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中国钢结构协会标准

CSCS

T/CSCSxxx-2025

# 钢结构建造质量控制标准

## 第 5 部分：焊接

**Steel structures — Execution of structural steelwork**

**Part 5: Welding**

2025-0X-XX 发布

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**Part 5: Welding**

**T/CSCS xxx-2025**

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## 前 言

本标准参照GB/T 1.2—2020 给出的规则起草。

本标准参考了ISO 17607:2023 Execution of Structural Steelworks 的技术内容。

T/CSCS xxx —2025《钢结构建造质量控制标准》分为如下七个部分：

- 第1部分：基本要求和术语；
- 第2部分：钢材；
- 第3部分：制造；
- 第4部分：安装；
- 第5部分：焊接；
- 第6部分：螺栓连接；
- 第7部分：涂装。

本部分为 T/CSCS xxx —2025的第5部分。

在采用ISO 17607:2023时，本部分做了一些修改。有关技术性差异已编入正文中并在它们所涉及的条款的页边空白处用垂直单线标识。在附录B中给出了这些技术性差异及其原因的一览表，以供参考。

对应于ISO 17607:2023，本部分还做了下列编辑性修改：

- “ISO 17607的本部分”修改为“T/CSCS xxx的本部分”；
- 用小数点“.”代替作为小数点的逗号“,”；
- 删除国际标准的前言和引言。

本部分的附录A为规范性、附录 B~D为资料性附录。

本标准由中国钢结构协会管理。

**本部分起草单位：**

**本部分主要起草人：**

## 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](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of 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 [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 167, *Steel and aluminium structures*.

A list of all parts in the ISO 17607 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

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# 1 范围

## 1 Scope

本标准结合 ISO 17607-1 定义了钢结构作为结构或建造部件执行焊接的一般要求。

This document defines the general requirements for welding in the execution of structural steelwork as structures or as manufactured components in conjunction with ISO 17607-1.

在建造钢结构工程（作为结构或预制部件）时需要解决的其他要求，可以在 ISO 17607 的其他部分中找到。

Additional requirements to be addressed in the execution of structural steelwork, as structures or as fabricated components, can be found in other parts of ISO 17607.

## 2 规范性引用文件

## 2 Normative references

以下规范的部分或全部内容构成本规范的要求。凡是注日期的引用文件，仅引用的版本适用。对于未注明日期的引用文件，应采用引用文件的最新版本（包括任何修订）。

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 636, 焊接材料—用于非合金钢和细晶钢的钨极惰性气体焊接的焊条、焊丝和焊缝金属—分类

ISO 636, *Welding consumables — Rods, wires and deposits for tungsten inert gas welding of non alloy and fine grain steels — Classification*

ISO 2560, 焊接材料—用于非合金钢和细晶钢的手工金属电弧焊的覆盖焊条—分类

ISO 2560, *Welding consumables — Covered electrodes for manual metal arc welding*

*of non-alloy and fine grain steels — Classification*

ISO 3452-1, 无损检测—渗透检测—第 1 部分：一般原则

ISO 3452-1, *Non-destructive testing — Penetrant testing — Part 1: General principles*

ISO 3834 (所有部分), 金属熔焊的质量要求

ISO 3834 (all parts), *Quality requirements for fusion welding of metallic materials*

ISO 4063, 焊接和相关工艺—工艺和参考编号的命名

ISO 4063, *Welding and allied processes — Nomenclature of processes and reference numbers*

ISO 5817:20—, 焊接—钢、镍、钛及其合金的熔焊接头（梁的焊接除外）—缺陷的质量等级

ISO 5817:20—, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections*

ISO 6520-1, 焊接和相关工艺—金属熔焊的几何缺陷分类—第 1 部分：熔焊

ISO 6520-1, *Welding and allied processes – Classification of geometric imperfections in metallic materials – Part 1: Fusion welding*

ISO 9606-1, 焊工资格测试—熔焊—第 1 部分：钢材

ISO 9606-1, *Qualification testing of welders — Fusion welding — Part 1: Steels*

ISO 9712, 无损检测—无损检测人员的资格和认证

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

ISO 10474, 钢和钢产品—检验文件

ISO 10474, *Steel and steel products — Inspection documents*

ISO 13588, 焊缝的无损检测—超声波检测—使用自动化相控阵技术

ISO 13588, *Non-destructive testing of welds — Ultrasonic testing — Use of automated phased array technology*

ISO 13916, 焊接—预热温度、层间温度和预热保持温度的测量

ISO 13916, *Welding — Measurement of preheating temperature, interpass temperature*

*and preheat maintenance temperature*

ISO 13918, 焊接—电弧螺栓焊用螺栓和陶瓷箍套

ISO 13918, *Welding — Studs and ceramic ferrules for arc stud welding*

ISO 14171, 焊接耗材—用于非合金钢和细晶粒钢的埋弧焊的实心焊丝、管状药芯焊丝和焊条/焊剂组合—分类

ISO 14171, *Welding consumables – Solid wire electrodes, tubular cored electrodes and electrode/flux combinations for submerged arc welding of non alloy and fine grain steels – Classification*

ISO 14174, 焊接耗材—用于埋弧焊和电渣焊的焊剂—分类

ISO 14174, *Welding consumables — Fluxes for submerged arc welding and electroslag welding — Classification*

ISO 14175, 焊接耗材—熔焊和相关工艺用气体和气体混合物

ISO 14175, *Welding consumables — Gases and gas mixtures for fusion welding and allied processes*

ISO 14341, 焊接耗材—用于非合金钢和细晶粒钢的气体保护电弧焊的焊丝和焊缝金属—分类

ISO 14341, *Welding consumables — Wire electrodes and weld deposits for gas shielded metal arc welding of non alloy and fine grain steels — Classification*

ISO 14555, 焊接—金属材料的电弧螺柱焊接

ISO 14555, *Welding — Arc stud welding of metallic materials*

ISO 14731, 焊接协调—任务和责任

ISO 14731, *Welding coordination — Tasks and responsibilities*

ISO 14732, 焊接人员—金属材料的完全机械化焊接和自动焊接的熔焊操作员和焊缝设置人员的资格测试

ISO 14732, *Welding personnel—Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials*

ISO 15607, 金属材料焊接工艺的规范和资格—一般规定

ISO 15607, *Specification and qualification of welding procedures for metallic materials*  
— *General rules*

ISO 15610, 金属材料焊接工艺的规范和资格—基于测试的焊接材料的资格

ISO 15610, *Specification and qualification of welding procedures for metallic materials*  
— *Qualification based on tested welding consumables*

ISO 15611, 金属材料焊接工艺的规范和资格—基于先前焊接经验的资格

ISO 15611, *Specification and qualification of welding procedures for metallic materials*  
— *Qualification based on previous welding experience*

ISO 15612, 金属材料焊接工艺的规范和资格—通过采用标准焊接工艺规范的资格

ISO 15612, *Specification and qualification of welding procedures for metallic materials*  
— *Qualification by adoption of a standard welding procedure specification*

ISO 15613, 金属材料焊接工艺的规范和资格—基于生产前焊接测试的资格

ISO 15613, *Specification and qualification of welding procedures for metallic materials*  
— *Qualification based on pre-production welding test*

ISO 15614-1, 金属材料焊接工艺的规范和资格—焊接工艺测试—第 1 部分：钢的电弧焊和镍及其合金的电弧焊

ISO 15614-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys*

ISO 16371-1, 无损检测—使用存储荧光体成像板的工业计算机断层扫描—第 1 部分：系统分类

ISO 16371-1, *Non-destructive testing — Industrial computed radiography with storage phosphor imaging plates — Part 1: Classification of systems*

ISO 16371-2, 无损检测—使用存储荧光体成像板的工业计算机断层扫描—第 2 部分：使用 X 射线和伽马射线对金属材料进行测试的一般原理

ISO 16371-2, *Non-destructive testing — Industrial computed radiography with storage phosphor imaging plates — Part 2: General principles for testing of metallic materials using X-rays and gamma rays*

ISO 16834, 焊接材料—用于高强度钢的气体保护电弧焊的焊丝、焊丝、棒材和焊缝金属—分类

ISO 16834, *Welding consumables — Wire electrodes, wires, rods and deposits for gas-shielded arc welding of high strength steels — Classification*

ISO 17607-1<sup>1</sup>, 钢结构—钢结构建造—第 1 部分：一般要求和术语

ISO 17607-1<sup>2</sup>, *Steel structures — Execution of structural steelwork— Part 1: General requirements and vocabulary*

ISO 17660-1<sup>3</sup>, 焊接—钢筋焊接—第 1 部分：受力焊接接头

ISO 17660-1<sup>4</sup>, *Welding — Welding of reinforcing steel — Part 1: Load-bearing welded joints*

ISO 17660-2<sup>5</sup>, 焊接—钢筋焊接—第 2 部分：非受力焊接接头

ISO 17660-2<sup>6</sup>, *Welding — Welding of reinforcing steel — Part 2: Non load-bearing welded joints*

ISO 17632, 焊接材料—用于非合金钢和细晶钢的气体保护和非气体保护金属电弧焊的管状药芯焊丝—分类

ISO 17632, *Welding consumables — Tubular cored electrodes for gas shielded and*

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<sup>1</sup> 正在准备中。出版时的阶段：ISO/DIS 17607-1

<sup>2</sup> Under preparation. Stage at the time of publication: ISO/DIS 17607-1.

<sup>3</sup> 正在准备中。出版时的阶段：ISO/DIS 17660-1

<sup>4</sup> Under preparation. Stage at the time of publication: ISO/DIS 17660-1.

<sup>5</sup> 正在准备中。出版时的阶段：ISO/DIS 17660-2

<sup>6</sup> Under preparation. Stage at the time of publication: ISO/DIS 17660-2.

*non-gas shielded metal arc welding of non-alloy and fine grain steels — Classification*

ISO 17635:2106, 焊缝的无损检测—金属材料的一般规则

ISO 17635:2106, *Non-destructive testing of welds — General rules for metallic materials*

ISO 17637, 焊缝的无损检测—熔化焊接接头的目视检测

ISO 17637, *Non-destructive testing of welds — Visual testing of fusion-welded joints*

ISO 17638, 焊缝的无损检测—磁粉检测

ISO 17638, *Non-destructive testing of welds — Magnetic particle testing*

ISO 17640, 焊缝的无损检测—超声波检测—技术、检测级别和评估

ISO 17640, *Non-destructive testing of welds – Ultrasonic testing – Techniques, testing levels, and assessment*

ISO 17652-1, 焊接—与焊接和相关工艺相关的车间底漆测试—第 1 部分：一般要求

ISO 17652-1, *Welding — Test for shop primers in relation to welding and allied processes — Part 1: General requirements*

ISO 17652-2, 焊接—与焊接和相关工艺相关的车间底漆测试—第 2 部分：车间底漆的焊接性能

ISO 17652-2, *Welding — Test for shop primers in relation to welding and allied processes — Part 2: Welding properties of shop primers*

ISO 18275, 焊接材料—用于高强度钢的手工电弧焊的涂覆焊条—分类

ISO 18275, *Welding consumables — Covered electrodes for manual metal arc welding of high-strength steels — Classification*

ISO 18276, 焊接材料—用于高强度钢的气体保护和非气体保护金属电弧焊的管状药芯焊丝—分类

ISO 18276, *Welding consumables — Tubular cored electrodes for gas-shielded and non-gas-shielded metal arc welding of high-strength steels — Classification*

ISO 23279, 无损检测—超声波检测—焊缝中不连续性的表征

ISO 23279, *Non-destructive testing – Ultrasonic testing – Characterization of discontinuities in welds*

ISO 26304, 焊接材料—用于高强度钢的埋弧焊的实心焊丝、管状药芯焊丝和焊丝/焊剂组合—分类

ISO 26304, *Welding consumables — Solid wire electrodes, tubular cored electrodes and electrode-flux combinations for submerged arc welding of high strength steels – Classification*

IIW-Doc. IIW-2259-15, 焊接接头和构件的疲劳设计建议

IIW-Doc. IIW-2259-15, *Recommendations for Fatigue Design of Welded Joints and Components*

### 3 术语和定义

### 3 Terms and definitions

对于本文件，适用 ISO 17607-1 中给出的术语和定义。

For the purposes of this document, the terms and definitions given in ISO 17607-1 apply.

ISO 和 IEC 在以下地址维护用于标准化的术语数据库：

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

—ISO 在线浏览平台：<https://www.iso.org/obp>

— ISO Online browsing platform: available at <https://www.iso.org/obp>

—IEC 电气百科全书：<https://www.electropedia.org/>

— IEC Electropedia: available at <https://www.electropedia.org/>

### 4 建造技术规格书和质量要求

### 4 Execution specification and quality requirements

可以部分或全部使用提供技术等效条件的国家标准和文件，代替参考的 ISO 标



准或本文件的要求。在这些情况下，应在建造技术规格书中引用国家标准和文件以及与本文件要求的偏差。

National standards and documents that provide technically equivalent conditions maybe used, in whole or in part, in place of referenced ISO standards or requirements of this document. In these cases, the national standards and documents and deviations from the requirements of this document shall be referenced in the execution specification.

在开始执行结构钢工作的每个部分之前，应就每个部分的建造所需的信息和技术要求达成一致并完整。应有程序对先前同意的建造技术规格书进行修改。

The necessary information and technical requirements for execution of each part of the structural steelwork shall be agreed upon and complete before commencement of execution of that part of the structural steelwork. There shall be procedures for making alterations to a previously agreed execution specification.

建造技术规格书应考虑以下相关项目：

The execution specification shall consider such of the following items as are relevant:

- a) 额外信息，见 A.1;
- a) additional information, see A.1;
- b) 选项，见 A.2;
- b) options, see A.2;
- c) 与建造级别（EXL）相关的要求，见 A.3;
- c) requirements related to execution levels (EXL), see A.3;

## **5 组成产品**

## **5 Constituent products**

### **5.1 一般规定**

### **5.1 General**

见 ISO 17607-1。

See ISO 17607-1.

除保护气体外，焊接材料的检验文件应符合 ISO 10474 的 2.2 条款。

The inspection documents for welding consumables, except for shielding gases, shall be 2.2 in accordance with ISO 10474.

对于保护气体，检验文件应是制造商出具的文件，声明所提供的产品符合订单规定的要求，无需测试结果。

For shielding gases, the inspection document shall be a document issued by the manufacturer declaring that the products supplied conform with the specified requirements of the order, without test results.

## **5.2 焊接材料**

### **5.2 Welding consumables**

焊接材料应符合表 1，或适用的国家标准或文件的要求。

Welding consumables shall be in accordance with Table 1, or, if applicable, the requirements of the national standard or documents.

焊接材料的类型应适合焊接工艺、待焊材料和焊接程序。

The type of welding consumables shall be appropriate to the welding process, the material to be welded and the welding procedure.

当焊接改进的耐候钢时，应选择能产生至少与母材相当的耐候的焊接材料。建造技术规格书应指定是否需要颜色匹配。

When welding improved atmospheric corrosion resistant steel, welding consumables shall be selected that will produce welds with atmospheric corrosion resistance at least equivalent to the parent metal. The execution specification shall specify if colour matching is required.

注：焊接材料的选择可以根据焊材产商、钢材产商的建议或适当的产品标准。

NOTE Selection of welding consumables can be based on welding consumable manufacturer recommendations, steel manufacturer recommendations or the

appropriate product standard.

表 1 焊接材料标准

Table 1 — Standards for welding consumables

焊接材料 Welding consumables	产品标准 Product standard
电弧焊和切割的保护气体 Shielding gases for arc welding and cutting	ISO 14175
用于非合金钢和细晶钢的气体保护金属电弧焊的焊丝和焊缝金属 Wire electrodes and deposits for gas-shielded metal arc welding of non-alloy and fine grain steels	ISO 14341
用于非合金钢和细晶钢的埋弧焊的实心焊丝、实心焊丝-焊剂和管状药芯焊丝-焊剂组合 Solid wires, solid wire-flux and tubular cored electrode-flux combinations for submerged arc welding of non alloy and fine grain steels.	ISO 14171
用于高强度钢的手工电弧焊的涂覆焊条 Covered electrodes for manual arc welding of high strength steels	ISO 18275
用于非合金钢和细晶钢的气体保护和非气体保护金属电弧焊的管状药芯焊丝 Tubular cored electrodes for metal arc welding with and without gas shield of non alloy and fine grain steels	ISO 17632
用于埋弧焊的焊剂 Fluxes for submerged arc welding	ISO 14174
用于非合金钢和细晶钢的钨极惰性气体焊的焊条、焊丝和焊缝金属 Rods, wires and deposits for tungsten inert gas welding of non alloy and fine grain steels	ISO 636
用于非合金钢和细晶钢的手工电弧焊的涂覆焊条 Covered electrodes for manual arc welding of non-alloy and fine grain steels	ISO 2560
用于高强度钢的气体保护电弧焊的焊丝、焊丝、棒材和焊缝金属 Wire electrodes, wires, rods and deposits for gas-shielded arc welding of high strength steels	ISO 16834
用于高强度钢的埋弧焊的焊丝、管状药芯焊丝和焊丝/焊剂组合 Wire and tubular cored electrodes and electrode-flux combinations for submerged arc welding of high strength steels	ISO 26304
用于高强度钢的气体保护金属电弧焊的管状药芯焊丝 Tubular cored electrodes for gas shielded metal arc welding of high strength steels	ISO 18276

### 5.3 螺柱焊接

### 5.3 Stud welding

螺柱和陶瓷套管应符合 ISO 13918 标准。

Studs and ceramic ferrules shall be in accordance with ISO 13918.

螺柱的检验文件应符合 ISO 10474 标准的 3.1 要求。

The inspection documents for studs shall be 3.1 in accordance with ISO 10474.

## 6 焊接

## 6 Welding

### 6.1 一般要求

#### 6.1 General

应根据 ISO 3834 的相关部分或适用的国家标准或文件的要求进行焊接。

Welding shall be undertaken in accordance with the relevant part of ISO 3834 or, if applicable, the requirements of the national standard or documents.

注：实施 ISO 3834 关于金属材料熔化焊接的质量要求的指南见 ISO/TR 3834-6。

NOTE Guidelines for implementation of ISO 3834 on quality requirements for fusion welding of metallic materials are given in ISO/TR 3834-6.

钢筋与结构钢的焊接应按照 ISO 17660-1 和 ISO 17660-2 中的建议进行。

The welding of reinforcing steel to structural steel shall be performed in accordance with the recommendations given in ISO 17660-1 and ISO 17660-2.

根据建造等级（EXL），以下 ISO 3834 的部分适用：

In accordance with the execution level (EXL), the following parts of ISO 3834 apply:

—EXL1: 第 4 部分 基本质量要求；

— EXL1: Part 4 Elementary quality requirements;

—EXL2: 第 3 部分 标准质量要求；

— EXL2: Part 3 Standard quality requirements;

—EXL3 和 EXL4: 第 2 部分 综合质量要求。

— EXL3 and EXL4: Part 2 Comprehensive quality requirements.

注：有关建造等级的信息，见 ISO 17607-1。

NOTE See ISO 17607-1 for information on execution levels.

## 6.2 焊接计划

### 6.2 Welding plan

#### 6.2.1 焊接计划的要求

##### 6.2.1 Requirements for a welding plan

焊接计划应作为 ISO 3834 相关部分要求的生产计划的一部分提供。

A welding plan shall be provided as part of the production planning required by the relevant part of ISO 3834.

#### 6.2.2 焊接计划的内容

##### 6.2.2 Content of a welding plan

对于 EXL1，焊接计划应符合 ISO 3834-4。

For EXL1 the welding plan shall be in accordance with ISO 3834-4.

对于 EXL2、EXL3 和 EXL4，焊接计划应包括以下相关内容：

For EXL2, EXL3 and EXL4, the welding plan shall include as relevant:

- a) 焊接工艺规范；
- a) the welding procedure specifications;
- b) 为降低焊接过程中及焊接后变形而采取的措施，包括施加的约束构造；
- b) measures to be taken to minimize distortion during and after welding, including details of restraints to be applied;
- c) 焊接顺序及任何限制或可接受的起始和停止位置，包括当接头几何形状使得无法连续执行焊接时的中间停止和开始位置；
- c) the sequence of welding with any restrictions or acceptable locations for start and stop positions, including intermediate stop and start positions where joint geometry is such that welding cannot be executed continuously;
- d) 中间检查焊接活动的要求；
- d) requirements for intermediate checking of the welding activities;
- e) 与焊接顺序相关的部件转动；

e) turning of components in the welding process, in connection with the sequence of welding;

f) 控制热输入并防止局部硬度问题的措施;

f) measures to control heat input and prevent local hardness issues;

g) 避免层状撕裂的措施;

g) measures to be taken to avoid lamellar tearing;

h) 焊接材料的处理和搬运 (储存、低氢、条件);

h) treatment and handling of welding consumables (storage, low hydrogen, conditioning);

i) 根据 6.6 的验收标准要求;

i) requirements for acceptance criteria of welds in accordance with 6.6;

j) 根据 7.2 的检验和测试计划的要求;

j) requirements for inspection and test plan in accordance with 7.2;

k) 焊接识别的要求;

k) requirements for weld identification;

l) 通过涂层进行焊接的要求。

l) requirements for welding through coatings.

如果焊接或组装重叠或掩盖了之前的焊缝,则需要特别注意哪些焊缝应首先执行,以及在执行第二个焊缝或组装遮盖组件之前是否需要检查或测试焊缝。

If welding or assembly overlaps or masks previous welds, special consideration shall be given concerning which welds are to be executed first and the possible need to inspect or test a weld before the second weld is executed or before masking components are assembled.

如果存在与疲劳或地震细节类别相关的焊接要求,则这些要求应包括在建造技术规格书中。

If there are welding requirements related to fatigue or seismic detail categories, these

shall be included in the execution specification.

如果存在与焊接设备的检查、维护和修理相关的特定要求，则这些要求应包括在建造技术规格书中。

If there are specific requirements related to the inspection, maintenance, and repair of welding equipment, these shall be included in the execution specification.

## **6.3 焊接过程**

### **6.3 Welding processes**

应使用 ISO 4063 定义的焊接过程，或建造技术规格书允许的过程进行焊接。

Welding shall be performed using the welding processes as defined in ISO 4063, or as permitted by the execution specification.

## **6.4 焊接工艺和焊接人员的资格认证**

### **6.4 Qualification of welding procedures and welding personnel**

#### **6.4.1 焊接工艺的资格认证**

##### **6.4.1 Qualification of welding procedures**

###### **6.4.1.1 一般规定**

###### **6.4.1.1 General**

应使用符合表 2 的合格焊接程序规范（WPS）进行焊接。WPS 的资格认证方法取决于建造等级、母材和机械化程度。

Welding shall be carried out using qualified welding procedure specifications (WPS) in accordance with Table 2. The method of qualification of the WPS depends on the execution level, the parent metal and the degree of mechanization.

焊接工艺的规范和资格认证应符合 ISO 15607。尽管 ISO 3834-4 中没有针对 ISO 15607 的焊接工艺规范的具体要求，但建造技术规格书可能规定，对于 EXL1，应提供适当的工作指导，以指定使用的焊接过程、消耗品和焊接参数。

The specification and qualification of welding procedures shall be in accordance with ISO 15607. Although there are no specific requirements for welding procedure

specifications to ISO 15607 in ISO 3834-4, the execution specification may specify that, for EXL1, appropriate work instructions that specify the welding process, consumables and welding parameters to be used shall be provided.

WPS 中应包括点焊的特定条件。

Specific conditions for tack welds shall be included in the WPS.

对于空心截面桁架结构的接头，WPS 应定义起始和终止区域以及用于处理焊缝从角焊缝变为焊缝周围的接头的方法。

For joints in hollow section lattice structures, the WPS shall define the start and stop zones and the method to be used to address locations where the welds change from a fillet weld to butt around a joint.

#### **6.4.1.2 根据 ISO 15613 或 ISO 15614-1 的资格认证**

#### **6.4.1.2 Qualification to ISO 15613 or ISO 15614-1**

在根据 ISO 15613 或 ISO 15614-1 进行焊接程序规范(WPS)的资格认证时，适用以下条件：

The following conditions apply when qualifying WPSs are in accordance with ISO 15613 or ISO 15614-1 (see also Table 2):

- a) 如果指定了冲击试验，应在被连接材料质量所需的最低温度下进行冲击试验。
- a) if impact tests are specified, they shall be carried out at the lowest temperature required for impact testing of the material qualities being joined.
- b) 对于淬火和回火钢，需要进行一次微观检查。应记录焊缝金属、熔合线区域和热影响区的照片。不允许存在微裂纹。
- b) for quenched and tempered steels, one specimen for micro-examination is necessary. Photographs of weld metal, fusion line zone and HAZ shall be recorded. Microcracks are not permitted.

注：关于微裂纹的信息，请参见 ISO 5817。

NOTE Information on microcracks can be found in ISO 5817.

- c) 如果在预制底漆上进行焊接，应在最大（名义值+公差）接受的涂层厚度上进



行试验。

c) if welding on prefabrication primers, tests shall be carried out on the maximum (nominal + tolerance) accepted layer thickness.

**表 2 焊接程序的资格认证方法**

**Table 2 — Methods of qualification of welding procedures**

资格认证方法 Method of qualification	标准 Standard	EXL2 <sup>a</sup>	EXL3 <sup>a</sup>	EXL4 <sup>a</sup>
焊接程序试验 Welding procedure test	ISO 15614-1 ISO 14555 ISO 17660-1 ISO 17660-2	X	X	X
预生产焊接试验 Pre-production welding test	ISO 15613 ISO 14555 ISO 17660-1 ISO 17660-2	X	X	X
标准焊接程序 Standard welding procedure	ISO 15612	X	X <sup>b</sup>	X <sup>b</sup>
过往焊接经验 Previous welding experience	ISO 15611 ISO 14555	X	—	—
测试过的焊接消耗品 Tested welding consumables	ISO 15610			

<sup>a</sup> X=允许, 破折号(—)=不允许

<sup>a</sup> X = Permitted,a dash (—) = Not permitted

<sup>b</sup> 如果建造技术规格书允许

<sup>b</sup> If permitted by the execution specification

#### 6.4.1.3 焊接程序的资格认证有效性

#### 6.4.1.3 Validity of a welding procedure qualification

焊接程序资格认证的有效性取决于用于资格认证的标准的要求。

The validity of a welding procedure depends on the requirements of the standard used for the qualification.

#### 6.4.2 焊工和焊接操作员

#### 6.4.2 Welders and welding operators

焊工（包括执行点焊的人员）应根据 ISO 9606 进行资格认证，焊接操作员应根据 ISO 14732 或提供等效技术条件的其他标准进行资格认证。

Welders (including personnel undertaking tack welding) shall be qualified in accordance with ISO 9606- 1 and welding operators in accordance with ISO 14732 or other standards that provide equivalent technical conditions.

钢筋焊工应根据 ISO 17660-1 或 ISO 17660-2 进行资格认证。

Welders of reinforcing steel shall be qualified in accordance with ISO 17660-1 or ISO 17660-2.

对于角度小于 60°的空心截面分支连接的焊工，除非另有规定，应根据 ISO 9606-1 或其他提供等效技术条件的标准进行资格认证，除非另有规定：

Welders of a hollow section branch connection with angles less than 60° shall be qualified in accordance with ISO 9606-1, or other standards that provide equivalent technical conditions, and as follows, unless otherwise specified:

- a) 试件尺寸、焊缝细节和焊接位置应与生产中使用的典型情况相符；
- a) test piece dimensions, weld details and welding positions shall be typical of those used in production;
- b) 对于圆形对圆形空心截面的焊接，试件检查应从附录 B 中的图 B.2 和 B.3 所示的四个位置 A、B、C 和 D 中各取一个。
- b) for welding of circular onto circular hollow sections, test pieces for examination shall be taken from each of the four positions A, B, C and D shown in Figures B.2 and B.3 in Annex B;

所有焊工和焊接操作员资格测试的记录应保留。

Records of all welder and welding operator qualification tests shall be retained.

### **6.4.3 焊接协调**

#### **6.4.3 Welding coordination**

对于 EXL2、EXL3 和 EXL4，在焊接建造过程中，应由适合并有经验监督他们监管的焊接操作的焊接协调人员进行焊接协调，如 ISO 14731 中规定。

For EXL2, EXL3 and EXL4, welding coordination shall be maintained during the execution of welding by welding coordination personnel suitably qualified for and

experienced in the welding operations they supervise as specified in ISO 14731.

焊接协调人员对焊接加固钢的技术知识应符合 ISO 17660-1 的规定。

The technical knowledge of welding coordination personnel for welding reinforcement steel shall be in accordance with ISO 17660-1.

#### **6.4.4 预制底漆**

#### **6.4.4 Prefabrication primers**

预制底漆应根据 ISO 17652-1 和 ISO 17652-2 证明其可焊性。如果试件中的缺陷在 ISO 5817 规定的质量等级 B 的指定限制之内，则焊接程序被视为合格，但孔洞除外，孔洞应如下：

Prefabrication primers shall demonstrate their weldability according to ISO 17652-1 and ISO 17652-2. The welding procedure is qualified if the imperfections in the test piece are within the specified limits of quality level B according to ISO 5817 except for porosity which shall be as follows:

a) 非线性孔洞（孔洞群的距离 $\leq$ 孔洞直径）；

a) no linear porosity (cluster of porosity with distance between pores  $\leq$  diameter of pores);

b) 对于通常或规定为承受疲劳的部件，孔洞最大为 ISO 5817:20—，附录 A 要求的 8%，或仅为 4%。

b) 8% maximum as required in ISO 5817:20—, Annex A for components generally or 4% maximum for components specified as being subject to fatigue.

### **6.5 焊接的准备和建造**

### **6.5 Preparation and execution of welding**

#### **6.5.1 接头准备**

#### **6.5.1 Joint preparation**

##### **6.5.1.1 一般规定**

##### **6.5.1.1 General**

接头的准备工作应适合焊接工艺。焊缝准备和装配的公差应在焊接程序规范

(WPS)中给出。

The joint preparation shall be appropriate for the welding process. Tolerances for joint preparations and fit-up shall be given in the WPSs.

如果为了确保焊接到而提供切削孔, 则其最小半径应为 40 毫米, 除非另有规定。

If cope holes are provided to ensure accessibility, they shall have a minimum radius of 40 mm unless otherwise specified.

注 1: ISO 9692-1 和 ISO 9692-2 提供了一些推荐的焊缝准备细节。

NOTE 1 ISO 9692-1 and ISO 9692-2 provide some recommended weld preparation details.

接头准备应无可见裂纹。对于屈服强度超过 460 MPa 的钢级, 切割区域应通过打磨去除氧化皮, 并通过目视检查(VT)、液体渗透检测(PT)或磁粉检测(MT)验证无裂纹。可见裂纹应通过打磨去除, 并在必要时校正接头几何形状。

The joint preparation shall be free from visible cracks. For steel grades with yield strengths higher than 460 MPa, cut areas shall be descaled by grinding, and verified to be free from cracks by VT, PT or MT. Visible cracks shall be removed by grinding and the joint geometry, corrected, as necessary.

如果通过焊接来校正大的缺口或其他接头几何形状误差, 应使用合格的程序, 并且随后应将该区域打磨平滑, 并平滑地过渡到相邻表面, 避免在轮廓上出现突然变化。

If large notches or other errors in joint geometry are corrected by welding, a qualified procedure shall be used, and the area shall be subsequently ground smooth and feathered into the adjacent surface without abrupt changes in contour.

所有待焊表面应无可能对焊缝质量产生不利影响或妨碍焊接过程的材料(例如锈、有机材料、镀锌)。

All surfaces to be welded shall be free from material (e.g. rust, organic material, galvanizing) that would adversely affect the quality of the welds or impede the process of welding.

预制底漆只有在不影响焊接过程的情况下才允许留在熔合面上。对于 EXL2、EXL3 和 EXL4，除非使用这些预制底漆完成了符合 ISO 15614-1 或 ISO 15613 的焊接程序测试，否则不应在熔合面上留下预制底漆。

Prefabrication primers may be left on the fusion faces only if they do not adversely affect the welding process. For EXL2, EXL3 and EXL4, prefabrication primers shall not be left on the fusion faces, unless welding procedure tests in accordance with ISO 15614-1 or ISO 15613 have been completed using such prefabrication primers.

注 2：ISO 17652-2 描述了评估预制底漆和车间底漆对焊接能力影响的测试。

NOTE 2 ISO 17652-2 describes tests for assessing the influence of prefabrication and shop primers on weldability.

#### **6.5.1.2 空心截面**

##### **6.5.1.2 Hollow sections**

用作焊接接头的分支组件的空心截面，其接头几何形状的装配应符合 WPS 的要求。圆管之间的分支接头可以切割成直线段，以准备在马鞍形接头处进行连接。For hollow sections being used as branch components in welded joints, the fit-up of the joint geometry shall suit the requirements of the WPS. Branch joints between circular hollow sections may be cut in straight segments to prepare them for interconnection at saddle joints.

附录 B 展示了圆形空心截面之间的分支接头。

Annex B illustrates branch joints between circular hollow sections.

对于空心截面桁架结构中的分支连接，通过焊接表面堆焊进行的任何间隙调整都应由适当的焊接程序覆盖。

For branch connections in hollow section lattice structures, any adjustment for lack of fit by a welded surface deposit shall be covered by a suitable welding procedure.

#### **6.5.2 焊接材料的储存和搬运**

##### **6.5.2 Storage and handling of welding consumables**

焊接材料应根据制造商的建议进行储存、搬运和使用。另见 6.5.2.1。

Welding consumables shall be stored, handled and used in accordance with the manufacturer's recommendations. See also 6.5.2.1.

焊材一旦从原包装中取出，应按照制造商的建议进行保护或储存，以使其规定的性能和焊接特性不受影响。

After consumables have been removed from their original packages, they shall be protected or stored in accordance with the manufacturer's recommendations so that their specified properties and welding characteristics are not adversely affected.

未在干燥条件下储存、未保持无锈、无油、无油脂或其他外来物质，或已受潮的焊材应予以丢弃。

Consumables that have not been stored in dry conditions, kept free from rust, oil, grease or other foreign materials or that have been wet shall be discarded.

显示损坏或恶化迹象的焊接材料应予以丢弃。

Welding consumables showing signs of damage or deterioration shall be discarded.

如果需要对焊条和助焊剂进行烘干和储存，应根据制造商的建议满足适当的温度水平和时间。

If electrodes and fluxes need to be dried and stored, appropriate temperature levels and times shall be fulfilled in accordance with the manufacturer's recommendations.

注：损坏或退化的情况包括涂层焊条的涂层开裂或剥落、焊条生锈或脏污，以及焊条上的铜涂层剥落或损坏。

NOTE Examples of damage or deterioration include cracked or flaked coatings on covered electrodes, rusty or dirty electrode wires and electrode wires with flaked or damaged copper coatings.

#### **6.5.2.1 手工电弧焊用的涂覆焊条和具有特定控制氢特性的助焊剂**

##### **6.5.2.1 Coated electrodes for manual metal arc welding and fluxes with specific controlled hydrogen properties**

手工电弧焊用的涂覆焊条（ISO 4063 工艺 111）和具有特定控制氢特性的助焊剂应根据焊接消耗品制造商的建议进行储存。

Coated electrodes for manual metal arc welding (ISO 4063 process 111) and fluxes with specific controlled hydrogen properties shall be stored in accordance with the welding consumable manufacturer’s recommendations.

如果没有针对焊接焊条的建议，烘焙和储存应按照表 3 进行。

If no recommendations are available for welding electrodes, baking and storage shall be in accordance with Table 3.

表 3 涂覆焊条烘焙和储存的温度和时间（ISO 4063 工艺 111）

Table 3 — Temperature and time for baking and storage of coated electrodes  
(ISO 4063 process 111)

条件 Condition	温度级别 $T/^{\circ}\text{C}$ Temperature level $T/^{\circ}\text{C}$	时间 $t$ Time $t$
烘焙 <sup>a</sup> Baking <sup>a</sup>	$260 < T \leq 370$	2 小时 2 h min.
	$370 < T \leq 430$	1 小时 1 h in.
储存 <sup>a</sup> Storage <sup>a</sup>	$\geq 150$	先焊后弯 prior to welding
储存 <sup>b</sup> Storage <sup>b</sup>	$\geq 100$	焊接期间 during welding
a: 固定烘箱。 a Fixed oven. b: 便携式箭筒。 b Portable quiver.		

涂覆焊条一旦从原包装中取出，应立即按照焊条制造商的建议存放在烤箱中。

Immediately after being removed from their original packages, coated electrodes shall be stored in ovens in accordance with the electrode manufacturer’s recommendations.

如果原包装显示损坏迹象，应按照焊条制造商的建议进行烘焙。

If the original packaging shows evidence of damage, electrodes shall be baked in accordance with the electrode manufacturer’s recommendations.

焊接班次结束时未使用的消耗品应按照焊条制造商的建议进行烘焙。

Consumables remaining unused at the end of the welding shift shall be baked in accordance with the electrode manufacturer’s recommendations.

对于涂覆焊条，烘焙不应超过两次。如果未使用的涂覆焊条在焊接班次结束时已经烘焙过两次，则应丢弃。

For coated electrodes, baking shall be carried out no more than twice. Unused coated consumables that have been baked twice shall be discarded if unused at the end of the welding shift.

### **6.5.3 气象防护**

#### **6.5.3 Weather protection**

焊接工、消耗品和工作区域应充分防护，以抵御风、雨和雪的影响。

The welder, the consumables and the working area shall be adequately protected against the effects of wind, rain and snow.

气体保护焊接过程特别容易受到风的影响。通常，焊缝附近的风速应最大为 2 米/秒（8 公里/小时）。

Gas shielded welding processes are particularly sensitive to wind effects. Typically, wind velocity in the vicinity of the weld should be a maximum of 2 m/s (8 km/h).

待焊表面应保持干燥，无凝结水。

Surfaces to be welded shall be maintained dry and free from condensation.

当基材温度低于 0°C 时，应预热至至少 10°C，并在焊接期间保持这一最低温度。

When the base metal temperature is below 0 °C, the base metal shall be preheated to at least 10 °C and this minimum temperature maintained during welding.

除非得到施工焊接协调员的明确同意，否则当环境温度低于-20°C 时，不得进行焊接。

Welding shall not be done when the ambient temperature is lower than -20 °C, except with the express consent of the constructor's welding coordinator.

附录 D 中描述了现场焊接的替代最低环境温度。

NOTE Alternative minimum ambient temperatures for field welding are described in Annex D.



#### 6.5.4 焊接组装

#### 6.5.4 Assembly for welding

待焊接的组件应通过点焊或外部装置对齐并固定在位置上，并在初始焊接期间保持不变。应进行组装，以使接头的匹配和组件的最终尺寸都在规定的公差范围内。应适当考虑变形和收缩。

Components to be welded shall be brought into alignment and held in position by tack welds or external devices and maintained during initial welding. Assembly shall be carried out such that the fit-up of joints and the final dimensions of the components are all within the specified tolerances. Suitable allowances shall be made for distortion and shrinkage.

待焊接的组件应组装并固定，以便待焊接的接头容易为焊工和检验人员靠近和观察。

The components to be welded shall be assembled and held in position such that the joints to be welded are readily accessible and easily visible to the welder and inspection personnel.

焊接空心截面组件的组装应按照附录 B 中的规定进行，除非在建造技术规格书中另有规定，或两者兼有。

Assembly of hollow section components to be welded should be in accordance with the guidance given in Annex B, as either appropriate or unless specified in the execution specification, or both.

在焊接之前，应批准对施工图上未显示的焊接细节的更改或增加的焊缝。加强焊接接头的方法应在空心截面桁架结构中便于测试焊接接头的完整性。也应考虑加厚组件的替代方案。

Changes to the welding details or the addition of welds not shown on the fabrication drawing shall be approved prior to welding. Methods of locally strengthening a welded joint in a hollow section lattice structure should facilitate the testing of the integrity of the as-welded joint. The alternative of thickening the component should also be considered.

### **6.5.5 预热**

#### **6.5.5 Preheating**

预热应按照 ISO 13916 和 ISO/TR 17671-2 进行。

Preheating shall be carried out in accordance with ISO 13916 and ISO/TR 17671-2.

预热应根据适用的 WPS 进行,并在焊接期间应用,包括点焊和临时附件的焊接。

Preheat shall be undertaken in accordance with applicable WPS and applied during welding, including tack welding and the welding of temporary attachments.

### **6.5.6 临时附件**

#### **6.5.6 Temporary attachments**

如果组装或安装程序需要使用通过焊接临时固定的组件,它们应定位在可以轻松移除而不会损坏永久钢结构的位置。所有临时附件的焊缝都应根据既定的 WPS 进行。应指明不允许焊接临时附件的任何区域。

If the assembly or erection procedure requires the use of components temporarily attached by welds, they shall be positioned such that they can easily be removed without damage to the permanent steelwork. All welds for temporary attachments shall be made in accordance with an established WPS. Any areas where welding of temporary attachments is not permitted shall be specified.

EXL3 和 EXL4 对使用临时附件的限制应在建造技术规格书中指明。

Any restrictions on the use of temporary attachments for EXL3 and EXL4 shall be specified in the execution specification.

通过切割、刨削或凿除临时焊接附件,应以不损坏母材的方式进行,随后应仔细打磨平滑,避免轮廓突然变化。

The removal of temporary welded attachments by cutting, gouging or chipping shall be carried out in such a way that the parent metal is not damaged and shall subsequently be carefully ground smooth without abrupt changes in contour.

移除位置应进行目视检查,对于屈服强度大于或等于 355 MPa 的钢级,这些位置应进行视觉增强的无损检测,即磁粉检测(MT)或液体渗透检测(PT)。

The removal locations shall be visually inspected and, for steel grades with yield strengths greater than or equal to 355 MPa, the locations shall be subjected to visually enhanced NDT i.e. MT or PT.

除非另有规定，否则不允许在屈服强度大于或等于 460 MPa 的钢材或承受疲劳的组件上进行铲除和凿除。

Chipping and gouging are not permitted on steel grades with yield strengths greater than or equal to 460 MPa or on components subject to fatigue, unless otherwise specified.

### **6.5.7 点焊**

#### **6.5.7 Tack welds**

对于 EXL2、EXL3 和 EXL4，点焊应使用合格的焊接程序进行。点焊的最小长度应为较厚部分的板厚的四倍或 50 毫米中的较小值，除非通过测试证明较短的长度是满足的。

For EXL2, EXL3 and EXL4, tack welds shall be made using a qualified welding procedure. The minimum length of the tack shall be the lesser of four times the thickness of the thicker part or 50 mm, unless a shorter length can be demonstrated as satisfactory by test.

被纳入最终焊缝的点焊应具有适当的形状，无缺陷，并在最终焊接前彻底清洁。Tack welds that are incorporated into the final weld shall have a suitable shape and be free from defects and be cleaned thoroughly before final welding.

除非建造技术规格书中另有规定，否则不纳入最终焊缝的点焊应予以移除。

Tack welds that are not incorporated into final welds shall be removed unless otherwise specified in the execution specification.

包含缺陷（包括裂纹）的点焊应予以移除。

Tack welds containing defects, including cracks, shall be removed.

### 6.5.8 角焊缝

#### 6.5.8 Fillet welds

焊接完成后的角焊缝，其焊喉厚度或焊脚尺寸或两者（根据具体情况而定）均不应小于规定的尺寸，并应考虑以下因素：

Fillet welds, as deposited, shall not be less than the specified dimensions for either throat thickness or leg length, or both, as appropriate, taking into account that:

- a) 可以使用深熔或部分熔透焊接工艺的 WPS 来实现规定的焊喉厚度；
- a) the specified throat thickness is achievable using WPSs for deep or partial penetration welding processes;

热输入的控制至关重要，应在制定焊接工艺规程（WPS）时予以考虑。

The control of heat input is critical and should be considered in developing the WPS.

- b) 如果间隙  $h$  超过缺陷极限，可以通过增加焊喉厚度  $a=a_{\text{nom}}+0.7h$  来补偿，其中  $a_{\text{nom}}$  是规定的标称焊喉厚度。如果配合不正确，则适用 ISO 6520-1（项目 617）的质量等级，只要焊喉厚度按照 ISO 6520-1（项目 5213）保持即可；

- b) if the gap,  $h$ , exceeds the imperfection limit, it may be compensated for by an increase in the throat thickness  $a = a_{\text{nom}} + 0.7h$ , where  $a_{\text{nom}}$  is the specified nominal throat thickness. For incorrect fit up ISO 6520-1 (item 617) quality levels apply provided that the throat thickness is maintained in accordance with ISO 6520-1 (item 5213).

- c) 对于桥梁正交板特别制造要求（例如角焊缝的喉厚），请参见 6.5.17。

- c) That for bridge orthotropic decks particular manufacturing requirements apply (e.g. for throat thickness of fillet welds), see 6.5.17.

### 6.5.9 对接焊缝

#### 6.5.9 Butt welds

##### 6.5.9.1 一般规定

##### 6.5.9.1 General

建造技术规格书（车间图纸）应指明用作接长的对接焊缝的位置，以适应构件产品的可用长度。

The execution specification (shop drawing) shall specify the location of butt welds used as splices to accommodate available lengths of constituent products.

对接焊缝的端部应以确保焊缝完全穿透的方式终止。对于所有未使用引弧/引出板的焊缝，所有焊坑都应填充到焊缝的整个横截面积。

The ends of butt welds shall be terminated in a manner that ensures sound welds with full penetration. For all welds where a run-on/run-off plate is not used, all craters shall be filled to the full cross-sectional area of the weld bead.

对于 EXL3 和 EXL4，以及如果指定，对于 EXL2，应使用引弧/引出板以确保边缘的完整熔透。这些引弧/引出板的可焊性不应低于母材。

For EXL3 and EXL4, and for EXL2 if specified, run-on/run-off plates shall be used to ensure full penetration at the edge. The weldability of such run-on/run-off plates shall not be less than that of the parent metal.

焊缝完成后，任何引弧/引出板或附加材料都应被移除，其移除应符合 6.5.6。

After completion of the welds, any run-on/run-off plates or supplementary material shall be removed and their removal shall conform with 6.5.6.

如果需要平整表面，则应去除多余的焊缝金属以满足质量要求。

If a flush surface is required, the excess weld metal shall be removed to satisfy the quality requirements.

### **6.5.9.2 单面焊缝**

#### **6.5.9.2 Single sided welds**

可以从单面焊接完整熔透焊缝，可以使用也可以不使用金属或非金属背衬材料。

Full penetration welds welded from one side maybe produced with or without metallic or non-metallic backing material.

除非建造技术规格书另有规定，否则可以使用永久性钢背衬材料。

Unless otherwise specified in the execution specification, permanent steel backing material maybe used.

如果使用钢背衬材料，背衬材料的碳当量值(CEV)不应超过 0.43%。碳当量值应

基于  $CE_{IIW}$  公式 (1) 计算:

If steel backing is used, the carbon equivalent value (CEV) of the backing material shall not exceed 0,43 %. The carbon equivalent value shall be based on the CEIIW formula (1):

$$CE_{IIW} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad (1)$$

注: ISO/TR 17844 提供了关于  $CE_{IIW}$  公式的额外信息。

NOTE ISO/TR 17844 provides additional information on the CEIIW formula.

在确定碳当量值时,应考虑其他有意添加的元素(例如硼)对碳当量和钢的可焊性的影响。

When determining the carbon equivalent value, consideration should be given to other intentionally added elements (e.g. boron) on the carbon equivalent and resulting weldability of the steel.

背衬材料应紧贴母材,并通常应连续整个接头长度。对于 EXL3 和 EXL4,永久性背衬材料应通过完整熔透对接焊缝进行连接。点焊应包含在对接焊缝中。

Backing materials shall be fitted tightly to the parent metal and should generally be continuous for the full length of the joint. For EXL3 and EXL4, permanent backing metal shall be made continuous by means of full penetration butt welds. Tack welds shall be incorporated into the butt welds.

在没有背衬的情况下执行的空心截面接头的单面对接焊缝的平整打磨是不允许的,除非建造技术规格书中另有规定;如果这些焊缝完全衬垫,则可以与母材的一般表面轮廓齐平打磨。

Flush grinding of single-sided butt welds in joints between hollow sections executed without backing is not permitted, unless specified in the execution specification; if those welds are fully backed they maybe ground off flush with the general surface profile of the parent metal.

### **6.5.9.3 背面刨削**

#### **6.5.9.3 Back gouging**

背面刨削应进行到足够的深度，以确保完全熔透到之前焊接的焊缝金属中。

Back gouging shall be carried out to a sufficient depth to ensure full penetration into the previously deposited weld metal.

背面刨削应产生一个单一 U 形槽的轮廓，其熔合面应易于焊接。

Back gouging shall produce a contour of a single U-shaped groove with its fusion faces readily accessible for welding.

### **6.5.10 耐候钢的焊接**

#### **6.5.10 Welding of improved atmospheric corrosion resistant steels**

耐候钢的焊接应使用合适的焊接材料。

Welding of improved atmospheric resistant steels shall be carried out using appropriate welding consumables.

焊接材料应具有改进的耐候性，或在以下条件下使用 C-Mn 材料：

Welding consumables shall either have improved atmospheric resistance or be C-Mn consumables used under the following conditions:

a) 对于多层填充的角焊缝或对接焊缝的主体，至少在所有暴露表面上使用具有改进耐候的焊接材料制作两层。当使用此选项时，应考虑去除引弧/引出板后多道焊缝暴露端的耐候性。

a) For the body of a multi-run fillet or butt weld provided at least two layers on all exposed surfaces are made using welding consumables with improved atmospheric resistance. When this option is used, consideration shall be given to the atmospheric resistance of the exposed ends of multi-pass welds after removal run-on/run-off plates.

b) 满足以下条件的单道焊缝：

b) single pass welds meeting the following conditions:

1) 从一侧对背板进行的单道坡口焊缝；

1) single pass groove welds made from one side onto backing;

- 2) 从两侧进行的单道坡口焊缝，每侧单道；
- 2) single pass groove welds made from both sides, with a single pass on each side;
- 3) 符合表 4 中最大尺寸标准的单道角焊缝。
- 3) single pass fillet welds that conform with the maximum size criteria as given in Table 4.

**表 4 C-Mn 材料单道角焊缝的最大尺寸标准**

**Table 4 — Single pass fillet welds maximum size criteria for C-Mn consumables**

工艺 Process a, b	最大单道角焊缝尺寸 Maximum single pass fillet size
11	6 mm
12	12 mm
13, 114	8 mm
a: 符合ISO 4063 a In accordance with ISO 4063. b: 建造技术规格书中指定的其他工艺 b Other processes if specified in the execution specification.	

#### **6.5.11 空心截面接头，包括分支连接**

#### **6.5.11 Joints in hollow sections including branch connections**

关于空心截面接头，包括分支连接的建议见附录 B。

Recommendations for joints in hollow sections including branch connections are given in Annex B.

#### **6.5.12 螺柱焊接**

#### **6.5.12 Stud welding**

螺柱焊接应按照 ISO 14555 进行。

Stud welding shall be carried out in accordance with ISO 14555.

按照 ISO 14555 进行的程序测试应与应用保持一致。

Procedure testing undertaken in accordance with ISO 14555 shall be consistent with the application.



### 6.5.13 槽焊和塞焊

#### 6.5.13 Slot and plug welds

槽焊和塞焊的孔应尺寸适当，以允许足够的焊接空间。

Holes for slot and plug welds shall be sized to permit adequate access for welding.

塞焊的孔尺寸应满足以下条件：

Dimensions for plug welds shall meet the following conditions:

—孔的最小直径应为  $T+8\text{mm}$ ；

—the minimum diameter of the hole shall be  $T + 8\text{mm}$ ; and

—孔的最大直径应为  $T+12\text{mm}$  或  $2.25T$ ，取较大者。

—the maximum diameter of the hole shall be the greater of  $T + 12 \text{ mm}$  or  $2.25T$ .

其中  $T$  是孔所在部分的厚度。

where  $T$  is the thickness of the part in which the hole is made.

槽焊的尺寸应满足以下条件：

Dimensions for slot welds shall meet the following conditions:

—槽的最小宽度应为  $T+8\text{mm}$ ；

—the minimum width of the slot shall be  $T + 8\text{mm}$ ; and,

—槽的最大宽度应为  $T+12\text{mm}$  或  $2.25T$ ，取较大者；

—the maximum width of the slot shall be the greater of  $T + 12\text{mm}$  or  $2.25T$ ; and,

—槽的最大长度应为  $10T$ ；

—the maximum length of the slot shall be  $10T$ .

其中  $T$  是孔所在部分的厚度。

where  $T$  is the thickness of the part in which the slot is made.

—槽的端部应为半圆形。

—the ends of the slot shall be semi-circular.

在填充塞焊或槽焊之前，任何在塞焊或槽焊中制作的角焊缝应进行目视检查。

Any fillet welds made in plug or slot welds shall be visually inspected prior to filling of the plug or slot weld.

#### **6.5.14 其他焊缝类型**

#### **6.5.14 Other weld types**

本文件未涵盖的其他焊缝类型的要求应符合适当的 ISO 或其他国家标准或文件。

The requirements for other weld types not within the scope of this document shall be in accordance with appropriate ISO or other national standards or documents.

#### **6.5.15 焊后热处理**

#### **6.5.15 Post-weld heat treatment**

如果建造技术规格书要求，焊后热处理应根据焊接程序规范/焊接程序资格记录 (WPS/WPQR) 进行。

If required by the execution specification, post-weld heat treatment shall be carried out in accordance with a WPS/WPQR.

注：关于热处理质量要求的指南见 ISO 17663。

NOTE Guidance for quality requirements for heat treatment is given in ISO 17663.

#### **6.5.16 焊接建造**

#### **6.5.16 Execution of welding**

应考虑防止杂散电弧。如果发生杂散电弧，应目视检查钢表面是否有裂纹或其他表面缺陷。

Considerations shall be given to prevent stray arcs. If stray arcs occur, the surface of the steel shall be visually inspected for cracks or other surface defects.

对于使用屈服强度为 350 MPa 或更低的静态应用，不需要打磨电弧击痕。对于使用屈服强度超过 350 MPa 的静态应用，应轻轻打磨电弧击痕，以确保平滑且齐平的表面条件。

For static applications using steels with yield strength of 350 MPa or less, arc strikes need not be ground. For static applications using steels greater than 350 MPa, arc strikes shall be lightly ground to ensure a smooth and flush surface condition.

对于疲劳、地震和特殊腐蚀应用，应轻轻打磨电弧击痕，以确保平滑且齐平的表面条件，随后进行液体渗透检测(PT)或磁粉检测(MT)。

For fatigue, seismic and special corrosion applications, arc strikes shall be lightly ground to ensure a smooth and flush surface condition followed by PT or MT.

应采取措施避免焊渣，如果需要对杂散电弧进行相同的处理。

Precautions should be taken to avoid weld spatter where the same treatment for stray arcs is to be applied.

在进一步的焊道/行程之前，应从每个焊道/行程中去除可见的缺陷，如裂纹、空洞和可避免的缺陷。

Visible imperfections such as cracks, cavities and rejectable imperfections shall be removed from each pass/run before deposition of further passes/runs.

如果建造技术规格书中有任何关于完成焊缝表面打磨和修整的要求，应予以说明。

Requirements for grinding and dressing of the surface of completed welds, if any, shall be stated in the execution specifications.

每次焊道表面应清除渣，特别注意焊缝与母材之间的连接处。

Slag should be removed from the surface of each weld pass, with particular attention to the junctions between the weld and the parent metal.

#### **6.5.17 桥梁正交异性钢桥面板的焊接**

#### **6.5.17 Welding of bridge orthotropic decks**

生产测试应按照 7.2.5 c)进行。对于不在道路(路缘)上的加劲肋-桥面板连接，不需要进行生产测试。

Production tests shall be carried in accordance with 7.2.5 c). Production tests are not required for stiffener-deck plate connection outside the roadway (curbs) which is without loading by vehicles.

对于加劲肋-桥面板连接和局部焊缝（例如，带拼接板的加劲肋-加劲肋连接），应去除起始和停止点。

For stiffener-deck plate connections and local welds (e.g. at stiffener-stiffener

connections with splice plates), the starts and stops shall be removed.

对于加劲肋-横梁连接，加劲肋通过有孔或无孔的横梁时，应先将加劲肋焊接到面板上，然后将横梁组装焊接。

For stiffener-crossbeam connections with stiffeners passing through the crossbeam with or without cope holes, the stiffeners should be welded first to the deck plate and the crossbeams subsequently assembled and welded.

## 6.6 验收标准

### 6.6 Acceptance criteria

#### 6.6.1 常规要求

##### 6.6.1 Routine requirements

除非在建造技术规格书中另有规定，对于 EXL1、EXL2 和 EXL3，焊缝缺陷的验收标准应如下，参考 ISO 5817，除了“焊趾不正确”（505）和“微小缺口”（401）不计入考虑。任何针对焊缝几何形状和轮廓的额外要求都应予以考虑。

Unless specified in the execution specification, for EXL1, EXL2 and EXL3 the acceptance criteria for weld imperfections shall be as follows, with reference to ISO 5817, except “Incorrect weld toe” (505) and “Micro lack of fusion” (401) which are not to be taken into account. Any additional requirements specified for weld geometry and profiles shall be considered.

—EXL1，质量等级 D，除了“喉部不足”（5213）为质量等级 C；

—EXL1, quality level D except quality level C for “Insufficient throat” (5213);

—EXL2，通常为质量等级 C，除了“重叠”（506）、“杂散弧”（601）和“末端坑”（2025）为质量等级 D，以及“喉部厚度不足”（5213）为质量等级 B；

—EXL2, generally quality level C except quality level D for “Overlap” (506), “Stray arc” (601) and “End crater pipe” (2025) and quality level B for “Insufficient throat thickness” (5213);

—EXL3，质量等级 B。

—EXL3, quality level B.

对于 EXL4, 所需焊缝质量应在建造技术规格书中针对已识别的焊缝进行规定, 并至少满足 EXL3 的要求。

For EXL4, the weld quality required shall be specified in the execution specification with respect to identified welds and shall meet the requirements for EXL3 as a minimum.

### **6.6.2 抗震要求**

#### **6.6.2 Seismic requirements**

除非在建造技术规格书中另有规定, 承受地震作用的焊缝应适用 6.6.1 中给出的要求。

Unless specified in the execution specification, the requirements given in 6.6.1 shall apply to welds subject to seismic actions.

### **6.6.3 疲劳要求**

#### **6.6.3 Fatigue requirements**

对于承受疲劳的焊缝, 建造技术规格书应根据 IIW-2259-15 规定的 FAT 疲劳分类, 明确相关的验收标准。

For welds subject to fatigue, the execution specification shall specify the relevant acceptance criteria in terms of the FAT fatigue classification in accordance with IIW-2259-15.

使用 FAT 分类的选择允许对承受相对较低疲劳载荷的焊缝在具有较高分类抗力的接头中规定较少的要求。对于焊缝的规范采取保守假设, 即应规定焊缝的验收标准以满足与该分类结构细节相关联的全抗力水平。

The option to use the FAT classification allows less onerous requirements to be specified for a weld subjected to relatively low fatigue loading in a joint with a higher classified resistance in accordance with IIW-2259-15. The conservative assumption for specification is that the acceptance criteria for a weld should be specified to meet the full resistance level associated with that classified structural detail.

对于 EXL2、EXL3 和 EXL4, 除了 6.6.1 中规定的标准外, 焊缝的验收标准应符

合 ISO 5817:20—, 附录 C:

For EXL2, EXL3 and EXL4, in addition to the criteria specified in 6.6.1, the acceptance criteria for welds shall be in accordance with ISO 5817:20—, Annex C:

—FAT 不超过 63: 质量等级 C63 (EXL2、EXL3 或 EXL4);

—FAT not exceeding 63: Quality level C63 (EXL2, EXL3 or EXL4);

—FAT 超过 63 且不超过 90: 质量等级 B90 (仅限 EXL3 或 EXL4);

—FAT above 63 and not exceeding 90: Quality level B90 (EXL3 or EXL4 only);

—FAT 超过 90 且不超过 125: 质量等级 B125 (仅限 EXL3 或 EXL4)。

—FAT above 90 and not exceeding 125: Quality level B125 (EXL3 or EXL4 only).

建造技术规格书应规定任何必要的额外建造要求, 以符合抗疲劳设计的假设。

The execution specification shall specify any additional execution requirements that are necessary to conform with the assumptions of design for fatigue resistance.

#### **6.6.4 不合格评定**

##### **6.6.4 Nonconformity assessment**

如果出现与本文档要求不符的不合格情况, 每个焊缝缺陷都可能根据发生缺陷的组件的功能以及缺陷的特性 (类型、大小、位置) 进行评估, 以决定是否接受或修复该焊缝。

In the case of a nonconformity with the requirements of this document, each weld defect maybe assessed on the function of the component in which the defect occurs and on the characteristics of the imperfection (type, size, location) in deciding if the weld is to be accepted or repaired.

如果能够通过断裂力学或其他适当的评估方法证明特定缺陷不会对结构的性能造成损害, 那么特定缺陷就无需修复或重新焊接, 前提是特定缺陷按照建造技术规格书的规定是可以接受的 (见 ISO 17607-1)。

Where it can be demonstrated, by the use of fracture mechanics or other suitable method of assessment, that a specific defect will not be injurious to the performance of the structure, that specific defect need not be repaired or re-welded, provided that the

specific defect is acceptable in accordance with the provisions of the execution specification (see ISO 17607-1).

修复后的焊缝应重新检查，以符合原始焊缝规定的相同质量水平（见 7.2.2.3）。

Repaired welds shall be re-inspected to the same quality level as that specified for the original weld (see 7.2.2.3).

### **6.6.5 桥面板**

#### **6.6.5 Bridge decks**

如果对桥面板需要额外的缺陷限制，应在建造技术规格书中规定。

If additional limits of imperfections are required for bridge decks, they shall be specified in the execution specification.

### **6.7 焊接不同种类的钢材**

#### **6.7 Welding dissimilar steels**

当焊接不同种类的钢材时，焊接协调员应考虑适当的焊接技术、焊接工艺和焊接材料。应仔细考虑与污染和电化学腐蚀相关的问题。

When welding dissimilar steels, the welding coordinator shall consider the appropriate welding techniques, welding processes and welding consumables. Issues associated with contamination and galvanic corrosion should be considered carefully.

## **7 检验、测试和校正**

### **7 Inspection, testing and correction**

#### **7.1 一般规定**

##### **7.1 General**

见 ISO 17607-1。

See ISO 17607-1.

## 7.2 焊接

## 7.2 Welding

### 7.2.1 一般规定

#### 7.2.1 General

焊接前的检验和测试应按照 ISO 3834 的相关部分要求包含在检验计划中。检验和测试计划应包括类型测试（见 7.2.2.2）、常规检验和测试（见 7.2.2.3）以及特定项目的检验和测试（见 7.2.2.4）。检验和测试计划应识别出可能在实现指定装配上存在困难的接头，以便进行特定的检验。

Inspection and testing before and during welding shall be included in the inspection plan in accordance with the requirements given in the relevant part of ISO 3834. The inspection and test plan shall include type testing (see 7.2.2.2), routine inspection and testing (see 7.2.2.3) and project specific inspection and testing (see 7.2.2.4). The inspection and test plan shall identify joints for specific inspection of the fit-up that are likely to present difficulties in achieving the specified fit-up.

用于检验的无损检测（NDT）方法应根据 ISO 17635 作为基础，选择用于焊接要求的检验和测试计划。除了视觉检验外，NDT 应由根据 ISO 9712 至少 2 级资格的合格人员执行。

Non-destructive testing (NDT) methods used for inspection shall be selected in accordance with ISO 17635 as the basis for the inspection and test plan required by the welding plan. NDT, with the exception of visual inspection, shall be performed by personnel qualified according to ISO 9712 minimum Level 2.

### 7.2.2 焊接后的检验

#### 7.2.2 Inspection after welding

##### 7.2.2.1 时机

##### 7.2.2.1 Timing

焊缝的视觉检验和补充 NDT 不应在表 5 选项 1 所示的焊接后最小保持时间之前完成，除非建造技术规格书中允许。

The visual inspection and supplementary NDT of a weld shall not be completed until



after the minimum hold time after welding shown in Table 5 Option 1, unless permitted in the execution specification.

如果按照 ISO/TR 17671-2:2002 附录 A 规定的预加热，焊缝的视觉检验和补充 NDT 应在表 5 选项 2 或 3 所示的焊接后最小保持时间之后完成，除非建造技术规格书中允许。

Where preheat is applied as specified in ISO/TR 17671-2:2002, Annex A, the visual inspection and supplementary NDT of a weld shall not be completed until after the minimum hold time after welding shown in Table 5 Option 2 or 3 as applicable, unless permitted in the execution specification.

如果指定在焊接后对焊缝附近的母材进行层状检查，也应遵守表 5 中的保持时间。

The hold times in Table 5 should also be observed if it is specified that the parent metal adjacent to a weld zone shall be inspected for laminations after welding.

对于需要预热的焊缝，如果焊接完成后对焊件进行了后热处理，则可以缩短这些时期。

For welds requiring preheat, these periods may be reduced if the weldment is post-heated for a period after welding is complete.

如果焊缝将因后续工作而无法接近，应在进行后续工作前对其进行检验。

If a weld will become inaccessible through subsequent work, it shall be inspected prior to subsequent work being carried out.

任何位于经过矫正的不可接受变形区域的焊缝都应重新检验。

Any weld located in a zone where unacceptable distortion has been corrected shall be inspected again.

表 5 最小保持时间

Table 5 — Minimum hold times

	保持时间 Hold time 小时 <sup>b</sup> hours <sup>b</sup>		
选项1: 未按ISO/TR 17671-2:2002附录A预热 Option 1: Preheat not applied in accordance with ISO/TR 17671-2:2002,Annex A			
焊缝尺寸 <sup>a</sup> mm Weld size mm <sup>a</sup>	屈服强度 Yield Strength 355 MPa至450 MPa 355 MPa to 450 MPa		屈服强度 Yield Strength > 450 MPa至700 MPa > 450 MPa to 700 MPa
(a或s) ≤ 12 (a or s) ≤ 12	仅冷却期 Cooling Period Only		12
12 < (a或s) ≤ 37 12 < (a or s) ≤ 37	仅冷却期 Cooling Period Only		24
37 < (a或s) 37 < (a or s)	48		48
选项2: 按ISO/TR 17671-2:2002附录A的A法预热 Option 2: Where preheat is applied in accordance with Method A of ISO/TR 17671-2:2002, Annex A			
焊缝尺寸 <sup>a</sup> mm Weld size mm <sup>a</sup>	热输入Q kJ/mm Heat input Q kJ/mm	屈服强度 Yield Strength 355 MPa至450 MPa 355 MPa to 450 MPa	屈服强度 Yield Strength > 450 MPa至700 MPa > 450 MPa to 700 MPa
(a或s) ≤ 6 (a or s) ≤ 6	全部 All	仅冷却期 Cooling Period Only	24
6 < (a或s) ≤ 12 6 < (a or s) ≤ 12	≤ 3	8	24
	> 3	16	40
(a或s) > 12 (a or s) > 12	≤ 3	16	40
	> 3	24	48
选项3: 按ISO/TR 17671-2附录A的B法预热 Option 3: Where preheat is applied in accordance with Method B of ISO/TR 17671-2,Annex A			
焊缝尺寸 <sup>a</sup> mm Weld size mm <sup>a</sup>	屈服强度 Yield Strength 355 MPa至450 MPa 355 MPa to 450 MPa		屈服强度 Yield Strength > 450 MPa至700 MPa > 450 MPa to 700 MPa
(a或s) ≤ 20 (a or s) ≤ 20	仅冷却期 Cooling Period Only		24
(a或s) > 20 (a or s) > 20	24		48
a: 对于角焊缝的喉部名义尺寸a或全穿透焊缝的名义材料厚度s。对于个别的部分穿透对接焊缝, 控制标准是名义焊深a, 但对于同时焊接的一对部分穿透对接焊缝, 则为焊缝喉部之和a。 a Size applies to the nominal throat thickness a of a fillet weld or the nominal material thickness s of a full penetration weld. For individual partial penetration butt welds the governing criterion is the nominal weld depth a, but for pairs of partial penetration butt welds welded simultaneously it is the sum of the weld throats a. b: 焊接完成和开始NDT之间的时间应在NDT报告中说明。在仅冷却期的情况下, 这是指直到焊缝冷却到足够进行NDT的程度。 b The time between weld completion and commencement of NDT shall be stated in the NDT report. In the case of cooling period only, this is until the weld is cool enough for NDT to commence.			

### 7.2.2.2 类型测试

### 7.2.2.2 Type testing

对于首次按照相同新的 WPS 制作的前五个接头, 应满足以下要求:

For the first five joints made to the same new WPS, the following requirements shall be fulfilled:

- a) 需要 ISO 5817 的质量等级 B，以证明在生产条件下的 WPS；
- a) the quality level B of ISO 5817 is required for demonstration of the WPS in production conditions;
- b) 要检查的最小长度为 900 毫米。
- b) the minimum length to be inspected is 900 mm.

如果测试结果不符合要求，应进行调查以找出原因，并测试一套新的五个接头。应遵循 ISO 17635:2016 附录 C 中的指导。

If testing gives non-conforming results, an investigation shall be carried out in order to find the reason and a new set of five joints shall be tested. The guidance in ISO 17635:2016, Annex C should be followed.

### **7.2.2.3 常规检验和测试**

#### **7.2.2.3 Routine inspection and testing**

所有焊缝应进行 100% 的目视检验。如果检测到表面断裂缺陷，应对检验焊缝进行渗透检测或磁粉检测的表面测试。

All welds shall be 100% visually inspected along their entire length. If surface breaking defects are detected, surface testing by penetrant testing or magnetic particle inspection shall be carried out on the inspected weld.

除非建造技术规格书中另有规定，EXL1 焊缝不需要补充无损检测。对于 EXL2 和 EXL3 焊缝，补充无损检测的范围如表 6 所示。

Unless otherwise specified in the execution specification, no supplementary NDT is required for EXL1 welds. For EXL2 and EXL3 welds, the extent of supplementary NDT is as specified in Table 6.

对于 EXL4 焊缝，补充无损检测的范围应在建造技术规格书中针对每个已识别的焊缝进行规定。

For EXL4 welds, the scope of supplementary NDT shall be specified in the execution

specification with respect to each identified weld.

补充 NDT 的范围涵盖表面或内部缺陷的测试（如果适用）。补充 NDT 的方法应由适当的焊接协调人员从 7.2.2.6 节中给出的方法中选择。

The extent of NDT covers both testing of surface or internal imperfections if applicable.

The methods to be used for supplementary NDT shall be selected by the appropriate welding coordination personnel from those given in 7.2.2.6.

注意 1：补充 NDT 是除视觉检验之外的任何 NDT。

NOTE 1 Supplementary NDT is any NDT other than visual inspection.

一旦确定按照 WPS 进行的生产焊接符合 7.2.2.2 节规定的质量要求，表 6 中规定的补充 NDT 的范围应适用于按照同一 WPS 焊接的后续焊缝，视为单一持续检验批次。百分比适用于每个检验批次内累计的补充 NDT 的范围。

Once it has been established that production welding according to a WPS meets the quality requirements according to 7.2.2.2, the required extent of supplementary NDT shall be in accordance with Table 6 with further joints welded according to the same WPS treated as a single continuing inspection lot. The percentages apply to the extent of supplementary NDT treated as the cumulative amount within each inspection lot.

表 6 中规定的测试百分比( $p\%$ )定义为根据以下规则选择的检验批次的一部分，除非执行规范中另有规定：

The percentage extent of testing ( $p\%$ ) according to Table 6 is defined as a part of an inspection lot according to the following rules, unless otherwise specified:

a) 检验批次中的每个焊缝都应至少按照个别长度的  $p\%$  进行测试。测试区域应随机选择；

a) each weld in the inspection lot shall be tested over a length of minimum  $p\%$  of the individual length. The area to be tested shall be selected at random;

b) 如果检验批次中所有焊缝的总长度小于 900 mm，则至少有一个焊缝应进行全长测试，不考虑  $p\%$ ；

b) if the total length of all the welds in an inspection lot is less than 900 mm, at least

one weld shall be tested in its entire length regardless of the  $p$  %;

c) 如果检验批次由几个长度小于 900 mm 的相同焊缝组成，则随机选择的焊缝应进行全长测试，其最小总长度为检验批次中所有焊缝总长度的  $p$  %。

c) if an inspection lot consists of several identical welds with individual length less than 900 mm, randomly selected welds with a minimum total length of  $p$  % of the total length of all welds in the inspection lot shall be tested in their entire length.

根据表 6 进行常规检验的接头应选择以确保尽可能广泛地覆盖以下变量：接头类型、构件产品等级、焊接设备以及焊工的工作。表 6 中的检验范围与年度滚动生产焊缝有关。

The joints for routine inspection according to Table 6 shall be selected to ensure that sampling covers the following variables as widely as possible: the joint type, the constituent product grade, the welding equipment, and the work of the welders. The extent of inspection in Table 6 is related to production welds over a rolling annual basis.

如果在特定车间内，年度基础上的生产焊缝的常规测试或使用电子方法监控焊接参数始终显示出特定类型的焊缝（即接头类型、构件产品等级和焊接设备）质量可接受，则在适当的焊接协调人员自行决定下，该车间的常规补充 NDT 的范围可以低于表 6 中给出的百分比，前提是实施并记录了三个月的生产审核测试计划。

If routine testing of production welds in a given workshop on an annual basis or using electronic methods of monitoring welding parameters demonstrates consistently acceptable quality for welds of a specific type (i.e. joint type, constituent product grade and welding equipment) the extent of routine supplementary NDT in that workshop may be reduced below the percentages given in Table 6 at the discretion of the appropriate welding coordination personnel, provided that a three monthly programme of production audit testing is implemented and documented.

建造技术规格书可能确定特定接头的检验以及测试的范围和方法（见 7.2.2.4）。如果适当，此测试可以计入常规测试的范围之内。

The execution specification may identify specific joints for inspection together with the

extent and method of testing (see 7.2.2.4). This testing may be counted within the extent of routine testing as appropriate.

如果检验结果不符合要求，应进行调查以找出原因。

If inspection gives non-conforming results, investigation shall be carried out in order to find the reason.

**表 6 无损检测补充程度**

**Table 6 — Extent of supplementary NDT**

焊缝类型 Type of weld	车间和现场焊缝 Shop and site welds		
	EXL1	EXL2	EXL3 <sup>d</sup>
横向对接焊缝和对接接头的部分穿透焊缝 Transverse butt welds and partial penetration welds in butt joints	0%	10%	20%
横向对接焊缝和部分穿透焊缝： Transverse butt welds and partial penetration welds: 在十字接头中 in cruciform joints 在T形接头中 in T joints	0% <sup>a</sup> 0%	10% 5%	20% 10%
受拉或剪力作用的横向角焊缝 <sup>b</sup> ： Transverse fillet welds in tension or shear <sup>b</sup> : $a > 12 \text{ mm}$ 或 $t > 30 \text{ mm}$ With $a > 12 \text{ mm}$ or $t > 30 \text{ mm}$ $a \leq 12 \text{ mm}$ 且 $t \leq 30 \text{ mm}$ With $a \leq 12 \text{ mm}$ and $t \leq 30 \text{ mm}$	0% 0%	5% 0%	10% 5%
吊车梁的腹板与上翼缘之间的全穿透纵向焊缝 Full penetration longitudinal welds <sup>c</sup> between web and top flange of crane girders	0%	10%	20%
其他纵向焊缝、焊至加强板的焊缝以及在建造技术规格书中规定为受压的焊缝 Other longitudinal welds and welds to stiffeners and welds specified in the execution specification as being in compression	0%	0%	5%
<sup>a</sup> : 对于此类焊缝，如果执行的是钢材等级 $\geq S420$ ，百分比为10%。 <sup>a</sup> 10 % for such welds executed in steel $\geq S420$ . <sup>b</sup> : 喉厚 $a$ 和 $t$ 分别指焊缝的喉部厚度和连接材料的最厚处。 <sup>b</sup> $a$ and $t$ refer respectively to the throat thickness and the thickest material being joined. <sup>c</sup> : 纵向焊缝是与构件轴线平行的焊缝。其他的被认为是横向焊缝。 <sup>c</sup> Longitudinal welds are those made parallel to the component axis. All the others are considered as transverse welds. <sup>d</sup> : 对于EXL4，百分比范围至少应与EXL3中给出的相同。 <sup>d</sup> For EXL4, the percentage extent shall be at least that given for EXL3.			

#### **7.2.2.4 特定项目的检验和测试**

##### **7.2.2.4 Project specific inspection and testing**

对于 EXL1、EXL2 和 EXL3，建造技术规格书可能会确定生产测试的要求和特定接头的检验以及测试的范围。

For EXL1, EXL2 and EXL3, the execution specification may identify requirements for production testing and specific joints for inspection together with the extent of testing.

对于 EXL4，建造技术规格书应确定特定接头的检验以及至少为 EXL3 规定的测试范围。

For EXL4 execution specification shall identify specific joints for inspection together with the extent of testing, which shall be that specified for EXL3 as a minimum.

如果指定，可以使用焊接检验等级（WICs）对特定焊缝进行分类，以确定补充测试的范围和百分比以及根据焊缝的关键性使用测试方法（见附录 C 指导）。如果使用焊接检验等级（WICs），建造技术规格书应用于确定每个相关焊缝的焊接检验等级（WIC）。

If specified, weld inspection classes (WICs) may be used to classify specific welds for inspection, and in this respect to define the scope and percentage extent of supplementary testing and the test methods to be used according to the criticality of the weld (see Annex C for guidance). If weld inspection classes (WICs) are used, the execution specification shall be used to identify the weld inspection class (WIC) for each relevant weld.

#### **7.2.2.5 焊缝的视觉检验**

##### **7.2.2.5 Visual inspection of welds**

焊缝的视觉检验应在完成焊接区域并进行任何其他无损检测（NDT）之前，按照 ISO 17637 进行。

Visual inspection shall be performed in accordance with ISO 17637 after completion of welding in an area and before any other NDT is carried out.

视觉检验应包括：

Visual inspection shall include:

- a) 所有焊缝的存在和位置;
- a) the presence and location of all welds;
- b) 根据 ISO 17637 对焊缝进行检验;
- b) inspection of the welds in accordance with ISO 17637;
- c) 杂散弧和焊渣区域。
- c) stray arcs and areas of weld spatter.

使用空心截面焊接的支管接头的形状和表面焊缝的视觉检验应特别注意以下位置:

Visual inspection of the shape and surface of welds of welded branch joints using hollow sections shall pay careful attention to the following locations:

- d) 对于圆形截面: 中趾、中跟和两个中侧位置;
- d) for circular sections: the mid-toe, mid-heel and two mid-flank positions;
- e) 对于正方形或矩形截面: 四个角落位置。
- e) for square or rectangular sections: the four corner positions.

如果通过视觉检验检测到平面缺陷, 应使用其他适当的无损检测方法测试焊缝的受影响部分, 以确定缺陷的程度。

If planar imperfections are detected by visual inspection, the affected segments of the weld shall be tested using other appropriate NDT methods to determine the extent.

#### **7.2.2.6 补充 NDT 方法**

#### **7.2.2.6 Supplementary NDT methods**

所有无损检测应按照各自测试方法的书面程序进行。

All non-destructive testing shall be performed in accordance with written procedures for the individual test methods.

- a) 渗透检测 (PT) 应按照 ISO 3452-1 执行;
- a) Penetrant testing (PT) in accordance with ISO 3452-1;
- b) 磁粉检测 (MT) 应按照 ISO 17638 执行;



- b) Magnetic particle (MT) in accordance with ISO 17638;
- c) 超声检测 (UT) 应按照 ISO 17640、ISO 23279 执行;
- c) Ultrasonic testing (UT) in accordance with ISO 17640, ISO 23279;
- d) 射线检测 (RT) 应按照 ISO 16371-1 和 ISO 16371-2 执行。
- d) Radiographic testing (RT) in accordance with ISO 16371-1 and ISO 16371-2.

如果建造技术规格书指定了 ISO 17635 未引用的 NDT 方法, 则应按照具有指定接受标准的书面程序进行, 例如按照 ISO 13588 进行的相控阵超声检测。

If an NDT method, that is not referenced in ISO 17635, is specified for use by the execution specification, it shall be carried out in accordance with a written procedure with specified acceptance levels, e.g. phased array UT in accordance with ISO 13588.

无损检测方法的应用领域在它们相关的标准或书面程序中指定。无损检测的接受标准应按照各自测试方法的书面程序执行, 例如 ISO 13588。

The field of application of NDT methods is specified in their relevant standards or written procedures. The acceptance levels of non-destructive testing shall be performed in accordance with written procedures for the individual test methods e.g. ISO 13588.

#### **7.2.2.7 焊缝的校正**

#### **7.2.2.7 Correction of welds**

对于 EXL2、EXL3 和 EXL4, 应按照合格的焊接程序进行焊接处理。

For EXL2, EXL3 and EXL4, repairs by welding shall be carried out in accordance with qualified welding procedures.

处理后的焊缝应进行检查, 并满足原始焊缝的要求。

Corrected welds shall be checked and shall meet the requirements of the original welds.

#### **7.2.3 复合钢和混凝土结构焊接剪力钉的检验和测试**

#### **7.2.3 Inspection and testing of welded shear studs for composite steel and concrete structures**

复合钢和混凝土结构焊接剪力钉的检验和测试应按照 ISO 14555 进行。

Inspection and testing of welded shear studs for composite steel and concrete structures

shall be carried out in accordance with ISO 14555.

注：此检验包括焊接后剪力钉长度的检查。

NOTE This inspection includes checking the length of the studs after welding.

不合格的剪力钉应进行修复或更换。建议在相邻的新位置焊接替换剪力钉。

Non-conforming studs shall be repaired or replaced. It is recommended that replacement studs be welded in an adjacent new position.

在现场使用焊接设备后，如果设备已移动或在每个班次或其他工作时段开始时，应通过按照 ISO 14555 焊接的剪力钉进行测试，重新检查焊接设备的正确操作。

The proper operation of welding equipment used on site should be rechecked after it has been moved and at the commencement of each shift or other period of work by using tests on studs welded with the equipment in accordance with ISO 14555.

#### **7.2.4 钢筋焊接的检验和测试**

##### **7.2.4 Inspection and testing of welding of reinforcing steel**

复合钢和混凝土结构中钢筋焊接的检验和测试应按照 ISO 17660-1 或 ISO 17660-2 进行。

Inspection and testing of welding of reinforcing steel for composite steel and concrete structures shall be carried out according to ISO 17660-1 or ISO 17660-2.

#### **7.2.5 焊接生产测试**

##### **7.2.5 Production tests on welding**

如果指定，对于 EXL3 和 EXL4，应按照以下方式进行生产测试：

If specified, for EXL3 and EXL4, production tests shall be carried out as follows:

a) 每种用于焊接屈服强度高于 460 MPa 钢等级的焊接程序合格证明都应通过生产焊缝进行检查。测试包括 VT、PT 或 MT、UT 或 RT（对于对接焊缝）、硬度测试和宏观检查。测试和结果应符合焊接程序测试的相关标准；

a) each welding procedure qualification used for welding steel grades of higher than 460 MPa yield strength shall be checked with a production weld. Testing includes VT, PT or MT, UT or RT (for butt welds), hardness testing and macroscopic examination.

The tests and results shall be in accordance with the relevant standard for the welding procedure test;

b) 如果焊接过程的深穿透用于角焊缝，应检查焊缝的穿透。实际穿透的结果应记录；

b) if the deep penetration of a welding process is used for fillet welds, the penetration of the welds shall be checked. The results of the actual penetration shall be documented;

c) 对于桥面正交异性钢板：

c) for bridge deck orthotropic steel plates:

1) 由全机械化焊接过程焊接的加强筋至桥面板连接应每 120 m 桥长进行检查，至少对一座桥进行一次生产测试，并进行宏观检查。宏观截面测试应在焊缝的开始、停止和中间准备；

1) stiffener to deckplate connections welded by fully mechanized welding process shall be checked with a production test for each 120 m length of bridge, with a minimum of one production test for a bridge and inspected by macro-examination. Macro section tests shall be prepared at start or stop and at the middle of the weld;

2) 加强筋与加强筋连接的拼接板应通过生产测试进行检查。

2) stiffener to stiffener connections with splice plates shall be checked with a production test.

## 8 声称符合本文件所需文件

## 8 Documents required to claim conformity to this document

### 8.1 一般规定

#### 8.1 General

施工方可以通过以下方式声称符合 ISO 17607-5 的要求：

Constructors may claim conformity with the requirements of ISO 17607-5 either by:

采用本文中提及的适用的 ISO 标准；或

— adoption of the ISO standards referenced as applicable; or

- 采用其他提供与本文中列出的 ISO 标准技术等效条件的标准或文件；
- adoption of other standards or documents that provide technically equivalent conditions to the ISO standards listed in this document
- 采用其他提供与本文中列出的 ISO 标准技术等效条件的文件。
- adoption of other documents that provide technically equivalent conditions to the ISO standards listed in this document

除非在建造技术规格书中另有列出，施工方有责任证明所选的标准或文件提供了与相应 ISO 标准中条件技术等效。

Unless otherwise listed in the execution specification, it is the responsibility of the constructor to demonstrate that the standards or documents selected provide technically equivalent conditions to those in the corresponding ISO standards.

在建造前，采用其他标准或文件应经规范制定者验证并批准，并应纳入建造技术规格书。

Prior to execution, adoption of other standards or documents shall be verified and approved by the specifier and shall be incorporated into the execution specifications.

## **8.2 符合性声明**

### **8.2 Declaration of conformity**

声称符合这些要求的施工方应列出适用的支持标准或文件。

A constructor claiming conformity with these requirements shall list the applicable supporting standards or documents.

## 附录 A

### Annex A

(规范性)

(normative)

—附加信息，与建造级别相关的选项和需求列表

#### Additional information, list of options and requirements related to the execution levels

##### A.1 所需附加信息列表

##### A.1 List of required additional information

表 A.1 提供了在本文档中需要的附加信息，这些信息适用于充分定义工作建造要求，以符合本文（即在文本中使用了“应规定”的措辞）。

Table A.1 provides the additional information that is required in the text of this document as appropriate to fully define the requirements for execution of the work to be in accordance with this document (i.e. where the wording “shall be specified” is used).

表 A.1 附加信息

Table A.1 — Additional information

条款 Clause	所需附加信息 Additional information required
6.4.1.2	空心截面接头的起始和终止区域以及方法 Start and stop zones and methods for hollow section joints
6.5.6	不允许焊接临时附件的区域 Areas where welding of temporary attachments is not permitted
6.5.6	EXL3和EXL4使用临时附件 Use of temporary attachments for EXL3 and EXL4
6.5.9.1	用于适应组成产品可用长度的对接焊缝的位置 The location of butt welds used as splices to accommodate available lengths of constituent products
6.5.13	槽焊和塞焊孔的尺寸 Dimensions of holes for slot and plug welds
6.5.14	其他焊缝类型要求 Requirements for other weld types
6.5.16	如果VT对<460MPa钢级的杂散弧进行检查，是否需要PT或MT补充 If VT of stray arcs on steel grades < 460MPa is to be supplemented by PT or MT
	对已完成焊缝表面进行打磨和修整的要求 Requirements for grinding and dressing of the surface of completed welds
6.6	焊缝几何形状和轮廓的任何额外要求 Any additional requirements for weld geometry and profile

6.6.1	EXL4的识别焊缝的焊缝质量 Weld quality for identified welds for EXL4
6.6.2	承受疲劳的焊接接头位置的细节类别（DC）的验收标准 Acceptance criteria in terms of detail category (DC) for welded joint locations subject to fatigue
7.6.1	每个识别的EXL4焊缝的补充NDT的范围 The scope of supplementary NDT for each identified EXL4 weld
7.6.1	检查的特定EXL4接头以及测试的范围 Specific EXL4 joints for inspection together with the extent of testing

## A.2 选项列表

### A.2 List of options

此列表列出了在建造技术规格书中可能指定的项目，以定义本文档中给出的选项要求的工作建造。

This lists the items which maybe specified in the execution specification to define requirements for the execution of the work where options are given in this document.

表 A.2 附加信息

Table A.2 — List of options

条款 Clause	应指定的选项 Option(s) to be specified
4	是否需要建造焊接的质量计划 If a quality plan for execution of the welding is required
5.2	是否为每个单独的组成产品指定可追溯性 If traceability for each individual constituent product is specified
5.2	是否使用表6中的其他选项 If other options than those in Table 6 shall be used
5.2	当焊接改进型大气腐蚀性钢材时是否需要颜色匹配 If colour matching is required for when welding improved atmospheric corrosion resistant steel
6.2	是否有与疲劳或地震细节类别相关的焊接要求 If there are welding requirements related to fatigue or seismic detail categories
6.2	是否有关于焊接设备检查、维护和修理的具体要求 If there are specific requirements related to the inspection, maintenance, and repair of welding equipment
6.3	是否明确允许使用其他焊接工艺 If use of other welding processes is explicitly allowed
6.4.1.1	是否需要特殊的定位焊的沉积条件 If special deposition conditions for tack welds are required
	对于EXL1是否需要使用工作指导 If work instructions are to be used for EXL1
6.4.1.2 a)	是否需要冲击测试 If impact tests are required
6.4.1.2	是否可以使用EXL3或EXL4的标准焊接程序 If standard welding procedures maybe used for EXL3 or EXL4
	根据ISO 9018的替代测试条件 Alternative conditions to testing in accordance with ISO 9018
6.5.1.1	如果cope孔的半径小于40毫米 If cope holes may have a radius less than 40 mm
6.5.4	与附录B不同的空心截面组件的组装规范 Other specification than in Annex B for assembly of hollow section components to be welded
6.5.6	是否允许在≥460 MPa等级或承受疲劳的构件上进行剥落和凿削

	If chipping and gouging are permitted on grades $\geq 460$ MPa or on components subject to fatigue 对于EXL3和EXL4是否允许切割和凿削 If cutting and chipping are permitted for EXL3 and EXL4
6.5.7	如果未并入最终焊缝的定位焊需要移除 If tack welds that are not incorporated into final welds need to be removed
6.5.9.1	对于EXL2, 是否需要用于全穿透横向对接焊缝的run-on/run-off件 For EXL2, if run-on/run-off pieces are required for full penetration transverse butt welds
	对于EXL2、EXL3和EXL4, 是否需要用于全穿透纵向对接焊缝或部分穿透对接焊缝的run-on/run-off件 For EXL2, EXL3 and EXL4, if run-on/run-off pieces are required for full penetration longitudinal butt welds or partial penetration butt welds
	如果需要平整的表面 If a flush surface is required
6.5.9.2	如果不使用永久性钢背材进行单面焊 If permanent steel backing material shall not be used for single side welds
6.5.9.2	如果允许在未加背材的空心截面连接的单面对接焊缝上进行平整打磨 If flush grinding of single-sided butt welds in joints between hollow sections executed without backing is permitted
6.5.13	是否允许在未先进行槽焊的情况下进行塞焊 If plug welds performed without previous slot welding are permitted
6.5.16	对于 $\geq 460$ MPa钢级, 是否不需要去除焊渣 If, for steel grades $\geq 460$ MPa, removing of weld spatter is not required.
6.6.1	对于EXL1、EXL2和EXL3, 是否需要其他焊缝缺陷的验收标准 If, for EXL1, EXL2 and EXL3, other acceptance criteria for weld imperfections are required
6.6.2	是否适用替代的可接受标准用于承受地震作用的焊缝 If alternative acceptable criteria for welds subject to seismic actions applies
6.6.3	如果不以细节类别 (DC) 的形式指定承受疲劳的焊缝的验收标准 Alternative criteria if acceptance criteria for welds subject to fatigue are not to be specified in terms of detail category (DC)
	是否使用ISO 5817:2014, 附录C中的验收标准 If acceptance criteria to ISO 5817:2014, Annex C are to be used
6.6.5	正交异性桥面焊缝的要求 Requirements for welds in orthotropic bridge decks
7.2.1	是否确定特定接头进行检查以及EXL1、EXL2和EXL3的测试范围和方法 If specific joints are identified for inspection together with the extent and method of testing for EXL1, EXL2 and EXL3
	是否使用焊接检验等级来定义补充检验的范围和百分比, 如果是, 每个相关焊缝的焊接检验等级 If weld inspection classes are to be used for defining the scope and percentage extent of supplementary, and, if so, the weld inspection class for each relevant weld
7.2.2.1	是否可以在指定的保持时间之前完成焊缝的视觉检验和补充NDT If visual inspection and supplementary NDT of a weld can be completed before the designated hold time
7.2.5	是否需要EXL3和EXL4的生产测试 If production tests are required for EXL3 and EXL4
<b>附录B — 空心截面中的焊接接头</b> <b>Annex B – Welded joints in hollow sections</b>	
B.4(d)	如果隐藏的趾部区域不需要焊接 If the hidden toe area is not to be welded

### A.3 与建造水平相关的要求

#### A.3 Requirements related to the execution levels

本条款列出了与本文档中引用的每个建造水平相关的特定要求。

This clause lists requirements specific to each of the execution levels referenced in this

document.

表格 A.3 中以粗体字标识的项目与整个结构钢制品（或结构钢制品的一个阶段）的一般控制体系相关，并且可以选择通用的建造水平。其他项目通常需要根据组件或连接细节选择适当的建造水平。

Items identified in bold letters in Table A.3 relate to the general system of control of execution and are amenable to a common choice of execution level across the whole of the structural steelwork (or a phase of the structural steelwork). The other items generally demand the selection of the appropriate execution level on a component-by-component or a connection detail-by-detail basis.

表 A.3 每个建造水平的要求

Table A.3 — Requirements to each execution level

条款 Clauses	EXL1a	EXL2a	EXL3	EXL4
<b>4 — 建造技术规格书和质量要求</b> <b>4 – Execution specification and quality requirements</b>				
质量文件 Quality documentation	—	是 Yes	是 Yes	是 Yes
<b>5 — 成分产品</b> <b>5 – Constituent products</b>				
检验文件 Inspection documents	见表1 See Table 1	见表1 See Table 1	见表1 See Table 1	见表1 See Table 1
可追溯性 Traceability	—	是（部分） Yes (partial)	是（全部） Yes (full)	是（全部） Yes (full)
	—	是（标记） Yes (by marking)	是（从收到货到交接） Yes (from receipt to handover)	是（从收到货到交接） Yes (from receipt to handover)
标记 Marking	—	是 Yes	是 Yes	是 Yes
<b>6 — 焊接</b> <b>6 – Welding</b>				
6.1 一般规定 6.1 General	ISO 3834-4	ISO 3834-3	ISO 3834-2	ISO 3834-2
<b>6.4 焊接程序和焊接人员的资格认定</b> <b>6.4 Qualification of welding procedures and welding personnel</b>				
6.4.1 焊接程序的资格认定 6.4.1 Qualification of welding procedures	—	见表2 See Table 2	见表2 See Table 2	见表2 See Table 2
6.4.2 焊工和焊接操作工 6.4.2 Welders and	焊工：ISO 9606-1 操作工：ISO 14732 Welders:	焊工：ISO 9606-1 操作工：ISO 14732 Welders:	焊工：ISO 9606-1 操作工：ISO 14732 Welders:	焊工：ISO 9606-1 操作工：ISO 14732 Welders:



welding operators	ISO 9606-1 Operators: ISO 14732	ISO 9606-1 Operators: ISO 14732	ISO 9606-1 Operators: ISO 14732	ISO 9606-1 Operators: ISO 14732
6.4.3 焊接协调 6.4.3 Welding coordination	—	技术知识和能力 ISO 14371 Technical knowledge and competence ISO 14371	技术知识和能力 ISO 14371 Technical knowledge and competence ISO 14371	技术知识和能力 ISO 14371 Technical knowledge and competence ISO 14371
6.5.1 接头准备 6.5.1 Joint preparation	—	—	预制底漆不允许 Prefabrication primers not allowed	预制底漆不允许 Prefabrication primers not allowed
6.5.6 临时附件 6.5.6 Temporary attachments	—	—	使用需指定 切割和凿削不允许 Use to be specified Cutting and chipping not permitted	使用需指定 切割和凿削不允许 Use to be specified Cutting and chipping not permitted
6.5.7 定位焊 6.5.7 Tack welds	—	合格焊接程序 Qualified welding procedure	合格焊接程序 Qualified welding procedure	合格焊接程序 Qualified welding procedure
6.5.9 对接焊缝 6.5.9.1 一般规定 6.5.9 Butts welds 6.5.9.1 General 6.5.9.2 单面焊接点 6.5.9.2 Single side welds	—	运行起始/终止件 (如果指定) 永久背材连续 Run on/runoff pieces if specified	运行起始/终止件 Run on/run off Pieces 永久背材连续 Permanent backing continuous	运行起始/终止件 Run on/run off Pieces 永久背材连续 Permanent backing continuous
6.5.16 焊接建造 6.5.16 Execution of welding	—	—	去除飞溅 Removal of spatter	去除飞溅 Removal of spatter
6.6 验收标准 6.6 Acceptance criteria	ISO 5817 质量等级D ISO 5817 Quality level D	ISO 5817 质量等级C 通常 ISO 5817 Quality level C generally	ISO 5817 质量等级B ISO 5817 Quality level B	ISO 5817 质量等级B 对于已识别的焊缝有特定标准 ISO 5817 Quality level B with specific criteria for identified welds
7 — 检验、测试和校正 7 – Inspection, testing and correction				
7.2.1 一般规定 7.2.1 General	VT	NDT: 见表6 NDT: See Table 6	NDT: 见表6 NDT: See Table 6	NDT: 见表6 NDT: See Table 6
7.2.2.7 焊缝校正 7.2.2.7 Correction of welds	无需WPQR No WPQR required	根据WPQR In accordance with WPQR	根据WPQR In accordance with WPQR	根据WPQR In accordance with WPQR
7.2.5 生产测试 7.2.5 Production tests	—	—	如果指定 If specified	如果指定 If specified
注: 破折号“—”表示文本中没有具体要求。 NOTE a dash "—" means no specific requirement in the text.				

## 附录 B

### Annex B

(资料性)

(informative)

—空心截面的焊接接头

### Welded joints in hollow sections

#### B.1 一般规定

#### B.1 General

本附录提供了空心截面焊接接头建造的指导。

This annex gives guidance for execution of welded joints in hollow sections.

#### B.2 起止位置的指导

#### B.2 Guidance for start and stop positions

以下指导可用于直线焊接接头：

The following guidance maybe used for in-line joints:

a) 应选择弦杆中直线拼接接头的焊接起始和停止位置，以避免这些位置直接位于随后的横撑与弦杆之间的焊接位置之下；

a) stop and start positions of welds for in-line splice joints in chords should be chosen to avoid these positions coming directly under the location of a subsequent weld between a brace and the chord;

b) 两个直线方形或矩形空心截面之间的焊接起始和停止位置不应位于或靠近角落位置。

b) stop and start positions for welds between two in-line square or rectangular hollow sections should not be located at or close to the corner positions.

以下指导可用于其他接头：

The following guidance maybe used for other joints:

c) 起始和停止位置不应位于或靠近两个圆形空心截面之间接头的趾部位置或侧面位置，如图 B.1 所示；

c) stop and start positions should not be located at or close to the toe position or lateral flank positions of a joint between two circular hollow sections in accordance with Figure B.1;

d) 起始和停止位置不应位于或靠近方形或矩形空心截面横撑与空心弦杆组件之间接头的角落位置；

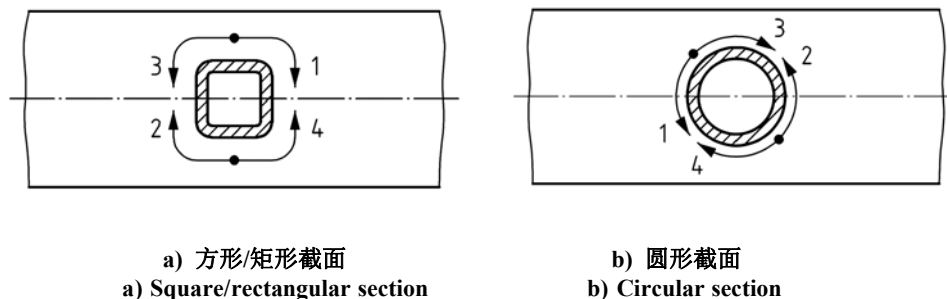
d) stop and start positions should not be located at or close to the corner positions of a joint between a square or rectangular hollow section bracing and a hollow chord component;

e) 图 B.1 给出了焊接横撑到弦杆接头的推荐焊接顺序；

e) recommended welding sequence for welding brace to chord joints are given in Figure B.1;

f) 即使出于强度原因不需要全部焊接长度，也应完成空心截面之间的全部周围焊接。

f) welding between hollow sections should be completed all round, even if this total length of weld is not necessary for strength reasons.



标引符号说明：

**Key**

• 焊接起始点

• weld start point

1, 2, 3, 4 焊接顺序

1, 2, 3, 4 order of welding

图 B.B.1 — 起始和终止位置及焊接顺序

Figure B.B.1 — Start and stop positions and welding sequence

## B.3 接头面的准备

### B.3 Preparation of joint faces

参考 6.5.1.2, 图 B.2 至 B.5 展示了根据 ISO 9692-1 标准, 对空心截面构件的横撑与弦杆接头的焊接准备和装配的示例。

With reference to 6.5.1.2, examples of application of ISO 9692-1 to brace to chord joints between hollow sections are given in Figures B.2 to B.5.

对于斜切接头的焊接准备和装配, 其要求与直线对接接头的焊接准备和装配相同, 需要增加斜切内侧的倒角角度, 并减少外侧的倒角角度, 如图 B.6 所示。

Recommendations for the weld preparation and fit-up for mitre butt joints are locally the same as for butt welds between two components in-line, which requires the bevel angle to be increased on the inside of the mitre and reduced on the outside as shown in Figure B.6.

## B.4 焊接组装

### B.4 Assembly for welding

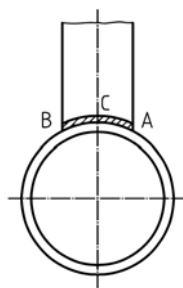
根据 6.5.4, 待焊接的空心截面组件的组装应符合以下要求:

In accordance with 6.5.4, assembly of hollow section components to be welded should be in accordance with the following requirements:

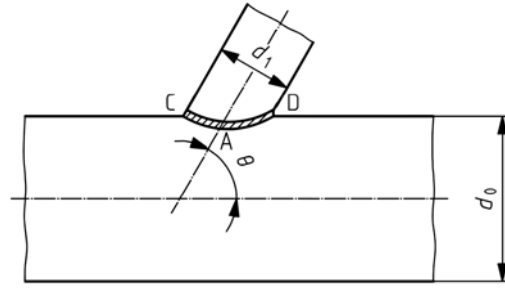
- a) 优先使用不重叠焊接的单独组件组装 (图 B.7 中的案例 A);
- a) assembly using non-overlapping welding of the separate components is preferred (Case A in Figure B.7);
- b) 应避免重叠组件的组装; 如果必要, 可以接受图 B.7 中的案例 B;
- b) assembly of overlapping components should be avoided; if necessary Case B in Figure B.7 is acceptable;
- c) 如果组件重叠 (如案例 B), 焊接细节应指定哪些组件需要切割以适应其他组件;
- c) if components overlap (as Case B), the welding details shall specify which components are to be cut to fit around other components;
- d) 除非在建造技术规格书中另有规定, 否则不需要焊接隐藏的趾部区域 (如案

例 B)。

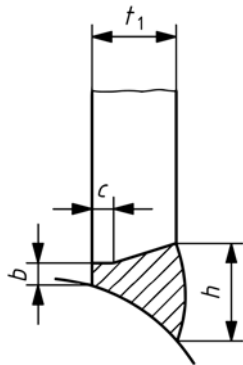
d) the hidden toe area (as Case B) does not have to be welded unless specified in the execution specification.



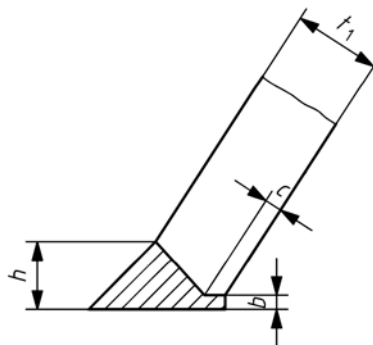
a) 端视图  
a) End view



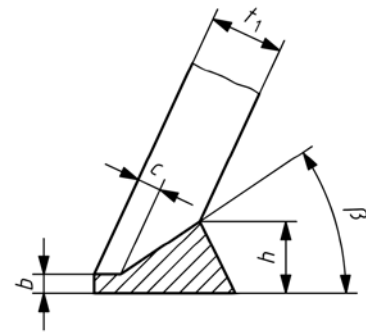
$d_1 < d_0$   
 $\theta = 60^\circ \sim 90^\circ$   
b) 侧视图  
b) Side view



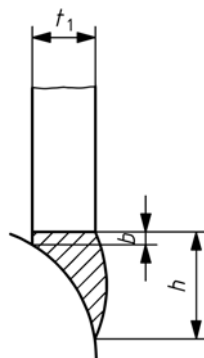
$b = 2\text{mm} \sim 4\text{mm}$   
 $c = 1\text{mm} \sim 2\text{mm}$   
c) A-B截面  
c) Detail at A or B



$b = 2\text{mm} \sim 4\text{mm}$   
 $c = 1\text{mm} \sim 2\text{mm}$   
d) C点  
d) Detail at C



$b = 2\text{mm} \sim 4\text{mm}$   
 $c = 1\text{mm} \sim 2\text{mm}$   
e) D点  
e) Detail at D:



$d_1 < d_0$   
 $b = \max. 2\text{ mm}$   
f) 当  $\theta < 60^\circ$  时, A点或B点的细节  
f) Detail at A or B for  $\theta < 60^\circ$

标引符号说明:

Key

$d_1$  横撑构件的直径

$d_1$  outside diameter of brace member

$c$  钝边

$c$  root face

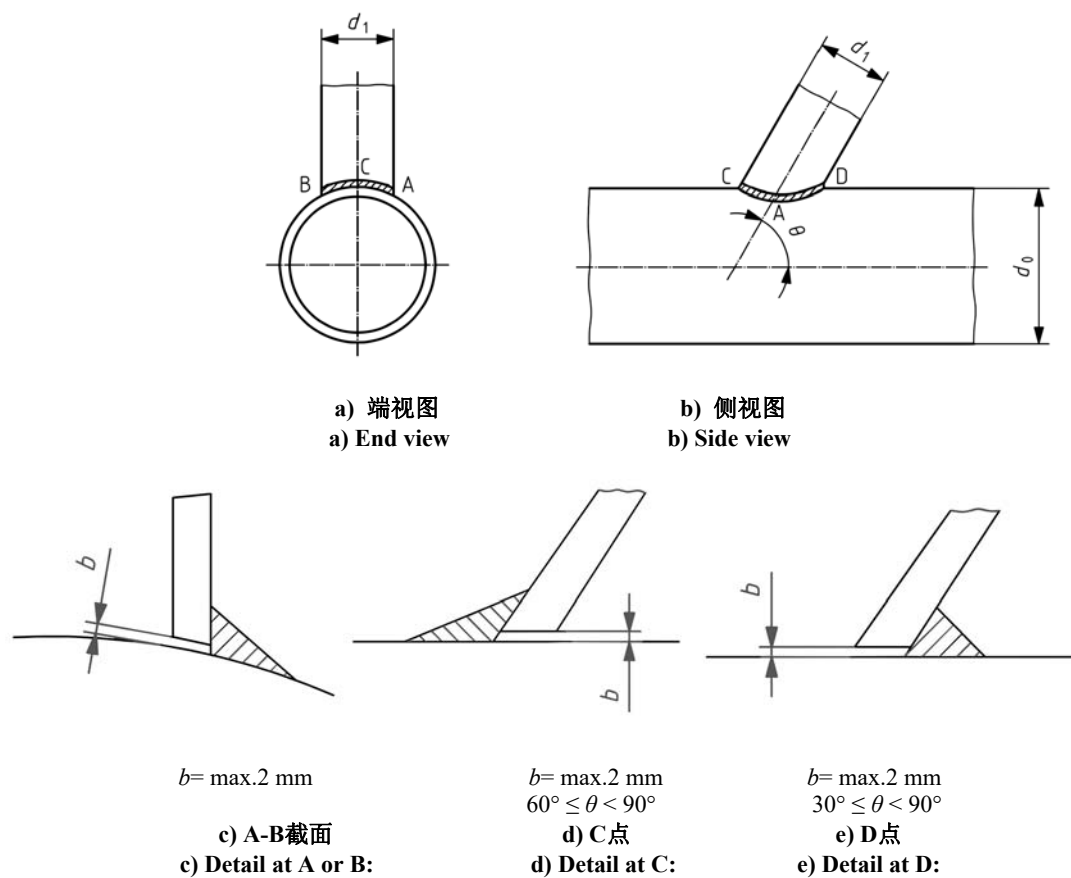
$d_0$  弦杆构件的外径  
 $d_0$  outside diameter of chord member  
 $\theta$  坡口角度  
 $\theta$  brace angle  
 $b$  根部间隙  
 $b$  root opening  
 $t_1$  横撑构件的厚度  
 $t_1$  thickness of brace member  
 $h$  焊脚尺寸  
 $h$  weld height

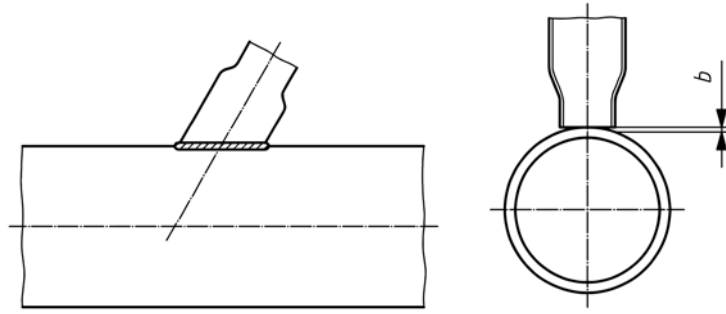
注：将ISO 9692-1案例1.4应用于圆形空心截面。

NOTE Application of ISO 9692-1 case 1.4 to circular hollow sections.

图 B.2 — 焊接准备和装配 — 圆形空心截面横撑与弦杆接头的对接焊缝

Figure B.2 — Weld preparation and fit-up – Butt welds in circular hollow sections brace to chord joints





$b = \max. 2 \text{ mm}$ , 沿着较大管径的纵轴测量。  
 $b = \max. 2 \text{ mm}$ , measured along  
the longitudinal axis of the  
larger pipe diameter

f) 侧视图  
f) Side view

g) 端视图  
g) end view

标引符号说明:

Key

$d_1$  支撑构件的外径

$d_1$  outside diameter of brace member

$d_0$  弦构件的外径

$d_0$  outside diameter of chord member

注: 将ISO 9692-1案例3.1.1应用于圆形空心截面。

NOTE Application of ISO 9692-1 case 3.1.1 to circular hollow sections.

$\theta$  坡口角度

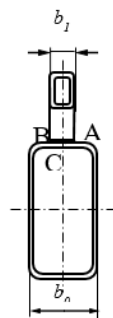
$\theta$  brace angle

$b$  根部间隙

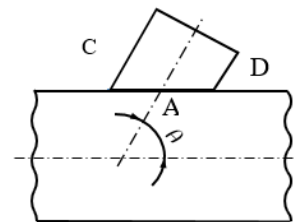
$b$  root opening

图 B.3 — 焊接准备和装配 — 圆形空心截面支撑与弦接头的角焊缝

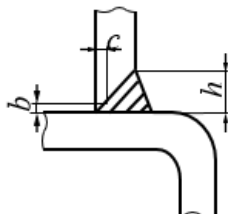
Figure B.3 — Weld preparation and fit-up – Fillet welds in circular hollow  
section brace to chord joints



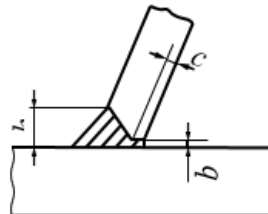
a) 端视图  
a) End view



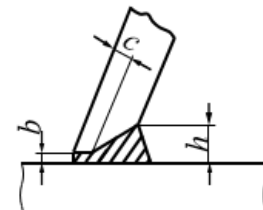
b) 侧视图  
b) Side view



$b_1 < b_0$   
 $b = 2 \text{ mm to } 4 \text{ mm}$   
 $c = 1 \text{ mm to } 2 \text{ mm}$



$b = 2 \text{ mm to } 4 \text{ mm}$   
 $c = 1 \text{ mm to } 2 \text{ mm}$



$b = 2 \text{ mm to } 4 \text{ mm}$   
 $c = 1 \text{ mm to } 2 \text{ mm}$   
 $60^\circ \leq \theta < 90^\circ$

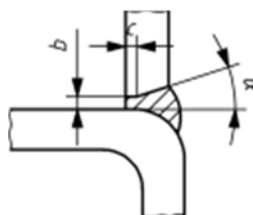
c) A点或B点  
c) Detail at A or B:

d) C点  
d) Detail at C:

e) D点  
e) Detail at D:

当 $\theta < 60^\circ$ ，在趾部区域的D点应使用角焊缝（如图B.5所示）——焊缝计算厚度折减值 $z$ 见表B-1和B-2。

For  $\theta < 60^\circ$ , a fillet weld detail (as Figure B.5) is preferred to the detail at D in the heel area – see also Tables B.1 and B.2 for  $z$ -loss allowances.



$b_1 = b_0$   
 $b = 2 \text{ mm max.}$   
 $c = 1 \text{ mm to } 2 \text{ mm}$   
 $\alpha = 20^\circ \text{ to } 25^\circ$

f) A点或B点(主管与支管外侧宽度相同)  
f) Detail at A or B where brace and chord of same width

标引符号说明:

Key

$b_1$ 支管的外径	$b_0$ 主管的外径
$b_1$ outside width of brace member	$b_0$ outside width of chord member
$\theta$ 坡口角度	$b$ 根部间隙
$\theta$ brace angle	$b$ root opening
$c$ 钝边	$h$ 焊脚尺寸
$c$ root face	$h$ weld height
$\alpha$ 主管坡口面角度	
$\alpha$ chord bevel angle	

注: ISO 9692-1范例1.4在方、矩形空心管中的应用。

NOTE Application of ISO 9692-1 case 1.4 to square or rectangular hollow sections.

图 B.4 — 方、矩形空心管相贯节点对接焊缝的形式与尺寸

Figure B.4 — Weld preparation and fit-up – Butt welds in square or rectangular hollow section brace to chord joints



表 B.1 非管状节点连接的焊缝计算厚度折减值  $z$

Table B.1 — Z loss dimension when determining minimum weld sizes in non-tubular connections

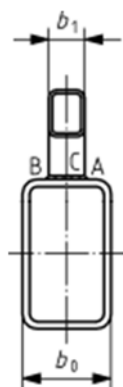
两面角 $\psi$ Dihedral angle, $\psi$	焊接位置 – PF/PG或 PC/PD <sup>b</sup> Welding position – PF/PG or PC/PD <sup>b</sup>		焊接位置– PC/PD或 PA <sup>b</sup> Welding position – PC/PD or PA <sup>b</sup>	
	焊接方法 <sup>a</sup> Process <sup>a</sup>	折减值 $z$ (mm) Z mm	焊接方法 Process <sup>a</sup>	折减值 $z$ (mm) Z mm
$60^\circ > \psi \geq 45^\circ$	焊条电弧焊 111	3	焊条电弧焊 111	3
	药芯焊丝自保护焊 114	3	药芯焊丝自保护焊 114	0
	药芯焊丝气体保护焊 137	3	药芯焊丝气体保护焊 137	0
	实心焊丝气体保护焊 131	/	实心焊丝气体保护焊 131	0
$45^\circ > \psi \geq 30^\circ$	焊条电弧焊 111	6	焊条电弧焊 111	6
	药芯焊丝自保护焊 114	6	药芯焊丝自保护焊 114	3
	药芯焊丝气体保护焊 137	10	药芯焊丝气体保护焊 137	6
	实心焊丝气体保护焊 131	/ N/A	实心焊丝气体保护焊 131	6
<sup>a</sup> 根据ISO 4063 确定焊接方法 <sup>a</sup> In accordance with ISO 4063. <sup>b</sup> 根据ISO 6947 确定焊接位置 <sup>b</sup> In accordance with ISO 6947.				

### B.B.2 圆管 T、Y、K 形相贯节点的焊缝计算厚度折减值 $z$

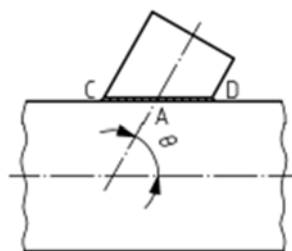
Table B.B.2 — Z loss dimension when determining minimum weld sizes in PJP T-, Y-, and K-tubular connections

夹角 $\phi$ Joint Included Angle $\phi$	焊接位置 – PF/PG或 PC/PD <sup>b</sup> Welding position – PF/PG or PC/PD <sup>b</sup>		焊接位置– PC/PD或 PA <sup>b</sup> Welding position – PC or PA <sup>b</sup>	
	焊接方法 <sup>a</sup> Process <sup>a</sup>	折减值 $z$ (mm) Z mm	焊接方法 Process <sup>a</sup>	折减值 $z$ (mm) Z mm
$\phi \geq 60^\circ$	焊条电弧焊 111	2	焊条电弧焊 111	0
	药芯焊丝自保护焊 114	0	药芯焊丝自保护焊 114	0
	药芯焊丝气体保护焊 137	0	药芯焊丝气体保护焊 137	0
	实心焊丝气体保护焊 131	/	实心焊丝气体保护焊 131	0
	实心焊丝气体保护焊 (短路过渡) 131-D	0	实心焊丝气体保护焊 (短路过渡) 131-D	0

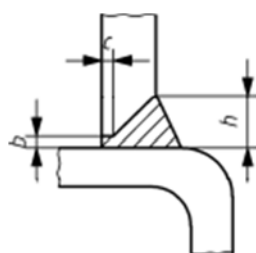
60°>φ≥45°	焊条电弧焊 111	3	焊条电弧焊 111	3
	药芯焊丝自保护焊 114	3	药芯焊丝自保护焊 114	0
	药芯焊丝气体保护焊 137	3	药芯焊丝气体保护焊 137	0
	实心焊丝气体保护焊 131	/	实心焊丝气体保护焊 131	3
	实心焊丝气体保护焊（ 短路过渡） 131-D	3	实心焊丝气体保护焊（ 短路过渡） 131-D	6
45°>φ≥30°	焊条电弧焊 111	6	焊条电弧焊 111	3
	药芯焊丝自保护焊 114	6	药芯焊丝自保护焊 114	6
	药芯焊丝气体保护焊 137	10	药芯焊丝气体保护焊 137	6
	实心焊丝气体保护焊 131	/	实心焊丝气体保护焊 131	6
	实心焊丝气体保护焊（ 短路过渡） 131-D	10	实心焊丝气体保护焊（ 短路过渡） 131-D	6
<sup>a</sup> 根据ISO 4063 确定焊接方法 <sup>a</sup> In accordance with ISO 4063. <sup>b</sup> 根据ISO 6947 确定焊接位置 <sup>b</sup> In accordance with ISO 6947.				



a) 端视图  
a) End view



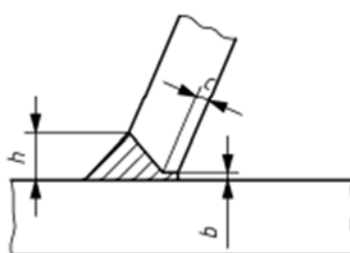
b) 侧视图  
b) Side view



c) A点或B点  
c) Detail A - B:

当  $b_1 < b_0$  时  
where  $b_1 < b_0$   
 $b = \max. 2 \text{ mm}$

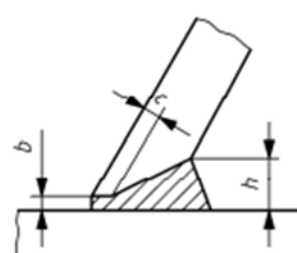
当  $\theta < 60^\circ$ , 在趾部区域的C点  
应使用对接焊缝 (如图B.2所  
示)。  
For  $\theta < 60^\circ$ , a butt weld detail  
(as Figure B.4) should be used  
at C in the toe area.



d) C点  
d) Detail at C:

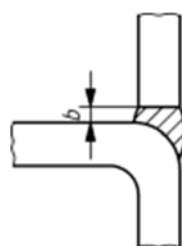
$60^\circ \leq \theta < 90^\circ$   
 $b = \max. 2 \text{ mm}$

对于更小的角度, 如果有  
足够的焊喉高度, 就不需  
要完全穿透。  
For the smallest angles,  
full penetration is not  
required provided  
there is adequate throat  
thickness



e) D点  
e) Detail at D:

$30^\circ \leq \theta < 90^\circ$   
 $b = \max. 2 \text{ mm}$



当  $b_1 = b_0$  时  
where  $b_1 = b_0$   
 $b = \max. 2 \text{ mm}$

f) A点或B点 (主管与支管外侧宽度相同)  
f) Detail at A or B  
where brace and chord of same width

标引符号说明:

Key

$b_1$  — 支管的外侧宽度  
 $b_1$  — outside width of brace member

$b_0$  — 主管的外侧宽度  
 $b_0$  — root opening

$b$ — 根部间隙	$c$ — 钝边
$b_0$ — outside width of chord member	$c$ — root face
$\theta$ — 坡口角度	$h$ — 焊脚尺寸
$\theta$ — brace angle	$h$ — weld height

注：ISO 9692-1中范例3.101在方、矩形空心管中的应用。

NOTE Application of ISO 9692-1 case 3.101 to square or rectangular hollow sections.

图 B.5 方、矩形空心管相贯节点角焊缝的形式与尺寸

Figure B.5 — Weld preparation and fit-up – Fillet welds in square or rectangular hollow section brace to chord joints

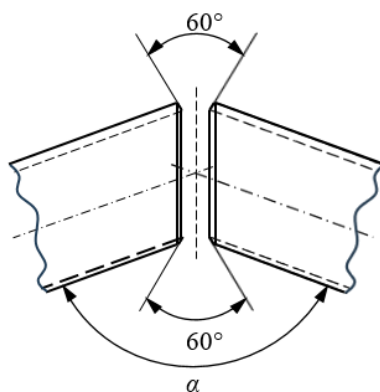
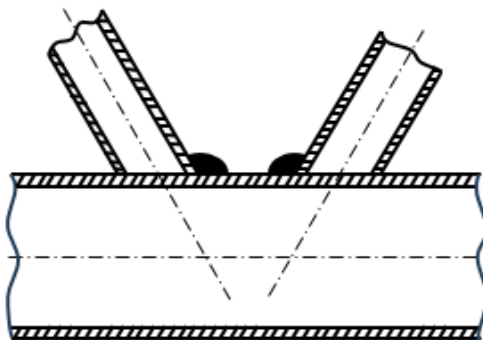


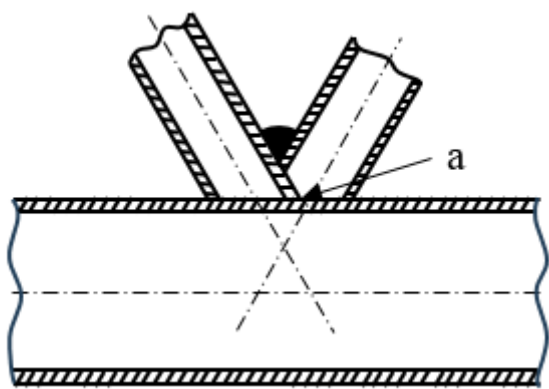
图 B.6 空心管斜焊缝的形式与尺寸

Figure B.6 — Weld preparation and fit-up for hollow section mitre joints



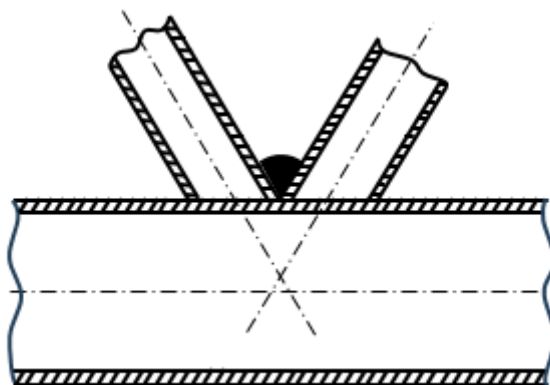
a) 无重叠焊缝的独立支管（推荐）

a) – Case A - Separate components, Non-overlapping welds – PREFERRED DETAIL



b) 重叠支管（可接受）

b) – Case B – Overlapping components – ACCEPTABLE DETAIL



c) 有重叠焊缝的独立支管（避免）

c) – Case C – Separate components but overlapping welds – DETAIL TO BE AVOIDED

标引符号说明：

Key

$a$  — 支管夹脚

$a$  angle between members

注：除非建造技术规格书中明确规定，否则隐藏的焊趾区域不宜焊接。

NOTE Hidden toe area does not need welding unless specified in the execution specification.

图 B.7 空钢管斜焊缝的形式与尺寸

Figure B.7 — Assembly of two brace components to a chord component

对于承受动荷载较小的节点，空钢管间的对接焊接头可允许存在根部间隙或钝边的偏差：

For joints not significantly subjected to dynamic loading, the following deviations maybe permitted for the alignment between the root edges or root faces of in-line butt joints between hollow section components:

a) 对于厚度小于 12 mm 的材料，最大偏差为较薄件厚度的 0.25；

- a) 25 % of the thickness of the thinner constituent product for material < 12 mm thick;
- b) 对于厚度大于 12 mm 的材料，最大偏差为 3 mm。
- b) 3 mm for material over 12 mm thick.

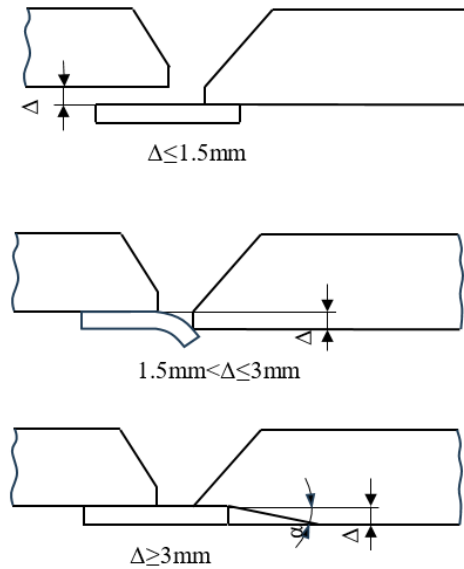
校正可通过机械加工来实现，包括修正壁厚，椭圆度或脱方度，但剩余材料的厚度要达到规定的最小值。

This alignment maybe achieved using machining of ends to correct wall thickness variation sand ovality or out-of-squareness of hollow sections, provided that the remaining material thickness conforms with the minimum specified.

对于不同厚度空心管间的直线拼接对接焊接头，可根据图 B.8 进行厚度设计：

For in-line splice butt joints between hollow sections of different thickness, the thicknesses may be matched using the following guidance in accordance with Figure B.8:

- c) 如果厚度差不超过 1.5 mm，可不进行处理；
- c) if the difference in thickness does not exceed 1,5 mm, no special measures are necessary;
- d) 如果厚度差不超过 3 mm，应采用衬垫材料的塑性以消除误差（局部热成型作用）；
- d) if the difference in thickness does not exceed 3 mm, the backing material may be shaped to accommodate the difference (local hot forming of the backing material maybe used);
- e) 如果厚度差超过 3 mm，应以小于等于 1/4 的坡度对较厚件的壁厚进行锥形处理。
- e) if the difference exceeds 3 mm the wall of the thicker component should be tapered with a slope of 1 in 4 or less.



标引符号说明:

Key

$\Delta$  — 厚度差

$\Delta$  — thickness difference

$\tan \alpha$  — 坡度 (不应超过1/4)

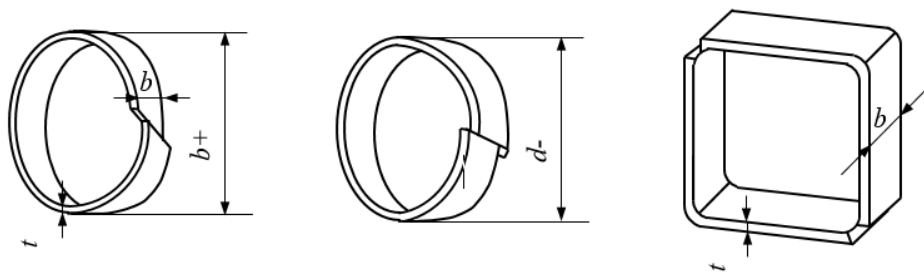
$\tan \alpha$  — slope (shall not exceed 1 in 4)

图 B.8 不同厚度空心管间的衬垫材料处理

Figure B.8 — Backing material details for components of different thickness

如果钢结构中的部件不宜作为衬垫材料，可参考图 B.9 选择合适的衬环和衬条。

If it is not appropriate to use part of the steel structure as backing material, Figure B.9 gives guidance on suitable shapes for backing rings or strips.



标引符号说明:

Key

$t$  — 厚度为3mm到6mm

$t$  — thickness = 3 mm to 6 mm

$b$  — 宽度为20mm到25mm

$b$  — breadth = 20 mm to 25 mm

$d-$  — 衬垫环直径的最小公差

$d-$  — backing ring diameter with minimum tolerance

$d+$  — 衬垫环直径的最大公差

$d+$  — backing ring diameter with maximum tolerance

图 B.9 衬环或衬条的形状

Figure B.9 — Suitable shapes for backing rings or strips

## B.5 角焊缝

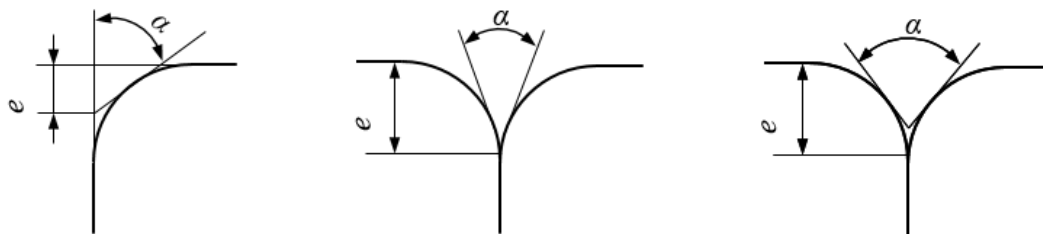
### B.5 Fillet welded joints

对于主管与支管的焊接接头，应选择合适的焊接工艺和坡口形式以确保焊缝的对接部分（应符合图 B.2 和图 B.4）与角焊部分（应符合图 B.3、表 B.1 和表 B.2 以及图 B.5）之间平缓过渡。

For brace to chord joints, the welding procedure and the local profile of weld gap should be chosen to ensure a smooth transition between those parts of the weld that are butts (which should be in accordance with Figures B.2 and B.4 and those that are fillets (which should be in accordance with Figure B.3, Tables B.1 and B.2 and Figure B.5).

对于喇叭形焊缝，用于焊接的夹角应超过  $60^\circ$ ，以确保焊缝的有效深度（如图 B.10 所示）。

For flare welds, the included angle of the weld preparation should exceed  $60^\circ$  for the effective depth of the weld, as shown in Figure B.10.



标引符号说明：

Key

$\alpha$  — 夹角  $60^\circ$

$\alpha$  included angle =  $60^\circ$

$e$  — 焊缝有效深度

$e$  effective depth of weld

图 B.10 喇叭形焊缝连接方、矩形空心管——基于  $60^\circ$  夹角的焊缝有效深度（无焊缝余高）确定

**Figure B.10 — Flare weld connecting two square/rectangular hollow section components - Determination of maximum effective depth of the weld,  $e$ , without reinforcement based on included angle,  $\alpha$ , of  $60^\circ$**



## **Annex C**

(资料性)

(informative)

### **焊缝检测等级评定指南**

#### **Guidance on the selection of weld inspection classes**

##### **C.1 概述**

##### **C.1 General**

对于不同重要程度的焊缝细节，仅有 EXL 等级的划分并不足以区分验收标准，检测的范围和程度，导致以下情况的发生：

It is possible that specification of EXL alone will not always be sufficient for the differentiation of the acceptance criteria and the extent of inspection for welds/details of different importance or criticality. This can result in the following:

- a) 对于不重要的焊缝，检测标准可能过于苛刻；
- a) the acceptance criteria can become too onerous for welds that are not important;
- b) 对于不重要的焊缝，检测范围可能过大；
- b) the extent of specified inspection can become too large for welds that are not important;
- c) 检测可能会遗漏关键位置。
- c) the specified inspection can miss the critical locations.

焊缝检测等级(WICs)的使用可以根据焊缝的关键性指导补充测试的范围和比例。

The use of weld inspection classes (WICs) can be useful in directing the scope and percentage extent of supplementary testing according to the criticality of the weld.

这从安全性和经济角度来看都是有益的，因为可以避免不必要的检查和修复。

This can be beneficial both from a safety aspect and from an economic point of view as unnecessary inspection and repair can be avoided.

最初选择焊缝检测等级(WICs)时应考虑特定焊接构造（例如，在困难条件下执行的焊接，如顶端焊缝、现场焊缝、临时连接焊缝）出现缺陷的可能性。

The initial choice of weld inspection classes (WICs) should take into account the likelihood that defects would arise for particular weld configurations (e.g. welds to be executed in difficult conditions such as overhead welds, site welds, welds for temporary attachments).

因此，焊缝检测等级(WICs)可根据焊接经验降低或重新设定。这种经验应针对每种焊接工艺和生产地点分别展开审查。

Subsequently, the weld inspection classes (WICs) may be reduced or re-instated based on experience in production. This experience should be reviewed separately for each welding process and production location.

## **C.2 标准选择**

### **C.2 Selection criteria**

如果要使用焊缝检测等级，那么表 C.1 提供了焊缝检测等级的选择指南。选择应遵循以下标准：

If weld inspection classes are to be used, then Table C.1 provides guidance on a systematic method for the selection of weld inspection class. Table C.1 is based on the following criteria for selection:

- a) 焊缝疲劳情况；  
a) utilization for fatigue;
- b) 焊缝失效对结构的影响；  
b) consequence of failure of weld for the structure;
- c) 应力的方向、类型和等级。  
c) direction, type and level of stresses.

## C.3 补充检测范围

### C.3 Extent of supplementary testing

表 C.2 规定了与焊缝检测等级相关的补充检测范围和方法。

Table C.2 specifies the extent and method of supplementary testing related to weld inspection classes.

表 C.1 焊缝检测等级评定指南

Table C.1 — Guidance on a method for selection of weld inspection class

焊缝疲劳损伤程度 <sup>a</sup> Level of fatigue utilization <sup>a</sup>	接头或组件失效引起的后果 <sup>c</sup> Consequences from failure of joint or component <sup>c</sup>	焊缝应力 <sup>b</sup> Stress in weld <sup>b</sup>	焊缝检测等级 Weld inspection class (WIC)
高疲劳损伤 High fatigue utilization	严重 <sup>b</sup> Substantial <sup>b</sup>	动态主应力的方向与焊缝方向交错（45°~135°） Welds with the direction of dynamic principal stress transverse to the weld (between 45° and 135°)	WIC5
		动态主应力的方向与焊缝方向一致（-45°~+45°） Welds with the direction of dynamic principal stress in the direction of the weld (between -45° and +45°)	WIC4
	不严重 <sup>c</sup> Not substantial <sup>c</sup>	动态主应力的方向与焊缝方向交错（45°~135°） Welds with the direction of dynamic principal stress transverse to the weld (between 45° and 135°)	WIC3
		动态主应力的方向与焊缝方向一致（-45°~+45°） Welds with the direction of dynamic principal stress in the direction of the weld (between -45° and +45°)	WIC2
		高拉伸应力 <sup>d</sup> 的方向与焊缝方向交错 Welds with high <sup>d</sup> tensile stresses transverse to weld	WIC5
		低拉伸应力 <sup>d</sup> 的方向与焊缝和（或）高剪切应力 <sup>d</sup> 方向交错 Welds with low tensile stresses transverse to weld and/or high <sup>d</sup> shear stresses	WIC4
无疲劳损伤（准静态）或低疲劳损伤 No fatigue (i.e. quasistatic) Or Low fatigue utilization	严重 <sup>b</sup> Substantial <sup>b</sup>	EXL3或EXL4等级中的高拉伸应力 <sup>d</sup> 焊缝 For welds in EXL3 or EXL4 with high <sup>d</sup> tensile stresses transverse to weld	WIC3
		除EXL1等级外的其他承载焊缝 All other load-bearing welds except welds in EXL1	WIC2
	不严重 <sup>c</sup> Not substantial <sup>c</sup>	EXL1等级和非承载焊缝 Welds in EXL1 and non-load-bearing welds	WIC1

<sup>a</sup>低疲劳损伤指的是计算的疲劳寿命超过所需疲劳寿命四倍的焊接节点。  
<sup>a</sup> Low fatigue utilization means connection with calculated fatigue life longer than four times the required fatigue life.  
<sup>b</sup>严重影响意味着接头或组件失效将导致：  
<sup>b</sup> Substantial consequences means that the failure of the joint or member will entail:  
—造成众多人员伤亡；  
— possible multiple loss of human life; and/or;  
—和/或引起较大污染；  
— significant pollution; and/or;  
—和/或出现重大经济损失。  
— major financial consequences.  
<sup>c</sup>如果结构具有足够的剩余强度以满足规定的意外荷载，那么其后果可以评估为“不严重”。  
<sup>c</sup> The consequences maybe assessed as Not substantial if the structure has been provided with sufficient residual strength to meet specified accidental actions.  
<sup>d</sup>高应力是指（准）静态应力超过焊缝拉伸或剪切能力的50%。相反，则为低应力。主应力方向与母材厚度方向一致时，选择焊接检测等级（WIC）时也应特别注意。  
<sup>d</sup> High stresses are those that (quasi-)static stresses that exceed 50 % of the welds tensile or shear capacity, as appropriate. Low stresses conversely. Special consideration should also be given to the selection of WIC where the principal stress is in the through-thickness direction of the parent material.

表 C.2 基于 WIC 进行补充检测的范围(单位: %)

Table C.2 — Percent extent of supplementary testing according to WIC

焊缝检测等级 (WIC) Weld inspection class (WIC)	接头类型 Type of Joint	RT	UT	MT/PT
WIC5	全熔透直线对接焊缝 Full penetration in-line butt weld	10	100	100
	全熔透T形焊缝 Full penetration T-butt weld	0	100	100
	部分熔透焊缝（熔透深度超12mm） Partial penetration welds with penetration depth greater than 12 mm	0	20	100
	其余部分熔透焊缝和所有角焊缝 Other partial penetration welds and all fillet welds	0	0	100
WIC4	全熔透直线对接焊缝 Full penetration in-line butt weld	0	50	100
	全熔透T形焊缝 Full penetration T-butt weld	0	50	100
	部分熔透焊缝（熔透深度超12mm） Partial penetration welds with penetration depth greater than 12 mm	0	10	100
	其余部分熔透焊缝和所有角焊缝 Other partial penetration welds and all fillet welds	0	0	100
WIC3	全熔透直线对接焊缝 Full penetration in-line butt weld	0	20	20
	全熔透T形焊缝 Full penetration T-butt weld	0	20	20
	部分熔透焊缝（熔透深度超12mm） Partial penetration welds with penetration depth greater than 12 mm	0	5	20
	其余部分熔透焊缝和所有角焊缝 Other partial penetration welds and all fillet welds	0	0	20
WIC2	全熔透直线对接焊缝	0	10	10

	Full penetration in-line butt weld			
	全熔透T形焊缝 Full penetration T-butt weld	0	10	10
	部分熔透焊缝（熔透深度超12mm） Partial penetration welds with penetration depth greater than 12 mm	0	5	5
	其余部分熔透焊缝和所有角焊缝 Other partial penetration welds and all fillet welds	0	0	5
WIC1	所有的焊接接头 All joint types	0	0	0

## 附录 D

### Annex D

(资料性)

(informative)

#### 建筑结构现场接头焊接的最低环境温度（俄罗斯）

#### Minimum ambient temperatures for the welding of field joints of building structures (Russia)

本附件基于俄罗斯标准 SP 70.13330 提供了焊接所需最低允许环境温度。

This annex provides unique criteria for minimum allowable ambient temperatures required for welding according to Russian standard SP 70.13330, unless otherwise noted.

表 D.1 焊接所需的最低允许环境温度（俄罗斯）

Table D.1 — Minimum allowable ambient temperatures required for welding  
(Russia)

工况 Condition	焊接组件的厚度 $t$ (mm) Thickness of welded elements, $t$ mm	结构焊接的最低环境温度 °C Minimum allowable ambient temperature for structural welding °C
1.1 碳钢制成的格构结构 1.1 Lattice structures made of carbon steels	$t \leq 16$ $16 > t \geq 30$ $30 > t \geq 40$ $t > 40$	-30° -30° -10° 0°
1.2 碳钢制成的空间片状结构和 实壁结构 1.2 Sheet volumetric and solid- wall structures made of carbon steels	$t \leq 16$ $16 > t \geq 30$ $30 > t \geq 40$ $t > 40$	-30° -20° -10° 0°
1.3 屈服强度低于390MPa的低合 金钢制成的格构结构 1.3 Lattice structures made of low-alloy steel with a yield strength of less than 390 MPa	$t \leq 16$ $16 > t \geq 30$ $30 > t \geq 40$ $t > 40$	-20° -10° 0° 5°
1.4 屈服强度高于390MPa的低合 金钢制成的空间片状结构和实壁 结构 1.4 Volumetric sheet and solid- walled structures made of low- alloy steel with a yield strength of more than 390 MPa	$t \leq 16$ $16 > t \geq 30$ $30 > t \geq 40$ $t > 40$	-20° 0° 2° 10°
1.5 屈服强度高于390MPa的低合 金钢制成的格构和片状结构	$t \leq 16$ $16 > t \geq 30$	-30° -30°

1.5 Lattice and sheet structures made of low-alloy steel with a yield strength of more than 390 MPa	$30 > t \geq 40$ $t > 40$	<p>对于<math>t &gt; 25</math> mm的情况，应独立于环境温度进行预热。</p> <p>For <math>t &gt; 25</math> mm, preheating should be carried out independently of the ambient temperature</p>
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