14 Coatings

14 Coatings

Coatings provide lasting protection for ductile iron pipelines. Coatings which are applied to pipes, fittings and valves in the works cater for soil conditions and are added to on site if necessary. Corrosion protection provisions specific to ductile iron pipes, and their fields of use, are described below.

14.1 General

As a general principle, pipes, fittings and valves are supplied with works-applied coatings which are added to on site if necessary. It is important for the provisions for corrosion protection to be selected in such a way as to ensure durability for the pipeline.

For this, it is necessary for an accurate knowledge to exist of the types of soil in which the pipelines are going to be laid.

The European product standards EN 545 [14.1] and EN 598 [14.2] include an informative Annex D in which the limits of use are given for different coating systems for pipes, fittings and accessories. These limits relate to important soil parameters which encourage the corrosion of ductile iron and these parameters include:

- resistivity of the soil,
- pH,
- reserve of acidity,
- position relative to the water table,
- heterogeneity (mixed soils),
- presence of refuse, cinders, slag, pollution from wastes or industrial effluents,
- peaty soils,
- occurrence of stray currents.

Whereas the polyethylene (EN 14628 [14.3]), polyurethane (EN 15189 [14.4]) and epoxy (EN 14901 [14.5]) coatings, which give high-resistance electrical insulation, and the conductive cement mortar coating (EN 15542 [14.6]) can be used in soils of all kinds, when the different variants of zinc-based active coatings are being selected attention must be paid to the soil parameters laid down for these coatings. These soil parameters have been selected in such a way as to rule out the use of the given variant. A table providing an overview of the fields of use follows in **section 14.2.1**.

Under the German rules, a systematic approach is adopted as follows: after a thorough investigation of the soil under DIN 50929-3 [14.7] along the route to be followed by the pipeline, the soil is classified as belonging to one of three classes of corrosiveness.

DIN 30675-3 [14.8] then governs the fields of use of the different types of corrosion protection for underground pipelines of ductile iron. The standard provides an overview of works-applied coatings and on-site measures as a function of the level of corrosiveness of the soil.

The fields of use for coatings for pipes, fittings and valves are grouped together in **table 14.1**.

Table 14.1:
Fields of use for underground pipelines of ductile iron with coatings to EN 14628 [14.3], EN 15189 [14.4], EN 15542 [14.6], DIN 30674-3 [14.9] and -5 [14.10], EN 14901 [14.5], DIN 51178 [14.14] in conjunction with DIN 30675-2 [14.8] for pipes, and EN 14901 [14.5] and DIN 51178 [14.14] for fittings and valves.

No.	Coating on pipes	Thickness of coating	Coating recommended for joints	Suitable bedding for corrosion protection	Fields of use in the form of soil classes
1	Zinc coating with finishing layer (cover coating), to DIN 30674-3 [14.9]	130 g/m² of zinc with finishing layer to EN 545 [14.1]	None	Not provided Provided	I, II I, II, III [2)]
2	Zinc coating with finishing layer, to OENORM B 2560 [14.11]	200 g/m² of zinc with ≥ 100 µm polyurethane finishing layer	None	Not provided Provided	I, II I, II, III [2)]
3	Cement mortar coating to EN 15542 [14.6]	5.0 mm	Heat-shrinkable material or B-50M[1)] coating to DIN 30672 [14.12] or rubber collars	Not provided	I, II, III
4	Polyethylene coating to EN 14628 [14.3]	1.8 to 3.0 mm	Heat-shrinkable material or B-50M[1)] coating to DIN 30672 [14.12]	Not provided	I, II, III
5	Polyurethane coating to EN 15189 [14.4]	≥ 700 µm	None	Not provided	I, II, III
6	Polyethylene sleeving to DIN 30674-5 [14.10] in conjunction with DIN 30674-3 [14.9]	0.2 mm	Same as pipes	Provided[3)]	I, II, III

No.	Coating on pipes	Thickness of coating	Coating recommended for joints	Suitable bedding for corrosion protection	Fields of use in the form of soil classes
7	Epoxy coating to EN 14901 [14.5]	≥ 250 µm	■ None if pipes are zinc coated (nos. 1 and 2) ■ Heat-shrinkable material or B-50M[1] coating to DIN 30672 [14.12] or rubber collars, if pipes are coated as in nos. 3 to 5	Not provided	I, II, III
8	Coating of technical enamel to DIN 51178 [14.14]	≥ 250 µm	■ None if pipes are zinc coated (nos. 1 and 2) ■ Heat-shrinkable material or B-50M[1] coating to DIN 30672 [14.12] or rubber collars, if pipes are coated as in nos. 3 to 5	Not provided	I, II, III

[1] At sustained temperatures of $T \leq 330$ °C, the B-50M coating to DIN 30672 [14.12] or the C-30M coating to DIN 30672 [14.12] may be used for joints.

[2] Not suitable when there is constant exposure to eluates of pH < 6 and in peaty, boggy, muddy and marshy soils

[3] The directions given in section 4.1 need to be followed.

Note: By agreement, materials for corrosion protection covered by DIN 30672 Part 1 [14.12] may be used for coating ductile iron pipes away from the joints

There is also standard DIN 30675-2 [14.8] which provides information on provisions for corrosion protection when there is an electrochemical action. As part of this it also deals with electrically insulating socket joints.

14.2 Works-applied coatings on pipes

14.2.1 Zinc coating with finishing layer

The standard coating given to ductile iron pipes is a zinc coating with a finishing layer, to EN 545 [14.1] and EN 598 [14.2]. In the majority of soils, this active coating provides lasting protection against damage by corrosion. The zinc coating and the finishing layer act synergistically, i.e. the combined effect they have in protecting against corrosion is better than the sum of the effects that the individual coatings would have.

For some years now, a coating which comprises a zinc-aluminium layer (proportion of zinc by mass 85 % and proportion of aluminium by mass 15 %) and an epoxy finishing layer has been available. For this coating, the mass of metal is increased to 400 g/m².

Another of the active protective systems is zinc applied in a mass of ≥ 200 g of Zn/m² with a polyurethane finishing layer at least 100 µm thick. There is a standard for this coating in Austria in the form of OENORM B 2560 [14.11].

The fields of use of these active protective systems are laid down in Annex D of EN 545 [14.1] in the form of exclusion criteria and they are shown in **Table 14.2**.

Under the German rules, these stipulations are supplemented by DIN 30675-2 [14.8]; Germany also recognises what is known as bedding suitable for corrosion protection. This consists of chemically neutral sands which stop the pipeline from coming into direct contact with corrosive types of soil.

Table 14.1 shows the fields of use for the systems, the soil classes being determined as indicated in DIN 50929-3 [14.7]. If the soil conditions call for a higher standard of corrosion protection, then the polyethylene coating to EN 14628 [14.3], the cement mortar coating to EN 15542 [14.6] or the polyurethane coating to EN 15189 [14.4] may be used, as desired.

The “zinc coating with protective finishing layer” corrosion protection system is stable in its field of use, the cast iron being separated from the soil by the finishing layer.

Pores in the finishing layer or injuries to the coating when the pipes are being installed “heal” and close due to the products of reaction produced by the zinc, which are only sparingly soluble in moist ground (a dielectric). These products form when metallic zinc reacts with constituents of the surrounding soil.

Fig. 14.1 shows the remote action of the zinc coating: in the rectangular areas, the coating had been injured by removing it before the test pipes were buried for nine years in a test field.

Table 14.2:
Fields of use and soil conditions for zinc-based active coatings, as specified in Annex D of EN 545 [14.1]

Type of protection under section 4.4.2 of EN 545 [14.1]	Soils in which protection of the given type is not to be used
Zinc coating ≥ 130 g of Zn/m² and finishing layer ≥ 70 μm	■ Soils with a resistivity < 1,500 Ω cm when laid above the water table, < 2,500 Ω cm when laid below the water table ■ Mixed soils. i.e. comprising two or more soil natures ■ Soil with a pH < 6 and a high reserve of acidity ■ Soils containing refuse, cinders, slag or polluted by waste or industrial effluents ■ If stray currents occur
Zinc coating ≥ 200 g of Zn/m² and finishing layer ≥ 100 μm	■ Soils with a resistivity < 1,500 Ω cm when laid above or below the water table ■ Mixed soils. i.e. comprising two or more soil natures ■ Soil with a pH < 6 and a high reserve of acidity ■ Soils containing refuse, cinders, slag or polluted by waste or industrial effluents ■ If stray currents occur
Zinc coating ≥ 400 g of ZnAl/m² and finishing layer ≥ 70 μm	■ Acidic peaty soils ■ Soils containing refuse, cinders, slag or polluted by waste or industrial effluents ■ Soils below the marine water table with a resistivity < 500 Ω cm ■ If stray currents occur

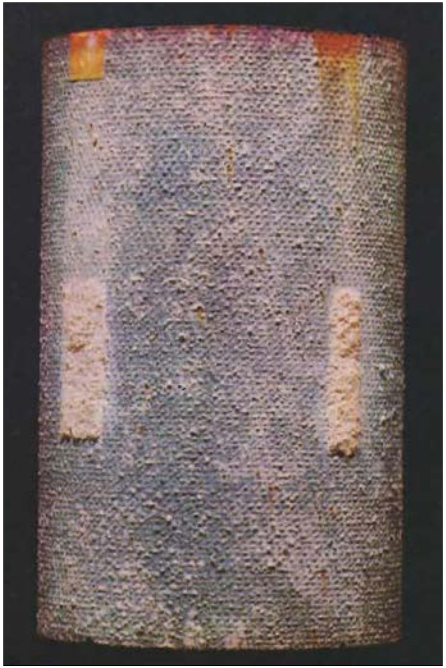

Fig. 14.1:
Autogenous healing of artificial injuries by products of reaction of zinc

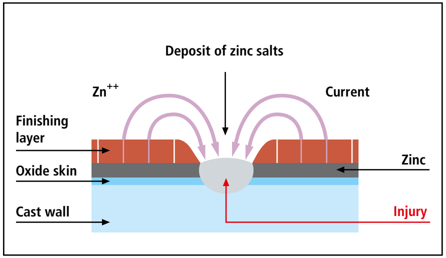

Fig. 14.2:
Cathodic protective effect of the zinc at injuries to the protective layer

By passing through the porous finishing layer for a few millimetres, the zinc ions are able to protect the exposed surface by depositing products of reaction which are hard to dissolve (a scarring or autogenous healing process). **Fig. 14.2** is a simplified schematic representation of the process.
All the relevant requirements for the pipe system are brought together in DVGW Arbeitsblatt GW 337 [14.13]. An additional requirement is that the mean mass of zinc per unit area must be at least 200 g/m^2 and for the Zn 85 – Al 15 system must be at least 400 g/m^2. In this way there is enough metallic zinc available for the zinc to be activated should any injuries occur at a later date, due say to movements of the ground or to subsequent digging work.

Under EN 545 [14.1] and EN 598 [14.2], the zinc coating on ductile iron pipes may also be provided with an at least 70 µm thick coating of bituminous paint. **Fig. 14.3** shows ductile iron sewer pipes to EN 598 [14.2] which have a reddish-brown coloured finishing layer of bituminous paint.

Fig. 14.3:
Ductile iron sewer pipes to EN 598 [14.2] with a zinc coating and a reddish-brown coloured finishing layer of bituminous paint.

14.2.2 Cement mortar coating

Ductile iron pipes with a cement mortar coating, **Fig. 14.4**, can be used in soils of all types. The cement mortar coating stops corrosive media from penetrating and withstands mechanical stresses during transport and installation. This coating has proved its worth particularly for the trenchless installation techniques of which increasing use is now being made. Under EN 15542 [14.6], the ability of the cement mortar coating to withstand mechanical loads is determined by two requirements:

- bond strength
- impact strength.

These requirements are formulated in such a way that the possibility of damage to the layer of cement mortar can be ruled out both in the course of proper transport and when installation takes place even in the most difficult terrain. For the production of the cement mortar coating see **Chapter 3**, **section 3.5**. Ductile iron pipes with a cement mortar coating are shown in **Fig. 14.4**.

Fig. 14.4:
Ductile iron pipes with a cement mortar coating

Should injuries nevertheless happen to occur (e.g. when installation is by the burst lining technique), the damaged areas are protected by the layer of zinc and the remote action which it has.

The joint regions are protected after assembly, see **section 14.4.2.**

14.2.3 Polyethylene coating

The polyethylene coating forms a layer of high electrical resistance separating the cast iron from the native soil. The layer needs to be at least 1 mm thick purely to provide corrosion protection and the rest of its thickness serves to improve the ability of the protective layer to withstand mechanical loads. **Fig. 14.5** shows ductile iron pipes with a polyurethane coating.

Fig. 14.5:
Ductile iron pipes with a polyethylene coating

EN 14628 [14.3] makes a distinction between the standard thickness coating and the increased thickness coating.

The requirements and tests specified in EN 14628 [14.3] are formulated in such a way that the polyethylene coating will withstand the usual stresses which occur during transport, storage and installation. The joint regions are protected after assembly, see **section 14.4.2**.

14.2.4 Polyurethane coating

The polyurethane coating **(Fig. 14.6)** forms a layer of high electrical resistance separating the cast iron from the native soil. Polyurethane resins are members of the thermoset family whose mechanical properties vary only slightly with temperature and which are not subject to cold flow.

The two-component resin system is sprayed onto the surface of the cast iron pipe, which has been blast-cleaned and heated, without solvents. Because of its relatively high hardness, impact resistance and resistance to indentation, a layer of a nominal thickness of 900 µm is adequate for the normal stresses occurring during transport, storage and installation. The polyurethane coating has also proved its worth for trenchless installation techniques. There is no need for the joint region to be provided with protection on site.
EN 15189 [14.4] lays down requirements and tests for the polyurethane coatings of ductile iron pipes.

Fig. 14.6:
Ductile iron pipes with a polyurethane coating

14.3 Coating of fittings and valves

Fittings and valves come in a wide variety of shapes and designs and because of this the characteristic feature of the methods and processes for coating them is often that the coating materials are applied simultaneously to all the surfaces of the components, i.e. both the internal and external surfaces, in a single step.

Automated processes employing programmed manipulators are increasingly being used for this purpose.

14.3.1 Epoxy coating

For use in both the drinking water field and for carrying sewage and wastewater, fittings and valves are usually given an epoxy coating **(Figs. 14.7 and 14.8)**. The coating is applied internally and externally in a mean thickness of at least 250 µm, predominantly in the form of epoxy powder, and the standard which applies to the coating is EN 14901 [14.5].

Fig. 14.7:
Epoxy coated resilient seated gate valve

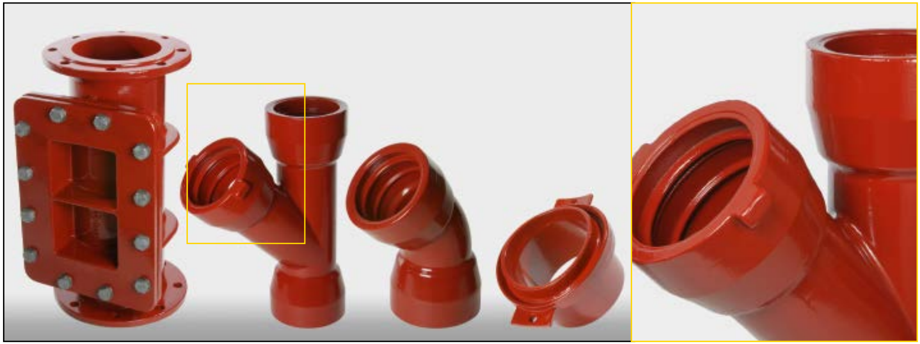

Fig. 14.8:
Epoxy coated fittings for sewage and wastewater

The quality and testing requirements for powder coatings of valves and fittings which are laid down in RAL-GZ 662 [14.20] are more demanding than those in EN 14901. The bond strength is higher than in EN 14901 (12 N/mm² as compared with 8 N/mm²) and the test voltage for freedom from pores is 3 kV rather than 1.5 kV. Also, the cathodic disbonding test was introduced as an indicator of resistance to undermining of the coating at injuries. The layer thickness and impact resistance are of the same levels. An extensive system of in-house and external monitoring ensures that the quality of the coating remains consistently high.

The method of producing the coating is described in **section 3.5.2**.

The coating can be used in soils of any desired corrosiveness.

14.3.2 Enamel coating of fittings and valves

Technical enamel can be used as a coating material for fittings and valves in soils of all types. DIN 51178 [14.14] , English title: Vitreous and porcelain enamels – Inside and outside enamelled valves and pressure pipe fittings for untreated and potable water supply – Quality requirements and testing, was published in October 2009.

The enamelling creates a strong physical and chemical bond (an ion bond) to the ductile iron. It is formed by processes of diffusion from the substrate material to the enamel and vice versa. Requirements and tests are given in DIN 51178 [14.14]. **Fig. 14.9** shows some fully enamelled fittings.

Fig. 14.9:
Fully enamelled fittings

The properties of the internal and external enamel coatings are as follows:

- internal corrosion protection of proven effectiveness,
- high resistance to corrosion in all soils,
- coating is continuous internally and externally,
- high resistance to mechanical stresses,
- secure against undermining of coating, even when the surface is injured locally,
- resistance to ageing

The enamelling process is described in **section 3.5.2**. Enamel coatings can be used in soils of any desired corrosiveness.

14.3.3 Bitumen coating of fittings

Ductile iron fittings are also available with an external coating of bituminous paint.

The thickness of the layer is at least 70 µm. Fittings coated in this way are generally provided with a cement mortar lining **(section 3.5.2)**.

Recently there has been an increasing trend towards this type of coating being replaced by the epoxy coating to EN 14901 [14.5].

Fig. 14.10 shows fittings with an external coating of bituminous paint and a variety of linings.

Fig. 14.10:
Fittings with an external coating of bituminous paint and a variety of linings
a) enamel
b) & c) cement mortar
d) bituminous paint

14.4 On-site measures

A distinction is made between measures at installation and repair measures in the case of the on-site measures.

Measures at installation supplement works-applied coatings which are already present. The pipeline or a section of the pipeline is provided with additional protection in this case. In the case of pipe coatings such as cement mortar or polyethylene coatings, it is the fittings which are provided with this later protection.

14.4.1 Bedding suitable for corrosion protection

Bedding suitable for corrosion protection is a layer of soil of soil class 1 (noncorrosive or only slightly corrosive under DIN 50929-3 [14.7]) which rests in a homogenous form against the surface of the pipeline on all sides.

Under DIN 30675-2 [14.8] it is used as a supplement to the zinc plus finishing layer system. Under EN 805 [14.15] and EN 1610 [14.16], it consists of the initial backfill, the side fill and the upper and lower bedding **(Fig. 14.11)**. This measure produces a homogeneous zone surrounding the pipeline, particularly in highly corrosive heterogeneous soils.

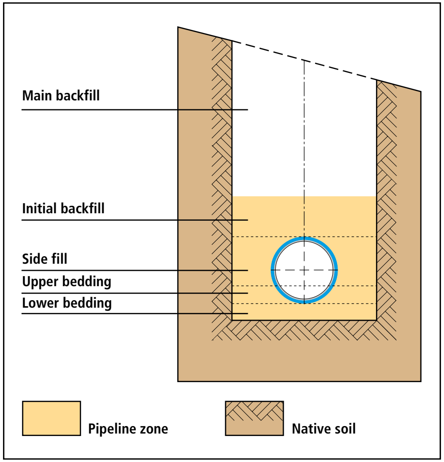

Fig. 14.11:
Terms relating to the bedding of pipes

As a result of this, spatially separated anode and cathode regions, which might cause deep or shallow pitting, do not form. Bedding suitable for corrosion protection should not be used where there is constant exposure to eluates whose pH is < 6 or in peaty, boggy, clayey or marshy soils.

14.4.2 Corrosion protection of joint regions

Once the joints have been assembled, the joint regions of pipelines with polyethylene or cement mortar coatings are coated as directed in the manufacturer's installation instructions (DIN 30675-2 [14.8]) **(Fig. 14.12)**.

What have proved successful for the protection of socket joints in polyethylene coated pipes is heat shrinkable material and, as an alternative for cement mortar coated pipes, rubber collars **(Fig. 14.13)**.

Fig. 14.12:
Application of a shrink sleeve

Fig. 14.13:
Ductile iron pipes with a cement mortar coating and with rubbers collars to protect the socket joints

14.4.3 Measures when there is electrochemical action

Corrosion protection when there is electrochemical action is dealt with in detail in DIN 30675-3 [14.8]. "Generally speaking, electrochemical action should not be expected in ductile iron pipelines with non-restrained joints due to the electrical break caused by the rubber-sealed joint between the pipes which occurs roughly every 6 m. Any measures to protect against electrochemical action can therefore be dispensed with."

What this standard mentions as causes of electrochemical actions are "Formation of electrochemical couples with extraneous cathodes and stray currents from direct current systems". The above is also true of pipelines with restrained joints where the restrained joints act as electrical insulators. It is only in pipelines with restrained joints where the joints are metal and conductive that provisions need to be made for electrochemical protection, such for example as:

- installation of pipe joints which act as electrical insulators approximately every 100 m,
- maintaining of an adequate distance from systems which have cathodic protection, by following the recommendations of the DVGW/VDE Working Party on Questions of Corrosion (the AfK) given in AfK 2 [14.17],
- drainage or forced drainage of stray currents in accordance with DIN EN 50162 and VDE 0150 [14.18].

Corrosion of buried ductile iron pipelines due to alternating current is dealt with in [14.19].

It is stated in the above article that the position is similar to that stated in DIN 30675-2 [14.8] for direct currents, namely that the only pipelines with restrained joints which are at risk from corrosion are ones more than about 100 m long which have metal conductive joints and whose coatings act as electrical insulators to alternating currents.

14.4.4 Repair measures

The coatings of pipes, fittings and valves are selected to be sufficiently robust for no significant injuries to occur to them provided they are properly handled.

If repairs nevertheless have to be made, e.g. if incorrect handling occurs or tapping or cutting is necessary, the manufacturer's installation instructions must be followed.

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