending on the rehabilitation procedure.

When burst-lining grey iron pipes, DVGW technical sheet GW 323 specifies the use of pipes with protective characteristics. If the surface of a pipe has been damaged by grooves, scratches or surface erosion affecting more than 10% of the total wall thickness, DIN EN 12007-2 and DVGW G472 (for gas) and DVGW W400-23 (for water) state that that section of the pipe may no longer be used,

For use with alternative installation procedures, the pipe manufacturer may certify the pipe's suitability with regard to the requirements set out in PAS 1075.

When using polyethylene pipes, the permissible pulling forces, bend radii and temperatures must be observed (- see for example DVGW worksheet GW 320-1).

Cross-linked polyethylene (PEX) pipes

Cross-linked polyethylene (PEX) differs from non-cross-linked polyethylene in the following material characteristics: higher temperature resistance, improved long-term behaviour, less susceptibility to stress cracking, better chemical resistance and higher abrasion resistance.

Because they are relatively insensitive to notching, PEX pipes are used both in open-trench installation without sand bedding and in trenchless replacement procedures. In internal pressure creep rupture tests, it has been shown that the minimum values for service life required by DIN 16892 were exceeded even where notching was up to 20% of wall thickness.

PEX pipes are mainly used as gas and water domestic service pipes.

For connecting these pipes, heated coil welding and small DN connector-clamps should be considered. Butt welding is not possible, since the polymer's cross-linked thermoplastic character is destroyed by welding. In trenchless operations, therefore, these pipes are installed in complete lengths, i.e. without connectors.

Regulations:

PAS 1075 "Pipes made from Polyethylene for alternative installation techniques. Dimensions, Technical Requirements"

6.4 GRP pipes

Depending on the application, pipes made of glass reinforced plastic (GRP) are used that meet the following product norms:

Drinking water, untreated water, process water: DIN EN 1796

Wastewater, grey water, black water: DIN EN 14364

GRP pipes are supplied in pressure ratings from PN1 to PN40. The permissible sustained operating pressure for GRP pipes must be in line with the nominal pressure rating for the pipes and moulded components. GRP pipes are dimensioned with dynamic pressures in mind. The permissible pressure surge during pipeline operation is the nominal pressure + 40% (e.g. 14 bar for PN10 pipes).

Given the scientific knowledge based on the last 60 years of product testing and materials development, qualified GRP pipe manufacturers expect a pipe operating life of up to 150 years. The data from laboratory tests, calculations and creep tests have been verified by studies of pipes and fittings from network operations.

After installation, pipes can be pressure tested up to 1.5 x PN as per EN 805/ DIN EN 1610 or DVGW W 400-2. Pipework safety precautions, e.g. abutments or pipe coupling clamps, must be observed (see also section on pressure testing).

The choice of load class with respect to external loads (traffic load, pipe cover) is made on the basis of static requirements (installation depth, weight of traffic, subsoil conditions, groundwater etc) and measured in standard nominal thicknesses of SN 2,500, SN 5,000, SN 10,000 up to SN 1,000,000.

For pipes and fittings as Table 7, DVGW W 400-1 (inc. GRP pipes and fittings as DIN EN 1796) with subsoil cover as DVGW W 400-2 (A), traffic load SLW 60 (LM 1) as DIN technical report 101 and load conditions & installation conditions as DIN EN 14801 (for special load cases see DVGW GW 312 (A), ATV-DVWK-A 127, VdTÜV 1063; for optimal overburden see 5.5) no separate static analysis is required for GRP pipes with an overburden of 0.8 – 6 metres.

GRP pipes can be supplied for use in temperatures from -50ºC to +100ºC. Customised solutions up to +150ºC are possible, based on glass fibre reinforced epoxy resin (EP-GF). Standard pipework systems as EN 1796/14364 must be used for ambient and/or media temperatures of from -50ºC to +35ºC. Where operating temperatures are higher, the permissible operating pressure should be limited as specified by the supplier.

GRP pipes as DIN EN 1796/DIN EN 14364 are designed for use in water supply and drainage. No additional corrosion protection is necessary for GRP pipes and fittings for the transport of drinking water, raw water, wastewater or in the presence of normal groundwater, surface water or rainwater.

Standard pipes based on unsaturated polyester resin are suitable for transport media with pH values on pH 1 to pH 10. Pipes based on vinyl ester resin are suitable for use up to pH 12.

For industrial wastewater, the choice of suitable material is made by the pipe supplier. The choice of chemical resistance class UP-GF, ISO-GF, VE-GF or EP-GF (epoxy resin based) depends on the chemical composition and temperature of the medium being transported. Note should be taken of the corrosion resistance of the type of glass fibre (E, C or ECR).

GRP drinking water pipes and fittings do not affect the quality of the water.

GRP pipes are UV stable. Under European environmental conditions they can be exposed to direct sunlight / outdoor weathering. Over time, the colour or visual aspect of the outer protective coat can change, but this does not affect the pipes' serviceability. The external protective coat absorbs sunlight's powerful UV radiation.

When choosing the coupling system in the light of site conditions, one must differentiate between push-in socket joints or tension-proof pipe connectors using lock joints, bonded joints, flanged joints, lay-up joints or screw connectors. The method of installation (push-in or pull-in) and the connection system must be co-ordinated at the planning stage.

When using push-together systems without positive locking, one must consider the design of the existing pipe with regard to reaction forces on fittings. Fittings may perhaps need to be secured with clamps.

For pulling in, skids or pipe supports with rollers are normally used, depending on nominal size. Whichever system is used will ensure clearance during pushing-in/ pulling-in.

Curves in the pipe run are possible within the limits authorised by the manufacturer for deviation tolerated in the couplings. If the radius of a curve is not achieved even by the use of short pipes, then compression mouldings, e.g. pipe elbows, should be installed at points prepared by the open-cut method.

Depending on the trenchless technique being used, GRP pipe systems with increased wall thickness and GRP or stainless steel connectors are used that fit flush on the outside.

7 Quality assurance

7.1 Rehabilitation and trenchless replacement: quality assurance

Quality assurance is particularly significant when trenchless technology is used, for the following reasons:

- The work is carried out mostly where it cannot be seen, so that checks are more difficult.
- There is a whole range of different rehabilitation procedures, so that the right choice is critical.

- Defects and consequential losses during installation work need to be avoided.

All quality assurance measures depend on the availability of detailed procedure manuals giving guidelines for the products and techniques to be used. What is critical for the project is not only fulfilling the legal requirements e.g. in relation to health and safety and accident prevention, but also the respective skills of the staff and the suitability of the technical equipment. The relevant requirements may be defined in laws, directives and regulations etc. (information sheets, worksheets or even DIN norms).

On the basis of these documents a conformity assessment or certification (for gas and water) or quality label can be gained, in so far as a relevant conformity assessment process or certification system exists.

Evidence of an effective quality management system as per DIN EN ISO 9001 may provide a check on the executing company with regard to its organisation and procedures

Passing a pre-qualification procedure would be further possible evidence of the company's suitability.

7.2 Drafting the rules

A basic precondition for satisfactory quality assurance is the existence of detailed specifications for the particular procedure, not only giving a technical description of the procedure but stipulating minimum standards, specifying quality assurance and setting out test requirements.

For rehabilitating drinking water and gas pipes the task of drafting the rules is performed by the DVGW.

7.3 Certification

A pressurised pipework conformity assessment or certification can cover personnel, products or procedures.

The pre-condition for a products and procedures conformity assessment is the existence of relevant minimum standards in the form of DVGW worksheets or test specifications (VP).

Conformity assessment of firms working in the area of pressurised gas and water pipes is based on DVGW worksheets GW 301 (for work on operational pipes as well as pressure tests and reconnections, etc) or GW 302 for trenchless construction in conjunction with the relevant worksheets for the particular groups of procedures.

For pressurised wastewater pipes there is no comparable conformity assessment.

7.4 Carrying out quality assurance

Carrying out quality assurance is the responsibility of the executing company. The latter must make sure that all the requirements set out in the technical rules have been met. This applies in particular to the selection and training of the personnel employed, and to the care taken to use appropriate materials and equipment and to follow the relevant operating instructions, as well as to take into account the specific characteristics of the pipework and of the installation procedure. In addition, adequate quality checks must be made on materials, and all essential data relevant to the procedure in terms of the relevant DVGW regulations must be recorded.

7.5 Pressure testing

At the end of rehabilitation, the pressurised pipework must undergo a pressure test. Depending on the medium transported, the following apply: DIN EN 805, DVGW W 400-2, DVGW G 469, DIN EN 1610, DWA-A 139, as well as procedure specific requirements or other procedures stipulated by the planner. For testing pressurised wastewater systems

DWA-A worksheet 116-2 applies, in conjunction with DIN EN 805. For testing vacuum drainage systems DWA-A worksheet 116-1 applies, in conjunction with DIN EN 1091.

8 Bibliography

8.1 Introduction

There follows a selection of recognised technical rules, regulations and guidelines that are generally used for the rehabilitation of pressurised pipes. The list makes no claim to be exhaustive and, in any case, not all the documents quoted apply to every procedure. The current versions of legislation and workplace rules and regulations must always be complied with.

It is the responsibility of planners, contracting authorities and contractors to check and specify which of these or other rules and guidelines are to be used. It should be noted that the latest edition should be used, where the text does not specify a particular edition of a norm or document. Checking the currency or applicability of a dated version of a document is therefore the responsibility of the person using this technical information.

8.2 Norms

DIN

DIN 8074 (2011-12) Polyethylene (PE) pipes - PE 80, PE 100, PE-HD – Dimensions

DIN 8075 (2018-08) Polyethylene (PE) pipes - PE 80, PE 100 - General quality requirements, testing

DIN 30658-1 (1998-01) Materials for the subsequent sealing of joints in underground gas mains - Part 1: Plastic foil and textile fibre linings used to seal gas pipes already in place; safety requirements and testing

DIN 30670 (2012-04) Polyethylene coatings of steel pipes and fittings - Requirements and testing

DIN 30672 (2000-12) External organic coatings for the corrosion protection of buried and immersed pipelines for continuous operating temperatures up to 50 °C - Tapes and shrinkable materials

DIN 30674-2 (withdrawn) Sheathing of ductile cast iron pipes; cement mortar coatings (1992-10) replaced by DIN EN 15542 (2008-06) Ductile iron pipes, fittings and accessories - External cement mortar coating for pipes - Requirements and test methods

DIN 30674-3 (2001-03) Coating of ductile cast iron pipes - Part 3: Zinc coating with protective finishing layer

DIN 30678 (2013-09) Polypropylene coatings on steel pipes and fittings - Requirements and testing

DIN EN

DIN EN 545 (2011-09) Ductile iron pipes, fittings, accessories and their joints for water pipelines - Requirements and test methods

DIN EN 805 (2000-03) Water supply - Requirements for systems and components outside buildings

DIN EN 969 (2009-07) Ductile iron pipes, fittings, accessories and their joints for gas pipelines - Requirements and test methods

DIN EN 1555-1 (2010-12) Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 1: General

DIN EN 1555-2 (2010-12) Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 2: Pipes

DIN EN 1555-3 (2013-01) Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 3: Fittings

DIN EN 1555-4 (2011-07) Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 4: Valves

DIN EN 1555-5 (2010-12) Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 5: Fitness for purpose of the system

DIN EN 1796: (2013-05) Plastics piping systems for water supply with or without pressure - Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP)

DIN EN 10224 (2005-12) Non-alloy steel tubes and fittings for the conveyance of water and other aqueous liquids - Technical delivery conditions

DIN EN 10298 (2005-12) Steel tubes and fittings for onshore and offshore pipelines - Internal lining with cement mortar

DIN EN 12007-1 (2012-10) Gas infrastructure - Pipelines for maximum operating pressure up to and including 16 bar - Part 1: General functional requirements

DIN EN 12007-2 (2012-10) Gas infrastructure - Pipelines for maximum operating pressure up to and including 16 bar - Part 2: Specific functional requirements for polyethylene (MOP up to and including 10 bar)

DIN EN 12007-3 (2015-07) Gas infrastructure - Pipelines for maximum operating pressure up to and including 16 bar - Part 3: Specific functional requirements for steel

DIN EN 12007-4 (2012-10) Gas infrastructure - Pipelines for maximum operating pressure up to and including 16 bar - Part 4: Specific functional requirements for renovation

DIN EN 12007-5 (2014-07) Gas infrastructure - Pipelines for maximum operating pressure up to and including 16 bar - Part 5: Service lines - Specific functional requirements

DIN EN 12068 (1999-03) Cathodic protection - External organic coatings for the corrosion protection of buried or immersed steel pipelines used in conjunction with cathodic protection - Tapes and shrinkable materials

DIN EN 12201-1 (2011-11) Plastics piping systems for water supply, and for drainage and sewerage under pressure - Polyethylene (PE) - Part 1: General

DIN EN 12201-2 (2013-12) Plastics piping systems for water supply, and for drainage and sewerage under pressure - Polyethylene (PE) - Part 2: Pipes

DIN EN 12889 (2000-03) Trenchless construction and testing of drains and sewers

DIN EN 14364 (2013-05) Plastics piping systems for drainage and sewerage with or without pressure - Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP) - Specifications for pipes, fittings and joints

DIN EN 14628 (2006-01) Ductile iron pipes, fittings and accessories - External polyethylene coating for pipes - Requirements and test methods

DIN EN 15885 (2011-03) Classification and characteristics of techniques for renovation, repair and replacement of drains and sewers

DIN EN ISO

DIN EN ISO 3183 (2018-09) Petroleum and natural gas industries - Steel pipe for pipeline transportation systems

DIN EN ISO 9080 (2013-02) Plastics piping and ducting systems - Determination of the long-term hydrostatic strength of thermoplastics materials in pipe form by extrapolation

DIN EN ISO 11295 (2018-06) Classification and information on design and applications of plastics piping systems used for renovation and replacement

DIN EN ISO 11297-1 (2018-09) Plastics piping systems for renovation of underground drainage and sewerage networks under pressure - Part 1: General

DIN EN ISO 11297-2 (2018-09) Plastics piping systems for renovation of underground drainage and sewerage networks under pressure - Part 2: Lining with continuous pipes

DIN EN ISO 11297-3 (2019-05) Plastics piping systems for renovation of underground drainage and sewerage networks under pressure - Part 3: Lining with close-fit pipes

DIN EN ISO 11297-4 (2018-09) Plastics piping systems for renovation of underground drainage and sewerage networks under pressure - Part 4: Lining with cured-in-place pipes

DIN EN ISO 11298-1 (2018-07) Plastics piping systems for renovation of underground water supply networks - Part 1: General

DIN EN ISO 11298-2 (2018-05) Plastics piping systems for renovation of underground water supply networks - Part 2: Lining with continuous pipes

DIN EN ISO 11298-3 (2018-12) Plastics piping systems for renovation of underground water supply networks - Part 3: Lining with close-fit pipes

DIN EN ISO 11299-1 (2019-04) Plastics piping systems for renovation of underground gas supply networks - Part 1: General

DIN EN ISO 11299-2 (2019-04) Plastics piping systems for renovation of underground gas supply networks - Part 2: Lining with continuous pipes

DIN EN ISO 11299-3 (2019-04) Plastics piping systems for renovation of underground gas supply networks - Part 3: Lining with close-fit pipes

DIN EN ISO 12162 (2010-04) Thermoplastics materials for pipes and fittings for pressure applications - Classification, designation and design coefficient

DIN EN ISO 21225-1 (2019-06) Plastics piping systems for the trenchless replacement of underground pipeline networks - Part 1: Replacement on the line by pipe bursting and pipe extraction

8.3 DVGW Regulations

Gas

DVGW G 402 (A) „Netz- und Schadenstatistik - Erfassung und Auswertung von Daten zum Aufbau von Instandhaltungsstrategien für Gasverteilungsnetze“ (2011-07)

DVGW G 462 (A) Entwurf „Gasleitungen aus Stahlrohren bis 16 bar Betriebsdruck – Errichtung“ (2018-11)

DVGW G 462-1 (A) „Errichtung von Gasleitungen bis 4 bar Betriebsdruck aus Stahlrohren“ (1976-09)

DVGW G 462-2 (A) „Gasleitungen aus Stahlrohren mit mehr als 4 bar bis 16 bar Betriebsdruck; Errichtung“ (1985-01)

DVGW G 463 (A) „Gashochdruckleitungen aus Stahlrohren für einen Auslegungsdruck von mehr als 16 bar; Errichtung“ (2016-07)

DVGW G 465-2 (A) “Gasleitungen mit einem Betriebsdruck bis 5 bar – Instandsetzung” (2002-04)

DVGW G 466-1 (A) „Gasleitungen aus Stahlrohren für einen Auslegungs-druck von mehr als 16 bar; Betrieb und Instandhaltung“ (2018-05)

DVGW G 469 (A) „Druckprüfverfahren Gastransport/Gasverteilung“ (2010-06)

DVGW G 472 (A) „Gasleitungen bis 10 bar Betriebsdruck aus Polyethylen (PE 80, PE 100 und PE-Xa) - Errichtung“ (2000-08)

DVGW VP 404 (P) “Rehabilitation von Gas-Hochdruckleitungen mit Gewebeschläuchen im Druckbereich von 4 bar bis 30 bar” (2005-02)

DVGW VP 643 (P) „Flexible, gewebeverstärkte Kunststoff-Inliner und zugehörige Verbinder für Gasleitungen mit Betriebsdrücken über 16 bar“ (2004-06)

Gas/Water

DVGW GW 301 (A) „Unternehmen zur Errichtung, Instandsetzung und Einbindung von Rohrleitungen - Anforderungen und Prüfungen” (2011-10)

DVGW GW 302 (A) „Qualifikationskriterien an Unternehmen für grabenlose Neulegung und Rehabilitation von nicht in Betrieb befindlichen Rohrleitungen” (2001-09)

DVGW GW 310 (A) „Widerlager aus Beton – Bemessungsgrundlagen“ (2008-01)

DVGW GW 320-1 (A) „Erneuerung von Gas- und Wasserrohrleitungen durch Rohreinzug oder Rohreinschub mit Ringraum“ (2009-02)

DVGW GW 320-2 (A) „Rehabilitation von Gas- und Wasserleitungen durch PE-Reliningverfahren ohne Ringraum“ (2000-06)

DVGW GW 322-1 (A) „Grabenlose Auswechslung von Gas- und Wasserrohrleitungen – Teil 1: Press-/Ziehverfahren – Anforderungen, Gütesicherung und Prüfung; mit Korrekturen vom Januar 2009” (2003-10)

DVGW GW 322-2 (A) „Grabenlose Auswechslung von Gas- und Wasser-rohrleitungen – Teil 2: Hilfsrohrverfahren – Anforderungen, Gütesicherung und Prüfung; mit Korrekturen vom Januar 2009” (2007-03)

DVGW GW 323 (M) „Grabenlose Erneuerung von Gas- und Wasserversorgungsleitungen durch Berstlining – Anforderungen, Gütesicherung und Prüfung; mit Korrekturen vom Januar 2009“ (2004-07)

DVGW GW 325 (A) „Grabenlose Bauweisen für Gas- und Wasser-Anschlussleitungen – Anforderungen, Gütesicherung und Prüfung“ (2007-03)

DVGW GW 327 (A) „Auskleidung von Gas- und Wasserrohrleitungen mit einzuklebenden Gewebeschläuchen“ (2011-03)

DVGW GW 335-A2 (A) „Kunststoff-Rohrleitungssysteme in der Gas- und Wasserverteilung; Anforderungen und Prüfungen - Teil A2: Rohre aus PE 80 und PE 100“ (2005-11)

DVGW GW 335-A3 (A) „Kunststoff-Rohrleitungssysteme in der Gas- und Wasserverteilung; Anforderungen und Prüfungen - Teil A3: Rohre aus PE-Xa“ (2003-06)

DVGW GW 340 (A) „FZM-Ummantelung zum mechanischen Schutz von Stahlrohren und -formstücken mit Polyolefinumhüllung; Anforderungen und Prüfung, Nachumhüllung und Reparatur, Hinweise zur Verlegung und zum Korrosionsschutz“ (1999-04)

DVGW- GW 368 (A) „Längskraftschlüssige Muffenverbindungen für Rohre, Formstücke und Armaturen aus duktilem Gusseisen oder Stahl“ (2013-02)

Water

DVGW W 270 (A) „Vermehrung von Mikroorganismen auf Werkstoffen für den Trinkwasserbereich - Prüfung und Bewertung“ (2007-11)

DVGW W 291 (A) „Reinigung und Desinfektion von Wasserverteilungsanlagen“ (2000-03)

DVGW W 330 (P) „Auskleidung von Gas- und Wasserrohrleitung mit ein-zuklebenden Gewebeschläuchen“ (2011-03)

DVGW W 343 (A) “Sanierung von erdverlegten Guss- und Stahlrohrleitungen durch Zementmörtelauskleidung – Einsatzbereiche, Anforderungen und Prüfungen” (2005-04)
DVGW W 400-1 (A) “Technische Regeln Wasserverteilung (TRWV) Teil 1 – Planung” (2015-02)

DVGW W 400-2 (A) “Technische Regeln Wasserverteilung (TRWV) Teil 2 – Bau und Prüfung” (2004-09)

DVGW W 400-3 (A) „Technische Regeln Wasserverteilung (TRWV) – Teil 3: Betrieb und Instandhaltung“ (2006-09)

DVGW W 403 (M) „Entscheidungshilfen für die Rehabilitation von Wasserverteilungsanlagen“ (2010-04)

8.4 Health & Safety Regulations

DGUV Vorschrift 1 „Grundsätze der Prävention“ (2013-11)

DGUV Vorschrift 2 „Betriebsärzte und Fachkräfte für Arbeitssicherheit“ (2011-01)

DGUV Vorschrift 3 „Elektrische Anlagen und Betriebsmittel“ (1997-01)

DGUV Vorschrift 38 „Bauarbeiten“ (1997-01)

DGUV Vorschrift 52 „Krane“ (2001-01)

DGUV Vorschrift „Winden, Hub- und Zuggeräte“ (2008-07)

DGUV Vorschrift 70 „Fahrzeuge“ (2007-08)

DGUV Regel 100-001 „Grundsätze der Prävention“ (2014-05)

DGUV Regel 100-500 „Betreiben von Arbeitsmitteln (aktualisierte Fassung)“ (2017/03)
Kap. 2.8: „Betreiben von Lastaufnahmeeinrichtungen im Hebezugbetrieb“ (2007-03)
Kap. 2.12: „Erdbaumaschinen“ (2008-10)
Kap. 2.26: „Schweißen, Schneiden und verwandte Verfahren“ (2004-11)
Kap. 2.31: „Arbeiten an Gasleitungen“ (2010-03)
Kap. 2.39: „Anlagen für Gase der öffentlichen Gasversorgung“ (2009-09)

DGUV Regel 112-189 „Benutzung von Schutzkleidung“ (2007-10)

DGUV Regel 112-190 „Benutzung von Atemschutzgeräten“ (2011-12)

DGUV Regel 113-004 „Behälter, Silos und enge Räume; Teil 1: Arbeiten in Behältern, Silos und engen Räumen“ (2013-07)

DGUV Information 201-012 „Verfahren mit geringer Exposition gegenüber Asbest bei Abbruch-, Sanierungs- und Instandhaltungsarbeiten (bisher: BGI 664)“ (2006-12)

DGUV Information 201-020 „Sicherheitshinweise für grabenloses Bauen“ (2008/04)
DGUV Information 201-052 „Rohrleitungsbauarbeiten“ (2015-01)

DGUV Information 203-032 „Auswahl und Betrieb von Stromerzeugern auf Bau- und Montagestellen“ (2018-01)

DGUV Information 203-081 „Arbeiten an Rohbiogasleitungen“ (2015-02)

DGUV Information 203-085 „Arbeiten unter der Sonne“ (2016-08)

DGUV Information 203-086 „Chlorung von Trinkwasser“ (2017-03)

DGUV Information 208-016 „Handlungsanleitung für den Umgang mit Leitern und Tritten“ (2007-11)

8.5 Further guidelines and documentation

„Anweisung zum Schutze unterirdischer Telekommunikationslinien der Telekom Deutschland GmbH bei Arbeiten Anderer (Kabelschutzanweisung)“ (Stand 2017-06)

„Leitlinie zur hygienischen Beurteilung von organischen Materialien in Kontakt mit Trinkwasser (KTW-Leitlinie)“ (2016-03)

„Leitlinie zur hygienischen Beurteilung von Beschichtungen im Kontakt mit Trinkwasser (Beschichtungsleitlinie)“ (2016-03)

PAS 1075 „Rohre aus Polyethylen für alternative Verlegetechniken - Abmessungen, technische Anforderungen und Prüfung“ (2009-04)

CEN/TS 14632 „Kunststoff-Rohrleitungssysteme für die Entwässerung und Wasserversorgung mit und ohne Druck – Glasfaserverstärkte duroplastische Kunststoffe (GFK) auf der Basis von ungesättigtem Polyesterharz (UP) – Empfehlungen für die Beurteilung der Konformität“ (2012-05)

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