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Paints and varnishes — Corrosion protection of steel structures by protective paint systems —

Part 3: Design considerations

Peintures et vernis — Anticorrosion des structures en acier par systèmes de peinture —

Partie 3: Conception et dispositions constructives

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 14, *Protective paint systems for steel structures*.

This second edition cancels and replaces the first edition (ISO 12944-3:1998), which has been technically revised.

The main changes compared to the previous edition are as follows:

— the terms and definitions which were not used in the main part of the standard have been deleted;

— the normative references have been updated;

— 5.1 "General" has been added;

— the requirement for gap sealing material has been added in 5.3;

— the requirements for surface preparation in case of high and very high durabilities for C4 and higher, as well as Im1 to Im4, have been added;

— the title of Table A.1 has been corrected;

— a key has been added to Figure B.1;

— Figure D.1 c) has been deleted;

— the requirements for the radius in Figures D.5 and D.7 have been added;

— a bibliography has been added;

— the text has been editorially revised.

A list of all parts in the ISO 12944 series can be found on the ISO website.

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Introduction

Unprotected steel in the atmosphere, in water and in soil is subjected to corrosion that can lead to damage. Therefore, to avoid corrosion damage, steel structures are normally protected to withstand the corrosion stresses to which they will be subjected during the service life required of the structure.

There are different ways of protecting steel structures from corrosion. ISO 12944 (all parts) deals with protection by paint systems and covers, in the various parts, all features that are important in achieving adequate corrosion protection. Additional or other measures are possible but require particular agreement between the interested parties.

In order to ensure effective corrosion protection of steel structures, owners of such structures, planners, consultants, companies carrying out corrosion protection work, inspectors of protective coatings and manufacturers of coating materials need to have at their disposal state-of-the-art information in concise form on corrosion protection by paint systems. It is vital that such information is as complete as possible, unambiguous and easily understandable to avoid difficulties and misunderstandings between the parties concerned with the practical implementation of protection work.

ISO 12944 (all parts) is intended to give this information in the form of a series of instructions. It is written for those who have some technical knowledge. It is also assumed that the user of ISO 12944 (all parts) is familiar with other relevant International Standards, in particular those dealing with surface preparation.

Although ISO 12944 (all parts) does not deal with financial and contractual questions, attention is drawn to the fact that, because of the considerable implications of inadequate corrosion protection, non-compliance with requirements and recommendations given in ISO 12944 (all parts) can result in serious financial consequences.

ISO 12944-1 defines the overall scope of ISO 12944. It gives some basic terms and definitions and a general introduction to the other parts of ISO 12944. Furthermore, it includes a general statement on health, safety and environmental protection, and guidelines for using ISO 12944 (all parts) for a given project.

This document gives guidance on how to minimize the risk of corrosion by appropriate design measures for steel structures to be coated by protective paint systems.

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Paints and varnishes — Corrosion protection of steel structures by protective paint systems —

Part 3:
Design considerations

1 Scope

This document deals with the basic criteria for the design of steel structures to be coated by protective paint systems in order to avoid premature corrosion and degradation of the coating or the structure. It gives examples of appropriate and inappropriate design, indicating how problems of application, inspection and maintenance of paint systems can be avoided. Design measures which facilitate handling and transport of the steel structures are also considered.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1461, *Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods*

ISO 8501-1, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

ISO 8501-3, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 3: Preparation grades of welds, edges and other areas with surface imperfections*

ISO 12944-1, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 1: General introduction*

ISO 12944-2, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 2: Classification of environments*

ISO 12944-4, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 4: Types of surface and surface preparation*

ISO 12944-5, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 5: Protective paint systems*

ISO 12944-6, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 6: Laboratory performance test methods*

ISO 12944-7, *Paints and varnishes — Corrosion protection of steel structures by protective c paint oating systems — Part 7: Execution and supervision of paint work*

ISO 12944-8, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 8: Development of specifications for new work and maintenance*

ISO 12944-9, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 9: Protective paint systems and laboratory performance test methods for offshore and related structures*

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ISO 14713-1, *Zinc coatings — Guidelines and recommendations for the protection against corrosion of iron and steel in structures — Part 1: General principles of design and corrosion resistance*

ISO 14713-2, *Zinc coatings — Guidelines and recommendations for the protection against corrosion of iron and steel in structures — Part 2: Hot dip galvanizing*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12944-1, ISO 12944-2, ISO 12944-4, ISO 12944-5, ISO 12944-6, ISO 12944-7, ISO 12944-8, ISO 12944-9 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
design
way in which a structure is built up, as represented by a detailed plan of the structure, considering corrosion protection

4 General

The objective of designing a structure is to ensure that the structure is suitable for its function, has adequate stability, strength and durability, is constructed at an acceptable cost and is aesthetically pleasing.

The overall design shall be planned to facilitate surface preparation, painting, inspection and maintenance.

The shape of a structure can influence its susceptibility to corrosion. Therefore, structures should be designed such that corrosion cannot easily establish a foothold (a corrosion trap) from which it can spread. It is therefore strongly recommended that the designer consult a corrosion protection expert at a very early stage in the design process. Ideally, the corrosion protection system should be selected at that time, with due consideration to the type of service of the structure, its service life and maintenance requirements.

The shapes of the structural elements and the methods used to join them should be such that fabrication, joining and any subsequent treatment will not promote corrosion. Similarly, consideration should be given to the shape of the structure and its elements with respect to the category of its environment (see ISO 12944-2) when specifying a protective paint system.

Designs should be simple and excessive complexity should be avoided. Where steel components are in contact with, embedded in or enclosed in other building materials, e.g. brickwork, they are no longer accessible. Therefore, the corrosion protection measures shall be effective throughout the service life of the structure.

Steelwork to be hot dip galvanized shall be designed in accordance with the requirements of ISO 1461, ISO 14713-1 and ISO 14713-2.

5 Basic design criteria for corrosion protection purposes

5.1 General

The surfaces of steel structures exposed to corrosion stresses should be small in extent. The structure should have the smallest possible number of irregularities (e.g. overlaps, corners, edges). Joints should

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have preferably been made by welding, rather than bolting or riveting, to achieve a smoother overall surface. Discontinous welds and spot welds should only be used where the corrosion risk is negligible.

5.2 Accessibility

Steel components should be designed to be accessible for the purpose of applying, inspecting and maintaining the protective paint system. This can be facilitated, for example, by the provision of fixed walkways, powered platforms or other auxiliary equipment. The accessories which will be required for carrying out maintenance work safely (e.g. hooks, lugs and anchorages for scaffolding, guide rails for blast-cleaning and paint application vehicles) should be provided at the design stage.

Providing access for maintenance at a later date is difficult and if not included in the design, the designer should indicate clearly how it can be provided in the future.

All surfaces of the structure which have to be coated should be visible and within reach of the operator by a safe method. Personnel involved in surface preparation, painting and inspection should be able to move safely and easily on all parts of the structure in conditions of good lighting. Surfaces which are to be treated should be sufficiently accessible to allow the operator adequate space to work in (see Annex A).

Special attention should be paid to ensure access to openings in box members and tanks. The openings shall be of sufficient size to allow safe access for operators and their equipment, including safety equipment (see Annex B). In addition, supplementary ventilation holes should be at a location and of a size to permit the application of the protective paint system.

Narrow spaces between elements should be avoided whenever possible. Where it is not possible to avoid narrow spaces for structural and practical reasons, the advice given in Annex C should be followed.

Components which are at risk of corrosion and are inaccessible after erection should either be made of a corrosion resistant material or have a protective coating system which shall be effective throughout the service life of the structure. Alternatively, an allowance for corrosion (thicker steel) should be considered.

5.3 Treatment of gaps

Narrow gaps, blind crevices and lap joints are potential points for corrosion attack arising from retention of moisture and dirt, including any abrasive used for surface preparation. Potential corrosion of this kind should normally be avoided by sealing. The gap sealing material shall be compatible with the corrosion protection coating. In the most corrosive environments, the space should be filled with shim steel which protrudes from the sections and is welded all round. Mating surfaces should be sealed by continuous welds to prevent entrapment of abrasives and the ingress of moisture (see Figure D.3).

Special attention should be paid to points of transition from concrete to steel, particularly in the case of composite structures subject to severe corrosion stresses (see Figure D.4).

5.4 Precautions to prevent retention of deposits and water

Surface configurations on which water can be trapped, and thus in the presence of foreign matter increase the corrosive stress, should be avoided. The designer should also be aware of the possible effects of run-off, for example, from mild steel on to austenitic or ferritic stainless steel under a rust deposit, with the resulting corrosion of the stainless steel. Suitable precautions to meet these objectives are

— designs with inclined or chamfered surfaces,

— the elimination of open sections at the top or their arrangement in an inclined position,

— the avoidance of pockets and recesses in which water and dirt can be trapped, and

— the drainage of water and corrosive liquids away from the structure.

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Suitable design features which may be used to avoid deposits or water being trapped are illustrated in Figure D.1.

5.5 Surface imperfections

Prior to surface preparation, the surface shall be in accordance with the preparation grades of ISO 8501-3 (e.g. weldings, edges, holes). The preparation grade shall be specified (e.g. according to ISO 12944-8). The preparation grade shall be P3 in case of high and very high durabilities for C4 and higher, as well as Im1 to Im4.

5.6 Bolted connections

5.6.1 Slip-resistant connections with high-tensile bolts

The friction surfaces in slip resistant connections shall be blast-cleaned prior to assembly, to a minimum preparation grade of Sa 2½ as defined in ISO 8501-1, with an agreed roughness. A coating material with a suitable friction factor can be applied to the friction surface.

5.6.2 Preloaded connections

Particular care shall be taken in the specification of paint films for preloaded bolted connections. See ISO 12944-5:—[1)], 5.5.

5.6.3 Bolts, nuts and washers

Bolts, nuts and washers shall be protected against corrosion to the same durability as the corrosion protection of the structure.

5.7 Box members and hollow components

Since they minimize the surface area exposed to atmospheric corrosion, box members (interior accessible) and hollow components (interior inaccessible) have, for corrosion purposes, a particularly suitable cross-section at shape, provided that the requirements given below are fulfilled.

Open box members and hollow components which are exposed to surface moisture shall be provided with drain openings and effectively protected against corrosion.

Sealed box members and sealed hollow components shall be impervious to air and moisture. For this purpose, their edges shall be sealed by means of continuous welds and any opening shall be provided with sealing covers. During the assembly of such components, care shall be taken to ensure that no water is trapped.

Where the components are required to be hot dip galvanized prior to painting, the design requirements to enable galvanizing to be carried out shall be met (see ISO 1461 and ISO 14713-2).

NOTE This is particularly important to prevent the risk of explosions when galvanizing hermetically welded components and to avoid ungalvanized spots.

5.8 Notches

Notches in stiffeners, webs or similar building components should have a radius of not less than 50 mm (see Figure D.7) to allow adequate surface preparation and application of a protective paint system. Where the plate in which the notch is cut is thick (e.g. > 10 mm), the thickness of the surrounding plate should be reduced to facilitate surface preparation and paint application.

1) Under preparation.

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5.9 Stiffeners

When stiffeners are required, for example, between a web and a flange (see Figure D.7), it is essential that the intersection between the stiffener and the abutting components is welded all round to prevent the formation of gaps. The design of stiffeners should not allow the retention of deposits or water (see 5.3) and shall allow access for surface preparation and application of a protective paint system (see Annex C).

5.10 Prevention of galvanic corrosion

Where an electrically conducting joint exists between two metals of different electrochemical potential in conditions of continuous or periodic exposure to moisture (electrolyte), corrosion of the less noble (i.e. more electronegative) of the two metals will take place. The formation of this galvanic couple also accelerates the rate of corrosion of the less noble of the two metals. The corrosion rate depends on, among other factors, the potential difference between the two metals connected, their relative areas and the nature and period of action of the electrolyte.

Therefore, care shall be taken when joining less noble metal components to more noble metal components. Particular care shall be taken where the less noble metal component has a small surface area in comparison with that of the more noble metal. There is no objection to the use, under less severe conditions, of fasteners of small surface area made of stainless steel in components made from less noble metals. Spring washers (e.g. lock washers, serrated washers), however, shall not be used as they may seriously impair the long- term performance of the joint by rendering it prone to crevice corrosion.

If the design is such that galvanic coupling cannot be avoided, contacting surfaces should be electrically isolated, for example by painting the surfaces of both metals. If it is only possible to paint one of the metals adjacent to the junction, it shall, as far as feasible, be the more noble metal. Alternatively, cathodic protection can be considered.

5.11 Handling, transport and erection

The handling, transport and erection of a structure should be taken into account at the design stage. Consideration should be given to the method of lifting, and lifting points included in the design where necessary. The need for jigs to support components during lifting and transport should be considered, and for the appropriate precautions to prevent damage to the protective paint system during lifting, transport and on-site operations, e.g. welding, cutting and grinding.

The corrosion protection, both temporary and permanent, of connection points between prefabricated sections should be considered at the design stage.

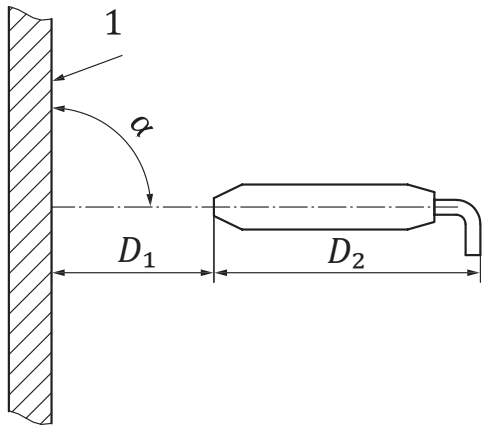
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Annex A
(informative)

Accessibility — Typical distances required for tools in corrosion protection work

Table A.1 — Typical distances required for tools in corrosion protection work

Operation	Length of tool (D_2)	Distance between tool and substrate (D_1)	Angle of operation (α)
	mm	mm	degrees (°)
Abrasive blast-cleaning	800	200 to 400	60 to 90
Power-tool cleaning			
— by needle gun	250 to 350	0	30 to 90
— by rubbing/grinding	100 to 150	0	—
Hand-tool cleaning			
— by brushing/chipping	100	0	0 to 30
Metal spraying	300	150 to 200	90
Paint application			
— by spraying	200 to 300	200 to 300	90
— by brush	200	0	45 to 90
— by roller	200	0	10 to 90



Key

1 substrate
α angle of operation
D_1 distance from tool to substrate
D_2 length of tool

Figure A.1 — Angle of operation and distance from tool to substrate

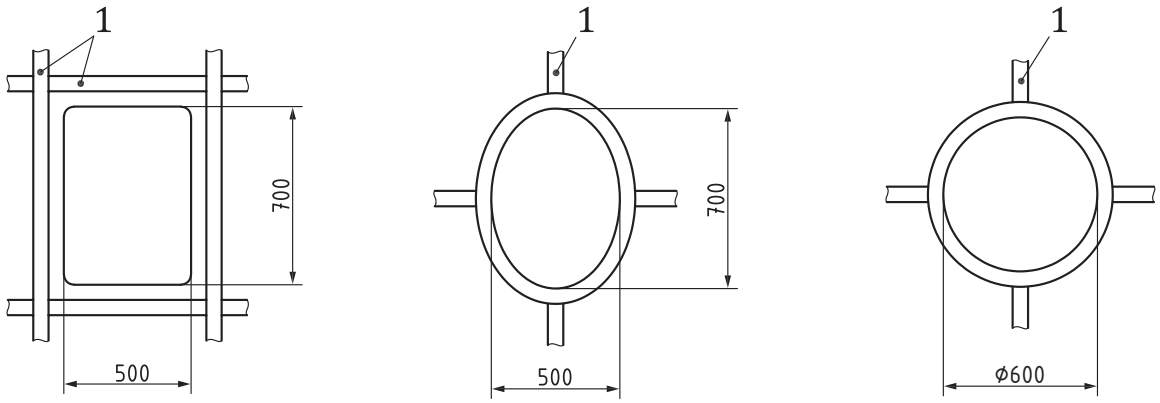
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Annex B
(informative)

Recommended minimum dimensions of openings for access to confined areas

Figure B.1 shows recommended minimum dimensions of openings for access to confined areas.

Dimensions in millimetres



a) Rectangular hole **b) Oval hole** **c) Round hole**

Key

1 stiffener

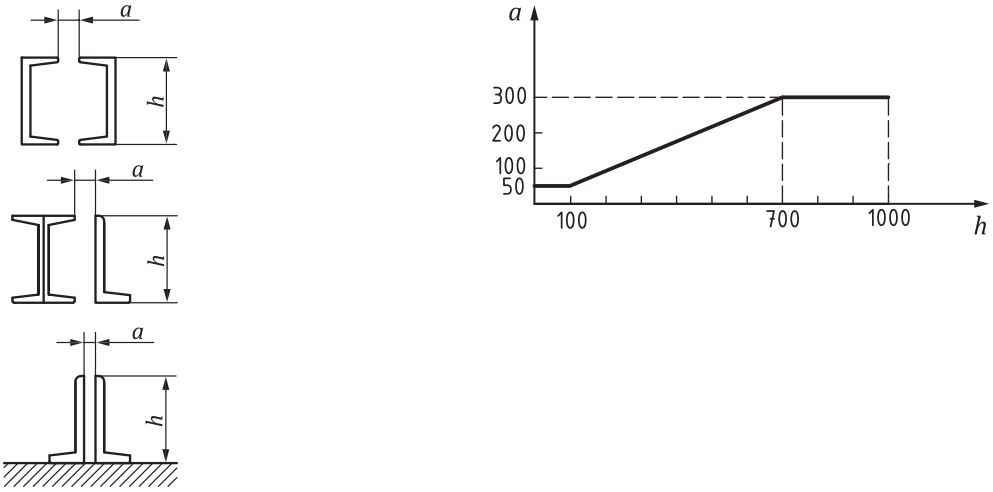
Figure B.1 — Recommended minimum dimensions of openings for access to confined areas

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Annex C
(informative)

Minimum dimensions for narrow spaces between surfaces

To make it possible to prepare, paint and maintain a surface, an operator needs to see and reach that surface with his tools. The criteria which are therefore important are access to see the surface and access to reach the surface.



Key

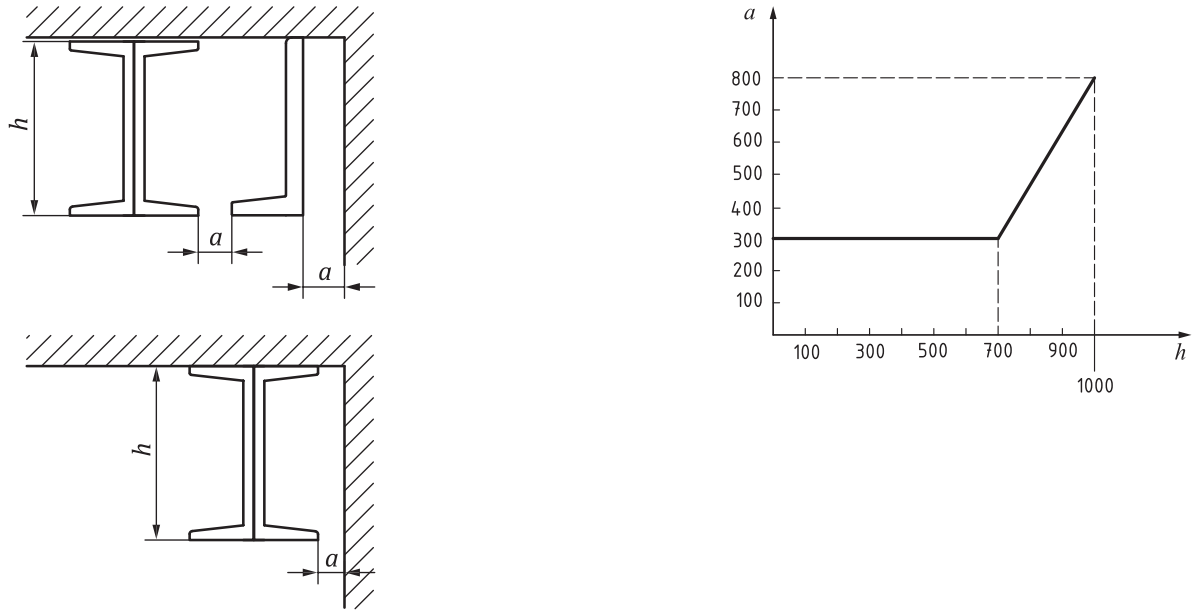
a minimum permitted distance between sections or between a section and an adjacent surface (mm)

h maximum distance an operator can reach into a narrow space (mm)

Figure C.1 — Minimum dimensions for narrow spaces between surfaces

The minimum permitted distance, *a*, between the two sections is given by Figure C.1, for a maximum distance an operator can reach into a narrow space, *h*, of up to 1 000 mm.

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Key

a minimum permitted distance between sections or between a section and an adjacent surface (mm)

h maximum distance an operator can reach into a narrow space (mm)

Figure C.2 — Minimum dimensions for narrow spaces between surfaces

The minimum permitted distance, *a*, between the section and the adjacent surface is given by Figure C.2.

If the operator has to reach distances greater than 1 000 mm, *a* in Figure C.2 should preferably be at least 800 mm.

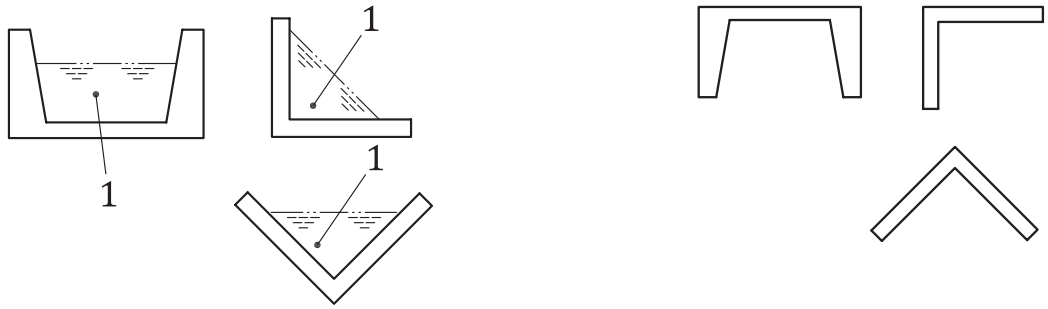
Where the designer cannot comply with the above recommendations, special measures shall be taken.

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Annex D
(informative)

Design features which can be used to avoid deposits accumulating or water being trapped

Drain holes, drip noses, drip spouts or breaks may be used to avoid deposits forming or water being trapped. Consideration should be given to the possibility of droplets of water being blown into a trap by the wind. When de-icing solutions are expected to be used, drainage pipes are particularly recommended to drain the solution off the structure.

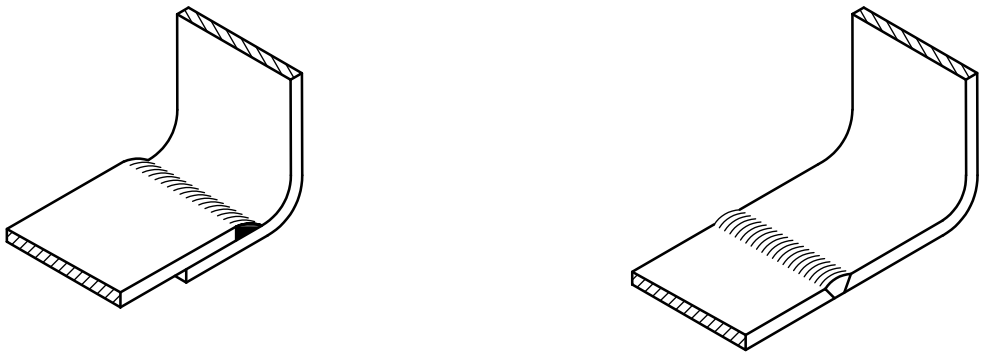


a) Bad **b) Good**

Key

1 trapped dirt and water

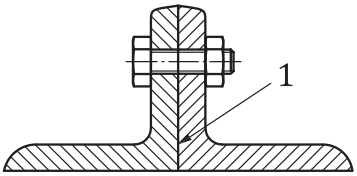
Figure D.1 — Avoidance of dirt and water traps



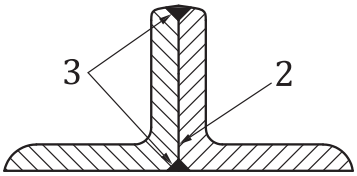
a) Difficult to clean and to paint **b) Easier to clean and to paint**

Figure D.2 — Design of welds

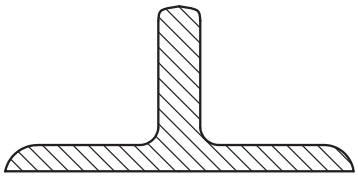
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a) Bad (narrow crevice, difficult to protect)



b) Better



c) Best (single solid component)

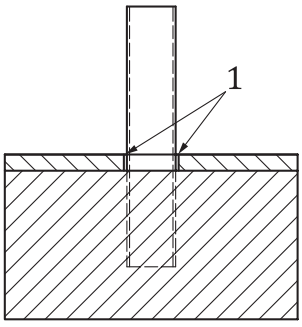
Key

1 crevice
2 closed crevice
3 continuous weld

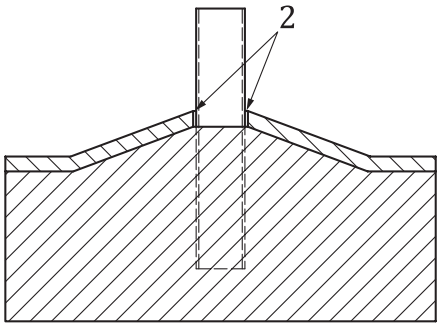
Figure D.3 — Treatment of gaps

NOTE 1 These examples are shown only to illustrate the principles.

NOTE 2 In the case of hot dip galvanizing, see 5.7.



a) Prone to corrosion



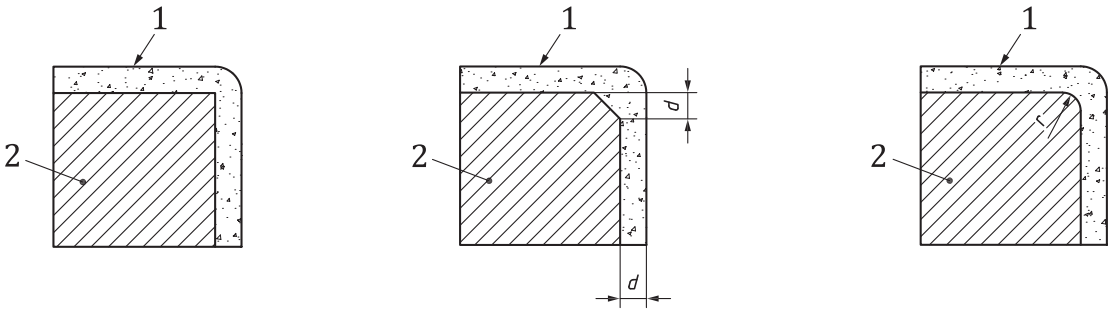
b) Application of protective coating system to steel component so the protection extends to a depth of approximately 5 cm into the concrete

Key

1 gap
2 gap closed by suitable means

Figure D.4 — Composite steel/concrete structure

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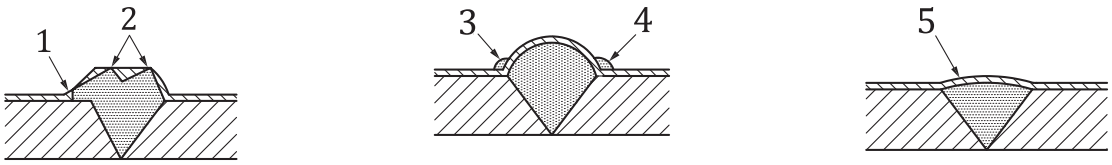


a) Sharp edge, poor **b) Chamferred edge, better** **c) Rounded edge ≥ 2 mm, good**

Key

1 protective paint system
2 steel

Figure D.5 — Avoidance of sharp edges



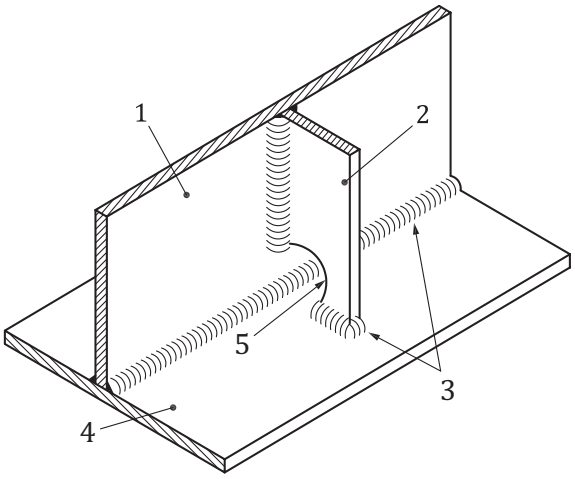
a) Poor **b) Better** **c) Good**

Key

1 protective paint system
2 irregularities
3 weld insufficiently flat
4 accumulated dirt
5 smooth weld surface

Figure D.6 — Avoidance of welding surface imperfections

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Key

1 web
2 stiffener
3 welds
4 bottom flange
5 notch (radius ≥ 50 mm)

Figure D.7 — Stiffener design recommended for corrosion protection

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Bibliography

[1] ISO 9223, *Corrosion of metals and alloys — Corrosivity of atmospheres — Classification, determination and estimation*

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ICS 87.020

Price based on 14 pages

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