15 Linings

15 Linings

What is meant by linings is protective coatings on the internal surfaces of pipelines. Their purpose is to protect the material of the pipes against chemical reactions with the medium flowing through the pipes. The aim is above all that drinking water, as a medium, will be transported to the end consumer without suffering any adverse effects. Ductile iron pipes are lined as standard with cement mortar or polyurethane (PUR). These linings are considered to be an integral part of the pipe.

Ductile iron fittings and valves on the other hand are, in the majority of cases, coated internally and externally with epoxy, although polyurethane and vitreous enamelling are becoming increasingly important in this application. Cement mortar linings however are becoming less frequently used in fittings.

Generally speaking, the types of lining depend on the applications for which ductile iron pipe systems are used.

15.1 General

Ductile iron pipelines are normally equipped with factory-applied linings, with the linings differing between pipes on the one hand and fittings and valves on the other due to the application processes used. Basically, the linings are matched to the types of water or other mediums such as sewage which are being transported. **Table 15.1** is a listing of the types of water and other mediums, together with their special properties and the main requirements which are important in each case.

Table 15.1:
Overview of types of water and similar media to be transported and the main requirements which the lining has to meet

Medium transported	Main properties of the medium	Requirements for the lining
Drinking water meeting the drinking water regulations	In lime-carbonic acid equilibrium	■ Corrosion protection ■ Drinking water hygiene
Water similar to drinking water such as water for non-drinking use and cooling water	In lime-carbonic acid equilibrium	■ Corrosion protection ■ Drinking water hygiene
Raw water not meeting the drinking water regulations	Often lime-dissolving (acid)	■ Corrosion protection
Wastewater complying with DWA (German Association for Water, Wastewater and Waste) Merkblatt M 115-2 [1]	Meets the guideline values laid down in DWA Merkblatt M 115-2 [1]	■ Corrosion protection in the submerged area and in the atmosphere in the drainage sewer ■ Abrasion resistance ■ Resistance to chemicals ■ Resistance to jet cleaning
Industrial wastewater which is outside the requirements of DWA (German Association for Water, Wastewater and Waste) Merkblatt M 115-2 [1]	Contains acid to alkaline components	■ Corrosion protection in the submerged area and in the atmosphere in the drainage sewer ■ Abrasion resistance ■ Resistance to chemicals ■ Resistance to jet cleaning ■ Temperature resistance
Brines	High in salt	■ Corrosion protection ■ Abrasion resistance

Tables 15.2 and 15.3 provide information on the linings commonly used for ductile iron pipelines for transporting water of all kinds and sewage. The tables relate to the coatings used for the internal surface of pipes **(Table 15.2)** and of fittings and valves **(Table 15.3)** and to the coatings used on the surfaces in the joint region.

Table 15.2:
Overview of the applications of linings for ductile iron pipes

Field of application	Internal surfaces of pipes	Surfaces in the joint region
Drinking water under EN 545 [2]	Cement mortar lining based on blast furnace cement	Coating based on bitumen or on epoxy paint
	Polyurethane lining to EN 15655 [3]	Coating based on polyurethane or epoxy paint
Sewage under EN 598 [4] and other types of water	Cement mortar lining based on high-alumina cement	Coating based on epoxy paint
	Polyurethane lining to EN 15655 [3]	Coating based on polyurethane or epoxy paint
Industrial wastewater	Cement mortar lining based on high-alumina cement	Coating based on epoxy paint
	Polyurethane lining to EN 15655 [3]	Coating based on polyurethane or epoxy paint

Table 15.3:
Overview of the applications of linings for fittings and valves

Field of application	Type of lining on		
	Internal surfaces of fittings	Internal surfaces of valves	Surfaces in the joint region
Drinking water under EN 545 [2]	Lining of polymer-modified cement mortar	Epoxy coating to DIN 3476 [7] and RAL GZ 662 [6]	Coating based on bitumen or on epoxy paint
	Epoxy coating to EN 14901 [5] and RAL GZ 662 [6]		
	Vitreous enamel to DIN 51178 [8]	Vitreous enamel to DIN 51178 [8]	As for internal surfaces
	Polyurethane lining to EN 15655 [3]	—	As for internal surfaces
Sewage under EN 598 [4] and other types of water	Lining of polymer-modified cement mortar	Epoxy coating to DIN 3476 [7] and RAL GZ 662 [6]	Coating based on polyurethane or epoxy paint
	Epoxy coating to EN 14901 [5] and RAL GZ 662 [6]		
	Vitreous enamel to DIN 51178 [8]	Vitreous enamel to DIN 51178 [8]	As for internal surfaces
	Polyurethane lining to EN 15655 [3]	—	As for internal surfaces
Industrial wastewater	Epoxy coating to EN 14901 [5] and RAL GZ 662 [6]	Epoxy coating to DIN 3476 [7] and RAL GZ 662 [6]	As for internal surfaces
	Vitreous enamel to DIN 51178 [8]	Vitreous enamel to DIN 51178 [8]	As for internal surfaces
	Polyurethane lining to EN 15655 [3]	—	As for internal surfaces

15.2 Linings of pipes, fittings and valves for drinking water pipelines

15.2.1 Cement mortar linings of pipes and fittings

The cement mortar linings of ductile iron pipes and fittings are considered to be an integral part of the product. The requirements and test methods for them are therefore given in the product standard EN 545 [2].

The purposes of the cement mortar lining are as follows:

- To optimise hydraulic properties
- To prevent damage from corrosion. Such damage includes:
  - damage to the metallic material of pipes due to reactions with water and with substances dissolved in the water,
  - adverse effects on the operation of the pipeline caused by products of reaction on the inner wall of pipes (e.g. incrustation),
  - adverse effects on the water caused by products of reaction, e.g. non-allowable changes in parameters of the water (contamination, discoloration or turbidity).

The fields of use and limits of use of the cement mortar coating described are given in informative Annex E to EN 545 [2].

Under the above, the standard lining with blast furnace cement mortar as a binder is, in general, suitable for unrestricted use in the field of drinking water if the drinking water being transported complies with the European drinking water directive or national drinking water regulations.

For wastewater, sewage and other types of water (e.g. raw water, water for non-drinking uses), other cements can be used as binders as shown in **Tables 15.2 and 15.3**.

DIN 2880 [9] provides a wide range of information on the fields of use and special features of cement mortar linings for metal pipes. It defines the behaviour of and requirements for the linings for all types of water, sewage, salt water and brines. In addition, it gives direction for assessing shrinkage cracks and drying cracks in cement mortar linings and information on their self-healing characteristics.

Fig. 15.1:
Charging the pipe with cement mortar before the spin centrifuging

DVGW Arbeitsblatt W346 [10] provides practical recommendations on the pressure testing, flushing, disinfection, running-in and operation of drinking water pipelines with cement mortar linings.

DVGW Arbeitsblatt W 347 contains drinking water hygiene requirements and test methods for cementitious materials used in the drinking water field and thus covers cement mortar linings for ductile iron pipes and fittings.

The methods by which linings are produced are described in detail in **Chapter 3**, Production of pipes, fittings and accessories. **Fig. 15.1** shows a ductile iron pipe which is going to be lined with cement mortar, before the spin centrifuging.

15.2.2 Polyurethane linings for pipes and fittings

The polyurethane lining to EN 15655 [3] is applied to the smoothed and abrasive blasted internal surfaces of pipes and fittings by the two-component hot spraying technique **(Fig. 15.2)**.

The polyurethane lining acts as a high-resistance electrical insulator between the medium flowing through and the iron.

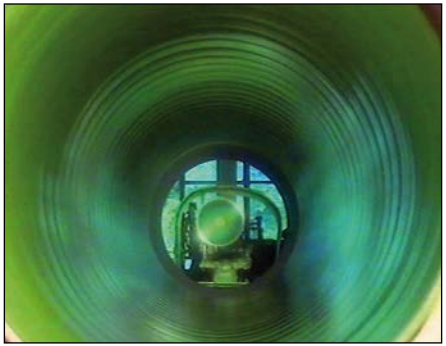

Fig. 15.2:
The polyurethane lining being applied in a pipe

Where pipes are cut on the installation site, the new cut face has to be re-coated with an epoxy-based repair paint.

The lining meets the requirements of the Guideline issued by the German Federal Environmental Agency (UBA) on the hygienic assessment of organic coatings in contact with drinking water and the requirements of DVGW-Arbeitsblatt W 270 [12].

15.2.3 Epoxy coating of fittings and valves

The technique usually employed for coating with epoxy powder consists of the following steps:

- activation of the surface of the fully fettled castings by blasting with sharp-edged steel grit – grade of cleanliness of the surface: SA 2 ½,
- heating in a continuous preheating oven,
- application of the powder by automated dipping into a fluidised bed of powder **(Fig. 15.3)** or by applying the powder with a spray gun **(Fig. 15.4)**,
- cross-linking of the fused-on layer of epoxy powder in a drying oven.

Fig. 15.3:
Application of epoxy powder by robot, using the fluidised bed technique

Fig. 15.4:
Electrostatic application of epoxy powder by means of a spray gun

The process technology, the monitoring to ensure that the production parameters laid down are observed and the quality testing of the finished coating are governed by the RAL-GZ 662 [6] quality assurance test specifications entitled "Heavy-duty corrosion protection of powder coated valves and fittings" which are issued by the GSK Quality Association for the Heavy Duty Corrosion Protection of Powder Coated Valves and Fittings.

The epoxy coating is also one of those listed in standards EN 545 [2] and EN 598 [4] and there are standards for the coating itself in the form of EN 14901 [5] and DIN 3476 [7].

15.2.4 Lining of fittings and valves with vitreous enamel

Enamel coatings have long proved their worth in the field of the lining of valves for use in drinking water applications **(Fig. 15.5)**. This lining is also being increasingly widely used for ductile iron fittings **(Fig. 15.6)**. There is a standard for it in the form of DIN 51178 [8].

Fig. 15.5:
Fully enamelled butterfly valve

Fig. 15.6:
Fittings during the enamel firing

15.2.5 Organic linings/coatings for the joint region

The surfaces in pipe joints are coated with organic materials. Such coatings are generally based on bitumen, epoxy or polyurethane.

Fig. 15.7 is a section through a push-in joint; it clearly shows that both the external surface of one pipe and the internal outline of the socket of the other pipe are in contact with drinking water.

The materials used for the epoxy coatings have to meet the requirements of the Guideline issued by the German Federal Environmental Agency (UBA) on the hygienic assessment of organic coatings in contact with drinking water.

The requirements for bituminous paints in the joint region are included in DVGW-Arbeitsblatt W 348 [13].

Generally speaking, all coatings and linings which are in contact with drinking water and which have organic constituents also have to be tested under DVGW-Arbeitsblatt W 270 [12] for their tendency to enhance microbial growth.

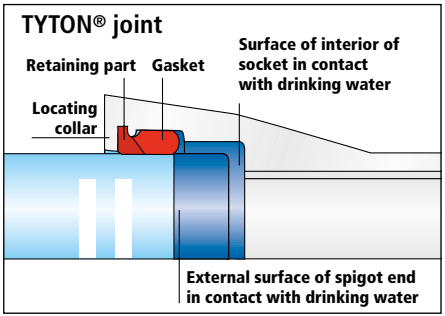

Fig. 15.7:
Surfaces in contact with drinking water in the region of the TYTON® joint

15.2.6 European rules and regulations

One special feature which exists in the field of drinking water is that there is a standard for pipelines for drinking water in the form of the European Construction Products Directive. The aim of this is to prevent there from being trade barriers of the sort which would result from differing national requirements.

The intention is however for the individual national rules and regulations to continue to exist. This means that a European approval procedure has to be set up under which requirements and test methods for components in contact with drinking water will be developed which can be adopted in all the member states without the national levels of protection having to be abandoned. Once this procedure comes into force, it will be possible for approval from the point of view of drinking water hygiene to be obtained for the component concerned in all the states of the EU by the passing of a single approval test.

15.3 Linings in pipelines for raw water

Raw water often does not meet the drinking water regulations. It is often highly lime-dissolving acid water.

In the course of time, lime-dissolving water may adversely affect the strength of cemetitious materials by dissolving the calcium carbonate containing in them.

The processes which this involves are all the more intensive the higher is the lime-dissolving capacity and the lower is the compaction of the lining.

Cement mortar linings based on high-alumina cement have proved successful for raw water which does not meet the drinking water directives. This lining is applied in pipes by the spin centrifuging technique and is therefore very highly compacted. High-alumina cement mortar contains virtually no free lime and is resistant to lime-dissolving water. Polymer-modified cement mortar too is resistant to lime-dissolving water.

Pipes with polyurethane linings to EN 15655 [3], fittings and valves with epoxy coatings to EN 14901 [5] and fittings and valves which are enamelled to DIN 51178 [2] are likewise suitable for transporting raw water.

15.4 Linings of pipes, fittings and valves for pipelines for wastewater and sewage

Wastewater and sewage contain considerably more materials than drinking water or raw water. Wastewater in public drainage systems must meet the guideline values given in DWA-Merkblatt M 115-2 [1]. This gives general guideline values for the most important criteria governing the characteristics of, above all, non-domestic wastewater.
However, there are many cases where these guideline values are exceeded by industrial wastewater before it is treated.

15.4.1 Cement mortar linings of pipes and fittings

There is a standard for ductile iron pipes and fittings for sewage disposal in the form of EN 598 [4]. The field of use in this case covers gravity and pressure sewers. The lining must withstand different mechanical and chemical stresses in the long term. It is produced with high-alumina cement as a binder.

This enables it to withstand not only chemical stresses such as those from soft, acid or very salt water but also mechanical stresses caused for example by detritus in the wastewater or sewage or by high-pressure jet-cleaning.

The lining of high-alumina cement mortar is highly compacted by the spin centrifuging process and is cured at high temperatures in special curing chambers in such a way that the aluminium hydrates acquire the stable cubic crystalline structure which is the basis for the high resistance of this lining.

The joint region is protected against attack by an epoxy coating.

15.4.2 Polyurethane linings of pipes and fittings

There is a standard for ductile iron pipes and fittings with polyurethane linings for sewerage applications in the form of EN 598 [4]. The field of use in this case covers gravity and pressure sewers. In the long term, the lining must withstand different mechanical and chemical stresses such as those from soft, acid or very salt water and also mechanical stresses caused for example by detritus in the sewage or by high-pressure jet-cleaning.

The polyurethane lining to EN 15655 [3] is applied to the smoothed and abrasive blasted internal surfaces of pipes and fittings by the two-component hot spraying technique. It acts as a high-resistance electrical insulator between the medium flowing through and the iron and ensures resistance to wastewater and sewage of all kinds.

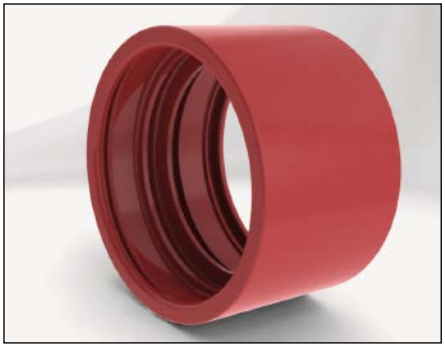

Fig. 15.8:
Sewer fitting with epoxy powder coating

15.4.3 Epoxy coating of fittings and valves for the transport of wastewater and sewage

In the wastewater and sewage field, fittings are provided as standard with an epoxy coating both internally and externally. The epoxy coating is listed in EN 598 [4] and the standard for it is EN 14901 [5]. **Fig. 15.8** shows a TYTON® collar which has an internal and external epoxy powder coating.

15.4.4 Lining of fittings and valves with vitreous enamel

Coatings and linings of vitreous enamel complying with DIN 51178 [8] are a possibility in the wastewater and sewage field. **Fig. 15.9** shows an enamelled gate valve for use in wastewater pressure pipelines.

Fig. 15.9:
Enamelled gate valve for use in wastewater pressure pipelines

15.5 Linings in pipelines for non-drinking and cooling water

Pipes and fittings from the range intended for drinking water can be used for transporting non-drinking and cooling water. Where there is any doubt it has to be established whether they are suitable. The technical departments of the various manufacturers provide advice on this.

With lime-dissolving water, what are suitable are pipes with linings based on high-alumina cement or polyurethane linings. The fittings and valves in such pipelines have to be protected with epoxy to EN 14901 [5] or vitreous enamel to DIN 51178 [8].

15.6 References

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[Valves and fittings for untreated and potable water – Protection against corrosion by internal epoxy coating of coating powder (P) or liquid varnishes (F) – Requirements and Test]
1996-08

[15.8] DIN 51178
Emails und Emaillierungen – Innen- und außenemaillierte Armaturen und Druckrohrformstücke für die Roh- und Trinkwasserversorgung – Qualitätsanforderungen und Prüfung
[Vitreous and porcelain enamels – Inside and outside enamelled valves and pressure pipe fitting for untreated and potable water supply – Quality requirements and testing]
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Anwendung von Zementmörtel-Auskleidung für Gußrohre, Stahlrohre und Formstücke
[Application of cement mortar lining for cast iron pipes, steel pipes and fittings]
1999-01

[15.10] DVGW-Arbeitsblatt W 346
Guss- und Stahlrohrleitungsteile mit ZM-Auskleidung – Handhabung
[DVGW worksheet W 346 Pipeline components of cast iron or steel with cement mortar lining – Treatment]
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[15.11] DVGW-Arbeitsblatt W 347
Hygienische Anforderungen an zementgebundene Werkstoffe im Trinkwasserbereich – Prüfung und Bewertung
[DVGW worksheet W 347 Hygienic requirements for cementitious products in contact with drinking water – Test methods and assessment]
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[15.11] DVGW-Arbeitsblatt W 270
Vermehrung von Mikroorganismen auf Werkstoffen für den Trinkwasserbereich – Prüfung und Bewertung
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